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## Weed Management in Organic Agriculture

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### ABSTRACT

Despite the serious threat which weeds offer to organic crop production, relatively little attention has so far been paid to research on weed management in organic agriculture, an issue that is often approached from a reductionist perspective. Compared with conventional agriculture, in organic agriculture weed interactions usually manifest themselves more slowly. It follows that weed management should be tackled in an extended time domain and needs deep integration with the other cultural practices, aiming to optimize the whole cropping system rather than weed control per se. In this respect, cover crop management is an important issue because of its implications for soil, nutrient, pest and weed management. It is stressed that direct (physical) weed control can only be successful where preventive and cultural weed management is applied to reduce weed emergence (e.g. through appropriate choice of crop sequence, tillage, smother D cover crops) and improve crop competitive ability (eg. through appropriate choice of crop genotype, sowing/planting pattern and fertilization strategy). Problem of weeds can be minimized by adopting right and integrated organic weed management approaches which, helps in reducing the competition by weeds without any adverse effect on yield, quality of produce and soil/ecosystem.

*Keywords:* Organic Agriculture, Organic weed management practices and Bio-herbicides

ORGANIC Agriculture has grown out of the conscious efforts by inspired people to create the best possible relationship between the earth and men. Since its beginning the sphere surrounding organic agriculture has become considerably more complex. A major challenge today is certainly its entry into the policy making field, its entry into global market and the transformation of organic products into commodities (Yadav *et al.*, 2009). During the last two decades, there has also been a significant sensitization of the global community towards environmental preservation and assuring of food quality. Keen promoters of organic farming consider that it can meet both these demands and become the mean for complete development of rural areas. After almost a century of development, organic agriculture is now being embraced by the main stream and shows great promise commercially, socially and environmentally. While, there is continuum of thought from earlier days to the present, the modern organic movement is radically different from its original form. It now has environmental sustainability at its core in addition to

the founders concerns for healthy soil, healthy food and healthy people.

In India, concept of organic farming is not new. In traditional India, only organic farming was practiced. Wherein, no chemical fertilizers and pesticides were used and only organic techniques where natural pesticides and organic manures were obtained from plant and animal products were used. During 1950s and 1960s, the ever increasing population of India lead to a food scarcity. The government was forced to import food grains from foreign countries and compelled to increase the food grain production of India to enhance the food security.

To overcome the problem of food scarcity, Green Revolution took place under the leadership of Dr. M. S. Swaminathan. During this period, high yielding varieties, chemical fertilizers, synthetic pesticides, mechanization, irrigation projects were introduced in the country, which helped in overcoming food crisis, self-sufficiency in food grain and buffer stock of food grains. But, over a period of time, this

lead to Stagnation or fall in productivity of crops, decline in soil fertility, salinity problem, lowering of water table, environmental pollution and others to overcome these problems farmers realized that the organic farming is the best solution.

TABLE 1

Percentage of Area under Organic Farming in the Total Cultivated Area of different Countries of the World

Country	Area (%)	Country	Area (%)
USA	0.23	Switzerland	7.94
UK	4.22	South Africa	0.05
Germany	4.10	Italy	3.70
Argentina	1.70	India	0.03
Austria	8.40	Pakistan	0.08
Australia	2.20	Srilanka	0.05

Source: Rajib Roy Chowdhury *et al.* (2013)

Organic agriculture is a production system that sustains health of soil, eco-system and people, by relying on ecological process, bio diversity and natural cycles and adapted to local conditions than use of inputs with adverse effects (Anon., 1997). It includes various methods like Natural farming, Bio-dynamic farming, Ecological farming, Homa farming, Homestead farming, Humus farming, Sewage farming and Zero chemical farming.

### Advantages of Organic Farming

1. Organic matter supplies all the essential macro and micro plant nutrients.
2. Organic matter improves physico - chemical and biological properties of soil.
3. Organic farming improves agro-ecosystem and helps in stopping environmental degradation.
4. Organically grown crops are preferred by most people as it is believed to be more nutritious compared to conventional ones.
5. Organic produce fetches more prices in national and international market.

### Constraints of Organic Farming

1. Organic manure contains fewer amount of nutrient;
2. Lack of awareness;
3. Pest management (Weed,

Insect and Diseases; 4. Marketing problems of organic inputs and products; 5. Shortage of organic biomass; 6. Poorly supporting infrastructure; 7. Lack of financial support; 8. Low yields during conversion period; 9. Political and social factors; 10. Complex certification procedure & 11. Lack of organic input responsive variety.

Weeds are often recognized as the most serious threat to organic crop production (Penfold *et al.*, 1995; Stonehouse *et al.*, 1996; Clark *et al.*, 1998) and fear of ineffective weed control is often perceived by farmers as one of the major obstacles to conversion from conventional to organic farming (Beveridge and Naylor, 1999). Despite this, researchers have so far paid relatively little attention to weed management-related issues in organic agriculture. Further more, weed management is often approached from a reductionist perspective, e.g. focusing only on the comparison between types and adjustments of implements for mechanical weed control in a given crop. This conventional approach neglects the systemic (holistic) nature of organic agriculture, which has long been recognized as a pillar for the design of real, effective organic crop production systems (Andrews *et al.*, 1990; Lockeretz, 2000). Cover crop use is then presented as an important link between soil, crop, pest and weed management in organic systems.

In this respect, a too narrow view of weed management is questionable, because of the likely under estimation of interaction effects among system components and of their carry over across growing seasons, which may also result in information of little practical value to farmers. After a reasoned analysis of the literature on this subject published recently, this paper illustrates how some peculiar features of organic systems suggest the need to undertake an integrated approach to weed management.

### How to Manage Weeds in Organic Farming?

Among the various constraints in organic farming, weeds are one of the major constraints. Organic farmers struggling to develop effective and economical weed management practices since, major yield losses are by weeds apart from pest and diseases. Farmers

rank weeds as the number one barrier to organic production (Walz, 1999) and organic farmers cite weed management as their number one research priority.

In approaching weed management within an organic system, it is important to remember the central goal; to reduce weed competition and reproduction to a level that the farmer can accept (Barberi, 2002). In many cases, this will not completely eliminate all weeds. Weed management should, however, reduce competition from current and future weeds by preventing the production of weed seeds and perennial propagules (the parts of a plant that can produce a new plant). Consistent weed management can reduce the costs of weed control and contribute to an economical crop production system.

**Organic weed management** : It begins with careful planning of the cropping system to minimize weed problems, and seeks to utilize biological and ecological processes in the field and throughout the farm ecosystem to give crops the advantage over weeds. In addition, mechanical and other control measures are usually needed to protect organic crops from the adverse effects of weeds. This is particularly true in vegetables and other annual crops, for which production practices keep natural plant succession at its earliest stages (Bond and Grundy, 2001).

### Strategies for Successful Weed Management in Organic Farming

Important practices / Methods to control weeds in organic farming are Prevention, Cultural, Mechanical, Biological, 5. Chemical (organically approved)

- I. *Prevention*: Avoid the entry of weed seeds on to the farm through Manures, Planting material, Mulching material, Intercultivation equipments / implements, Animals and Water *etc.*

### II Cultural Methods/Practices

#### Improve Crop Competitiveness

1. Increase crop density through narrow row spacing and increased seeding rate.
2. Use transplants, rather than seed.

3. Choose competitive crop cultivars.
4. Manage fertility according to crop needs; avoid excess application.
5. Spot application of organic fertilizers.

### Cultural Methods

i) *Crop rotation*: Crop rotation involves alternating different crops in a systematic sequence on the same land. It is an important strategy for developing a sound long term weed control program. Weeds tend to thrive with crops of similar growth requirements as their own and cultural practices designed to contribute to the crop may also benefit the growth and development of weeds. Mono culture, that is growing the same crop in the same field year after year, results in a build-up of weed species that are adapted to the growing conditions of the crop. When diverse crops are used in a rotation, weed germination and growth cycles are disrupted by variations in cultural practices associated with each crop (tillage, planting dates, crop competition, etc.).

Within a rotation, crop choice will determine both the current and the potential future weed problems that a grower will face. Traditionally, potato (*Solanum tuberosum* L.) was included in the rotation to reduce weed problems before a less competitive crop was grown (Shreshta *et al.*, 2000). For an organic grower, crop choice is complicated further by the need to consider soil fertility levels within the cropping sequence and to include fertility building periods in the rotation. Variations in crop and weed responses to soil nutrient levels can also play an important part in weed management. The inclusion of a fallow period in the rotation is known to reduce perennial weeds. It is best to alternate legumes with grasses, spring planted crops with fall planted crops, row crops with close planted crops and heavy feeders with light feeders.

ii) *Cover crops*: Rapid development and dense ground covering by the crop will suppress weeds. The inclusion of cover crops such as rye, red, clover, buckwheat and oilseed radish or over wintering crops like winter wheat or forages in the cropping system can suppress

weed growth. Highly competitive crops may be grown as short duration 'smother' crops within the rotation. Additionally, cover crop residues on the soil surface will suppress weeds by shading and cooling the soil. When choosing a cover crop, consideration should always be given to how the cover crop will affect the succeeding crop. In addition, decomposing cover crop residues may release allelochemicals that inhibit the germination and development of weed seeds.

iii) *Intercropping*: Intercropping involves growing a smother crop between rows of the main crop. Intercrops are able to suppress weeds. However, the use of intercropping as a strategy for seed control should be approached carefully. The intercrops can greatly reduce the yields of the main crop if competition for water or nutrients occurs.



Sunflower+groundnut



Sugarcane+soybean

Zahid Hussain *et al.* (2014) reported that, weed densities in the intercropping treatments were less than the weed densities in the sole crops.

iv) *Field Scouting*: It involves the systematic collection of weed and crop data from the field (weed distribution, growth stage, population, crop stage *etc.*). The information is used, in the short term, to make immediate weed management decisions to reduce or avoid economic crop loss. In the long term, field scouting is important in evaluating the success or failure of weed management programs and for making sound decisions in the future.

v) *Mulching*: Mulching or covering the soil surface can prevent weed seed germination by blocking light transmission preventing seed germination. All allelopathic chemicals in the mulch also can physically suppress seedling emergence. There are many forms of mulches available. Listed are three common ones.

Anup Das *et al.* (2016) recommended that, mulching with fresh Eupatorium 10 t/ha after earthing up at 30 DAS followed by soybean green manure incorporation in situ + one hand weeding 45 DAS had suppressed the weeds drastically and resulted in higher grain weight per cob in maize.

Significantly higher rice grain (4816 kg/ha) and straw yield (7108 kg/ha) was obtained in the treatment rice bran at 2 t/ha on 3 DAT + hand weeding in 35 DAT due to significant reduction in weed dry density and dry weight followed by *Azolla* + conoweeder incorporation on 20 and 40 DAT as compared to unweeded control which has fetched higher B:C ratio (2.45) (Table 2).

vi) *Planting patterns*: Crop population, spatial arrangement, and the choice of cultivar (variety) can affect weed growth. For example, studies have shown that narrow row widths and a higher seeding density will reduce the biomass of later-emerging weeds by reducing the amount of light available for weeds located below the crop canopy. Similarly, fast growing cultivars can have a competitive edge over the weeds.

vii) *Crop/Variety selection*: Careful selection of crop varieties is essential to limit weeds and pathogen problems and to satisfy market needs. Any crop variety that is able to quickly shade the soil between the rows and is able to grow more rapidly than the weeds will have an advantage.

viii) *Stale seed bed*: A false or stale seed bed is a useful weed control technique which involves creating a seedbed some weeks before seed is due to be sown. Preparation of such seedbed makes sure that any weed seeds that have been disturbed and brought to the soil surface during cultivation will thus have a chance to germinate and can then be hoed off or eliminated with the use of a flame weeder before sowing of the actual crop is carried out.

Patil and Reddy (2014) reported that, in finger millet crop, at 60 DAP the total weed density and weed dry weight was significantly lower in hand weeding twice

TABLE 2  
Effect of organic weed management practices on productive tillers, grain and straw yields of rice during *rabi* 2012 at TNAU, Coimbatore

Treatments	Weed dry weight (g) at 30 DAT	Productive tillers (No./m <sup>2</sup> )	Grain yield (kg/ha)	Straw yield (Kg/ha)	B:C ratio
T <sub>1</sub> - <i>S. aculeata</i> as intercrop and incorp. on 35 DAT	3.81 (12.54)	160.0	3856	6175	1.96
T <sub>2</sub> - <i>Azolla</i> + manual incorpn. on 20 and 40 DAT	3.21 (8.32)	165.0	4256	6558	1.97
T <sub>3</sub> - <i>Azolla</i> + rotary weeder incorpn. on 20 and 40 DAT	3.21 (8.33)	174.0	4321	6400	2.09
T <sub>4</sub> - <i>Azolla</i> + conoweeder incorpn. on 20 and 40 DAT	3.09 (7.54)	188.7	4716	6905	2.28
T <sub>5</sub> - Rotary weeder four times on 10, 20, 30 and 40 DAT	3.14 (7.87)	168.0	3874	6218	2.14
T <sub>6</sub> - Conoweeder four times on 10, 20, 30 and 40 DAT	3.11 (7.70)	182.0	4282	6441	2.36
T <sub>7</sub> - Rice hull solution (50%) on 3 DAT + HW on 35 DAT	6.44 (39.51)	143.0	3604	5964	1.87
T <sub>8</sub> - Rice hull solution (50%) on 15 DAT + HW on 35 DAT	7.23 (50.30)	130.0	3423	5909	1.78
T <sub>9</sub> - Sunflower dried stalk on 3 DAT + HW on 35 DAT	7.24 (50.46)	147.0	3550	5868	1.87
T <sub>10</sub> - Sunflower dried stalk on 15 DAT + HW on 35 DAT	7.20 (49.88)	141.0	3436	5796	1.81
T <sub>11</sub> - Rice straw at 3 t/ha on 3 DAT + HW on 35 DAT	3.73 (11.93)	154.3	3658	5993	1.87
T <sub>12</sub> - Rice bran at 2 t/ha on 3 DAT + HW on 35 DAT	2.71 (5.34)	192.2	4816	7108	2.45
T <sub>13</sub> - Hand weeding on 15 DAT and on 35 DAT	3.18 (8.11)	185.0	4512	6585	2.20
T <sub>14</sub> - Unweeded control	8.01 (62.25)	105.3	2577	4471	1.50
LSD (P=0.05)	0.28	16.66	380.0	539.8	

at 20 and 30 DAP (26.32 and 6.4 g/m<sup>2</sup>) treatment and it was on par with stale seed bed technique + inter cultivation twice at 20 and 35 DAP (29.67 and 8.0 g/m<sup>2</sup>) and passing wheel hoe at 20, 30 and 40 DAP + one hand weeding (41.26 and 10.7 g/m<sup>2</sup>). Also, significantly higher grain yield was obtained in hand weeding twice at 20 and 30 DAP (5460 kg/ha) as compared to unweeded control (2730 kg/ha) and it was on par with stale seedbed technique + Inter cultivation twice at 20 and 35 DAP (5365 kg/ ha). The trends were similar in the straw yield (Table 3).

ix) *Tillage system*: Tillage systems alter the soil seed bank dynamics and depth of burial of weed seeds. Studies have found that almost 75 per cent of the seedbank was concentrated in the upper 5 cm of soil in no-till fields. In the moldboard plough system however, the seed bank is more uniformly distributed over depth. Other conservation tillage systems are intermediate to these two systems.

Weed seedling emergence is often more uniform shallow buried weed seeds and may result in better weed control. Weed seeds closer to the soil are more

TABLE 3

Effect of organic weed management practices on weed density, weed dry weight, weed control efficiency grain and straw yield at 60 days after planting infinger millet during *kharif*, 2013 at MRS, UAS, Bengaluru

Treatments	Weed density (No./m <sup>2</sup> ) at 60 DAP	Weed dry weight (g/m <sup>2</sup> ) at 60 DAP	WCE(%) at 60 DAP	No. of productive tillers	Grain yield (kg/ha)	Straw yield (kg/ha)
T <sub>1</sub> -Passing wheel hoe at 20, 30 and 40 DAP	1.72 (50.22)	1.62 (39.7)	58.2	4.2	4095	6567
T <sub>2</sub> - Inter cultivation twice at 20 and 35DAP	1.92 (80.95)	1.76 (55.8)	41.3	4.2	3937	6300
T <sub>3</sub> Stale seedbed technique	2.25 (177.51)	1.91 (80.0)	15.8	3.9	3397	4900
T <sub>4</sub> -T <sub>1</sub> + one hand weeding	1.64 (41.26)	1.10 (10.7)	88.7	4.9	5143	7100
T <sub>5</sub> - T <sub>2</sub> + one hand weeding	1.69 (47.34)	1.65 (42.9)	54.9	4.1	4222	6200
T <sub>6</sub> -T <sub>3</sub> + Inter cultivation twice at 20 and 35 DAP	1.50 (29.67)	1.00 (8.0)	91.6	5.6	5365	7533
T <sub>7</sub> -Organic mulching @ 10 t ha <sup>-1</sup> after transplanting	2.10 (124.0)	1.74 (52.4)	45.2	3.9	3778	6300
T <sub>8</sub> - Growing cover crops (Horse gram / cowpea) and passing blade hoe	1.89 (76.08)	1.74 (53.5)	43.7	3.7	3206	6200
T <sub>9</sub> -Spray of Eucalyptus leaf extract on weeds	2.22 (165.5)	1.92 (81.3)	14.5	4.0	2921	5267
T <sub>10</sub> -Spray of cattle urine on weeds	2.27 (185.8)	1.84 (67.7)	28.8	4.1	3302	5600
T <sub>11</sub> -Hand weeding twice at 20 and 30 DAP	1.45 (26.32)	0.92 (6.4)	93.2	5.9	5460	7200
T <sub>12</sub> -Unweeded check	2.45 (279.6)	1.99 (95.1)	0.0	3.2	2730	4500
LSD(P=0.05)	0.20	0.06	NA	0.82	945.6	639.8

Figures in parenthesis are original values; data analyzed using transformation  $\log(x+2)$ , NA: Not Analyzed

likely to be eaten or damaged by insects, animals, other predators and disease causing organisms.

x) *Sanitation*: It is possible to prevent many new weeds from being introduced onto the farm and to prevent existing weeds from producing large quantities of seed. The use of clean seed, removing weeds around the edges of fields or after harvest to prevent weeds from going to seed and thoroughly composting manure before application can greatly reduce the introduction of weed seeds and difficult weed species. It is even possible to selectively hand-eradicate isolated

outbreaks of new weeds, effectively avoiding future infestations. Planting clean, high-quality seed is essential to crop success. Other sanitation factors to consider would include thorough cleaning of any machinery which might have been used in weedy fields, and the establishment of hedge rows to limit wind blown seeds.

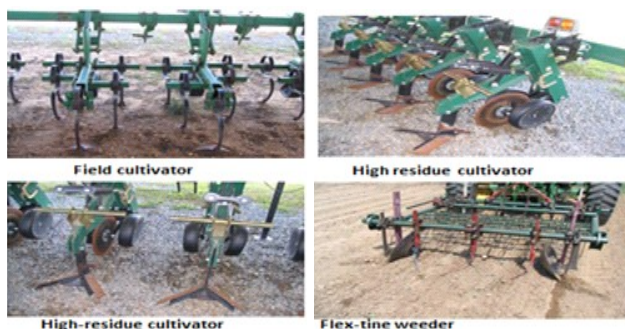
xi) *Irrigation*: Effective water management is key to controlling weeds in organic farming. There are a number of ways that careful irrigation management can help to reduce weed pressure on crops. Drip irrigation is more water efficient and also by directing

water to the crop it minimizes weed germination and reduces need to cultivate.

### III. Mechanical Methods

Mechanical removal of weeds is both time consuming and labor-intensive but is the most effective method for managing weeds. The choice of implementation, timing, and frequency will depend on the structure and form of the crop and the type and number of weeds. Cultivation involves killing emerging weeds or burying freshly shed weed seeds below the depth from which they germinate. It is important to remember that any ecological approach to weed management begins and ends in the soil seed bank. The soil seed bank is the reserve of weed seeds present in the soil. Observing the composition of the seed bank can help a farmer make practical weed management decisions. Burial to 1.0 cm depth and cutting at the soil surface are the most effective ways to control weed seedlings mechanically.

i) *Improved Farm Equipment's /Machineries:* Mechanical weeders include cultivating tools such as hoes, harrows, tines, high residue cultivator, brush weeders, cutting tools like mowers and stimmers and dual-purpose implements like thistle-bars. The choice of implement and the timing and frequency of its use depends on the morphology of the crop and the weeds. Implements such as fixed harrows are more suitable



for arable crops, whereas inter-row brush weeders are considered to be more effective. The brush weeder is mainly used for vegetables such as carrots, beetroot, onions, garlic etc. The optimum timing for mechanical weed control is influenced by the competitive ability of the crop and the growth stage of the weeds.

ii) *Thermal Weed Control : Flamers* - These are useful for weed control. Thermal weed control involves the use of flaming equipment to create direct contact between the flame and the plant. This technique works by rupturing plant cells when the sap rapidly expands in the cells. Sometimes thermal control involves the outright burning down of the weeds. Flaming can be used either before crop emergence to give the crop a competitive advantage or after the crop has emerged. However, flaming at this point in the crop production cycle may damage the crop. Although the initial equipment cost may be high, flaming for weed control may prove cheaper than hand weeding.

iii) *Soil solarization:* During summer and fall, organic farmers sterilize their soil through solarization. In this process, a clear plastic film is placed over an area after it has been tilled and tightly sealed at the edges. Solarization works when the heat created under the plastic film becomes intense enough to kill weed seeds.

iv) *Infrared weeders:* Infrared weeders are a further development of flame weeding in which the burners heat ceramic or metal surfaces to generate the infrared radiation directed at the target weeds. Some weeders use a combination of infrared and direct flaming to kill the weeds. In general, flame weeders are considered to be more effective because they provide higher temperatures, but burner height and plant stage are important too. Infrared weeders cover a more closely defined area than those of the standard flame weeder, but may need time to heat up.

### IV. Biological Weed Control

Biological control would appear to be the natural solution for weed control in organic agriculture.

i) *Allelopathy:* Allelopathy is the direct or indirect chemical effect of one plant on the germination, growth or development of neighboring plants. It is now commonly regarded as component of biological control. Species of both crops and weeds exhibit this ability. Allelopathic crops include barley, rye, annual ryegrass, buckwheat, oats, sorghum, sudan sorghum hybrids, alfalfa, wheat, red clover and sunflower. Vegetables, such as horse radish, carrot and radish, release

particularly powerful allelopathic chemicals from their roots. Suggestions have been made that all elochemicals and other natural products or their derivatives could form the basis of bio herbicides. However, it is unclear whether the application of natural weed killing chemicals would be acceptable to the organic standard authorities.

ii) *Beneficial organisms*: Little research has been conducted on using predatory or parasitic micro organisms or insects to manage weed populations. However, this may prove to be a useful management tool in the future. Natural enemies that have so far been successful include a weevil for the aquatic weed salvinia, a rust for skeleton weed and probably the most famous, a caterpillar (*Cactoblastis* sp.) to control prickly pear. There is also considerable research effort aimed at genetically engineering fungi (myco-herbicides) and bacteria so that they are more effective at controlling specific weeds. Myco-herbicides are a preparation containing pathogenic spores applied as a spray with standard herbicide application equipment.

iii) *Breeding for Crop Competitiveness and Weed Suppression*: Plant breeding is one way to improve weed management in organic systems. Development of crops with increased competitive ability and enhanced weed suppressive qualities. Crop qualities that promote crop competitiveness include early, rapid establishment in less favorable conditions, crop structures that limit weed access to light and nutrients increased plant hardiness etc.

a) Commercial Myco-herbicides

Trade name	Pathogen	Target weed
Devine	<i>Phyophthorapalmivora</i>	<i>Morreriaodorata</i> (Strangler vine) in citrus
Collego	<i>Colletotrichum gleosporoides</i> f.sp. <i>aeschynomene</i>	<i>Aeschynomene virginica</i> (Northen Joint Vetch) in rice and soybean
Biopolaris	<i>Biopolarissorghicola</i>	<i>Sorghum halepense</i> (Johnson grass)
Biolophos	<i>Streptomyces hygroscopius</i>	General vegetation (non-specific)
LUBAO 11	<i>Colletotrichum gleosporoides</i> f.sp. <i>Cuscuttae</i>	<i>Cuscutasp.</i> (Dodder)
01	<i>Alternaria cassiae</i>	<i>Cassia abtusifolia</i>
ABG 5003	<i>Cercosporarodmanii</i>	<i>Eichhorneacrassipes</i> (water hyacinth)

V. Chemical Methods (Organically Approved)

Extensive use of synthetic herbicides poses serious threats to both the environment and public health. From both public health and environmental perspectives, there is a great incentive for biologically active natural products from higher plants that are as good as or better than synthetic herbicides and that are likely to be much safer. Further more, in comparison to long-persistence, non-target toxicity, polluting, carcinogenic and mutagenic activities of synthetic herbicides, natural plant products are biodegradable, somewhat specific, and likely to be recycled through nature. Commonly used bio herbicides are:

*Processed from naturally occurring products -*

- Vinegar (Acetic acid) C<sub>2</sub>H<sub>4</sub>O<sub>2</sub>
- Clove oil (about 85 % eugenol)
- Eugenol (extract from clove, cinnamon, basal or bay leaf)
- Citric acid C<sub>6</sub>H<sub>8</sub>O<sub>7</sub>
- Lactic acid C<sub>3</sub>H<sub>6</sub>O<sub>3</sub>
- Corn gluten meal
- Fatty acid soaps
- Fe HEDTA



*Corn gluten meal (Turf builder, Weed Ban and Corn Weed Blocker)*: It has been used successfully on lawns and high-value crops as pre-emergent herbicide.



## b) Use of bio-control agents for weed control

Name of the weed	Bio-agent
<i>Cyperus rotundus</i>	<i>Bactra verutana</i>
<i>Ludwigia parviflora</i>	<i>Halticacynea</i> (Steel blue beetle)
<i>Parthenismhy sterophorus</i>	<i>Zygrogramma bicolorata</i>
<i>Lantana camara</i>	<i>Crociosema lantana</i> , <i>Teleonnemiascrupulosa</i>
<i>Opuntia dilleni</i>	<i>Dactylopiustomentosus</i> , <i>D. indicus</i> (cochineal scale insect)
<i>Eichhorneacrassipes</i>	<i>Neochetinaeichhornea</i> , <i>Bruchi</i> (Hyacinthweevil) <i>Sameodesalliguttalis</i> (hyacinth moth)
<i>Salvinia molesta</i>	<i>Cryptobagussingularis</i> (weevil) <i>Paulinia acuminata</i> (grasshopper), <i>ameamutipicalis</i>
<i>Alternanthera philoxaroides</i>	<i>Agasideshygrophilla</i> (fleabeetle) <i>mynothripsandersoni</i>
<i>Tribulus terrestris</i>	<i>Microlarinuslypriformis</i> , <i>M. lareynii</i>
<i>Solanum elaegnifolium</i>	<i>Frumentanephalomicta</i>

Commonly used vinegar or lemon juice or clove oil ingredients -

- Burnout: 23 per cent acetic acid.
- Biogenic: 10 per cent acetic acid plus clove oil and thyme oil.
- Matran & Weed Bye Bye *etc.*,
- Post-emergent herbicides..



### Future Line of Work

- Development and evaluation of mechanically operated weeders are to be taken up on priority.
- Evaluation of cover crop, green manure species and different mulches with respect to their time, dosage and methods of using is essential.
- Standardization of duration of stale seedbed technique in combination with inter cultural implements for different types of soils and crops is needed.

- Standardization of concentration and time of spraying of eucalyptus leaf extractions and other allelopathic botanicals needs to be done.

Problem of weeds can be minimized by adopting right and integrated organic weed management approach's which, helps in reducing the competition by weeds without any adverse effect on yield, quality of produce and soil/ecosystem.

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## Bulk Segregant Analysis Using Micro Sattelites for Powdery Mildew Resistance in Mungbean RIL Population Derived from Chinamung × LM-1668

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### ABSTRACT

Sixty four F<sub>8</sub> Recombinant inbred lines derived from a cross between Chinamung (highly susceptible to powdery mildew disease) and LM-1668 (highly resistant to Powdery mildew) were analyzed to identify the SSR markers associated with powdery mildew disease resistance. Parental polymorphism was performed with 248 primer pairs of simple sequence repeats (SSR), which revealed 17 polymorphic markers for the parents. In order to detect the markers linked to powdery mildew disease resistance, a strategy of combining the DNA pooling from selected segregants and genotyping was adopted. The association of putative markers identified based on DNA pooling from selected segregant was established by Single Marker Analysis (SMA). The results of SMA revealed that SSR markers, CEDG044 and DMBSSR080 showed significant association with powdery mildew and accounted for 81.5 per cent and 77.5 per cent of the total variation, respectively. The results obtained from the DNA pooling of phenotypic extremes could be a useful strategy to detect the genetic loci with major effects of the complex trait such as disease resistance in mungbean.

*Keywords:* Bulk segregant analysis, Powdery mildew, Mungbean and SSR markers

MUNGBEAN [*Vigna radiata* (L.) Wilczek], also known as green gram is widely cultivated in south and Southeast Asia. India alone accounts for most of the mungbean harvest worldwide with more than half of the world's total production, with the total cultivable area of about 6 million hectares (Nair *et al.*, 2013), being occupied by mungbean. Apart from its importance as food and cash crop, mungbean has emerged as an important source of proteins, carbohydrates (51%), protein (24% - 26%), minerals (4%), and vitamins (3%) (Karthikeyan *et al.*, 2014). Their roots fix atmospheric nitrogen through symbiosis with nitrogen-fixing Rhizobium bacteria that in turn improves the soil quality (Yaqub *et al.*, 2010).

In the present scenario of the increasing global human population, decreasing arable land, predicted increases of water scarcity, soil salinity, severe diseases, emerging resistance of pests and pathogens to pesticides and climate change pose significant challenges to modern mungbean research. The biotic stresses *viz.*, yellow mosaic virus, cercospora leaf spots and powdery mildew diseases cause severe economic losses to

mungbean production. Among them powdery mildew disease (PM) is an important fungal disease caused by *Erysiphe polygoni* causing more than 40 per cent of yield loss if there is no prevention or even cause death of the plants if it occurs at the seedling stage apart from degrading the seed quality (Bainade *et al.*, 2014).

Although the disease can be controlled by chemical spraying, the farmers rarely practice such control measures due to the increase in production cost. In addition, the use of pesticides can negatively affect health and environment. Therefore, using resistant varieties is the most desirable means of managing the disease. The study was therefore conducted with the aim of identifying Recombinant inbred lines (RILs) resistant to powdery mildew disease (PM) using bulk segregant analysis

### MATERIAL AND METHODS

*Plant material and field design:* Sixty four mungbean RILs derived from the cross of chinamung×LM-1668 were screened for identification of resistance sources

against natural infection by powdery mildew disease under field conditions at the University of Agricultural Sciences, Bangalore during *rabi* 2018-19. The RILs were planted during mid October and harvested during the first weeks of January. Each test entry was planted in a single row subplot of 1m length in an augmented design with row to row and plant to plant spacing of 45 cm and 10 cm, respectively. Susceptible check (Chinamung) was also planted in each plot along with test entries. All the recommended package of agronomic practices were followed except spraying of plant protection chemicals, which was meant to allow maximum inoculum of powdery mildew. The natural disease incidence was quite severe during the season due to conditions favourable for the development of the disease. Disease intensity on each accession was recorded on 40 days after sowing (DAS), 50 DAS and at the time of harvesting. Powdery mildew was scored on 0-5 scale as recommended by Reddy *et al.* (1994) where as the susceptible check rows exhibited hundred percent infections.

*DNA extraction and parental polymorphism study:* Genomic DNA was isolated from fresh leaf tissue of 64 F<sub>8</sub> recombinant inbred lines along with both the parents (chinamung and LM-1668) as described by Doyle and Doyle, 1987. The quality and quantity of DNA were estimated using both 0.8 per cent agarose gel electrophoresis and Nano Drop.

The final DNA concentration was adjusted to 50 ng/μl. Parental polymorphism survey involving 248 SSR markers was carried out. PCR was performed in a 9 μl volume containing 50 ng of template DNA, 0.3 units of Taq DNA polymerase (Bangalore Genei Ltd., Bengaluru, India), 2.5 mM of dNTPs, and 0.2 μM primers in a 1 × PCR Taq buffer containing MgCl<sub>2</sub>. The amplification was carried out by Eppendorf Mastercycler Germany. PCR conditions included 94°C of 5 min. for initial denaturation followed by 35 cycles each consisting of a denaturation step for 1 min at 94°C, an annealing step for 45 sec at 40°C, an extension step for 1 min at 72°C and the final extension for 10 min at 72°C. Amplified products were separated by 3.0 per cent Metaphor agarose gel

electrophoresis at 70 V. The gels were stained with ethidium bromide and visualized on a digital gel documentation and image analysis system (Alpha Innotech, Multimage TM Light, Cabinet Filter Positions - JH Bio Innovation Pvt., Ltd., Bengaluru, India).

### **Bulk Segregant Analysis and SSR Analysis**

BSA was performed using the protocol given by Liu *et al.* (2001). DNA bulks of plants with extreme resistance and those with extreme susceptibility were prepared from phenotyped progenies. This was done by pooling aliquots, containing equivalent amounts of total DNA approximately, 50 ng/μl from each of ten highly resistant and ten highly susceptible plants of the RILs based on phenotypic observations. Polymorphic SSR primers between the parents were used to screen the parents and the two bulked DNA samples. DNA of individual RILs that were included in bulks was also analyzed with co-segregating markers to confirm their linkage to the PM disease resistance. The SSR markers that were polymorphic among the parents and the bulks were used for progeny analysis. DNA of the RILs and parents were analyzed to study co-segregation of these markers.

### **Data Analysis**

The clearly resolved amplicons of SSR were scored manually as homozygote for the allele for susceptible parent (A), homozygote for the allele for resistant parent (B) in the data sheet. Chi-square ( $\chi^2$ ) test was performed to test the goodness of fit of the F<sub>8</sub> population for the phenotyping and marker data by comparing an observed frequency distribution with an expected one. Marker-trait association was analyzed by simple linear regression method to know the association between the markers and the PM disease score using software Microsoft Office 2007 Excel frequency distribution curve for PM resistance of 64 F<sub>8</sub> RILs were drawn separately using Microsoft Office 2007 Excel.

### **RESULTS AND DISCUSSION**

In order to validate the markers associated with PM resistance, RILs derived from a cross between

chinamung x LM-1668 were phenotyped as resistant and susceptible based on the field evaluation by using rating scale. The results revealed a considerable amount of variability among RILs for powdery mildew resistance. Out of 64 F<sub>8</sub> RILs screened for powdery mildew under field condition, 12 RILs were resistant (R0), 20 moderately resistant (R1), 13 moderately susceptible (MS), 8 susceptible (S), 10 were highly susceptible (HS) to powdery mildew while none recorded higher resistance (HR). The varying responses of each RIL screened for powdery mildew in the season are presented in Table 1. The chi-square test ( $\chi^2$ ) was employed for phenotypic analysis which

revealed a significant 1:1 segregation ratio of the resistance trait in the F<sub>8</sub> RIL population. This segregation pattern (Table 2) of resistance trait showed that PM resistance and susceptibility is controlled by a single or a group of closely linked genes, thus confirming the earlier findings of Priya *et al.*, 2012 and Reddy, 2009.

### Identification of PM Resistance using Bulk Segregant and SSR Analysis

Several strategies have been proposed to identify molecular markers near a gene / QTL of interest with reduced number of plants to be genotyped. The two

TABLE 1  
Grouping of 64 F<sub>8</sub> RILs of the cross Chinamung × LM-1668 based on Powdery mildew reaction under field conditions

Scale	Per cent leaf infection	Disease Reaction	Number of RILs	RILs
0	0	HR	0	
1	1 - 5	Resistant (R0)	12	C2-6-1, C2-14-3, C2-17-1, C2-63-2, C2-108-1, C2-115-3, C2-120-4, C2-134-2, C2-237-5, C2-243-3, C2-270-2, C2-H-78-1
2	5.1 - 30	Moderately Resistant (R1)	21	C2-15-1, C2-34-1, C2-72-2, C2-89-1, C2-93-1, C2-106-1, C2-247-3, C2-259-1, C2-J-95-2, C2-I-104-2, C2-J-123-1, C2-J-171-1, C2-113-2, 3, C2-K-187-1, C2-K-192-2, C2-K-199-1, C2-K-207-1, C2-K-211-4, C2-K-213-1, C2-K-227-1
3	30.1 - 65	Moderately susceptible (MS)	13	C2-65-2, C2-121-1, C2-199-2, C2-236-2, C2-243-3, C2-H-78-1, C2-J-96-3, C2-101-2, C2-K-185-1, C2-K-188-1, C2-193-2, C2-K-212-1, C2-K-252-3
4	65.1 - 90	Susceptible (S)	8	C2-9-1, C2-30-1, C2-82-1, C2-83-1, C2-110-1, C2-117-1, C2-119-1, C2-K-211-1
5	90.1 - 100	Highly susceptible (HS)	10	C2-122-1, C2-I-122-1, C2-I-124-1, C2-J-160-2, C2-J-161-2, C2-J-170-1, C2-J-173-2, C2-K-206-4, C2-K-214-1, C2-K-210-1

TABLE 2  
Chi-square test for segregation of resistance and susceptibility in F<sub>8</sub> populations during *rabi* season, 2018/19 revealing nature of inheritance to powdery mildew disease

F <sub>8</sub> Generation	Total plants	Powdery mildew				Ratio S:R	$\chi^2$	P value
		Observed		Expected				
		R	S	R	S			
Chinamung×LM1664	64	34	30	32	32	1:1	0.125	3.85

main strategies are selective genotyping and bulk segregant analysis (BSA). Selective genotyping is relatively a low-cost approach to detect QTL with large effects by genotyping individuals from the two tails of the phenotypic distribution. Bulk segregant analysis, a gene tagging technique (Collard *et al.*, 2005), has been successfully used to identify markers associated with disease resistance (Akinbo *et al.*, 2007; Priya *et al.*, 2013 and Yi *et al.*, 2013). Several studies have been conducted to identify resistant sources of powdery mildew in mungbean (Zhang *et al.*, 2008; Kasethanan *et al.*, 2010 and Chankaew *et al.*, 2013). In this study, an attempt was made to identify markers linked to resistance to powdery mildew disease using bulk segregant analysis.

Using the BSA method, two bulks having distinct and often contrasting phenotypes for the trait of interest are generated from a segregating population from a single cross. Seventeen polymorphic markers between the parents were used for screening of parents Chinamung, LM-1668, resistant bulk (RB) and susceptible bulk (SB) along with the RIL populations used to obtain the respective bulks. Two markers CEDG044 and DMBSR088 clearly distinguished the susceptible bulks from resistant bulks (Fig. 1 and 2). Bainade *et al.* (2014) reported that out of 54 primers used to screen greengram lines, only one

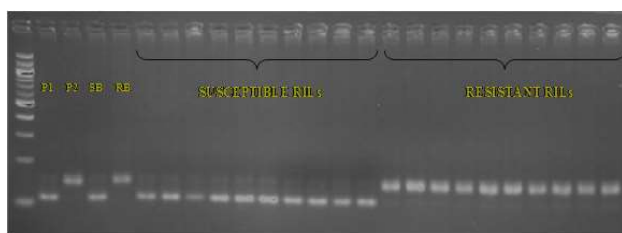


Fig.1 : Co-segregation of the SSR marker CEDG044 showing clear polymorphism in parents, bulks and RILs that made up the bulks.

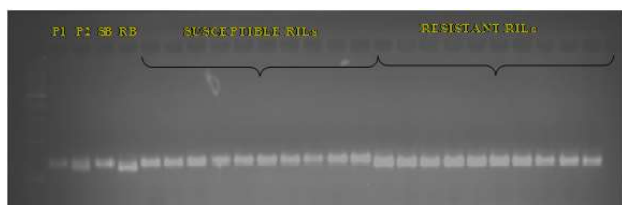


Fig. 2 : Co-segregation of the SSR marker DMBSR080 showing clear polymorphism in parents, bulks and RILs that made up the bulks.

produced specific fragment in both the bulks and was found polymorphic between the parents as well as resistant and susceptible bulk, indicating its possible linkage in BSA. The 64 RILs were therefore genotyped with these two primers to ascertain / understand their possible association with powdery mildew resistance. Segregation pattern with marker CEDG044 recorded a resistant allele in 34 RILs; susceptible allele of recipient was amplified in 30 RILs. Similarly for marker DMBSR080 RILs showing donor allele while 30 RILs of recipient allele. Genetic analysis with chi-square test indicated goodness of fit to the expected ratio of 1:1 for co-dominant marker indicating the association of CEDG044 and DMBSR088 with PM resistant gene in the present RIL population. To determine the strength of association between the putative markers and the respective phenotypes, linear regression analysis was carried out using marker genotype as groups. The simple regression analysis between phenotypic data of PM resistance and the genotypic data of SSR markers CEDG044 and DMBSR088 indicated that these markers are significantly linked with PM resistance (Table 3). Similar results have been reported by Karthikeyan *et al.*, 2014; Sudha (2009) and Anushya (2009). Such lines which are showing stable resistant response to the powdery mildew can be screened for yield related traits and should be recommended for the development of highly resistant breeding lines for powdery mildew disease with high yielding ability in green gram (Priya *et al.*, 2013; Pool Sawat, 2017). Several similar studies have been conducted in different crops using BSA. Gupta and Gupta (2013) used 31 markers that were found to be polymorphic between the parents in mungbean to study genes linked to mungbean yellow mosaic virus

TABLE 3

Association of molecular markers with powdery mildew resistance by single marker analysis

SSR Marker	MSS	F-Value	P-Value	R <sup>2</sup> (%)
CEDG044	56233.609 ***	273.764 ***	<0.001	81.5
DMBSR080	93.81869 ***	130.99 ***	<0.001	77.5

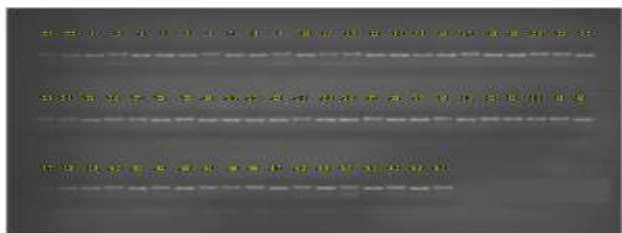


Fig. 3 : Genotyping of the RILs with CDG044

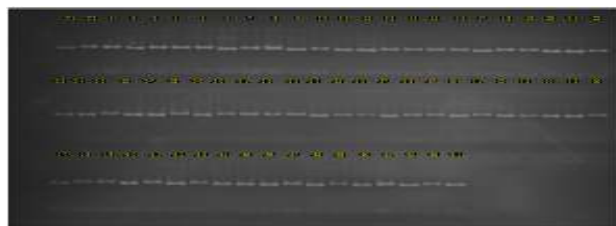


Fig. 4 : Genotyping of the RILs with DMBSSR080

P1:Chinamung,	P2: LM1668,	1: C2-6-1,	2: C2-9-1,	3: C2-14-3,
4: C2-15-1,	5: C2-17-1,	6: C2-30-1,	7: C2-34-1,	8: C2-63-2,
9: C2-65-2,	10: C2-72-2,	11: C2-82-1,	12: C2-83-1,	13: C2-89-1,
14: C2-93-1,	15:C2-106-1,	16: C2-108-1,	17: C2-110-1,	18: C2-113-2,
19:C2-115-3,	20:C2-117-1,	21:C2-119-1,	22: C2-120-4,	23: C2-121-1,
24: C2-122-1,	25:C2-134-2,	26: C2-199-2,	27: C2-236-2,	28: C2-237-5,
29: C2-238-3,	30: C2-243-3,	31: C2-247-3,	32: C2-259-1,	33: C2-270-2,
34: C2-H-78-1,	35: C2-H-80-1,	36:C2-J-95-2,	37:C2-J-96-3,	38: C2-J-101-2,
39: C2-J-104-2,	40: C2-J-122-1,	41: C2-J-123-1,	42: C2-J-124-1,	43:C2-J-160-2,
44:C2-J-161-2,	45: C2-J-170-1,	46: C2-J-171-3,	47:C2-J-173-2,	48: C2-K-185-1,
49: C2-K-187-1,	50:C2-K-188-1,	51: C2-K-192-2,	52:C2-K-193-2,	53:C2-K-199-1,
54: C2-K-200-3,	55: C2-K-206-4,	56: C2-K-207-1,	57:C2-K-209-3,	58: C2-K-210-1,
59: C2-K-211-4,	60: C2-K-212,	61: C2-k-213-1,	62:C2-K-214-1,	63: C2-K-227,
64: C2-K-252-4				

resistance. The marker CEDG 180 marker was found to be linked with resistance gene by the bulk segregant analysis. Shoba *et al.* (2012) identified the SSR marker PM384100 allele for late leaf spot disease resistance in groundnuts by bulked segregant analysis. The identified SSR marker PM 384100 was able to distinguish the resistant and susceptible bulks and individuals for late leaf spot disease in groundnut.

The association of these two markers with powdery mildew resistance can be employed for selection of powdery mildew resistant genotypes in mungbean. This is because once powdery mildew disease resistance-responsible gene (or genes) have been identified and further characterized is not only potentially useful for the development of durable powdery mildew-resistant cultivars but also is likely to be of value for the improvement of other related cultivated leguminous plants.

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## Molecular Evaluation of Mungbean Recombinant Inbred Lines from Cross, Chinamung and BL849 for Powdery Mildew Disease Resistance through Bulk Segregant Analysis

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### ABSTRACT

In mungbean yield reduction is mainly due to wide spread of powdery mildew disease, which is the most devastating in mungbean. It can be effectively controlled through incorporation of disease resistance genes into susceptible species through Marker Assisted Selection (MAS). In present study, 96 Recombinant Inbred Lines (RIL) derived from cross between Chinamung (highly susceptible to powdery mildew disease) and BL849 (highly resistant) lines were analyzed by PCR technique by using Simple Sequence Repeats (SSR) markers. Phenotypic data was collected by screening the 96 F<sub>8</sub> RILs population according to the presence of infections by pathogen. Results revealed that 9 are moderately resistant, 60 are moderately susceptible, 24 are susceptible and 3 are highly susceptible. Parental polymorphism study with 248 SSR primers revealed that 14 showed polymorphic for parents. For Bulk Segregant Analysis (BSA) to identify Polymorphic DNA marker linked to a powdery mildew resistance DNA was pooled from selected segregants and genotyping was followed. The markers association was also studied by Single Marker Analysis (SMA) for 14 polymorphic markers. The SMA revealed that two markers DMBSSR130 and DMBSSR125 showed significant association with powdery mildew resistance with 79 per cent and 73 per cent to total variation, respectively. The DMBSSR130 was confirming the association in both the BSA and SMA but DMBSSR125 showed association in SMA not in BSA.

*Keywords:* Bulk segregant analysis, Single marker analysis, Powdery mildew, Mungbean and SSR markers

MUNGBEAN (*Vigna radiata* (L). Wilczek) also well known as green gram. It is a *kharif* pulse cultivated since long time in India. To meet the demand of mungbean at global level, there is a need to improve the average production and productivity.

The yield in case of mungbean is greatly affected by numerous biotic and abiotic factors. Among biotic factors, Powdery mildew is one of the major disease that leads to reduction in crop yield. Powdery mildew disease is a foliar nature caused by the fungal pathogen *Erysiphe polygoni* DC. Occurrence of this disease can be widely seen under cool-dry season. This powdery growth which covers the leaf surface affects photosynthesis and leads to yield reduction to an extent of 40 per cent. This disease severe symptoms can be observed in 35-40 days standing crop (Khare *et al.*, 1998).

Powdery mildew disease can be controlled by using strategies such as cultural practices and chemical

application. In case of cultural practices disease can be controlled to the some extent but not up to the level. Chemical control of powdery mildew disease is one of most effective practice. However, in developing countries, poor farmers cannot meet the expense of fungicides to control the disease. Use of chemicals also leads to serious environmental hazards. Continuous use of chemical fungicides also leads to the appearance of resistant races of the pathogen. Practically, the chemical treatment turns out to be ineffective, if not performed at proper plant growth stage. High infestation demands huge quantity of fungicides, which often may not be economic, accessible and also large scale indiscriminate use may consequently have serious ecological repercussions. The fungus also overcomes chemical treatments, which is a continuous threat. Further the fungus as evolved resistance over almost varieties. Therefore the practice of effective approaches to control powdery mildew disease is very important to get good yield, as it is inflicting heavy

yield loss so this study was taken to evaluate available mungbean genotypes (RILs) for identification of resistance genotypes (RILs) to identify resistance cultivars for powdery mildew disease.

#### MATERIAL AND METHODS

During the 2018 *rabi*, the field experiment was cultivated at the 'K' block of the University of Agricultural Sciences, GKVK, Bengaluru. The mungbean RILs used were developed from a cross, Chinamung × BL-849. All the RILs used were collected from the Department of Genetics and Plant breeding at the University of Agricultural Sciences, Bangalore.

The current F<sub>8</sub> RILs were developed from the cross Chinamung × BL849, the F<sub>1</sub> from this cross was forwarded up to F<sub>5</sub> generation by selfing to attain stability in population further, F<sub>6</sub> and F<sub>7</sub> generations were forwarded to the present generation *i.e.*, F<sub>8</sub> (Divya and Savithamma *et al.*, 2014).

The parents used to develop these RILs have distant characteristics. Chinamung is high yielding but highly susceptible to powdery mildew disease used as female parent, BL849 is the low yielding yet highly resistant (HR) to powdery mildew disease with a score of zero in the scale of 1-5 used as male parent. Chinamung, BL849, KKM3, and Pusabaisakhi were used in each block as checks which are help in spreading the disease to RILs.

Genomic DNA was extracted by using modified CTAB method (Doyle and Doyle, 1990) from both the parents and their F<sub>8</sub> RILs. The final DNA concentration was adjusted to 50 ng/μl. Parental polymorphism survey involving 248 SSR markers was carried out. The SSR markers were taken from research papers related to powdery mildew of mungbean includes Chankaew *et al.*, 2013, Zhang *et al.*, 2008. PCR was performed in a 9 μl volume containing 50 ng of template DNA, 0.3 units of Taq DNA polymerase (Bangalore Genei Ltd., Bengaluru, India), 2.5 mM of dNTPs, and 0.2 μM primers in a 1×PCR Taq buffer containing MgCl<sub>2</sub>. The amplification was carried out by Eppendorf

Mastercycler Germany. PCR conditions included 94°C of 5 min for initial denaturation followed by 35 cycle each consisting of a denaturation step for 1 min at 94°C, an annealing step for 45 sec at 40 °C, an extension step for 1 min at 72 °C and the final extension for 10 min at 72 °C. Amplified products were separated by 3.0 per cent Metaphor agarose gel electrophoresis at 70 V. The gels were stained with ethidium bromide and visualized on a digital gel documentation and image analysis system (Alpha Innotech, Multimage TM Light, Cabinet Filter Positions - JH Bio Innovation Pvt., Ltd., Bengaluru, India).

#### RESULTS AND DISCUSSION

In order to study the variation among the RILs for Powdery mildew disease, screening for the disease done at weekly intervals along with, parents and checks. This revealed reference for high resistant with scoring 0 from five point scale, among 96 RILs 9 were moderately resistant 'MR' with infection percentage 5.1-30 per cent, 60 were moderately susceptible 'MS' with infection of 30.1-65 per cent, 24 were susceptible 'S' with 65.1-90 per cent disease infection and 3 were highly susceptible 'HS' with 90- 100 per cent infection (Table 1).

Molecular evaluation was carried out to study the Bulk Segregant Analysis (BSA) and Single Marker Analysis (SMA) by using SSR markers linked to powdery mildew resistance. Initially parental polymorphism was studied with 248 primers, out of 248 only 14 are polymorphic for the parents. Among the 14 polymorphic primers only one primer DMBSSR130 showed polymorphism between bulks similar to the parents. So the DMBSSR130 was used to study BSA. Bulk segregating analysis (BSA) did for only one primer *i.e.*, DMBSSR130, as it produced specific polymorphic bands between parents rather than other 13 polymorphic primers (other 13 polymorphic markers did not show much difference between bulks). BSA was carried out using gel electrophoresis technique by serially loading parents (female parent and male parent), bulks (susceptible and resistant bulk),

TABLE 1

Distribution of 96 F<sub>8</sub> RILs of the cross Chinamung x BL849 according to the screened Powdery mildew disease reaction under fields conditions based on five point scale by Reddy *et al.* (1994)

Scale	Per cent leaf infection	Disease Reaction	Number of RILs	RILs
0	0	Highly Resistant (R <sub>0</sub> )	0	0
1	1-5	Resistant (R <sub>1</sub> )	0	0
2	5.1-30	Moderately Resistant (MR)	9	C <sub>1</sub> -94-1, C <sub>1</sub> -117-3, C <sub>1</sub> -118-1, C <sub>1</sub> -121-1, C <sub>1</sub> -124-4, C <sub>1</sub> -190-1, C <sub>1</sub> -245-3, C <sub>1</sub> -246-1 and C <sub>1</sub> -248-1
3	30.1-65	Moderately susceptible (MS)	60	C <sub>1</sub> -7-3, C <sub>1</sub> -8-1, C <sub>1</sub> -9-2, C <sub>1</sub> -11-1, C <sub>1</sub> -12-3, C <sub>1</sub> -16-3, C <sub>1</sub> -18-2, C <sub>1</sub> -21-1, C <sub>1</sub> -28-1, C <sub>1</sub> -30-1, C <sub>1</sub> -31-3, C <sub>1</sub> -36-3, C <sub>1</sub> -36-3, C <sub>1</sub> -36-3, C <sub>1</sub> -49-1, C <sub>1</sub> -53-2, C <sub>1</sub> -55-3, C <sub>1</sub> -65-1, C <sub>1</sub> -67-1, C <sub>1</sub> -76-1, C <sub>1</sub> -77-1, C <sub>1</sub> -78-1, C <sub>1</sub> -80-1, C <sub>1</sub> -81-4, C <sub>1</sub> -86-3, C <sub>1</sub> -85-5, C <sub>1</sub> -91-1, C <sub>1</sub> -101-3, C <sub>1</sub> -109-2, C <sub>1</sub> -114-2, C <sub>1</sub> -115-2, C <sub>1</sub> -119-2, C <sub>1</sub> -120-5, C <sub>1</sub> -122-3, C <sub>1</sub> -123-2, C <sub>1</sub> -126-1, C <sub>1</sub> -128-3, C <sub>1</sub> -135-3, C <sub>1</sub> -149-4, C <sub>1</sub> -155-3, C <sub>1</sub> -156-1, C <sub>1</sub> -159-1, C <sub>1</sub> -164-1, C <sub>1</sub> -166-2, C <sub>1</sub> -167-3, C <sub>1</sub> -169-4, C <sub>1</sub> -170-2, C <sub>1</sub> -171-1, C <sub>1</sub> -172-1, C <sub>1</sub> -184-1, C <sub>1</sub> -186-2, C <sub>1</sub> -192-1, C <sub>1</sub> -192-1, C <sub>1</sub> -192-1, C <sub>1</sub> -198-1, C <sub>1</sub> -231-1, C <sub>1</sub> -233-1, C <sub>1</sub> -242-1, C <sub>1</sub> -250-2 and C <sub>1</sub> -266-1.
4	65.1-90	Susceptible (S)	24	C <sub>1</sub> -1-3, C <sub>1</sub> -32-4, C <sub>1</sub> -46-1, C <sub>1</sub> -74-1, C <sub>1</sub> -104-3, C <sub>1</sub> -107-1, C <sub>1</sub> -113-2, C <sub>1</sub> -125-2, C <sub>1</sub> -160-1, C <sub>1</sub> -163-1, C <sub>1</sub> -174-1, C <sub>1</sub> -194-3, C <sub>1</sub> -201-1, C <sub>1</sub> -206-2, C <sub>1</sub> -207-1, C <sub>1</sub> -208-3, C <sub>1</sub> -209-2, C <sub>1</sub> -218-1, C <sub>1</sub> -221-1, C <sub>1</sub> -222-1, C <sub>1</sub> -249-1, C <sub>1</sub> -254-2, C <sub>1</sub> -262-1 and C <sub>1</sub> -284-1.
5	90.1-100	Highly susceptible (HS)	3	C <sub>1</sub> -116-2, C <sub>1</sub> -252-1 and C <sub>1</sub> -265-2

then ten susceptible and ten resistant individuals which were used in preparing bulks in 3 per cent metaphor agarose gel (Table 2) (Fig. 1).

Similar kind of work was carried out by Priya *et al.*, 2013 in blackgram by screening 80 polymorphic primers for BSA. But out of 80 primers, only two primers showed specific proper bands with difference of some base pairs between parents and also with the bulks. The report was given in 2009 by Somta *et al.*, that is only few SSRs were developed in mung bean by Data base mining and their cross species amplification in 19 Asian *vigna* species. This is also one of the important reason that the SSR markers developed for other crops can produce polymorphism between parents (with less chances) and are not able to distinguish the bulks.

TABLE 2

List of Polymorphic SSR markers between the parents Chinamung and BL849

Sl.No.	Susceptible RILs list	Sl.No.	Resistant RILs list
1	C <sub>1</sub> -116-2	1	C <sub>1</sub> -94-1
2	C <sub>1</sub> -252-1	2	C <sub>1</sub> -117-3
3	C <sub>1</sub> -265-2	3	C <sub>1</sub> -118-1
4	C <sub>1</sub> -1-3	4	C <sub>1</sub> -121-1
5	C <sub>1</sub> -32-4	5	C <sub>1</sub> -124-4
6	C <sub>1</sub> -46-1	6	C <sub>1</sub> -190-1
7	C <sub>1</sub> -74-1	7	C <sub>1</sub> -245-3
8	C <sub>1</sub> -104-3	8	C <sub>1</sub> -246-1
9	C <sub>1</sub> -107-1	9	C <sub>1</sub> -248-1
10	C <sub>1</sub> -113-2	10	C <sub>1</sub> -7-3

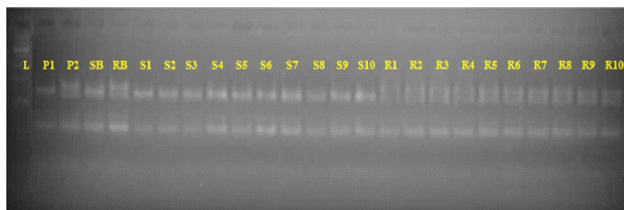


Fig. 1: Bulk Segregant Analysis with DMBSSR130 show polymorphism between the parents, bulks (susceptible and resistant) and the RILs selected for preparing bulks derived from the cross of Chinamung and BL-849 by using 3 per cent metaphor agarose gel

Legend : L=100 bp ladder, P<sub>1</sub>= female parent, P<sub>2</sub>= male parent, S<sub>1</sub> - S<sub>10</sub> are susceptible RILs and R<sub>1</sub>-R<sub>10</sub> are resistant RILs listed on Table 2

In this study, SMA was performed with all the polymorphic markers for identifying linkage between selected polymorphic marker and powdery mildew disease resistance trait to confirm the result with BSA. Among the 14 polymorphic markers, the two markers (DMBSSR130 and DMBSSR125) were showed good association in SMA.

Marker DMBSSR130 shows positive result in both BSA and SMA study but marker DMBSSR125 shows association only in SMA not in BSA.

All 96 RILs were genotyped employing DMBSSR 130 primer. Out of which, 44 RILs matched with the female susceptible parent and 52 RILs matched with the male resistant parent (Fig. 2) and when the same

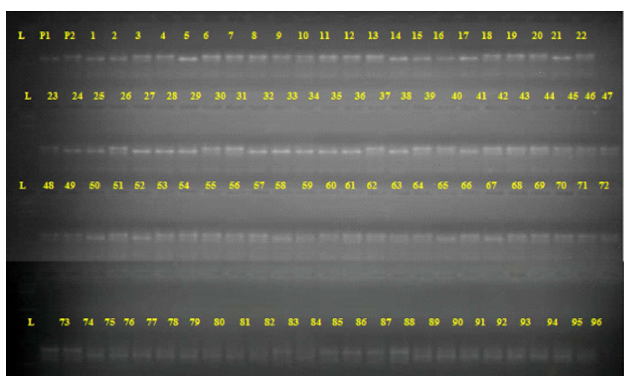


Fig. 2 : Genotyping of 96 RILs derived from cross Chinamung x BL-849 along with parents using polymorphic marker DMBSSR SSR 130 by using 3 per cent metaphor agarose gel

Legend : L=100 bp ladder, P<sub>1</sub> = female parent Chinamung, P<sub>2</sub> = male parent BL849, 1 to 96 are RIL lines.

RILs were subjected to genotyping with DMBSSR 125, 42 RILs resembled the susceptible female parent, 49 RILs showed resemblance with resistant male parent (Fig. 3).

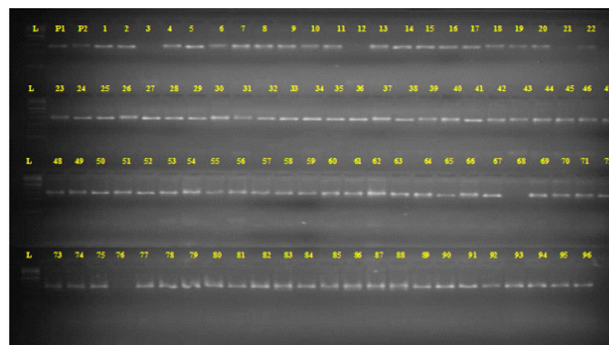


Fig. 3 : Genotyping of 96 RILs with parents derived from cross Chinamung x BL- 849 along with parents using poly morphic marker DMBSSR125 SSR which was not showing difference between bulks by using 3 per cent meta phor agarose gel

Legend : L=100 bp ladder, P<sub>1</sub> = female parent Chinamung, P<sub>2</sub> = male parent BL849, 1 to 96 are RIL lines.

SMA was performed to determine the association between SSR markers and powdery mildew resistance. Simple linear regression analysis was carried out to study the linkage between the markers (DMBSSR130 and DMBSSR125) by taking phenotypic data and genotyping scoring data. This analysis explains that the markers (DMBSSR130 and DMBSSR125) were significantly linked with powdery mildew disease resistance. The results indicated that the two markers co-segregate with powdery mildew resistance gene in mungbean. Similar results were explained by Bainade *et al.* (2014) in his work.

One way ANOVA was carried out to study the association of marker and powdery mildew disease resistance trait. The one way ANOVA study on DMBSSR130 and DMBSSR125 markers scoring data and correspondence phenotypic disease scoring data revealed that respective and markers showed 79 per cent and 73 per cent of Phenotypic variance association with Powdery mildew disease resistance. Both the markers (DMBSSR130 and DMBSSR125) were significantly associated with trait at 0.05 per cent level of significance (Table 3).

TABLE 3

Association of molecular markers with powdery mildew resistance by single marker analysis

SSR Marker	MSS	F-value	P-value	R <sup>2</sup> (%)
DMBSSR-130	201.28 ***	380.58 ***	<0.001	79
DMBSSR-125	179.72 ***	294.98 ***	<0.001	73

In a study validation of SSR markers for powdery mildew disease resistance in mungbean carried out by Pooja *et al.* 2018, revealed that single marker analysis for four polymorphic markers CEDG121, CEDG245, MBSSR238 and GMES5773, only MBSSR238 showed significant association with powdery mildew resistance at 0.01 per cent level significance indicated marker was linked to the trait of interest.

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## Standardization of Direct Shoot Regeneration and Glyphosate Sensitivity of Finger Millet (*Eleusine coracana* (L.) Gaertn.)

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### ABSTRACT

A simple and efficient way of plant regeneration has been established using in vitro- derived, actively growing shoot apical meristems (SAMs) in finger millet (GPU 28). Shoot apical meristems from three - day old seedlings were evaluated for the efficiency of direct shoot induction on varied concentrations and combinations, of 6-benzy laminopurine (BAP) and 2, 4 - dichlorophenoxyacetic acid (2, 4D). The highest shoot induction was observed in medium supplemented with 3 mg/L BAP (13.05). An increase in the number of shoots per explants was observed when SAMs were sub - cultured in a fresh MS medium once in every 2 weeks. The regenerated shoots rooted easily in half strength MS medium containing 2.8  $\mu$ M indole-3-acetic acid and successfully acclimated in the field. To study glyphosate sensitivity SAMs were cultured on MS medium supplied with different concentration (1, 2, 3, 4 and 5 mg/L) of glyphosate and 3 ppm/L BAP. At 5 ppm of glyphosate, SAMs did not show any response for shoot initiation and all the SAM explants were turned brown due to cell death. Based on this investigation 5 ppm of glyphosate was chosen as lethal dose. This study was used to select the - transformed explants and to allow the selective growth of transformed tissues on the MS selection medium.

*Keywords:* SAMs, Regenerations and Calus

FINGER millet is the staple diet food that supply a major portion of calories and protein to large segment of populations in tropical dry land regions. Finger millet has superior nutritional value compared to rice and wheat. Finger millet is grown worldwide more than 4 million hectares with an annual production of at least 4.5 million tons of grain. Other than its direct use as table and feed stock, finger millet is also a candidate for the production of renewable plant products such as ethanol (Tekaligne *et al.*, 2015).

Plant tissue culture technology is an important biotechnological tool used for efficient transfer of genetic traits to plants regeneration under various biotic and abiotic stresses (Kumar *et al.*, 2015). In cereal crops several regeneration and genetic transformation protocols are available and finger millet has got little attention compared to rice, maize, wheat and oats (Ceasor and Ignacimlthu, 2009). The current finger millet regeneration system depends on somatic embryogenesis, predominantly involving a callus phase

and is limited by low regeneration frequencies and long regeneration period (Dey *et al.*, 2012).

Direct organogenesis is an effective approach to minimize somaclonal variation omitting the callus induction and subculturing cycles (Arockiasamy and Ignacimuthu, 2007). Direct plant regeneration by culturing shoot apical meristems (SAMs) is a simple and promising tool for plant regeneration because of rapid and effective regeneration capacity. The present research revealed a rapid and efficient direct plant regeneration system for the Indian finger millet genotype 'GPU28' using invitro-derived shoot apical meristem as explants, without an intermediate callus phase. For multiple shoot induction and regeneration, the concentration and combination of plant growth regulators (PGR) were optimized and MS media concentration for rooting, was also standardized. This procedure is rapid, reliable, reproducible and can immensely be used for genetic transformation of finger millet in the future.

## MATERIAL AND METHODS

**Plant Materials and Explants Preparation**

The mature seeds of finger millet were pretreated with sterile water for 30 minutes in order to remove the husk. These were surface sterilized with 0.1 per cent (w/v) mercuric chloride ( $\text{HgCl}_2$ ) for 5 minutes and further rinsed three times, in each 1 minutes, with sterile distilled water. Surface-sterilized seeds (GPU28) were inoculated on Murashige and Skoog (MS; Murashige and Skoog, 1962) basal medium containing 3 per cent (w/v) sucrose, 0.8 per cent (w/v) agar-agar type 1. The pH of the media was adjusted to 5.8 before autoclaving ( $121^\circ\text{C}$  and 15 lbs per sq. inch). For shoot meristem initiations seeds were incubated in dark at  $26 \pm 2^\circ\text{C}$  for 3 days.

**Shoot Induction and Elongation**

Aseptically grown 3-days-old SAMs (Shoot apical meristem) were excised and utilized as explants. The SAMs (4-6 mm) were cultured on shoot induction medium (SIM) comprising of MS basal medium supplemented with 30 per cent sucrose and various concentrations and combinations of cytokinins and auxin as shown in Table 1. The medium pH was adjusted to 5.8 before adding 0.8 per cent (w/v) agar-agar type I. The culture bottles were incubated in the growth room in 16/8 hours light/dark at  $26 \pm 2^\circ\text{C}$  for 14 days. The shoots formed after 14 days were transferred to fresh SIM (Shoot induction medium) and incubated in growth chamber with 16/8 hours light/dark at  $26 \pm 2^\circ\text{C}$  for a further 14 days to elongate the induced shoot. The percentages of the number of shoots that formed in each shoot clump and the mean number of shoots induced in each explants were calculated following 28 days of culture. After 28 days elongated shoots were transferred to half-strength MS medium with 1.5 per cent (w/v) sucrose and indole-3-acetic acid (IAA;  $1.4 \mu\text{M}$ ). Cleri Gel 3 per cent (w/v) was used for solidifying rooting media. The cultures were incubated for 10 days at  $28^\circ\text{C}$  in 16/8 h light/dark and 75/50 per cent relative humidity (RH). Rooted shoots were hardened in pots containing sterile soilrite and peat (1:1 w/w), and established in the field up to flowering and seed setting.

TABLE 1

Effect of plant growth regulators on direct plant regeneration

Treatments	Concentration and composition of ingredients
T1	MS basal salts, 3mg/L BAP, 500 mg/L casein enzymichydrolysate, 750 mg/L proline, 30 g/L of sucrose, 8 g/L (w/v) agar-agar type-1 and pH 5.8
T2	MS basal salts, 3 mg/L BAP, 1 mg/L 2,4 D, 500 mg/L casein enzymichydrolysate, 750 mg/L proline, 30 g/L of sucrose, 8 g/L (w/v) agar-agar type-1 and pH 5.8
T3	MS basal salts, 2 mg/L BAP, 1 mg/L 2,4 D, 500 mg/L casein enzymichydrolysate, 750 mg/L proline, 30 g/L of sucrose, 8 g/L (w/v) agar-agar type-1 and pH 5.8
T4	MS basal salts, 2 mg/L BAP, 0.19mg/L 2,4 D, 500 mg/L casein enzymichydrolysate, 750 mg/L proline, 30 g/L of sucrose, 8 g/L (w/v) agar-agar type-1 and pH 5.8
T5	MS basal salts, 4 mg/L BAP, 1 mg/L 2,4 D, 500 mg/L casein enzymichydrolysate, 750 mg/L proline, 30 g/L of sucrose, 8 g/L (w/v) agar-agar type-1 and pH 5.8

**Glyphosate Sensitivity Assay**

To determine the concentration of glyphosate for the effective selection of transformed plants, 3 days old seedling-derived SAMs were cultured on MS medium (pH 5.8) supplied with different concentrations (1, 2, 3, 4 and 5 mg/L) of glyphosate and plant growth regulators (PGRs) (Table 2). The cultures were maintained in a growth chamber with a 16/8 h light/dark cycle using  $50 \mu\text{mol photons m}^{-2} \text{s}^{-1}$  of cool white fluorescent illumination and 75/50 per cent RH at  $28^\circ\text{C}$  for 12 days. SAM explants cultured on MS medium devoid of glyphosate were kept as control. The percentage of explant survival was calculated after 12 days of incubation in the light.

TABLE 2

Standardization of glyphosate concentration for screening transgenics

Treatments	Concentration and composition of ingredients
T1	MS basal salts, 3 mg/L BAP, 500 mg/L casein enzymichydrolysate, 750 mg/L proline, 30 g/L of sucrose, 8 g/L (w/v) agar-agar type-1 and pH 5.8
T2	MS basal salts, 3 mg/L BAP, 1 mg/L glyphosate, 500 mg/L casein enzymichydrolysate, 750 mg/L proline, 30 g/L of sucrose, 8 g/L (w/v) agar-agar type-1 and pH 5.8
T3	MS basal salts, 3 mg/L BAP, 2 mg/L glyphosate, 500 mg/L casein enzymichydrolysate, 750 mg/L proline, 30 g/L of sucrose, 8 g/L (w/v) agar-agar type-1 and pH 5.8
T4	MS basal salts, 3 mg/L BAP, 3 mg/L glyphosate, 500 mg/L casein enzymichydrolysate, 750 mg/L proline, 30 g/L of sucrose, 8 g/L (w/v) agar-agar type-1 and pH 5.8
T5	MS basal salts, 3 mg/L BAP, 4 mg/L glyphosate, 500 mg/L casein enzymichydrolysate, 750 mg/L proline, 30 g/L of sucrose, 8 g/L (w/v) agar-agar type-1 and pH 5.8
T6	MS basal salts, 3 mg/L BAP, 5 mg/L glyphosate, 500 mg/L casein enzymichydrolysate, 750 mg/L proline, 30 g/L of sucrose, 8 g/L (w/v) agar-agar type-1 and pH 5.8

TABLE 3

Shoot induction of finger millet seeds on various concentrations of cytokinins and auxin after 14 days of incubation

Treatments (ppm/L)	Survival (%)	Multiple shoot induction (%)	Multiple shoot number
T1	100	100	1.35
T2	100	20	0.20
T3	20	5	0.05
T4	100	100	1.20
T5	50	100	0.10
Mean	74	65	0.58
Min	20	5	0.05
Max	100	100	1.35
C.D	13.60	10.39	0.12
SE (m)	4.47	3.40	0.04
SE (d)	6.32	4.83	0.05
CV	12.09	14.53	14.08

The finger millet (GPU 28) exhibited remarkably different regeneration responses depending on the growth regulator type and concentration in the medium. A combination of BAP and 2, 4 D was tried. The best shoot induction and survival percentage was observed in medium supplemented with 3 mg / L BAP (Table 3) after 14 days of incubation. The addition of lower concentration of 2, 4 D along with BAP increased shoot induction, while higher concentration 2, 4 D was used along with BAP decreased the efficiency of shoot induction.

The successful use of SAM explants in this study implies that they are a better choice for plant regeneration in cereals compared to other explants. Direct shoot regeneration without callus phase is the most preferred pathway for plant regeneration in finger millet. In our study, BAP (3 ppm) was found to be more effective in direct shoot induction from SAM explants of finger millet. Pande *et al.* (2015) reported that optimal multiple shoot induction response was recorded on MS basal media supplemented with 3.0 mg/L of BAP, while Satish *et al.* (2015) reported 8.3 shoots per explants of finger millet variety 'CO (Ra) -14' in MS basal medium containing 17.6

## RESULTS AND DISCUSSION

**Effects of Induction of Shoot Apical Meristems (SAMs)**

Surface - sterilized mature seeds of finger millet (GPU 28) were inoculated on plant growth regulator free MS media, for shoot meristem initiation in dark for 3 days. When 3 days old meristemic shoot tips, consisting of apex and part of mesocotyl were excised and cultured on MS basal medium containing various concentration of BAP and 2, 4 D (Table 3) to determine the effect of growth regulator for direct organogenesis.

µM 6 BAP, 0.9 µM 2, 4-D in combination with 750 mg/L proline, 500 mg/l casein enzymatic hydrolysate and 2 mg/l glycine.

**Effect of Plant Growth Regulators on Multiple Shoot Induction**

Marked differences in multiple shoot induction rates were observed among the different concentrations and combinations of BAP and 2, 4 D. However, shoot survival response and number of shoots per explants varied based on the concentration and combination of BAP and 2, 4 D. After 28 days of incubation, more number of multiple shoots were observed in medium containing 3mg/L BAP (Table 4). Statistical analysis of variance indicated that significant difference was observed among the different concentration of BAP and 2, 4 D in plant regeneration response. Induction medium supplemented with 3mg/L BAP exhibited significantly better response. When MS + 4mg/L BAP + 1mg/L 2,4 D and MS + 2mg/L BAP + 1mg/L 2, 4 D was used in media the response was 0 per cent respectively on 28<sup>th</sup> day in plant regeneration response. When MS media was supplemented with 2mg/L BAP and 0.19 mg/L 2, 4 D the response was 75 per cent on 28<sup>th</sup> day in plant regeneration response. It was

observed that by increasing the concentration of 2, 4 D direct organogenesis duration was increased. The regenerated shoots rooted easily and showed nodule like structure. The roots were produced on the medium containing IAA. The plantlets were transferred to the soil (Plate 1).

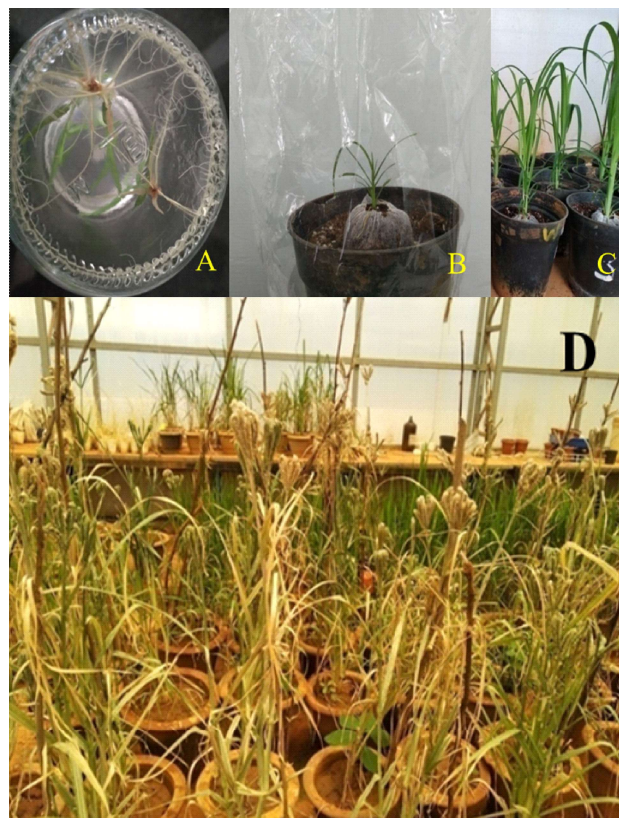


Plate 1 : Different stages of finger millet growth and hardening

A) Rooting of transgenic plant (B) and (C) Growth of healthy plantlets well rooted putative transformant of finger millet transfer to green house; (D) Fertile transgenic finger millet plant.

TABLE 4  
Shoot induction of finger millet seeds on various concentrations of cytokinins and auxin after 28 days of incubation

Treatments (ppm/L)	Survival (%)	Multiple shoot number
T1	100	13.05
T2	15	0.20
T3	0	0.00
T4	75	1.35
T5	0	0.00
Mean	38	2.92
Min	0	0.00
Max	15	13.50
C.D	9.619	0.096
SE(m)	3.162	0.032
SE(d)	4.472	0.045
C.V	16.644	2.16

The induction of shoots in cereals and millets is commonly achieved by BAP or thidiazuron (TDZ) (Bayer *et al.*, 2014; Dosad and Chawla, 2016). Ramakrishna *et al.* (2013) reported that BAP is one of the active plant growth regulator frequently used for tissue culture of monocotyledon plants. In our study SAMs from 3 days old seedlings were found to be optimal resulting in an excellent regeneration response in 3 BAP supplemented with 3 mg/L BAP. In this study comparison of several concentration and combination of the plant growth regulators has shown that the efficiency for multiple shoot formation is regulated by

balance between particular types of cytokinins and auxins. Previously a large number of studies focused on embryogenic calli mediated plant regeneration in cereals inclusive of finger millet (Sharma *et al.*, 2011) barley (Xue *et al.*, 2010) and rice (Ramesh *et al.*, 2009) has been published. However, the results of present study suspect that this more complex regeneration procedure may not be required for finger millet (GPU 28).

### Glyphosate Sensitivity Assay

The SAMs inoculated on MS medium containing 3 mg/L BAP and devoid of glyphosate were viable and initiated multiple shoots after 12 days of incubation (Fig 1). The frequency of shoot initiation and multiple shoot induction decreased drastically with the increased concentration of glyphosate in MS medium (Table 5). There was a significant difference among the frequency of regeneration for glyphosate concentration between 0 ppm to 5 ppm. At above 3 ppm glyphosate, there was a complete decrease in chlorophyll pigmentation coupled with arrest in shoot regeneration and growth. At 5 ppm concentration of glyphosate in MS media SAMs did not show any response for shoot

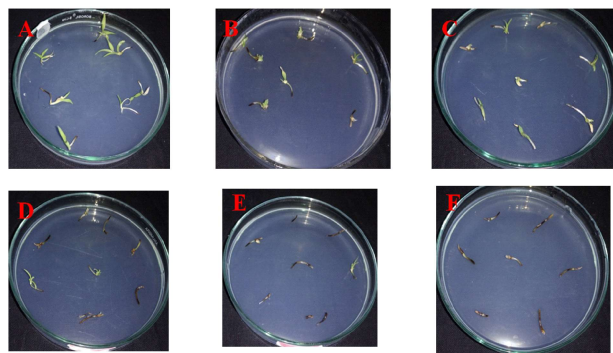


Plate 2: Glyphosate sensitivity of regeneration of shoot apical meristems derived from 5 days old seedlings of finger millet (GPU 28).

A- Multiple shoot induction from shoot apical meristems of GPU 28 on MS medium containing 3ppm BAP, 500 mg l<sup>-1</sup> casein enzymichydrolysate and 30 g l<sup>-1</sup> of sucrose. B-F Re-generation of 5 days old shoot apical meristems from GPU 28 in MS medium containing 3ppm BAP, 500 mg l<sup>-1</sup> casein enzymichydrolysate, 30 g l<sup>-1</sup> of sucrose along with 1, 2, 3, 4, 5 ppm glyphosate for 12 days.

initiation and all the SAM explants were turned brown due to cell death (Plate 2). Based on this investigation 5 ppm of glyphosate was chosen as lethal dose. This study was used to select the non - transformed explants and to allow the selective growth of transformed SAMs on MS medium.

TABLE 5

Details of sensitivity test for shoot apical meristems of finger millet (GPU 28) to glyphosate on shoot regeneration medium

Treatments (ppm/L)	Survival (%)
T1	8.00
T2	8.00
T3	7.33
T4	1.33
T5	0.67
T6	0.00
Mean	5.07
Min	0.00
Max	8.00
C.D	1.038
SE(m)	0.333
SE(d)	0.471
CV	13.674

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## Influence of Foliar Application of Boron and Plant Growth Regulators on Hybrid Seed Yield and Quality of Bitter Gourd (*Momordica charantia* L.) under Protected Cultivation

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### ABSTRACT

A field experiment was conducted at Main Agricultural Research Station, University of Agricultural Sciences, Raichur during the *rabi* season of 2017-18, to study the influence of foliar application of boron and plant growth regulators on hybrid seed yield and quality of bitter gourd under protected cultivation, which was laid in a randomized block design with three replications. The experiment consisted of seven treatments involving five growth regulators in combination with micronutrient Boron *viz.*, T<sub>1</sub>- control, T<sub>2</sub>- boron (1 g/l), T<sub>3</sub>- boron (1 g/l) + GA<sub>3</sub> (50 ppm), T<sub>4</sub>- boron (1 g/l) + NAA (0.3 ml/l), T<sub>5</sub>- Boron (1g/l) + triacontanol (1.5 ml/l), T<sub>6</sub>- Boron (1 g/l) + homobrassinolide (0.5 ml/l), T<sub>7</sub>- Boron (1g/l) + humic acid (2%) were sprayed at three different stages *viz.*, two to three leaf stage, peak flowering and fruit initiation. The results revealed that among various treatments the foliar application of (T<sub>6</sub>) boron (1 g/l) with homobrassinolide (0.5 ml/l) recorded significantly higher fruit length, fruit diameter, fruit weight, number of fruits per plant, number of seeds per fruit, seed weight per fruit, 100 seed weight, hybrid seed yield per plant and hectare and higher monetary results with higher seed quality parameters like seed germination, shoot length, root length, seedling dry weight, seedling vigour index-I and dehydrogenase enzyme activity and the maximum vine length was recorded by (T<sub>3</sub>) boron (1 g/l) + GA<sub>3</sub> (50 ppm) and the control recorded significantly lower parameters. Benefit cost ratio for T<sub>6</sub> was highest (3.08) as compared to control (2.51) in seed production of Bitter Gourd.

**Keywords:** Plant growth regulators, Bitter gourd, Foliar application and Hybrid seed yield

AGRICULTURE plays an important role in the overall economic development of country where the vegetable sector alone contributes 2.20 per cent to the country's gross domestic product. Substantial increase in yield and quality of vegetable crops depend upon a number of factors. The input like fertilizers, irrigation and plant protection measures and suitable agronomic practices contribute greatly towards enhancing yield and quality of the produce. If good quality seed is not used, the full benefit of such inputs and agronomic practices cannot be realised. The cost of seed represents a mere fraction (2-3%) of the total cost of production, but the quality of seed plays a decisive role in influencing the grower's profitability. Quality seeds, therefore, is the basic critical input upon which all other inputs will depend for their full effectiveness.

Bitter gourd (*Momordica charantia* L.) belongs to family Cucurbitaceae, is one of the most important vegetable crops which can be cultivated all round the

year. It is also known as balsam pear, karela or bitter melon which is a fast growing tropical vegetable. In India, it is cultivated in an area of 930 lakh hectare with a production of 1,053 metric tonnes and the productivity of 11.33 tonnes per hectare. In Karnataka, it is cultivated in an area of 1,872 hectare with a production of 13,676 tonnes and productivity of 7.0 tonnes per hectare (Anon., 2016).

Under protected condition many vegetable crops especially cucurbits can be grown round the year with high quality fruit and minimum incidence of disease and pest because it achieved efficiently high water and nutrients. It also helps to increase the photosynthetic efficiency and reduces the transpiration losses.

Boron is an important micronutrient required for pollen germination, pollen tube formation, for better fruit set it also regulates plant metabolism of carbohydrates. It

is non-mobile in plants and a continuous supply is necessary at all growing points. The plant growth regulators (PGR's) are considered as a new generation agro chemicals have key role in certain changes in metabolism of fruit and seed growth as a result of which there would be better accumulation of food reserves resulting in higher seed yield. With this background in view, an experiment on the 'Influence of foliar application of boron and plant growth regulators on hybrid seed yield and quality of bitter gourd (*Momordica charantia* L.) under protected cultivation' was undertaken.

#### MATERIAL AND METHODS

The present investigation was carried out at Main Agricultural Research Station, University of Agricultural Sciences, Raichur during the year 2017-18 under protected condition. The experiment was conducted on black clay loam soil with 7.2 pH. The experiment consisted of seven treatments viz., T<sub>1</sub>- control, T<sub>2</sub>- boron (1 g/l), T<sub>3</sub>- boron (1 g/l) + GA<sub>3</sub> (50 ppm), T<sub>4</sub>- boron (1 g/l) + NAA (0.3ml/l), T<sub>5</sub>- Boron (1g/l) + triacontanol (1.5ml/l), T<sub>6</sub>- Boron (1g/l) + homobrassinolide (0.5 ml/l), T<sub>7</sub>- Boron (1g/l) + humic acid (2%) which were sprayed once in three different stages viz., two to three leaf stage (before crossing), peak flowering (at the time of crossing) and fruit initiation (after crossing). The experiment was laid under protected cultivation in a randomized block design with three replications. The healthy and bold seeds of both male and female parents of hybrid (MBTH 102) were sown in pro trays of 98 wells filled with coir pith on the same day and watered. The beds of 28m × 1.2m were prepared in the main seed production field. The well decomposed farm yard manure of one tonne was applied uniformly to all the beds. Later on, the black polythene mulch was put over the beds with drippers were laid inside. The 21 day old healthy seedlings of both parents were transplanted to main field on the same day at the spacing of 4 × 6 feet in the block system by maintaining the planting ratio of 3:1.

In the experiment, fertilizer application was followed on the basis of package of practice recommended by

the University of Agricultural Sciences, Raichur and Dharwad. The recommended dose of fertilizer to be applied per hectare is 50-100 kg. N, 40-60 kg P<sub>2</sub>O<sub>5</sub> and 30-60 kg K<sub>2</sub>O. Half the N and entire P & K should be applied before planting and the 25 kg of remaining nitrogen was applied as top dressing. The staking with bamboo stick was provided and the vines were trailed on the jute thread.

Crossing work was initiated during peak flowering from 55 days after sowing continuously for 15 days. Female flower buds which are likely to open on next day were selected in the evening hours (4 to 6 pm). The selected buds were covered with white coloured butter paper. Next day morning (8 to 10 am) optimum size male flowers were collected from the male parent. The pollen from male flowers was gently dusted on the stigma of female flower. The crossed female flower buds were covered with brown coloured pockets and the flower stalk was tied with coloured thread for identifying the crossed fruit.

Five plants from each plot was randomly selected and marked with label for taking various observations. The hybrid fruits from the female parent was harvested at 85-90 DAS, when the fruit colour turned to yellowish orange and the fruits were cut open longitudinally and the pulp along with seeds were scooped out and kept for fermentation overnight and the seeds were washed and dried under diffused sunlight until safer moisture level achieved. The various observations on growth and yield parameters were recorded at the time of harvest.

#### Seed Germination (%)

The standard germination test was carried out by following between paper method as per ISTA procedure. Hundred seeds in four replications were taken from each treatment and placed on germination paper uniformly. The roll towels were kept in a germination chamber maintained at 25 ± 2°C temperature and 90 ± 5 per cent relative humidity. Then the first count was taken on 4<sup>th</sup> day and final count on 14<sup>th</sup> day. The number of normal seedlings

from each replication was counted and the mean germination was expressed in per cent (ISTA, 2013).

### Seedling Vigour Index (SVI)

The seedling vigour index-I was calculated by employing the formula given by Abdul-Baki and Anderson, 1973.

$$\text{SVI-I} = \text{Germination (\%)} \times \text{Total seedling length (cm)}$$

### RESULTS AND DISCUSSION

The results from the above experiment revealed that foliar application of boron and plant growth regulators significantly influenced the growth, hybrid seed yield and its attributing characters, economics and seed quality parameters of bitter gourd.

A remarkable increase in vine length (375.0 cm) was observed with foliar spray of boron @ 1g/l + GA<sub>3</sub> 50 ppm compared to control (320.0 cm) (Table 1). This maximum vine length in combination of GA<sub>3</sub> with boron might be due to cell division, cell elongation and quicker multiplication of cells in the shoot apex. These osmotic driven responses under the influence of gibberellins might have been attributed to increase in photosynthetic activity, accelerated translocation and efficiency of utilizing photosynthetic products, thus resulting in increased cell elongation and rapid cell

division in the growing portion. Similar effects were also reported by Hilli *et al.* (2010) in ridge gourd.

Generally yield depends on traits such as number of fruits per plant, fruit length, fruit diameter, fruit weight, number of seeds per fruit, seed weight per fruit and 100 seed weight. In the present study, significantly higher number of fruits (14.47), fruit length (25.8 cm), fruit diameter (7.2 cm), fruit weight (151.9 g), No. of seeds per fruit (24.7), seed weight (5.48 g) per fruit, 100 seed weight (22.32 g), hybrid seed yield (79.6 g) per plant and (497.3 kg) per hectare was recorded by the combined application of boron @ 1g/l + homobrassinolide @ 0.5 ml/l compared to control (13.60, 19.7 cm, 6.3 cm, 115.7 g, 22.6, 4.74 g, 20.93 g, 64.1 g/plant, 401.1 kg/ha) recorded significantly lowest parameters (Table 1).

This may be due to the action of Brassinosteroids, which play a regulatory role in early fruit development. It is worth noting that fruit development is a complex process and Brassinosteroids could cross-talk with other hormones such as auxins and GA<sub>3</sub> (Roghabadi and Pakkish, 2014) in sweet cherry. The increase in fruit length and diameter might be due to the fact that, Brassinosteroids stimulate cell elongation, cell division and differentiation that promote fruit growth (Kang

TABLE I  
Effect of boron and plant growth regulators on yield and its attributing parameters

Treatment	Vine length (cm)	Number of fruits per plant	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Number of seeds per fruit	Seed weight per fruit (g)	100 seed weight (g)	Hybrid seed yield (g/plant)	Hybrid seed yield (kg/ha)
T <sub>1</sub>	320.0	13.60	19.7	6.3	115.7	22.6	4.74	20.93	64.1	401.1
T <sub>2</sub>	328.7	13.73	21.7	6.4	121.6	22.7	4.83	21.26	66.2	413.9
T <sub>3</sub>	375.0	14.43	24.5	7.1	141.1	24.5	5.43	22.17	78.2	488.8
T <sub>4</sub>	364.0	14.07	23.2	7.0	139.3	24.4	5.25	21.62	73.5	459.4
T <sub>5</sub>	344.0	13.90	23.2	6.8	137.9	23.3	4.97	21.38	69.3	433.0
T <sub>6</sub>	368.7	14.47	25.8	7.2	151.9	24.7	5.48	22.32	79.6	497.3
T <sub>7</sub>	334.0	13.80	23.1	6.6	131.6	22.8	4.89	21.31	67.1	419.4
Mean	347.8	14.00	23.0	6.8	134.2	23.6	5.08	21.57	71.1	444.7
S. Em±	4.2	0.11	0.7	0.1	5.1	0.4	0.11	0.28	1.4	8.6
C.D at 5%	12.9	0.34	2.3	0.3	16.1	1.2	0.35	0.89	4.3	24.5

and Guo, 2011). Due to increase in fruit length and diameter consequently the fruit weight and number of seeds were automatically increased. Roghabadi and Pakkish (2014) reported that trees sprayed with brassinosteroid 0.75 mg/l at swollen bud stage recorded the biggest yield in terms of fruit weight in sweet cherry.

The increase in seed yield might be due to foliar application of plant growth regulators along with boron which might have brought certain metabolic changes during fruit and seed development there by increased the food reserve accumulation and resulted in higher seed yield. This overall increase in seed yield could be attributed to the capacity of brassinolide and epibrassinolide to increase the seed number per fruit and fruit size by stimulating the translocation of photosynthates into seeds. Brassinosteroids activate proton pump, thereby get involved in cell division and enlargement besides, associated with increased metabolic processes like photosynthesis and protein synthesis. Sumathi *et al.* (2017) in pigeon pea reported that 0.1 ppm of homobrassinolide was effective in increase the number of seeds per pod and 100 seed weight. Homobrassinolide (HBR) stimulate plant metabolism and growth, leading to an increase in number of ears per plant, grains per ear and grain size

in wheat. Prakash *et al.* (2008) reported that 1.0 ppm of homobrassinolide improved yield in sesame.

Economics worked out from the present study indicated that foliar application of boron @ 1g/l + homobrassinolide @ 0.5 ml/l recorded highest monetary returns in terms of gross returns (Rs.5,47,030 ha<sup>-1</sup>), net returns (Rs.3,69,862 ha<sup>-1</sup>) and BC ratio (3.08). While, lowest returns was obtained from control (Rs.4,41,210 ha<sup>-1</sup>, Rs.2,65,890 ha<sup>-1</sup> and 2.51, respectively) (Table 2).

The higher B:C ratio might be due to increased seed yield and this might be due to foliar application of boron and plant growth regulator which were found to be more effective in increasing the yield attributing characters by increasing higher source to sink ratio which ultimately results in the overall seed yield and in turn resulted in enhanced gross returns and net returns in bitter gourd hybrid seed production.

After the harvest of crop, seeds were extracted from the fruit and were analyzed for various quality parameters. Growth regulators spray along with boron, which had a significant influence on the seed quality parameters over control. The seeds extracted from the fruits which received boron @ 1g/l + homobrassinolide (HBR) @ 0.5 ml/l noticed

TABLE 2  
Effect of boron and plant growth regulators on cost of cultivation, gross returns, net returns and benefit cost ratio of hybrid seed production in bitter gourd

Treatment	Cost of cultivation (Rs. ha <sup>-1</sup> )	Gross returns (Rs. ha <sup>-1</sup> )	Net returns (Rs. ha <sup>-1</sup> )	Benefit cost ratio
T <sub>1</sub>	175763	441210	265,890	2.51
T <sub>2</sub>	176158	455290	279,597	2.58
T <sub>3</sub>	179834	537680	358,442	2.99
T <sub>4</sub>	176393	505340	329,495	2.86
T <sub>5</sub>	176870	476300	299,929	2.69
T <sub>6</sub>	177783	547030	369,862	3.08
T <sub>7</sub>	177179	461340	284,635	2.60
Mean	177140	489170	312,550	2.76
S. Em±	-	-	691	0.004
C.D at 5%	-	-	2152	0.012

significantly higher seed germination (99.3 %), shoot length (24.8 cm), root length (16.9 cm), seedling dry weight (1052.3 mg), seedling vigour index- I (4141) and dehydrogenase enzyme activity of (0.939 OD value) (Table 3) and the control recorded significantly lowest of all above parameters (94.0 %, 21.8 cm, 13.1 cm, 843.8 mg, 3281 and 0.624 OD value) (Table 3), respectively.

The Homobrassinolide (HBR) had beneficial effect on seed germination by increasing the amylase activity, photosynthesis, translocation, membrane stability and stress tolerance. Probably, the increase in water content of the HBR-treated seeds is an act of the hormone on the proton pump of the cell wall facilitating its loosening, thus, favouring the cellular elongation and result in better germination. Brassinosteroids (BS) enhances shoot and root growth, cell elongation, vascular differentiation, xylem formation in epicotyls, and also in the regulation of expression of several genes involved in xylem development. Similar findings were noticed by who observed that 0.01 and 0.05 ppm homobrassinolide enhances the seedling growth in wheat.

The positive influence of growth regulators and boron was noticed on seed germination, shoot and root parameters consequently their significant increase on seedling dry weight and seedling vigour index- I. This increase could be due to adequate supply of food reserves for the embryo growth and synthesis of hydrolytic enzymes which in turn affects the seed germination, seedling emergence ultimately seedling vigour. Brassinosteroids found to be cross talk with GA<sub>3</sub> during germination involved in the activation of hydrolytic enzymes which could breakdown the macromolecules into simple sugars makes them available to growing tip of seedling for uniform growth and establishment. Similar effects were reported by Sirhindi *et al.* (2009) in mustard and Srivastava *et al.* (2011) in mung bean due to application of growth regulators.

On the basis of findings of present investigation, following conclusions have been drawn. Foliar application of boron @ 1g/l + homobrassinolide @ 0.5 ml/l was found significantly superior in terms of hybrid seed yield and quality parameters and significantly higher monetary returns (3.08) can be realized by spraying boron @ 1g/l + homobrassinolide @ 0.5 ml/l during hybrid seed production.

TABLE 3  
Effect of boron and plant growth regulators on seed quality parameters of bitter gourd

Treatment	Seed germination (%)	Shoot length (cm)	Root length (cm)	Seedling dry weight (mg)	Seedling vigour index- I	Dehydrogenase enzyme activity (OD Value)
T <sub>1</sub>	94.0 (75.8)	21.8	13.1	843.8	3281	0.624
T <sub>2</sub>	95.3 (77.4)	22.2	13.9	873.8	3450	0.648
T <sub>3</sub>	98.3 (82.3)	24.5	16.5	964.3	4030	0.837
T <sub>4</sub>	96.8 (79.6)	23.2	16.2	927.5	3814	0.760
T <sub>5</sub>	96.0 (78.5)	23.1	14.9	894.0	3648	0.700
T <sub>6</sub>	99.3 (85.0)	24.8	16.9	1052.3	4141	0.939
T <sub>7</sub>	95.5 (77.8)	22.4	14.5	877.3	3524	0.669
Mean	96.4 (79.1)	23.1	15.1	919.0	3692	0.740
S. Em±	0.9	0.6	1.0	23.6	116	0.016
C.D at 1%	2.9	1.8	3.1	70.0	344	0.048

Note: Figures in the parenthesis indicates arc sign transformed values

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## Standardization of Optimum Fruit Maturity Stage and Post Harvest Ripening Period to Achieve Better Seed Quality in Sponge Gourd

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### ABSTRACT

A laboratory experiment was conducted in the Department of Seed Science and Technology, UAS, Raichur during 2017-18. The treatments details include three maturity stages ( $M_1$ : complete yellow,  $M_2$ : 50 per cent brown and  $M_3$ : 100 per cent brown) and four post harvest ripening periods,  $R_1$  (0<sup>th</sup> day),  $R_2$  (5<sup>th</sup> day),  $R_3$  (10<sup>th</sup> day) and  $R_4$  (15<sup>th</sup> day). The results revealed that among the various maturity stages, fruits harvested at  $M_3$  (100 per cent brown) stage was found to be best and among the post harvest ripening periods,  $R_1$  (0 days) was found to be best for sponge gourd. Among the interactions,  $M_3R_1$  (100 per cent brown and 0<sup>th</sup> day) *i.e.*, the fruits harvested at complete brown stage and seed extraction done on the day of harvest was found to be superior in terms of seed quality parameters like seed weight per fruit, seed germination, dehydrogenase enzyme activity, shoot length, root length, seedling dry weight, seedling vigour index I, seedling vigour index II (24.5g, 88.1 %, 1.003 OD value, 24.2 cm, 24.3 cm, 910.9 mg, 4275, 80292 respectively). Lowest seed quality parameters noticed in  $M_1R_1$  was (12.9 g, 70.1 per cent, 0.447 OD value, 19.9 cm, 19.9 cm, 775.9 mg, 2794, 54481).

**Keywords:** Sponge gourd, Postharvest ripening, Germination and Dehydrogenase enzyme activity

SPONGE GOURD [*Luffa cylindrica* (L.)] is also known as 'Luffa, Bath sponge, Towel gourd, Dishrag gourd, Vegetable sponge, Rag gourd, Smooth luffa, Scrubber gourd and Wild vegetable sponge'. Luffa is widely cultivated vegetable in the family Cucurbitaceae, which is easy to grow hence it is grown throughout Asia and the United States for the food and scrubbers although it is inherent to Tropical Africa and Asia. Sponge gourd is highly cross pollinated and monoecious crop with chromosome number  $2n = 26$ . Flowers are deep yellow in color, unisexual and situated at different internodes. Sponge gourd contains high fibre which is used as cleansing agent and making table mats, shoes soles etc. In India, it is cultivated extensively in the states of Madhya Pradesh, Tamil Nadu, Uttar Pradesh, Andhra Pradesh, Kerala and Maharashtra. In India it occupies an area of 41 m ha with the production of 641 m t and productivity of 15.63 t/ha (Handbook of Horticulture Statistics, 2014). Most of the cucurbitaceous vegetables are usually cultivated in relatively small areas for local consumption and hence the statistical data on area and production are lacking (Anon., 2016). Harvesting

of fruits at optimum stage of maturity and drying not only minimizes the loss of viability and vigour of seeds but also prevents adverse effect of environmental conditions. Research work on stages of harvest is scanty. The fruits develop and attain physiological maturity at different times owing to indeterminate flowering habit. Generally, fruits harvested at physiological maturity produce high quality seed in terms of germination and vigour as compared to fruits harvested at earlier or later stage of maturity. It is also argued that seeds obtained from fruits harvested even before attainment of physiological maturity and allowed for post harvest ripening for few days may also produce good quality seeds. Since, the development of seed continues in fleshy fruits owing to continuous supply of nutrients and food reserve from fruit to seed. Under open field condition, there is a chance of incidence of diseases, pest and also development of more number of male flowers in cucurbits due to increased temperature condition. Hence, the present study was planned and executed to know the influence of maturity stages and post

harvest ripening periods in seed quality parameters of sponge gourd seeds.

#### MATERIAL AND METHODS

Laboratory experiment was conducted in the Department of Seed Science and Technology, College of Agriculture, University of Agricultural Sciences, Raichur, during 2017-18 to find out the influence of fruit maturity stages and post harvest ripening periods on seed quality of sponge gourd. The treatments details include three different maturity stages ( $M_1$ : complete yellow,  $M_2$ : 50 per cent brown and  $M_3$ : 100 per cent brown) and four different post harvest ripening periods,  $R_1$  (0<sup>th</sup> day),  $R_2$  (5<sup>th</sup> day),  $R_3$  (10<sup>th</sup> day) and  $R_4$  (15<sup>th</sup> day). Germination percentage and seedling length, were determined as per International Seed Testing Association rules for seed testing (ISTA, 2013). Hundred seeds each in four replications were placed in rolled paper towels and incubated at a constant temperature of 25°C and 90 per cent relative humidity and the per cent germination was evaluated on 14<sup>th</sup> day and was expressed on normal seedling basis. Seedling length of ten randomly selected normal seedlings was measured replication wise from tip of shoot to root tip and the mean length was calculated and expressed as seedling length in centimeter. Ten randomly selected seedlings used for measuring seedling length were dried at 70±1°C for 24h in hot air oven and the mean seedling dry weight was expressed in gram. The seedling vigour index I and II were determined by multiplying the germination percentage and total seedling length and multiplying germination percentage and total seedling dry weight respectively (Abdul-Baki and Anderson, 1973). For assessing dehydrogenase activity twenty five representative seeds from each treatment were taken and preconditioned by soaking in water over night at room temperature then embryos were excised and steeped in 0.25 per cent solution of 2, 3, 5 - triphenyl tetrazolium chloride and kept in dark for two hours at 40 °C for staining. The stained embryos were thoroughly washed with water and then soaked in 10ml of 2-methoxy ethanol (methyl cellosolve) and kept overnight for extracting the red colour formazan. The intensity of red colour was measured using ELICO UVVIS

spectrophotometer (model SC-159) using blue filter at 470 nm wavelength and methyl cellosolve as blank. The OD value obtained was reported as dehydrogenase activity (Kittock and Law, 1968).

#### RESULTS AND DISCUSSION

Seed production is highly technically skilled job and involves huge labour and financial risk. The seed crop may be raised successfully but harvested at inappropriate stage may lead to complete loss of seed yield and quality on account of field weathering besides heavy financial loss. Hence, among several cultural practices, harvesting of the seed crop at right stage of maturity assumes greater importance for obtaining higher seed yield and quality. Seeds harvested at right stage (physiological maturity) will be well developed, matured and possess maximum viability and vigour. On the contrary, early harvesting prior to physiological maturity drastically lowers seed yield and quality on account of under developed and immature seeds.

Therefore, the present investigation was carried out with three fruit maturity stages viz.,  $M_1$ : 100 per cent complete yellow,  $M_2$ : 50 per cent brown,  $M_3$ : 100 per cent brown and four stages of post harvest ripening periods viz.,  $R_1$ : 0 day,  $R_2$ : 5 days,  $R_3$ : 10 days,  $R_4$ : 15 days to determine the optimum fruit maturity stage and post harvest ripening period in sponge gourd. The findings of the investigations are discussed below. Successful completion of the experiment which are carried exclusively for seed production depends on the quantity of seeds produced at the end. The main and foremost objective of any such experiment is to have optimum seed yield and better returns. The seed yield is inherent to the quality of crop produced. In the present study, fruit weight differed significantly due to maturity stages and post harvest ripening. The treatment,  $M_1$  recorded higher fruit weight (80.2gm) and lower was in  $M_3$  (49.0gm). The loss in fresh weight of fruit recorded during the maturity stages can be attributed to dehydration, maturity drying and loss of moisture (Table 1). The reduction in fruit moisture content with advancement of maturity might be due to the development of seeds and fiber in the fruit. The results obtained are in conformity with the findings of

TABLE 1  
Effect of maturity stages and post harvest ripening period on fruit weight, seed moisture content and number of seeds per fruit in sponge gourd

Treatments	Fruit weight (g)				Seed moisture content (%)				Number of seeds per fruit			
	M1	M2	M3	Mean	M1	M2	M3	Mean	M1	M2	M3	Mean
R1	130.2	63.3	51.5	81.6	25.0 (30.0) *	23.0 (28.6)	10.1 (18.5)	19.31 (25.7)	93.6	192.3	194.3	193.4
R2	95.0	56.5	49.0	67.1	19.0 (25.8)	14.0 (21.9)	9.2 (17.6)	14.0 (21.8)	193.0	194.0	194.0	193.6
R3	49.9	48.0	45.5	47.8	12.0 (20.2)	10.0 (18.4)	8.6 (17.0)	10.2 (18.5)	194.0	194.1	194.2	194.1
R4	47.6	45.7	44.8	46.0	10.0 (18.4)	9.0 (17.4)	8.3 (16.7)	9.1 (17.5)	193.3	194.2	194.1	193.8
Mean	80.2	52.5	49.0	60.5	16.5 (23.6)	14.0 (21.6)	9.0 (17.5)	13.1 (20.8)	193.5	193.6	194.1	193.7
Factors	S.Em±		CD @ 1 %		S.Em±		CD @ 1 %		S.Em±		CD @ 1 %	
M	0.5		1.6		0.1		0.3		0.4		NS	
R	0.6		1.8		0.1		0.4		0.4		NS	
M x R	1.1		3.2		0.2		0.7		0.8		NS	

Legend M : fruit maturity stage R : post harvest ripening period  
M<sub>1</sub>: 100 Per cent yellow R<sub>1</sub>: 0 day R<sub>3</sub>: 10 days  
M<sub>2</sub>: 50 Per cent brown R<sub>2</sub>: 5 days R<sub>4</sub>: 15 days  
M<sub>3</sub>: 100 Per cent brown NS: Significant

Shamsheer (2006). Mean seed weight per fruit and 100 seed weight were highest in M<sub>3</sub> (21.8 mg and 11.7 gm) while, lowest in M<sub>1</sub> (13.8 gm and 7.0 mg). At physiological maturity, seeds are said to be completely developed due to maximum accumulation of food reserves, amino acid, phosphorous active substances, dry matter, sugar, water soluble proteins, acids level in the seeds. This might be due to better development of seeds on account of greater accumulation of food reserves in the seeds resulting in higher seed weight. Lower seed test weight at early harvest might be due to less accumulation of dry matter/food reserve as compared to optimum maturity. The decrease in seed weight over a period of ripening was due to high maintenance of respiration after physiological maturity during which there is no extra food reserve moving from source to sink. So, seeds have to utilize food reserve stored in endosperm to continue the normal biochemical processes (Devaraju *et al.*, 2013 in

cucumber). Germination is one of the key criteria for determining the physiological aspect of seed and gives an idea about the ability of seed to produce normal and healthy seedlings under the field condition. In the present investigation, among different maturity stages, maximum germination and dehydrogenase enzyme activity was recorded in M<sub>3</sub> (82.1 % and 0.899 OD value) while, minimum was in M<sub>1</sub> (74.7 % and 0.688 OD value) (Table 2). This might be due to better development of seeds on account of greater accumulation of food reserves in the seeds resulting in higher vigour and germinability. At physiological maturity, seeds are said to be completely developed due to maximum accumulation of food reserves, amino acids, phosphorous active substances, dry matter, sugar, water soluble proteins, acids and nicotinic acid levels in the seeds. On the contrary, all seed quality parameters were low in early harvested fruits (M<sub>1</sub>), due to presence of large number of immature and under

TABLE 2  
Effect of maturity stages and post harvest ripening period on 100 seed weight,  
Seed weight per fruit and germination in Sponge gourd

Treatments	100 seed weight (g)				Seed weight per fruit (g)				Germination			
	M1	M2	M3	Mean	M1	M2	M3	Mean	M1	M2	M3	Mean
R1	6.7	8.2	12.5	9.0	12.9	15.7	24.5	17.7	70.1 (56.8) *	71.4 (57.6)	88.1 (69.9)	76.5 (61.5)
R2	6.8	8.3	12.1	9.0	13.8	16.6	23.3	17.9	71.4 (57.7)	76.2 (60.7)	86.1 (69.4)	77.9 (62.6)
R3	7.1	8.6	11.4	9.1	13.9	20.7	21.4	18.6	72.1 (58.1)	86.7 (68.6)	81.1 (68.0)	79.9 (64.0)
R4	7.6	12.4	11.0	10.3	14.7	24.1	18.0	18.9	85.1 (67.3)	87.0 (69.4)	73.1 (68.1)	81.7 (68.3)
Mean	7.0	9.3	11.7	9.3	13.8	19.2	21.8	18.2	74.7 (59.9)	80.3 (64.1)	82.1 (68.5)	78.5 (64.3)
Factors	S.Em ±		CD @ 1 %		S.Em ±		CD @ 1 %		S.Em ±		CD @ 1 %	
M	0.08		0.2		0.1		0.4		0.6		1.9	
R	0.09		0.2		0.1		0.5		0.7		2.2	
MXR	0.16		0.4		0.3		0.8		1.3		3.9	

Legend M : fruit maturity stage R : post harvest ripening period  
M<sub>1</sub>: 100 Per cent yellow R<sub>1</sub>: 0day R<sub>3</sub>: 10days  
M<sub>2</sub>: 50 Per cent brown R<sub>2</sub>: 5days R<sub>4</sub>: 15 days  
M<sub>3</sub>: 100 Per cent brown

developed seeds with lesser food reserves and nutrients in the seeds. Attainment of maximum seed quality at the end of seed filling *i.e.* physiological maturity is crucial in seed crops where viability and vigour is essential for seedling establishment in the field. In a number of cucurbits, seed maturation usually continues until the fruit starts to turn light green or yellow colour with senescence. The very low seed germination in the fresh fruit might be due to the dormancy associated with fresh seeds.

Among the ripening periods, highest seed germination and dehydrogenase enzyme activity were recorded in R<sub>4</sub> (81.7 % and 0.870 OD value) whereas, R<sub>1</sub> (76.5 % and 0.718 OD value) recorded lower seed germination and dehydrogenase enzyme activity (Table 3). Among the interactions, M<sub>3</sub>R<sub>1</sub> recorded higher seed germination (88.1%) and dehydrogenase enzyme activity (1.003 OD value). Whereas, lowest in M<sub>1</sub>R<sub>1</sub>

(70.1%). Shoot length and root length were recorded highest in M<sub>3</sub> (23.1 cm and 23.7 cm) whereas, M<sub>1</sub> (20.4 cm and 20.5 cm, respectively) recorded lower shoot and root length. So also, shoot length (22.3 cm) and root length (23.0 cm) was highest in R<sub>4</sub> while, R<sub>1</sub> (21.3 cm and 22.0 cm) recorded the lowest. Similarly, seedling dry weight (880.7 mg), seedling vigour index I (4091) and seedling vigour index II (76875) were highest in M<sub>3</sub> whereas, M<sub>1</sub> (812.8) recorded the lowest (Table 4). Among the interactions, M<sub>3</sub> R<sub>1</sub> recorded higher seedling dry weight (910.9 mg), seedling vigour index I (4275) and seedling vigour index II (80292). Whereas, lowest was in M<sub>1</sub> R<sub>1</sub>. This might be due to better development of seeds on account of greater accumulation of food reserves in the seeds resulting in higher vigour and germinability.

In Sponge gourd seed production, fruits harvested at complete brown stage and seed extraction done on

TABLE 3  
Effect of maturity stages and post harvest ripening period on dehydrogenase enzyme activity, shoot and root length in sponge gourd

Treatments	Dehydrogenase enzyme activity (OD value)				Shoot length (cm)				Root length (cm)			
	M1	M2	M3	Mean	M1	M2	M3	Mean	M1	M2	M3	Mean
R1	0.447	0.747	1.003	0.718	19.9	19.8	24.2	21.3	19.9	21.8	24.3	22.0
R2	0.750	0.815	0.880	0.817	20.0	20.7	23.3	21.3	20.0	22.3	23.7	22.0
R3	0.760	0.900	0.870	0.843	20.7	21.4	23.2	21.8	20.7	22.4	23.6	22.2
R4	0.777	0.990	0.843	0.870	21.0	24.1	22.8	22.3	21.5	24.2	23.4	23.0
Mean	0.688	0.863	0.899	0.859	20.4	21.5	23.1	21.6	20.5	22.7	23.7	22.3
Factors	S.Em ±			CD @ 1 %	S.Em ±			CD @ 1 %	S.Em ±			CD @ 1 %
M	0.007			0.021	0.1			0.5	0.1			0.5
R	0.008			0.024	0.2			0.6	0.2			0.6
MXR	0.014			0.041	0.3			1.0	0.3			1.1

Legend M : fruit maturity stage R : post harvest ripening period  
M<sub>1</sub>: 100 Per cent yellow R<sub>1</sub>: 0day R<sub>3</sub>: 10days  
M<sub>2</sub>: 50 Per cent brown R<sub>2</sub>: 5days R<sub>4</sub>: 15 days  
M<sub>3</sub>: 100 Per cent brown

TABLE 4  
Effect of maturity stages and post harvest ripening period on seedling dry weight, seedling vigour index I and seedling vigour index II in sponge gourd

Treatments	Seedling dry weight (mg)				Seedling vigour index - I				Seedling Vigour Index - II			
	M1	M2	M3	Mean	M1	M2	M3	Mean	M1	M2	M3	Mean
R1	775.9	752.4	910.9	813.1	2794	2975	4275	3348	54481	53810	80292	62861
R2	821.4	839.1	890.6	850.4	2860	3277	4119	3419	58745	63333	78057	66711
R3	823.6	854.8	882.0	853.5	2989	3803	4078	3624	59480	74234	76861	70192
R4	830.1	901.0	839.2	856.8	3622	4238	3893	3918	61590	79059	72291	70980
Mean	812.8	836.8	880.7	843.4	3067	3573	4091	3577	58574	67609	76875	67686
Factors	S.Em ±			CD @ 1 %	S.Em ±			CD @ 1 %	S.Em ±			CD @ 1 %
M	7.1			21.3	30			89	583			1714
R	8.2			24.6	35			103	674			1979
MXR	14.2			41.8	61			179	1167			3428

Legend M : fruit maturity stage R : post harvest ripening period  
M<sub>1</sub>: 100 Per cent yellow R<sub>1</sub>: 0day R<sub>3</sub>: 10days  
M<sub>2</sub>: 50 Per cent brown R<sub>2</sub>: 5days R<sub>4</sub>: 15 days  
M<sub>3</sub>: 100 Per cent brown

the day of harvest M<sub>3</sub>R<sub>1</sub> (100 % brown and 0<sup>th</sup> day), found to be superior in terms of seed quality parameters.

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## Biology of Jasmine Bud Worm, *Hendecasis duplifascialis* Hampson (Lepidoptera : Crambidae) on Star Jasmine, *Jasminum multiflorum*

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### ABSTRACT

The bud worm *Hendecasis duplifascialis* is the major pest of jasmine, *Jasminum multiflorum* and pose serious threat for its cultivation. The biology of bud worm on *J. multiflorum* revealed that the female moth prefers to lay eggs singly into each bud either on the salk or around the petals of unopened bud. The incubation period ranged from 3.0 to 4.0 days with a mean of  $3.25 \pm 0.5$  days. There were five larval instars with a total mean larval duration of  $11 \pm 0.57$  days. The mean pupal duration was  $5.5 \pm 0.57$  days. The average female and male moths longevity was  $3.5 \pm 0.57$  and  $3.0 \pm 0.00$  days, respectively. The over all total life cycle duration of bud worm was  $27 \pm 1.83$  days.

*Keywords:* Bud worm, Biology, *Hendecasis duplifascialis* and *Jasminum multiflorum*

JASMINE is a highly valued commercial flower crop native to the tropical and subtropical regions of the world. It was introduced to South Asia in the mid sixteenth century. Jasmine belongs to family Oleaceae of the order Oleals and genus *Jasminum*. The genus *Jasminum* contains more than 200 species comprising both fragrant and non-fragrant flowers.

The *J. multiflorum* commonly called as star jasmine is an evergreen shrub with branching vine of 10 ft tall and just as wide that can be trained. In Karnataka state, many small and marginal farmers grow jasmine for livelihood. Since from last one decade farmers are experiencing difficulty in cultivating jasmine due to few insect and mite pests. In recent years, the bud worm *H. duplifascialis* is known to pose a serious threat for jasmine cultivation.

The caterpillar makes a hole on the flower bud and feeds on the inner floral structures during the initial stage and later make a circular hole on the bud and comes out for attacking the adjacent buds in the same cymose. During severe infestation, the larva makes a web like structure in the cymose and feeds on the buds. Most of the times infested flowers dry up and drop off (Kamala and Kennedy, 2016). The damage caused by bud worm ranges from 40 to 50 per cent, affecting the quality of the flowers and attributed for 30 to 70 per cent yield loss (Jasmine growers personal

communication, 2018). The knowledge about the biology of insect pests is a pre-requisite for effective pest management. Especially IPM practices requires information about species biology to manage it successfully and to reduce yield losses.

### MATERIAL AND METHODS

The larvae collected during the field surveys were reared separately in the insect rearing cages by providing fresh flower buds collected from jasmine gardens at Chandurayanahalli village, Magadi taluk, Ramangara district. These branches were kept in the 250 ml conical flask with 20 per cent sugar solution and were replaced as and when required. The bud worm pupae obtained from lab culture and as well as pupae collected from the field were placed in petri plates and kept in adult emergence cage. Five pairs of adults emerged from pupae on the same day were released into the oviposition cage. The cotton swab with 10 per cent sugar solution in petri plate was kept in the oviposition cage as food for adult moths.

In oviposition cage (30 cm x 30 cm x 30 cm), fresh healthy jasmine branches with approximately 50 to 75 unopened buds placed in 20 per cent sugar solution in 250 ml conical flask and plugged with cotton were placed for females to oviposit on the buds (Fig. 1). After 48 hrs, the branches with buds were taken out

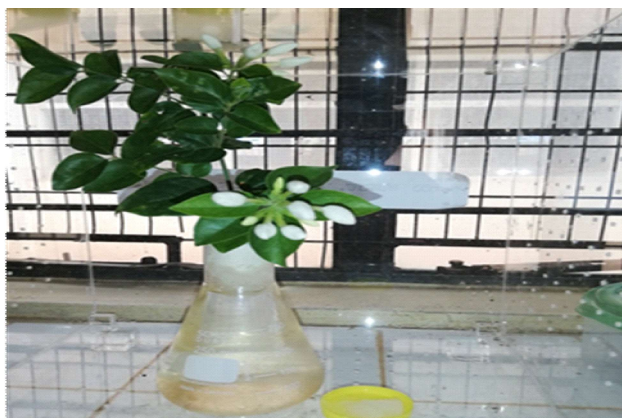


Fig. 1: The biology of *H. duplifascialis* under laboratory

from the oviposition cage and closely observed under the microscope to record number of eggs laid on buds. The larvae were reared in the rearing cage till the completion of first instar. Later the first instar larvae were released on the cymoses of *J. multiflorum* plants



Fig. 2: Biology of bud worm on plants raised in pots under greenhouse conditions

raised in pots under greenhouse conditions to study the duration of different larval instars (Fig. 2).

Each cymose of *J. multiflorum* plants had 4-7 buds. One or two larvae were released on each cymose based on the number of unopened buds present. The observations were recorded during morning and evening on a daily basis to find out larval duration by destructive sampling method and number of days taken for pupation were also recorded of each instar. The pupation of bud worm occurs in silken cocoon on leaves or cymoses. The pupae collected along with the leaves / cymoses were placed in petri plates and

kept in rearing cage to know the pupal duration. Later observations were recorded on number of days taken for adult emergence. The cotton swab with 10 per cent sugar solution was placed in petri plate kept in the cage to provide food for adults. The male and female adult duration was recorded separately.

RESULTS AND DISCUSSION

The biology of budworm, *H. duplifascialis* was studied for four generations (Table 1) at laboratory conditions at Zonal Agricultural Research Station, University of Agricultural Sciences, GKVK, Bengaluru. The results of the pooled data on duration of different developmental stages of bud worm are given in

TABLE 1

The biology of *H. duplifascialis* under laboratory conditions in four replications

Developmental stages of bud worm	Duration ( in days )			
	Gener-1	Gener-2	Gener-3	Gener-4
Egg	3	4	3	3
I Instar	3	3	2	3
II Instar	2	3	1	3
III Instar	1	2	1	2
IV Instar	2	2	2	2
V Instar	3	4	3	4
Pupa	5	6	6	5
Female moth	3	2	3	3
Male moth	4	3	4	3
Total life cycle duration	26	29	25	28

Table 2. It was found that the female moth inserted only one egg into the single bud, around the petals or bud stalk (Fig. 3). The eggs of the bud worm were small and white in colour and later turned to creamish colour with estimated incubation period of  $3.25 \pm 0.5$  days.

The larvae were pale green in colour with black head prothoracic shield and had five instars with total duration of  $11.0 \pm 0.57$  days (Fig. 4).

TABLE 2  
The biology of *H. duplifascialis* under laboratory conditions

Developmental stage	Sample size (n)	Duration (days)			
		Min.	Max.	Avg.	
Egg	Estimated incubation period	20	3	4	3.25 ± 0.5
Larva	I	20	2	3	2.75 ± 0.5
	II	20	1	3	2.25 ± 0.95
	III	20	1	2	1.50 ± 0.57
	IV	20	2	2	2.00 ± 0.00
	V	20	3	4	3.50 ± 0.57
Pupa	Pupa	20	5	6	5.50 ± 0.57
Adult	Male	20	3	3	3.00 ± 0.00
	Female longevity	20	3	4	3.50 ± 0.57
Total life cycle		20	25	29	27.00 ± 1.82



Fig. 3: Damage symptom due to egg laying by bud worm on jasmine buds

**First Instar**

The first instar larva was around 2 mm in length with pale green body and black head. The larva soon after hatching from the egg made a small pinhole into the bud and started feeding inside the bud. The first instar mean larval duration was 2.75 ± 0.5 days.

**Second Instar**

The second instar larva measured 2.5 - 3.5 mm with light green colour body, black head and prothoracic shield with mean larval duration of 2.25 ± 0.95 days.

**Third Instar**

The third instar larva measured 3.5 - 4.5 mm with light green coloured body, black head and prothoracic shield with a mean duration of 1.50 ± 0.57 days.



Fig. 4: Different larval stages of jasmine bud worm

**Fourth Instar**

The fourth instar larva measured 4.5 - 6.0 mm with a light green coloured body, black head and prothoracic shield with a mean duration of 2.0 ± 0.00 days.

**Fifth Instar**

The fifth instar larva measured 6.5 - 8.0 mm with dark green colour body, black head and well developed prothoracic shield and with few hairs on the body. The mean fifth instar duration was 3.50 ± 0.57 days. The fifth instar larva cause severe damage to the buds by making holes, feeding inside and depositing excreta. The bud worm larva requires 4-6 buds to complete its entire larval duration and thus reducing the quality of the buds.

**Pupa**

Pupa measured about 2.5 - 3.0 mm in length and 0.6 - 0.7 mm in width. The pupation occurs inside the brown coloured cocoon and is attached to the leaves with the silken frassy material. The mean pupal duration was about 5.50 ± 0.57 days ( Fig. 5 )

**Adults**

The adult male moths are small with pale creamy markings on the wings and with a mean longevity of 3.00 ± 0.00 days (Fig. 6).



Fig. 5: Pre pupa (5a) and pupa (5b) of jasmine bud worm



Fig. 6: Adult male moth of jasmine bud worm *H. duplifascialis*

The female moths are also small with the pointed ovipositor and similar markings like males on their wings. The mean longevity of female moth was  $3.5 \pm 0.57$  days (Fig. 7).



Fig.7: Adult female moth of jasmine bud worm *H. duplifascialis*

In present study it was found that the female moth inserted only one egg into the single bud, around the petals or bud stalk. Our present findings were supported by Krishna Chaitanya and Kumar (2018) who reported that the eggs of the bud worm were small and white in colour and later turned to creamish

colour. The morphological characters of different stages of bud worm reared on *J. multifloram* in the present study were similar with that of colouration and morphology of eggs, larvae, pupae and adults as described by Krishna Chaitanya and Kumar (2018) when reared on *Jasminum sambac*. The incubation period, larval duration and pupal duration were  $3.25 \pm 0.5$ ,  $11.0 \pm 0.57$  and  $5.5 \pm 0.57$  days, respectively. Further, the total duration for male and female moths were found to be  $3.00 \pm 0.00$  and  $3.5 \pm 0.57$ , respectively. The total life cycle of bud worm on *J. multifloram* was found to be  $27 \pm 1.82$  days. These findings with respect to the life cycle of bud worm of different stages were almost similar to that reported by Krishna Chaitanya and Kumar (2018). The bud worm was found to be a highly voracious feeder by causing huge amount of damage to the buds and the cymoses. During its entire life cycle the pest damages almost 4-6 buds on an average.

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## Influence of Nano Zinc Oxide on Yield and Economics of Maize (*Zea mays* L.)

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### ABSTRACT

A field study was conducted during *kharif* 2018 at Zonal Agricultural Research Station, GKVK, UAS, Bengaluru to know the effect of nano zinc oxide particles on growth and yield of maize. In field, eight treatments were laid out in RCBD with three replications and the cultivar used was BRMH-1. The results revealed that seed priming with 800 ppm of nano zinc oxide for 30 minutes and foliar application of nano ZnO at 500 ppm along with RDF (FYM @ 10 t + 150 kg N + 75 kg P<sub>2</sub>O<sub>5</sub> and 37.5 kg K<sub>2</sub>O ha<sup>-1</sup>) recorded higher cob length (21.2 cm), number of kernels cob<sup>-1</sup> (616.8), 100 kernels weight (30.80 g) ultimately resulted in higher kernel yield (8750 kg ha<sup>-1</sup>) and stover yield (11136 kg ha<sup>-1</sup>), higher gross returns (Rs.1,33,636/- ha<sup>-1</sup>) and net returns (Rs.84,777/- ha<sup>-1</sup>). Whereas, higher B:C ratio of 3.45 was recorded in the seed treated with 800 ppm of nano zinc oxide for 30 minutes with recommended dose of fertilizer.

*Keywords:* Nano ZnO, ZnSO<sub>4</sub> and Maize

MAIZE (*Zea mays* L.) is the third most important cereal crop in the world after wheat and rice with an area of 185.9 m ha, production of 1075.5 mt and average productivity of 5790 kg ha<sup>-1</sup> (Anon., 2017). In India, it is cultivated on an area of 9.89 m ha with a production of 25.9 mt and the productivity of 2690 kg ha<sup>-1</sup> (Anon., 2017). In Karnataka, it is cultivated on an area of 1.3 million ha with a production of 4.4 million tonnes with an average productivity of 2970 kg ha<sup>-1</sup> (Anon., 2017a). It comes up well under a wide range of soil and climatic conditions, there is a lot of scope to expand the present maize yields.

Indian soils are being exhausted heavily as 30 mt of nutrients removed, while 20 mt added by crops leaving a shortage of 10 mt consistently. Fertilizer response ratio of crops has declined radically. Socio and economic issues such as exodus of people from farming, inaccessibility of labourers and raising cost of cultivation add enormous pressure on agricultural scientists to evolve technologies that target multifaceted problems of Indian agriculture.

Nano technology is a field of assembly among life sciences, material science and information technology. It is a rising field of science capable of resolving issues

and problems that are impossible to tackle in engineering and biological sciences. Among the advancement in sciences, nano technology is being visualized as a rapidly evolving field that has potential to revolutionize agriculture and food systems and improve the condition of the poor.

Nano technology is gradually moving from the experimental stage to the operational and practical stage. This will lead to a more tangible presence of the technology in the agricultural sector (Baruah and Dutta, 2009). In this regard, using nano fertilizer to control release of nutrients can be an effective step towards achieving sustainable agriculture and sustainable environment (Cui *et al.*, 2010).

The present study was taken up to investigate the promontory or inhibitory effects of various concentrations of ZnO nano particles on growth and yield of maize (*Zea mays* L.). Nano particles with small size and large surface area are expected to be the ideal forms for use as a Zn fertilizer in plants. Farmers are using both sulphates and chelated Zn (with ethylene di ammine tetra acetic acid, EDTA) for soil and foliar applications; however, the efficacy is low.

## MATERIAL AND METHODS

A field experiment was conducted during *kharif* 2018 at Zonal Agricultural Research Station, GKVK, UAS, Bengaluru to know the effect of nano zinc oxide particles on growth and yield of maize. The soil was red sandy loam having nearly neutral pH (6.56), low electrical conductivity (0.17) and medium in available nitrogen (445.69 kg ha<sup>-1</sup>), phosphorous (46.36 kg ha<sup>-1</sup>), potassium (243.9 kg ha<sup>-1</sup>) and Zinc (0.45 ppm). The experiment was laid out in a RCBD having eight treatments with three replications. The treatment consisted of five levels of nano zinc oxide as foliar application at 30 DAS and zinc sulphate (10 kg ha<sup>-1</sup> and 0.5 %) applied to soil and foliage, respectively.

The treatment details are as follows :

T<sub>1</sub>: Seed priming with Nano ZnO @ 800 ppm for 30 minutes

T<sub>2</sub>: T<sub>1</sub>+Foliar application of Nano ZnO @ 200 ppm

T<sub>3</sub>: T<sub>1</sub>+Foliar application of Nano ZnO @ 300 ppm

T<sub>4</sub>: T<sub>1</sub>+Foliar application of Nano ZnO @ 400 ppm

T<sub>5</sub>: T<sub>1</sub>+Foliar application of Nano ZnO @ 500 ppm

T<sub>6</sub>: T<sub>1</sub>+Foliar application of Nano ZnO @ 600 ppm

T<sub>7</sub>: Foliar application of ZnSO<sub>4</sub> @ 0.5 per cent

T<sub>8</sub>: Soil application of ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup>

RDF: FYM @ 10 t + 150 kg N + 75 kg P<sub>2</sub>O<sub>5</sub> and 37.5 kg K<sub>2</sub>O ha<sup>-1</sup> was applied for all the treatments.

**Preparation of Particle Suspensions and Zinc Ion Solution**

The nano particles were suspended directly in double distilled water (DDW) and dispersed by using magnetic stirrer for 30 min. Small magnetic beads were placed in the suspensions for stirring before use to avoid aggregation of the particles. Zinc ion (Zn<sup>2+</sup>) solution was prepared by dissolving zinc sulfate heptahydrate (ZnSO<sub>4</sub>.7H<sub>2</sub>O) in DDW.

The cultivar of maize BRMH-1 was sown at 60 cm × 30 cm spacing. All other agronomic practices were followed as per the UAS, Bengaluru recommended package of practices (Anon., 2016). Observations were made at 30, 60, 90 and at harvest in respect of growth parameters and the yield and yield parameters of maize were recorded at harvest. The experimental data were analyzed using ANOVA technique. The significance of the treatment effect was judged with the help of “F” table and tested at 5 per cent probability level.

## RESULTS AND DISCUSSION

**Effect of Nano Zinc Oxide Particles on Yield and Yield Attributes of Maize**

Significantly higher cob length, number of kernels per cob, test weight, kernel yield and stover yield was

TABLE I

Effect of nano zinc oxide particles on growth and growth attributes of maize

Treatments	Plant height(cm)	Number of leaves plant <sup>-1</sup>	Leaf area (cm <sup>2</sup> plant <sup>-1</sup> )	Total Dry weight (g plant <sup>-1</sup> )
T <sub>1</sub> : Seed priming with Nano ZnO @ 800 ppm for 30 minutes	254.9	9.4	2305	298.9
T <sub>2</sub> : T <sub>1</sub> +Foliar application of Nano ZnO @ 200 ppm	263.6	9.6	2465	328.9
T <sub>3</sub> : T <sub>1</sub> +Foliar application of Nano ZnO @ 300 ppm	268.4	9.8	2698	348.7
T <sub>4</sub> : T <sub>1</sub> +Foliar application of Nano ZnO @ 400 ppm	272.2	11.4	3192	365.5
T <sub>5</sub> : T <sub>1</sub> +Foliar application of Nano ZnO @ 500 ppm	286.5	12.2	3616	387.5
T <sub>6</sub> : T <sub>1</sub> +Foliar application of Nano ZnO @ 600 ppm	268.5	10.8	3133	358.2
T <sub>7</sub> : Foliar application of ZnSO <sub>4</sub> @ 0.5 %	254.7	8.6	2195	281.3
T <sub>8</sub> : Soil application of ZnSO <sub>4</sub> @ 10 kg ha <sup>-1</sup>	246.1	8.4	2022	262.0
S.E(m)±	8.00	0.64	168.4	11.68
C.D. at 5 %	24.28	1.97	511.0	35.46

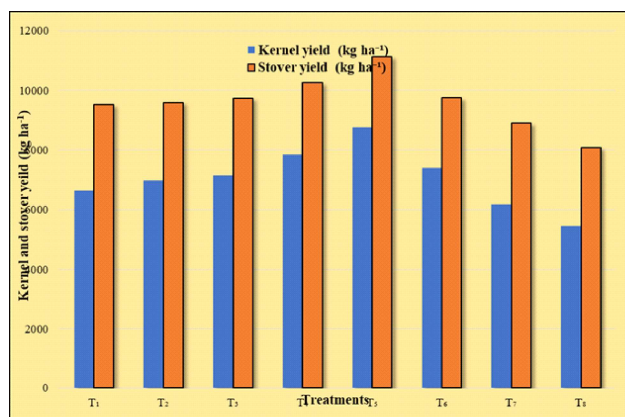


Fig.1: Effect of nano zinc oxide particles on kernel yield and stover yield of maize

recorded in seed treatment with 800 ppm of nano ZnO for 30 minutes followed by foliar application of nano ZnO at 500 ppm *i.e.*, T<sub>5</sub> (21.2 cm, 616.8, 30.80 g, 8750 kg ha<sup>-1</sup> and 11136 kg ha<sup>-1</sup> respectively), Seed treatment with 800 ppm of nano ZnO for 30 minutes followed by foliar application of nano ZnO at 400 ppm (20.7 cm, 604.0, 29.37 g, 7848 kg ha<sup>-1</sup>, and 10254 kg ha<sup>-1</sup>, respectively) was the next best treatment (Table 2). The improvement in yield and yield attributes might be due to improved growth factors like plant

height (286.5 cm), number of leaves (12.2), leaf area (3616 cm<sup>2</sup> plant<sup>-1</sup>) and dry matter production (387.5 g plant<sup>-1</sup>). This was mainly due to small size and large effective surface area of nano particles which could easily penetrate into the plant leading to better uptake of zinc. Zinc plays as an activator of enzymes in plants and is directly involved in the bio synthesis of auxin, which produces more cells and dry matter that in turn will be stored in seeds as sink. Thus, the increase in kernel yield is more expected, (Parmar Snehal Bhai, 2016). At higher concentration of ZnO nano particles, kernel yield decreased, these results were in accordance with reports on radish, rapeseed, ryegrass, corn and lettuce (Lin and Xing, 2007). Increase in stover yield in the present study can be attributed to significant increase in dry matter accumulation in plants which in turn mainly attributed to increase in growth factors like plant height.

**Effect of Nano Zinc Oxide Particles on Growth and Growth Attributes of Maize**

Significantly higher plant height, number of leaves per plant, leaf area per plant and dry matter production

TABLE 2  
Effect of nano Zinc oxide particles on yield and yield attributes of maize

Treatments	Cob length (cm)	Number of kernels cob <sup>-1</sup>	Test weight (g)	Kernel yield (kg ha <sup>-1</sup> )	Stover yield (kg ha <sup>-1</sup> )
T <sub>1</sub> : Seed priming with Nano ZnO @ 800 ppm for 30 minutes	19.1	519.4	28.93	6632	9520
T <sub>2</sub> : T <sub>1</sub> +Foliar application of Nano ZnO @ 200 ppm	19.5	549.4	29.07	6985	9592
T <sub>3</sub> : T <sub>1</sub> +Foliar application of Nano ZnO @ 300 ppm	19.9	570.6	29.30	7148	9739
T <sub>4</sub> : T <sub>1</sub> +Foliar application of Nano ZnO @ 400 ppm	20.7	604.0	29.37	7848	10254
T <sub>5</sub> : T <sub>1</sub> +Foliar application of Nano ZnO @ 500 ppm	21.2	616.8	30.80	8750	11136
T <sub>6</sub> : T <sub>1</sub> +Foliar application of Nano ZnO @ 600 ppm	20.1	594.1	29.33	7400	9742
T <sub>7</sub> : Foliar application of ZnSO <sub>4</sub> @ 0.5 %	18.5	498.9	27.93	6161	8896
T <sub>8</sub> : Soil application of ZnSO <sub>4</sub> @ 10 kg ha <sup>-1</sup>	18.3	466.9	26.63	5441	8076
S.E(m)±	0.57	16.65	0.70	266.21	313.60
C.D. at 5 %	1.74	50.53	2.14	807.54	951.29

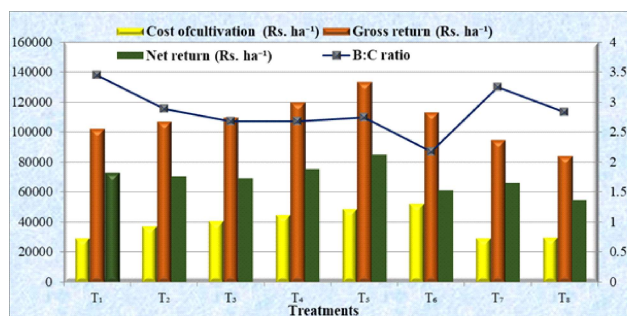


Fig. 2: Economics of nano zinc oxide particles in maize cultivation

per plant were observed in seed treatment with 800 ppm of nano ZnO for 30 minutes followed by foliar application of nano ZnO at 500 ppm (286.5 cm, 12.2, 3616 cm<sup>2</sup> plant<sup>-1</sup> and 387.5 g plant<sup>-1</sup>) respectively. Lower plant height, number of leaves per plant, leaf area per plant and dry matter production per plant were recorded in soil application of ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup> (246.1 cm, 8.4, 2022 cm<sup>2</sup> plant<sup>-1</sup> and 262.0 g plant<sup>-1</sup> respectively). This is due to adequate supply of zinc which accelerates the activity of enzyme and auxin metabolism in the plant, which in turn enlarges the cell and cell elongation resulting in taller plants (Nithya *et al.*, 2018). The dry matter production depends on photosynthetic capacity of the plant which in turn depends on the dry matter accumulation in leaves. The highest dry matter production was observed as a result of higher plant height, more number of leaves plant<sup>-1</sup> and increase in leaf area plant<sup>-1</sup>. These results are in accordance with the findings of Rani *et al.* (2009).

### Influence of Nano Zinc Oxide on Economics of Maize Production

The cost of cultivation differed due to different treatment combinations. It was observed that seed treatment with 800 ppm of nano ZnO for 30 minutes followed by foliar application of nano ZnO at 600 ppm recorded higher cost of cultivation (Rs.52344 ha<sup>-1</sup>) due to more quantity and more cost of nano ZnO. Lower cost of cultivation was incurred towards foliar application of ZnSO<sub>4</sub> @ 0.5 per cent (Rs.29265 ha<sup>-1</sup>).

Higher gross and net returns were found in seed treatment with 800 ppm of nano ZnO for 30 minutes and foliar application of nano ZnO at 500 ppm, *i.e.*, T<sub>5</sub> (Rs.133636 ha<sup>-1</sup> and Rs.84777 ha<sup>-1</sup> respectively) due to higher kernel yield. Lower gross and net returns were recorded in the treatment receiving soil application of ZnSO<sub>4</sub> @ 10 kg ha<sup>-1</sup> (Rs.84250 ha<sup>-1</sup> and Rs.54455 ha<sup>-1</sup> respectively) due to lower kernel yield obtained for this treatment.

The result showed that seed priming with 800 ppm of nano ZnO for 30 minutes recorded higher B:C ratio (3.45) due to higher kernel yield as well as comparatively low cost of cultivation. Lower B:C ratio was observed for Seed treatment with 800 ppm of nano ZnO for 30 minutes followed by foliar application of nano ZnO @ 600 ppm (2.17), because of higher cost of cultivation incurred for this treatment. Hence seed treatment with 800 ppm of nano ZnO for 30 minutes or this treatment followed by foliar

TABLE 3

Influence of nano zinc oxide on economics of maize production

Treatments	Cost of cultivation (Rs. ha <sup>-1</sup> )	Gross return (Rs. ha <sup>-1</sup> )	Net return (Rs. ha <sup>-1</sup> )	B:C ratio
T <sub>1</sub> : Seed priming with Nano ZnO @ 800 ppm for 30 minutes	29656	102368	72712	3.45
T <sub>2</sub> : T <sub>1</sub> + Foliar application of Nano ZnO @ 200 ppm	37219	107382	70163	2.89
T <sub>3</sub> : T <sub>1</sub> + Foliar application of Nano ZnO @ 300 ppm	41000	109811	68811	2.68
T <sub>4</sub> : T <sub>1</sub> + Foliar application of Nano ZnO @ 400 ppm	44781	120126	75345	2.68
T <sub>5</sub> : T <sub>1</sub> + Foliar application of Nano ZnO @ 500 ppm	48859	133636	84777	2.74
T <sub>6</sub> : T <sub>1</sub> + Foliar application of Nano ZnO @ 600 ppm	52344	113342	60998	2.17
T <sub>7</sub> : Foliar application of ZnSO <sub>4</sub> @ 0.5 %	29265	95150	65885	3.25
T <sub>8</sub> : Soil application of ZnSO <sub>4</sub> @ 10 kg ha <sup>-1</sup>	29795	84250	54455	2.83

application of nano ZnO at 500 ppm can be recommenced as cost effective methods for increasing the kernel yield of maize.

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## Oyster Mushrooms Spent Substrate in Arbuscular Mycorrhizal Inoculum Production

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### ABSTRACT

Mushrooms are the edible fruiting bodies of fungi, belonging to either phylum Basidiomycota or Ascomycota which is mainly cultivated for food. Spent mushroom substrate (SMS) is the substrate left after harvesting of mushrooms. The present study was undertaken to know the effect of oyster mushrooms spent substrate on Arbuscular mycorrhizae (AM) inoculum production. Two oyster mushroom species (*Pleurotus eous* and *Hypsizygus ulmarius*) were cultivated and among them *Hypsizygous ulmarius* showed significantly higher yield (577.94g) and bio-efficiency (113.73%). *Hypsizygous ulmarius* spent substrate shown higher nutrient content like N, P, K and narrow C: N ratio. Two oyster mushrooms (*Pleurotus eous* and *Hypsizygus ulmarius*) spent substrates were incorporated to pots with sterilized sand : soil (1:1) as substrate and another set with unsterilized sand : soil (1:1) as a substrate with AM fungi *Glomus mosseae* and *Glomus fasciculatum*. Sorghum was used as a host plant. Both the SMS were found to enhance plant growth and mycorrhizal associations like per cent root colonization and AM spores in the substrate. Among the two SMS, *Hypsizygus ulmarius* SMS significantly increased the plant height of sorghum, number of spores and per cent root colonization of *Glomus fasciculatum* compared to *Pleurotus eous* SMS. Increased mycorrhizal association characteristics were observed in sterilized substrate compared to in unsterilized substrate.

*Keywords:* Oyster mushroom, SMS, Mycorrhizal inoculum

OYSTER mushroom is consumed for its taste, medicinal and its nutritional properties and has been recommended to patients with cholesterol-related ailments. Oyster mushrooms are efficient lignin degraders and can be grown well on various types of lignocellulosic materials. Spent mushroom substrate (SMS) is the substrate left after harvesting of mushroom fruiting bodies. SMS is useful as soil amendment for improving the physical and chemical properties of the soil providing nutrients for the plants. It improves the structure of the soil, reduces surface crusting and compaction, increases microbial activity and provide nutrients and intern promotes faster crop growth establishment, improved crop density and yield.

The word Mycorrhiza is derived from the two Greek words, *Mycos* and *Rhiza* which means fungus and roots, respectively. Arbuscular mycorrhizae are the fungal symbionts of plants, associated with more than 80 per cent of terrestrial plants. Mycorrhizal fungi are also known as endophytes and necrotrophs. AM fungi are obligate biotrophic fungi forming symbiotic relationship with roots of many plants. They confer

benefits directly to the host plant's growth and yield through acquisition of P and other immobile micro and macro-nutrients like P, K, Ca, Cu and Zn and thus become a significant component in low input Agri system.

Broad use of AM fungi has been limited because none of the AM fungi have been cultivated *in vitro* and hence it is difficult to obtain large quantity of prime inoculum. AM fungi can be grown in presence of host plants. The growth and physiology of host plants have been postulated to influence the spore production of AM fungi.

With this background, the study was aimed to know the effect of oyster mushrooms spent substrate on Arbuscular mycorrhizal inoculum production.

### METHODOLOGY

The pure cultures of Oyster mushrooms (*Pleurotus eous* and *Hypsizygus ulmarius*) used were collected from Mushroom Laboratory, Department of Agricultural Microbiology, UAS, GKVK, Bengaluru.

**Spawn production and Cultivation of Oyster mushrooms:** Spawn for the cultivation of *Pleurotus eous* and *Hypsizyguis ulmarius* was prepared by following the standard procedure (Krishnamoorthy and Muthuswamy, 1997). Cultivation of Oyster mushrooms was carried out by following the method of Yang *et al.* (2013). After bud initiation, water was sprayed on the buds at regular intervals to avoid drying of the buds. Fruiting bodies of mushroom were harvested before the basidiospores were shed.

The number of days taken for bud initiation was recorded. The fresh weight of the mushrooms was recorded at different flushes and the total yield of mushrooms per bag was calculated. Bags were maintained up to three harvests for about 45 days. Bioefficiency of the mushrooms was calculated using the formula:

$$\text{Bio efficiency (\%)} = \frac{\text{Fresh weight of mushrooms (g)}}{\text{Dry weight of substrate (g)}} \times 100$$

**Preparation of mushrooms spent substrate:** The substrate gets degraded after the cultivation of mushroom. The degraded substrate was shade dried for 2 days. After shade drying, it was oven-dried at 45 °C for three days in a hot air oven until the constant weight was gained. Then, the substrate was powdered using a mixer grinder and sieved using 2mm mesh size sieve. The finely powdered substrate was stored in polythene covers for use in further experiments.

**Chemical analysis of oyster mushrooms spent substrates:** Chemical analysis of oyster mushrooms spent substrate was carried out. N, P and K analysis were carried out by following the standard procedure as described by Piper (1966). C:N ratio and organic carbon by the following standard methods as described by Mikhailova *et al.* (2003).

**Collection of arbuscular mycorrhizal inoculum:** Sand and soil-based cultures of arbuscular mycorrhizal inoculum of *Glomus mosseae* and *Glomus fasciculatum* were collected from Department of Agricultural Microbiology, University of Agricultural Sciences, GKVK, Bengaluru. The inoculum was mass

multiplied for larger quantity using sand and soil (1:1) as substrate and finger millet as host plant. Mass multiplied AM inoculum was observed for spore numbers/ g of substrate by following Wet-sieving and Decanting method (Gerdemann and Nicholson, 1963).

**Glass House evaluation:** Soil was collected from Zonal Agriculture Research Station, UAS, GKVK, Bengaluru. The soil was red sandy loam. Pot culture experiment was conducted to study the effect of mushroom (*Pleurotus eous* and *Hypsizyguis ulmarius*) spent substrates on the AM (*Glomus mosseae* and *Glomus fasciculatum*) inoculum production using sand : soil (1:1) as substrate and Sorghum (*Sorghum bicolor*) as a host plant. Sand and soil were sterilized in an autoclave at 121 °C under 15 psi pressure for 45 minutes. One kg of sterilized sand and 1 kg of sterilized soil were mixed and filled into the pots. Another set of pots were filled with unsterilized sand and soil in 1:1 ratio. Hundred gram of mushroom spent substrate and 100 g of mycorrhizal inoculum (1:1 ratio) were mixed with the following treatments and put in the pots. A layer of sand and soil mixture was put on the inoculum. Sorghum seeds were sown. Thirty ml of Hoagland's nutrient solution was added to each pot once in 15 days. The plants were maintained for about 45 days.

There were six treatments like, T<sub>1</sub>- *Glomus mosseae*: T<sub>2</sub>- *Glomus fasciculatum*: T<sub>3</sub>- *Pleurotus eous* SMS + *Glomus mosseae*: T<sub>4</sub>- *Pleurotus eous* SMS + *Glomus fasciculatum*: T<sub>5</sub>- *Hypsizyguis ulmarius* SMS + *Glomus mosseae*: T<sub>6</sub>- *Hypsizyguis ulmarius* SMS + *Glomus fasciculatum*

Data on Plant height (cm) / plant and Spore numbers (/g of substrate) were recorded. Per cent root colonization by AM fungi was assessed by the following method described by Philips and Hayman (1970). Root colonization was measured using the below formula:

$$\text{Root colonization (\%)} = \frac{\text{No. of roots infected}}{\text{Total No. of roots taken}} \times 100$$

The data obtained from the experiment were subjected to statistical analysis by using Completely Randomized

Design (CRD). Comparison between treatment means was made using Duncan's Multiple Range Test (DMRT) for drawing conclusions

#### RESULTS AND DISCUSSION

The number of days taken for first bud initiation and the number of buds / per bag was recorded. Earlier (14 days) bud initiation of oyster mushroom species *Pleurotus eous* was observed on paddy straw substrate followed by *Hypsizygyus ulmarius* (21 days). Number of buds per bag was observed higher in *Pleurotus eous* (32.50) followed by *Hypsizygyus ulmarius* (20.75). (Table 1). Higher total yield of mushrooms was recorded in *Hypsizygyus ulmarius* (577.94 g/bag) with higher bio-efficiency (113.73%) compared to *Pleurotus eous* yield (422.92 g/bag) and bio-efficiency (92.16%). The results of the present study agreed with Mohapatra and Behera (2013) who reported higher bioefficiency of *Hypsizygyus ulmarius* (102.83%) when compared to *Pleurotus eous* (84.41%) (Table 1).

TABLE 1

Days for bud initiation, number of buds, total yield and bioefficiency of oyster mushrooms grown on paddy straw

Oyster mushrooms	Number of days for bud initiation	Number of buds/bag	Total yield (g)	Bioefficiency (%)
<i>Pleurotus eous</i>	14 <sup>b</sup>	32.50 <sup>b</sup>	422.92 <sup>b</sup>	92.16 <sup>b</sup>
<i>Hypsizygyus ulmarius</i>	21 <sup>a</sup>	20.75 <sup>a</sup>	577.94 <sup>a</sup>	113.73 <sup>a</sup>

**Note:** Values are mean of 13 replications

Means superscribed by the same letter in a column do not vary significantly

The chemical properties such as nitrogen (2.17%), phosphorus (0.74%) and potassium (2.52%) were recorded higher in *Hypsizygyus ulmarius* spent substrate when compared to nitrogen (1.81%), phosphorus (0.63%) and potassium (2.14%) content of *Pleurotus eous* spent substrate. C:N ratio (20.65:1) and organic carbon (37.64%) were higher in *Pleurotus eous* spent substrate compared to C:N ratio (17.27:1) and organic carbon (33.47%) of *Hypsizygyus ulmarius* spent substrate (Table 2). These

results were in agree with Ahlawat *et al.* (2005) who reported that *Hypsizygyus ulmarius* SMS contains higher nutrient content when compared to *Pleurotus eous* and *Pleurotus florida* SMS. Spent mushroom substrate contains narrow C:N ratio and higher amount of nutrients.

TABLE 2

Chemical properties of oyster mushrooms spent substrate

SMS	N content (%)	C: N ratio	P content (%)	K content (%)	Organic carbon (%)
<i>Pleurotus eous</i>	1.81 <sup>b</sup>	20.65: 1 <sup>b</sup>	0.63 <sup>b</sup>	2.14 <sup>b</sup>	37.64 <sup>b</sup>
<i>Hypsizygyus ulmarius</i>	2.17 <sup>a</sup>	17.27: 1 <sup>a</sup>	0.74 <sup>a</sup>	2.52 <sup>a</sup>	33.47 <sup>a</sup>

*Note:* Values are mean of 13 replications

Means superscribed by the same letter in a column do not vary significantly

At 30 DAS in sterilized substrate, significantly increased plant height (28.00 cm) was recorded in T<sub>6</sub> (*Hypsizygyus ulmarius* SMS + *Glomus fasciculatum*) followed by in T<sub>5</sub> (*Hypsizygyus ulmarius* SMS + *Glomus mosseae*) (25.25 cm). Minimum plant height was observed in T<sub>1</sub> (*Glomus mosseae*) (21.75 cm). At 45 DAS, significantly increased plant height (43.50 cm) was recorded in T<sub>6</sub> (*Hypsizygyus ulmarius* SMS + *Glomus fasciculatum*) followed by in T<sub>5</sub> (*Hypsizygyus ulmarius* SMS + *Glomus mosseae*) (39.00 cm). Minimum plant height was observed in T<sub>1</sub> (*Glomus mosseae*) (34.75 cm) (Table 3).

At 30 DAS un sterilized, significantly increased plant height (35.33 cm) was recorded in T<sub>6</sub> (*Hypsizygyus ulmarius* SMS + *Glomus fasciculatum*) followed by in T<sub>5</sub> (*Hypsizygyus ulmarius* SMS + *Glomus mosseae*) (32.33 cm). Minimum plant height was observed in T<sub>1</sub> (*Glomus mosseae*) (25.66 cm). At 45 DAS, significantly maximum plant height (48.33 cm) was recorded in T<sub>6</sub> (*Hypsizygyus ulmarius* SMS + *Glomus fasciculatum*) followed by in T<sub>5</sub> (*Hypsizygyus ulmarius* SMS + *Glomus mosseae*) (46.67 cm). Minimum plant height was observed in T<sub>1</sub> (*Glomus mosseae*) (38.00 cm) (Table 3).

The findings of this study are similar to that of Gbolagade *et al.* (2013) findings in which they reported

TABLE 3

Effect of oyster mushrooms spent substrate and AM fungi on plant height of sorghum in sterilized and unsterilized substrate

Treatments	Plant height (cm) in sterilized substrate		Plant height (cm) in unsterilized substrate	
	30 DAS	45 DAS	30 DAS	45 DAS
T <sub>1</sub> - <i>Glomus mosseae</i>	21.75 <sup>d</sup>	34.75 <sup>d</sup>	25.66 <sup>d</sup>	38.00 <sup>d</sup>
T <sub>2</sub> - <i>Glomus fasciculatum</i>	21.50 <sup>cd</sup>	33.75 <sup>cd</sup>	25.67 <sup>d</sup>	39.33 <sup>d</sup>
T <sub>3</sub> - <i>Pleurotus eous</i> SMS + <i>Glomus mossae</i>	20.00 <sup>c</sup>	39.00 <sup>bc</sup>	27.67 <sup>cd</sup>	44.00 <sup>c</sup>
T <sub>4</sub> - <i>Pleurotus eous</i> SMS + <i>Glomus fasciculatum</i>	18.50 <sup>c</sup>	37.00 <sup>b</sup>	28.33 <sup>c</sup>	45.00 <sup>c</sup>
T <sub>5</sub> - <i>Hypsizygus ulmarius</i> SMS + <i>Glomus mossae</i>	25.25 <sup>b</sup>	39.00 <sup>b</sup>	32.33 <sup>b</sup>	46.67 <sup>b</sup>
T <sub>6</sub> - <i>Hypsizygus ulmarius</i> SMS + <i>Glomus fasciculatum</i>	28.00 <sup>a</sup>	43.50 <sup>a</sup>	35.33 <sup>a</sup>	48.33 <sup>a</sup>

**Note:** Values are mean of 4 replications  
Means superscribed by the same letter in a column do not vary significantly DAS – Days after sowing

significantly higher plant height of *Abelmoschus esculentum* L. in AM fungi (*Glomus mosseae*) + SMC (*Pleurotus pulmonarius*) treatment than AM fungi alone.

In sterilized substrate, significantly higher per cent root colonization (85.25 %) was recorded in T<sub>6</sub> (*Hypsizygus ulmarius* SMS + *Glomus fasciculatum*) followed by T<sub>5</sub> (*Hypsizygus ulmarius* SMS + *Glomus mosseae*) (80.50%). Lowest per cent root colonization (61.00%) was recorded in T<sub>1</sub> (*Glomus mosseae*) (Table 4). In unsterilized substrate, significantly higher Per cent root colonization (67.50%) was recorded in T<sub>6</sub> (*Hypsizygus ulmarius* SMS + *Glomus fasciculatum*) followed by in T<sub>5</sub> (*Hypsizygus ulmarius* SMS + *Glomus mosseae*) (62.00 %). Lowest Per cent root colonization (46.25 %) was observed in T<sub>1</sub> (*Glomus mosseae*) (Table 4). The

results of the study are similar to that of Tallapragada *et al.* (2011) in which they observed that addition of *Pleurotus florida* SMS increased root colonization of *Glomus intraradices* compared to *Glomus intraradices* alone.

In sterilized substrate, significantly more number of spores (43.75/g) were recorded in T<sub>6</sub> (*Hypsizygus ulmarius* SMS + *Glomus fasciculatum*) followed by in T<sub>5</sub> (*Hypsizygus ulmarius* SMS + *Glomus*

TABLE 4

Effect of oyster mushrooms spent substrate on per cent root colonization by AM fungi in sorghum roots in sterilized and unsterilized substrate

Treatments	Root colonization (%) in sterilized substrate	Root colonization (%) in unsterilized substrate
T <sub>1</sub> - <i>Glomus mosseae</i>	61.00 <sup>c</sup>	46.25 <sup>c</sup>
T <sub>2</sub> - <i>Glomus fasciculatum</i>	62.75 <sup>c</sup>	48.50 <sup>bc</sup>
T <sub>3</sub> - <i>Pleurotus eous</i> SMS + <i>Glomus mossae</i>	74.25 <sup>cd</sup>	55.25 <sup>bc</sup>
T <sub>4</sub> - <i>Pleurotus eous</i> SMS + <i>Glomus fasciculatum</i>	78.00 <sup>bc</sup>	58.50 <sup>b</sup>
T <sub>5</sub> - <i>Hypsizygus ulmarius</i> SMS + <i>Glomus mossae</i>	80.50 <sup>b</sup>	62.00 <sup>b</sup>
T <sub>6</sub> - <i>Hypsizygus ulmarius</i> SMS + <i>Glomus fasciculatum</i>	85.25 <sup>a</sup>	67.50 <sup>a</sup>

**Note:** Values are mean of 4 replications  
Means superscribed by the same letter in a column do not vary significantly  
DAS – Days after sowing

*mosseae*) (39.50/g). Lowest numbers of spores (28.00/g) were recorded in T<sub>1</sub> (*Glomus mosseae*) (Table 5). In unsterilized substrate, significantly higher number of spores (34.75/g) were recorded in T<sub>6</sub> (*Hypsizygus ulmarius* SMS + *Glomus fasciculatum*) followed by in T<sub>5</sub> (*Hypsizygus ulmarius* SMS + *Glomus mosseae*) (30.00/g). Lowest number of spores (22.00/g) was recorded in T<sub>1</sub> (*Glomus mosseae*)

TABLE 5

Effect of oyster mushrooms spent substrate on spore numbers of AM fungi in sterilized and unsterilized substrate

Treatments	Spore numbers / g of sterilized substrate	Spore numbers / g of unsterilized substrate
T <sub>1</sub> - <i>Glomus mosseae</i>	28.00 <sup>e</sup>	22.00 <sup>d</sup>
T <sub>2</sub> - <i>Glomus fasciculatum</i>	29.25 <sup>e</sup>	23.25 <sup>d</sup>
T <sub>3</sub> - <i>Pleurotus eous</i> SMS + <i>Glomus mossae</i>	33.75 <sup>d</sup>	26.75 <sup>c</sup>
T <sub>4</sub> - <i>Pleurotus eous</i> SMS + <i>Glomus fasciculatum</i>	36.00 <sup>c</sup>	28.50 <sup>bc</sup>
T <sub>5</sub> - <i>Hypsizygus ulmarius</i> SMS + <i>Glomus mossae</i>	39.50 <sup>b</sup>	30.00 <sup>b</sup>
T <sub>6</sub> - <i>Hypsizygus ulmarius</i> SMS + <i>Glomus fasciculatum</i>	43.75 <sup>a</sup>	34.75 <sup>a</sup>

Note: Values are mean of 4 replications

Means superscribed by the same letter in a column do not vary significantly

DAS – Days after sowing

(Table 5). The results of the study are similar to that of Tallapragada *et al.* (2011) in which they observed that addition of *Pleurotus florida* SMS increased spore numbers of *Glomus intraradices* compared to *Glomus intraradices* alone.

From the above experiments, it could be concluded that, both the oyster mushrooms spent substrates enhances the mycorrhizal symbiosis characteristics like spore numbers and per cent root colonization. Among two SMS, *Hypsizygus ulmarius* SMS increases the mycorrhizal symbiosis characteristics of *Glomus fasciculatum* compared to *Pleurotus eous* SMS. Sterilized substrate enhances the mycorrhizal symbiosis characteristics compared to unsterilized substrate.

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## Attitude of Consumers Towards Yelahanka Raithara Santhe

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### ABSTRACT

The farmer's markets called as 'Raithara Santhe' in Bangalore has achieved success through an efficient marketing system of direct sale of fresh vegetables and fruits from producers (farmers) to the consumers. At these markets, buying directly from the farmer means lower prices and choice of large variety of produce, as well as access to primary producers. Farmers markets also make it easier for people interested in home processing to purchase large quantities of produce at affordable prices. In this backdrop, the present study was undertaken during 2017-18 to examine the consumer preference for buying fruits and vegetables at Raithara santhe and to analyze the attitude of consumers towards Yelahanka Raithara santhe. Ninety consumers were selected randomly based on their availability during the investigation. Data was collected by using a pre tested interview schedule. The results revealed that, majority of consumers preferred to buy fruits and vegetables at Raithara santhe due to: (1) availability of fresh, good quality and specific variety of fruits and vegetables, (2) Raithara santhe is at convenient distance from home, (3) fruits and vegetables are available at reasonable price throughout the year, (4) absence of middlemen, and (5) courteous behavior of the sellers. It was found that 40.00 per cent of the consumers were having more favourable attitude towards Raithara santhe, whereas 36.66 and 23.34 per cent of the consumers were having favourable and less favourable attitude towards Raithara santhe, respectively. Age, gender, education, marital status, family size, occupation, annual income, rural-urban background and mass media participation had no significant association with the attitude of consumers towards Raithara santhe. Around 29 per cent of the variation in the attitude level of consumers was explained by all the ten personal and socio-economic characteristics selected for the study.

*Keywords:* Attitude, Consumers and Raithara santhe

AGRICULTURAL markets create place utility, time utility, form utility and a link between the agricultural producers and consumers. An efficient agricultural marketing system can be defined as a situation where all the agricultural commodities produced are consumed with minimum wastage, least marketing cost, farmer gets maximum share in consumer rupee and the consumer gets better quality of products at reasonable price. As a direct marketing channel, Raithara santhe (Apna mandi / Farmers market) facilitates growers to sell products to consumers without the assistance of middlemen. This one-step marketing outlets attract local growers because they can obtain better profit margins, making farming a viable economic activity. Raithara santhe is providing producers a unique opportunity to stay in business and preserve open space in Bengaluru. The major objectives of establishing Raithara santhe is to:

(1) establish farmers markets without intermediaries, (2) provide a platform for direct interface between farmers and consumers, (3) provide facilities for easy and adequate flow of fruits and vegetables to farmers market, (4) provide infrastructure facilities for the growers of fruits and vegetables to sell their produce directly to consumers, (5) ensure reasonable price to the farmers of fruits and vegetables, (6) ensure availability of fresh and quality fruits and vegetables at a competitive price to the consumers, (7) curb malpractice to protect the interest of both producers and consumers, (8) maintain price stability in the related markets and (9) avoid seasonal fluctuations in the prices of vegetable and fruits (Srikanth, 2016).

Consumers flock to Raithara santhe for two main reasons: (1) the wide selection of affordable, fresh produce, and specialty fruits, vegetables and other food

items and (2) the opportunity to gather with friends. At Raithara santhe, buying directly from the farmer means lower prices and choice of large variety of produce, as well as access to primary producers. Consumers can clarify from farmers to questions about their growing methods and other related matters. Raithara santhe also make it easier for people interested in home processing to purchase large quantities of produce at affordable prices. Selling the fruits and vegetables directly to consumers at the Raithara santhe allows farmers (producers) to sell produce in a way that they receive more income and have better consumer contact which would not be possible through other channels.

The first Raithara santhe in Karnataka was established by the Government of Karnataka during March 2002 at Yelahanka, a suburb of Bangalore city, and the other two farmer's market in Karnataka were established in Hubli and Chitradurga. The Karnataka State Agricultural Marketing Board has embarked on programme of establishing 'Raithara santhe' in other prominent towns of the state. It is reported that, Raithara santhe in Bangalore has achieved success through an efficient marketing system of direct sale of fresh fruits and vegetables. Against this background, the present study was carried out with the following specific objectives ;

1. To study the personal and socio-economic characteristics of consumers of Raithara santhe
2. To examine the consumer preference for purchasing the fruits and vegetables at Raithara santhe
3. To analyse the attitude of consumers towards Raithara santhe
4. To find out the association and extent of contribution of personal and socio-economic characteristics of consumers on their attitude towards Raithara santhe

#### METHODOLOGY

The present investigation was undertaken during 2018-19 in Raithara santhe located at Yelahanka in Bangalore urban district. Ninety consumers were selected randomly based on their availability during

the investigation and required information was collected from the respondents using a pre-tested interview schedule. The research design adopted for this study was ex-post-facto technique.

The consumers preference for buying fruits and vegetables at Raitha Santhe was recorded on 11 aspects *viz.*, availability of fresh fruits and vegetables, availability of specific variety of fruits and vegetables, good quality of fruits and vegetables, reasonable/competitive price, convenient/less distance from home, discount on bulk purchase, bargain, availability of organically grown fruits and vegetables, availability of fruits and vegetables throughout the year, absence of middlemen and courteous behaviour of sellers.

Attitude is the degree of positive or negative effect associated with some psychological object (Thurstone, 1945). In the present research, the attitude towards consumers is operationalised as the degree of positive or negative feelings of consumers towards Yelahanka Raithara santhe. The attitude scale developed by Ahmed and Dey (2012) was used to analyze the attitude of consumers towards Raithara santhe. The attitude scale consisted of 11 statements on a three response continuum *viz.*, agree, undecided, disagree with a score of 3, 2 and 1, respectively. The summed score for all the 11 statements obtained was considered as attitude score of individual consumer. The maximum score an individual could get was 33 and the minimum score was 11. Based on the mean (27.28) and half standard deviation (3.48), the consumers were grouped in three attitude categories namely, less favourable, favourable and more favourable.

Attitude category	Score
Less favourable	<23.80
Favourable	23.80 to 30.76
More favourable	>30.76

Information on the nine personal and socio-economic characteristics (age, gender, education, marital status, family size, occupation, annual income, rural urban background and mass media participation) of consumers were collected using suitable procedure / scales. The collected data was scored, tabulated and

analyzed using frequency, mean, standard deviation, chi square test and multiple regression analysis.

RESULTS AND DISCUSSION

**Personal and Socio - Economic Characteristics of the Consumers**

The personal and socio - economic characteristics of consumers who visited Raithara santhe for purchasing fruits and vegetables are presented in Table 1. The results in Table 1 reveals that 44.45 per cent of the consumers are of old age (>50 years), while 38.89 and 16.66 per cent of the consumers are of middle age (35-50 years) and young age (<35 years), respectively.

A greater majority of the consumers (80.00%) who visited Raithara santhe were male and the other 20.00

TABLE 1  
Personal and socio - economic characteristics of the consumers (n=90)

Particulars	Consumers	
	No.	%
Age (in years)		
Young (< 35)	15	16.66
Middle (35 – 50)	35	38.89
Old (> 50)	40	44.45
Gender		
Female	18	20.00
Male	72	80.00
Education		
Primary school	6	6.66
Middle school	3	3.33
High school	12	13.34
Pre- university	15	16.67
Diploma	6	6.66
Graduation	36	40.00
Post- graduation	12	13.34
Marital status		
Single	21	23.34
Married	69	76.66

Particulars	Consumers	
	No.	%
Family size		
Small (less than 4)	60	66.66
Medium (4-6)	15	16.67
Large (more than 6)	15	16.67
Occupation		
Students	9	10.00
Government employee	3	3.33
Private sector employee	27	30.00
Homemaker	21	23.33
Business	15	16.67
Any others (auto driver, cook)	15	16.67
Annual income (Rs.)		
<50,000	20	22.23
50,000 to 1,00,000	24	26.66
1,00,000 to 1,50,000	30	33.33
>1,50,000	16	17.78
Rural –urban background		
Rural	18	20.00
Peri-urban	15	16.66
Urban	57	63.34
Mass media participation		
Low	25	27.78
Medium	27	30.00
High	38	42.22

per cent of the consumers were female. The education level of consumers were analysed and it was found that a greater proportion of them were graduates (40.00%), 16.67 per cent had completed PUC and an equal percentage of consumers (13.34% each) had completed post-graduation and high school education. Similarly, an equal percentage of consumers (6.66% each) had completed diploma and primary school education, whereas a meager percentage of consumers (3.33%) had completed middle school education (Table 1).

Table 1 also indicates that, a little over three-fourth of the consumers (76.66%) were married and the

remaining 23.34 per cent of the consumers were unmarried. Two-third of the consumers (66.66%) had small family, while an equal percentage of the consumers (16.67% each) had medium size and large family. The occupation pattern of the consumers revealed that among 90 consumers, 30.00 per cent of consumers were working in private sectors, followed by homemakers (23.33%), business (16.67%), others (cooks, autorickshaw driver etc.) (16.67%) and students (10.00%). While, 3.33 per cent of the consumers who visited Raithara santhe were Government employees (Table 1).

The data in Table 1 also reveals that one-third of the consumers (33.33%) were belonging to the annual income category of Rs.1,00,000-1,50,000/- whereas 26.66, 22.23 and 17.78 per cent of the consumers had an annual income of Rs.50,000-1,00,000/- less than Rs.50,000/- and more than Rs.1,50,000/- respectively. A majority of consumers who visited Raithara santhe were from urban areas (63.34%), while 20.00 and 16.66 per cent of them were from rural and peri-urban areas, respectively. As high as 42.22 per cent of the consumers were having high level of mass media participation, while 30.00 and 27.78 per cent of the consumers had medium and low level of mass media participation, respectively.

### Consumer Preference for Buying Fruits and Vegetables at Raithara Santhe

A perusal of Table 2 reveals that all the consumers (100.00%) preferred Raithara santhe to purchase fruits and vegetable because of availability of fresh fruits and vegetables, whereas 93.33 per cent of the consumers preferred Raithara santhe due to availability of good quality of fruits and vegetables. An equal percentage of consumers (90.00% each) had preferred Raitha santhe due to availability of specific variety and fruits and vegetables are available at reasonable/competitive price. A vast majority of the consumers (86.67%) visited Raithara santhe due to availability of fruits and vegetables throughout the year. An equal percentage of consumers (80.00% each) preferred to buy fruits and vegetables at Raithara santhe due to convenient / less distance from home and absence of middlemen. A little over three-fourth of consumers (76.66%) preferred to buy fruits and vegetables at Raithara santhe because of courteous behaviour of the sellers. Less than half of the consumers prefer to buy fruits and vegetables at Raithara santhe due to discount of bulk purchase (36.66%), could bargain (36.66%) and availability of organically grown fruits and vegetables (13.33%). More or less similar findings

TABLE 2  
Consumer preference for buying fruits and vegetables at Raithara santhe (n=90)

Particulars	Consumers			
	Yes		No	
	No.	%	No.	%
Availability of fresh fruits and vegetables	90	100.00	0	0.00
Availability of specific variety of fruits and vegetables	81	90.00	9	10.00
Good quality of fruits and vegetables	84	93.33	6	6.67
Reasonable /competitive price	81	90.00	9	10.00
Convenient/less distance from home	72	80.00	18	20.00
Discount on bulk purchase	33	36.66	57	63.34
Can bargain	33	36.66	57	63.34
Availability of organically grown fruits and vegetables	12	13.33	78	86.67
Availability of fruits and vegetables throughout the year	78	86.67	12	13.33
Absence of middlemen	72	80.00	18	20.00
Courteous behaviour of sellers	69	76.66	21	23.34

were reported by Choudary (2015), Verma (2015), Srikanth (2016), and Yazhini (2016).

### Statement-Wise Attitude of Consumers towards Raithara Santhe

The results in Table 3 reveals that a vast majority of the consumers agreed for the statements: Raithara santhe is a boon to consumers (93.34%), the timings of Raithara santhe is convenient for the consumers (93.34%), Raithara santhe offers value for money (90.00%), fruits and vegetables sold in Raithara santhe are fresh, tasty and are safer (83.34%), one can find good choice of fruits and vegetables in Raithara santhe (76.66%), one can find large stock of fruits and vegetables in Raithara santhe (63.33%), and fruits and vegetables from the surrounding areas are available in Raithara santhe (56.67%). While, exactly half of the consumers (50.00% each) agreed to the statements: display of fruits and vegetables are systematic and easy to find a particular fruit and vegetable and the presence of producer is a guarantee of the quality of fruits and vegetables. Whereas, less than half of the consumers agreed for the statements

: one can find cleanliness throughout the business hours in the Raithara santhe (46.67%) and Raithara santhe allows farmers to receive fair remuneration (43.33%).

It can be referred that most of the consumers have responded 'agreed' to the attitude statements highlighting the advantages of Raithara santhe, hence the findings denotes that the consumers have favourable attitude towards Raithara santhe.

### Overall Attitude of Consumers towards Raithara Santhe

The results in Table 4 reveals that, 40.00 per cent of the consumers were having more favourable attitude towards Raithara santhe, whereas 36.66 and 23.34 per cent of the consumers were having favourable and less favourable attitude towards Raithara santhe, respectively.

It can be concluded that more than three-fourth of the consumers (76.66%) had favourable to more favourable attitude towards Raithara santhe. Long working hours, proximity to home, wide range of availability of fruits and vegetables, quality and

TABLE 3  
Statement-wise attitude of consumers towards Raithara santhe (n=90)

Statement	Agree		Undecided		Disagree	
	No.	%	No.	%	No.	%
Raithara santhe is a boon to consumers	84	93.34	3	3.33	3	3.33
Raithara santhe offers value for money	81	90.00	6	6.67	3	3.33
One can find cleanliness throughout the business hours in the Raithara santhe	42	46.67	18	20.00	30	33.33
Display of fruits and vegetables are systematic and easy to find a particular fruit and vegetable	45	50.00	9	10.00	36	40.00
One can find good choice of fruits and vegetables in Raithara santhe	69	76.66	15	16.67	6	6.67
One can find large stock of fruits and vegetables in Raithara santhe	57	63.33	27	30.00	6	6.67
The timings of Raithara santhe is convenient for the consumers	84	93.34	3	3.33	3	3.33
Fruits and vegetables sold in Raithara santhe are fresh, tasty and are safer	75	83.34	12	13.33	3	3.33
Raithara santhe allows farmers to receive fair remuneration	39	43.33	42	46.67	9	10.00
The presence of producer is a guarantee of the quality of fruits and vegetables	45	50.00	30	33.33	15	16.67
Fruits and vegetables from the surrounding areas are available in Raithara santhe	51	56.67	27	30.00	12	13.33

TABLE 4

Overall attitude of consumers towards  
Raithara santhe (n=90)

Particulars	Consumers	
	Yes	No
Less favourable (<23.80 score)	21	23.34
Favourable (23.80 to 30.76 score)	33	36.66
More favourable (>30.76 score)	36	40.00
<b>Total</b>	<b>90</b>	<b>100.00</b>

Mean = 27.28; Standard deviation = 6.96

freshness of huge stock of fruits and vegetables, and reasonable price of fruits and vegetables are the major reason for more than three-fourth (76.66%) of the consumers for having favourable to more favourable attitude towards Raithara santhe. Similar findings were reported by Rehman and Selvaraj (2013).

#### Association and Extent of Contribution of Personal and Socio-Economic Characteristics on the Attitude towards Raithara Santhe

The association between ten personal and socio-economic characteristics of consumers with their attitude towards Raithara santhe are presented in Table 5. It could be observed from the Table 5 that the personal and socio-economic characters *viz.*, age, gender, education, marital status, family size, occupation, annual income, rural - urban background and mass media participation had no significant association with the attitude of consumers towards Raithara santhe. The results reveals that there is no bearing on consumers in developing favorable attitude towards Raithara santhe, irrespective of the difference in age, gender, education, marital status, family size, occupation, annual income, rural - urban background and mass media participation. More or less similar findings were observed by Brown (2002).

The results in Table 5 also reveals that 28.39 per cent of the variation in the attitude level of consumers was explained by all the ten personal and socio-economic characteristics *viz.*, age, gender, education, marital status, family size, occupation, annual income, rural - urban background and mass media participation) included in the study as evident by R<sup>2</sup> value of 0.2839.

TABLE 5

Association and extent of contribution of personal and socio-economic characteristics of consumers on their attitude towards Raithara santhe (n=90)

Characteristics	Chi square values	Regression coefficient	Standard error of Regression coefficient	't' value
Age	1.567 <sup>NS</sup>	0.30	0.28	0.93 <sup>NS</sup>
Gender	2.012 <sup>NS</sup>	0.21	0.21	0.99 <sup>NS</sup>
Education	5.611 <sup>NS</sup>	0.89	0.42	0.51 <sup>NS</sup>
Family size	6.013 <sup>NS</sup>	0.18	0.26	1.42 <sup>NS</sup>
Occupation	1.621 <sup>NS</sup>	0.62	0.52	0.83 <sup>NS</sup>
Marital status	2.612 <sup>NS</sup>	0.41	0.38	0.92 <sup>NS</sup>
Annual income	4.619 <sup>NS</sup>	0.42	0.20	0.47 <sup>NS</sup>
Rural urban background	3.111 <sup>NS</sup>	0.31	0.26	0.83 <sup>NS</sup>
Mass media participation	2.622 <sup>NS</sup>	0.61	0.50	0.81 <sup>NS</sup>

NS: Non-significant; R<sup>2</sup>=0.2839

It was found from the research results that more number of consumers who visited Raithara santhe were of old age (44.45%), male (80.00%), married (76.66%) completed graduation (40.00%), had small family (66.66%) and were urbanities (63.34%). A greater proportion of the consumers who visited Raithara santhe were working in private sectors (30.00%), having an annual income of Rs.1,00,00 to 1,50,000 (33.33%) and high level of mass media participation (42.22%). It is also evident from the findings that more than three-fourth of the consumers (76.66%) had favourable to more favourable attitude towards Raithara santhe since due to: (1) the availability of fresh, good quality and specific variety of fruits and vegetables, (2) Raithara santhe is at convenient distance from home, (3) fruits and vegetables are available at reasonable price throughout the year, (4) absence of middlemen, and (5) courteous behavior of the sellers.

The results also revealed that a vast majority of the consumers were having medium to high level of mass media participation (72.22%), hence the government should give wider publicity through mass media

(television, radio, newspaper etc.) so that more and more number of consumers visit the Raithara santhe for purchasing fresh and quality fruits and vegetables at reasonable price directly from the producers throughout the year.

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## Attitude of Ragi Growers towards Agricultural Technology Management Agency

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### ABSTRACT

The present study was carried out during 2018-19 in Chikkaballapura and Kolar districts of Karnataka state to analyse the attitude of ragi growers towards Agricultural Technology Management Agency. Ninety ragi growers (who had availed benefits under ATMA) from Shidlaghatta taluk of Chickaballapura district (45 Nos.) and Kolar taluk of Kolar district (45 Nos.) were randomly selected for the present study. Ex-post-facto research design was followed for the research study. The results revealed that a majority of beneficiary ragi growers (71.10%) were having favourable to more favourable attitude towards ATMA. Education, achievement motivation, management orientation, innovativeness, cosmopolitanism, mass media exposure training on ATMA, extension agency contact and extension participation of beneficiary ragi growers had significant to highly significant association with their attitude towards ATMA.

*Keywords:* ATMA, Ragi growers, Attitude, Mass media and Extension participation

AGRICULTURAL Technology Management Agency (ATMA) is a centrally sponsored scheme launched under National Agricultural Technology Project implemented to provide support to State Extension Reforms by the Indian Council of Agricultural Research during 1998-99. ATMA was implemented on a pilot basis in four districts of each of the states of Andhra Pradesh, Bihar, Himachal Pradesh, Jharkhand, Maharashtra, Orissa and Punjab. ATMA was launched under the guidance of National Institute of Agriculture Extension Management (MANAGE), Hyderabad. The evaluation report of Indian Institute of Management, Lucknow revealed that ATMA's extension approaches have been proving to be promising in execution of the reforms and thus ATMA was extended to other states of the country.

ATMA programme was launched in Karnataka during 2005-06 in districts namely, Bidar, Gulabarga, Koppala, Bijapura, Hassan, Shivamogga, Chamarajanagara and Kolar (undivided). During the year 2006-07, ATMA programme was spread to Belgaum, Chitradurga, Chickamagalur and Kodagu districts. After 2007-08, the remaining districts have been included under ATMA in the state.

ATMA is a registered society consisting of stake holders (farmers, line / development departments,

non-government organizations, input dealers, mass media, agri-business companies, farmers organizations, etc.) engaged in agriculture and allied activities for bringing the sustainable agricultural development in the district. It provides flexible working environment and establishes effective co-ordination of all the stake holders at the district level. Having linkages with all line departments, ATMA is aided as a key point for integrating research and extension activities and decentralizing day to day management of Public Agricultural Technological System (Shamshadunnisa *et al.*, 2018). The specific features of ATMA include: (1) demand driven farmer-based activities, (2) public private partnership for extension services, (3) development of village level institutions like farmers associations, farmers interest groups or commodity interest groups, (4) creation of rural infrastructure and marketing, (5) decentralized decision-making and bottom up approach, (6) integrated farming system approach, (7) market led extension, (8) formation and strengthening of farmer's interest group, and (9) in-service training to increase competence extension personnel.

The success of any programme depends upon the attitude of farmers / beneficiaries regarding various aspects / components of the programme. The analysis

of attitude of farmers / beneficiaries towards programme will help us to trace and upgrade the manipulable variables (personal, socio-economic and communication characteristics) for developing favorable attitude of ragi growers towards ATMA. Against this background, the present study has been taken up with the following specific objectives:

1. To know the personal, socio - economic, psychological and communication characteristics of beneficiary ragi growers
2. To analyze the attitude of beneficiary ragi growers towards ATMA
3. To find out the association between personal, socio-economic, psychological and communication characteristics of beneficiary ragi growers with their attitude level towards ATMA

#### METHODOLOGY

The study was conducted during 2018-19 in Chikkaballapura and Kolar districts of Karnataka state. Un-divided Kolar (Kolar and Chikkaballapura) district was one of the eight districts in Karnataka, where ATMA was first implemented in the state during 2005-06. Hence, Kolar and Chikkaballapura districts were selected for the study. Ragi is the main staple crop cultivated in all the six taluks of Chikkaballapura district and five taluks of Kolar district, hence ragi crop was selected for the study. The major area under ragi was in Shidlaghatta taluk (11,122 ha) in Chikkaballapura district and Kolar taluk (13,112 ha) of Kolar district during 2017-18. Hence, Shidlaghatta taluk from Chikkaballapura district and Kolar taluk from Kolar district was purposively selected for the study.

Ninety ragi growers (who had availed benefits under ATMA) from Shidlaghatta taluk of Chikkaballapura district (45 Nos.) and Kolar taluk of Kolar district (45 Nos.) were randomly selected for the present study. Ex-post-facto research design was followed for the research study. Data was collected personally using a pre-tested interview schedule.

#### Attitude of Farmers towards ATMA (Dependent Variable)

Attitude of ragi growers towards ATMA in the present study is operationalized as the degree of positive or negative feelings of ragi growers towards ATMA. The respondent's attitude was measured using the scale developed by Patel *et al.* (2017). The scale consisted of 12 statements rated on a five-point continuum, namely 'Strongly Agree', 'Agree', 'Undecided', 'Disagree', and 'Strongly Disagree' with assigned scores of five, four, three, two and one, for each statement. Ragi growers were asked to choose their response for each statement on a five-point continuum. The minimum and maximum possible score one could get was 12 and 60, respectively. On the basis of the total attitude score obtained for the 12 statements, the respondents were grouped into three categories namely, less favourable, favourable and more favourable considering mean (38.08) and half standard deviation (3.23).

Category	Criteria	Score
Less favourable	< (Mean - ½ SD)	Below 34.84
Favourable	(Mean ± ½SD)	34.84 to 41.82
More favourable	> (Mean + ½ SD)	Above 41.82

Fourteen personal, socio-economic, psychological and communication characteristics of ragi growers (Age, education, family size, land holding, farming experience, achievement motivation, management orientation, innovativeness, cosmopolitaness, mass media exposure, training on ATMA, extension agency contact and extension participation) were considered as independent variables for the research study. They were measured using a standardized procedure/suitable scales. The collected data were score, tabulated and analyzed using frequency, percentage, standard deviation, chi square test and multiple regression analysis.

## RESULTS AND DISCUSSION

**1. Personal, Socio-Economic, Psychological and Communication Characteristics of Beneficiary Ragi Growers**

The data in Table 1 presents the findings of the personal, socio-economic, psychological and communication characteristics of beneficiary ragi growers.

Table 1 reveals that as high as 45.56 per cent of the beneficiary ragi growers were belonging to middle age group, while one-third (33.33%) of the beneficiary ragi growers were belonging to old age group and the remaining 21.11 per cent of the beneficiary ragi growers were belonging to young age group. It is also observed from the Table 1 that 17.81, 16.66, 15.55, 14.44, 10.00 and 7.77 of beneficiary ragi growers had studied up to higher secondary, high school, middle school, primary school, graduation and diploma, respectively. Whereas, ten per cent of the beneficiary ragi growers were able to read and write and 7.77 per cent of them were illiterate.

The data in Table 1 reveals that a larger number of beneficiary ragi growers (45.56 %) had small family, while 31.11 and 23.33 per cent of the beneficiary ragi growers had medium and large family, respectively. Table 1 also shows that more number of beneficiary ragi growers were belonging to low income group (37.77 %), while 34.44 and 17.79 per cent of beneficiary ragi growers were belonging to high and medium income groups, respectively.

A larger number of the respondents interviewed were marginal farmers (47.78%), whereas 32.22 and 20.00 per cent of the respondents interviewed were small and big farmers, respectively (Table 1). The table also reveals that a greater number of beneficiary ragi growers (43.33%) had medium level of farm experience followed by 34.45 per cent of beneficiary ragi growers were having more farming experience and 22.22 per cent of beneficiary ragi growers were having less farming experience.

More number of beneficiary ragi growers (43.33%) were having medium level of achievement motivation, whereas 28.90 and 27.77 per cent of the beneficiary ragi growers were having high and low level of achievement motivation, respectively (Table 1). The table also shows that 43.33 per cent of the beneficiary ragi growers had medium level of management orientation, while one third (33.33%) and 23.34 per cent of the beneficiary ragi growers had high and low level of management orientation, respectively.

A greater number of beneficiary ragi growers (40.01%) were belonging to medium innovativeness category, while 31.11 and 28.88 per cent of the beneficiary ragi growers were belonging to high and low innovativeness category, respectively (Table 1). It is also observed from the table that more number of beneficiary ragi growers (43.34%) were having high level of cosmopolitaness, whereas a little over one third (34.44%) and 22.22 per cent of the beneficiary ragi growers were having low and medium level of cosmopolitaness, respectively.

Table 1 reveals that as high as 42.22 per cent of the beneficiary ragi growers were falling under medium level of mass media exposure, while 32.22 and 25.56 per cent of the beneficiary ragi growers were falling under low and high level of mass media exposure, respectively. The data in Table 1 also shows that a majority of the beneficiary ragi growers (70.00%) had undergone training on ATMA and the remaining 30.00 per cent of the beneficiary ragi growers had not undergone training on ATMA.

A greater number of beneficiary ragi growers (41.11%) were having high level of extension agency contact, while 30.01 and 28.88 per cent of the beneficiary ragi growers were having medium and low level of extension agency contact, respectively (Table 1). The findings in Table 1 also reveals that two-fifth (40.00%) of the beneficiary ragi growers had medium level of extension participation, whereas 31.12 and 28.88 per cent of the beneficiary ragi growers had high and low level of extension participation, respectively.

It is observed from the results in Table 1 that a larger number of beneficiary ragi growers were of middle

TABLE 1  
Personal, socio-economic, psychological and communication characteristics of beneficiary ragi growers  
(n=90)

Characteristics	Category	Ragi growers	
		Number	Per cent
Age	Young (< 35 years)	19	21.11
	Middle (35 to 50 years)	41	45.56
	Old (> 50 years)	30	33.33
Education	Illiterate	7	7.77
	Can read and write	9	10.00
	Primary school	13	14.44
	Middle school	14	15.55
	High school	15	16.66
	Higher secondary	16	17.81
	Diploma	7	7.77
	Graduation	9	10.00
Family size	Small	41	45.56
	Medium	28	31.11
	Large	21	23.33
Annual income	Low (< Rs.23798)	34	37.77
	Medium (Rs.23798 to Rs.34598)	31	34.44
	High (> Rs.34598)	25	17.79
Land holding	Marginal farmers	43	47.78
	Small farmers	29	32.22
	Big farmers	18	20.00
Farming experience	Less	20	22.22
	Medium	39	43.33
	More	31	34.45
Achievement motivation	Low	25	27.77
	Medium	39	43.33
	High	26	28.90
Management orientation	Low	21	23.34
	Medium	39	43.33
	High	30	33.33
Innovativeness	Low	26	28.88
	Medium	36	40.01
	High	28	31.11
Cosmopolitaness	Low	31	34.44
	Medium	20	22.22
	High	39	43.34
Mass media exposure	Low	29	32.22
	Medium	38	42.22
	High	23	25.56
Training on ATMA	Not undergone training	27	30.00
	Undergone training	63	70.00
Extension agency contact	Low	26	28.88
	Medium	27	30.01
	High	37	41.11
Extension participation	Low	26	28.88
	Medium	36	40.00
	High	28	31.12

age (45.56%), marginal farmers (47.78%), studied up to high secondary (17.81%), having small size family (45.56%) with medium level of farming experience (43.33%), achievement motivation (43.33%), management orientation (43.33%), innovativeness (40.01), mass media exposure (42.22%), extension agency contact (41.11%) and extension participation (40.00%). A majority of beneficiary ragi growers had undergone training on ATMA (70.00%) and were belonging to medium annual income group (34.44%) and high level of cosmopolitaness (43.34%). More or less similar findings were observed by Singh *et al.* (2016), Kailash *et al.* (2017) and Subhash (2018).

## 2. Statement-Wise Attitude of Beneficiary Ragi Growers towards ATMA

It is observed from Table 2 that among the 12 attitude statements, the statement 'ATMA enables farmers to increase knowledge regarding improved scientific technology' obtained an attitude score of 401 and was accorded the first rank, followed by the statement

'ATMA is an effective in increasing agricultural production' received a score of 400 and was ranked second. The statement 'ATMA has made extension system farmers driven and farmer accountable' obtained an attitude score of 378 and was ranked third by the beneficiary ragi growers. 'ATMA provide need based advisory service to the farmers' was ranked fourth with an attitude score of 371. The statement 'ATMA promotes group extension approach by promoting the formation of Farmers Organisations (FOs) / Farmers Interest Groups (FIGs)' received an attitude score of 369 and was ranked fifth. 'Farm scientists, extension functionaries and farmers work together to plan and implement ATMA activities in the village' obtained an attitude score of 360 and was ranked sixth.

The statement 'ATMA is a boon to farmers' obtained an attitude score of 351 and was ranked seventh, while the statement 'ATMA extends benefit to all the

TABLE 2  
Statement-wise attitude of beneficiary ragi growers towards ATMA (n=90)

Attitude statements	Beneficiary ragi growers	
	Attitude score	Rank
ATMA is a boon to farmers	351	VII
ATMA enables farmers to increase knowledge regarding improved scientific technology	401	I
ATMA is an effective in increasing agricultural production	400	II
ATMA extends benefit to all the categories of farmers	340	VIII
ATMA helps in getting agricultural inputs/technologies from both public and private sectors	301	IX
ATMA helps the farmers in procurement of improved seeds, fertilizers and pesticides on time	250	X
Farm scientists, extension functionaries and farmers work together to plan and implement ATMA activities in the village	360	VI
ATMA increases the capacity building of farmers	241	XI
ATMA helps in developing the confidence of farmers in agriculture	221	XII
ATMA provide need based advisory service to the farmers	371	IV
ATMA promotes group extension approach by promoting the formation of Farmers Organisations (FOs) /Farmers Interest Groups (FIGs)	369	V
ATMA has made extension system farmers driven and farmer accountable	378	III

categories of farmers' received an attitude score of 340 and was ranked eighth. The statement 'ATMA helps in getting agricultural inputs / technologies from both public and private sectors' obtained an attitude score of 301 and was ranked ninth.

The remaining three statements, namely, 'ATMA helps the farmers in procurement of improved seeds, fertilizers and pesticides on time', 'ATMA increases the capacity building of farmers' and 'ATMA helps in developing the confidence of farmers in agriculture' were ranked tenth, eleventh and twelfth with attitude scores of 250, 241 and 221, respectively.

The findings clearly indicate that the beneficiary ragi growers have favourable attitude towards ATMA. It evidently proves that the ATMA extends benefits to all categories of farmers, farmers are involved in planning and implementation of ATMA activities in the villages, helps in getting the agricultural inputs of both public and private agencies, provide need based advisory services, enables farmers to increase knowledge regarding improved scientific technology and is effective in increasing agricultural production.

### 3. Overall Attitude of Beneficiary Ragi Growers towards ATMA

The data in Table 3 shows that more number of beneficiary ragi growers (36.68%) had more favourable attitude towards ATMA, followed by 34.42 per cent of the beneficiary ragi growers were having favourable attitude towards ATMA and the remaining

TABLE 3

Overall attitude of beneficiary ragi growers towards ATMA

	Beneficiary ragi growers (n=90)	
	Number	Per cent
Less favourable (< 34.84 score)	26	28.90
Favourable (34.84 to 41.82 score)	31	34.42
More favourable (> 41.82 score)	33	36.68
Total	90	100.00

Mean= 38.08; Standard deviation= 6.47

28.90 per cent of the beneficiary ragi growers were having less favourable attitude towards ATMA. It could be concluded that a majority of beneficiary ragi growers (71.10%) were having favourable to more favourable attitude towards ATMA. The beneficiary ragi growers are receiving Rs.4000 worth of agricultural inputs (seeds, *Trichoderma*, phosphorous solubilising bacteria (PSB) for seed treatment, bio fertilizer and micro nutrients (zinc sulphate and need based oil), enriched compost and pesticides) and the also reasons quoted under item 2 also holds-good here also for a greater majority (71.10%) of beneficiary ragi growers having favourable to more favourable attitude towards ATMA. The findings of the study in line with the findings reported by Nisha (2014) and Shamshadunnisa *et al.* (2018).

### 4. Association between Personal, Socio-Economic, Psychological and Communication Characteristics of Beneficiary Ragi Growers with their Attitude towards ATMA

The data in Table 4 shows the association between personal, socio-economic, psychological and communication characteristics of beneficiary ragi growers with their attitude towards ATMA. A perusal of Table 4 reveals that age, family size, annual income, land holding and farming experience of beneficiary ragi growers had no association with their attitude towards ATMA. Education, achievement motivation, management orientation, innovativeness, cosmo politeness and mass media exposure of beneficiary ragi growers had significant association with their attitude towards ATMA at five per cent level. Variables, such as training on ATMA, extension agency contact and extension participation of beneficiary ragi growers had highly significant association with their attitude towards ATMA. Similar findings was reported by Subhash (2018). The explanation for the independent variables having significant to highly significant association with the attitude towards ATMA is given in the ensuing paragraphs.

Education widens the vision and minds of people, besides orienting them to the outside world. Educated farmers might have contacted the agricultural extension workers to obtain the information on ATMA

TABLE 4

Association between personal, socio-economic, psychological and communication characteristics of beneficiary ragi growers with their attitude towards ATMA

(n=90)

Characteristics	Degrees of freedom	Chi-square value
Age	4	1.69 <sup>NS</sup>
Education	4	10.16 *
Family size	4	2.60 <sup>NS</sup>
Annual income	4	3.11 <sup>NS</sup>
Land holding	4	0.99 <sup>NS</sup>
Farming experience	4	5.78 <sup>NS</sup>
Achievement motivation	4	11.67 *
Management orientation	4	10.01 *
Innovativeness	4	12.61 *
Cosmopolitaness	4	9.99 *
Mass media exposure	4	12.66 *
Training on ATMA	4	15.11 **
Extension agency contact	4	13.67 **
Extension participation	4	14.11 **

NS = Non-significant, \* = Significant at 5% level, \*\* = Significant at 1% level

(importance, operative mechanism and the benefits to farmers) and have developed favourable attitude towards ATMA. Achievement is the value associated with an individual that drives them to excel in farming and thereby attain a sense of personal accomplishment. In order to achieve this distinction, the farmers would have availed the benefits of ATMA in the form of getting subsidy for agricultural inputs and technical guidance. Management orientation offers a chance for better management of resources resulting in greater efforts toward excellence in farming. The urge to perform better than others will act as an instrument to acquire and adopt managerial components relating to agriculture. ATMA provide need based advisory service to the farmers and increases the capacity building of farmers thereby helping the beneficiary in managing their farm enterprise. The interest and desire of the farmers to adopt new farm technologies predisposes them to seek more information from

agricultural extension functionaries and participation in extension activities organized for popularizing ATMA.

A cosmopolitan farmer always looks for more information on improved agricultural technologies and various schemes implemented by the Development departments. Hence, these farmers will more frequently visit the offices of the Department developments located at towns to derive more benefits from State and Centrally sponsored agricultural programmes. As a consequence, there exists a highly significant association between the cosmopolitaness of beneficiary ragi growers and their attitude towards ATMA. Exposure to mass media like radio, television, newspaper, magazines etc., has helped the beneficiary ragi growers in knowing the various schemes and benefits under ATMA. The farmers feel that the ATMA enables them to increase their knowledge on improved cultivation aspect and is an effective means to increase agricultural production. Training provides an opportunity to the beneficiaries about the various schemes / benefits available to farmers and gain knowledge on the improved agricultural technologies. Frequent contacts with the agricultural extension functionaries have helped the farmers in knowing about the benefits available to farmers under ATMA. The farmers believe that ATMA would help in increasing the crop productivity and income. Frequent and active participation of beneficiaries in extension activities organized under ATMA might act as strong motivational factor for possessing favourable attitude towards ATMA.

Frequent contact with extension personnel and regular participation of beneficiary ragi growers in the agricultural extension activities [meetings, demonstrations, field days, farm school, krishimela / fairs, district level exhibitions, kisan gosties (farmers-scientist's interaction), agricultural campaign etc.] will help the farmers in familiarizing the activities and deriving full benefits of ATMA. Further, mass media has significantly influenced the beneficiary ragi growers in developing favourable attitude towards ATMA, therefore the Agricultural Department should publish/telecast/broadcast on the various benefits available for farmers under ATMA through mass

media (radio, newspaper, television, internet etc.) helping the farmers to utilize the benefits of ATMA, which leads to developing favourable attitude towards ATMA.

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## Economics of Production and Marketing of Crossandra in Chickballapur District, Karnataka

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### ABSTRACT

The study was conducted to assess the production and marketing of crossandra in Chickballapur district. The primary data were collected from 60 farmers and 20 market intermediaries. The study revealed that the cost of cultivation per acre was Rs.1,94,377.92. The average yield per acre was 16.50 quintal which accrued a gross return of Rs.3,46,500.00 per acre and net return per acre was Rs.1,52,122.08. The return per rupee investment was Rs.1.78. About 75.00 per cent of the farmers sold through channel-I (Producer - Commission agent cum wholesaler - Retailer - Consumer) and about 25.00 per cent in channel-II (Producer - Commission agent - Wholesaler - Retailer - Consumer). Price spread was higher in channel-II (Rs.11,000.00 per quintal) compared to channel-I (Rs.8000.00 per quintal). It is due to more number of intermediaries in channel-II.

*Keywords:* Crossandra, Cost of cultivation, Marketing channels and Price spread

FLORICULTURE is an essential agribusiness gaining commercial importance in the vital scenario of Indian agriculture. India which is a tropical country has several advantages in floriculture. The floriculture includes producing and marketing of flowers, potted plants, garden plants, ornamental foliage plants, cut flowers and greens. The horticulture industry has undergone a significant transformation in the last decade as a booming commercial activity.

Crossandra (*Crossandra undulaefolia* Salisb.) Syn. *C. infundibuliformis* (L). Nees., a local of India which belongs to the family Acanthaceae. Crossandra is one among the significant traditional flower crop which is grown commercially in the country and well recognized in South India. The flowers, however not fragrant are very popular due to its attractive bright colour and light weight.

Crossandra is a very important traditional flower crop of South India. In India, it is cultivated commercially in southern states of Karnataka, Tamil Nadu and Andhra Pradesh. As it is produced commercially, the area and production of crossandra is gaining importance in the country and more so in Karnataka state. In Karnataka, crossandra stands 4<sup>th</sup> in position

with regard to the area and production of 2,401 hectare and produce 16,214 metric tonnes (Anon., 2017). In South India, these flower crop is mainly produced in Madurai, Coimbatore, Chennai, Chittoor, Hyderabad, Bellary, Chitradurga, Haveri, Chickballapur, Tumakuru, Ramanagara and Kolar. Many high tech floriculture plants have been introduced in the country in the recent years. Similarly, number of farmers coming forward to cultivate the flower crop have also increased. It is, therefore worth while to know the status of the cultivation of this flower crop in Karnataka, where it is produced as a predominant flower crop so that proper production strategy could be developed to cultivate this crop on scientific lines knowing the problems in producing and marketing of this flower crop. The objectives of the study were:

1. To estimate the cost and returns structure of crossandra
2. To examine the price spread in different marketing channels

### METHODOLOGY

Chickballapur consists of six taluks, of which one crossandra flower growing taluk was selected purposively viz., Gauribidnur. As the Gauribidnur taluk

stands 1<sup>st</sup> in area and production of crossandra flower cultivation among Chickballapur district. The primary data was collected from 60 crossandra growing farmers and 20 market intermediaries. The information collected from the respondents include area under crossandra, cost of cultivation, input use, marketing channels involved, marketing cost incurred *etc.*, were acquired from the sample respondents and market intermediaries *via* personal interview using pre-tested schedule prepared for the purpose. To achieve the objectives of the study, by the nature and extent of information, appropriate quantification techniques were used and computed with the aid of averages, frequency and percentage to obtain meaning full results.

## RESULTS AND DISCUSSION

### 1. Cost of Cultivation

The average quantity of different inputs used and their values per acre of sample respondents are presented in Table 1.

It was observed that the cost of cultivation of crossandra per acre was Rs.1,94,377.92 out of this, 96.60 per cent was variable cost. The major variable cost was of human labour *i.e.*, Rs.1,07,275.34 (55.19%) followed by seedling cost (Rs.17,632.38), farm yard manure (Rs.16,015.13), interest on working capital (Rs.13,099.67), irrigation cost (Rs.12,223.90), machine labour (Rs.8711.04), fertilizer (Rs.6845.69), bullock labour (Rs.3591.53), marketing cost (Rs.1705.22) and plant protection chemicals (Rs.662.03), respectively.

Hence the results clearly indicate that the share of variable cost to the total cost was high. This may be attributed to use of more labour by the respondent growers. Pushpa (2007) in her study on cost and returns structure for the production of crossandra in Guntur represented that crossandra was labour intensive crop and incurred significantly high cost on human labour.

The other major components of variable cost is the seedling cost and farm yard manure. This was because only less number of nurseries were involved in seedlings / plantings of crossandra and also it was due

TABLE 1  
Cost of cultivation of crossandra  
(n=60) (Rs. / acre)

Costs	Value	Percentage of total
<b>Value cost</b>		
FYM (Rs.)	16,015.13	8.24
Seedling (Rs.)	17,632.38	9.07
Fertilizer (Rs.)	6845.69	3.52
PPC (Rs.)	662.03	0.34
Human labour (Rs.)	1,07,275.34	55.19
Bullock labour	3591.53	1.85
Machine labour	8711.04	4.48
Marketing cost	1705.22	0.88
Irrigation cost	12,223.90	6.29
Total working capital	1,74,662.26	89.86
Interest on working capital @ 7.5 %	13,099.67	6.74
<b>Total variable cost</b>	<b>1,87,761.93</b>	<b>96.60</b>
<b>Fixed Cost</b>		
Depreciation	504.00	0.26
land revenue	38.00	0.02
Rental value of land	5500.00	2.83
Total FC	6042.00	3.11
Interest on fixed capital @ 9.5%	573.99	0.30
<b>Total fixed cost</b>	<b>6615.99</b>	<b>3.40</b>
<b>Total cost of cultivation</b>	<b>1,94,377.92</b>	<b>100.00</b>

to the long distance from point of production to the point of market as crossandra is a perennial crop.

The average fixed cost per acre was Rs.6615.99 which accounted for 3.40 per cent of total cost of cultivation. The major items of fixed cost incurred by the farmers were, rental value of land accounting for Rs.5500 per acre which formed (2.83%) it is due to the value of land in use. The depreciation charges of pump sets and other implements accounted for Rs.504 (0.26%) and land revenue Rs.38 per acre (0.02%), managerial cost was taken at 9.50 per cent

of the working capital *i.e.*, Rs.573.99 per acre (0.30%) based on the interest charged by the banks in the study area. The study clearly reveals that the total fixed cost of crossandra was very marginal.

## 2. Yield and Returns

The average yield, gross and net returns per acre of crossandra among the sample farmers are represented in Table 2. The table indicated that the average yield of crossandra was 16.50 quintals per acre. The average price realized by farmer respondents was Rs.21,000 per quintal of crossandra flowers. The gross returns on crossandra production was Rs.3,46,500.00.

TABLE 2  
Yield and returns from crossandra cultivation  
(n=60)

Particulars	Values
Yield (Qtl)	16.50
Price (Rs/Qtl)	21,000.00
Gross return (Rs./acre)	3,46,500.00
Total cost (Rs.)	1,94,377.92
Net return (Rs.)	1,52,122.08
Benefit cost ratio	1.78

Total cost (which include TVC+TFC) was Rs.1,94,377.92 per acre. Hence, the net returns was Rs.1,52,122.08, due to high yield and better management practices adopted by the crossandra growers.

The analysis of cost and returns indicates that the net return per rupee of expenditure in crossandra production was Rs.1.78. As the ratio is above unity, the cost of cultivation could be considered as a profitable venture. Chandra (2012) analyzed the overall cost on investment in floriculture in Chittoor district of Andhra Pradesh. The results showed that the establishment cost of crossandra gardens was Rs.29,561.60 per hectare, respectively. The per hectare total cost of above mentioned flower crops was Rs.3,17,381.20 for the entire flowering period respectively. The total net income received for crossandra was Rs.1,38,378.80 per hectare,

respectively. The results of project evaluation techniques revealed that, the input - output ratio for crossandra was 1.77.

## 3. Cost and Price Spread in Marketing of Crossandra

Farmers in the study region choose different channels for marketing. The channels chosen by the farmers vary from season to season. In the study area two marketing channels were identified and marketing cost, price spread was computed to understand the marketing of crossandra. The sample respondents marketed crossandra through the following channels:

- a) Channel I: Producer - Commission agent cum Wholesaler - Retailer - Consumer
- b) Channel II: Producer - Commission agent - Wholesaler - Retailer - Consumer

In the channel-I commission agent cum wholesalers receives the produce from the producer and sell the product to retailer. The commission agent cum wholesalers will transport the commodity to distance market and sell to the retailers. About 45 farmers (75.00%) sold their produce through this channel as shown in Table 3. In channel-II, commission agent's buys produce from the producer and sell the produce to wholesalers. The wholesalers in turn sell to the retailers who ultimately sell it to the consumers. About 25.00 per cent sold their produce through this channel as shown in Table 3. Harish (2010) in his study on

TABLE 3  
Major channels for crossandra marketing  
(n=60)

Channels	No. of Intermediaries involved	No. of farmers	Percentage of total
I	Producer - Commission agent cum Wholesaler - Retailer - Consumer	45	75
II	Producer - Commission agent - Wholesaler - Retailer - Consumer	15	25
Total		60	100

marketing behavior of crossandra growers found that majority of the crossandra growers (91.66%) sell their produce directly to the wholesalers, followed by local market (21.67%), village merchant (10.83%) and commission agent (2.50%).

#### 4. Marketing Costs Incurred by Producers in Channel-I

The details of marketing costs incurred by the crossandra producer-sellers and intermediaries in channel-I are presented in Table 4. The table reveals that the total marketing cost incurred by producer-seller in the marketing of crossandra was Rs.1705.22 (69.08%). In the total cost of marketing, commission charges alone accounted for Rs.1330.40, followed by transportation cost (Rs.329.62), personal expenses (Rs.30.04) and packaging material (Rs.14.76) as indicated in channel-I.

The major component of marketing cost is commission charge *i.e.*, the producers paid 10 per cent of the total value of the produce as commission charge which is exorbitant and is a burden on producers. The flowers are mainly transported by two wheelers. The distance of the market also increase the transportation cost. Therefore, the share of transportation cost on per acre basis work out to be higher. Further, exploitation by commission agent cum wholesalers by way of market practices have also caused lower price realization by the crossandra growers.

#### 5. Marketing Costs Incurred by Market Intermediaries in Channel - I

The total marketing cost incurred by commission agent cum wholesaler in channel-I was Rs.400.00 (16.21%) per quintal (Table 4). Transportation cost accounts for 6.08 per cent followed by loading and unloading (3.24%), labour charges (3.11%), personal expenses (2.70%), license fee (0.44%), market charges (0.30%), shop rent (0.27%), spoilage (0.08%), respectively. In channel-I, commission agent also acts as wholesaler, so he incur less cost compare to wholesaler and commission agent. Here commission agent cum wholesaler incurred cost of six per cent on the value

TABLE 4  
Marketing costs incurred by producer and market intermediaries in channel-I (n=80)

Particulars	Rs./Qtl	Percentage
<i>Producer</i>		
Packaging material	14.76	0.60
Transportation	329.62	13.35
Commission charge	1330.40	53.90
Personal expenses	30.44	1.23
Sub total	1705.22	69.08
<i>Commission Agent cum Wholesaler</i>		
Shop rent	6.58	0.27
License fee	10.96	0.44
Labour salary	76.71	3.11
Market charges	7.30	0.30
Spoilage	2.00	0.08
Personal expenses	66.66	2.70
Loading and unloading	80.00	3.24
Transportation	150.00	6.08
Sub total	400.00	16.21
<i>Retailer</i>		
Shop rent	15.00	0.61
License fee	10.00	0.41
Labour salary	53.00	2.15
Transportation	95.00	3.85
Spoilage	10.00	0.41
Personal expenses	180.00	7.29
Sub total	363.00	14.71
Total Marketing cost	2468.00	100.00

of transportation which is major component followed by personal expenses.

The marketing cost incurred by the retailer in channel-I was Rs.363.00 (14.71%) per quintal (Table 4). Among various components personal expenses constituted (7.29%) followed by transportation cost (3.85%), labour salary (2.15%), shop rent (0.61%), license fee and spoilage shares 0.41 per cent each. The table revealed that personal expenses at retail level in more compared to other intermediaries in channel-I

## 6. Marketing Cost Incurred by Producer In Channel - II

The details of marketing costs incurred by the crossandra producer-sellers and intermediaries in channel-I are presented in Table 5.

TABLE 5

Marketing costs incurred by producer and market intermediaries in channel-II (n=80)

Particulars	Rs./Qtl	Percentage of total
<i>Producer</i>		
Packaging material	14.76	0.54
Transportation	329.62	12.16
Commission charge	1330.40	49.10
Personal expenses	30.44	1.12
Sub total	1705.22	62.93
<i>Commission Agent</i>		
Shop rent	6.58	0.24
License fee	10.96	0.40
Labour salary	30.00	1.11
Personal expenses	75.00	2.77
Sub total	123.00	4.52
<i>Wholesaler</i>		
Shop rent	14.00	0.50
License fee	10.96	0.40
Labour salary	85.00	3.14
Transportation	180.00	6.64
Loading and unloading	8.00	0.30
Market charges	8.50	0.31
Spoilage	20.00	0.74
Personal expenses	120.00	4.43
Sub total	446.00	16.46
<i>Retailer</i>		
Shop rent	20.00	0.74
License fee	10.00	0.37
Labour salary	60.00	2.21
Transportation	100.00	3.69
Spoilage	16.00	0.59
Personal expenses	230.00	8.49
Sub total	436.00	16.09
Total Marketing cost	2710.00	100.00

The table reveals that the total marketing cost incurred by producer-seller in the marketing of crossandra was 62.93 per cent (Rs.1705.22). In the total cost of marketing, commission charges alone accounted for 49.10 per cent, followed by transportation cost (12.16%), personal expenses (1.12%) and packaging material (0.54%) as indicated in channel-II.

The producers paid 10 per cent of the total value of the produce as commission charge which is exorbitant and major component of marketing cost. The transportation cost of the produce is high due to the distance of market which increase the share of transportation cost on per acre basis workout to be higher.

## 7. Marketing Costs Incurred by Market Intermediaries in Channel-II

The total marketing cost incurred by commission agent in channel-II was Rs.123.00 (4.52%) per quintal (Table 5). Personal expenses accounts for 2.77 per cent followed by labour salary (1.11%), license fee (0.40%), shop rent (0.24%). The commission agent doesn't handle the produce so he neither incur loss or profit but gets commission charge for the service in which he spent major on his personal expenses and followed by the charges to pay for the labour.

The marketing cost incurred by wholesaler in channel-II was Rs.446.00 (16.46%) per quintal (Table 5). Among various components transportation cost constituted (6.64%), followed by personal expenses (4.43%), labour salary (3.14%), spoilage (0.74%), shop rent (0.50%), license fee (0.40%), market charges (0.31%), loading and unloading (0.30%), respectively. Wholesaler transport the produce from local market to distant retailer hence incur more transportation cost and personal expenses. While transportation incur loss during handling the produce, should also pay charges on transaction amount for labours.

The total marketing cost incurred by the retailer in channel-II was Rs.436.00 per quintal (16.09%) (Table 5). Personal expenses constituted as major component (8.49%) followed by transportation cost (3.69%), labour charges (2.21%), shop rent (0.74%), spoilage (0.59%), license fee (0.37%), respectively.

The personal expenses are more as the standard of living is increasing followed by high transportation cost for the retailer.

### 8. Price Spread in Crossandra Marketing under different Channels

The price spread is one of the measures of marketing efficiency. It indicates the extent of increase in the price of a commodity as it changes hand from one intermediary to another in the marketing channel. The price spread comprises of marketing cost incurred by

different intermediaries and their profit margin. As flowers are perishable in nature so the price spread will be higher, as a result of which consumer has to pay a higher price, while the producer doesn't receive a higher share in consumer's rupee. Here price spread was studied to know the share of marketing costs and margins of marketing of crossandra.

The price spread in crossandra marketing under different channels is presented in Table 6. The price spread is major indicator of market efficiency and performance. It revealed that the producer's share in consumer rupee was found to be more in channel-I (72.41%) in contrast with channel-II (65.63%). Correspondingly the net price received by the producer per quintal of crossandra was Rs.19,294.78 in both channel-I and channel-II. The price spread was considerably high in channel-II (Rs.11,000.00 per quintal) in contrast to channel-I (Rs.8000.00 per quintal). In the channel-I margin of retailer was less (Rs.3137.00 per quintal), whereas commission agent cum wholesaler's margin was high *i.e.*, Rs.4100 per quintal. Similarly, in channel-II, the, margin of commission agent was Rs.1207.4 per quintal, for retailer it was Rs.4564 per quintal and wholesaler's margin was more *i.e.*, Rs.5554 per quintal, respectively.

In both channels all intermediaries keep large margin in selling produce to next, so the producer's share in consumer's rupee differs based on number of intermediates involved in each. The crossandra growers using channel-I realized higher share in consumer rupee and lower price spread is recorded compared to channel-II. This is because of marketing channel with fewer number of market intermediaries in channel-I. Hence, channel-I is considered to be better marketing channel as compared to channel-II. Holajogi (2014) examined the production and marketing of major flower crops in Haveri district. The results revealed that the producer's share in consumer rupee in Channel-I and Channel-II was 70.98 per cent and 75.81 per cent, respectively.

TABLE 6

Price spread in crossandra under different marketing channels  
(Rs. per Quintal)

Particulars	Chanel-I	Chanel-II
<i>Producer</i>		
Gross Price received	21,000.00	21,000.00
Marketing cost	1705.22	1705.22
Net price	19,294.78	19,294.78
<i>Commission agent</i>		
Commission charge	-	1330.40
Marketing cost	-	123.00
Profit margin	-	1207.40
Sale price	-	21,000.00
<i>Wholesaler</i>		
Purchase price	-	21,000.00
Marketing cost	-	446.00
Profit margin	-	5554.00
Sale price	-	27,000.00
<i>CA cum wholesaler</i>		
Purchase price	21,000.00	-
Marketing cost	400.00	-
Profit margin	4100.00	-
Sale price	25,500.00	-
<i>Retailer</i>		
Purchase price	25,500.00	27,000.00
Marketing cost	363.00	436.00
Profit margin	3137.00	4564.00
Sale price	29,000.00	32,000.00
Price spread	8000.00	11,000.00
Producer's share in	72.41	65.63

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## Performance of Tomato Marketing in Kolar Mandi of Karnataka

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### ABSTRACT

Despite over 60 years of history, the problems of agricultural marketing are either persisting since independence or mutated into newer forms, while newer problems have crept in. Majority of farmers still subscribe to the APMC as their most accessible channel to sell their produce. The present study was undertaken in Kolar APMC market of Karnataka and used primary and secondary data of the production year 2015-16. The present study empirically prove that tomato arrival in market is under reported, which could give false signals to policy makers and thus lead to over production, market inefficiency and welfare loss to farmers, market and state as well. Recording detailed data by quality or grade would make it more useful and relevant. The causes and repercussions of under reporting and some of the functional aspects of market are discussed. Prioritization of market development activities, use of qualified manpower, automation, etc. are some of the issues to be addressed. There is a need to study the repercussions of simultaneous auction, rate of market fee, modalities of financing by market intermediaries to create win-win situation for all stakeholders.

*Keywords:* Tomato production, Market arrivals, Under reporting, Market fee and Market functioning

SEVERAL studies have analyzed the performance of regulated agricultural marketing system and reforms. While many studies analyzed agricultural marketing scenario at a macro level (Chand, 2012; Chand, 2016; Purohit, 2016 and Dey, 2016) others analyzed the efficiency in the marketing system. Various studies focused field level situations considering parameters like marketable and marketed surplus, price volatility, market integration etc. Functioning of agricultural markets has attracted very little attention. It can address many research questions such as whether the actual market functioning is in line with the established rules and regulations? Whether violations, if any, lead to inefficiencies? Whether regulated markets are regulating the marketing process? What are its welfare implications?

Recent studies by Purohit (2016) and Chand (2012) identifies lack of market infrastructure across the APMCs in different states. Each APMC collects market fee (at prescribed rates) and a major portion of the fee collected is meant for market development. Is collected fee not sufficient? How is it utilized? Why market infrastructure has not developed for over

several years? Gulati (2009) reported illegal collection of commission from farmers in Azadpur market, Delhi (for a mere 1½ minutes of auction) and the same seems to be the fate in most agricultural markets of the country (Chengappa *et al.*, 2012 and Chand, 2012). How to address such irregularity? The exploitative role of Commission Agents (CAs) has been raised by Singh and Bhogal (2015). There are many such questions that needs to be addressed and the present study attempts to raise some of these issues where irregularities in the regulated agricultural marketing system have been identified with empirical evidence.

Despite many attempts by both central and state governments, improvement in agricultural marketing is still an unaccomplished task. Only a few states have adopted modifications suggested under 'Model APMC Act, 2003' while others are either still in the process of formulating rules or not passed the amendments at all. 'Agricultural marketing' being state subject, the individual states are supposed to bring amendments and they are at different stages of implementation. Investment in private market has been largely limited probably due to huge investment and government

enforcements. In the wake of reluctance of states to adopt the above modification, some studies suggest the possibility of including agricultural marketing under the concurrent list so that policy amendments can be brought about quickly (Chand, 2012).

At this juncture, since the effect of policy initiatives is limited, strengthening and improving the existing agricultural marketing system in terms of its effectiveness in functioning is highly desirable. The present study calls for considering 'functioning' and 'conduct' of agricultural markets. Considering the conduct and functioning of Kolar APMC, this paper evidences the underreporting of market arrivals, its causes and possible repercussions.

#### METHODOLOGY

##### Description of the Study Area

Karnataka is the leading producer of tomato in the country (Indian Horticultural Database 2011) which supplies to the neighboring districts and far off states. According to the statistics (2016-17), among vegetables, tomato is grown in about 61 thousand hectares, next only to onion (1.6 lakh hectares). Kolar, Belgaum, Mandya, Haveri and Mysore are leading producers in Karnataka. Kolar district accounts for 16 per cent of tomato area in the state. But it contributes 28 per cent to production because of high productivity (56.5 tons/ha). Kolar district is located in the south eastern part of the state and is bound by Andhra Pradesh and Tamil Nadu states. It is also close (about 60 kms) to the state capital, Bengaluru. The district has 5 blocks and each block headquarter houses a regulated market (APMC). Though market located in Kolar town is the biggest (in terms of tomato arrivals), even Mulbagal and Srinivasapur markets report substantial tomato arrivals. Thus, Kolar district is leader in terms of both production and marketing of tomato.

##### Primary and Secondary Data

An effort was made to collect primary data about the tomato marketing in Kolar APMC<sup>1</sup>. Primary data on some of the functional aspects that affected the welfare of different stake holders in the APMC was

collected. There are as many as 345 CAs (about 200-plus were functional) in the APMC and they hold auctions almost simultaneously. Since it was found difficult to collect data from all, two leading CAs based on volume of arrivals were identified by consulting the market officials and data on auctions was elicited when the process was underway, through visual observation<sup>2</sup>. The data on quantity of arrivals (depicted by the individual lot size) has been used in this paper. In addition, 80 farmers, 30 traders and 30 commission agents were also interviewed to collect information on cultivation and marketing aspects and logistic arrangements pertaining to tomato. The ambiguity in the secondary data published by the APMCs is compared with the primary data so as to understand whether accurate information is available from the secondary sources. The study has made use of secondary data on arrivals and prices of tomato from the website of the Karnataka State Agricultural Marketing Department / Board ([www.krishimaratavahini.kar.nic.in](http://www.krishimaratavahini.kar.nic.in)). The data pertaining to market fee collected and its utilization was collected from official documents of APMC Kolar.

#### RESULTS AND DISCUSSION

##### Supply Chain of Tomato in Kolar APMC

In marketing of agricultural produce in APMCs, commission agents play very important role in connecting buyers (demand) and sellers (supply), by charging commission. On buyers' side, commission agents hold close relationship<sup>3</sup> with both outstation and local buyers so that they have consistent demand. Meaning that, usually a commission agent will have a set of buyers buying regularly from him. Higher the number of buyers a CA has, higher will be the competition and hence higher price could be expected (helps in attracting more farmers also). But these buyers do not have any compulsion to buy exclusively from any CA and he would purchase from several CAs. On supply side, CAs are supposed to arrange for the proper display of the produce so that buyers can see the representative sample and will be able to quote their price bids.

### Production and Arrival Pattern of Tomato in Major Markets of Karnataka

Annual tomato production and arrival pattern in selected blocks (Fig. 1) in respective APMCs indicated that though Kolar district produces about 5.5 lakh tons of tomato per annum, the arrivals (as per the secondary data) into the market is a miniscule. During 2013-14, only about 1.5 lakh tons have been reported to have arrived in the APMCs of the district (the four major APMCs in the district are Kolar, Mulbagal, Malur and Srinivasapur<sup>4</sup>). As a percentage of total production it forms only 27 per cent. Though it

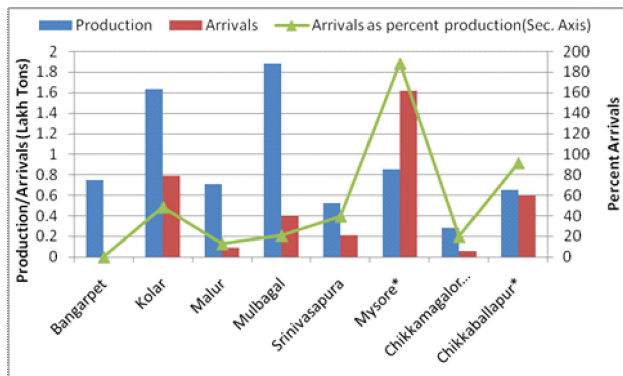


Fig. 1 : Tomato production versus arrivals in selected locations of Karnataka (July 2013 to June 2014 Crop year)

Note: Mysore district production, arrivals in Mysore and Nagamangala APMCs; Chikkamagalore district production, arrivals in Chikkamagalore APMC; Chikkaballapur district production, arrivals in Chikkaballapur, Bagepalli and Chintamani APMCs

is quite possible that the produce would have been sold in other markets like Bengaluru (Binny Mill Fruit & Vegetable Market, K.R. Puram Market, K.R. Market etc.) and neighboring states (Madanapalli market in Andhra Pradesh) etc. it would not be possible that the arrivals could be such low percentage of production. As per market officials, because of the high demand for tomatoes in Kolar market, the produce arrives into this market from even distant localities like Chikkamagalore, Davanagere, Hassan etc. Arrival from Andhra Pradesh<sup>5</sup> is a common phenomenon. Despite such huge production in the district and substantial arrivals from outside, the arrivals reported is extremely low. The questions that arise are, whether the arrivals are under reported? If so why? How to

confirm the under-reporting? Are the arrivals in other major markets of the state comparable? These are some of the questions that focus our attention in this section.

As noted earlier, tomato production is concentrated in Kolar district while the other districts like Belgaum, Mandya, Haveri and Mysore are the other leading producers. These other major districts put-together have about the same production as Kolar district. In some years tomato arrivals in Mysore APMC is higher (2 lakh tonnes in 2014) than that in Kolar district APMCs put together (Fig. 2). This is quite ambiguous. Though Kolar stands first in tomato production in Karnataka, arrivals is about the same as that in Mysore APMC<sup>6</sup>. Higher arrivals in Mysore APMC may be having some rationale. Most of the vegetable to (northern) Kerala is supplied from Mysore, apart from catering to the need of Mysore city and suburbs. Kolar and Mysore APMCs put together account for a major share (50-60%) of state's tomato arrivals. The other major markets are Binny Mill Fruit & Vegetable market (5-16% share) in Bengaluru and Chikkaballapur district APMCs (Chintamani, Bagepalli and Chikkaballapur) (10-15% share). The remaining APMCs account for only 15-30 per cent of the total market arrivals of tomato in the state. In all, out of 155 APMCs in the state, about 50 reported tomato arrivals. Binny Mill is a terminal wholesale market in Bengaluru city. The increase in operation of modern retailers seems to have affected arrivals in Binny Mill (July 2014 onwards).

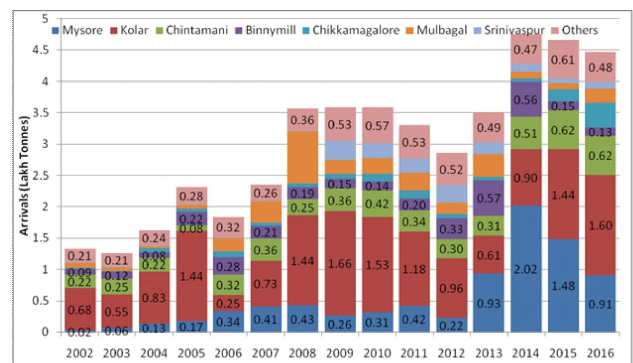


Fig. 2: Annual arrival of tomato in major (APMCs) of Karnataka

Note: Kolar includes Kolar, Malur, Mulbagal, Srinivasapura markets put-together; Chikkaballapur includes Chikkaballapur, Chintamani, Bagepalli APMCs put together

Monthly arrivals in Kolar market (Fig. 3) over the years depict clear seasonality; higher arrivals in only a few months (between June and September, many-a-times prolonging up to November) coinciding with *kharif*. Though the analysis depicted rise in tomato arrivals in January again, the intensity is not comparable with that of winter months. We do not see a second peak in tomato arrivals for Kolar APMC. Arrivals in Mysore APMC (Fig. 4) are higher than that in Kolar during the off-peak months. Unlike Kolar, arrival in Mysore APMC is more or less uniformly spread throughout the year. But, over the years there is a tendency of increasing arrivals in Mysore.

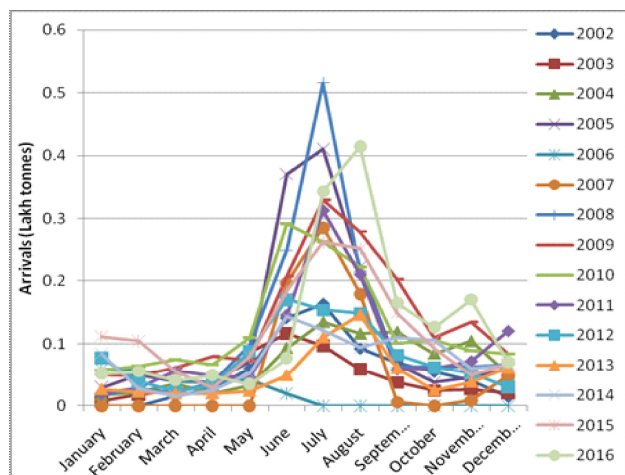


Fig. 3: Tomato arrival pattern in Kolar APMC

Narrowing down the analysis, daily arrival of tomato (Table 1) at the two leading commission agents (primary data) is compared with the total market arrivals reported by the APMC (secondary data). The primary data on arrivals were collected in terms of number of crates of tomato (of 15 kg each) has been converted into quintals. For most of the days, the lot-wise data pertaining to these two CAs was collected<sup>7</sup>.

The comparison of secondary data on arrivals with primary data showed a lot of discrepancies. Four out of eighteen days, for which the primary data was collected, the actual arrivals at just two major CAs in the market were more than the arrivals reported by the APMC (see last column of Table 1). On additional seven days, the difference between primary and secondary data is less than 500 quintals. There are

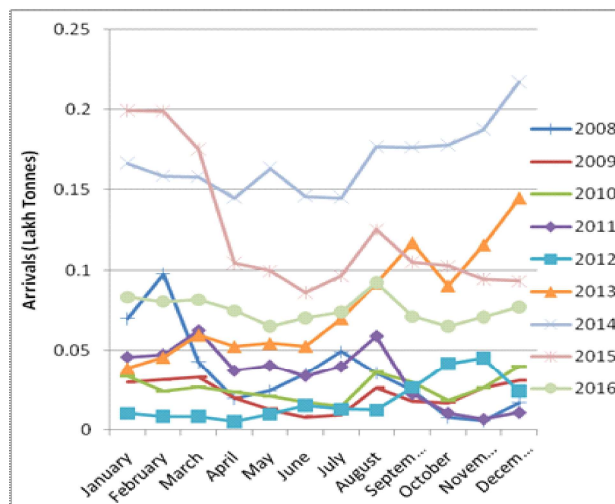


Fig. 4: Tomato arrival pattern in Mysore APMC

about 375 CAs in the market and the actual arrivals will be more than double or triple. Overall, for eighteen days, the secondary data shows a meager difference of only about 7 thousand quintals (about half a quintal per day). Therefore, it gives us a distinct proof that the arrival data is under reported for sure. Under reporting of arrivals has become a practice which seems to be common in many APMCs (Chengappa *et al.*, 2012).

An instance quoted by a market official during an informal discussion is worth mentioning (truthfulness of the instance could not be ascertained). A few years ago, the ‘actual’ daily market arrivals of different commodities (especially tomato) was collected and posted (calculated by recording the number of trucks leaving the market premises) by one of the market secretaries. But, the collection of market fee was based on the voluntary declaration by the individual buyers/CAs. Since such declaration was lower (than actual), there was a mismatch between actual arrivals (reported by APMC) and the market fee (collected @ 1 per cent of total value). It was told that, it resulted in penalizing official by auditing team and since then the practice of reporting correct arrival was stopped.

**Causes of Under Reporting and its Possible Redress**

The study tried to find out a few reasons based on observation and perception.

TABLE 1  
Discrepancy in daily arrivals (in quintals) reported by the APMC

Date	Arrivals at selected leading commission agents (Primary data)				Arrivals as per APMC (Secondary data)	Discrepancy (+/-)**
	CA 1	CA 2	Others*	Total		
13/11/2015	443	531	NC	974	826	148
14/11/2015	674	270	NC	944	1024	-80
16/11/2015	863	NC	NC	863	1824	-961
17/11/2015	NC	540	NC	540	464	76
18/11/2015	292	389	NC	681	936	-255
19/11/2015	320	880	NC	1200	1108	92
20/11/2015	558	NC	NC	558	927	-369
23/11/2015	710	NC	NC	710	928	-218
24/11/2015	509	488	NC	998	1235	-237
25/11/2015	302	640	NC	942	1435	-493
26/11/2015	NC	390	703	1093	1335	-242
27/11/2015	NC	NC	507	507	1576	-1069
1/12/2015	1062	786	NC	1848	2025	-177
2/12/2015	1303	308	NC	1612	2474	-862
9/11/2015	701	548	36	1284	2500	-1216
12/11/2015	960	221	NC	1181	3000	-1819
3/12/2015	2466	NC	NC	2466	2430	36
4/12/2015	1174	NC	NC	1174	2376	-1202
Grand Total	12338	7848	1246	21432	28423	-6991

Note: CA 1 & CA 2 refers to the major commission agents; NC - 'Not Collected'

\* - sum of arrivals at a few other CAs than CA1 & CA2

\*\* - '+' sign indicates lower reporting and '-' sign indicates higher reporting.

APMCs charge a user fee<sup>8</sup> @ 1 per cent of the value of transaction (to be collected from buyers when produce leaves the market<sup>9</sup>). Given the high value of horticultural commodities, the inter-mediaries end up paying considerably high fees for the meager service provided by the market committees. The purpose of charging fee is to undertake market development. The kind of developmental activities undertaken is evidenced below. By looking at the kind of facilities developed, one would be clarified as to why CAs would be reluctant to make prompt payment of user fees which is claimed to be used for market development.

The actual guideline for use of user fee is as follows: Consolidated Fund - 25 per cent, State Agricultural

Marketing Board - 5 per cent, Contribution to Agricultural Universities - 1 per cent, Contribution to Revolving Fund - 0.5 per cent, The balance is to be utilized for market development (by individual APMCs with approval from the Director of the state agricultural marketing department (<http://krishimaratavahini.kar.nic.in/department/deptmenu.htm>). Details of user fee collected in Kolar APMC and its utilization (Table 2) shows a consistent increase market fee collected over the years. Every year at least Rs. 1 crore is available for market development.

The details of utilization of funds for market development in Kolar APMC (Table 3) shows that,

TABLE 2  
Details of market fee collected and its utilization pattern in Kolar APMC

Years	Market fee collected	Funds not available for APMC	Funds available with APMC for market development	Estimated expenditure (Lakh Rs.)	Excess or deficit expenditure *
2012-13	1,21,91,969	38,40,470	83,51,499	NA	-
2013-14	1,59,72,185	50,31,238	1,09,40,947	1,13,00,000	-3,59,053
2014-15	1,66,98,273	52,59,956	1,14,38,317	1,21,00,000	-6,61,683
2015-16	1,80,20,578	56,76,482	1,23,44,096	1,00,00,000	23,44,096

Source: Annual progress report of APMC, Kolar 2015-16

Note: \* positive sign refers to deficit and negative sign refers to excess expenditure over the funds available for APMC for market development as per user fee collected.

these funds being scarce, it is expected that it is utilized to bring about overall improvement to benefit the different stake holders of the market. That is, funds should be used such that it is need based and prioritized. In the year 2013-14, funds were allocated for building concrete roads. This seems to be most useful (if properly utilized) as good roads facilitate smooth flow of vehicles in, through and out of the market. Construction of arch (Rs.10 lakh spent) in the entrance gate only adds to beautification and hence may not have any productive use. Probably keeping the long-run need, a hefty amount of Rs.30 lakhs is spent on building administrative block. The toilet and inspection room have got a general use. But, a spending of Rs.5 lakh on animal shed is misleading. Neither the APMC has reported sale/purchase of animals nor are animal drawn carts in use at the market place. The purpose of building it is questionable.

In 2014-15 also, roads and lighting received priority, while repair of auction platform and civil work to increase height of compound was also undertaken. Admin block again gulped up another Rs.10 lakhs while road construction still was a priority in 2015-16.

As depicted in table, the actual or proposed expenditure has a deficit of funds for market development except in the year 2015-16 (Table 3). As per informal interaction with the market officials, they indicated that the shortage of funds was met out of RKVY funds. It was not clear whether proposed works were a part of the RKVY funds.

Overall, it gives an impression that creating most essential infrastructure in market has not been prioritized and many of the basic necessities of a primary agricultural market have been overlooked. Any visitor to the market can easily notice important infrastructure inadequacies. For example,

1. During the winter season, it is not possible for anyone to walk inside the market without submerging foot in the mud (while loading, unloading and auctioning people need to move near the lots arranged either on road or auction platform. To reach platform, one has to cross the muddy areas). There is a strong need to create hygienic conditions to avoid such nuances.
2. The tomato auctions are held even on the roads (due to paucity of auction platforms) even when it is raining (it was raining heavily in November, December 2015 when the data was collected). The produce gets wet in rain and may lead to increased post harvest losses. This indicates insufficient auction platforms and lack of coping mechanisms.
3. After the auction, tomatoes are sorted and packed in crates. During the process, a lot of tomatoes are discarded. During any time of the year, we can find heaps of discarded tomato in many parts of the market. There is no proper disposal mechanism. At times, the tomatoes rot and produce a foul smell apart from serving as host for several insects that could be infectious. The issue needs to be addressed.

TABLE 3  
Market fee utilized for market development activities in Kolar APMC

Specific Development activities	Expenditure (Lakhs Rs.)	Percentage
<b>2013-14</b>		
Construction of administrative building with meeting hall	30.00	26.55
Construction of Arch for 3 market gates	10.00	8.85
Construction of general toilets	10.00	8.85
Construction of concrete roads	40.00	35.40
Construction of inspection room at main gate entrance	3.00	2.65
Workers' building	15.00	13.27
Animal shed	5.00	4.42
<b>Total</b>	<b>113.00</b>	<b>100.00</b>
<b>2014-15</b>		
Construction of concrete roads	81.00	66.94
Repair of auction platform	4.50	3.72
Increasing height of market compound	5.50	4.55
Installation of solar light	10.00	8.26
Repair of street light	20.00	16.53
<b>Total</b>	<b>121.00</b>	<b>100.00</b>
<b>2015-16</b>		
Improvement of administrative block	10.00	10.00
Construction of concrete roads	84.00	84.00
Installation of bore well	6.00	6.00
<b>Total</b>	<b>100</b>	<b>100.00</b>

Source: Annual progress report of APMC, Kolar 2015-16

Note: \* positive sign refers to deficit and negative sign refers to excess expenditure over the funds available for APMC for market development as per user fee collected.

4. Need for a weigh bridge: Both incoming and outgoing market arrivals are not weighed. Lack of weighing facility could be one of the reasons for underreporting. Weigh bridge in an APMC also benefit farmers, transporters and buyers, as they are presently using it outside APMC.
5. Sufficient scope for automation such as installing CCTV cameras at important locations, especially

at gates (probably, instead of personal inspection) so that the market proceeds and movement of vehicles can be easily monitored for effective supervision, especially when the staff size is fewer. There are many more things that can be thought of, so as to bring about smooth flow of marketing. Many clues can be taken from the markets like the one in Gultekady near Pune that can help in systematizing the market processes.

If such infrastructural development (which would really reduce the work burden and improve efficiency) can be introduced in the market, the market functionaries would be enthused to be prompt. Even, it is unjustifiable for anyone to expect the buyers to make payment for minute improvement in infrastructure and well being. The volume of trade being considerably huge, it requires considerable manpower in order to supervise the marketing activities. Leave apart the existing staff position in Kolar APMC, the sanctioned post itself is just 12 (8 technical and 4 supporting). Secretary (1), Assistant Secretary (1), Accountant (1), FDA (1), SDA (1) and Marketing Assistant (3) are the sanctioned technical posts. Approximately 500-1000 truckloads (even more) of tomato may be traded in peak season and the transaction during off-peak season is also quite high. The value of transaction could be in Crores of Rupees. A single Second Divisional Assistant and one accountant supervised by the secretary were looking after the market when the survey was undertaken. One can expect that the market committees may not be able to deliver the expected duties without sufficient and qualified human resource. The market officials have the crucial role of supervising day to day functioning such as, 1) maintain the log of produce and vehicles arriving and leaving the market premises; 2) be present at the auction site to ensure smooth and fair conduct of auctioning; 3) record the price and arrival for official purposes; 4) ensure collection of market fee, apart from the official administrative duties. With huge quantum of produce hitting the market, it is extremely hard to justify 3 technical persons to maintain the above said processes.

Adequate and specialized manpower is highly relevant to the supervision of market activities including reporting of market arrivals. Since it is understaffed, even the market functionaries can easily take benefit of situation to override officials. In the present era of modern technology, it is highly essential to recruit specialized manpower and make use of sophisticated technology. The graduates in the marketing discipline, especially agricultural marketing, can better understand practicalities of the agricultural marketing system, whose skills can be effectively utilized. The Karnataka state has modified its Cadre and Recruitment Rules in 2007 to accord preference to the graduates of agricultural universities, to some of the technical posts. This is a welcome step and further concrete steps can be taken to make use of the available qualified man power. Poor staffing is a common phenomenon in many APMCs.

It is also possible that middlemen are unwilling to make market fee payment which helps them save tax and maintain unaccounted money. This could be another reason for under reporting of arrivals.

### Repercussions of under reporting of arrivals

Most analysis in agricultural marketing ignores the authenticity of market data mainly because they focus price irregularity and market integration. Market prices, as we know, are closely related to market arrivals and demand. While making any economic/econometric modeling, if we use incorrect data, the analysis may result in incorrect conclusions. In this study the repercussions of incorrect data about market arrivals is conceptualized by using basic demand-supply curves. The study tried to illustrate how this incorrect information may mislead analysts and policy makers to understand a market situation as ‘surplus’ or ‘shortage’ and thus signal to either expand or contract area under crop. This is nothing but supply response model.

*Area shift and price fluctuations:* Probable impact of underreporting of market arrivals on production (Fig. 5a) shows that interaction between actual demand (D) and supply (S) results in equilibrium quantity (Q) and equilibrium price (P<sub>1</sub>). We assume

that the APMCs are correctly reporting market price of the produce (according to market official, CAs report the ‘correct’ or indicative daily market prices). The under reported quantity at a given market price (P<sub>1</sub>) is indicated by Q<sub>1</sub> which denotes a lower demand (D<sub>1</sub>) and lower supply (S<sub>1</sub>). There could be two possible situations as follows:

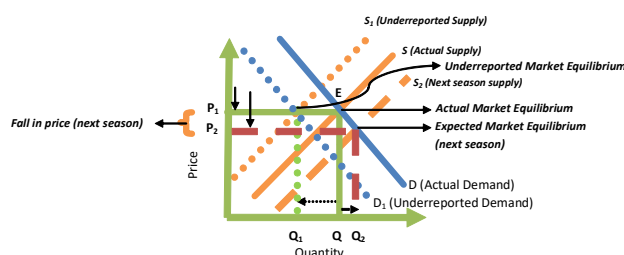


Fig. 5a: Situation 1: When market price is high enough to bring positive net returns to the farmers

**Situation 1:** When market price is high enough to result in positive and high net returns to farmers: When price is remunerative (higher), the above situation depicts a supply shortage. Therefore, underreported quantity may give the impression to analysts and policy makers that they have sufficient scope to increase production. This could lead to a rightward shift in Supply curve (S to S<sub>2</sub>). Assuming that the pattern of market demand will be unchanged as represented by ‘D’, the excess supply leads to a fall in price to P<sub>2</sub>.

**Situation 2:** When market price is lower leading to negative net returns to farmers: When the market price is not remunerative and causes loss to farmers, it could exert a pressure on producers (as demand is misinterpreted as ‘D<sub>1</sub>’ instead of ‘D’) to reduce area under the crop for next season (Fig. 5b). This is a situation in which underreported arrival could lead to

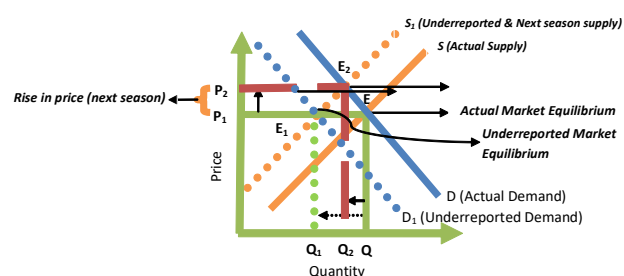


Fig. 5b: Situation 2: When market price is lower than cost of production (negative net returns to the farmers)

a false impression of a surplus supply and hence signals the farmers to reduce area under crop. Thus, an area contraction would shift supply curve leftwards ( $S_2$ ). Again, demand being unchanged at 'D', the new equilibrium quantity will be  $Q_2$  and the corresponding price will be  $P_2$  which is a higher price. Thus, underreporting could lead to false conclusions that are misleading and misguide the decision making.

*Social welfare loss:* In addition to its impact on price fluctuations, under reporting also causes welfare loss to different stake holders including farmers, buyers and commission agents. It is known that reporting of arrivals at the APMC attracts payment of market fee. That is, graphically, if actual arrival is reported, the buyer is supposed to pay 1 per cent of the value ( $OQEP_1$ ). But because of under reporting, the buyer would be paying market/user fee @ 1 per cent of the value of rectangle  $OQ_1E_1P_1$ . As known to us, a majority of this amount collected is utilized for the market development. The amount corresponding to 1 per cent of value (rectangle  $Q_1QEE_1$ ) represents funds not available for market development. As discussed in the previous section, there is deficit of funds for even creating basic infrastructure. Hence, under reporting results in welfare loss to different stake holders, including buyers and CAs.

Empirically, assume that a truck load can accommodate about 18 tons of tomato which could value about Rs.1.8 lakh (keeping an average price of Rs.1000/quintal) and its one per cent would be Rs.18,000. An amount of Rs.18,000/- is the social loss because of under reporting of 1 truck load. Which means Rs.18,000 is not available for social welfare activities such as market development, market research, implement farmer welfare schemes. The amount of welfare loss would be extremely high for the volume of under reported arrivals.

Some of the other concerns about market data are highlighted and may form a scope for future research.

1. It is highly appreciable that, the website of state marketing department publishes market data online and its call center/SMS facility is also involved in its dissemination. But, the price and arrival data is

incomplete. For example, no bifurcation of data on hybrids and local varieties or such quality grades. If market information is not available at disintegrated level, it may be less useful and many times, may not be useful at all. In case of tomato, if the price ranged between Rs.250-500, it does not represent for which variety (hybrid/local) or grade does it pertain. Market intermediaries (CAs and traders) have an edge with information on price of all quality grades

2. Mismatch between production and market arrivals would lead to unnecessary puzzles with no answers, especially to academicians and researchers.
3. The above irregularities are only an indicative of probable poor market regulation. Taking cue, the market functionaries could indulge in unsolicited practices like charging commission from farmers, financing and charging heavy charges, etc. and many a times, deprive farmers of fair market transactions.

### Financing tomato production

Marketing of agricultural commodities being a state subject, in Karnataka it is regulated under the KAPMR Act 1966 and subsequent Rules. The Act provisions, sale and purchase of produce at the APMCs through the CAs. Apart from trade facilitating functions CAs are providing other facilities. In case of tomato marketing at Kolar, the CAs have enlarged their scope by providing multitude of services. The CAs were the important sources of non-institutional of finance to farmers. Given the poor status of institutional finance for farming (according to NSSO agricultural credit data only 57 per cent of farm credit is served by institutional agencies), farmers prefer to obtain the 'door-delivered' credit without hazels of paper work and visiting bank. The CAs provide finance to ensure supplies to their *mandi* which would ensure higher turn over and profits. About 40 per cent of farmers access loan from CAs for input purchase as well as other social obligations in return for a commitment in supply of produce they grow and of course a very high commission charges (Urs, 2015). The article highlights

the need for plugging this liquidity trap in order to bring about farmer's welfare.

When enquired about the charging commission from farmers, which is violation of KAPMR Act, the CAs point to the risk of farmers breaking the deal and selling to other CAs in the *mandi* and interest on finance. If this risk were to be the logic for charging commission, then why are the farmers charged for the entire sales proceeds instead of the amount of credit supplied? Also, even the farmers selling to a CA but have not availed loan would also be charged a commission at the same rate. Then, this reason of 'farmers breach the deal' for charging commission, would not be acceptable. Even from farmers availing credit, CAs end up making huge profits. A small illustration would reveal the gain accruing to CAs. The average amount of credit supplied to farmer per acre is Rs.32,500 to Rs.42,500 (Table 4). Considering (the district) average yield of 22.6 tons/acre and an average price of Rs.10,000/tonne, the sales realization per acre works out to Rs.2.26 lakh. Eight percent of this amount works out to about Rs.18,000. Tomatoes being a crop of 4-5 months duration, for this small duration CAs manage to recover a very high rate of return. This works out to >8 per cent interest per month, as against the annual interest rate of 4 per cent offered by the institutional agencies. Singh and Bhogal (2015) notes credit supply by commission agents without appropriate lending related licensing to be illegal. The Economic survey (2014) quotes this inadequacy of model APMC Act as, "though the model APMC Act bars the APMCs and commission agents from deducting the market fee/commission from the seller, the incidence of these fees/commission falls on the farmers since buyers would discount their bids to the extent of the fees/commission charged by the APMC and the Commission agents."

Such worries put farmers in a position not to protest market fee collection thus putting them in a disadvantageous position. The above charging of commission by CAs is further facilitated by the payment mechanism followed in APMCs. The buyers are supposed to make payment for purchase. But in actual practice, the CAs make payment to farmers and literally there is no financial relationship between

the buyers and sellers of produce. Thus farmers depend entirely on CAs for payment and hence deductions get easier. Singh and Dhaliwal (2011) highlight many other peculiarities in Punjab regulated markets such as not making money payment to farmers (instead giving purchase vouchers to be used with agricultural input suppliers and ration shops) etc.

It can be observed (Table 4) that all the farmers interviewed and 33 per cent of the CAs consent the collection of commission from farmers. In order to counter the exploitation, there is need for strong enforcement. Since financing through the institutional agencies felt to be cumbersome, government can think of allowing CAs to finance by formalizing the process. Such formalizing of finance (and also the repayment) can be done through the involvement of APMCs, so that the chances of non-payment or default can be reduced. The CAs can be allowed to charge a fixed rate of interest on the extent of credit offered. On the one hand, farmers get production finance easily and on the other hand CAs will also be benefitted in organizing their supplies.

#### **Other important services provided by CAs that have welfare effects**

The CAs offer even transport facility and plastic crates (to reduce wastage) at a charge (Table 4). This facility comes into vogue once CA's functionaries give the information that farmer's produce is ready for harvest. Apart from people to get farmer's contact, CAs also maintain a group of transporters who operate in village routes assigned by the CAs. They collect empty crates from CAs' office and deliver it at the farm gate of different farmers. Harvested and graded tomatoes are filled in crates by farmers. Transporters collect filled crates (from different farmers) to be delivered at the particular CA's *mandi*. Thus, the chances of farmers supplying to a different CA are avoided to a great extent. Both these facilities needs to be appreciated because, it helps farmers to deliver produce with less damage and with a great ease. For many commodities, since farmers have lower marketable surplus, they end up making farm gate sales often at low prices. Since transport facility is available for any small quantity

TABLE 4  
Commission collection and details of facilities  
influencing supply chain at the Kolar APMC

Particulars	Farmers	Traders
Collection of commission from farmers (% indicating yes)	100	30.3
Farmers availing credit facility from CAs (Per cent)	43.2	71.9
Average amount of finance (per acre per farmer)	32,500 - 42,500	-
Average time taken for making payment to farmers selling their produce (days)	5	2-3
Provision of crates (Per cent)	85	75
Provision of transport (Per cent)	65	75
Charges for crate (Rs./crate)	2	2
Charges on transport (Rs./crate)		
<10 km	5-10	-
10-25 km	10-15	-
25-50 km	15-30	-
>50 km	25-50	-
Cases of non-receipt of payment by commission agents from buyers for produce sold	-	10% of transaction Value

Source: Compiled by authors using primary data

harvested by farmers (not necessarily a full load), it brings a great convenience to farmers. Transporting small quantity of surplus by individual farmers would cost more. Even, provision of crates by CAs can reduce the post harvest loss of tomatoes. Farmers need not have to incur heavy investment on buying crates and just need to pay a small charge (Rs.2/crate). This facilitation provides win-win situation for both farmers and CAs.

In the eve of less effect of the changes brought in the agricultural marketing policies on marketing process and efficiency, the present paper attempts to take an alternative view of market functioning. The various marketing practices are taken a closer look in the perspective of improved benefit to the different stakeholders of marketing system. As a representative, Kolar APMC is chosen. Most of the argument in the

paper could be generalized for other agricultural commodities and markets.

The study got clear evidence that the arrivals are underreported. It was seen that the actual arrivals with just two leading CAs in the market equaled the total market arrivals reported by the APMC. Under reporting leads to many problems and thus act as an indicator of poor market functioning. It was noted that the under reported quantity, when used in policy analysis, could signal unnecessary increase or decrease in production. The foregone collection of market fee results in a welfare loss in terms of market development, while there could be a scope for accumulation of unaccounted money with certain interest groups. Apart from under reporting, the market information collected is also incomplete. The variety-wise (hybrid/local) or grade-wise price is valuable information both to farmers as well as policy makers. This is nothing but information asymmetry, with the trading community having better price/arrival information than policy makers and hence the former can take better decisions, for personal advantage depriving farmers of improved price realization.

The evidences show that the development expenditure in APMC during past three years to be illogical and lack prioritization. Many basic necessities were ignored. Automation such as CCTV surveillance for gate entry, exit, weighbridge, waste disposal mechanisms, sophisticated auction platforms are some of the necessities of market that have not received attention. Non-provision of these infrastructure facilities despite considerable market fee payment demotivates trading community in prompt reporting of arrivals. Poor staffing greatly affected market regulation. Appointing specialized manpower with suitable automation could remedy the problem considerably.

Though tomato production financing by CAs is helping farmers, the CAs seem to be exploitative. While farmers get production finance to some extent, CAs are benefitted through assured supply, high turn over and hence profits (commission). Though this unlawful

practice is followed in most Indian agricultural markets, nothing much could be done. Charging commission from buyers would pass on cost to consumers in terms of small increase in unit price. This imposition has to happen in all markets throughout the country if it has to be effective. Possibilities of formalizing credit provision to farmers by CAs could also be thought of. Lastly, most of the issues raised in the paper are universal to many agricultural markets and products in India. Problem of under reporting, persisting infrastructure lacuna despite heavy government spending on infrastructure, lack of prioritizing in spending market development funds by APMCs, exploitation by market intermediaries, information asymmetry etc. could be universal.

### Way ahead

The study also raised some of the research issues that need to be addressed.

1. Analyzing impact of holding auctions simultaneously by different CAs on price.
2. There is need to quantify the welfare gain/ loss of farmers in tomato production in order to improve the existing marketing system.
3. Identify reasons for tomato arrivals to Kolar market from far away regions (what is the comparative advantage)

The primary data was collected by utilizing the students placed at the APMC during their institutional placements held for 14 days during October and November 2015. The students were oriented about the survey schedule and were asked to collect the data.

It included recording information on lot number, lot size (in terms of number of crate; each crate weighing 15 kgs each), fruit size (big, medium & small), color (green, yellow & red), local/hybrid, auction reserve price, auction final price, amount of time taken to complete auction. These information could be collected without consulting anyone, by visual observation by the enumerator. by giving certain incentives like giving additional time for settlement of payment, supply of

required quantity, quality and other logistic support. Hence, these buyers would tend to be loyal with those CAs. One more APMC in Bangarpet has negligible arrivals of tomato

As was witnessed during 2017 February, local production being considerably low, there was arrivals from Orissa, Chattisgarh, Gujarat etc, while demand was mainly from southern states.

Note that in many markets tomato arrival is far below its production. Further, tomato production in Karnataka state is reported at 19.5 lakh tonnes during 2013-14 while the total arrivals in the APMCs of Karnataka during the same period is 4.11 lakh tonnes. Only ¼th of the total production is reported as market arrivals. The possibilities for mismatch could be, 1) village sales (mostly in village shandis, nearby townships and in urban markets, for eg., K. R. Market in Bangalore, SAFAL, private buyers like reliance, Namdharis etc that are not reported in official APMC data, 2) post-harvest losses, 3) direct selling by farmers in other state markets (very common in the districts like Belgaum where most of the agricultural produce especially fruits and vegetables reach markets in Maharashtra). But underreporting could still be a possibility, and a matter of scrutiny of present study.

But, during some of the days for lack of sufficient number of enumerators, data could not be elicited and the respective cells indicate NC indicating that data was not collected on that day. On a few days, misinterpreting our guidelines, students collected data from other CAs and it has been clubbed and put under 'Others' column.

Previously, it was collected as Market Fee. Since 2013 (Anon., 2013; Roy, 2012), the central government has exempted the fruits and vegetables from purview of APMCs. States like Odisha (Anon., 2014) and Karnataka are collecting the market (user) fee in disguise. In Karnataka, a user fee @ 1 per cent advalorem is charged for these commodities.

In practice, CAs pay the fee. Buyers make payment for their purchase only after a period of time, based on his understanding with CA.

Before provision of this facility, it was told that farmers used gunny bags and bamboo baskets which lead to substantial post harvest losses

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## Knowledge Level of Beneficiary Farmers Regarding the Activities of Agricultural Technology Information Centre, UAS, Bangalore

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### ABSTRACT

The study focusing on Agricultural Technology Information Centre (ATIC), UAS-B was conducted during 2019. Ninety beneficiary farmers who visited ATIC during the last three years were selected purposively to elicit the knowledge level of beneficiary farmers towards ATIC. It was found that nearly half (42.22%) of the beneficiary farmers belonged to medium level of knowledge category, while nearly one fourth (25.56 %) of them belonged to low and the remaining 32.22 per cent of them belonged to high level of knowledge category. Further a great majority of the beneficiary farmers (91.11 %) had knowledge that ATIC provides consultancy services, followed by 87.78 per cent of the beneficiary farmers who had correct knowledge with respect to areas of services provided by ATIC. More than three fourth of the beneficiary farmers (77.78%) had knowledge that ATIC provides recent varieties followed by 76.67 percent of beneficiary farmers who had knowledge that ATIC provides ready made seed kits. Only few of the beneficiary farmers had correct knowledge with respect to agri-portal service (16.67%) and availability of feedback services (17.78 %). More than 50 per cent of the farmers had correct knowledge with respect to availability of planting materials, biofertilizers, availability of literature related to agriculture and allied aspects. Variables such as scientific orientation, achievement motivation, innovative proneness and extension contact had significant association with knowledge level of beneficiary farmers regarding the activities of ATIC at one per cent level of significance. While farming experience, information seeking behaviour, extension participation, education and risk orientation had significant association at five per cent level of significance.

*Keywords:* Agricultural technology information centre, Knowledge and Beneficiary farmers

DEVELOPMENT efforts over the last few decades have demonstrated that sustained improvements in the productivity and livelihood depend on the technological development and refinement made by the National Agricultural Research System in India. Information is considered to be a basic necessity for development in any sphere of activity. Communication of information has prime importance in the present information age. Hence, ATICs were established in different states with the main idea of providing a mechanism beyond the individual unit of a research institution and to contribute to the dissemination of information as a single window delivery system for research products and services.

ATIC was started at UAS, Bangalore during the year 1999 under the National Agriculture Technology Project (NATP) which is a single window system for agricultural information as well as products such as seeds, planting material, biofertilizers, nutrient mixtures,

value added products, bio-pesticides and other technologies developed by the University. In addition, a platform was created to allow optimistic interaction between farmers and Subject Matter Specialists for effective technology transfer and livelihood improvement. Thus, ATIC is functioning as a repository of agricultural information (Anon., 2019).

Indian Council of Agricultural Research is giving thrust to transform the agricultural technical know-how for increasing the productivity and to enhance the income. Recently, Government of India is giving much thrust to double the income of farmers through the adoption of the agricultural technologies. Therefore, providing advisory services becomes critical and vital to address both the productivity and doubling the income of farmers. Among the several approaches, the ICAR is thriving hard to push these twin issues through Agricultural Technology Information Centre. Unless farmers know

the existence of ATIC and its activities, the purpose would not be served. Hence, a study was conducted to assess the knowledge level of the beneficiary farmers regarding the activities of Agricultural Technology Information Centre and to analyze the association between profile characteristics of beneficiary farmers with their knowledge towards Agricultural Technology Information Centre.

#### METHODOLOGY

The investigation was conducted during the year 2019 and an Ex-post facto research design was followed to assess the knowledge level of the beneficiary farmers regarding the activities of ATIC and to analyze the association between profile characteristics of beneficiary farmers with their knowledge level. The study was therefore carried out in involving ATIC, UAS, Bangalore. Ninety beneficiary farmers who visited ATIC during the last three years were selected purposively. Based on the objectives of the study interview schedule was prepared and the information was elicited from beneficiary farmers with the help of pre-tested interview schedule and the criteria to select the beneficiary was that he or she might have visited ATIC at least once during the last three years. In total, 18939 farmers have visited ATIC during the last three years. Later the collected data was analyzed by using frequencies, percentages, mean, standard deviation, chi square and regression analysis. To measure the knowledge level of beneficiary farmers, the knowledge test questions and answers were carefully framed in consultation with scientists of ATIC and Agricultural Extension. The answers obtained from the farmers for the knowledge test were quantified by giving a score of one and zero for correct and wrong answers respectively. Respondents were grouped in to low, medium and high categories, based on the total scores using mean and standard deviation as a measure of check.

#### RESULTS AND DISCUSSION

##### Overall knowledge level of beneficiary farmers regarding the activities of ATIC

The results presented in Table 1 revealed that, nearly half (42.22%) of the beneficiary farmers belonged to medium level of knowledge category, while nearly one

fourth (25.56%) of them belonged to low and the remaining 32.22 per cent of them belonged to high level of knowledge category. The reason might be that most of the beneficiary farmers had relatively high information seeking behavior and high scientific orientation which might have made them to visit ATIC more than once and hence the medium level of knowledge. The finding is in conformity with the findings of the studies conducted by Meena (2016), Shamshadunnisa (2017) and partially inline with the findings of Abdullah Faiz and Narayana Swamy (2012) & Gaikwad *et al.* (2013).

TABLE 1

Overall knowledge level of beneficiary farmers regarding the activities of ATIC (n=90)

Category	No.	%
Low (<16.97)	23	25.56
Medium (16.97-20.47)	38	42.22
High (>20.47)	29	32.22

##### Component wise knowledge level of beneficiary farmers regarding the activities of ATIC

The results depicted in Table 2 revealed that, a great majority of the beneficiary farmers (91.11%) possessed knowledge that ATIC provides consultancy services followed by 87.78 per cent of the beneficiary farmers who had correct knowledge with respect to areas of services provided by ATIC. Further more than three fourth of the beneficiary farmers (77.78%) had knowledge that ATIC sells recent varieties followed by 76.67 per cent beneficiary farmers who had knowledge that ATIC provides readymade seed kits and very few of them had correct knowledge with respect to Agri portal service (16.67%), availability of feedback services (17.78%). More than 50 per cent of the farmers had correct knowledge with respect to availability of planting materials, bio-fertilizers and availability of literature related to agriculture & allied aspects.

Majority of the beneficiary farmers had knowledge with respect to consultancy services, areas of services provided by ATIC. The reason might be that majority

TABLE 2

Component wise knowledge level of beneficiary farmers regarding the activities of ATIC (n=90)

Knowledge items	Knowledge	
	No.	%
<b>I Inputs</b>		
A) Seeds		
Availability of readymade seed kit	69	76.67
Availability of recent varieties	70	77.78
B) Fertilizers		
Availability of biofertilizers	45	50.00
Availability of farm manures	32	35.55
Availability of nutrient mixtures	30	33.33
C) Planting materials		
Availability of ornamental planting material	62	68.89
Availability of fruit plant sapling	54	60.00
Availability of medicinal planting material	49	54.44
Availability of flowering planting material	51	56.67
D) Farm implements		
Availability of farm implements	46	51.11
<b>II Advisory services</b>		
Areas of services provided by ATIC	79	87.78
Facility for diagnosing the infested plant	45	50.00
Availability of advisory services through phone calls	69	76.67
Availability of consultancy services	82	91.11
Availability of multidisciplinary team	60	66.67
Facility for diagnostic visit	39	43.33
Availability of literature related to agriculture and allied aspects in Kannada	51	56.67
<b>III ICT</b>		
Information/data base available in kiosk	43	47.78
Agri portal web address (e-krushiuasb.karnataka.gov.in)	15	16.67
Availability of WhatsApp group to quickly address farmers queries	31	34.44

Knowledge items	Knowledge	
	No.	%
Availability of CD related to agriculture and allied aspects	37	41.11
Need based video conference facility	18	20.00
<b>IV Availability of value-added products</b>	32	35.56
<b>V Others</b>		
Availability of feedback services provided by ATIC	16	17.78
Knowledge about mandate about ATIC	23	25.55
Knowledge about operational level of ATIC	24	26.67
Provision of training on request basis	16	17.78

of the beneficiary farmers belonged to medium category of information seeking behaviour (45.56%), extension contact (46.67%), achievement motivation (47.78%) and high category of scientific orientation (47.78%).

#### Association between profile characteristics of beneficiary farmers with their knowledge towards ATIC

The results indicated in Table 3 revealed that the characteristics of beneficiary farmers (independent variables) such as scientific orientation, achievement motivation, innovative proneness, extension contact had significant association with their knowledge level regarding the activities of ATIC at one per cent level of significance. Characteristics like farming experience, information seeking behaviour, extension participation, education, risk orientation, mass media exposure and cosmopolitaness had significant association at five per cent level of significance. The reason might be that farmers are educated and consult various sources for obtaining information related to crop production and allied activities during which time they might have come across the existence of ATIC and its activities. Similar findings were reported by Bar (2015) and Kaur & Garg (2017).

TABLE 3

Association between profile characteristics of beneficiary farmers and their knowledge regarding the activities of ATIC (n=90)

Independent variables	Chi-square value	Contingency Co-efficient
Age	2.27 <sup>NS</sup>	0.15
Education	10.11 <sup>*</sup>	0.31
Family size	5.67 <sup>NS</sup>	0.24
Annual income	6.11 <sup>NS</sup>	0.25
Size of land holding	5.99 <sup>NS</sup>	0.24
Farming experience	9.86 <sup>*</sup>	0.31
Scientific orientation	22.67 <sup>**</sup>	0.44
Risk orientation	9.66 <sup>*</sup>	0.31
Achievement motivation	16.67 <sup>**</sup>	0.39
Innovative proneness	19.60 <sup>**</sup>	0.42
Cosmopoliteness	9.51 <sup>*</sup>	0.30
Mass media exposure	10.23 <sup>*</sup>	0.31
Extension agency contact	17.86 <sup>**</sup>	0.40
Extension participation	10.89 <sup>*</sup>	0.32
Information seeking behaviour	8.52 <sup>*</sup>	0.29
Distance from ATIC	4.66 <sup>NS</sup>	0.22

#### Extent of contribution of characteristics of beneficiary farmers on knowledge regarding the activities of ATIC

Data presented in the Table 4 revealed that, the variables like scientific orientation, information seeking behavior and cosmopoliteness had positive and significant relationship with their knowledge level regarding the activities of ATIC. However remaining variables indicated in the table did not show any significant relationship. The co-efficient of determination ( $R^2$ ) of the independent variables was 0.695 meaning that 69.5 per cent of total variation in the knowledge was explained by the 16 selected independent variables put together. Hence, these variables could be considered as good predictors of knowledge level regarding the activities of ATIC. It also implied that there might be other variables contributing to the variation not included in the present study which would pave way for further probing.

TABLE 4

Extent of contribution of characteristics of beneficiary farmers on knowledge regarding the activities of ATIC (n=90)

Independent variables	Regression co-efficient ( $\beta$ )	Standard Error	't' value
Age	0.081	0.695	0.10
Education	0.296	0.897	0.12
Family size	0.193	1.105	0.34
Annual income	0.183	0.257	1.05
Size of Landholding	0.113	0.247	1.90
Farming experience	0.796	1.198	0.47
Scientific orientation	1.397	0.400	3.49 <sup>**</sup>
Risk orientation	0.632	0.897	1.70
Achievement motivation	0.494	1.122	0.82
Innovative proneness	0.389	0.776	0.93
Cosmopoliteness	1.386	0.398	2.98 <sup>**</sup>
Mass media exposure	0.121	0.175	1.36
Extension agency contact	0.315	0.558	0.63
Extension participation	0.362	0.558	0.631
Information Seeking Behaviour	0.783	0.335	2.37 <sup>*</sup>
Distance from ATIC	0.145	0.258	1.36

$R^2$  0.695

\*\* Significant at 1 per cent level \* Significant at 5 per cent level  
NS- Non-Significant

Similar results were noted by Kavitha *et al.* (2014), Preethi *et al.* (2017) and Patel (2018).

More than one third of the beneficiary farmers belonged to medium knowledge category which means that majority of the beneficiary farmers still do not have complete knowledge regarding the overall activities of ATIC. It indicates that there is a scope to expand more approaches for increasing the knowledge level of farmers. Further, educational programmes about the activities of ATIC have to be strengthened. It was noticed that only few beneficiary farmers had knowledge with respect to agri-portal service and availability of feedback services. Hence there is a need to create awareness and enhance the knowledge about

the services of ATIC through workshops, interpersonal meetings and mass media. However, the results cannot be generalized since it is region specific and there is a need to conduct similar studies involving the established ATICs across the country.

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## Nutrient Composition of Drumstick Leaves (*Moringa oleifera*) with Different Drying Methods

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### ABSTRACT

This research was carried out to investigate the four different drying methods *i.e.*, shade, sun, oven and tray drying on the proximate composition and some minerals of *Moringa oleifera*. The proximate analysis and some minerals were analyzed using standard analytical procedures. The study revealed that the tray drying method was observed suitable for dehydration of drumstick leaves. The results revealed that four different drying methods varied from 4.26 to 6.30 per cent, 19.86 to 25.42 g, 2.79 to 4.44g, 10.17 to 14.90g, 7.60 to 9.80g, 41.18 to 53.28g, 306 to 317 Kcal, 20.03 to 26.17mg, 86.03 to 168.30mg, 27597 to 35488.53 µg/100g for moisture, protein, fat, crude fibre, ash, carbohydrate, energy, iron, vitamin C and β - carotene. The study revealed that in tray drying method the retention of nutrients is more when compare to other processing methods and suitable for dehydration of *Moringa oleifera*.

*Keywords:* Oven drying, Tray drying, Shadow drying, Sun drying and *Moringa oleifera*

INDIA is one of the largest producers of fruits and vegetables in world. It is estimated that India processes less than 1 per cent of production and about 30-35 per cent production cannot be utilized due to lack of adequate technology for processing, handling, storage and processing infrastructure. Drying is the best method to increase the shelf life of fruits and vegetables (Agbede, 2012).

*Moringa oleifera* is one of the most widely cultivated species of a monogeneric family, the *Moringaceae*. The tree is an origin of Indian subcontinent and has become naturalized in the tropical and subtropical areas around the world. It grows best in dry sandy or loamy soil. India is the largest producer of *Moringa* and the annual production is between 1.1 to 1.3 million tonnes of tender fruits from an area of 380 km<sup>2</sup> The leaves are highly nutritious and also the rich source of beta-carotene, vitamin C, protein and iron (Farooq *et al.*, 2012).

It is used in the treatment diarrhoea, urinary disorder and gastric ulcer due to its antibacterial and anti-inflammatory action. *Moringa* leaves help to purify the blood, lowering of blood glucose and cholesterol level. In ethno medicine, *Moringa oleifera* leaves have been used by local traditional healers in

treatment of various ailments such as gastric discomfort, stomach ulcers, diarrhoea, dysentery and skin infections (Adeyemi, 2014).

In certain case of diabetes, *Moringa* can also be used to stabilize sugar levels and can stabilize arterial tension. The leaves have also been found to possess antitumour, antipyretic, antiepileptic, antiinflammatory, antiulcer, antispasmodic, diuretic, antihypertensive and antioxidant properties (Bukar *et al.*, 2010).

*Moringa oleifera* is one of the most helpful tropical trees and is generally grown at backside of the home. It is good sources of vitamins and minerals. *Moringa oleifera* tree emphasizing its nutritional applications for humans, industrial areas and its propagation methods, as not everyone knows the enormous benefits. It has significant source of bioactive compounds *viz.*, terpenoids, alkaloids, p - cymene, eugenol, chavicol, flavonoids, saponins, allyl catechol, estragol, caryophyllene, chavibetol, cineole etc. It is recognized for its food and nutritional value, with forage, medicinal and seasoning properties, being used in culinary, fuel, and cosmetics industries and in water treatment for human consumption (Parvathi *et al.*, 2015).

*Moringa* leaves can be used as a food for human consumption in addition to being used as feed or fodder for animals. It can be prepared in different forms for human consumption and eaten either raw or dry by animals. In the tropics, it is used as forage for livestock and in many countries as vegetables that have the potential to improve nutrition ensure food security, foster rural development and support sustainable land care (Ogbe and John, 2012). The objective of this study to investigate the four different drying methods *i.e.*, shade, sun, oven and tray drying on the proximate composition and some minerals of *Moringa oleifera*.

#### MATERIAL AND METHODS

The drumstick leaves samples were collected from the Horticulture Department, University of Agricultural Sciences, GKVK, Bengaluru. As represented in Fig. 1 the leaves were cleaned, dried with different processing methods.

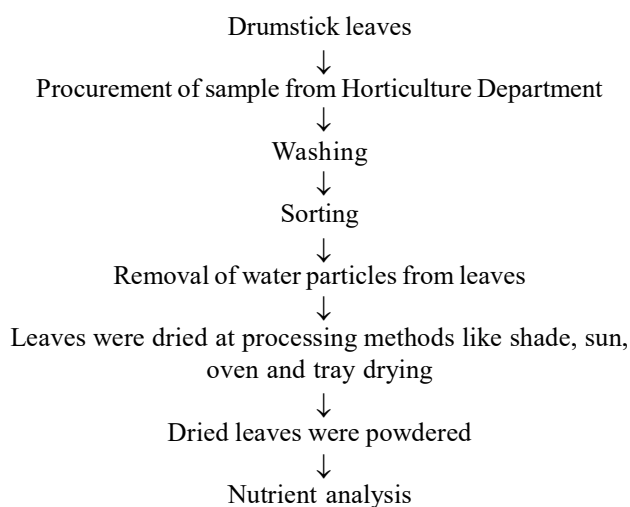


Fig. 1: Flow chart of different processing methods of drumstick methods

**Shade drying:** In this drying method the air dried leaves were spread on filter papers and kept in the room which was well ventilated. Natural current of air was used for 2 days.

**Sun drying:** In sun drying method the leaves were washed and kept for air drying and then put on the filter paper. Filter paper along with tray were placed at a where adequate amount of sunlight for 10 hours.

**Oven drying:** The oven was preheated to 60 °C and then the single layer loaded trays were kept. The temperature was maintained at 60 °C and the process was carried out for 6 hours.

**Tray drying:** In tray drying method, the fresh samples were washed with sufficient amount of luke warm water till it was free from dust, rodents. The leaves were spread on the tray and placed into the cabinet tray drier at 60 °C for 3 hours.

Dried leaves were ground to fine powder passed through a 60 mm mesh sieve and stored at ambient temperature for further use in High Density Polyethylene (HDPE) food grade packing of 350 gauges.

#### Effect of processing methods on nutrient composition of drumstick leaves

The processed drumstick leaves samples were subjected for nutrient analysis. The nutrients analyzed were moisture, protein, fat, crude fibre, ash, iron, vitamin - c and  $\beta$  - carotene by AOAC methods (AOAC, 1990). Carbohydrate and energy values were computed. All determinations were done in duplicates. One way analysis of variance was applied for nutritional analysis. The statistical analysis was done by using SPSS 16 software. Significant difference was defined as  $p \geq 0.05$ .

#### RESULTS AND DISCUSSION

Table 1 depicts, the mean score of proximate composition of different processing methods of drumstick leaves/100g.

The moisture content of the different processing methods of the dehydrated *Moringa oleifera* leaves powder was in the range of 4.26 -6.30 per cent. Maximum moisture content was in shade dried sample (6.30%) and minimum was in the tray dried sample (4.26%). The shade dried leaves had the highest moisture and relatively dried leaves obtained from tray drying method might be due to the extremely high temperature (60 °C for 3 hrs) applied at a moderately short time. This was because, during the long hours of drying, the heat was conducted from the surface to

TABLE 1  
Mean score of macronutrients of different processing methods from drumstick leaves/ 100g

Processing methods / Nutrients	Moisture(g)	Protein(g)	Fat (g)	Crude Fibre(g)	Ash (g)	Carbohydrates(g)	Energy (K Cal)
Shade drying	6.30	19.86	2.79	10.17	7.60	53.28	317
Sun drying	6.14	21.55	3.35	11.10	8.10	49.75	315
Oven drying	5.53	22.40	4.30	13.23	8.89	45.65	310
Tray drying	4.26	25.42	4.44	14.90	9.80	41.18	306
SEm±	0.02	0.09	0.04	0.13	0.10	0.12	0.19
CD at 5%	0.06	0.27	0.12	0.39	0.30	0.36	0.57

the interior of the leaves and the rate of evaporation of water on the surface of the leaves was faster than the rate of diffusion to the surface. This result was consistent with the findings (Amabye *et al.*, 2016).

The protein content of different processing methods of the dehydrated leaves was in the range of 19.86-25.42g. Maximum protein content was in the cabinet tray - dried sample (25.42 g) and minimum protein contained was recorded in the sun dried sample (19.86 g). The protein content was maximum in tray drying process due to the moisture loss (Foline *et al.*, 2011).

The fat content of different processing methods of the dehydrated leaves was in the range of 2.79-4.44 per cent. The fat content was highest in the tray dried samples (4.44) and lowest in the shade dried sample (2.79). In dehydrated leaves has higher amount of fat content as compared to the fresh one was reported by Aremu (2014).

The fibre content of the tray dried sample was highest in (14.90g) and the lowest was recorded in shade dried sample (10.17g). The highest fibre content was found more tray dried sample this may be due to the concentrated nutrient accumulated due to the loss of moisture.

The results showed that ash contents in tray dried sample were significantly higher when compared to the other processing methods. Ash content of dehydrated leaves was in the range of 7.60-9.80g.

Carbohydrate content of different processing methods of the dehydrated leaves was in the range of

41.18-53.28 g. The carbohydrate content in the dehydrated powder of shade dried sample was maximum (53.28g) and minimum was recorded in the tray dried sample (41.18g). Tray dried leaves relatively lost more carbohydrates than all the other drying methods because during the heating, the starch was turned to dextrin which drove off the water, whilst the sugar caramelised quickly and then burnt carbohydrates, which are usually lost during heating Satwase (2010).

The Energy content of processing methods of drum stick leaves ranges between 306 to 317 Kcal. The highest energy was found in shade drying (317 Kcal) and lowest in tray drying (306). It is due to the concentration effect through the removal of water content in drumstick leaves. The present study is on par with the studied conducted by the Aremu and Akintola (2014).

Fig. 2 represents the iron content of shade drying was 20.03g, sun drying 22.66g, oven drying 24.33g and tray drying 26.17/100g. The iron content was found to be more in tray dried sample it may be due to the concentration increased in total ash content.

Fig. 3 depicts the vitamin C content of different processing methods was 100.53, 86.03, 168.30, 133.16 mg/100g for shade drying, sun drying, oven drying and tray drying. The vitamin C content was highest in shade drying and lowest in tray drying. It may be due to the vitamin C and a heat labile and is destroyed when exposed to direct sunlight and heat due to oxidation.

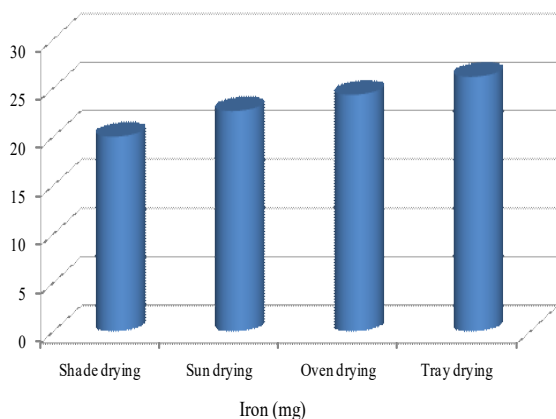


Fig.2: Iron content of different processing methods of drumstick leaves

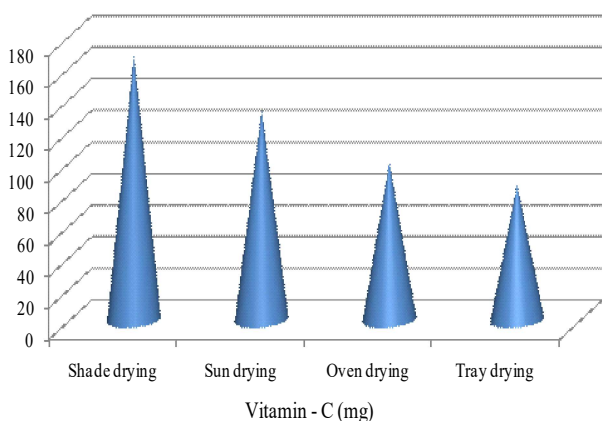


Fig.3: Vitamin C content of different processing methods of drumstick leaves

The present study is on par with the study conducted by the Joshi and Mehta (2010).

Fig. 4 represents the beta carotene content for shade drying, sun drying, oven drying, tray drying were 32.570, 67.275, 97.30, 35488.53 and 30146.57  $\mu\text{g}/100\text{g}$ . The  $\beta$  carotene content is highest in shade drying and lowest in tray drying and it is due to the shade drying though took longer than sun, tray and oven drying carotene losses were lowest in the shade dried sample and it is dependent on the method of drying.

From the results of the present study, it can be concluded that the different processing methods of *Moringa oleifera* was found to be having all the nutrients in good amounts and possess good nutritive value interims both micro and macro minerals. Tray

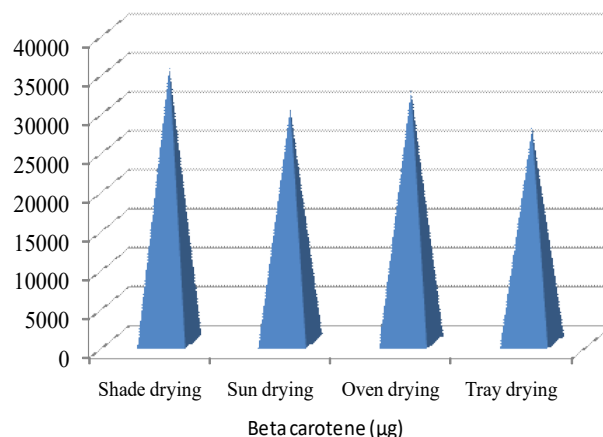


Fig. 4: Beta carotene content of different processing methods of drumstick leaves

drying method was the best method of dehydration of drumstick leaves. The nutrients like protein, fat, crude fibre, ash and iron retained more in tray as compared to the shade, oven and sun drying methods but Vitamin C and beta carotene was more in shade dray method than other three drying methods. Dehydration was one of the most possible strategies for preservation of green leafy vegetables, which were highly seasonal and perishable too. Value added products can be developed by using drumstick leaves powder in future studies.

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## Physico Chemical Parameters and Shelf Life Study of Murabba, Developed from Mango Ginger (*Curcuma amada*)

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### ABSTRACT

Mango ginger (*Curcuma amada*) is rhizomatous aromatic herb of the family *Zingiberaceae*. The fresh cut rhizomes have the flavor and the color of mango and resemble ginger in morphology hence the name mango ginger. The rhizomes are sweet, sour aromatic and bitter. Mango ginger is valued for their medicinal properties. It is used in the treatment of anorexia, dyspepsia, flatulence, colic, bruises, wounds, chronic ulcers, skin diseases, fever, constipation, cough, bronchitis, sprains, gout, halitosis, and inflammations. Hence, the present study was undertaken to standardize the process of *murabba* development and study its shelf life. Among four variations MGM1 (Control), MGM2 (12.5 %), MGM3 (25 %) and MGM4 (37.5 %) with different levels of mango ginger incorporation. MGM4 was best accepted with overall acceptability of 8.02. MGM1, MGM3 and MGM4 were kept in glass jars and sensory characteristics, physico-chemical parameters and microbial population was studied on initial, 30<sup>th</sup> and 60<sup>th</sup> day of storage. Sensory score of control increased from 7.85 to 7.88 and MGM4 decreased from 8.02 to 8.00. Among physico-chemical parameters pH in control decreased from 2.79 to 2.38 and MGM4 3.10 to 2.90. TA increased from 0.49 to 0.83 and 0.21 to 0.29 in control and MGM4, respectively. TSS decreased from 73.0 to 72.5 in Control and 77.0 to 76.5 in MGM4. Microbial study revealed that yeast population decreased from  $2 \times 10^2$  cfu to nil in MGM4. Moulds increased from nil to  $1.05 \times 10^2$  cfu. *Coliforms* were not observed throughout study. Hence, value added product with good shelf life can be developed from mango ginger.

*Keywords:* Mango ginger, Murabba, Shelf life and Aromatic herb

MANGO ginger (*Curcuma amada*) is rhizomatous aromatic herb of the family *Zingiberaceae*. The fresh cut rhizomes have the flavor and the color of mango and resemble ginger in morphology hence the name mango ginger. It originated in Indo-malayan region, and is cultivated throughout India, Sri Lanka, Bangladesh and in many South-East Asian countries for its rhizomes (Ravindran *et al.*, 2004). It is found wild in parts of West Bengal and is cultivated in Gujarat, Uttar Pradesh, Kerala, Karnataka, Tamil nadu and north eastern states. The rhizomes are sweet, sour aromatic and bitter (a mixture of tastes, starting from sweet initially, turning to a sour aromatic and then bitter sensation).

Mango ginger is valued for their medicinal properties. It is used as an appetizer, carminative, digestive, stomachic, demulcent, febrifuge, alexeteric, aphrodisiac, laxative, diuretic, expectorant, anti-inflammatory and antipyretic and used in the

treatment of anorexia, dyspepsia, flatulence, colic, bruises, wounds, chronic ulcers, skin diseases, pruritus, fever, constipation, hiccup, cough, bronchitis, sprains, gout, halitosis and inflammations. A whole mango ginger plant paste with crushed long peppers (*Piper longum*) is reported to be effective for the treatment of piles, and a decoction of the rhizome with common salt is an effective treatment for colds and coughs and is used to improve blood quality. The antioxidant activity of mango ginger has shown to suppress multiple signaling pathways and inhibit cell proliferation, invasion, metastasis, and angiogenesis (Kunnumakkara *et al.*, 2008). Its safety combined with its low cost, and multiple targeting potential makes *C. amada* an ideal agent to be explored for prevention and treatment of various cancers and fits very well as a candidate for chemo prevention by edible phytochemicals (Aggarwal, 2008).

It is used in South Asian and South East Asian as well as Far East Asian cuisines and, most commonly, in Thai cooking. In India, it is most widely used in chutneys and pickles. It is prepared for use in cooking like fresh ginger. Hence, present study was undertaken to develop *murabba* (fruit preserve) out of mango ginger and study its shelf life.

#### MATERIAL AND METHODS

##### Procurement

Mango ginger rhizomes were procured from local market, Malleshwaram, Bengaluru. They were thoroughly washed under running water to remove dirt and mud.

##### Product development

Washed fresh mango ginger rhizomes were peeled and grated into small pieces and *murabba* was prepared by incorporating at different levels with mango.

##### Mango ginger *murabba*

Three variations of mango ginger *murabba* containing different levels of fresh peeled and grated mango ginger (12.5, 25 and 37.5 per cent) were prepared as indicated in figure 1 and quantity of ingredients used are represented in Table 1. *Murabba* prepared with

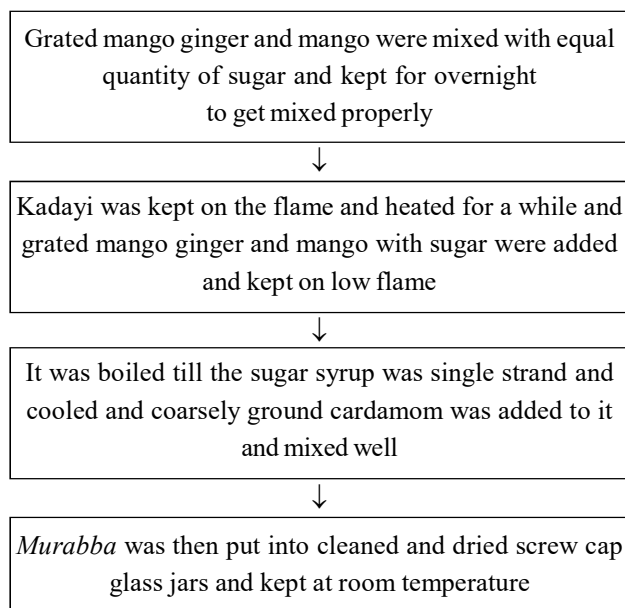


Fig. 1: Procedure for preparation of mango ginger *murabba*

TABLE 1  
Development of mango ginger *murabba*

Ingredients (g)	Quantity			
	MGM1 (Control)	MGM2	MGM3	MGM4
Peeled and grated mango	50	37.50	25	12.50
Peeled and grated mango ginger	-	12.50	25	37.50
Sugar	50	50	50	50
Cardamom (No.)	1	1	1	1
Total	100	100	100	100

MGM1- Mango ginger *murabba* 1 (Control), MGM2- Mango ginger *murabba* 2, MGM3- Mango ginger *murabba* 3, MGM 4- Mango ginger *murabba* 4

only grated mango, without any incorporation of grated mango ginger was considered as the control.

##### Sensory evaluation

All the variations of mango ginger *murabba* along with control were given for evaluation to 21 semi trained panelists. 9-point hedonic scale was used for evaluation.

##### Nutrient composition of the developed products

Nutrient composition of the best accepted *murabba* variation and control was computed based on the nutritional composition of the ingredients (Gopalan *et al.*, 2009 and Longvah *et al.*, 2017)

##### Shelf life studies

Three variations of mango ginger *murabba* (Control, 25% and 37.5%) were stored in 9 different screw cap glass jars. on the day of preparation and kept at room temperature for 60 days. The stored samples were analyzed for organoleptic characteristics, physico-chemical parameters and microbial population on initial, 30<sup>th</sup> and 60<sup>th</sup> day according to standard protocol.

#### RESULT AND DISCUSSION

##### Sensory evaluation of mango ginger *murabba*

Mango ginger *murabba* MGM4 was best accepted with sensory scores of 8.04, 7.71, 7.88, 7.00, 8.07, 7.97 and 8.02 for appearance, consistency, texture,

sweetness, sourness, taste, flavor and overall acceptability respectively. Mean sensory scores of *murabba* are depicted in Table 2 and figure 2.

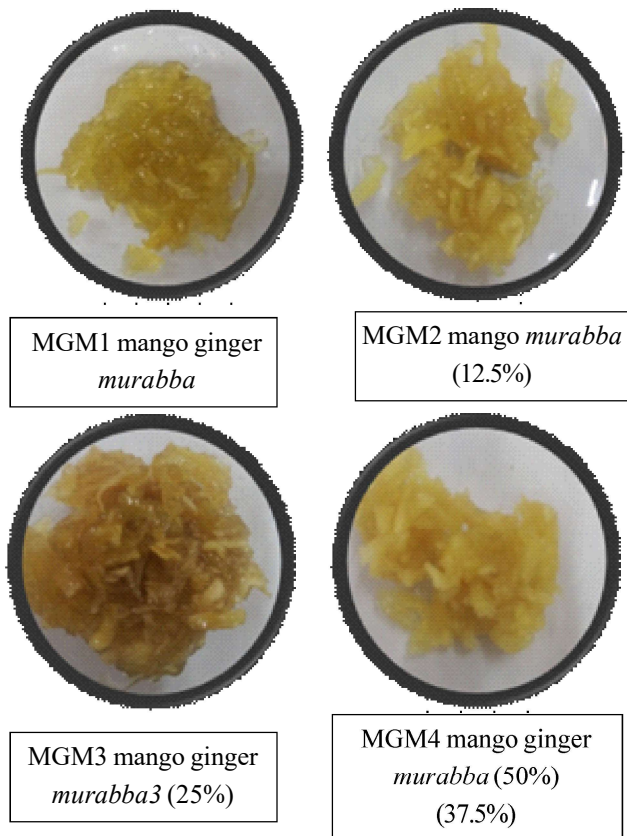


Plate 1: Mango ginger *murabba*

MGM1 (Control) scored 7.71, 7.80, 7.66, 7.57, 7.16, 8.07, 7.95 and 7.85 for appearance, texture, consistency, sweetness, sourness, taste, flavor and overall acceptability respectively. Sensory evaluation scores for overall acceptability showed that MGM4 (8.02), followed by MGM1 (7.85), MGM2 (7.71) and MGM3 (7.47) was scored least. The statistical analysis showed that there was a significant difference in mean sensory scores for texture, sweetness, taste and flavor, whereas, appearance, consistency, sourness and overall acceptability showed non significant difference at 5 per cent level of significance among the variations.

MGM4 made up of 37.5 per cent mango ginger *murabba* scored higher than control. It might be due to yellow color of mango ginger giving brighter appearance, possess mango as well as ginger aroma and flavor.

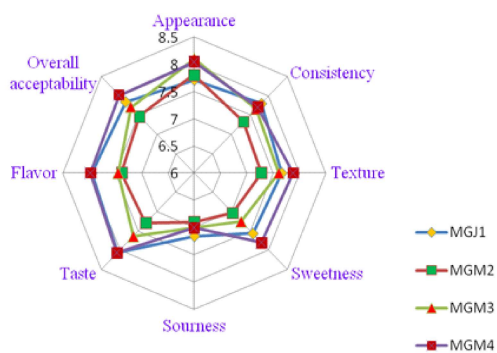
Similar results were obtained by Inam *et al.* (2012) who developed mixed fruit marmalades from malta, mango and pineapple juices at different ratios. Sample containing malta juice: mango juice: pine-apple juice in the ratio of 2:1:1 scored higher among other variations 8.417 for color, 8.083 for flavor, 8.167 for texture, 7.917 for overall acceptability.

TABLE 2  
Mean scores for sensory attributes of mango ginger *morabba*

Products	Sensory attributes							Overall acceptability
	Appearance	Consistency	Texture	Sweetness	Sourness	Taste	Flavor	
MGM1	7.71	7.80	7.66	7.57	7.16	8.07	7.95	7.85
MGM2	7.80	7.33	7.28	7.04	6.90	7.30	7.38	7.47
MGM3	8.09	7.66	7.61	7.26	7.00	7.64	7.45	7.71
MGM4	8.04	7.71	7.88	7.80	7.00	8.07	7.97	8.02
F value	NS	NS	*	*	NS	*	*	NS
SEm±	0.181	0.245	0.195	0.250	0.277	0.182	0.174	0.704
CD at 5%	-	-	0.549	0.704	-	0.512	0.489	-

\* Significant at 5% and NS- Non significant at 5%

MGM1- Mango ginger *murabba*1 (Control), MGM2Mango ginger *murabba*2(12.5%), MGM3Mango ginger *murabba*3(25%), MGM3Mango ginger *murabba*4(37.5%)



MG1-Control    MG2-12.5%    MG3-25%    MG4-37.5%

**Computation of nutritional composition of the developed products**

Macronutrient and micronutrient composition of the control and best accepted variation of murabba is computed and represented in Table 3 and Table 4.

*Murabba* had lower moisture content (84.20 %) and higher protein, fat and ash (0.67, 0.52 and 0.75 g/100 g) and lower energy 51.90 Kcal when compared with control which has 84.84 per cent, 0.28, 0.43, 0.35 g/100g and 58.33 Kcal moisture, protein, fat, ash and energy respectively.

**Shelf life study of the developed products**

**Sensory evaluation**

In control there was no significant difference in consistency and flavor throughout the storage period.

But there was significant decrease in appearance and texture from 7.71 to 7.23 and 7.66 to 7.62 respectively. However there was increase in scores for sweetness (7.57 to 7.63), sourness (7.16 to 7.18), taste (8.07 to 8.23) and overall acceptability (7.8 to 7.88).

In MGM3 there was no significant difference for sourness, taste, flavor and overall acceptability throughout storage period of 60 days whereas there was significant decrease in appearance (8.09 to 7.96) and consistency (7.66 to 7.54) and there was significant increase in sweetness (7.26 to 7.32). But mean score of all attributes showed that values were in between 7.00 to 8.09 showing that *murabba* was acceptable in the range between moderately like to like very much on till 60<sup>th</sup> day of the storage.

In MGM4 there was no significant difference in sweetness, sourness, taste, flavor and overall acceptability but, there was significant decrease in appearance, consistency and texture and this might be due to slight crystallization of sugar. Similar findings were reported by Anna *et al.* (2018) who reported that for consistency, aroma and flavor the score of 5.00 throughout the storage period of 12 months. However, there was increase in appearance and color (4.6 to 5.0) of gooseberry jam stored at 20 °C which were not in line with present study. This may be

TABLE 3  
Macro nutrient composition of developed products (per 100g)\*

Products	Moisuture %	Protein (g)	Fat (g)	Total ash (g)	Crude fiber (g)	Carbohydrate (g)	Energy (Kcal)
<i>Murabba</i> Control	84.84	0.28	0.43	0.35	1.21	12.92	58.33
MGM4	84.2	0.67	0.52	0.75	2.26	10.74	51.90

\*- Computed values

TABLE 4  
Macro nutrient composition of developed products (per 100g/ml)\*

Products	Vitamin C (mg)	Calcium (mg)	Magnesium (mg)	Potassium (mg)	Phosphorus (mg)	Sodium (mg)	Iron (mg)
<i>Murabba</i> Control	6.35	37.90	53.28	391.68	45.33	9.44	3.26
MGM4	2.92	33.27	37.26	370.98	66.90	5.37	3.62

\*- Computed values

TABLE 5  
Mean sensory score for shelf life studies of Mango ginger *murabba*

Products	Sensory Attributes								Overall acceptability
	Duration	Appearance	Consistency	Texture	Sweetness	Sourness	Taste	Flavor	
MGM1	Initial	7.71	7.80	7.66	7.57	7.16	8.07	7.95	7.85
Control	30 <sup>th</sup> day	7.50	7.63	7.63	7.65	7.20	8.20	7.96	7.89
	60 <sup>th</sup> day	7.23	7.48	7.62	7.63	7.18	8.23	7.95	7.88
	F value	*	NS	*	*	*	*	NS	*
	SEm±	0.010	0.193	0.008	0.008	0.006	0.008	0.006	0.006
	CD at 5%	0.035		0.029	0.029	0.021	0.029		0.021
MGM3	Initial	8.09	7.66	7.61	7.26	7.00	7.64	7.45	7.71
	30 <sup>th</sup> day	7.99	7.62	7.58	7.30	7.03	7.67	7.45	7.73
	60 <sup>th</sup> day	7.96	7.54	7.57	7.32	7.02	7.65	7.45	7.72
	F value	*	*	NS	*	NS	NS	NS	NS
	SEm±	0.006	0.006	0.010	0.010	0.008	0.012	0.006	0.008
	CD at 5%	0.021	0.021		0.035				
MGM4	Initial	8.04	7.71	7.88	7.80	7.00	8.07	7.97	8.02
	30 <sup>th</sup> day	8.02	7.66	7.85	7.80	7.00	8.05	7.96	8.00
	60 <sup>th</sup> day	7.99	7.62	7.81	7.78	7.00	8.03	7.94	8.00
	F value	*	*	*	NS	NS	NS	NS	NS
	SEm±	0.008	0.011	0.010	0.008	0.006	0.010	0.008	0.008
	CD at 5%	0.029	0.040	0.035					

\*- Significant at 5 per cent and NS-Non significant

MGM3 - Mango ginger murabba 3 (25 %), MGM4- Mango ginger murabba 4 (37.5 %)

because in the present study the *murabba* was stored at room temperature ( $33 \pm 2$  °C).

#### Shelf life study by physico chemical parameters

Physico-chemical parameters like pH, titrable acidity and total soluble solids of best accepted variations of mango ginger *murabba* and mango ginger *tokku* along with control were analyzed. For *murabba* the analysis was done on the initial, 30<sup>th</sup> and 60<sup>th</sup> day and for mango ginger *tokku*, it was done on initial, 4<sup>th</sup> day and 8<sup>th</sup> day of storage.

In control sample pH was decreased from 2.79 to 2.38. In MGM3 the decrease was from 2.95 to 2.63 and In MGM4 the decrease was from 3.10 to 2.90. pH and TA seem to be very close with values reported by

Inam *et al.* (2012) who noted decrease of pH of mixed fruit marmalade from 2.87 to 2.73 within 90 days of storage period and increment of TA 0.74 to 0.84.

Titrable acidity of all three variations of mango ginger *murabba* (control, MGM3 and MGM4) increased significantly from initial day to 60<sup>th</sup> day of storage. Rise in titrable acidity was from 0.49 to 0.83 in control, 0.38 to 0.43 in MGM3 and 0.21 to 0.29 in MGM4 and this may be due to decrease in pH.

Similar observations were reported by Brandao *et al.* (2018) who noted that titrable acidity of mixed cerrado fruit jam increased from 0.41 to 1.2 per cent during a storage period of 140 days.

TABLE 6  
Physico-chemical parameters of mango ginger *murabba* at different intervals on storage

Physico-chemical parameters	Products	Duration (days)			
		Initial	30 <sup>th</sup> day	60 <sup>th</sup> day	Mean
pH	Control	2.79	2.50	2.38	2.557
	MGM3	2.95	2.67	2.63	2.750
	MGM4	3.10	2.95	2.90	2.983
	Mean	2.947	2.707	2.637	
		F value			CD at 5%
	Treatment	*	0.006		0.019
	Duration	*	0.006		0.019
	T×D	*	0.011		0.032
TA		Initial	30 <sup>th</sup> day	60 <sup>th</sup> day	Mean
	Control	0.49	0.68	0.83	0.667
	MGM3	0.38	0.42	0.43	0.410
	MGM4	0.21	0.23	0.29	0.243
	Mean	0.36	0.44	0.51	
		F value			CD at 5%
	Treatment	*	0.005		0.015
	T×D	*	0.009		0.026
TSS		Initial	30 <sup>th</sup> day	60 <sup>th</sup> day	Mean
	Control	73.00	73.00	72.50	72.83
	MGM3	72.50	72.00	72.00	72.00
	MGM4	77.00	76.00	76.50	73.82
	Mean	74.16	73.66	73.66	
		F value			CD at 5%
	Treatment	*	0.054		0.163
	T×D	*	0.094		0.282

\*-Significant, NS- Non significant

MGM3 - Mango ginger *murabba*3 (25 %), MGM4 - Mango ginger *murabba*4 (37.5 %)

Total soluble solids in control decreased slightly from 73.00 per cent to 72.5 per cent and from 72.5 to 72 per cent in MGM3 and decreased more in MGM4 from 77.00 to 76.50 in *murabba*. It can be due to utilization of sugar by yeast. Similarly decrease in TSS was reported by Rababah *et al.* (2014) in Cherry jam which increased from 66.80 (%) to 66.30 (%) during storage period of 15 days.

#### Shelf life study by microbial population

Microbial population was estimated for yeast, mould and *coliforms* by standard plate count method. The yeast population increased from  $1.65 \times 10^2$  cfu/gm to  $2.00 \times 10^2$  cfu/gm, whereas yeast population decreased from  $1.66 \times 10^2$  cfu/gm to  $0.16 \times 10^2$  cfu/gm in MGM3 and  $2.00 \times 10^2$  cfu/gm to nil in MGM4. Yeast population might have decreased because of decrease in available sugar.

TABLE 7  
Microbial population of mango ginger *murabba* at different intervals of storage

Organisms	Products	Duration			Mean
		0 day	30 <sup>th</sup> day	60 <sup>th</sup> day	
Yeast (× 10 <sup>2</sup> CFU/ g)	Control	1.65 (1.466)	1.65 (1.466)	2.00 (1.581)	1.504
	MGM3	1.66 (1.469)	0.66 (1.077)	0.16 (0.812)	1.119
	MGM4	2.00 (1.581)	0.22 (0.848)	0.00 (0.707)	0.712
	Mean	1.505	1.130	1.033	
		F-value	SEm±	CD at 5%	
	Treatment	*	0.000	0.001	
	Duration	*	0.000	0.001	
	T×D	*	0.001	0.002	
		0 day	30 <sup>th</sup> day	60 <sup>th</sup> day	Mean
	Mould (× 10 <sup>2</sup> CFU/ g)	Control	0.00 (0.707)	0.00 (0.707)	2.25 (1.658)
MGM3		0.00 (0.707)	0.00 (0.707)	0.00 (0.707)	0.707
MGM4		0.00 (0.707)	0.00 (0.707)	1.05 (1.244)	0.886
Mean		0.707	0.707	1.203	
		F-value	SEm±	CD at 5%	
Treatment		*	0.000	0.001	
Duration		*	0.000	0.001	
T×D		*	0.001	0.002	
		0 day	30 <sup>th</sup> day	60 <sup>th</sup> day	Mean
Coliforms (× 10 <sup>2</sup> CFU/ g)		Control	0.00 (0.707)	0.00 (0.707)	0.00 (0.707)
	MGM3	0.00 (0.707)	0.00 (0.707)	0.00 (0.707)	0.707
	MGM4	0.00 (0.707)	0.00 (0.707)	0.00 (0.707)	0.707
	Mean	0.707	0.707	0.707	
		F-value	SEm±	CD at 5 %	
	Treatment	NS	0.00	-	
	Duration	NS	0.00	-	
	T×D	NS	0.00	-	

\*-Significant, NS- Non significant  
MGM3-Mango ginger *murabba*3 (25%), MGM4- Mango ginger *murabba*4 (37.5 %)  
Values in parenthesis indicate ( $\sqrt{x + 0.5}$ )

There were no mould colonies reported in control, MGM3 and MGM4 till 30 days of storage. Mould population of  $2.25 \times 10^2$  cfu/gm in control and MGM3 and  $1.05 \times 10^2$  cfu/gm in MGM4 respectively was observed on 60<sup>th</sup> day and this might be due to decrease in pH.

There were no *coliforms* colonies reported till 60 days of storage in all three variations. The water was not used in the preparation of *murabba* and this may be the reason for no *coliform* colonies. As per the report of Venugopalan *et al.* (2014) hexane, ethyl acetate, dichlorometane and acetone extracts of *Curcuma amada* were effective against *Escherichia coli*, *Pseudomonas aeruginosa*, and *Staphylococcus aureus*.

Mango ginger *murabba* can be developed as value added product and can be stored for 60 days with acceptable sensory scores, microbial population and physic-chemical parameters. MGM 4 was best accepted than control.

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## AGRICULTURAL ECONOMICS

### Role of Institutions, Technologies, Markets and Governance in Irrigation Tank Management in Central Dry Zone of Karnataka - An Economic Analysis

S. C. RAVI

THE present study was undertaken in Central Dry Zone of Karnataka to estimate the role of institutions, technologies, markets and governance in irrigation tank management. Two tanks Bukkarayanakere (farmers managed) and Ayyanakere (Minor Irrigation Department - MID managed) in Kadur taluk of Chikkamagaluru district were chosen purposively in addition to control area where farmers had no access to tank irrigation. The required data was collected from 90 farmers from each regime. Innovative institution in distribution of tank water was followed in farmers managed tank area where water was distributed from tail to head reach farms. Whereas, in MID managed tank area there was non-equity in the distribution of tank water. Net returns per ha, economic and physical water use efficiency was higher in farmers managed tank area than MID managed tank area. Returns per rupee of expenditure on irrigation water were higher in tank command managed by farmers than MID managed tank command. Partial budgeting of micro irrigation technology over flood irrigation in arecanut+coconut revealed that, net gain from micro irrigation was Rs.1,17,557 per ha. The profitability of adopting mechanical dehusking over manual dehusking was Rs.28,989 per ha. The mean willingness to pay for assured irrigation and equity in distribution of water was Rs.894, Rs.809 and Rs.895 per acre per year by the farmers in farmers managed tank, MID managed tank and control area, respectively. The average net returns per ha was higher by Rs.43,079, Rs.85,162 and Rs.85,036 in arecanut, arecanut + coconut and arecanut + coconut + banana, respectively for conjunctive use farms than groundwater use farms. Transaction cost incurred per ha was high in MID managed tank (Rs.2782) than farmers managed tank (Rs.491). The study emphasizes the need of innovative institutions to realize higher net returns, equitable distribution of tank water and to reduce transaction cost.

2018

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## AGRICULTURAL ENTOMOLOGY

### Molecular Diversity of *Conogethes* spp. Guenee, (*Lepidoptera* : *crambidae*) Infesting on Select Hosts in the Indian Sub - Continent

VASUDEV KAMMAR

MOTHS of *Conogethes* spp. are economically important polyphagous pests infesting >120 wild and cultivated crops worldwide. Study was undertaken to unravel the difference between *Conogethes* spp. populations feeding on castor and cardamom. Based on the morphological and molecular studies *Conogethes* feeding on cardamom was diagnosed as *C. sahyadriensis* and on castor as *C. punctiferalis*. Results revealed that nucleotide variations occurred between *C. punctiferalis* and *C. sahyadriensis* to an extent of 5.32 per cent indicating high genetic divergence. The pairwise genetic distance analysis between the *Conogethes* species varied from 0.000 to 0.043. Within a *Conogethes* species complex, the two *Conogethes* species (*C. punctiferalis* and *C. sahyadriensis*) were formed in to two distinct clades and results revealed divergence of *C. punctiferalis* and *C. sahyadriensis* apparently began around 0.03 mya. The haplotypes network analysis substantiated the results by showing distinct haplotypes. We opined that speciation of *C. punctiferalis* and *C. sahyadriensis* seems to have independent lineages and diversification may be host-related as *C. punctiferalis* is a polyphagous species while *C. sahyadriensis* is oligophagous preferring Zingiberaceae crop plants. Under the lock-and key hypothesis, allometric relationships between somatic and genitalic traits of both sexes of each species and observed that, male genital and associated structures were prone to changes more than the female genitalia associated structures. Further species-specific markers based on COI gene were identified for *Conogethes* species for rapid identification of these pests in India. Developed markers can be used to identify *Conogethes* populations which are indistinguishable and cryptic in nature. In this study clearly established that two species of *Conogethes* remained skewed for a long time in India and many other neighboring countries despite several studies on different aspects of the two *Conogethes* populations.

2018

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## Standardization of Mass Rearing Technique and Field Evaluation of Pheromone of Shoot and Fruit Borer, *Conogethes* spp. (Lepidoptera : Crambidae) on Select Host Plants

K. P. KUMAR

STUDIES conducted on standardization of mass rearing technique and field evaluation of pheromone of shoot and capsule borer, *Conogethes* spp. (Lepidoptera : Crambidae) on selected host plants brought out striking differences in the pest species. The studies on artificial diet clearly showed that the diets incorporated with castor and cardamom powders were suitable for growth and development of *C. punctiferalis* and *C. sahyadriensis*, respectively. Further studies on standardization of other ingredients in the diet like Casein 35g/ml, Vit-E capsule (1g/ml), Sorbic acid (1g/ml), Methyl parahydroxy benzoate (2g/ml) and Streptomycin sulphate (0.5g/ml) recorded higher percentage of fecundity, survivability and pupal weight of *C. punctiferalis* and *C. sahyadriensis*. Field observations on seasonal incidence of *C. punctiferalis* in castor fields revealed that maximum infestation occurred during November to December. The incidence of *C. sahyadriensis* in cardamom plantations was maximum cardamom shoot during May and in capsule during October to November which coincided with tillering and capsule formation. Similarly, in ginger plantations results revealed that maximum borer infestation occurred during September to October. The influence of abiotic factors showed that temperature and relative humidity played a major role in the incidence of these borers in cardamom, castor and ginger. Studies on standardization of trapping technique indicated that all the traps baited with pheromone lures had significantly higher catches over the traps without pheromone lures. Among four types of traps (delta, water, funnel and cross-vane trap) tested, delta trap with lure (contained (*E*)-10-hexadecenal (E10-16: Ald), (*Z*)-10-hexadecenal (Z10-16: Ald) and hexadecenal (16: Ald) at 100:8:16) proved the most effective for trapping males of *C. punctiferalis* moths compared to other traps. Further studies on colour and height of traps revealed that yellow delta traps installed at the crop canopy level trapped maximum moths of *C. punctiferalis*.

2018

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## Studies on Population Dynamics, Host Age Preference and Management of Grape Stem Borer *Celosterna scabrator* Fab. (Cerambycidae : Coleoptera)

N. D. SUNITHA

INVESTIGATIONS on species identity, population dynamics, nature of damage, larval preference for age and physiological condition of host plant and evaluation of different methods of management of cerambycid stem borer were carried out between 2015-18 in the grape orchards of Vijayapura district, Horticulture Research Station, Tidagundi and Department of Agricultural Entomology, College of Agriculture, Vijayapura. All the experiments were carried out in orchards with Thompsons seedless variety. Studies on species identity indicated the presence of *Celosterna scabrator* Fab. (1871). Investigations on population dynamics revealed that *C. scabrator* has staggered emergence patterns and emerge between 26<sup>th</sup> SMW and 32<sup>nd</sup> SMW and continue to emerge up to 52<sup>nd</sup> SMW (Between June to December). Grubs were active in vine orchards for a period of 6-8 months and the period of their activity depended on emergence of adults. Significant positive correlation was found between length of tunnel, quantity of wood powder and excreta ejected from live tunnels and stage of the grub. Mean feeding duration of grubs and adults of *C. scabrator* was 209.70 ± 9.49 and 21.90 ± 0.98 days respectively. There was significant reduction in the fruit yield due to infestation by *C. scabrator*. Significantly highest mean yield of 9.05 kg/vine was recorded from healthy grape vines as against 3.95 kg /vine from grape vines affected by *C. scabrator*. One and two years aged vine orchards recorded significantly lowest mean live tunnels (8.30 ± 2.86 and 11.15 ± 5.75, respectively). Grape vines stressed by other biotic and abiotic factors recorded significantly highest mean number of live tunnels (37.43 ± 5.15) and unstressed grape vines recorded 19.56 ± 2.63 mean live tunnels. Stem injection with DDVP 76 per cent EC @ 8.00 per cent was found significantly superior to other treatments in the management of *C. scabrator*. Highest cost benefit ratio (1:2.83) was obtained in soil application of Chlorantraniliprole 0.4 per cent G @ 20.00 gm/vine.

2018

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## AGRICULTURAL EXTENSION

### A Study on Entrepreneurial Behaviour of Rural Youth Practicing Integrated Farming System in Chamarajanagara District

N. T. NARESH

THE present study was conducted in Chamarajanagara district of Karnataka state during 2016-17 to analyse the entrepreneurial behaviour of rural youth practicing IFS. The data was collected from total sample of 160 rural youth using pre-tested interview schedule through personal interview method. Standardized scale to measure the entrepreneurial behaviour of rural youth practicing IFS was developed and found reliable, valid and internally consistent. The overall entrepreneurial behaviour of rural youth revealed that majority of them (70.00 %) had medium to high level of entrepreneurial behavior. The relationship between land holding, training received and competition orientation were significant and positive association at one per cent level of significance whereas, the education, family annual income, extension contact, extension participation, mass media exposure, social participation, cosmopolitanism and farm assets were significant at five per cent level of significance. The linear multiple regression analysis showed that, education, land holding, family annual income, extension participation, mass media exposure, social participation, cosmopolitanism, training received, farm assets and competition orientation was showing significant contribution at 1 per cent level of significance. Limited and irregular power supply (86.25 %), High cost of inputs (86.25%), inadequate subsidy (85.00%), exploitation by the middle men in the markets (83.12 %), lack of clinical services for livestock (78.75 %) were the major constraints faced by the rural youth. Suggestions expressed by them were availability of quality seeds at affordable price, inputs should be made available at cheaper rate, assured irrigation facility, credit should be made available at cheaper interest rate. The majority of rural youth were involved in integration of various enterprises. This kind of livelihood could be seen as a good sign of sustainability. Small and marginal farmers could cope with and recover from stress and shocks and thereby reduce their vulnerability in conventional farming through IFS.

2018

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## AGRICULTURAL MICROBIOLOGY

### Evaluation of Different Inoculant Consortium Formulations on Finger Millet (*Eleusine coracana* L. Gaertn.) and Green Gram (*Vigna radiata* L.)

VIJAYKUMAR GANGARADDI

AN investigation was carried out to study the survival of agriculturally important micro organisms (*Azotobacter chroococcum*, *Rhizobium* sp., *Bacillus megaterium* and *Pseudomonas fluorescens*) in four different formulations (alginate based, fluid bed dryer based, lignite and liquid formulations) and their effect on plant growth promotion. After 180 days of survival study, it was evident from the results that the consortia of *Azotobacter chroococcum*, *Bacillus megaterium* and *Pseudomonas fluorescens* recorded higher population in triple inoculants followed by dual and single inoculants in liquid formulation followed by alginate, lignite and fluid bed dryer based formulations. Similar trends were observed in triple inoculants (*Rhizobium* sp., *Bacillus megaterium* and *Pseudomonas fluorescens*) recorded maximum populations followed by dual and single inoculants in liquid formulation followed by alginate, lignite and fluid bed dryer based formulations. Green house experiment revealed that the maximum plant height, number of leaves, chlorophyll content, shoot and root nitrogen concentration, shoot and root phosphorus concentration, shoot and root biomass and total biomass in finger millet was recorded in plants receiving triple inoculants of *Azotobacter chroococcum*, *Bacillus megaterium* and *Pseudomonas fluorescens*. In green gram, plants treated with triple inoculants of *Rhizobium* sp., *Bacillus megaterium* and *Pseudomonas fluorescens* recorded maximum plant growth parameters (plant height, number of leaves) chlorophyll content, shoot and root nitrogen concentration, shoot and root phosphorus concentration, shoot and root biomass and total biomass. The current study revealed that the microbial inoculants perform better in liquid formulation.

2018

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## Evaluation of Microbially Enriched Spent Mushroom Substrate for Crop Growth

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INVESTIGATION using paddy straw, sugarcane trash and their combination as substrates for the cultivation of oyster and milky mushroom species was carried out. Early bud initiation was observed in paddy straw substrate (17.83 days) followed by the combination of paddy straw and sugarcane trash (23.16 days). The highest yield in oyster mushroom species *Hypsizygus ulmarius* (524.33 g/bag), *Pleurotus eous* (411.83 g/bag) and *Pleurotus florida* (396.00 g/bag) was observed on paddy straw substrate whereas, in milky mushroom (*Calocybe indica*) combination of paddy straw and sugarcane trash recorded highest yield (446.50 g/bag) and bio-efficiency (111.63 per cent). Spent mushroom substrate obtained after mushroom cultivation was analysed for nutrient content and it showed increase in the N P K content and narrow C:N ratio in the spent mushroom substrate over the initial observations. Spent mushroom substrates were enriched with plant growth promoting microorganisms (*Pseudomonas fluorescens*, *Bacillus megaterium* and *Trichoderma harzianum*). *Trichoderma harzianum* showed better survivability in mushroom spent substrate. Microbially enriched spent mushroom substrate application had positive effect on the overall growth parameters and yield of the *Capsicum annum* and *Phaseolus vulgaris*. Plant growth parameters (plant height, number of leaves, number of branches) shoot biomass, root biomass, number of flowers and yield parameters (number of fruits, fruit diameter and fruit yield) found to be maximum in the treatment Talc + Consortia inoculum followed by in the Milky SMS based consortia and oyster SMS based Consortia inoculum. In both the crops N, P and K content and uptake was significantly varied among the treatment as influenced by the application of microbially enriched spent mushroom substrate.

2018

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## AGRONOMY

### Studies on Nutrient and Weed Management in Hybrid Cotton (*Gossypium* spp.) under Southern Dry Zone of Karnataka

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THE study comprising of two field experiments were conducted at ZARS, V. C. Farm, Mandya during *kharif* season of 2016 and 2017 in Southern Dry Zone of Karnataka to optimize levels of major nutrients and to identify suitable herbicides for effective controlling of weeds in hybrid cotton. The experiment on nutrient management was laid out in RCBD with three replications using factorial concept involving nitrogen, phosphorus and potassium levels. The results revealed that application of 150 kg N ha<sup>-1</sup> (irrespective of P and K) recorded significantly higher seed cotton yield (1857 kg ha<sup>-1</sup>), nutrient uptake (114.01, 33.31 and 127.44 kg NPK ha<sup>-1</sup>) and net returns (Rs.46,198 ha<sup>-1</sup>). Among the phosphorus levels, significantly higher seed cotton yield (2046 kg ha<sup>-1</sup>), nutrient uptake (125.63, 36.70 and 140.42 kg NPK ha<sup>-1</sup>) and net returns (Rs.54,383) were recorded with application of 75 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> (irrespective of N and K). Among potassium levels, application of 100 kg K<sub>2</sub>O ha<sup>-1</sup> (irrespective of N and P) recorded significantly higher seed cotton yield (1942 kg ha<sup>-1</sup>), nutrient uptake (119.25, 34.84 and 133.29 kg NPK ha<sup>-1</sup>) and net returns (Rs.49,608 ha<sup>-1</sup>). The experiment on weed management was laid out in RCBD and replicated thrice. Pendimethalin 38.75 EC @ 0.75 kg a.i. ha<sup>-1</sup> as pre-emergence spray at 3 DAS *fb* Pyriithiobac sodium 10 SC @ 62.5g a.i. ha<sup>-1</sup> + Fenoxaprop p ethy 19 EC @ 62.5 g a.i. ha<sup>-1</sup> at 2 to 4 leaf stage of weeds with hoeing at 60 DAS recorded higher seed cotton yield (2104 kg ha<sup>-1</sup>), WCE (72.80 %) and net returns (Rs.56,296 ha<sup>-1</sup>) over weedy check.

2018

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## Organic Nutrient Management in Okra [*Abelmoschus esculentus* (L.) Moench]

VISHWAJITH

FIELD experiments were conducted during *khariif*, 2016 and summer, 2017 at organic farming research and development block, UAS, Bangalore to study the effect of Organic Nutrient Management in Okra [*Abelmoschus esculentus* (L.) Moench] under Factorial Randomised Complete Block Design with 12 treatments replicated thrice. The first experiment consisted of three factors *viz.*, FYM (100, 150 and 200 % N equivalents through FYM), jeevamrutha (0 and 2000 L ha<sup>-1</sup>) and panchagavya (0 and 5 %) levels. Application of 200 per cent N equivalent through FYM recorded significantly higher fruit yield (9.59 and 11.31 t ha<sup>-1</sup>) as compared to 100 per cent N equivalent through FYM (7.38 and 8.52 t ha<sup>-1</sup>). Soil application of jeevamrutha (2000 L ha<sup>-1</sup>) recorded significantly higher fruit yield (9.56 and 11.11 t ha<sup>-1</sup>) as compared to without application of jeevamrutha (7.64 and 9.07 t ha<sup>-1</sup>) and foliar spray of panchagavya (5 %) recorded significantly higher fruit yield (9.15 and 10.58 t ha<sup>-1</sup>) as compared to without panchagavya (8.05 and 9.60 t ha<sup>-1</sup>) application during both the years, respectively. Interaction of these treatments did not differ significantly. The second experiment was laid out in Randomised Completely Block Design. There were twelve treatments consisted with different proportions of organic manures *viz.*, compost, vermicompost and poultry manure and were replicated thrice. Among the different proportions of organic manure treatments, T<sub>12</sub> [T<sub>5</sub>(C:VC:PM-50:25:25 %) + application of jeevamrutha at 20, 40, 60 and 80 DAS] recorded significantly higher fruit yield (7.41 and 8.98 t ha<sup>-1</sup>) as compared to rest of treatments. Whereas, application of 100 per cent N equivalent through compost alone (T<sub>1</sub>) recorded lower fruit yield (T<sub>1</sub> 5.43 and 6.37 t ha<sup>-1</sup>) during *khariif*, 2016 and summer, 2017, respectively.

2018  
Department of Agronomy  
UAS, GKVK, Bengaluru

N. DEVAKUMAR  
Major Advisor

## CROP PHYSIOLOGY

### Molecular Basis of Genetic Diversity in Iron Acquisition and Transport in Rice (*Oryza sativa* L.)

K. N. NISARGA

IRON is an indispensable plant micronutrient and its deficiency severely impairs crop growth. Although iron is abundant in soil, it is not readily available to plants due its low solubility, especially under high pH condition. In crops, like rice even aerobic soil conditions affects iron acquisition and further accentuated with increase in soil pH. However, genotypes differ in iron acquisition under these conditions. In view of this, the emphasis is to identify rice accessions differing in iron acquisition and aim is to characterize and identify the relevant mechanisms associated with iron acquisition. Among 200 genotypes grown under aerobic condition, few contrasting lines were identified varying in shoot and grain iron content. These selected genotypes showed considerable variation in shoot and grain Fe content under aerobic condition. Further, characterisation of selected rice genotypes showed reduced root, shoot and active iron content under high pH condition. The tolerant genotypes JBT37/128 and PS-369 showed higher chlorophyll content, root and shoot iron content, translocation index, Ferric chelate reductase activity and phytosiderophore release at high pH condition compared to relatively susceptible genotypes like CTH-1 and JBT-3/60. In JBT37/128 and CTH-1 genotypes under iron deficiency conditions we have examined the expression profile of reported iron deficiency responsive genes (*OsIRO2*, *OsIRT1*, *OsNAS1*, *OsTOM1*, *OsNRAMP1*, *OsYSL15*) and 10 putative Fe deficiency responsive genes, shown to be expressed in micro array analysis of other studies. JBT37/128 showed higher expression level compared to CTH-1. The differential expression could also be due to altered expression of microRNA's regulating these genes. In CTH-1 the expression of microRNA's (*Osa-miR531b*, *miR1848* and *miR2104*) was high and target genes was low. The differentially expressed genes in tolerant type could be potential candidate genes to improve iron acquisition in rice under iron deficiency condition.

2018  
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I. S. AFTAB HUSSAIN  
Major Advisor

## Characterizing and Assessing the Bio-Efficacy of Nano Zinc Synthesized by Biological and Chemical Approach

RAMESHRADDY

ZINC (Zn) is one of the important micro nutrients for plant and human nutrition. Soil Zn deficiency is a major problem and hence, adequate Zn supply during crop developmental stages are recommended to improve the Zn content in the edible parts and also to improve productivity. However, excess use of Zn fertilizers has detrimental effect on soil and plant health. Hence, it is need of the hour to have formulations of Zn with improved use efficiency for a given input. In this context, present investigation was taken up to study the impact of Zn Oxide (ZnO) nanoparticles synthesized by biological (*Cassia fistula* leaf extract) and chemical approaches on uptake, translocation and growth of maize plants. Nano ZnO particles were characterized using SEM, TEM, FTIR, XRD and UV-VIS-NIR. The efficacy of nano ZnO particle was studied at high soil pH condition and at high phosphorus levels. The nano ZnO treated plants showed better growth. In addition, under the water stress and PEG stress conditions the nano ZnO treatment showed an improved tolerance by maintaining higher SOD and proline content with less MDA and ROS depicted by NBT stain. Localization study showed that nanoparticles are mostly restricted to root cortex cells. The field grown maize plants showed significantly higher growth, yield, leaf Zn and seed Zn content with ZnO nano particles application. With respect to bio safety component, the nano ZnO treated human peripheral blood mono nuclear cell found more viable compared to ZnSO<sub>4</sub> and ZnNO<sub>3</sub> application. Biologically synthesized nano ZnO particle performed on par with chemically synthesized nano ZnO particles and these nano ZnO treatments were superior to bulk ZnSO<sub>4</sub> for all of growth and yield traits in addition to high grain Zn content.

2018  
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A. G. SHANKAR  
Major Advisor

## FOOD SCIENCE AND NUTRITION

### Effect of Dietary Approaches and Eating Behaviour among Overweight Home Makers

B. M. VEENA

A study was conducted to assess the relationship between socio economic and nutritional status of women. Standardization of low calorie food formulation for over weight home makers was done and its functional properties, chemical composition and shelf life was evaluated followed by intervention studies to see the effect of low calorie food formulation along with education on anthropometric and biochemical parameters of the selected subjects. Most of the respondents (46.7%) belonged to 36-45 years of age group, 32.5 per cent belonged to 26-35 years age group and 20.8 per cent of respondents were of > 45 years age group. More than half of the women respondents were house wives (59.2%) followed by working group (30%) and entrepreneurs (10.8%). 34.2 per cent of respondents had only one child, more than half of the respondents had 2 children (53.3%) and only 12.5 per cent of respondents had 3 children. Developed food formulation contained moisture -5.0 per cent, protein - 18.6 g/100g, fat -5.8 g/100g, carbohydrate -67.3 g/100g energy value -396 k cal/100g, crude fiber -11.0 per cent, total dietary fiber -10.45 per cent, ash -3.32 per cent, calcium -308.66 mg/100g, iron -6.89 mg/100g, β-carotene -1123.5 μg/100g, Zinc -1.89 mg/100g, Phosphorous -277.66 mg/100g, potassium -54.06 mg/100 g and sodium -2.53 mg/100g. A significant decrease in the total cholesterol, (from 182.3±33.9 to 163.3±32.4 mg/dl and 209.5±38.4 to 193.1±32.1 mg/dl for group I and II was observed after intervention of food formulation for six months. With regard to high density lipoprotein, significant increase was observed among the subjects of group I and group II from 38.7±9.8 to 46.3±8.3 mg/dl and 43.0±8.0 to 48.6±7.1 mg/dl, respectively. Significant change in BMI from 27.2±1.9 to 25.4±2.0 was observed for group I. Hence low calorie food formulation along with lifestyle modifications played an important role in weight management.

2018  
Department of Food Science & Nutrition  
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USHA RAVINDRA  
Major Advisor

**GENETICS AND PLANT BREEDING****Development of Integrated Map and Identification of Stable QTLs for Traits Related to WUE in Groundnut (*Arachis hypogaea* L.)**

E. ERADASAPPA

AN investigation on development of integrated molecular map and identification of stable QTLs for traits related to water use efficiency in groundnut was carried out. The material consisting of 160 F<sub>5</sub> and F<sub>10</sub> RIL population derived from GKVK 4×NRCG 12473, parents and two checks were evaluated in an augmented design in Bengaluru and Chintamani during summer 2016 and 2017 under well-watered (WW) and water-stress (WS) conditions. Water stress was imposed for 20 days from 50-70 days after sowing in WS condition. Significant differences among RILs were observed for most of the traits in both the conditions. Relative water content (RWC-After Stress), Specific leaf area (SLA), pods per plant and pod yield per plant showed more variation, high heritability with high genetic advance. Four out of 15 drought tolerant indices tested *viz.*, MP, GMP, HMP and STI were found as better. RIL No.92 and 155 showed higher pod yield in WW and WS conditions across years and locations based on *per se* performance, biplot analysis and ranking method. An integrated linkage map was developed with 125 SSR marker loci on 20 linkage groups using a genotypic data of 94RILs. The length of improved linkage map was 1372.05 cM while that of previous map was 763.1 cM. Two M-QTLs one each for SCMR at Chintamani in 2016 and SLA at GKVK in 2017 in WS condition at LOD threshold of 2.5 were detected. Overall two minor QTLs for RWC, four M-QTLs for days to 50 per cent flowering and four M-QTLs for plant height were detected as stable QTLs across locations, years and moisture conditions. A total of 79 Di-QTL interactions with > 5 per cent PVE were detected at LOD score of 5.0. Stable M-QTLs identified can be utilized for marker assisted back cross breeding. Stable RILs can be tested in multilocations or could be used in future breeding for drought tolerance.

2018

Department of Genetics and Plant Breeding  
UAS, GKVK, Bengaluru

D. L. SAVITHRAMMA  
Major Advisor

**SSR Markers-Assisted Mapping and Validation of Reported Markers Linked to Genomic Regions Controlling Anthesis-Silking Interval (ASI) and Productivity *per se* Traits Using Recombinant Inbred Lines in Maize (*Zea mays* L.)**

H. H. SOWMYA

AN investigation was undertaken (i) to assess the genetic variability and identify reproductive-stage moisture stress tolerant F<sub>5</sub> recombinant inbred lines (RILs), (ii) to identify superior combiners for grain yield from F<sub>4</sub> RILs and (iii) to map anonymous SSR markers and validate SSR markers linked to ASI and productivity *per se* traits in F<sub>5</sub> RILs derived from MAI 349 × BGD 89 from 2016 summer to 2018 *kharif* at University of Agricultural Sciences, GKVK, Bengaluru. The study revealed ample evidence for the presence of genetic variability among the F<sub>5</sub> RILs for grain yield and ASI. The F<sub>5</sub> recombinant inbred lines 265, 338, 368, 346, 317, 170 251, 73, 287 and 166 were found superior than both the parents MAI 349 and BGD 89 for grain yield and ASI. The F<sub>4</sub> inbred line, 163 was identified as good general combiner for both ASI and grain yield plant<sup>-1</sup>. The linkage map was constructed using genotypic data of 86 polymorphic SSR markers on 122 F<sub>5</sub> RILs at LOD score of 2.5. The total length of map spanned 2515.10 cM with an average density of 29.24 cM. One major QTL for ASI (qASI-1-1) was detected on LG 1 at 161.00 cM, flanked by the markers bnlg 2328 and bnlg1892 with an interval of 39.50 cM and explained phenotypic variance of 12.96 per cent. A major QTL for grain yield plant<sup>-1</sup> (qGY-7-1) was detected on LG 7 at 57.00 cM, flanked by the markers umc 1759 and bnlg 292 with an interval of 35.35 cM and explained 13.03 *per cent* phenotypic variance. A total of 38 di-QTL interactions were detected for days to silking, ASI, cob length and grain yield plant<sup>-1</sup>. The association of two SSR markers (bnlg 2248 and bnlg 2328) with ASI was validated in F<sub>5</sub> RIL.

2018

Department of Genetics and Plant Breeding  
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E. GANGAPPA  
Major Advisor

## Fruiting Habit Genetics and its Influence on Fruit Traits and Yield in Chilli (*Capsicum annuum* L.)

C. ANILKUMAR

FRUITS node<sup>-1</sup> and fruit orientation are economically important fruiting habit traits in chilli. Fruiting habit(s) could be solitary-erect (SE), solitary-pendant (SP), clustered-erect (CE) and clustered-pendant (CP). Farmer preferences for fruiting habit traits varies from region to region. An understanding of genetics of fruiting habit traits help accelerate breeding chilli cultivars with farmer-preferred desired combination of fruiting habit traits in high fruit yield background. Nine diverse genotypes contrasting for fruiting habit traits were crossed to develop fourteen F<sub>1</sub> hybrids of seven distinct fruiting habit trait combinations, namely CE × SE, CP × SP, CE × CP, CE × SP, CP × SE, SE × SP and SE × SP during 2015 rainy season; the F<sub>2</sub> and backcross generations (B<sub>1</sub> and B<sub>2</sub>) were developed during 2016 summer. F<sub>1</sub>, F<sub>2</sub>, B<sub>1</sub> and B<sub>2</sub> of all the seven distinct types of crosses were evaluated and pattern of segregation for fruiting habit traits was recorded during 2016 and 2017 rainy seasons at the experimental plots of the Department of Genetics and Plant Breeding, University of Agricultural Sciences, Bangalore. Results indicated bi-allelic monogenic inheritance of fruits node<sup>-1</sup> and fruit orientation with solitary being dominant over clustered and pendant being dominant over erect orientation, respectively. Genes controlling fruits node<sup>-1</sup> and orientation of fruits segregated independently. Magnitude and direction of additive genetic effects [a] and dominance genetic effects [d] and additive genetic variance ( $\sigma^2_D$ ) and dominance genetic variance ( $\sigma^2_D$ ) varied with the genetic background of the crosses and traits. Non-significant differences between fruiting habit classes such as (1) S & E, (2) S & P and (3) CE & CP for fruit yield and its contributing traits in both F<sub>2</sub> and back cross populations and one pair of near isogenic lines (NILs) indicated the lack of influence of fruiting habit traits on fruit yield and its contributing traits.

2018

Department of Genetics and Plant Breeding  
UAS, GKVK, Bengaluru

A. MOHAN RAO  
Major Advisor

## Genetic Analysis for Fruit Yield and Yield Components and Tagging Traits Related to Water Use Efficiency in Tomato (*Solanum* spp.)

K. SURESH

THE present investigation was carried out to assess the variability and diversity for traits to water use efficiency and fruit yield in tomato germplasm during 2013 at UAS, GKVK, Bengaluru. The study revealed moderate to high PCV and GCV in most of the traits studied. K-mean cluster analysis revealed high level of morphological diversity as indicated by diverse clusters which is informative for breeding programs. Drought tolerance analysis identified MP, GMP, HAM and STI as more effective indices and EC 677068, EC 608271, EC 676792, EC 586980 and EC 676783 as most drought tolerant accessions. Further, twelve inter-specific hybrids developed from seven parents selected on basis of SCMR, SLA and  $\Delta^{13}C$  were evaluated in RCB design during *khariif*2014. The parents EC 771612 and LA 2567 and crosses VRCT 174 × EC 519100, EC 771597 × EC 771612 × LA 2657 recorded significant *gca* and *sca* effects for most of traits related to WUE and fruit yield, respectively. Moderate to high coefficient of variability was noticed in F<sub>2</sub> and F<sub>3</sub> populations of cross EC *S. lycopersicum* cv. EC 771612 × *S. pennellii* cv. LA 2567 and positive platykurtic skewed distribution indicating dominance based complementary gene interaction in the inheritance of traits studied. Five generations of the cross EC 661257 × LA 2657 revealed additive gene effect (d) and presence of duplicate dominant epistasis in all the traits except specific leaf area. Out of 212 SSRs surveyed for polymorphism only 24 were found to be polymorphic between the parents and were used in Bulk segregant analysis. SSR 19 and SSR 218 showed putatively linkage to SCMR and SLA, respectively can be used for selection of high water use efficient genotypes.

2018

Department of Genetics and Plant Breeding  
UAS, GKVK, Bengaluru

D. L. SAVITHRAMMA  
Major Advisor

**PLANT BIOTECHNOLOGY****Molecular Genetics Evidence for Gametophytic Selection for Heat Tolerance in Maize (*Zea mays* L.)**

ASHUTOSH SINGH

In the present study, the effect of pollen selection for heat tolerance in the  $F_1$  generation on the frequency of heat tolerant plants in  $F_2$  generation was studied. The heat susceptible inbred line BTM4 was crossed to heat tolerant BTM6 and the true  $F_1$  plants were identified using two SSR markers. Three different methods of pollen selection for heat tolerance; incubating the freshly dehisced pollen grains of  $F_1$  plants at 36 °C for three hours in growth chamber (GRC), dry bath (DB) before selfing and growing  $F_1$  plants during summer at ARS, Bheemarayanagudi producing selected  $F_2$  (GRC), selected  $F_2$  (DB) and selected  $F_2$  (BGD), respectively. The control  $F_2$  was also produced without heat treatment to pollen grains. The control and selected  $F_2$  populations were compared for heat tolerance by selfing the  $F_2$  plants with heat stressed pollen grains. The selected  $F_2$  (GRC) showed significantly higher cob diameter, number of seeds per cob and seed yield per plant compared to control  $F_2$  under stress suggesting its superiority over other methods and also positive effect of pollen selection for heat tolerance. One selected  $F_2$  and one control  $F_2$  populations were studied for the segregation of twenty polymorphic SSR markers. The  $\chi^2$  test suggested that the control  $F_2$  showed 1:2:1 ratio for 19 out of 20 markers while in selected  $F_2$  only two markers recorded Mendelian inheritance. The frequency of alleles from tolerant parent was more in selected  $F_2$  providing molecular genetic evidence for the positive effect of pollen selection. The heat tolerance of  $F_4$  generation progenies of the same cross suggested that the cyclic pollen selection for heat tolerance in  $F_1$ ,  $F_2$  and  $F_3$  generations has significantly improved the tolerance of the progenies. The results suggest that the pollen selection is an effective strategy for improvement of heat tolerance in plants.

2018

Department of Plant Biotechnology  
UAS, GKVK, BengaluruR. L. RAVIKUMAR  
Major Advisor**SOIL SCIENCE AND AGRICULTURAL CHEMISTRY****Assessment of Soil Carbon Stock under Arecanut and Coconut Plantations in Karnataka**

R. VASUNDHARA

A study was undertaken across different agro-climatic zones (ACZ) of Karnataka, with an objective to assess the vertical distribution of soil carbon stock in coconut and arecanut plantations. The higher soil carbon stock was found in arecanut (2.71 kg m<sup>-2</sup>) as compared to coconut (2.32 kg m<sup>-2</sup>) plantations. Significantly higher soil carbon stock was observed in hilly zone (3.25 kg m<sup>-2</sup>) followed by southern transitional zone (2.52 kg m<sup>-2</sup>), coastal zone (2.51 kg m<sup>-2</sup>), southern dry zone (2.3 kg m<sup>-2</sup>), and eastern dry zone (1.96 kg m<sup>-2</sup>). Irrespective of crops and zones, arecanut soils had higher carbon content than coconut soils. The pooled data revealed that surface (0-30 cm) soil depth had 35.7 and 36.4 per cent higher carbon stock in arecanut and coconut, respectively as compared to sub-surface soil depth. In sub-surface soil (30-120 cm), 64.3 and 63.6 per cent soil carbon stock was noticed in arecanut and coconut, respectively. Significantly ( $p < 0.05$ ) higher soil carbon stock was recorded within 0 - 30 cm (3.63 kg m<sup>-2</sup>) soil depth and it was found to decline with depth. The interaction effect between crops, zones and depths was found to be significant for soil organic carbon in plantations across ACZ's. Significant difference was observed for dehydrogenase (DHA), alkaline phosphatase (ALP) and acid phosphatase (ACP) in arecanut and coconut soils but no difference was observed for available N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O. A significant positive correlation was observed for different carbon pools with pH, clay, CEC, available N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O, DHA, ALP and ACP activity and negative correlation with sand and bulk density of soil. In general, low management attained less soil carbon status in whole soil profile (0-120 cm) than the high level management in both crops representing all agro climatic zones.

2018

Department of Soil Science and Agril. Chemistry  
UAS, GKVK, BengaluruN. B. PRAKASH  
Major Advisor

**AGRICULTURAL ECONOMICS****Marginalization of Agriculture and its Influence on Income and Savings of Farmers in Kannur District, Kerala**

A. SANJANA

IN Kerala, dependence on agriculture as major source of livelihood is declining with emergence of non-farm activities as major income source. The present study assessed the degree of marginalization of agriculture and its influence on income and savings of farmers. The study area was classified as more urbanised and less urbanised taluks. Primary data were collected from 120 respondents through structured schedules. The descriptive statistics, compound annual growth rate, regression analysis, garret ranking, livelihood diversification and heirfindhal indices were used to analyze the data. The share of agriculture income in the total income had decreased significantly among farm households. Over the years, drastic decline was seen in the share of food crops to the total income. More than 95 per cent of the holdings in the study area belonged to marginal size category. Wage rate of both skilled and agricultural labourers increased during the period but the raise in wage rate of skilled labourers was more. Migration of family members, proximity to urban area and subdivision & fragmentation of agricultural holdings were the major factors influencing marginalization. Occupational diversification was higher in more urbanised area and the income among pure farmer category had shown a high of variance, whereas, income of organised sector employees was steadier. Saving propensity of farm households increased over the years. Investment on productive agriculture assets was very low among the respondents. The share of non-farm activities to the total income had increased considerably among the farm households.

2018

Department of Agricultural Economics  
UAS, GKVK, Bengaluru

B. V. CHINNAPPA REDDY  
Major Advisor

**Economic Analysis of Dairy Farming in Rural-Urban Interface of North Bengaluru**

D. M. SANTHOSH

THE present study was undertaken in North Bengaluru to examine the economic analysis of dairy farming in rural-urban interface. The data was collected from randomly selected 30 farmers each from rural, interface and urban areas. The estimated parameters of Cobb-Douglas production function *viz.*, green fodder, dry fodder and labour were positive and significant in both crossbred and indigenous cows. Hence, it can be inferred that by increasing use of these inputs, milk production could be increased. Efficiency in crossbred cow milk production was more than the indigenous cow as indicated by Data Envelopment Analysis. Except dry fodder, there is gap in supply and demand of green fodder and concentrates across the gradients. Majority of the dairy farmers were not adopting balanced ration feeding. Total variable cost and total fixed cost constitutes 88 and 12 per cent of total cost, respectively. Out of total variable cost, labour and feed & fodder cost constituted around 80 per cent. Net revenue per year from crossbred cow was highest in urban area (Rs.36,720) followed by interface (Rs.31,499) and rural areas (Rs.26,214). For indigenous cow, net return per year was Rs.2,231 in urban area, Rs.626 in interface and Rs.129 in rural areas. The milk yield gap was more in rural area both in crossbred cow and indigenous cow. Highest quantity of milk (1,251 litres/day) was handled by channel III, which constitutes milk producer, MPCS, processing unit, milk parlour and consumer.

2018

Department of Agricultural Economics  
UAS, GKVK, Bengaluru

B. V. CHINNAPPA REDDY  
Major Advisor

## Economic Analysis of Conjunctive Use of Irrigation Water in Tungabhadra Command Area of Karnataka

M. ANUPAMA

THE study was undertaken in Tungabhadra river basin (Koppal and Raichur district) of Karnataka to analyze economics of irrigation among the farms across surface water (SW), ground water (GW) and conjunctive use (CU) regimes. The data was collected using stratified multistage sampling technique, 60 farmers randomly under the each three regimes with a total sample size of 180. The annual cost of irrigation per acre was highest under GW regime (Rs.5870) followed by CU (Rs.5083) and surface water (Rs.104). The net return in the farms where CU was practiced was highest (Rs.15,325 per acre) compared to the farms irrigated by SW and GW (Rs.4,296 per acre and Rs.2,975 per acre, respectively). Among the farms irrigated by GW, the share of energy cost in total cost of irrigation was highest under sprinkler irrigation systems (26%) compared to conventional irrigation systems (20%) and drip irrigation systems (19%). In case of farms irrigated by CU the share of energy costs to the total cost of irrigation under conventional irrigation system was 19 per cent. In surface water regime the factor share of machine labour was highest (37 %) followed by fertilizer (23%) and hired labour (18 %). In ground water regimes the factor shares of irrigation was highest (41%) and in CU regime highest factor share was contributed by irrigation (30%) compared to hired labour (17%) and fertilizer (15%).

2018

Department of Agricultural Economics  
UAS, GKVK, Bengaluru

G. S. MAHADEVAIAH  
Major Advisor

## AGRICULTURAL ENGINEERING

### Production of *Simarouba glauca* Leaf Extract Health Drink Powder using Vacuum Concentration and Spray Drying Techniques

M. MANASA

PHYSICAL, chemical and phytochemical properties of fresh and shade dried *Simarouba glauca* leaves were studied. Dried leaves contained, total phenols-288.99 mgGAE/g; total flavonoids-102.84 mg Quercetin/g; and antioxidant capacity-205.08 mg AEAC/g. From shade dried simarouba leaves of three different particle sizes (Small-25 mesh (BS); Medium-4 mesh; Large - whole leaf), decoction was extracted using hot water (sample to water ratio - 1: 50) at three temperatures (60, 80 and 100 °C) for extraction durations of 15, 30 and 45 minutes. Among various combinations of extraction parameters studied, extraction with medium sized particles at 80 °C for 30 minutes was selected as optimum since the resultant decoction was of higher strength (TSS) and contained relatively more phytochemicals : total phenols (86.04 mg GAE/100ml); total flavonoids (504.33 mg Quercetin/100ml); and antioxidant capacity (41.87 mg AEAC/100ml). Bulk quantity of simarouba decoction was produced at optimized extraction conditions which were then vacuum concentrated to 4° Brix using a vacuum tray drier (@ 630 mm Hg; 7h). Maltodextrin (bulk carrier) @ 10 per cent was added to concentrated decoction and spray dried. Among different spray drying combinations of inlet drying air temperatures (170, 190 & 210 °C) and feed flow rates (40, 50 and 60 ml/min), simarouba leaf decoction health drink powder prepared at 210 °C and 50 ml/min flow rate was adjudged to be best based on phytochemicals content. Storage study of health drink powder using three packaging material (LDPE, MMPE and PET jars) at ambient conditions for two months indicated that MMPE (metalized multilayer polyethylene) package was ideal for storage.

2018

Department of Agricultural Engineering  
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V. PALANIMUTHU  
Major Advisor

## AGRICULTURAL ENTOMOLOGY

### Management of Coconut Black Headed Caterpillar, *Opisina arenosella* (Walker) through Syringe Injection Method of Chemical Treatment

BHARATH MOHAN

COCONUT black headed caterpillar, *Opisina arenosella* (Walker) is a very serious pest on coconut palms. Caterpillar infested palms are treated with insecticides through root feeding method, which is cumbersome and time consuming. In the present study, it was aimed at standardizing syringe injection method of chemical treatment as an alternative to root feeding and assessing efficacy of newer insecticidal molecules for managing *O. arenosella*. The results suggested that the appropriate angle for syringe insertion was 45° compared to 60° and 75°. A drill depth of 3cm for inserting syringe was found effective compared to 2.0 and 2.5cm. Syringe injection on first leaf scar area of palm was most efficient and safer. Fungicide application and carpenter wax sealing at injected area prevented secondary infections. Syringe injection with fipronil 5 per cent SC, spirotetramat 11.01 per cent + imidacloprid 11.01 per cent SC, imidacloprid 17.8 per cent SL, thiacloprid 21.7 per cent SC, thiomethoxam 25 per cent WG and dinotefuran 20 per cent SG recorded poor absorption into palm. Only tolfenpyrad 15 per cent EC, azadirachtin 10000 PPM and mono crotophos 36 per cent SL recorded good absorption and found effective on caterpillar. Laboratory leaf assay from insecticide treated plants recorded 100, 91.67 and 85 per cent larval mortality in monocrotophos, tolfenpyrad and azadirachtin, respectively. In field study 70.67, 43.75 and 50.48 per cent reduction in population over control was recorded in mono crotophos, tolfenpyrad and azadirachtin, respectively. Comparative assessment of stem injection and root feeding suggested that both the methods are on par in controlling *O. arenosella*. Hence, due to ease & convenience in treating palms, syringe injection method can be explored as an alternative to root feeding method.

2018

Department of Agricultural Entomology  
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K. MURALI MOHAN  
Major Advisor

### Biology and Management of Stem Fly, *Melanagromyza sojae* (Zehntner) (Diptera: Agromyzidae) on Soybean [*Glycine max* (L.) Merrill]

S. R. NAGENDRA

INVESTIGATION on the biology and management of stem fly, *Melanagromyza sojae* (Zehntner) on soybean was carried out at the Zonal Agricultural Research Station, Gandhi Krishi Vignana Kendra, Bengaluru during *kharif*2017. The mean incubation, larval and pupal period of *M. sojae* was 3.60, 10.20 and 10.60 days, respectively. The adult longevity of male and female were  $5.60 \pm 0.89$  and  $7.40 \pm 1.67$  days, respectively. *M. sojae* completed its one life cycle in 20 to 30 days, with a mean duration of  $24.40 \pm 4.29$  days. Seeds treated with thiamethoxom 30 FS @ 10 ml/kg seed - foliar application of thiamethoxam 25 WG 0.40 g/l at 30 days after germination was found effective in combating the menace of *M. sojae* and registered the maximum yield of 1794.48 kg/ha with C: B ratio of 1: 4.22, it was on par with seed treated with imidacloprid 48 FS @ 1.25 ml/kg seed - foliar application of imidacloprid 17.8 SL @ 0.50 ml/l at 30 days after germination. Field screening of 30 soybean entries for their resistance against stem fly revealed that, the entries DSB-21, JS-9305, DSB-23-02, RVS-2007-6, MAUS-2 and RKS-18 were found promising against *M. sojae* and recorded significantly least per cent seedling mortality and stem tunnelling. Two hymenopteran parasitoids viz., *Gronotoma* sp., *Syntomopus* sp. parasitized the pupae of stem fly. However, maximum per cent pupal parasitization of 44.00 was recorded by the *Syntomopus* sp. and it was found to be the predominant pupal parasitoid of *M. sojae*.

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## Antimicrobial Peptides from Insects: Prospecting Hymenoptera for Antimicrobial Peptides and an Assessment of Synergistic Role of Peptide Fractions on Antimicrobial Activity

B. SHIVA DATTA

INSECTS, living and evolving closely with other dominant life forms such as microbes, have developed an amazingly strong resistance to pathogenic microbes. This resistance is mediated by cellular and humoral immune system, the humoral system, among other constituents, chiefly comprises anti-microbial peptides. The anti-microbial peptides (AMPs) present in the haemolymph offer protection against pathogens. Interestingly, the AMP's are found as major constituents in the venom of Hymenoptera. This study explored the potential of wasp venom as a source of anti-microbial peptides. Among four species of wasps and one bee species screened for antimicrobial peptides only two wasp species viz. *Ropalidia marginata* and *Vespa tropica* showed strong antimicrobial activity against *Staphylococcus aureus* strain (MTCC 3160) a Gram+ve bacteria were not active against *Escherichia coli* strain (MTCC 2692), a major Gram-ve bacteria. RP-HPLC was carried out with peptide specific protocol to separate fractions of peptides in venom. A total of 13 and 12 fractions were recorded from *V. tropica* and *R. marginata*, respectively. All these fractions were found to have antimicrobial activity against *S. aureus* and *E. coli*. In order to test for possible antagonistic or synergistic role of peptide constituents of the venom extracts, the fractions were pooled into all possible combinations and evaluated for antimicrobial activity. An important finding of this study was that isolation and purification of crude venom extract recovers the antimicrobial properties and variable response of the test microorganisms to the crude venom and in different combinations upholds the synergistic action between the constituent of the venom.

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## Developing Smart Packaging System for Small Millets Rice to Prevent Infestation by *Tribolium castaneum* (Herbst)

H. D. KISHOR KUMAR

THE mortality of red flour beetle can be reduced by lowering the oxygen level, using oxygen absorbers, with the above concept a set of beetle sand oxygen absorbers were introduced into pouches of foxtail millet rice to study their effect on shelf life. An experiment was carried out by packing foxtail millet rice with four different packaging materials with and without insects and oxygen absorbers to assess their effect on the shelf life of grain by reducing oxidation of fatty acids. The grain filled pouches containing beetles and oxygen absorbers (200cc) showed 100 per cent mortality within a day and emergence of beetles was not observed during the experimental period. The pouches containing only beetles and without oxygen absorber showed up to 70 per cent mortality. Beetles emerging in these pouches reached 70 numbers in each pouch. Whereas, in pouches containing both beetles and oxygen absorbers, no beetles emerged throughout the experimental period. However, in controlled pouches, zero per cent mortality and emergence of beetle takes place and reached to a level of 31 numbers of beetles at the end of experiment. The highest number of volatiles was seen in LDPE pouches (25) and lowest in Swiss Pac and Ecotact pouches (10). Polymeric compounds were also reported only from LDPE (3) and HDPE (1) pouches. Fatty acids were reported from the pouches without oxygen absorbers and controlled pouches, where as in pouches containing oxygen absorbers, no free fatty acids were observed by GCMS analysis.

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## AGRICULTURAL EXTENSION

### **Adoption and Economic Performance of Bi -Voltine Silkworm Rearing Farmers in Chitradurga District**

IMRANKHAN JIRAGAL

THE present study was conducted in Chitradurga district of Karnataka. To study the adoption, economic performance and major constraints faced by the Bi-voltine silkworm rearing farmers during 2017-18. A sample of 120 Bi-voltine silkworm rearing farmers were randomly selected from three taluks of Chitradurga district viz., Molakalmuru, Challakere and Hiriyur taluks. The results revealed that majority of the respondents (61.67 %) of Bi-voltine silkworm rearing farmers belong to high adoption category, whereas, 22.50 and 15.83 per cent of the farmers belong to medium and low adoption categories, respectively. It was observed that 40.00 per cent of the Bi-voltine silkworm rearing farmers were found to have medium level of economic performance followed by low (33.33 %) and high economic performance (26.66 %). Further, results revealed that annual income, attitude towards sericulture, innovativeness, achievement motivation, scientific orientation, economic motivation, education, mass media participation, extension agency contact and extension participation were significantly related to both extent of adoption and economic performance of Bi-voltine silkworm rearing. Whereas, social participation was found to be significant only for extent of adoption. In case of economic performance, risk orientation is also significantly related. Lack of e-trading in cocoon market, high fluctuation of market prices and exploitation by traders were the major constraints faced by the Bi-voltine silkworm rearing farmers. Hence, the different developmental departments has to organize educational activities such as, demonstrations, trainings, group discussion meetings and field visits etc. in order to enhance the adoption level of Bi-voltine silkworm rearing practices among farmers.

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### **Impact of Diploma in Agricultural Extension Services for Input Dealers (DAESI) Training on Agricultural Input Dealers**

D. N. MAMATHA

THE study was conducted in Davanagere district of Karnataka during the year 2017-18. Total 80 number of input dealers were selected as a sample for the study, out of them 40 trained and 40 untrained input dealers were randomly selected. The present study revealed that 45.00 per cent and 57.50 per cent of trained dealers had high level of knowledge and diagnostic skills, respectively. About 50.00 per cent and 55.00 per cent of untrained dealers had medium level of knowledge and diagnostic skills, respectively. Education, mass media use, extension contact, extension participation, social participation and scientific orientation had significant relationship with level of knowledge and diagnostic skills of trained dealers. Education, mass media use, extension contact and social participation had significant relationship with level of knowledge and diagnostic skills of untrained dealers. Regarding opinion of DAESI training majority of the trained dealers opinioned training content is very good (92.50 %) followed by training methodology (85.00%) and facilities (80.00%). More number of trainees suggested to increase the class room session's (95.00%), conduct the classes more in the field (80.00%) and to give more importance to display the specimens chart related to nutrient deficiency, insect damage and disease symptoms in the training hall (70.00%).

2018  
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**AGRICULTURAL MARKETING, CO-OPERATION AND BUSINESS MANAGEMENT**

**Performance Analysis of Farmers Producer Organizations (FPOs)  
in Chamarajanagar District of Karnataka State**

T. H. BHUVANESHWARI

THE present study was undertaken in Kollegala, Chamarajanagar and Gundlupete taluks of Chamarajanagar district in Karnataka State during 2017-18 to evaluate the performance of FPOs. Three FPOs were selected for the study, ninety members were selected from six villages and the collected data was analyzed by appropriate statistical tools. More than one third (37%) of the respondents had a medium level of participation. About 41.11 per cent of the members opined that they had a medium level of satisfaction with respect to the services provided by the FPO. Education and landholding were having a positive and significant relationship with the participation of members in various activities of FPO, whereas, experience in farming, land holding and education were having a positive and significant relationship with the services provided by the FPOs. Performances of FPOs assessed through the liquidity ratio current, quick and liquid assets to total ratio were observed to be satisfactory. Solvency ratios were satisfactory, the debt-equity ratio was not desirable because of the FPOs were dependent on Government funds. Profitability and efficiency ratios of FPOs were found to be bit non-satisfactory. Nearly half of members (42.22%) of the respondents had a medium level of satisfaction towards working of FPO. The study concluded that the FPOs have not been able to make significant growth in terms of expansion of services to meet the diversified needs of members.

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**A Study on Pesticide Brand Preference of Pomegranate Growers in Tumakuru  
District of Karnataka**

AJEET NAGARAL

INDIA is the fourth largest producer and tenth largest consumer of pesticides in the world. In spite of being one of the largest producer and consumer, the crop losses in India due to pest attack is very high which resulted in huge losses (Rs.90,000 crores per annum). Keeping this issue in mind the study was conducted in Tumakuru district with the objective of analyzing factors influencing the farmer's brand preference for pesticides. Among the companies selling pesticides in the district, Bayer Crop Science has the highest market share followed by Indofil Industries Ltd. and Hindustan Antibiotics Ltd. The study also analyzed the factors influencing farmers pesticide purchase decision. The study revealed that Long term protection emerged as first consideration followed by Brand popularity and Effectiveness. With regard to the pesticide brand preferred by farmers, majority of farmers (88.89 %) were using Confider followed by Diathin M-45 (81.11 %). The study also revealed that the retailer and dealers suggestions were the most important among the others various factors influencing the purchase decision of farmers. Hence, the companies need to focus more on encouraging the retail traders and employees by motivating them to interact with farmers and provide relevant information required by them to sustain in the business for the long run.

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## **An Analysis of Consumer Preference for Ready-Made Idli / Dosa Batter in Bengaluru City**

S. BHAVYA

THE present study was conducted with the objective of analysing consumer preference for ready-made idli/dosa batter in Bengaluru city. The primary data was collected from 100 respondents through a pre-tested schedule, which include consumers (90), manufacturers (5) and retailers (5). The analytical tools employed include measures of central tendency, factor analysis and Garrett's ranking. The study revealed that iD, Reliance's Healthy life, Hallimane and Asal were the most popular brands among the 11 brands of ready-made idli/dosa batter available in Bengaluru city. External factors like influence of family, friends and retailers were major in influencing consumer preference for ready-made idli/dosa batter followed by price and quality. Other factors which influenced preferences were close relationship, positive appeal, frame of mind and brand image. The study also revealed that price was the main reason for switching brands of ready-made idli/dosa batter. The major constraint faced by manufacturers in production was huge investment on machines. While in marketing the major constraint faced by manufacturers was competitive market. The major constraint of retailers was competition followed by low margin, then difficulties in returning batter after expiry date.

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## **Consumer Preference for Milk and Milk Products in Rural-Urban Interface of Bengaluru - An Economic Analysis**

Y. C. ARCHANA

MILK and milk products are the essential parts of human dietary consumption and as the increase in rural and urban prosperity, the demand for milk is likely to increase. The main objectives of the present study were to analyze the factors influencing consumer preference towards milk and milk products, to map the value chain of major milk and milk products and to analyze the market share of different brand of milk and milk products along rural-urban interface of Northern Bengaluru. The data was collected through pre-tested schedule from 90 consumers and was analyzed using Garrett's ranking technique, descriptive statistics and value chain mapping. The results indicated that Nandini, Dodla, Dairy Day, Thirumala, Heritage, Shivashakthi, GRB, Pathanjali, Hatsun, Sri Krishna, Amul, Milky Mist, Cavin's, Kwaliti Wall's and Arpitha were most prevalent brands in various milk and milk products. Health benefits, quality, price and easy availability were the major factors that influenced the consumers to buy milk and milk products in all the three gradients. Among branded milk, Dodla had market share of 56.67 per cent in transition and 23.33 per cent in rural region. Whereas, Nandini had market share of 56.66 per cent in urban region. It is suggested that the popularity of milk based products like paneer, ice cream, yogurt, shrikhand, etc., are gaining acceptance from the rural consumers also. Hence, the companies have to concentrate on these value-added products for a good turnover and profitability.

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## **Performance Analysis of Dharmavaram Handloom Silk Saree Weaving Units in Anantapur District of Andhra Pradesh**

VANAMALA SAROJA

DHARMAVARAM saree is the flagship product of Dharmavaram in Andhra Pradesh. Primary data was collected from 70 weavers for performance analysis of Dharmavaram handloom silk saree weaving Units in Anantapur district. Four types of weavers were identified viz., independent weavers, master weavers, weavers under master weavers and weavers under *dani*. More than 70 per cent of own and independent of weavers took this profession as it was their family tradition and regular earnings. Weavers were employed for 300 to 330 days per annum and the working hours ranged from 8 to 12 hours daily. Among the nine types of Dharmavaram silk sarees produced, Brocket sarees (35.71%) was popular, followed by (14.29 % each) producing Double side kuttu and Embozu. The net income per annum was more for weaver under *dani* (Rs.1,44,107) as compared to owner operated weaver (Rs.1,28,763) because the major share of expenditure was towards purchase of silk yarn, dyeing and design cards in the case of own operators. The net income for master weavers operating in large units got more (Rs.90,72,500) compared to medium and small units. Raw materials are like warp and weft is sourced from Sidlaghatta and Ramanagara areas in Karnataka and Zari from Surat. The woven sarees and *pavadas* were supplied to Dharmavaram, Vijayawada, Hyderabad, Bengaluru and Tamil Nadu. The major production and marketing constraints of weavers were higher taxes, high cost of raw material, high investment and lower profits.

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## **A Study on Landscaping Business in Bangalore City**

C. SHILFA JEROME

IN every corner of the world, landscapes can be found which have been shaped by the interactions of people and nature over time. India's landscape industry has devised its own architectural creativity in the modern period particularly during the last six decades. The objectives of the present study was to document different types of landscape designs in Bangalore city to analyse the management practices followed in landscape design and maintenance activities and to document various stakeholders involved in landscaping business. The data was collected through pre-tested schedules from 90 various players of landscaping industry in Bangalore city. The data was analysed using Measures of Central Tendency, Garrett's Ranking Technique and Stakeholder mapping. Based on the analysis, Bangalore city has plethora of landscape designs maintained by BBMP. The management practices followed by large scale companies follow clear and highly professional management practices. The core and primary stakeholders were found to be important in any landscaping project whereas the role of secondary stakeholders varies upon the elements in the landscape design. It is suggested that the scientific documentation of landscape related research is essential to make this business more transparent for customers, small players and even Government.

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## **An Analysis of Supply Chain Management of Coconut and Coconut Products in Tumakuru District**

H. M. SAHANA

THE coconut palm (*Cocos nucifera*) also known as 'Kalpavriksha' is a member of the family Arecaceae. The study on supply chain management of coconut and coconut products was carried out in Tumakuru district of Karnataka. Primary data was collected from 60 farmers of Tumakuru district, while secondary data regarding area, production and productivity from Karnataka state department of horticulture and prices from Krishimaratavahini website. Area, production and productivity of coconut has increased with positive growth rate of 2.05 per cent, 7.63 per cent and 5.49 per cent, respectively. Seasonal index of prices was highest during the month of May, March and November in Tumakuru market and March, May, October to December in Bengaluru market because decreased arrivals to the market. Similarly the lowest price prevailed in the months of June to August in Tumakuru and January, April and July in Bengaluru was due to high arrivals. In case of backward linkages majority of farmers used planting materials from fellow farmers, purchased fertilizers from government department and pesticides and insecticides from dealers and for creation of water source farmers availed loans from Nationalized banks and co-operative banks for coconut planting and replanting. In case of forward linkages farmers sold coconut and coconut products through intermediaries. It was found that the major production constraints were inadequate irrigation facilities, the incidence of pests & disease and low yield. The major marketing constraints were price fluctuation, exploitation by middlemen and improper storage facilities.

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## **Production and Marketing of Pomegranate - A Study in Vijayapura District, Karanataka**

M. H. SUNITHA

THE study was conducted to examine the profitability, resource use efficiency, marketing channels in pomegranate and constraints in production and marketing. Primary data were collected from 30 pomegranate farmers and 30 market intermediaries from Vijayapura taluk. The establishment cost per acre for the first year was Rs.177264.40, the average annual maintenance cost from second year onwards was Rs.125862.20 and the net return per acre was Rs.93511.80 with an average yield of 4.37 MT. The resource use efficiency analysis using Data Envelopment Analysis (DEA) showed that more than 50 per cent of farms were technically and allocatively efficient with an average score of 0.91 and 0.90, respectively, the cost/economic efficiency was below 0.90 indicating low cost efficiency (0.82). About two-third of the farmers (33.33%) sold the produce through first channel: Producer - Pre-harvest contractor - Wholesaler - Retailer - Consumer, 23.34 per cent sold through second channel: Producer - Wholesaler - Retailer - Consumer and 43.46 per cent used both the channels. Marketing cost per MT of Pre-harvest contractor, Wholesaler and Retailer were respectively Rs.4290.93, Rs.6690.57 and Rs.2770.91. Production constraints of pomegranate through mean Garrett's score indicated that lack of irrigation facilities was the main problem (84.56), followed by non-availability of good quality planting material (81.10). Price fluctuation/low price was the main marketing constraint of farmers (85.10), followed by distant markets (82.20).

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## **Business Performance of Tumakuru Grain Merchants Co-Operative Bank Limited in Tumakuru District**

H. C. NAYANA

THE study was conducted on Business Performance of Tumakuru Grain Merchants Co-operative Bank (TGMC Bank) Limited in Tumakuru District. TGMC Bank is working with its headquarters at Tumakuru. The main objective of the study was analysing the performance of Tumakuru Grain Merchants Co-operative Bank Limited in Tumakuru district, to study the satisfaction level of the members of the bank and to study the problems faced by the employees and members of the bank. For the study, primary data was collected from 20 employees and 50 members of the bank, secondary data was collected from the Annual Reports of TGMC Bank regarding the financial performance for a period of five years (2013-14 to 2016-17). Percentages, Financial ratio analysis, Measure of central tendency and Garrett's ranking technique were used for analysing the data. The growth in the number of branches, membership and numbers of employees in the bank were increased gradually. The net profit of the bank was increased from Rs.105.79 Cr. to Rs.211.09 Cr. during the year 2012-13 and 2016-17. eight per cent of members very happy and satisfied with quality of the services provided by the bank. Heavy work load in the bank was main problem faced by the employees of the bank. Low availability of parking place near the bank branches was the main problem faced by the members of the bank. The bank is suggested to implement the core banking solutions and automated teller machines to manage the work with existing staff.

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## **Consumer's Preference for Herbal Products - A Study in Bengaluru City**

M. R. SHRUTHI

THE present study made an attempt to examine the brand-wise categories of herbal products, factors influencing the purchase decision of herbal products by consumers, purchase behaviour of consumers of herbal products and brand loyalty of consumers for herbal products in Bengaluru city. For the study, data were elicited from 120 consumers drawn purposively from the city. The major brands of herbal products available in the city were Himalaya Herbals, Biotique, Lotus, Ayur Herbal, VLCC, Khadi Naturals, Forest Essentials, Just Herbs, Vaadi Herbals, Jovees Herbal and Patanjali. Quality was the major factor which influenced the consumers to purchase herbal products. Television was one of the sources of information about herbal products for all the sample respondents as it is the most popular mass media among people. Majority (64.17 %) of the consumers were influenced by friends and relatives with regard to purchase of herbal products. Most (87.50 %) of the sample consumers found it very convenient to shop for their requirements including herbal products in modern retail formats such as hyper markets, super markets, department stores, etc., as they provide a wide range of brands and products including herbal products under one roof. The availability of products in a store was the most significant factor which influenced the consumers' preference for the store for making their purchases of products. With regard to brand loyalty among consumers, Biotique brand was the most stable brand as it had the highest retention probability of 0.60.

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## A Comparative Analysis of Functioning of Selected APMCs in Haveri District of Karnataka

AYESHABANU A. LOHAR

THE present study was conducted in Haveri district of Karnataka State. The study was undertaken to analyse the functioning of Byadgi, Haveri and Ranebennur APMCs in terms of trend in arrivals and prices of major commodities; structure, conduct and performance and constraints. The primary data was collected from 30 farmers, five traders and five commission agents, from each APMCs, resulting in a total sample size of 120 respondents. There was an increasing trend in arrivals of dabbi, guntur and kaddi varieties of dry chilli, maize, soybean and sunflower while there was a decreasing trend in arrivals of cotton for the reference period (2008-09 to 2017-18). There was an increasing trend in prices of all the major commodities in the selected APMCs. All the selected APMCs were oligopolistic in nature as the Gini concentration ratios were found to be 0.90, 0.85 and 0.88, respectively. The operational ratios of the selected APMCs were less than 0.50 and there was a declining trend for the reference period indicating that the operational efficiency of APMCs has increased. The gross ratios showed a declining trend for the reference period which was desirable from the performance point of view. The major constraints faced by the farmers in the selected APMCs were lack of timely market information, lack of infrastructural facilities and poor maintenance and delay in payments while the major constraints faced by traders and commission agents were delay in payment by buyers, lack of storage facilities and inadequate infrastructural facilities.

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## Consumers Preference for Litchi and its Products - A Study in Bengaluru City

TRISHNA U. SANDRA

LITCHI, *Litchi chinensis*, is one of the important sub-tropical edible fruits in India. The objectives of the present study was to examine the trend in area and production of litchi in India; to examine the socio-economic profile of consumers of litchi and its products; to analyse the factors influencing the consumers preference for litchi and its products; to analyse the constraints in production and marketing of litchi and its products. The data was collected through pre-tested schedule from 60 consumers, 15 retailers (Bengaluru) and 10 producers (Coorg). The data was analysed using Factor Analysis, Compound Annual Growth Rate and Garrett's Ranking Technique. The Compound Annual Growth Rate from 2007 - 2017, area increased from 69,000 hectares to 93,000 hectares (3.18 %) under litchi and production increased from 418 MT to 568 MT (3.41 %). Factor Analysis indicated that litchi ice cream, squash, cordial, candy, honey and jam were the most preferred litchi products by consumers. Quality, color, freshness and taste were the major factors which influenced consumers. Based on Garrett's Ranking Technique post-harvest losses (84.86 %) was the major constraint in production, while perishability of fruits (94.57 %) was the major constraint in marketing of litchi fruits by growers and grading facility (68.66 %) was the major constraint faced by modern retail formats. There is ample scope for expanding business opportunities in retail outlets and farmers must be encouraged to cultivate on large scale since it is profitable and an export oriented crop.

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### **Management of Agribusiness Enterprise - An Analysis of Sheep Rearing in Chikkaballapur District**

S. SHABEER UL HASAN

THE present study was conducted in Bagepalli taluk of Chikkaballapur district of Karnataka state to analyse the backward and forward linkages in sheep rearing to assess the financial viability of sheep rearing; and to identify the constraints in sheep rearing. The primary data for the study was collected from 40 sheep rearers. Majority of the sample sheep rearers used their own money realized from horticultural and agricultural crops for investing in sheep enterprise while some of them, especially women borrowed credit from SHGs. The family members met the labour requirements of sheep rearing. Chelur sheep shandy is the only sheep market located in Bagepalli taluk. It is a popular weekly shandy held every friday where sheep is traded in large numbers. The total cost incurred and the gross returns realised per annum for rearing a flock size of 61 sheep was Rs.1,59,577 and Rs.2,74,788, respectively resulting in a net returns of Rs.1,15,211 among the variable costs, labour was the major cost accounting for about 83 per cent of the total variable cost. The sale of adult sheep accounted for about 75 per cent of the gross returns followed by sale of lambs (18.76%), sale of manure (4.13%), sale of meat (1.95%) etc. At 12 per cent discount rate, the NPW, BCR and IRR were found to be Rs.3,56,943.40, 1.72 and 53.77 per cent, respectively indicating the financial viability of sheep rearing. Scarcity of water and exploitation by middlemen were the major constraints faced by sheep rearers.

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### **Value Chain Analysis of Soybean - A Study in Bidar District of Karnataka**

ASHWINI C. THAMKE

THE present study examined the cost and returns of soybean cultivation; trend in arrivals and prices of soybean in Bidar and Humanabad APMCs; various stake holders in soybean value chain; marketing channels of soybean; and consumer preference for value-added products of soybean. The primary data was collected from a sample of 40 soybean farmers, 10 traders, 10 wholesalers and 10 retailers of Bidar district; and 80 consumers in Bengaluru city. The results indicated that the average yield of soybean was 10.50 quintals per acre in the study area. The total cost of cultivation of soybean was about Rs.31,906/- per acre. The gross returns amounted to Rs.34,387/- per acre and the corresponding net returns was Rs.2,481/- per acre. In the case of Bidar APMC, the arrivals and prices of soybean registered CAGRs of 44.52 per cent and 5.84 per cent, respectively for the reference period while the corresponding CAGRs were 53.90 per cent and 7.52 per cent, respectively for Humanabad APMC. In soybean value chain, the major actors/players involved include producers, wholesalers (soybean and/or value-added products of soybean), processors, retailers (soybean and/or value-added products of soybean) and consumers. Majority (67.50 %) of the soybean farmers sold their produce through commission agents in APMCs followed by those (32.50 %) who sold to processors while the rest (5.04 %) sold to village merchants. Among the value-added products of soybean, majority (70 %) of the consumers preferred chunks followed by oil (65 %), sauce (44 %), flour (20 %) etc.

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## **A Study on Consumer Preference for Marine Fish and Fish Products in Mangaluru City**

P. D. GANA

THE present study was conducted with an objective of assessing Consumers' preference for marine fish and fish products in Mangaluru city, document different types of marine fish and marine fish products available in the market; socio-economic factors influencing the purchase and preference of consumers on different type of market outlet and to identify the constraints faced by the retailers of fish and fish products. The primary data were collected from 110 randomly selected respondents through a pre-tested schedule, which include consumers (90) and retailers (20). The analytical tool employed includes descriptive statistics, Garrett's ranking and factor analysis. The results revealed that the most important factors impacting the purchase of marine fishes was the unique taste of the fish which was ranked first by the consumers' with a mean Garrett's score of 68.34. Among the various factors promoting increased consumption of Marine fish, reasonable price was the most important factors with a mean Garrett's score of 59.74. Among various preferred varieties of Marine fishes, the Sardine was ranked first by the sample consumers with the mean Garrett's score of 61.68. Among the various preferred varieties of Marine fish products, the dried fish was ranked first with a mean Garret's score of 61.89. The high transportation and storage costs were the major constraints expressed by the modern retailers which ranked first with a mean Garret's score of 84.50.

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## **AGRICULTURAL MICROBIOLOGY**

### **Studies on Antifungal Activity of Bacterial Symbionts of Entomopathogenic Nematodes in Tomato**

R. S. RASHMI

AN attempt was made to isolate bacterial symbionts of entomopathogenic nematodes by soil sampling and *Galleria melonella* baiting technique. A total of ten isolates were isolated from haemolymph of infected larvae. All the isolates were subjected for morphological and biochemical characterization. These isolates were examined for their antifungal activity against five plant pathogens of Tomato like *Alternaria solani*, *Rhizoctonia solani*, *Fusarium oxysporum* f sp *lycopersici*, *Sclerotium rolfsii* and *Pythium aphanidermatum*. From preliminary dual plate culture technique, five best isolates were selected for further studies. These five bacterial symbionts were further tested for quantification of antifungal activity by using agar plug method and mycelial biomass method. From the result obtained, it was found that BEG4 and BEG6 have shown highest biocontrol activity against all five plant pathogens. These five bacterial symbionts were used for further seedling tray and pot culture experiment under greenhouse condition. Under pot culture conditions plants inoculated with consortium of five isolates recorded significantly higher plant height, number of branches, number of flowers, root and shoot length and root and shoot weight. These five isolates were identified based on 16S rRNA sequencing and it was found that three isoates belonged to genus *Photorhabdus* and two isolates belonged to *Xenorhabdus*. This study clearly shows that bacterial symbionts can be used to control plant pathogens.

2018

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## Isolation and Screening of Efficient Bacterial Cellulose Producing Bacteria from Different Fruit Sources

PUTTESH

AN investigation on 'Isolation and screening of efficient bacterial cellulose producing bacteria from different fruit sources' was conducted at the Department of Agricultural Microbiology. The bacterial cellulose is a type of biopolymer produced by *Gluconacetobacter xylinum* with high purity, high water holding capacity and high tensile and these characters makes it more useful for industrial level and it also demonstrated benefits, for health maintenance. The over ripened, physically damaged waste fruits pulp was used as substrate for cellulose production. Cellulose producing bacterial isolates were isolated from different fruits samples collected from different locations in Bengaluru. Totally 69 cellulose producing bacterial isolates were isolated and screened for their cellulose producing ability, based on this 3 isolates were selected. The fruits broth at the ratio of 3:1 (fruit juice: water, w/v) was found to be the best for cellulose production. Among the different isolates, *Iso-Pin* yielded maximum bacterial cellulose. Optimization of nutritional, physical and biochemical factors was done by considering the efficient isolate and concentration. Among different sugars like glucose, sucrose and lactose used as carbon source, lactose yielded highest cellulose yield (16.59g/50ml). The pH level of 4.5, temperature 30 °C and 15 days of incubation period were found to be optimum for the maximum production of cellulose.

2018

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## Biopreservation of Papaya (*Carica papaya* L.) using Lactic Acid Bacteria

J. S. ANUSHA

PAPAYA is a pulpy fruit, cultivated in tropical and subtropical regions of the world. It is a rich source of carotenoids, vitamin C, iron and fibre. It is highly perishable fruit. The post-harvest losses of papaya is reported to an extent of 25-30 per cent due to improper storage and transportation facilities. Therefore, a study was conducted to investigate the influence of isolated lactic acid bacterial (LAB) isolates inoculation on papaya fruits. LAB are Generally Recognized As Safe (GRAS) and produce antimicrobial compounds like organic acids, hydrogen peroxide, reuterin, diacetyl, cations *etc.* Lactic acid bacteria were isolated from papaya plant parts and were tested against spoilage moulds isolated from papaya fruit. Moulds were identified as *Aspergillus niger*, *Aspergillus flavus*, *Penicillium* sp. and *Fusarium* sp. Antifungal activity was tested by biomass determination method and agar plug diffusion method. Isolate L<sub>3</sub> exhibited the highest inhibition (91.27 %) and L<sub>1</sub> recorded the least inhibition (84.92 %). Therefore, L<sub>3</sub> culture was considered for *in situ* studies. There were six treatments *viz.*, Control, LAB, Gum acacia (10 % solution), Gum acacia + LAB, Paper and Paper + LAB. Fruits treated with LAB and wrapped with paper exhibited less spoilage followed by LAB treatment and Gum acacia plus lactic acid bacterial treatments during seven days of storage at room temperature. Therefore, dipping of papaya fruits in lactic acid bacterial broth would be a simple biopreservative method to extend shelf life and to reduce post-harvest losses of papaya.

2018

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SUVARNA V. CHAVANNAVAR  
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### Studies on the Effect of Beneficial Microorganisms on Growth and Yield of Foxtail Millet (*Setaria italica* L.)

BAWANKULE NITIN DNYANESHWAR

THE plant growth promoting rhizo bacteria are exogenous bacteria introduced into the agricultural ecosystems which influence plant growth positively. There are only limited reports on the effect of plant growth promoting bacteria on the growth of foxtail millet, but their successful application would encourage efforts towards development of a crop and climate-specific biofertilizer. Eleven isolates were isolated from two locations viz., ZARS, UAS, GKVK, Bengaluru and KVK, Konehally, Tiptur. Further, they were characterized on the basis of morphological and biochemical tests such as catalase test, oxidase test *etc.*, Isolates FMB-2, FMT-2 and FMT-3 were selected for pot culture experiment among eleven isolates based on phosphate solubilization potential, nitrogen fixation ability and plant growth promoting activity (IAA, GA and Cytokinin). Thirteen treatments were formulated in single and different combinations to evaluate the efficacy of selected isolates for growth and yield of foxtail millet under glass house conditions. Out of the total 13 treatments, T<sub>9</sub> was found to be the best involving FMB-2 + Reference *Bacillus megaterium* + FMT-3 in terms of various growth parameters such as germination percentage, plant height, number of leaves per plant, chlorophyll content, panicle characteristics and yield parameters such as weight of panicle, grain weight per panicle *etc.*, whereas T<sub>1</sub> (control) was found to be lowest.

2018

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L. KRISHNA NAIK  
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### AGRICULTURAL STATISTICS, APPLIED MATHEMATICS AND COMPUTER SCIENCE

#### Statistical Study of Soil Productivity in Selected Sub Watersheds

N. ARCHANA

THE study was conducted to analyse the soil productivity in Siddappanapalya sub watershed having eight micro watersheds. From each micro-watershed forty grid soil samples were collected and for each soil sample different physico-chemical characters, major nutrients, secondary nutrients, micro nutrients were analysed and used for statistical analysis. In order to assess the statistical significance between different soil properties having a different characteristics in micro watersheds, multivariate analysis of variance was performed and results indicated the significant difference between soil properties among the micro watersheds. To assess the variation of particular soil character between the micro watersheds, univariate analysis of variance which is considered as a post hoc analysis of multivariate analysis were carried out. The results of the univariate analysis clearly indicated the significant differences in the average values of each soil character between the micro-watersheds. Based on the statistical mean differences, homogeneous micro watersheds were formed for each of the soil character. The fertility status of the soil is also analysed by using nutrient index approach. For calculating nutrient index values the soil test values for different nutrients, samples were classified into low, medium and high based on available standards. Further, forty soil samples in each micro-watershed were grouped into low, medium and high with respect to nutrient index. In general based on all soil properties the low nutrient index in Siddappanapalya sub watershed was observed.

2018

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### Statistical Analysis of Area, Production and Productivity of Cotton Crop in Selected Districts of Karnataka

RAMESH

In the present study an attempt was made using secondary data for forty six years (from 1970 to 2016) to understand the growth rates and trend in area, production and productivity of cotton crop in selected districts of Karnataka viz., Dharwad, Ballari and Raichur. Further, forecast was made for the production of cotton crop. The results revealed that area, production and productivity of cotton crop marked significant increasing growth rate during the study period. In case of both Dharwad and Ballari districts, increasing growth in area, production and productivity was observed. Whereas, in case of Raichur district, a decreasing growth under area and an increasing growth in production and productivity was seen. The polynomial regression models were fitted to assess the trend in area, production and productivity of cotton crop. Based on adjR<sup>2</sup> and RMSE values, it was evident that quadratic, cubic and linear models were best fit for area, production and productivity of cotton in Dharwad district. For Ballari district, quartic model was found to be best for area and production, while, cubic model was best fit for productivity. Similarly, for Raichur district, area and production was best fitted with quadratic model while, cubic model was best fit for productivity. Forecasting was carried out using ARIMA based on RMSE and MAPE values for production of cotton crop in selected districts of Karnataka. It was found that ARIMA (2, 1, 2) model was appropriate for both Dharwad and Ballari districts while, ARIMA (1, 1, 1) model was found to be most suitable for forecasting production of cotton in Raichur district.

2018

Department of Agril. Statistics, Applied Mathematics & Computer Science  
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K. N. KRISHNAMURTHY  
Major Advisor

### Statistical Appraisal of Decision Making Process in Adopting Agricultural Innovations by Farmers of Karnataka

G. S. NAVEENKUMAR

In the present study, secondary data on 372 farmers cultivating five crops and spread across 11 villages of Karnataka were collected for two years from 2014-15 to 2015-16 for the purpose of analyzing the decision pattern among respondent farmers while adopting agricultural innovations in Karnataka. Further, an attempt was made to understanding the type and pattern of decision making process and factors influencing the decision pattern in adoption of agricultural innovations by farmers. Data on Adoption of agricultural innovations through decision process initiation, decision loci and decision pattern across 11 villages, 5 crops, 5 categories of agricultural innovations, year of adoption and time gap was computed through chi-square statistic. The result shows that decision making by farmers in five different situations is dependent on all the categorical variables individually. This implies that farmers face a complex situation while deciding adoption of agricultural innovations in various stages due to the influence of various factors such as locale, crop technology, year of adoption and time gap in adoption. Different factors influencing the decision pattern was analyzed using statistical techniques like decision tree and multinomial logistic regression. The major determinants of decision pattern from best fitted models were Age, Number of children, Socio-economic status (SES total score), Yield, Cost of cultivation, number of innovations adopted, Gross income and Net income which controls the decision pattern of farmers in perception of any new technology. Results show that Multinomial logistic regression model was found to be the best fit compared to decision tree (CHAID) for classification and prediction of data.

2018

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MALLIKARJUN B. HANJI  
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## Pattern Classification of Rice (*Oryza*) on Genomic Sequences

K. N. VEENA

A Phylogenetic tree construction in order to know compel of ancestral relationship of genome sequences, tracing the transmission of functional and genetic. It also plays predominant role in conservation of biodiversity, to analyze quantitative behavior of phylogenetic and effective heuristics of obtaining accurate trees. The study has been conducted to know higher accuracy from efficient algorithm to inferring phylogenetic relationship among Rice (*Oryza*) species. A sample of 428 *Oryza* genome sequences were drawn from a total of 1949 *Oryza* sequences collected from NCBI dataset. Different algorithms like Neighborhood joining (NJ), Unweighted Pair Group Method with Arithmetic Mean (UPGMA) and Maximum Likelihood (MLE) were considered to construct the phylogenetic tree. The NJ with Maximum composite likelihood model out performs highest accuracy whereas MLE with Tamura Nei model gives the least. Computational biology of statistical results justifiable were compare the functional relationship between different models in which error percentage had been reduced. The same algorithms carried out for the individual species under different models, NJ with Maximum composite Likelihood model was found more efficient than others to differentiate the species genomic sequences and group them to correct taxon.

2018

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S. S. PATIL

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## AGRONOMY

### Characterization of Sugarcane Juice and Jaggery from Adverse Production Conditions in Mandya District

SALIM NADAF

A study was undertaken to characterize the sugarcane juice and jaggery from adverse production conditions in Mandya district. Sugarcane juice was analysed from seven different adverse production conditions during 2017-2018 adopting RCBD design with three replications. The purpose of the study was to compare and characterize the quality of sugarcane juice and jaggery in different sugarcane production conditions. Sugarcane growth parameters like cane length, cane girth and inter nodallength were higher in cane of normal production conditions whereas number of internodes was maximum under moisture stress condition. Cane of normal production conditions recorded higher juice brix and purity per cent whereas juice sucrose content was maximum under moisture stress condition. Cane from saline soil condition recorded higher reducing sugar, total phenols and ash content of juice. Jaggery yield parameters like cane weight, juice weight, juice extraction per cent, jaggery yield and jaggery recovery per cent were higher in cane of normal production condition. Normal production condition recorded better physical quality parameters of jaggery viz., colour (OD value) with crystalline texture, sweeter in taste, hardness and porosity. Chemical quality parameters recorded was higher with respect tobrix, sucrose, calcium and iron with lower in reducing sugar, moisture content, total salts, sodium, dirt and insoluble, ash and microbial load. Jaggery from normal production condition recorded higher Net Rendement value (NR values) with A<sub>2</sub> grade and good quality with longer shelf life of jaggery.

2018

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Major Advisor

## Weed Management in Groundnut using Pre and Post Emergence Herbicides

V. VENKATARAYAPPA

A field experiment entitled “Weed management in groundnut using pre and post emergence herbicides” was conducted during *kharif* 2013 at Main Research Station, Hebbal, Bengaluru in sandy loam soil (pH 5.6; OC 0.61%) with medium available nitrogen (245.40 kg ha<sup>-1</sup>), phosphorus (35.40 kg ha<sup>-1</sup>) and potassium (187 kg ha<sup>-1</sup>). Experiment was laid out in RCBD with 12 treatments replicated thrice and the cultivar used was TMV-2. Major weed flora observed in the experimental plots were *Cyperus rotundus*, *Cynodon dactylon*, *Digitaria marginata*, *Dactyloctenium aegyptium*, *Eleusine indica* and *Echinochloa colona*. The results revealed that two hand weeding at 20 and 40 DAS resulted in significantly lower weed density at 30, 45, 60 DAS and at harvest (11.80, 14.74, 36.74 and 24.86 No. m<sup>-2</sup>, respectively) and weed dry weight at 30, 45, 60 DAS and at harvest (2.90, 3.69, 9.40 and 6.32 g m<sup>-2</sup>, respectively) in groundnut compared to all other treatments and it recorded higher weed control efficiency (94.2%). Similarly with respect to growth and yield attributes of groundnut significantly higher growth and yield attributes were recorded in two hand weeding at 20 and 40 DAS as compared to other treatments. The higher gross returns (Rs.67,838), net returns (Rs.40,405) and B:C ratio (2.47) was obtained in two hand weeding at 20 and 40 DAS as compared to unweeded control (Rs.20,060, Rs.2,057 and 1.11, respectively)

2018  
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## Studies on Foliar Application of Nutrients on Productivity of Soybean [*Glycine max* (L.) Merrill]

BRANDON LYNGDOH

A field experiment was conducted during the *kharif* season of 2016 at the Zonal Agricultural Research Station, University of Agricultural Sciences, Bengaluru to evaluate the effect of foliar nutrition on productivity of soybean crop (variety MAUS-2). The experiment was laid out in Randomized Block Design with three replications. There were ten treatments consisting of various combinations of nutrient application *viz.*, RDF + water spray, RDF + Urea @ 2 per cent spray, RDF + DAP @ 2 per cent spray at pod initiation, RDF + MOP @ 0.5 per cent spray, RDF + NPK (19:19:19) @ 2 per cent spray, RDF + Molybdenum @ 0.5 per cent spray, RDF + Boron @ 0.5 per cent spray, RDF + Zinc chelated @ 0.5 per cent spray, RDF + bio-digester liquid spray and RDF through organic source (FYM) @ 13.44 kg plot<sup>-1</sup>. The treatments were imposed during pod initiation stage of crop growth (45 DAS). The application of RDF + DAP @ 2 per cent spray resulted in significantly higher plant height at harvest (40.32 cm), number of leaves plant<sup>-1</sup> at 60 DAS and at harvest (37.73 and 10.46, respectively), leaf area plant<sup>-1</sup> at 60 DAS and at harvest (850.00 cm<sup>2</sup> and 394.34 cm<sup>2</sup>, respectively), number of pods plant<sup>-1</sup> (43.00), number of seeds pod<sup>-1</sup> (3.00), number of seeds plant<sup>-1</sup> (88.37), higher grain yield (3772 kg ha<sup>-1</sup>) and higher uptake of NPK (302.95, 35.42 and 108.88 kg ha<sup>-1</sup>, respectively) compared to the other treatments. Foliar application of DAP @ 2 per cent also recorded significantly higher oil content (22.01 %), protein content (40.41 %), higher net return of Rs.55,808 ha<sup>-1</sup> and BC ratio of 2.84.

2018  
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N. KRISHNAMURTHY  
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## APICULTURE

### **Studies on Non-*Apis* Pollinators of Sunflower with Special Reference to Stingless Bee, *Tetragonula iridipennis* smith**

R. HEMANTH KUMAR

FIELD investigations on insect pollinators were carried out at the Zonal Agricultural Research Station, GKVK, Bengaluru during *khari*2017 on KBSH-44 sunflower. The abundance and diversity of pollinators was recorded during the flowering period from 06.00 to 18.00 hrs. Seventeen species of pollen and nectar feeders were observed during the flowering period belonging to order Hymenoptera, Diptera and Lepidoptera. The percent pollinator species composition was more from Hymenoptera (98.61%), followed by Diptera (1.29%) and Lepidoptera (0.10%). Within Hymenoptera, *Apis* bees contributed for maximum species diversity (72.87%) followed by Non- *Apis* bees (18.18%). The mean time spent by *Apis* bees was 161.6 sec/ capitulum and non- *Apis* bees was found to be 140.6 sec/capitulum. Shannon - Weiner Index of Diversity (H) values ranged from 0.57 to 1.42 throughout the day. Maximum diversity was observed between 13.00 to 14.00 hrs., with an 'H' value of 1.42. The mean number of *A. cerana* and *Tetragonula iridipennis* pollen foragers was 1.42 and 1.18 bees / capitulum / 5 minutes, whereas mean number of *A. cerana* and *T. iridipennis* nectar foragers was 1.84 and 0.25 bees/capitula/ 5 minutes, respectively. Maximum seed setting (1246.7) was recorded in sunflower enclosed with *T. iridipennis*, followed by *A. cerana* (1163.4). Significantly, maximum yield per hectare was observed in sunflower enclosed with *T. iridipennis* (2770.1 kg) and least yield per hectare was noticed in sunflower enclosed with *A. cerana* (2686.9 kg).

2018

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### **Studies on the Effect of Plant Extracts of *Amomum* Spp. on *Apis dorsata* Fab.**

VINAY RAMA HEGDE

THE behaviour of *Apis dorsata* Fab. to the stem extracts of *Amomum aculeatum* Roxb. were studied in field and laboratory condition. The field experiments were conducted on the rock bee colony which was located at UAS, GKVK, Bengaluru and the laboratory experiments were conducted at NCBS, Bengaluru. The chemical compositions of the stem extract were analysed in this study. In field experiments, the effects of boiled and crude stem extracts of *A. aculeatum* was worked out. The bees moved away from the comb, when crude stem extract was held close to the comb, which showed the clear significant repellent effect on bees. Boiled stem extract had no effect on the colony which indicated the importance of volatiles in the plants that repels bees. In laboratory condition, the individual bee was exposed to fresh air and crude stem extract odour in a fabricated setup. But, bees did not show significant response to the crude stem extract, which may be due to change in behaviour of individual bee as compared to social behaviour. The chemical compounds present in the *A. aculeatum* stem extract was analysed by means of Gas Chromatography-Mass Spectrometry (GC-MS) technique. The results of the GC-MS analysis of the stem extract showed that there were about 70 compounds present in it. The classes of compounds identified in the stem extract were monoterpene hydrocarbons, sesquiterpene hydrocarbons, oxygenated monoterpenes and oxygenated sesquiterpenes. Out of these, the main compounds identified were  $\alpha$ - (+) -Pinene (30.68%) and Caryophyllene (25.22%).

2018

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## Risk Analysis of Bio-Pesticides and Newer Molecules on Honey Bee Pollinators in Sunflower Ecosystem

S. SHABARISH KUMAR

STUDIES on effect of bio-pesticides and newer molecules on honey bee pollinators in sunflower ecosystem were carried out at Department of Apiculture and Zonal Agricultural Research Station, GKVK, Bengaluru during 2017-18. Insecticides *viz.*, *Bacillus thuringiensis*, NPV, NSKE, Indoxacarb, Cyantraniliprole, Chlorantraniliprole, Spinosad and Emamectin benzoate were sprayed during flowering period on sunflower crop. The foraging activity of different honey bee species was observed for 7 days. Emamectin benzoate was found to be more toxic to honey bee pollinators followed by spinosad, cyantraniliprole, indoxacarb, NSKE, chlorantraniliprole, *Bacillus thuringiensis* and NPV. Emamectin benzoate was found to be highly toxic to *A. dorsata* and *A. cerana* followed by spinosad, cyantraniliprole, indoxacarb, NSKE, chlorantraniliprole, *Bacillus thuringiensis* and NPV under field condition. NPV was found to be relatively safer to *A. florea* followed by *Bacillus thuringiensis*, chlorantraniliprole, NSKE, spinosad, indoxacarb, cyantraniliprole and Emamectin benzoate, whereas NPV was found to be least toxic followed by *Bacillus thuringiensis*, chlorantraniliprole, indoxacarb, spinosad, NSKE, cyantraniliprole and emamectin benzoate to *Tetragonula irridipennis* under field conditions. In laboratory conditions NSKE was found to be least toxic to *A. cerana* whereas Emamectin benzoate was found to be highly toxic.

2018  
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## CROP PHYSIOLOGY

### *In vitro* Propagation of Potato and Characterization of *In vitro* Grown Plants

PAVITHRA BANNIKALLU

MAJOR constraints in potato cultivation has been insufficient availability of quality and disease-free seed/planting material. Thus, availability of a good quality planting material at affordable price is a great challenge in potato cultivation. Although different approaches are available for multiplication of virus-free planting material, micro-propagation seems to be the best approach. In this study, *In vitro* propagation of potato was attempted in three different varieties of potato *viz.*, Kufri Jyothi, Kufri Himalini and Kufri Chipsona-1. The response of *in vitro* multiplication was good in modified 75 per cent basal MS medium compared to potato establishment medium (PEM). Further, table sugar (30g/L) and gelrite (3g/L) without growth regulators in the medium was found to be effective for *in vitro* multiplication and thus, cost of multiplication reduced significantly. Among different explants *viz.*, sprouts, shoot tips, single node and double node cuttings, the single node cuttings with full leaf was found to be effective in maximizing the plantlets. Further, a plant density of five plants per bottle (250 ml) was found to be ideal for generating healthy plants as higher plant density lead to aerial root production. With the use of AgNO<sub>3</sub>, the aerial root formation was prevented. Among different hardening treatments used, temperature hardened (at 28°C) plants performed well over others. Further, when examined for survival and growth of plantlets under aeroponic system, tuber grown plants survived and put on more growth than *in vitro* grown plants. Although survivability of *in vitro* grown plants is less, it offers an opportunity to develop disease free plantlets in large numbers.

2018  
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## Functional Relevance of Fe-S Cluster Biogenesis Proteins in Growth and Development of Rice Under Stress

C. MEGHANA REDDY

IRON-SULFUR (Fe-S) clusters are cofactors of more than 200 proteins in plants. Many vital cellular processes in plants such as photosynthesis, respiration, nitrogen assimilation, hormone synthesis depend on the functioning of Fe-S proteins. The Fe-S clusters in proteins are highly prone to oxidative damage which is ubiquitous under most stresses experienced by crop plants. Maintaining the Fe-S protein activity needs continuous supply of cluster cofactors under stress. However, Fe-S cluster biogenesis (ISCB) is complex process involving several genes and specific localised pathways. For better understanding of tolerance mechanism in relation to ISCB, 20 rice genotypes with known history of stress response were screened for methylviologen induced oxidative stress. Based on Z-distribution analysis of various parameters, 7 contrasting genotypes were identified and further subjected to moisture stress using mini lysimeters. Results indicated AC39020 as the highly tolerant and BPT5204 as the highly susceptible genotypes. *In silico* analysis re-established that proteins containing Fe-S clusters are affected under various abiotic stresses. We observed differential activity of Fe-S enzymes (Nitrite reductase and Succinate dehydrogenase) in contrasting genotypes. *In silico* gene expression analysis of 41 rice ISCB genes showed differential expression under abiotic stresses. Among the qRT-PCR of few selected ISCB genes involved in plastidial SUF and mitochondrial ISC mechanisms, major scaffolding proteins of chloroplast - SUFC and mitochondria - ISU1 were highly up-regulated under stress in both contrasts. Our findings reveal potential candidate genes which seem to be contributing to tolerance that can be further functionally validated.

2018  
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A. G. SHANKAR  
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## Evaluation of Variability in Partitioning Co-Efficient and Harvest Index Among Advanced Breeding Lines of Rice (*Oryza sativa* L.)

B. UDAYKUMAR SHINTRI

THE crop yield in several crops has reached a plateau in recent years. Further improvement is possible through incorporation of physiological traits rather than yield *per se* alone. Therefore, it would be appropriate to analyze critically the yield components and exploit the germplasm for such traits. Hence, identification of rice genotypes for physiological traits attributing to higher grain yield and their incorporation in breeding programme would be highly effective. Therefore, a set of 101 advanced breeding lines of rice including popular varieties were characterized for physiological and yield attributes. Biomass and harvest index had direct positive influence on grain yield and were determined by panicle weight, number of tillers and test weight. Among the physiological traits, the flag leaf area, total dry matter and specific leaf weight indirectly influenced the grain yield through biomass production. The superior rice genotypes over exhibited higher flag leaf area (GE-17, GE-67, GE-58), higher total dry matter of >91.28 g/plant (GE-76, GE-74, GE-33) and lower specific leaf weight of <0.03 (GE-85, GE-90, GE-80) with higher seed yield, compared to the check hybrid KRH-4, these donors can be used as multi-parents to exploit their genetic potential, these genotypes can beneficially be used in the further breeding programs for improved grain yield. Selected high yielding rice genotypes showed higher partitioning co-efficient (76.70 %) and harvest index (0.44 %) as compared to the low yielding genotypes. These parameters may be used as surrogate for preliminary screening of large number of germplasm for yield potential in rice.

2018  
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K. V. SHIVAKUMAR  
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## Determination of Optimum Leaf Area and Productive Tillers for Yield Potential of Finger Millet (*Eleusine coracana* (L.) Gaertn.)

MUJAHID ANJUM

FINGER millet is cultivated as rainfed crop under poor and marginal lands and the yield potential of the crop has reached a plateau. One of the strategies for further improvement in yield potential is through the physiological approach. In this view, two experiments were conducted at Field Unit, ZARS, UAS, GKVK, Bengaluru. The first experiment was conducted using three finger millet genotypes (GPU-28, GE-292 and GE-199) in different plant spacings to arrive at different leaf area per plant. Maximum grain yield (754.7 g m<sup>-2</sup>) with a maximum LAI of 7.5 was obtained in the spacing of 15 cm x 10 cm as compared to the recommended spacing of 22.5 cm x 10 cm. The productive tillers per unit area were increased with an increased plant density however, 190.9 tillers per square meter at 15 cm x 10 cm produced highest grain yield. Early tillering being most important trait for productivity, the influence of nitrogen on tillering was attempted. Highest tillering and advanced seed germination by one day was observed with overnight soaking of seeds in 1 per cent urea solution when compared to the control and the higher concentrations decreased the seed germination and plant growth. This investigation suggests the optimum LAI is 7.5 and optimum productive tillers are 190.9 m<sup>-2</sup> to produce higher grain yield as compared to LAI of 6.58 in the recommended spacing of 22.5 cm x 10 cm. The early tiller production is possible through soaking the seed in 1 per cent urea solution overnight before sowing.

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Y. A. NANJA REDDY  
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## FOOD SCIENCE AND NUTRITION

### Bio Accessibility of Minerals from Selected Small Millets

K. NITHYASHREE

MILLETS are staple food for majority of the population around the world. Though millets are nutritionally superior to other staple crops. The presence of antinutrients in them makes micronutrients to become less bioavailable to the body. Hence, the study was undertaken to assess the bio accessibility of minerals from selected small millets along with rice and wheat. Physico-chemical, micronutrients, antinutrients and bioaccessibility of micronutrients among the millets were analysed by standard procedure. Physical characteristics thousand seed weight, seed volume, hydration capacity, bulk density and specific gravity ranged from 1.70 to 4.60g, 2.28 to 4.40 ml, 0.26 to 1.1g, 0.62 to 1.55g/ml and 0.64 to 1.88, respectively. The moisture content ranged from 8.0 to 10.1 per cent, protein 6.3 to 12.3 g, fat 0.9 to 4.4 g, crude fibre 2.3 to 9.9 g and carbohydrate 67 to 76.3 g/100g and energy 330 to 362 Kcal/100g, respectively. Minerals namely iron, zinc and calcium ranged from 2.91 to 5.83 mg, 2.68 to 5.32 mg and 22 to 301.67 mg/100g, respectively. Phytic acid and tannin content ranged from 765.13 to 1318.85 mg/100g and 90.92 to 218.46 TAE/100g, respectively. Bioaccessibility of iron among small millets ranged from 7.46 to 15.57 and that of rice and wheat was 16.43 and 10.53 per cent, respectively. Bioaccessible zinc and calcium among millets ranged from 6.73 to 16.83 and 8.04 to 31.54 per cent. Significant negative correlation was observed for phytic acid with bioaccessible iron. Presences of different amount of minerals and antinutrients have influence on bio accessibility of particular minerals in grain.

2018  
Department of Food Science and Nutrition  
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K. GEETHA  
Major Advisor

### **Exploring Eggshell Powder as Fortificant in Food**

D. KAVANA

A study was undertaken to explore the possibility of eggshell powder as a calcium fortificant in food. Wheat flour being one of the most commonly used bases for popular meal products, an attempt was made to enrich wheat flour with calcium through processed eggshell powder. As the study indicated, the best acceptable process method was eggshell powder dried in Microwave oven at 75 °C for 90 minutes without shell membrane which had moisture, total ash and calcium content of 0.70, 96.5 per cent and 346.6 mg, respectively. The Microwave oven dried eggshell powder without shell membrane was incorporated at the level of 400 mg per 100g of whole-wheat flour and products namely Chapathi and biscuits were prepared using the above eggshell powder fortified flour. The products were found to be highly acceptable with a yield of 19 biscuits and 7 Chapathies per 100g of fortified flour which had a shelf-life of highest duration of 45 days at ambient temperature. Addition of eggshell powder significantly increased the level of calcium in Chapathi from 36.7 to 38.1 mg and in biscuits from 67.8 to 69.18 mg. The microbial load was within the permissible limit even after 45 days of storage period at ambient temperature, which also confirms improved shelf life of product. Overall study confirms that suitably processed eggshell powder could be the best biological source of calcium supplement through daily foods to meet the daily calcium requirements.

2018

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H. B. SHIVALEELA  
Major Advisor

### **FORESTRY AND ENVIRONMENTAL SCIENCE**

#### **Evaluation of Biofuel Programme in Alur Taluk of Central Western Ghats, Karnataka**

K. B. GOUTHAMI

THE study entitled Evaluation of biofuel programme in Alur taluk of Central Western Ghats, Karnataka was carried out during 2017-18. Totally 150 respondents were selected from ten villages of Alur taluk and data were collected by personal interview method. Before the personal interview with farmers the biofuel park, Madenur, Hassan conducted meetings, training programmes at regular intervals and seedlings were distributed. The results of the study revealed that the biofuel programme has resulted in significant increase in socio-economic status of the beneficiaries like annual income has increased from 36.00 per cent to 48.66 per cent in medium group, from 18.00 per cent to 21.34 per cent increase in the income of high income group. Perception of the farmers on biofuels has increased and helped the farmers to take up planting of biofuel tree species. The results on personal characteristics of farmers showed that there was medium risk orientation (55.33%), high achievement motivation (60.00%), medium innovativeness (36.00%) and low economic motivation (45.33%). Ecological benefits derived or the advantages of biofuel tree plantations on the environment after the implementation has improved and the farmers are enthusiastic to take up more planting of biofuel trees. Difficulty in collection of seeds from the trees and providing equal benefits to all the respondents were the major constraints and suggestions offered by the beneficiaries of the programme. Therefore, the study revealed positive impact of biofuel programme on its beneficiaries and the environment.

2018

Department of Forestry and Environmental Science  
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K. T. PRASANNA  
Major Advisor

## Assessment of Tree Biomass with Respect to Soil Health of Different Tree Species Established in Arboretum at UAS, GKVK, Bengaluru

K. L. RAMYASHREE

THE study was carried out in 30 year old plantation at tree arboretum at UAS, GKVK, Bengaluru. The study involved assessment of growth, above ground biomass production, carbon sequestration, nutrient accumulation in soil and R/S ratio general micro flora of four different tree species. The results revealed that among different tree species the maximum tree height was observed in *Artocarpus hirsutus* (15.74 m) and maximum girth at breast height (147 cm), volume (1.93 m<sup>3</sup>), above ground biomass (453.75 kg/tree), tree C sequestration (204.19 kg/tree) was recorded for *Ceiba pentandra*. At depth of 0-15 cm and 15-30 cm, R/S ratio for Bacteria, Fungal population and Actinomycetes population was found to be highest in *Artocarpus hirsutus*. Maximum soil moisture was found in *Ceiba pentandra* (12.02 %) and (12.9 %) and bulk density was found highest in *Sterculia companulata* (1.14 g/cm<sup>3</sup>) and (1.6 g/cm<sup>3</sup>) at depth of 0-15 cm and 15-30 cm, respectively. At depth of 0-15 cm and 15-30 cm, electrical conductivity (0.20 ds/m) and (0.19 ds/m), organic carbon (2.38%) and (2.25%) and phosphorous (40.74 kg/ha) and (24.1 kg /ha) content was found highest in *Artocarpus hirsutus*. The available nitrogen (287.31 kg/ha) and (270.95 kg/ha), potassium (109.3 kg/ha) and (96.0 kg/ha) and pH (6.45) and (6.2) was found highest in *Ceiba pentandra* at depth of 0-15 cm and 15-30 cm, respectively. Therefore study revealed findings are useful in the field of environmental science.

2018

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C. NAGARAJIAH  
Major Advisor

## GENETICS AND PLANT BREEDING

### Stability Analysis for Grain Yield and Quality Traits in Selected Traditional and Improved Varieties of Rice (*Oryza sativa* L.)

ASHWINI GOPAL LAMANI

AN investigation was undertaken at five different locations of Karnataka during *kharif* 2017 using four traditional rice varieties (TRVs) *viz.*, Rajamudi red, Rajamudi white, Ratna choodi, Jeerigesanna; four high yielding varieties (HYVs) *viz.*, BPT-5204, Tunga, BR-2655, Mugadsiri and two farmers' varieties (FVs) *viz.*, BKB and PUB to study genotype and environment interaction (GEI) for grain yield and quality traits. Additive Main effect and Multiplicative Interaction (AMMI) model and Genotype and Genotype by environment (GGE) biplots statistical tools were used to assess the GEI. The AMMI analysis of variance showed highly significant GEI for yield and quality traits except for panicle length, gelatinization temperature, alkali spreading value and cooking time. Two Interaction Principle Component Axis *viz.*, IPCA1 and IPCA2 were highly significant for all traits. IPCA1 explained maximum (>50%) per cent of GEI for all traits except number of tillers (43.46%). AMMI stability value (ASV) revealed that Ratnachoodi was stable for grain yield and Mugadsiri was unstable. Gel consistency had stable expression in Jeerigesanna, but unstable in Rajamudi white. BPT-5204 was stable for amylose content, whereas Ratnachoodi and Tunga were unstable. Genotypic selection index (GSI) revealed that BR-2655 was the best genotype for yield, while BPT-5204 was the best for cooking quality. TRVs were distinct for 34 DUS (Distinctness, Uniformity and Stability) characters as compared to HYVs. BKB, PUB and Rajamudi red were moderately resistant for leaf blast, while other varieties were moderately susceptible. Attempt was also made for DNA finger printing of all the above rice varieties using SSR markers.

2018

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M. P. RAJANNA  
Major Advisor

### Genetic Diversity for Fodder Yield and its Attributes in Cowpea (*Vigna unguiculata* (L.) Walp.)

V. RAMACHANDRA

A study was conducted to assess genetic diversity for fodder yield and its attributes and to identify high yielding genotypes with high leaf protein in cowpea. The experiment was carried out both in summer and late *kharif* season 2017 at MRS, Hebbal, Bengaluru. One hundred and twenty one genotypes were laid out in 11x11 simple lattice design with two replications. The analysis of variance revealed significant differences of genotypes and also high GCV and PCV estimates were noticed for most of the characters indicating considerable amount genetic variability and predominance of additive gene action. High broad sense heritability coupled with high genetic advance as a per cent of mean observed for all the characters studied except for days 50 per cent flowering indicating the predominant role of additive gene action. Assessment of Genetic diversity using Mahalanobis D<sup>2</sup> statistic. Grouping of genotypes into clusters using Torcher's method resulted in formation of twelve clusters of which cluster II was biggest with 49 genotypes. The inter cluster distance varied from 10.09 to 300.03. Genotypes NBC-41, IIHR-137 and RI-27 belonging to cluster II were found to be promising for the green fodder yield per plant and could be used in fodder improvement programmes. Based on protein estimation using Kjeldahl method the following genotypes were found to be promising IC-2532051, E-157, GC-3 and IC-25105.

2018

Department of Genetics and Plant Breeding  
UAS, GKVK, Bengaluru

M. R. KRISHNAPPA  
Major Advisor

### Suitability of Lam Chilli (*Capsicum annum* L.) Lines for Different Dates of Sowing in Bengaluru Region

S. SRINATHAREDDY

AN investigation was carried out at three environments *viz.*, July, September, November for three dates of sowing at K-block, Department of Genetics and Plant Breeding, GKVK, UAS, Bengaluru. During November sowing apart from Bengaluru, sowing was taken at Siddalaghatta and Srinivaspura during 2017-18. Experiment was carried out to detect and quantify Genotype x Environment interaction and to identify LCA genotypes suitable across different dates and locations of sowing. 17LCA varieties were evaluated along with four checks (KBCH-1, US 341, Arka Meghana and Arka Haritha) in a RCBD with two replications. Among the three environments sown for different dates November sowing and for different locations GKVK were found most suitable for expressing most of all characters. Per cent variance contributed due to genotype was evident for most of the traits across both dates and locations of sowing. Per cent variance due to Genotype x Environment was highly significant for days to 50 per cent flowering across both dates and locations of sowing. This indicates considerable differences among genotypes and their interaction effect in the expression of all the traits. The genotypes, LCA 334, LCA 424 and LCA 336 for dates of sowing and the genotypes, LCA 336, LCA 206 and LCA 235 for locations of sowing had lowest estimate of and Stability Index for green fruit yield were widely adapted. The genotypes LCA 639 for July, LCA 334 for September and LCA 620 for November sowing were specifically adaptable. The genotypes US 341 for GKVK sowing, KBCH-1 for Siddalaghatta sowing and LCA 625 for Srinivaspur sowing were specifically adaptable.

2018

Department of Genetics and Plant Breeding  
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M. K. JAYASHREE  
Major Advisor

### Genetic Variability for Quality Traits in Rice (*Oryza sativa* L.)

B. NETRAVATHI

RICE is the most important cereal crop and main source of energy for majority of world population. The present investigation was taken up in local land races of rice with the objective to study the genetic variability parameters and to identify the desirable recombinants for yield and quality traits in  $F_2$  generation of three crosses *viz.*, Mosale Puttabatta  $\times$  Bettasanna, Bettasanna  $\times$  SKAU 334 and Banavasi selection  $\times$  Kaduva Kalongi at the Zonal Agricultural Research Station, V. C. Farm, Mandya, Karnataka, during *kharif* 2017-2018. Observations were recorded on 16 quantitative characters. The mean and range were high for all the characters in three  $F_2$  populations. High genotypic and phenotypic coefficient of variability with less difference observed for grain yield and quality traits indicating less influence of environmental factors on their expression. High heritability and high genetic advance were recorded for productive tillers per plant, number of tillers per plant and panicle weight. This indicated that these traits were predominantly controlled by additive gene action and more amenable for selection. Correlation and path analysis revealed high positive association and direct effect of productive tillers on grain yield followed by number of tillers per plant, panicle weight, amylose content and grain L/B ratio. Hence, it would be desirable to lay stress on these characters in selection programme for increasing the yield. In the present investigation superior segregants were identified which would be worth while to advance to isolate high yielding genotypes with better quality traits.

2018

Department of Genetics and Plant Breeding  
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M. S. UMA

Major Advisor

### Combining Ability Analysis of New CMS and Testers of Rice (*Oryza sativa* L.)

U. MARUTHI

AN investigation was carried out to estimate genetic diversity, combining ability and heterosis in newly developed CMS lines and testers of rice (*Oryza sativa* L.) at Zonal Agricultural Research Station, V. C. Farm, Mandya during *kharif* 2017. One hundred newly developed parental lines were analysed for their genetic diversity using Mahalanobis  $D^2$ -analysis using data recorded on 10 quantitative traits and grouped into 11 clusters. Among them cluster I accommodated maximum number of lines (46) followed by cluster II (32), cluster V (9) and IV (6). Seven solitary clusters indicated larger diversity of lines. Combining ability analysis was performed using eight new CMS lines and five testers selected from diversity studies using line  $\times$  tester design. The ratio of GCA to SCA variance revealed that there was preponderance of non-additive gene action in the expression of all traits under study. The lines *viz.*, IR 68896A/MSN 36-2, IR 68902A/MSN 20-12-1-2, IR 68902A/MSN 43-1, IR 68896A/MSN 20-13-11A/MSN 20-13 and testers IET 21341/MSN 54 (25-3-1-1), IR 60919/MSN 36 (1-16-2-1-1-B), MSN 36, IR 60919/MSN 36 (1-9-4-2-2-1-1-B) were identified as best general combiners for yield and yield attributes. Among the crosses, IR 70369A/MSN 96  $\times$  IR 60919/MSN 36 (1-16-2-1-1-B), IR 68896A/MSN 36-2  $\times$  IET 2134/MSN 54 (25-3-1-1), IR 68896A/MSN 43  $\times$  MSN 36 and IR 68896A/MSN 36-2  $\times$  MSN 36 exhibited highest significant *sca* effects and high heterosis over checks for grain yield. These hybrids need to be further evaluated across locations and over seasons to select best hybrids for commercial exploitation.

2018

Department of Genetics and Plant Breeding  
College of Agriculture, V. C. Farm, Mandya

N. SHIVAKUMAR

Major Advisor

**HORTICULTURE****Studies on Softwood Grafting in Tamarind (*Tamarindus indica* L.)**

K. G. THEJASHWINI

A field experiment was carried out on softwood grafting in tamarind to study the success and survival percentage using *Tamarindus indica* L. as root stock in different growing conditions over the months of (February to March) under three different growing environment *i.e.*, low cost polyhouse, shade net and open field condition in the Department of Horticulture, GKVK, UAS, Bengaluru. Significantly maximum number of sprouts (12.02), leaves (42.31), scion diameter (1.02cm), number of branches per graft (7.15), SPAD reading (34.15), success (85.55%) and survival (77.77%) was observed in the month of march under low cost polyhouse condition. Low cost polyhouse shows least number of days for first sprout emergence (20.47 days) in the month of march as compared to shade net and open field condition. Interaction effect also has significant influence on almost all parameters of the softwood graft. Among the different combinations of growing environment and months, under low cost polyhouse in the month of march was found to be significant for obtaining large number of good quality planting material of tamarind.

2018  
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M. CHANDRE GOWDA  
Major Advisor

**Effect of Different Levels of Plant Growth Regulators with Pruning and Training in Cucumber (*Cucumis sativus* L. Hyb. Malini F<sub>1</sub>) under Open Field and Protected Condition**

ABDUL BAQI

AN investigation was conducted at PFDC, Department of Horticulture, GKVK, UAS, Bengaluru during 2017-18. The results of the present experiment revealed significantly higher growth parameters of cucumber Hyb. Malini F<sub>1</sub> under open field and natural ventilated greenhouse in terms of vine length (115.33 and 172.67 cm), number of leaves per plant (40.67 and 47.00), number of branches per plant (19.63 and 19.70, respectively), fresh weight of the plant (198.00 and 278.13 g, respectively) and dry weight of the plant (72.07 and 135.80 g). Yield parameters such as fruit yield per plant (0.71 and 2.67 kg) and fruit yield per hectare (28.88 and 106.67 tons, respectively) and cost benefit ratio (1:1.94 and 1:4.13) were observed with treatment combination of T<sub>6</sub> (GA<sub>3</sub> 50 ppm + NAA 500 ppm + double stem pruning). Significantly higher total soluble solids at initial stage of harvest under both growing condition (4.43 and 4.78 °B) was noticed in the treatment combination of T<sub>2</sub> (GA<sub>3</sub> 25 ppm + NAA 500 ppm + double stem pruning). It is recommended that maximum growth, yield and quality in hybrid Malini F<sub>1</sub> cucumber crop could be obtained by the foliar application of GA<sub>3</sub> (25 and 50 ppm), NAA (500 ppm). With regard to pruning levels double stem pruning was found to be more profitable compared to no pruning level under both growing conditions. T<sub>1</sub> (control) under both growing conditions had recorded significantly lowest values pertaining to growth, yield and quality parameters.

2018  
Department of Horticulture  
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R. KRISHNA MANOHAR  
Major Advisor

### Studies on the Performance of Yellow Melon (*Cucumis melo* L.) under Different Growing Conditions at Different Levels of Spacing

A. N. VIKASA

The field investigation on the performance of yellow melon (*Cucumis melo* L.) under different growing conditions at different levels of spacing was undertaken between January and April, 2018 at the Department of Horticulture, UAS, GKVK campus, Bengaluru. The results revealed that the plants grown under protected condition were recorded significantly longest vine (372.66 cm), highest number of leaves plant<sup>-1</sup> (118.04), highest number of shoots plant<sup>-1</sup> (5.58), highest leaf area plant<sup>-1</sup> (373.79 cm<sup>2</sup>), highest number of male and bisexual flowers plant<sup>-1</sup> (38.74 and 13.29 flowers, respectively), higher number of fruits plant<sup>-1</sup> (2.17 fruits), highest fruit weight plant<sup>-1</sup> (2.26 kg), highest fruit yield plant<sup>-1</sup> (4.06 kg) and higher TSS (12.06 °Brix) at 1.0×0.75 m spacing level. However, under open-field condition, significantly longest vine (310.33 cm), highest number of leaves plant<sup>-1</sup> (115.50), highest number of shoots plant<sup>-1</sup> (6.33), highest leaf area plant<sup>-1</sup> (340.76 cm<sup>2</sup>), highest number of male and bisexual flowers plant<sup>-1</sup> (35.00 and 12.35 flowers, respectively), higher number of fruits plant<sup>-1</sup> (3.41 fruits), highest fruit weight plant<sup>-1</sup> (1.14 kg), highest fruit yield plant<sup>-1</sup> (3.53 kg) and higher TSS (11.72 °Brix) at 1.50×1.50 m spacing level. Similarly, the highest estimated fruit yield per hectare (109.33 t ha<sup>-1</sup>) and (35.06 t ha<sup>-1</sup>), higher net returns (Rs.10,85,042) and (Rs.2,54,066) benefit: cost ratio (1.95) and (1.53) were recorded at 1.0×0.30 m and 1.50×0.50 m spacing level under protected and open-field conditions, respectively. In general, better vegetative growth, higher yield, good quality of fruits and higher net returns with highest benefit: cost ratios were obtained from protected grown yellow melon compared to open-field condition.

2018  
Department of Horticulture  
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G. K. MUKUNDA  
Major Advisor

### Effect of Spacing and Fertigation on Marigold under Open Field and Protected Conditions

P. N. CHAITRA

INVESTIGATIONS were carried out to study the 'Effect of Spacing and Fertigation on Marigold under Open Field and Protected Conditions' at Department of Horticulture, College of Agriculture, GKVK, UAS, Bengaluru during 2017-18. Under open field condition, T<sub>5</sub> produced maximum height (43.07 cm) and spread of plant (42.06 cm in N-S direction) and (41.87 cm in E-W direction), took minimum number of days for first flower bud initiation (35.34 days), first flowering (37.00 days) and 50 per cent flowering (67.95 days), maximum number of flowers per plant (30.80), per unit area (450.50), single flower weight (6.20 g), weight of 30 flowers (163.22 g) and diameter of flower (5.74 cm), yield of flowers per plant (91.58 g), per unit area (3.40 kg), and per hectare (11.30 t). Under protected condition T<sub>5</sub> produced maximum height (53.78 cm) and spread of plant (43.56 cm in N-S direction) and (43.91 cm in E-W direction), took minimum number of days taken for first flower bud initiation (33.00 days), first flowering (35.34 days) and 50 per cent flowering (62.78 days), maximum number of flowers per plant (33.18), per unit area (485.50), single flower weight (6.73 g), weight of 30 flowers (180.45 g) and diameter of flower (6.11 cm), yield of flowers per plant (119.60 g), per unit area (3.80 kg), and per hectare (12.66 t). It could be concluded that wider spacing (60 cm x 60 cm) with 100 per cent of recommended dosage of fertilizers was better compared to all the treatment combinations as the lowest cost: benefit ratio (1:1.85) was found to be associated with vegetative, flowering, yield and yield attributing traits of the crop.

2018  
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G. GOPINATH  
Major Advisor

## PLANT BIOTECHNOLOGY

### Protoplast Isolation, Culture and Quantification in Selected Varieties of Rice (*Oryza sativa* L.)

M. ASHWINI

RICE is being consumed by most of the people around the globe. So production of rice is very important to fulfill the needs of people. Many methods have been followed for crop improvement. Plant Biotechnological tools help in designing innovative crop improvement strategies. Plant tissue culture which is the part of plant biotechnology has been exploited to create genetic variability and crop improvement. *In vitro* methods for the culture of protoplasts, microspores, anthers, embryos and ovules are being used to create novel genetic variation in the breeding, often *via.*, haploid production. In the present study effort has been made to standardize the protoplast isolation protocol and varietal difference between diverse lines of rice regarding protoplast yield was studied. Study was done in at the Department of Plant Biotechnology, University of Agricultural Sciences, Bangalore. Protoplast isolation is influenced by factors like the type of explant, age of explant, pH of isolation medium, incubation time and enzyme combinations. These parameters were studied to the best conditions to obtain more protoplast yield. Statistical analyses revealed significant difference among all parameters as they influenced protoplast yield. Protoplast yield was better in *japonica* species compared to *indica* species.

2018  
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H. V. VIJAYAKUMAR SWAMY  
Major Advisor

### Molecular Aspects of Management of Grasserie Disease of Silk Worm (*Bombyx mori* L.) with Botanicals

VEERESH SAWALGI

PHYTOEXTRACTS are known to prevent grasserie disease caused by *Bombyx mori nuclear polyhedrosis virus* in the silkworm. The present study aimed at understanding the molecular aspects of management of grasserie disease of the silkworm *Bombyx mori* L. with botanicals. The fourth instar silkworms inoculated with virus were utilized for this followed by real time polymerase chain reaction for expression of red fluorescent protein (RFP) gene also known as *Chbp* using specific primers. *Phyllanthus*, Lime + *Liquidambar orientalis*, Lime + *Phyllanthus* and *Liquidambar orientalis* were effective in significantly increasing the larval weight in winter (23.88, 23.21, 22.93 and 22.93g, respectively) and in summer crop it was in Lime + *Phyllanthus* (24.42g), Lime + *Liquidambar orientalis* (23.06g), *Phyllanthus* (22.62g), Lime + *Curcuma longa* + *Liquidambar orientalis* (22.07g). Cocoon weight in winter crop was significantly higher in *Phyllanthus*, *Liquidambar orientalis*, Lime + *Liquidambar orientalis*, Lime + *Curcuma longa* and Lime + *Phyllanthus* (1.28, 1.2, 1.19, 1.15, and 1.15g, respectively), in summer it was in *Phyllanthus*, *Curcuma longa*, Lime + *Phyllanthus* and Lime + *Liquidambar orientalis* (1.29, 1.21, 1.14, and 1.14g, respectively). Significantly higher pupal weight was observed in *Phyllanthus* (1.04g) and *Liquidambar orientalis* (1.02g) compared to uninoculated control (0.73g) in the winter crop and in *Phyllanthus* and *Curcuma longa* (1.23 and 0.99g, respectively) over uninoculated control (0.73g) in the summer crop. The expression level of *Chbp* gene was higher with botanicals and highest in only *Phyllanthus*.

2018  
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ANITHA PETER  
Major Advisor

## Role of *Cocculus hirsutus* Trypsin Inhibitor (ChTI) against Bacterial Pathogens Associated with Postharvest Losses in Tomato

B. J. MANJUNATHA

SERINE protease inhibitor (SPIs) are proteins has multiple roles in plant defense against biotic and abiotic stresses. They act by diminishing enzyme required for metabolic processes like nutrient assimilation and / or protein turnover. Serine protease (SPs) are the inevitable component in all microbes. SPIs from both animal and plant origin have been reported to have the inhibitory effect against various strains of bacterial pathogens. *Cocculus hirsutus* trypsin inhibitor (ChTI) from *Cocculus hirsutus* has stability up to 70 °C with a narrow pH range of 7.0 - 9.0 accounting for 18KD. Study on effect of ChTI against postharvest bacterial pathogens in tomato fruit has done. It was identified that *Leucono stoccitreum* and *Lacto bacillus fructivorans* are the bacterial pathogens associated with postharvest tomato fruit rot. The IC<sub>50</sub> value for trypsin-like activity (TLA) of these organisms ranges from 10 to 14 µg/ml. Nutritive analysis and HPLC analysis of β-carotene of tomato fruits showed a significant difference between ChTI treated and control fruits. Interaction of ChTI with bacterial cell wall protein observed by passing bacterial cell wall protein through ChTI column, bound protein stained with modified Alcian blue-Silver staining. Further western blot analysis was done to see the binding of ChTI with bacterial cell wall protein. The study showed that ChTI inhibiting the postharvest bacterial pathogen binding with cell wall protein which results in enhancement of shelf life of tomato fruits to 6 days leads to the reduction of postharvest losses.

2018

Department of Plant Biotechnology  
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D. DAYAL DOSS  
Major Advisor

## Marker Assisted Introgression of Major Blast Resistance Genes into IR-64 and KMP-175 Varieties of Rice

M. G. CHINMAYI

RICE blast caused by *Magnaporthe oryzae* is one of the most destructive diseases that affected rice productivity. In order to sustain the yield levels of rice varieties, it is highly inevitable to develop disease resistant varieties. In this study, attempt was made to improve blast resistance of KMP-175 by intercrossing KMP-175 x DHMAS70Q-164-1b and KMP-175 x Monogenic line for *Pi9* harboring blast resistance genes *Pi54* and *Pi9*, respectively. Gene pyramiding was facilitated by marker aided selection to survey resistant and susceptible genotypes. Resulting F<sub>1</sub> plants possessing both the blast resistance genes viz., *Pi54* and *Pi9* were back crossed with KMP-175 as recurrent parent to generate BC<sub>1</sub>F<sub>1</sub> lines. Out of 47 double cross F<sub>1</sub> seeds, only five F<sub>1</sub> plants were selected for the backcross program. The study also involved the generation of BC<sub>3</sub>F<sub>1</sub> and BC<sub>4</sub>F<sub>1</sub> plants of cross IR-64 x DHMAS70Q 164-1b harboring blast resistance genes *Pi1*, *Pitp* and *Pi54*. In the BC<sub>3</sub>F<sub>1</sub> generation five lines viz., plant number 1, 3, 4, 6 and 8 were identified to be pyramided with three genes and subjected to background analysis. The background selection was done using 81 SSR markers that were polymorphic between donors and recipient. Genome recovery of these 5 plants varied from 87.65 to 93.80 per cent and was further advanced to BC<sub>4</sub>F<sub>1</sub> generation. GGT ver. 2.0 software showed that maximum recurrent parent genome was recovered in chromo some 7 and 8. Morphological, yield and grain quality traits were similar to the recurrent parent IR-64.

2018

Department of Plant Biotechnology  
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K. M. HARINIKUMAR  
Major Advisor

## **Genetic Diversity Estimation for Pod and Seed Quality Traits in Bush Type French Bean (*Phaseolus vulgaris* L.) Accessions**

D. ASHWINI

FRENCH bean is an important grain legume grown for its green pods and dry seeds. The present study on diversity estimation for pod and seed quality characters was carried out on thirty French bean accessions along with check varieties based on morphological characters and SSR markers. The accessions IC329154, EC500474, EC559576 and EC283179 showed higher number of fresh pods per plant and total fresh pod weight. The accessions EC500474, EC530843, EC512801 and IC311676 showed higher number of dry pods per plant, seeds per pod and seed length. Majority of the accessions showed slightly curved pods with pear shaped pod cross section and all the accessions possessed string. In majority of the accessions seed shape observed was truncate fastigiate and exhibited varying seed coat pattern. The dominant pod colour was yellow green and dominant seed coat colour was orange white. The SSR markers, BM175 and BM164 exhibited higher polymorphism among the accessions and varieties. The PIC value ranged from 0.19 - 0.36. Dendrogram constructed to assess the genetic diversity among French bean accessions and varieties using SSR marker data grouped accessions into two major clusters. The accessions mentioned above can be used in the breeding programme, for pod and seed quality traits.

2018  
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## **Induction of Mutagenesis and Evaluation of Microalgae for Biomass and Lipid Content**

K. N. NANDITHA

MICROALGAE have a robust photosynthetic capability for fixing CO<sub>2</sub> where the CO<sub>2</sub> captured is stored as lipids primarily in the form of triacylglycerides which can be extracted and used for biodiesel production. Biomass and lipid content are the important parameter for biodiesel. EMS mediated mutagenesis is known as a suitable and powerful method to improve strains. In this present study twelve microalgal strains isolated from different regions and were exposed to induce mutation by using Ethyl Methane Sulphonate (EMS) as a mutagen with the objective of improving biomass and lipid content. Microalgal strains were exposed to different concentration of EMS ranging from 0.1M-0.4M. Among all treatments the 0.4M concentration EMS was found to be the best. Out of which three strains under 0.4 M was screened for increased biomass where the mutated strain S3 (*Tetranephris brasiliensis*), S5 (*Senedesmus granulatus*) and W1 (*Chlorella sorokiniana*) showed maximum growth when compared to wild type. Further biomass and lipid quantification was done in both wild and mutated strains where the mutated strains showed increased biomass yield, mutant S3, S5 and W1 showed 83 per cent, 87 per cent and 91.3 per cent increased dry biomass, respectively. Similarly lipid quantification was done where S3, S5 and W1 showed 16 per cent, 27 per cent and 30 per cent increased lipid content over wild types, respectively. From the above study it can be concluded that EMS can be used as potential mutagen in order to improve the biomass and lipid content in various microalgal strains which can be used as viable feedstock for Biodiesel production.

2018  
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### Physiological and Molecular Diversity in Rice Bean (*Vigna umbellata*)

K. N. LAKSHMISHA

RICE bean *Vigna umbellata* is one of the underutilized leguminous crops. The seeds of rice bean are an excellent source of quality protein and play an important role in human nutrition. The present investigation was carried out to study the extent of genetic variability in physiological parameters contributing to productivity. Molecular diversity among the fifty genotypes of rice bean was examined using 30 SSR primers. Fifty rice bean genotypes were grown both in *kharif* and *rabi* seasons. Plants were harvested at 30 and sixty days after sowing. Based on the leaf area and dry weight accumulated various physiological parameters were calculated. Total biomass of the plant was correlated with seed weight per plant. Leaf area was found to positively correlate with pods per plant. Correlating the physiological parameters with yield or yield attributing parameters will be useful in breeding programs. DNA was isolated from fifty genotypes of rice bean, PCR amplification was carried out using 30 SSR primers and forty one loci were amplified. The size of amplified products ranged between 100 to 400bp. The data were scored to generate pair wise matrix. The similarity coefficient ranged from 0.19 to 1.00. Identification of SSR markers would be useful for markers assisted selection of rice bean.

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### Potato Somaclonal Variants and Selection for Abiotic Stress Tolerance in Potato Cultivars

SPURTI M. BENNUR

LATE blight a devastating foliar disease, caused by *Phytophthora infestans*, greatly hinders the cultivation of potato. The earlier studies by Anil and coworkers developed two somaclonal variants (SVs) from Kufri jyoti viz., KJT<sub>4</sub>, KJT<sub>6</sub> and one SV (KCT<sub>4</sub>) from Kufri chandramukhi. In this study call of these SVs were exposed to pathogen or its elicitors and the defense response monitored. The resistant SVs KJT<sub>4</sub> and KCT<sub>4</sub> showed higher activity of POX and SOD. The SVs also exhibited depolarization of membrane potential when exposed to *P. infestans*. This depolarization was Ca dependent and could be inhibited by EGTA, La and W7 treatments. The study also used NaCl and mannitol stress as selection pressure for selecting abiotic stress resistant SVs from Kufri jyoti. The tolerant calli were screened and stress response was studied. The SV selected on the treatment T<sub>4</sub> (100 mM NaCl) for salt stress and T<sub>5</sub> (serial subculture in Mannitol medium) for drought stress showed salt and water stress tolerance and exhibited higher activity of defense enzymes, accumulated higher levels of phenolics and proline compared to source calli. Another SV generated in the treatment T<sub>9</sub> (75 mM NaCl + 2% mannitol) was found to be tolerant for both salt and drought stress with high stress enzyme activities. In case of late blight resistant SVs higher cell death due to higher peroxide can be considered a marker for resistance. However in case of abiotic stress tolerant SVs, which had robust peroxidase activity, higher peroxide did not result in cell death.

2018  
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## **Phytosynthesis of Silver Nanoparticles and Evaluation of their Bioactivity on Plants, Pests and Phytopathogen**

C. A. ARCHANA

NANO science research is moving forward in a fast pace as nanoparticles have special features that can be exploited in field of Medicine, Cosmetics, house hold products and even Agriculture. Chemical methods used for the synthesis of nanoparticles are expensive and are responsible for various biological risks. Synthesis of nanoparticles using plant extracts is an ecofriendly production method of nanoparticles. In this study silver nanoparticles were phytosynthesized using leaf extracts of Sandal wood and Neem was identified by the appearance of the brownish red color. The NPs were characterized using UV spectra, FTIR and SEM. These studies confirmed the presence of silver nanoparticles formation. The formation of Ag NPs was confirmed by the appearance of characteristic surface Plasmon peak in the absorption spectra around 390 nm. FTIR identify the phenols and aromatic groups are involved in the capping and reduction of silver nanoparticle. SEM imaging shows the presence of silver nanoparticle formation with an average size of 20-25 nm when phytosynthesized at room temperature and 40-45 nm when high temperature of 95 °C was used. In vitro exposure of plant cells to Ag NPs does not hinder the growth of groundnut and potato calli. The cells show increases in SOD and POX enzyme activity. Biological evaluation of the silver nanoparticles was done against the phytopathogen *Pythium* sps micro organism and insect Diamond back moth which showed significant inhibitory effect at very low concentrations (<2 ppm). The observation suggests a potential application of the phytosynthesized Ag NPs in management of pest and pathogens in Agriculture.

2018

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## **Effect of Lower Number of Compost Tea Sprays and Seed Treatments on Growth Promotion, Yield and on Disease Management in Potato (*Solanum tuberosum* L.) and Groundnut (*Arachis hypogaea*) Crops: Biochemical Characterization of Compost Tea Induced Response**

D. SANDEEP

CROP diseases like late blight of potato and tikka of groundnut cause extensive yield losses globally. The excessive use of agrochemicals leads to environmental pollution and health hazards and thus development of alternative approaches of biocontrol becomes important. One such approach is the foliar spray of 'compost teas'. Aerated and non-aerated fermentation are the two dominant approaches in preparation of compost tea. Earlier study of Anil and coworkers, 2017, showed that, ten foliar sprays of aerated compost tea in an integrated formulation helps in management of Late blight and an enhancement of potato tuber yield. In this study we used the potato variety kufri jyoti and groundnut varieties GKVK5, GKVK13 and TMV2 to evaluate the efficacy of compost tea under field conditions. Five sprays of compost tea along with single spray of fungicide and compost tea seed treatments showed higher biomass, yield (15%) and lower disease severity in potato. In case of groundnut, five or ten sprays of compost tea along with single fungicidal spray helps to manage tikka disease and enhances yield (15-18%). Increased levels of superoxide dismutase, peroxidase, phenols and flavonoids indicated defense preparedness in compost tea treated potato and groundnut plants. Compost tea fermented for four days, showed increased levels of proteins, superoxide dismutase, phenols and flavonoids as compared to compost water. *In-vitro* study of compost tea and compost tea bacterial isolates showed inhibition of pathogen, *Ralstonia* growth. The results showed that compost tea based strategy is an effective biocontrol and biofertilizer in potato and groundnut crops.

2018

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## Genetic Diversity Analysis for Growth, Yield and Lycopene Content in Tomato (*Solanum lycopersicum* L.) Germplasm

VIJESH KUMAR NEGI

TOMATO germplasm exhibits huge diversity in growth, yield and biochemical components. Hence, twenty-four tomato accessions were evaluated, ten exhibited determinate habit and fourteen were indeterminate type. Higher (116 cm) plant height and more (7.33) no. of branches were recorded in PKM. The fruit length and width was maximum in EC-214998 (6.80 cm) and EC-614997 (8.54 cm), respectively. Higher (9 mm) pericarp thickness was observed in L-124 and minimum (2 mm) no. of locules were observed in EC-614997. The accession EC-614997 recorded higher (107.84 g) individual fruit weight, high (6.16 kg) fruit yield per plant and higher (4.80 °Brix) TSS, whereas maximum number of fruits per cluster (7.67) were recorded in EC-620472. The biochemical parameters such as total phenols were higher (52.73 mg/100g FW) in EC-620456 and lycopene and carotenoids were higher (11.72 mg/100g FW and 16.79 mg/100g FW) in EC-620521, respectively. The TSS content varied from 2.80 to 4.80 °Brix and vitamin-C varied from 3.56 to 27.73 mg/100g FW. High GCV and PCV values were recorded for carotenoids (28.92 and 29.52), lycopene content (31.83 and 32.47), vitamin-C (40.76 and 40.93) content and yield per plant (44.96 and 45.27), respectively. The heritability estimate was very high for lycopene content (96.12%), total phenol (99.16%), titratable acidity (100%) and fruit yield (98.64%). The lycopene specific primers LEaat 003 and TOM 184 could identify the tomato genotypes with high lycopene content, thus they can be used for MAS for lycopene content. The promising genotypes can be utilized as improved breeding lines for further crop improvement.

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## PLANT PATHOLOGY

### Studies on Rust of Cowpea (*Vigna unguiculata* L. Walp) Caused by *Uromyces phaseoli* var. *Vignae* (Barclay) Arthur and it's Management

JAYASHREE BAMBALAWAD

COWPEA [*Vigna unguiculata* (L.) Walp.] is an important annual legume crop grown in tropical and sub-tropical countries of the world. Among the diseases, rust caused by *Uromyces phaseoli* var. *vignae* has been reported to occur in all the cowpea growing areas of India and Karnataka. A roving survey was employed to assess rust disease severity in different taluks of Mandya district during *kharif* 2017. Maximum average disease severity of 39.14 per cent was recorded in Mandya taluk followed by Maddur taluk (34.61%) and minimum average disease severity was recorded in Krishnarajpet taluk (20.76%) followed by Srirangapatna taluk (22.10%). Maximum uredospores germination was observed on sucrose (36.10%), potassium nitrate (68.07%), temperature of 20 °C (80.50%) and relative humidity of 100 per cent (83.67%). Among 57 genotypes screened against rust, highest average disease severity was recorded in C-152 (81.45%) followed by PGCP-6 (48.75%) and least disease severity of 0.13 per cent was recorded in IC-249593 and 59. Investigations on the effect of different dates of sowing on the disease severity revealed that the least average disease severity of 4.65 per cent on 3<sup>rd</sup> October and highest average disease severity of 45.20 per cent on 17<sup>th</sup> February, while delayed dates of sowing led to early infection by pathogen. Propiconazole 25 per cent EC was superior in inhibiting the uredospores germination (78.87%) at 50ppm, over other fungicides *in vitro*. Similarly, under field conditions propiconazole 25 per cent EC recorded the lowest average disease severity (12.40%) at 0.2 per cent concentration with maximum yield (13q/ha). Among the botanicals evaluated neem leaf extract showed maximum inhibition (68.06%) at 7.5 per cent concentration *in vitro*.

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## Harnessing the Bio-Control Potential of Endophytes and the Rhizosphere Micro-Flora against Rice Blast

L. M. NETRAVATHI

RICE, staple food crop of India is threatened by blast disease which demands integration of biological management. Majority of microbes in soil influence the plants as PGPR's or antagonistic against plant pathogens. The present study reveals the data on metagenome analysis of rice rhizosphere and soil profiles which were mapped using geostatistical tool. Metagenome of rice rhizosphere soil revealed high abundance of beneficial microbes like PGPR's in Chamarajnar (51.59%) and low in Mandya (4.02%). Comparison of metagenome and soil physico-chemical characteristics showed high abundance of nitrogen fixers, nitrifiers and phosphorus mineralizers corresponding to low amount of available nitrogen and phosphorus content in the rice rhizosphere soils. Similarly, metagenome of soil profiles of Kaggalodu micro watershed of Tumakuru district revealed high abundance of PGPR's at T1P3 (28.18%) and lowest in T2P2 (1.85%) profile location. KEGG pathway analysis of rice rhizosphere and soil profile locations of micro watershed revealed that majority of the reads corresponded to metabolic pathways. A total of 156 isolates were isolated from rice rhizosphere (67), ragi rhizosphere (69) and soil profiles (20). These isolates along with the seven endophytes obtained from bacteriology lab of the department, were tested *in vitro* against *Magnaportheoryzae*. Among seven ragi endophytes, an endophyte, *Bacillus* sp strain GPUR-12 (58.18 %) showed highest inhibition, followed by Mandya rice rhizosphere isolate, *Bacillus wiedmannii* strain MP1a (65.00%) and Tumakuru ragi rhizosphere isolate, *Proteus terrae* strain TR3b (82.6%). These investigations supported that endophytes and soil microbes can play a vital role in managing the rice blast.

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## Studies on Fusarium Stalk Rot of Maize in Southern Karnataka

AYESHA TABASSUM

MAIZE is prominent cereal crop belonging the family *Poaceae* is consumed as a staple food in many parts of the world. Among the diseases of maize, Fusarium stalk rot caused by *Fusarium verticillioides* is a serious stalk and root disease of maize causing 38 per cent loss in total yield. In the present investigation, among seven isolates, six isolates viz., FV 1, FV 2, FV 3, FV 5, FV 6 and FV 7 were identified as *Fusarium verticillioides*, whereas FV 4 isolate was identified as *Fusarium verticillioides* based on morphological identification, but it was not confirmed with PCR assay. Among the different media tested for growth of six isolates of *Fusarium verticillioides*, Takahashii's medium and broth were found best for the growth and sporulation. Maximum radial growth and sporulation was obtained at 30°C. At pH 7 maximum radial growth of all isolates were obtained except FV 1 and FV 7 isolates which produced maximum radial growth at pH 6. Exposure to continuous darkness yielded maximum radial growth in all isolates except in FV 6 isolate which produced maximum radial growth when exposed to continuous light. Maximum radial growth was observed on soluble starch by FV 2 and FV 7 isolate, on sucrose by FV 3 and FV 6 isolate and on Fructose and Maltose by FV 1 and FV 5 isolate, respectively. Out of fifty maize inbred lines screened against Fusarium stalk rot by artificial inoculation, fourteen inbred lines were found resistant to disease with a mean disease score of 2.49.

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## SEED SCIENCE AND TECHNOLOGY

### Long Term Effect of Organics, Inorganic Nutrients and Cropping System on Growth, Seed Yield and Quality in Finger Millet (*Eleusine coracana* L. Gaertn)

K. R. ARCHANA

A field and laboratory experiments were conducted to study the long term effect of organics, inorganic nutrients and cropping system on growth, seed yield and quality in finger millet (*Eleusine coracana* L. Gaertn) at AICRP on Dryland Agriculture and in the Department of Seed Science and Technology, respectively. UAS, GKVK, Bengaluru during *kharif* 2017. The experiment consists of sixteen treatments and replicated twice in Randomized Complete Block Design. The results disclosed that, the treatment incorporated with 10 t ha<sup>-1</sup> FYM + 100 per cent RDF (50:50:25 N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O kg ha<sup>-1</sup>) with groundnut crop rotation (T<sub>13</sub>) registered highest growth and seed yield parameters *viz.*, plant height (96.51 cm), chlorophyll content at 60 DAS (47.40 SPAD units), number of productive tillers plant<sup>-1</sup> (4.76 at harvest), number of fingers earhead<sup>-1</sup> (7.81), finger length ear<sup>-1</sup> (10.18 cm), earhead weight plant<sup>-1</sup> (14.35 g), bulk seed yield (2538 kg ha<sup>-1</sup>), graded seed yield (2388.26 kg ha<sup>-1</sup>), straw yield (3988 kg ha<sup>-1</sup>) and seed recovery (94.10 %) and higher seed quality parameters *viz.*, test weight (3.78g), seed germination (91.50 %), mean seedling length (21.08 cm), mean seedling dry weight (2.93 mg), seedling vigour index-I (1929), total dehydrogenase activity (0.382 A<sub>480 nm</sub>) and least electrical conductivity (511 μS cm<sup>-1</sup>) and highest nutritive value of the seed *viz.*, carbohydrate (76.81 %), protein (9.12 %) and calcium (1.25 %) as compared to control and other treatments.

2018

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R. PARAMESH

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### Seed Processing and Storability on Seed Quality Parameters in Red Gram

[*Cajanus cajan* (L.) Mill sp.]

FATHIMA BANU SUTAR

THE experiment was conducted at SPU, NSP, GKVK, Bengaluru. The bulk seed lots of red gram cv. BRG-5 were graded and upgraded using five different round screen sizes *viz.*, 4.50, 4.75, 5.00, 5.50 and 6.00 mm. Among different screen sizes, the highest seed quality parameters such as seed germination (97.00 %), mean seedling length (33.55 cm) and seedling vigour index-I (3254) were obtained in 5.00 mm (S<sub>8</sub>) screen size with specific gravity separator with maximum seed recovery of 85.53 percentage and the lowest was found in bulk seeds. Then the upgraded seeds were treated with thiram @ 3 g, spinosad 45 SC @ 0.04 ml, powdered dry pepper 10 g, neem leaf powder 10 g and pongamia oil 5 ml / kg of seeds and were stored in cloth bag, biodegradable bag and super grain bag for a period of ten months. Results revealed that seeds treated with thiram @ 3 g / kg of seeds and stored in super grain bag recorded lowest seed moisture (9.79 %), electrical conductivity (377 μS / cm), seed infection (23.11 %) and infestation (6.00 %). While, maximum seed quality parameters *viz.*, seed germination (78.67 %), seedling vigour index-II (3015), field emergence (68.00 %) and total dehydrogenase activity (1.71 A<sub>480 nm</sub>) at ten months after storage. The study could be concluded that the red gram cv. BRG-5 seeds treated with thiram @ 3 g / kg of seeds and stored in super grain bag-maintained seed quality parameters above IMSCS up to 10 MAS.

2018

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PARASHIVAMURTHY

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## Identification of Diagnostic Molecular Markers for Genetic Purity Testing in Cowpea [*Vigna unguiculata* (L.) Walp.]

B. S. CHANDANA

GENETIC purity is one of the important quality criteria required for successful seed production and seed certification. Hence, the experiment was set to evaluate the usefulness of SSR markers to determine genetic purity of commercial seed lots of cowpea, which are present in the seed chain of Karnataka. Out of 55 SSR markers studied, 10 SSR markers showed polymorphism for each of the 7 varieties, which revealed 25 alleles at 10 loci with an average of 2.5 alleles per locus. The SSR 6292 showed the highest number of alleles with the PIC value of 0.71. PKB-4 cultivar was found to be most divergent from dendrogram constructed by UPGMA clustering. The genetic purity of the seed lots was tested by following the 20 × 20 matrix, where the purity levels recorded cent per cent for all the seed lots except for KBC-2, IT-38956-1 and C-152 varieties, for which the purity levels are 98 per cent, 96 per cent and 97 per cent, respectively. This analysis revealed that SSR marker is a potential tool for fingerprinting of varieties as well as for the genetic purity testing of the seed lots. Thus, it is helpful for delivering pure seed lots to the farmers.

2018

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N. NETHRA

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## SERICULTURE

### Assessment of Productivity of Tree Mulberry, *Morus alba* L.

C. VANITHA

A study on 'Assessment of Productivity of Tree Mulberry, *Morus alba* L.' was undertaken in farmer's fields of Chikkaballapura and Kolar districts. There was a significant difference with regard to number of shoots (36.06 and 67.93), shoot length (108.00 and 112.03 cm), number of leaves/shoot (23.06 and 21.92) and leaf yield/ tree (2167.00 and 3409.83 g per tree) in tree mulberry. Leaf moisture (73.24 and 72.34%) and leaf moisture after 6 hours of harvest of leaves (62.10 and 61.02%) were minimum in tree mulberry. The carbohydrates (17.44 and 17.89 mg/100g), proteins (27.72 and 32.77 mg/100g), phenols (3.02 and 3.22 mg/100g), nitrogen (4.43 and 5.24%), phosphorous (0.36 and 0.42%), potassium (1.26 and 1.33%), calcium (1.92 and 2.11%), magnesium (0.49 and 0.54%) and sulphur (0.12 and 0.14%) were significantly maximum in tree mulberry. Totally, 62 species of insects belonging to 38 families under 6 orders and 25 species of spiders belonging to the 11 families of the order of Araneae were found on tree mulberry. Larval (4.16 and 4.79 g), cocoon (1.74 and 1.78 g), shell (0.39 and 0.43 g) and pupal weights (1.36 and 1.36 g), shell ratio (20.94 and 24.61%) and cocoon yield (94.95 and 110.67 kg/100 DFLs) were significantly maximum in the batches fed with tree mulberry leaves, respectively in Chikkaballapura and Kolar districts. There was a significant positive relationship ( $p < 0.05$ ) between leaf moisture and pupal weight ( $r = 0.931$ ) and total proteins and larval weight ( $r = 0.905$ ).

2018

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K. C. NARAYANASWAMY

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### Studies on Response of Thermotolerant Bivoltine Silkworm Breeds to White Muscardine Disease

A. KEERTHANA

THE study on the response of thermotolerant bivoltine silkworm breeds to white muscardine disease was conducted at the Department of Sericulture, UAS, GKVK, Bengaluru. Ten thermotolerant silkworm breeds viz., B1 to B8, APS12 and APS45 along with CSR<sub>2</sub> as control were used in the experiments. The breed B4 showed highest LC<sub>50</sub> value (68,625.71 spores/ml) for *Beaveria bassiana* infection and significantly highest LT<sub>50</sub> value at 10<sup>-1</sup> (5.56 days) and 10<sup>-3</sup> (6.63 days) fungal spore dilutions. Further, B4 performed significantly better than any other breed at 10<sup>-3</sup> fungal spore dilution for ERR, fifth instar larval weight, cocoon yield by number, cocoon yield by weight, single cocoon, pupal and shell weights, shell ratio, filament length and filament weight. Under both muscardine inoculation and high temperature treatment (36 ± 1 °C), per-se performance and evaluation index was found better in B4 breed for ERR, fifth instar larval weight, cocoon yield by number and weight, shell weight, filament length and filament weight and B8, B1 and B6 for other characters. Significantly positive correlation was observed for fifth instar larval weight, shell weight, filament length and filament weight between thermal treatment and muscardine infected batches. Regression under both thermal treatment and muscardine infections revealed positive contribution of cocoon yield by number and single cocoon weight to cocoon yield by weight. The study revealed that there could be some association in tolerance to high temperature and muscardine infection and the breeds B4, B8, B1 and B6 which performed better under both the conditions could be utilized for further studies on dual tolerance.

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### Combining Ability for Growth and Yield Traits in Mulberry (*Morus* spp.) and Rearing Performances of Silkworm (*Bombyx mori* L.)

D. EVELIN KUMARI

THE study was conducted to evaluate Combining ability for growth and yield parameters in ten mulberry crosses which were obtained by crossing five lines with two testers in linextester design. The combining ability analysis revealed the presence of higher magnitude of SCA than GCA variance for most of the characters under study except for internodal distance, leaf area and leaf moisture content and the ratio of additive to dominance variance was lower than one, indicating predominance of non-additive gene action for most of the traits except for internodal distance. Among five lines, MI-139 was the best general combiner since it recorded significant positive gca effect for number of branches per plant, number of leaves per plant, leaf to shoot ratio, leaf yield per plant. Whereas, ME-18 was found to be the best general combiner for plant height. Among testers MI-04 was found to be the best general combiner since it expressed significant negative gca effect for internodal distance in desirable direction. Out of ten crosses MI-516×MI-04, MI-139×C-776 and MI-47×MI-04 were good performers with high sca effects. Bioassay was conducted by feeding leaves of each mulberry crosses separately to silkworm hybrid PM×CSR<sub>2</sub> during favorable conditions of rainy and winter season. When silkworms were fed with leaves of MI-516×MI-04 recorded highest larval weight (22.70g/10 larvae) in fifth instar fifth day, total larval duration (25.50days), ERR (98.00%), single cocoon weight (1.51g), single shell weight (0.34g), silk productivity (6.18cg/day), silk filament length (872.10m) and silk filament weight (0.26g) compared to other crosses under study.

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## Studies on Evaluation of Plant Products for the Management of Late Larval Flacherie of Silkworm, *Bombyx mori* L.

G. C. MANJUNATH

*In-vitro* and *in-vivo* studies on evaluation of acetone extract of medicinal plants for the management of late larval flacherie of silkworm, *Bombyx mori* L. was carried out during 2017-18. Among the nine medicinal plants tested in *in-vitro* studies, *Ocimum tenuiflorum* recorded maximum zone of inhibition against *Bacillus* sp., *Asparagus officinalis* against *Staphylococcus* sp. and *Phyllanthus emblica* against *Streptococcus* sp., respectively for the 10<sup>-4</sup> and 10<sup>-6</sup> dilutions compared to control. In *In-vivo* studies, flacherie inoculated silkworms (CSR<sub>2</sub> and PM x CSR<sub>2</sub>) fed on mulberry leaves fortified with acetone extract of medicinal plant at 6 per cent concentration and its influence on larvae and economic traits were studied. Among the nine medicinal plants extracts experimented, *A. officinalis* administration was found significantly effective by enhancing the larval and cocoon quality parameters viz., larval duration (114.32, 161.55, 197.48 h and 82.74, 140.24, 189.10 h) III, IV and V instars respectively, mature larval weight (3.27 and 2.86 g/larva, 33.66 and 29.28 g/10 larvae), ET<sub>50</sub> value for larval mortality (184.66 and 205.84 h), reduced larval mortality (18.00 and 12.66 %), ERR (79.33 and 86.67 %), cocoon weight (1.79 and 1.31 g / cocoon, 17.92 and 13.63 g / 10 cocoon), shell weight (0.356 and 0.247 g / shell, 3.743 and 2.480 g / 10 cocoon shell), pupal weight (1.40 and 1.06 g / pupa, 14.32 and 11.15 g / 10 pupae), shell ratio (20.03 and 18.90 % / shell, 20.92, 18.15 % / 10 cocoon shell), silk filament length (1066.33 and 752.00 m) and denier (2.61 and 2.64) in both the breeds viz., CSR<sub>2</sub> and PM x CSR<sub>2</sub> compared to control.

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## SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

### Effect of Humic Acid on Soil Properties, Growth and Yield of Finger Millet in Soils of Long Term Fertilizer Experiment

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A greenhouse experiment was conducted during 2017 in Department of Soil Science and Agricultural Chemistry, GKVK, Bengaluru to study the effect of humic acid on soil properties, growth and yield of finger millet in soils of long term fertilizer experiment. Humic acid used in the study was characterized and found that C : N of the humic acid was 14.46 : 1 and total acidity was 5.46 meq g<sup>-1</sup>. The experiment was laid out in completely randomized factorial design with 22 treatment combination. The results revealed that significantly higher yield was obtained with the treatment receiving 100 per cent NPK + FYM + lime along with humic acid *i.e.*, 21.35 g pot<sup>-1</sup> grain and 31.25 g pot<sup>-1</sup> straw yield, respectively. Significantly higher nutrient uptake was recorded in 100 per cent NPK + FYM + lime along with humic acid. Among the available nutrients in soil, significantly higher available phosphorus and micronutrients were recorded with application of application of humic acid. With respect to fertilizer nutrient treatments, treatment receiving 100 per cent NPK + FYM + lime recorded significantly higher available nutrient status in soil. However, it was statistically on par with 100 per cent NPK + FYM application. Results of the incubation studies indicated that, significantly higher available phosphorus was recorded in humic acid applied treatment at 60 and 90 days after incubation. The humic acid might have helped in solubilizing P from insoluble to soluble form resulting in its increase. However, difference in available nitrogen and potassium content of soil was not significant at different intervals of incubation.

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the 1990s, the number of people with a mental health problem has increased in the Netherlands. The prevalence of mental health problems has increased from 10% in 1980 to 15% in 1995 (Van Tilburg *et al.* 1998). The prevalence of mental health problems is expected to increase further in the coming years (Van Tilburg *et al.* 1998).

There are several reasons for the increase in the prevalence of mental health problems. One reason is that the number of people with a mental health problem has increased in the Netherlands. Another reason is that the number of people with a mental health problem has increased in other countries as well. The prevalence of mental health problems is expected to increase further in the coming years (Van Tilburg *et al.* 1998).

The increase in the prevalence of mental health problems is a result of several factors. One factor is the increase in the number of people with a mental health problem. Another factor is the increase in the number of people with a mental health problem in other countries as well. The prevalence of mental health problems is expected to increase further in the coming years (Van Tilburg *et al.* 1998).

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