3rd International Symposium On Coconut Research And Development

10 - 12 December 2016

ICAR - Central Plantation Crops Research Institute
Kasaragod, Kerala, India

Abstracts

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Organisers

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PROGRAMME

Saturday, 10 December 2016

09.00 to 10.00	Registration
10.00 to 10.30	**Tea /coffee**
10.30 to 13.30	**INAUGURAL FUNCTION** (Centenary Expo and Farmers' meet Near South Gate of CPCRI)
13.30 to 14.30	**Lunch**
14.30 to 15.30	**Poster review (Session 1 and 2)**
15.30 to 17.30	**INAUGURATION OF ISOCRAD 3**
17.30 to 18.00	**Tea /coffee**
18.00 to 20.00	**Session 1** **GERMPLASM CONSERVATION AND UTILIZATION** Chair : N. M. Nayar Co-chair : Alexia Prades Lalith Perera Convenor : V. Niral
20.00 to 21.00	**Dinner**

Note:

1. Registration will be at DJ Hall
2. Refreshments and poster review session will be in the Quadrangle
3. Technical sessions will be held in the PJ Hall

Sunday, 11 December 2016

08.00 to 08.45	**Breakfast**	
08.45 to 09.15	**Poster review (Session 3)**	
09.15 to 11.00	**Session 2**	
	BIOTECHNOLOGY FOR CROP IMPROVEMENT	
	Chair	: T. R. Sharma
	Co-chair	: Madan Kumar Bhattacharyya
	Convenor	: Anitha Karun
11.00 to 11.15	**Tea /coffee**	
11.15 to 13.00	**Session 3**	
	ENHANCING INPUT USE EFFICIENCY	
	Chair	: P. Rethinam
	Co-chair	: Vimala D. Nair
	Convenor	: Ravi Bhat
13.00 to 13.45	**Lunch**	
13.45 to 14.15	**Poster review (Session 4 and 5)**	
14.15 to 16.00	**Session 4**	
	MANAGEMENT OF PESTS AND DISEASES	
	Chair	: Julian Smith
	Co-chair	: Dulce Regina Nunes Warwick
	Convenor	: Vinayaka Hegde
16.00 to 16.15	**Tea /coffee**	

16.15 to 18.00	**Session 5** **CLIMATE CHANGE: EFFECTS AND MITIGATION** Chair : P. K. R. Nair Co-chair : V. Rajagopal Convenor : K. B. Hebbar
18.00 to 18.30	**'Coconut feast'**
18.30 to 20.30	**Cultural Evening**
20.30 to 21.30	**Symposium Dinner**

Monday 12 December 2016

08.00 to 08.45	**Breakfast**
08.45 to 09.15	**Poster Review (Session 6, 7 & 8)**
09.15 to 11.00	**Session 6** **VALUE ADDITION AND PRODUCT DIVERSIFICATION** Chair : A. K. Singh Co-chair : Jacob Annamalai Convenor : A. C. Mathew
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11.15 to 13.00	**Session 7**	
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	Chair	: Uron N. Salum
	Co-chair	: M. Thomas Mathew
	Convenor	: K.Muralidharan
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	Chair	: Jayantha Jayewardene
	Co-chair	: J. Vasanthakumar
	Convenor	: C. Thamban
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Keynote address

Does the coconut have a future?

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The coconut (*Cocos nucifera* L., Arecaceae) has been the most useful plant to the humans, because every part of the palm used to be put to active economic uses in much of the areas where the coconut was being grown. It is presently either grown, or it occurs naturally in over 12 million ha in 94/243 countries/ territories of the world (FAOSTAT 2016). The coconut forms also a component of the strand vegetation in most of the ca. 35,000 islands of the Pacific and Indian Oceans.

Until the end of the Second World War, for the previous more than a century, the coconut oil was the most traded vegetable oil in the world. In 1961, when the FAO began publishing area–production figures, the coconut oil had slipped already to the fourth position among the 12 major vegetable oils of the world. Further, in 2014, it had slipped down further to the nineth position. In area and production, the coconut had doubled its area and production during 1961–2011, while in most other oils, the maximum increase was 230 times, and, on an average, 4–6 times. This appears to be because the coconut has become an orphan crop with no multilateral financial support or promotion, and it is being grown in some of the least developed and deprived countries/territories of the world. Further, the national and multilateral agencies tasked with coconut development, appears to have been unable to stem the downward slide.

This happened because of to a variety of reasons. A very decisive one was the influence of a powerful lobby operating in the US in the 1980s in favour of soybean oil interests that was lobbying strongly against the palm-based oils alleging their adverse effects on human health (Mcnamara 2011). And, the adverse impact of this lobbying was severe. There was also no organized voice or resource available at that time to counter this argument. The presence of certain antinutritional factors in cotton seed, rape & mustard, and palm-based

(coconut and oil palm) oils was indeed a major issue to be taken note of. While rape & mustard, cotton seed, and palm oils interests were able to overcome / bypass the allegations and antinutritional factors through a variety of measures, there was no agency to do this for the coconut, it being an orphan crop.

It has been pointed out also that more than three-fourths of the coconut palms in all the Pacific and Indian Ocean countries and two-thirds areas in south and southeast Asia are in need of replanting.

Some of the steps to overcome this impasse are: (a) Pressurise the FAO and the CGIAR to get the coconut as a mandated crop of the ICRAF Nairobi (World Agroforestry Centre) to initiate organised research on the coconut; (b) Induce determinacy in the coconut to conclude its life in 40–50 years at the most (Genes for this are available in the Genbank). In addition, the genome of oil palm may be searched for the presence of determinacy genes. Incorporation of these genes in the coconut genetic system will make it possible to harvest the fruits of coconut from the ground using lightweight telescopic polls. This is already being done in the case of oil palm; (c) It has been estimated that with the present practice, a minimum one-third of the mature fruits are lost because of the absence of an organized system to harvest the ripe nuts from the tree; (d) Set up an international consortium to study the numerous diseases of uncertain etiology prevalent in the coconut; and (e) Initiate allround and intensive efforts to introduce domesticated characters in the coconut, especially to reduce excessive button shedding, total inflorescence sterility, and so on.

SESSION 1

GERMPLASM CONSERVATION AND UTILIZATION

Abstract S1L-01

Coconut breeding - A synthesis

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Coconut breeding, involving selection of palms based on field experience and raising their progenies for generations can be considered to have been in vogue ever since the crop was in cultivation for some 2000 to 3000 years. The first effort on recorded information on coconut breeding became available about 275 years ago from the Indonesian publication "Herbarium Amboinense". Formal and scientific breeding started in 1916, in India. The special features like long gestation period, height, heterozygosity, large nut size, requirement of considerable space and other resources, poor multiplication ratio, lack of vegetative propagation, monotypic nature of the genus Cocos are all factors discouraging scientists to undertake coconut breeding work. Considerable progress has however been made in this field in spite of all these odds, which is briefly analysed.

Coconut breeders all over the world adopted well accepted classical methods of breeding *viz*. Introduction, selection and hybridisation with priority on increased yield. Since wide genetic base is a basic requirement for breeding, prospection and collection of various coconut types was given priority since the beginning. With no known wild/domesticated related species, there is no possibility of tapping gene pools of related sources. With the initiative under COGENT, international germplasm exchange was made possible between the member countries. CPCRI now has the largest germplasm collection with 455 accessions (323 indigenous and 132 exotic) from 28 countries. The Institute also hosts the International gene bank for South Asia.

In view of the inter and intra population variability, it is but natural that selecting the best ones available was the first option to farmers much before scientific breeding was started. In the absence of results from field trials, the best method was mass selection (pooling seed nuts from high yielding local palms). Results available across the coconut growing countries show the significance of this procedure for coconut improvement.

Selection is practised at three stages, of which the mother palm selection is the most important. Only palms which have stabilised their yield (preferably more than 20 years) yielding at least 80 nuts $year^{-1}$, with 20 kg of copra $palm^{-1}$ are considered as mother palms of Tall. Selection is also practised at the seed nut stage, ensuring selection of good and healthy nuts, though this is done more from an agronomic consideration. In the seedling stage, the most important criteria used for selection are speed of germination, vigour, girth at collar, number of leaves and splitting of leaves.

Ever since the report of coconut hybrids in 1932 by Patel in India, the attention was completely turned to hybridisation between the two major coconut varieties, the Talls and Dwarfs. Though the first hybrid was produced by Marechal in 1928, by crossing Niu Leka and Malayan Dwarf in Fiji, the work was discontinued due to financial crisis. The major problem faced was the highly variable performance between hybrids involving different parental palms. This was minimised to a certain extent by identifying parents on the basis of combining ability tests (Line x Tester, diallel) for selection of parents. In India, a total of 49 improved varieties of coconut, including 20 high yielding hybrids have been released. The best among them yield as much as 167 $nuts^{-1}palm^{-1}year^{-1}$ equivalent to 5.01 t copra/ ha/year as compared to 80 nuts $palm^{-1}year^{-1}$ and 1.5 t copra ha^{-1} $year^{-1}$ given by the local WCT. Apprehension is often raised on the longevity of the hybrids. It is now known that yield of hybrids do not decline even after 80 years as is evidenced from the present day performance of hybrids planted as early as in 1935 in India. The hybrids can be further improved using information on the individual combining ability and by exploiting within population variability

Though most commercial hybrids are D x Ts, and T x Ds, some T x T hybrids have a comparable potential. They are more suitable as a main crop for intercropping and offer better prospects for long-term genetic progress. So far, Thailand is the only country where T x T hybrids have been released to farmers.

Efforts were also made to evolve 'complex hybrids' (crosses of a hybrid with another hybrid or a variety). In 1990s, three-way hybrids (D x T) x T and (T x T) x D were produced in Thailand, which not known to have reached a logical conclusion.

Unfortunately coconut production is seriously affected in most of the major coconut producing countries due to very serious diseases; whether it is root (wilt) disease in India, LYD in central America and Africa, Cadang cadang in Philippines or Weligama Coconut Leaf Wilt Disease (WCLWD) in Sri Lanka. In the absence

of any chemical cure, the only option left is evolving and planting resistant/ tolerant varieties. CPCRI had released three root (wilt) disease resistance/ tolerance coconut varieties *viz.* Kalparaksha (MGD), Kalpasree (CGD) and Kalpa Sankara (CGD x WCT). It is observe in all the countries the dwarfs, especially the Dwarf Green, as the source of resistance which has to be investigated further.

In the recent years, several biotechnology tools for coconut improvement are used. Which include i) tissue culture of elite palms ii) production of homozygous lines iii) in vitro testing for tolerance to biotic stress iv) germplasm movement v) cryopreservation and vi) molecular characterisation.

Abstract

S1L-02

The home of coconut – finding its roots through history and molecular biology

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The origin and evolution of coconut, a montypic genus, *Cocos nucifera*, is shrouded with confusion and not mystery. The original home of the crops can be researched with information available on iconography, ancient literature, paleobotanical and archeological evidences and more scientifically using molecular tools. Hugh Harries in his series of articles places Pacific region as a centre of origin. The home of coconuts could be somewhere in Asia and would have spread far and wide. The maritime travelers and sea farers contributed a lot to its spread. One of the evidences suggesting the South Indian origin (be it primary or secondary) gains support from the ancient Sangam literature of Tamil (200 BCE to 200CE) which richly mentions the crops grown in ancient Tamil country. One of the main crops mentioned is Coconut. The literature also mentions the maritime routes made by the Chola kings to present day Indonesia where they had built Hindu temples. In Hindu tradition, Coconut is one of the main offerings to the Hindu gods. Valmiki Ramayana (300 BCE) mentions about Coconut in Kishkinda Kandam and Aaranya Kandam (present day South India). The Naval superiority of the Chola King Rajendra Chola made him to conquer Malaya (Malaysia and Indonesia) in 1025 CE. The invasion also led to the introduction of crops like Black Pepper. It is interesting to note that if Cholas had taken some varieties of Coconut from India, it is likely that some of the Malayan varieties would have reached India also. Bee Fong Gunn (2016) presented a detailed study on origin and dispersal of coconut for her doctoral thesis to Australian National University. She used Bayesian analysis of population genetic structure and proposed. Two centers of domestication - Island Southeast Asia and the southern margins of the Indian subcontinent. She found uncovered evidence for admixtures between these populations consistent with Austronesian trade routes from Southeast Asia to Madagascar and Arab trading along east African coast.

Abstract S1O-01

A pollination strategy to increase the setting of Dwarf x Tall hybrid seed coconut under heat and water stress

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The study assessed the possible influence of heat and water stress around flower meiosis on the quality of female (Sri Lanka Green Dwarf, SLGD) and male (Sri Lanka Tall, SLT and San Ramon Tall, SRT) flowers and the fruit set of respective hybrids (SLGD x SLT and SLGD x SRT) with pollination between similarly stressed parents and between stressed and non/low stressed parents, under controlled hand pollination. Flowers developed under eight different stress levels; six with heat and/or water stress at stages around meiosis and two controls without stress around meiosis were selected. One set of female flowers of emasculated SLGD opened in the selected eight months were hand-pollinated with SLT and SR pollen produced in the same months and, the other set of SLGD palms were subjected to reciprocal pollination (stressed female flowers pollinated with non/low stressed pollen and vise versa). The quality of female flowers and pollen varied with the stress level around meiosis. When the SLGD female flowers developed under no stress were pollinated with the pollen developed under same condition, the FS% in both crosses was higher (88% in SLGD x SRT, 78% in SLGD x SLT) compared to those pollinated with stressed pollen (44% in SLGD x SRT, 30% in SLGD x SLT). In contrast, when the heat and water stressed female flowers were pollinated with the pollen produced under same stress condition the FS% was lower (39% in SLGD x SR and 33% in SLGD x SLT) compared to those pollinated with non-stressed pollen (57% in SLGD x SRT and 51% in SLGD x SLT). The results revealed two important aspects; one is the importance of quality of pollen for a successful fruit set in the production of dwarf x tall seed coconuts, and the other is an important strategy to increase the fruit set during stressed months by using non stressed pollen to pollinate the stressed female flowers in controlled hand pollination.

Abstract S1O-02

Performance of Dwarf varieties and hybrids combinations of coconut in the root (wilt) disease prevalent tract

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A field experiment was planted at ICAR-CPCRI, Regional Station, Kayamkulam during July 2009 with three dwarf varieties (MGD, MOD, MYD) and four hybrid combinations (CGD X WCT, CGD X MGD, MGD X WCT, MYD X WCT). The experimental design was Randomized Block Design with three replications and 15 palms per replication. The planting material of dwarfs was raised by selfing. Growth observations recorded during the initial four years revealed that hybrid combinations were more robust compared to dwarfs for morphological characters like palm height, number of functional leaves and palm girth. Root (wilt) disease incidence recorded four years after planting revealed that MGD, CGD X WCT, CGD X MGD took up disease only to 4.4% whereas MYD X WCT recorded 15.6% disease incidence followed by MGD X WCT and MOD with 11.1% disease incidence. More than 85% flowering was noticed in all hybrid combinations within five years after planting, whereas only 50-75% flowering was recorded in dwarf varieties. The disease incidence recorded after seven years revealed that higher incidence of root (wilt) was noticed in MYD X WCT (28.6%) followed by MGD X WCT (25.7%) and the lowest disease incidence was in 8.8% was in CGD X WCT followed by CGD X MGD. However, MGD recorded 22.2% disease incidence seven years after planting. Yield performance during the initial two years of harvest revealed that the hybrid combinations were significantly superior to the dwarf varieties.

Abstract S1O-03

Palm diversity in India and the need of conserving their genetic resources

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Palms are the icons of tropics and stand next to grasses in the welfare of human beings. From the very beginning, it had developed an intricate relationship with the Socio, Economic and Cultural spheres of man. There is no substitute for the gracefulness that palm offer. Palms tend to attract attention, perhaps because of their recognisable rather simple growth form, their ecological and economic importance, or indeed simply because of their association with the exotic. This group in India (wild and naturalised) is represented by 20 genera and about 110 species (excluding recently introduced and cultivated exotic varieties) among which 29 species belonging to 9 genera are endemic to India. The largest genus is Calamus followed by Phoenix, Pinanga and the rest with a few number of species each. In addition, *Cocos nucifera*, *Areca catechu* and *Elaeis guineensis* are widely cultivated as plantation crops. The genera like *Borassus*, *Salacca*, *Nypa*, *Hyphaene* and *Rhopaloblaste* etc. are confined to a solitary species. The present paper deals with the distribution and key features of important palm species growing in India, wild and naturalised, their possible uses and current conservation status both *in situ* and *ex situ*. Further, it emphasises the need to conserve their genetic resources for effective breeding and management of allied crops and also for the benefit of evolving superior plantation crop varieties in future.

Abstract

S1O-04

Phenotypic expression of some hybrids of coconut at Central Dry Zone of Karnataka

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One of the major problems of coconut farmers is the lack of well-adapted and high yielding coconut varieties and as it is widely cultivated across the country, there is need for high yielding and good quality genotypes suitable to specific regions. In order to increase the yield and quality of coconut, development of hybrids are essential to bring superior combination of desirable traits and they are expected to perform well over the varieties. Hence, nine different hybrids of coconut were evaluated at HREC, Arsikere during 2010-15 after planting them in 1987 and showed significant differences for growth, yield and quality parameters against ruling check variety TPT. More number of functional leaves were recorded in GBGD x PHOT (33.7 leaves/palm) compared to TPT (32.9 leaves/palm). Higher nut yield was recorded in GBGD x LCOT (132.3nuts/palm/year) compared to local check (90.1nuts/palm/year). When yield and quality parameters were considered, both the cross combinations GBGD x LCOT and GBGD x PHOT expressed on par the highest values for coconut yield, copra content, copra yield, oil yield, ball copra content and ball copra yield as compared to other combinations and check variety. This study revealed that both GBGD x LCOT) and GBGD X PHOT hybrids are superior for most of the parameters and hence, are most suitable to this Central Dry Zone region.

Abstract S1O-05

Sustaining regional coconut diversity through *ex situ* conservation at ICG-SA, India

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ICAR-CPCRI hosts the International Coconut Genebank - South Asia (ICG-SA), one of the five multi-site gene banks of coconut in which about 91 diverse coconut accessions are being conserved in field gene banks. The accessions in the ICG-SA represent coconut germplasm from the host country (India) as well as from Sri Lanka, Bangladesh and the Indian Ocean Islands. With a focus to improve productivity and overall profitability to the coconut farmers, research at the institute has focussed on characterization and utilization of conserved genetic resources for development and identification of high yielding varieties and promising lines for future breeding programmes. Descriptor traits *viz.*, growth characters, flowering and reproductive traits and fruit characters are recorded to facilitate better understanding of the diversity. Fruit component analysis undertaken in selected accessions, including South East Asian, African, South American, South Asian and Indian Ocean germplasm, indicated higher copra content comparable to SNRT in the Aukchung Tall collected from Nicobar Tall coconut population. Evaluation of tender nut water quality in selected accessions indicated good tender nut water quality with higher tender nut water content in Rennell Island Tall, British Solomon Islands Tall, SSAT and Yellow Spicata. Development of trait specific genetic stocks *viz.*, a dwarf green selection with good quantity and quality of tender nut water from Coco Bleu Tall, dwarf population bearing large, bright apricot coloured fruits with higher tender nut water volume from SSAT, a dwarf yellow Spicata from Spicata Tall population has been initiated. The genetic base available in the ICG-SA will sustain the collections safely and contribute to the better utilization in crop improvement research for the benefit of the coconut growers.

Abstract

S1O-06

Biochemical criteria for selection of high yielding seedlings from coconut nursery

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Coconut is predominantly an open pollinated tree crop which is conventionally propagated through seedlings. Due to its highly heterozygous nature, the seedlings exhibit a high degree of variability in yield and related characters. Traditionally, coconut farmers have used certain morphological characters to select high yielding seedlings from the nursery. However, the success rate of obtaining high yielders has been rather low, usually not more than 50%. Hence, in order to boost the productivity of plantations, it is essential to resort to better methods of selection which could ensure at least up to 80% of high yielders. Biochemical indices which are highly conservative and are not influenced by environmental and cultural conditions could be employed to achieve this objective.

Biochemical studies conducted over a period of 15 years on a population of one-year-old seedlings raised from open pollinated West Coast Tall variety and hybrids developed by crossing MDO x WCT, COD x WCT, MYD x WCT and transplanted into the main field at CPCRI, Kasaragod for monitoring their yield as adult palms have established that selection of hybrid seedlings based on biochemical criteria provide the best means of obtaining >80% high yielders with an average productivity of 100 nuts/year/palm. An attractive feature of the biochemical method is that it is rapid, reliable and relatively easy to perform even on a large population of seedlings. The procedure does not require expensive instrumentation and hence could be adopted on a large scale for selection of high yielding seedlings in order to ensure uniformly high yielding population of coconut palms thereby boosting coconut productivity.

Abstract S1P-01

Trait based selection for copra content in Tall coconut

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Coconut (Cocos nucifera L.) is an important multi-purpose palm widely grown in the tropics. Being a perennial crop, trait based selection could pave way for identification of better mother palms with good pre-potency which in turn produce good seedlings having high yield potential. Since Tall coconut types are grown for their copra, an analysis was made on association of morphological traits with copra content in 40 Tall coconut population. In case of vegetative traits, leaf length and petiole length were observed to have significant positive correlation with copra content (0.435 and 0.340 respectively). This indicates the importance of photosynthetic area with regard to copra yield of coconut. Among the nut traits, fresh kernel weight and Kernel thickness were observed to have significant positive correlation with copra content (0.887 and 0.342 respectively. Hence selection for these traits could result in simultaneous improvement of copra content.

Abstract S1P-02

Development and evaluation of promising Tall x Tall coconut hybrid

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An evaluation trial conducted over 30 years on coconut hybrid combinations has resulted in identification of a superior, high yielding Tall x Tall hybrid, released as national variety VPM 5 involving Laccadive Ordinary Tall as female parent and Cochin China Tall as male parent. This hybrid is better performing over other hybrids and local check with higher nut yield (161 nuts palm^{-1} year^{-1}), higher copra out turn of 24.1 kg palm^{-1} year^{-1} and copra yield (4.2 t ha^{-1} year^{-1}) with an estimated oil recovery of 2.90 tonnes/ha under irrigated conditions of Tamil Nadu. The hybrid took on an average of 45 months for initiation of first flowering which was earlier than other Tall x Tall hybrids, possess good tender nut water quality (TSS 5.5 0 Brix) and with 300 ml of tender nut water. The hybrid recorded 44 percent more nut yield, 48 percent more copra yield and 48.2 percent more oil yield over the released Tall x Dwarf hybrid 'VHC 1'. The seedlings of this hybrid are more vigorous, producing higher number of leaves within 12 months, having higher leaf area and dry weight indicating precocity in growth and development. The flowering, morphological and fruit component traits of VPM5 hybrid were compared with parental palms and found superior. The characteristics of this hybrid and its performance indicated the potential to increase the productivity and over all coconut production. Molecular finger printing studies showed their parental confirmation.

Abstract S1P-03

Evaluation of coconut cross combinations suitable for Andhra Pradesh

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In coconut, the palms are broadly grouped into two categories based on stature and breeding habit *viz.*, Tall and Dwarf types. The Talls are often cross pollinated and commercially grown for production of copra and oil while the Dwarf types are self pollinated and usually grown for tendernut, ornamental and breeding purpose. In general, Talls are medium to high yielders where as dwarfs are medium to low yielders. To exploit hybrid vigour an evaluation trial was conducted at AICRP on Palms center, Ambajipeta involving different coconut cross combinations namely ECT x MGD, GBGD x ECT, GBGD x FJT, GBGD x PHOT, GBGD x LCOT, ECT x GBGD (Godavari ganga) as control for a period of 26 years. The results of their performance lead to identification of two superior Dwarf x Tall hybrids suitable for the state of Andhra Pradesh . The observations revealed that the hybrids GBGD x LCOT followed by GBGD x PHOT were found superior over hybrid check (ECT x GBGD). The cross combinations GBGD x LCOT and GBGD x PHOT recorded significantly higher nut yield (136 and 125 nuts/ palm/year), high copra out turn (3.8 t and 3.7 t/ha/year) and estimated oil yield of 2.7 t/ha and 2.6 t/ha respectively. The palms of these hybrids are semi tall, precocious (comes to bearing in 40 -50 months after planting), having good tender nut water content (346 & 395 ml per tender nut) with TSS (5.6 & 6.2° Brix). Owing to its superior performance with respect to nut yield, copra output and oil yield and tender nut qualities over hybrid check indicates their potential to increase the production and productivity of coconut in Andhra Pradesh.

Abstract

S1P-04

Geographical distribution of Dwarf coconut (*Cocos nucifera* L.) population

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Coconut (*Cocos nucifera* L.) is a livelihood crop for millions of people in the tropical and sub-tropical world. Dispersal of coconut has been aided by both nature and man, through ocean currents and human migrations in prehistoric times. Two major forms of coconut, Talls and Dwarfs, have developed during the course of evolution. The commonly cultivated ones are Tall types. The Dwarf types, which are suggested to have originated from Tall type by mutation or inbreeding or both, are sparingly distributed. Evolution and diversification of Dwarf coconut were not restricted to any geographical region but occurred in many coconut populations around the world. Dwarf coconuts are encountered in countries like India, Malaysia, Sri Lanka, Nigeria, Brazil, the Philippines, Thailand and Fiji. Though Dwarf coconuts developed in many places, their proportion in the world coconut population is not more than five percent. Diversity encountered in dwarf coconut populations in different geographical regions includes that for husk content, resistance to diseases and pests, sweet tender nut water, copra and nut yield. In India, Dwarf coconut populations have been identified from various geographical locations like West coast, East coast, Lakshadweep Islands and Andaman & Nicobar Islands. Occurrence and distribution of Dwarf coconut population is discussed in the paper.

Abstract S1P-05

Kalpa Sreshta - a promising Dwarf x Tall coconut hybrid

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An experiment was planted at ICAR-CPCRI and AICRP on Palms Centre at Arsikere in 1991 with four hybrid combinations of coconut, along with a control, with the objective of identifying high yield varieties. Analysis of the stabilized yield data, under irrigated conditions, revealed superiority of the hybrid involving IND 058S as female parent and IND 125S as male parent and was selected for variety release as "Kalpa Sreshta". The average annual nut yield of this variety is 167 nuts/palm/annum, with estimated annual copra out turn of 35.9 kg/palm/year (6.28 t/ha). Kalpa Sreshta is superior to the earlier released D x T hybrid Chandra Sankara (COD x WCT), with 35.75% more nut and 30.29% more copra yield over Chandra Sankara. Kalpa Sreshta palms are characterized by vigorous growth habit, regular bearing, higher rate of spathe production, high nut yield, green coloured fruits, more female flowers/inflorescence and good quality of tender nut water. The palms, under rain fed conditions, commence flowering in 6-7 years after planting, while under irrigated conditions flowering is expected within 4 years after planting. The tender nut water content is around 368 ml and good in taste with TSS of 5.89° Brix, total sugars - 5.81 g/100 ml and amino acid - 1.34 g/100 ml, sodium - 33.3 ppm and potassium - 2081 ppm. The average copra content is 215 g and oil content is about 64.1%. Kalpa Sreshta is found to be high yielding under irrigated conditions both at CPCRI Kasaragod and at AICRPP Centre, Arsikere and is recommended for cultivation in the coconut growing tracts of Kerala and Karnataka.

Abstract S1P-06

Kalpa Shatabdi - A promising dual purpose coconut variety

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An experiment was planted at ICAR-CPCRI in 1990 with 10 lines of coconut, along with a control (WCT), with the objective of identifying high yielding selections for development of improved varieties. Analysis of the stabilized six year yield data, indicated significant variation among the accessions. Selections from San Ramon Tall, Kenya Tall, Federated Malay States Tall, Philippines Lono Tall, Palawan Tall and Fiji Tall recorded significantly higher yield than West Coast Tall (local control), with more than 24 kg copra/palm/year. The SNRT selection in addition to recording the highest copra yield, also has large fruits with high tender nut water content (612 ml), average copra content of 272.9 g and is recommended for release as Kalpa Shatabdi, a dual purpose variety (copra and tender nut). Kalpa Shatabdi gives high copra out turn of 28.65 kg/palm/year or 5.01 t copra/ha, with estimated oil yield of 18.34 kg oil/palm or 3.21 t/ha. The variety gives 61.14% more copra out turn and 54.33% more oil yield per hectare than the local check. The variety produces an average yield of 105 nuts/palm/year. The palms are regular bearers and commence flowering six years after planting under recommended package of practices. The palms are categorized as tall with slight bole at the base. The stem is stout with higher girth, closely arranged leaf scars. The variety bears greenish yellow, large sized fruits and the dehusked fruits are round in shape. The seedlings are vigourous, producing more number of leaves within 12 months (9-10), and characterized by higher collar girth and seedling height. The palms of this selection recorded lesser incidence of rhinoceros beetle damage when compared to other accessions in the trial. Kalpa Shatabdi is suitable for cultivation in the coconut cultivation tracts of Kerala, Karnataka and Tamil Nadu and has the potential to enhance coconut productivity and profitability in the country.

Abstract S1P-07

Characterization of coconut germplasm and varieties for DUS testing

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A study on the Juvenile growth characters, such as palm height, girth, length of leaf, petiole length, length of leaf bearing portion, leaflet count, leaflet length, leaflet breadth, annual leaf production, total leaves on the crown were recorded in 22 coconut lines, including germplasm accessions and released varieties planted during 2013 at closer spacing (4m x 4m and 6m x 6m), for characterisation and generation of characterisation DUS descriptor data. Analysis of variance indicated significant difference between the treatments, for the characters *viz*; palm height, girth, total leaf length, length of petiole, length of leaf bearing portion, leaflet count, leaflet length, leaflet breadth, number of leaves in produced in year. Variability was negligible for the total leaves on the crown. Palm height, length of petiole, length of leaf bearing portion and total leaf length were significantly higher in Kalpa Mitra and lower in Chowghat Green Dwarf. Chandra Kalpa was found to be have more leaflets and also longer leaflets among the varieties studied, while significantly broader leaf lets was recorded in Kalpa Dhenu. The accession Federated Malay States Tall was found to have significantly higher trunk girth in the present study as compared to than the rest of the coconut accessions. Number of leaves produced in one year also showed significant variation is higher leaf production in Chowghat Green Dwarf and significantly lower leaf production in West Coast Tall. No significant differences in the growth characters was observed during the current year among the two different spacings adapted, due to lesser canopy size in the juvenile stage of growth. Information on growth characters recorded on germplasm/varieties will aid in development of descriptors and in formulating appropriate strategies for coconut improvement, as well as production technologies.

Abstract S1P-08

Pink husked coconut selection - a trait of promise

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A coconut palm bearing fruits with pink coloured mesocarp was identified at ICAR-CPCRI, from San Ramon Tall population, for exploitation in breeding programme to develop new tender coconut varieties. Tender nut water content was observed to be 600 ml and copra content 260 g. The male and female flowers and fruits from all bunches of the palm exhibit the ring of pink colour over the surface of fruits below the tepals, slightly extending outwards. It was observed that when the tender fruits are trimmed, husk fibres also exhibit the colour ranging from intense to light pink from outer to inner side giving an attractive appearance. The pink colour also appeared on the inner surface of the young fruits of 3 to 5 months age. However, the pink colour is exhibited only in a proportion of male flowers: Two types of male flowers having differently coloured anther filaments, one with dark pink and another with normal yellow were observed. Although few coconut palms bearing pink ringed fruits have been reported earlier from India and Philippines belonging to West Coast Tall population, East Coast Tall population, Yellow Dwarf and Philippines populations, there have been no reports about the differential colour of male flowers in an inflorescence, which presents a new line of thought for further investigating the trait. However, no morphological difference could be seen on size of male flowers and anthers, but flowers with pink filaments could be easily identified even at unopened stage as the pink tinge is present in the bottom of tepals.

Abstract S1P-09

Morphological characterization of coconut seed nuts and seedlings

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An experiment to characterize important seed nut and seedling morphological characters of three tall (POT, LCT and WCT) and four dwarf (MGD, MYD, CGD and COD) coconut populations under breeding behavior study was conducted at ICAR-CPCRI Research centre, Kidu, Karnataka, India during 2015-16. Three palms under each variety were identified for collecting seed nuts and their characterization. Fifteen nuts were collected from each palm and were sown in poly bags after recording nut characters. Among the varieties POT seednuts were found to be superior in terms of germination (27 DAS), nut weight (1200 g) and nut width (17.45 cm). They also found to exhibit significantly profound seedling vigour in terms of maximum plant height (105 cm, 167 cm and 238 cm), maximum collar girth (3.34 cm, 5.06 cm and 6.62 cm) and more number of splitted leaves (0, 1.8 and 3.3) at six, nine and twelve months after sowing, respectively. The superiority for the said characters was followed by MGD with added quality of more number of leaves (6.13 and 6.77) at nine and twelve months after sowing, respectively. On the other hand seed nuts of WCT weighing optimally with medium size, comparatively took highest number of days (109 days) for germination with average seedling vigour.

Abstract

S1P-10

Seasonal and varietal specificities in floral development and pollen characteristics of coconut (*Coconut nucifera* L.)

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Coconut is a perennial crop that produces one inflorescence in each leaf axil throughout the year. Approximately 12 to 14 inflorescences are produced in a year. Seasons in a year influence inflorescence production as well female and male flower behaviour of coconut varieties. Seasonal and varietal specificities are important factors for developing cross combinations in coconut. The information is required for selecting suitable varieties as parents in a cross as well as for deciding time of the year for doing the crossing. Four seasons considered for the study were South West monsoon, North East monsoon, winter and summer. Four varieties studied are West Coast Tall (WCT), Laccadive Ordinary Tall (LCT), Chowghat Orange

Dwarf (COD) and Malayan Yellow Dwarf (MYD). Duration of female flower receptivity changes with variety and season of the year in which the bunch opens. Female phase lasted more days in dwarfs compared to talls and the duration was reduced in summer for all varieties. Pollen yield and germination is influenced by the variety and season. Pollen yield and germination was more in North East monsoon and winter seasons than in other seasons. More quantum of pollen produced and faster growth of pollen tube as revealed in this study may provide competitive advantage to tall varieties to contribute more to diversity in a mixed population. These factors may account for some of the variability found in a progeny of dwarf parent in spite of overlapping male and female phases aiding self pollination.

Abstract S1P-11

Innovative approach for pollination in coconut (*Cocos nucifera* L.) - whole spikelet method

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Hybrid seed production in coconut is a laborious process that involves climbing the palm many times. Any alternative that reduces the number of climbing will make the whole process more cost effective by way of economizing labour component. Among the various steps of crossing, pollen application alone requires three to five climbing. A study was conducted to find the suitability of detached whole spike with intact male flowers in pollination. A detached whole spike was observed in laboratory condition for seven days. Pollen shed from the spike was quantified and tested for germination. It was observed that pollen release increased gradually and then decreased. Pollen germination was up to 80% on the first day which reduced to below 20% after six days. Following the positive results from laboratory, a field experiment was conducted to find out setting of fruit when whole spike was used for pollination. West Coast Tall (WCT) and Chowghat Orange Dwarf (COD) were used in the study. Whole spike was tied to emasculated inflorescence and observed for fruit development. Fruit set could be obtained on par with the traditional method. Whole spike method developed here will reduce the number of climbing for pollen application to one instead of four or five required in traditional method. Moreover, pollen processing required in the present method can be completely avoided. The method will reduce the cost of hybrid seed production in coconut approximately to one third by reducing the labour cost to one fifth.

Abstract

S1P-12

Seedling age in selection of quality planting material in coconut (*Coconut nucifera* L.) varieties

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Coconut (*Cocos nucifera* L.) is a perennial crop with 4 – 6 years juvenile period and nearly 80 – 100 years of productive life. Seedling selection is very important in realising the production potential of a variety. Seedling height, girth and number of leaves are the major criteria used for seedling selection. Based on these characters seedling standards at twelve months from sowing are available for talls, dwarfs and hybrids. Standards for individual varieties are not available at present. In this work, 21 cultivars including eight dwarfs, four hybrids and nine talls were studied for developing standards. Seedlings are normally selected at the age of one year from sowing. There are situations where early selection at the age of six or nine months required for planting in certain field conditions. Seedlings in the age group of six and nine months along with 12 months are studied to explore the possibility of early selection of seedlings. Correlation of characters in six and nine month old seedling to that of twelve month old seedlings showed difference among varieties studied. When a selection method was used by setting 70% selection based on each character, 65% seedlings were common in three stage selections. Variety wise analysis showed that COD seedlings could be selected at 6 months with 88% accuracy whereas in WCT, only 40% seedlings selected at 6 month stage were matching with 12 month selection. The analysis also revealed that by reducing the selection to 50% (by increasing selection cut off for each character), seedling selection at 6 month stage could be practised with better selection accuracy.

SESSION 2

BIOTECHNOLOGY FOR CROP IMPROVEMENT

Abstract S2L-01

Identification and application of nonhost immunity genes in enhancing disease resistance

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Host specific resistance has been playing a major role in securing constant food supply. A series of resistance (*R*) genes encode race-specific or cultivar-specific resistance. It is becoming evident that all most all *R* genes isolated to date encode nucleotide binding-leucine rich repeat (NB-LRR) containing proteins. Unfortunately, *R* genes are short-lived and usually confer resistance against only a set of physiological races or isolates of pathogens. Breeding crop plants for disease resistance (R) genes is a constant struggle for plant breeders.

Nonhost resistance (NHR) provides durable and broad-spectrum immunity of a plant species against all races or isolates of a non-adapted pathogen species. For example, soybean is immune to all maize pathogens and the model plant *Arabidopsis thaliana* is immune to soybean pathogens. It is widely considered that nonhost resistance mechanisms are multilayered and are strategically employed by plant species in response to non-adaptive pathogens. Unfortunately, very little is known about NHR. Arabidopsis has been shown to use two distinct mechanisms to confer nonhost immunity against the barley pathogen *Blumeria graminis* f. sp. *hordei* governed by three genes, *PEN1*, *PEN2*, and *PEN3*. *PEN1* encodes a syntaxin protein involved in vesicular transport of free radicals to the penetration sites to suppress growth of the invading powdery mildew pathogen *B. graminis* f. sp. *hordei*. PEN2 and PEN3 work in a team; *PEN2* encodes a glycosyl hydrolase that generates toxic products from glucosinolates during infection. The toxic antimicrobial products are then translocated into the infection sites by the ABC transporter encoded by *PEN3*.

We have demonstrated that the oomycete pathogen *Phytophthora soja* that causes root and stem rot in soybean can penetrate single cells of the Arabidopsis penetration deficient mutant, *pen1-1* that lacks PEN1 function. *P. soja*, however, cannot penetrate the wild-type ecotype Columbia-0. To understand the complexity of Arabidopsis nonhost resistance mechanisms against the soybean pathogens, *P. sojae* and *Fusarium virguliforme*, a mutant screen was undertaken in *pen1-1* background to identify mutants that are infected by P. sojae. Over 3,500 individual mutant families were generated by treating over 6,000 *pen1-1* seeds with ethyl methanesulfonate (EMS). Thirty putative *P. sojae* susceptible (*pss*) mutants, *pss1* through *pss30*, showing visible necrosis following inoculation with *P. sojae* zoospores were identified. Fourteen of these mutants are also susceptible to the fungal pathogen *F. virguliforme* that causes sudden death syndrome (SDS) in soybean. We have applied a novel map-based cloning approach based on mapping, sequencing of the *pss* mutants, characterization of T-DNA insertion mutants and complementation analyses, and cloned five Arabidopsis *PSS1, 6, 21, 25* and *30* genes that are required for Arabidopsis NHR immunity against *P. sojae* and *F. virguliforme*. *PSS1* encodes a glycine-rich protein and is localized to plasma membrane. *PSS6* encodes vesicle associated membrane protein 724 (VAMP 724). *PSS21* encodes an ABC1-like protein. *PSS25* encodes a member of the BEL family of homodeodomain protein (BLH2). *PSS30* encodes a folate transporter (AtFOLT1) localized to chloroplasts. We have shown that two T-DNA-insertion Arabidopsis folate biosynthetic pathway mutants are compromised also in nonhost resistance against *P. sojae*. The loss of nonhost immunity in *pss30* and folate biosynthetic mutants to *P. sojae* was rescued by feeding the mutants with folic acid. PSS30 is also required for expression of effector triggered Arabidopsis host resistance against a bacterial pathogen. Following *P. sojae* infection, folate rapidly accumulates in soybean presumably to induce effector-triggered as well as basal resistance.

To determine the utility of nonhost resistance encoded by *PSS* genes in enhancing disease resistance, we generated transgenic soybean lines for all five *PSS* genes. All five *PSS* genes except *PSS25* enhanced SDS resistance in transgenic soybean plants suggesting possible application of NHR in enhancing disease resistance in crop plants.

Abstract S2L-02

Application of DNA technology in the genetic improvement of coconut: Current status and future possibilities

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The discovery of restriction enzymes and the polymerase chain reaction (PCR) provided the opportunity to distinguish genetic differences among organisms at DNA sequence level, through molecular markers. Estimation of genetic diversity, establishment of genetic relationships, DNA fingerprinting, identification of somoclonal variation, genetic resource management, construction of phylogeny are some of the accomplishments of DNA technology while marker-trait associations and genetic linkage maps construction for marker assisted selection are in progress. Molecular markers generated through various techniques such as RFLP, RAPD, AFLP and SSR have been adequately used to study coconuts. Overall a very high level of genetic diversity has been found in coconut and most diversity observed in out-breeding Talls. Genetic variation between populations was more in Dwarf coconuts compared to Talls. Genetic relationship studies revealed two major groups of Talls, one comprising of Southeast Asia and the Pacific Talls and other comprising South Asia and Africa Talls. The Dwarfs, in contrast, formed a separate group, within the former group, indicating Dwarfs originated from Tall form. Fingerprinting of individuals, variety identification and hybrid testing are some of the other accomplishments (using molecular markers) in coconut while a linkage map with identification of QTL for yield parameters has also been developed. With the recent advances in massive scale sequencing, comparative genomics, bioinformatics and transciptomics, there is a very high potential for coconut breeding to be taken to very high standards for more targeted genetic improvement to meet the challenges in cultivating coconut.

Abstract

S2L-03

Introduction of cryobiotechnology in plants and its application to coconut germplasm

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Recent advances in developing cryopreservation methodology has underpinned the wider application of cryogenic storage for the long-term conservation of important agricultural crops such as potato, banana, garlic, fruit trees, etc. The use of cryotherapy for the production of virus-free plant materials is also increasing. The challenge in developing cryopreservation methods, however, remains, for example, due to intolerance of some materials to desiccation, and toxicity of most widely used cryoprotectant solutions. This presentation briefly reviews the existing methodology for plant cryopreservation and suggests alternative approaches to the development of cryopreservation protocols based on the initial characteristics of plant materials, and introducing specific steps in a droplet-vitrification method.It will also cover the current status of cryopreservation studies on coconut germplasm, with especial emphasis on preculture-desiccation and vitrification methods.

Abstract

S2O-01

In vitro shoot regeneration from immature inflorescence of coconut

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A technology for mass propagation of coconut is needed for large scale production of elite coconuts required for establishment of gardens of disease resistant varieties as well as replanting of existing senile or diseased plantation. As coconut is a cross pollinated crop propagated only by seed, tissue culture has been the only possible clonal propagation method available. Over the past few decades, the problem of cloning coconut has been addressed in a number of research centres worldwide. However, the success has been very limited. This is due to very poor response of coconut tissues to in vitro conditions and thus it is classified as one of the most recalcitrant species to regenerate in vitro. Immature inflorescence has shown to be a promising source of explants for coconut tissue culture. In the present study, four different inoculation media combinations were evaluated. Immature inflorescences of 2-12 cm size were collected from West Coast Tall palms and the rachilla segments obtained from these inflorescences were cultured on the above media. Maximum response was obtained in Y3 media supplemented with 1 ppm 2,4-D (92 %) followed by Medium 72 with 10 ppm Picloram + 10 ppm Putricine + 1 ppm TDZ (87 %). Transluscent outgrowths developed directly from the floral buds within four weeks of culturing in dark condition. The cultures in Y3 media subcultured into three different media (Y3 I, Y3 II and Y3 III). Shoot like out growth was more in Y3 III (66%) followed by Y3 I (42%). After 8 months incubation in dark, the cultures were transferred to ½ MS I and ½ MS II and gradually shifted to light condition. Shoot regeneration was more in ½ MS supplemented with 1ppm each of NAA and BAP. The study indicated the feasibility of developing an in vitro plant regeneration protocol with the use of immature inflorescence of coconut as the explants.

Abstract

S2O-02

Genotypic variability in coconut embryo cryopreservation

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The development of a viable cryopreservation strategy for coconut requires optimization of protocol suitable for specific explants such as zygotic/somatic embryo, embryonic axis or shoot apex. In recalcitrant seeded coconut, desiccation tolerance exhibited by its zygotic embryos makes them an ideal explant for cryopreservation. A solution based vitrification protocol (PVS3) has already been developed by ICAR-CPCRI for coconut zygotic embryo cryopreservation. The adaptability of this protocol is to be tested for wide range of accessions so that the protocol can be incorporated along with other protocols among international laboratories engaged in conservation programmes. In the present study, the PVS3 protocol was validated in 10 coconut accessions (Chowghat Orange Dwarf, Cameroon Red Dwarf, Chowghat Green Dwarf, Malayan Yellow Dwarf, Malayan Orange Dwarf, Kulasekharam Green Dwarf, Federated Malay States Tall, Strait Settlement Apricot Tall, Tiptur Tall, Java Tall and one hybrid (Malayan Yellow Dwarf X West Coast Tall). Plantlet development after cryopreservation ranged from 3 to 40% depending upon the accessions. The result obtained from this study could be utilized for sharing the methodologies in setting coconut cryo gene banks in different laboratories internationally.

Abstract S2O-03

Comparative proteome analysis of zygotic and somatic embryogenesis in coconut (*Cocos nucifera* L.)

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In the present study, proteins expressed in the different developmental stages of somatic (SE) and zygotic (ZE) embryos were identified by combining the one-dimensional SDS-PAGE gel electrophoresis with matrix associated laser desorption ionization time of flight mass spectrometry (MALDI-TOF/TOF MS). SDS- PAGE analysis showed that the number of protein bands resolved in the different stages studied were higher in SE (27-29 bands; 15-100 kDa) than in ZE (19-23 bands; 15-120 kDa). Seven major protein bands were observed to be common in SE and ZE; of these, four were identified as 6-phosphogluconate dehydrogenase (54.9 kDa), LIM-domain containing protein (24.49 kDa), thioredoxin (15.6 kDa) and glycine rich cell wall structural protein (12.78 kDa), while the other three were uncharacterized proteins. Three unique proteins identified in ZE *viz*., eta-carotene desaturase (64 kDa), adenylate kinase (26.67) and AT5G11810-like protein (25.77). The important proteins identified in the different stages of SE were eukaryotic initiation factor 4A (eIF4A) and aldo- keto reducatse. The former was present in the stages of somatic embryo, meristemoid and embryonic shoot meristem whereas the latter was present throughout the different stages of SE. The accumulated evidence of eukaryotic initiation factor 4A during the somatic embryo development indicates that protein metabolism is a key factor in SE, especially during the late stages of embryo development. The identification of proteins that are differentially expressed during SE and ZE could provide information contributing to understanding *in vitro* recalcitrance.

Abstract

S3O-04

Development of genic SSR marker resources from RNA-Seq data in coconut (*Cocos nucifera* L.)

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Coconut is an important plantation crop which sustains marginal and fragile ecosystems in the tropics. In spite of its economic significance, genomic resources are limited in coconut. In this study, we have utilized three sets of transcriptome data (two from leaf and one more embryogenic callus), generated from Illumina Hi-Seq 2000 platform, for identification and characterization of microsatellite markers in the species. Trinucleotide motifs were the most abundant repeats followed by di-, tetra-, hexa- and penta-nucleotide repeats. Based on these SSR containing sequences, PCR primer pairs were designed for the SSR loci and a set of randomly selected 120 primer pairs were further used for characterization. A majority of these markers showed cross-transferability across three cultivated palms *viz*., arecanut, oil palm and date palm, thereby expanding their utility. A set of 10 polymorphic EST-SSR markers were used to study the genetic relationship among 50 coconut accessions (25 each of talls and dwarfs). UPGMA dendrogram showed, in general, distinct clustering of accessions based on their geographic affinities. We have also generated a comprehensive database incorporating information of gene-based SSR (EST-SSR) markers. This study provides a detailed insight into frequency, type and distribution of SSRs in the genic region of coconut. The comprehensive set of novel genic-SSR markers developed in this study would form an important genomic resource for diversity analysis and association mapping studies in coconut.

Abstract S2P-01

Feasibility of collection and cryopreservation of coconut pollen during monsoon months for hybrid seed production

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The coconut pollen is mainly utilized for producing hybrids for supply to the farmers and also for the creation of variability by breeders. The demand from the farmers for quality hybrids is always high. The hybrid seed production starts after the end of the rainy season, usually from November to May in Kerala State, India. In order to utilize the pollen during rainy season, a two step drying technique was standardized in the present study so that pollen from healthy pollen parents could be collected and stored under cryogenic condition for its effective utilization for hybrid seed production a two step drying process, followed by cryogenic storage, resulted in 37 to 74 % germination in West Coast Tall (WCT) and 22 to 30 % in Chowghat Orange Dwarf (COD). The same pollen from WCT utilized for pollination in COD resulted in 8 % nut set using desiccated pollen whereas it was 9.5 % with cryopreserved pollen after four months. The procedure can be utilized for long term storage of pollen and also for supply of quality pollen for the production of hybrids by coconut growers.

Abstract

S2P-02

Anther and isolated microspore culture of coconut (*Cocos nucifera* L.)

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In vitro culturing of anthers and isolated microspores is an extremely useful technique for the production of doubled haploid in cultivated crops. In the present study, anthers in tetrad stage (-3 position) were isolated from pre-treated (cold at 10 °C and heat at 40 °C for 5 and 3 days, respectively) of West Coast Tall (WCT) coconut variety and inoculated on to eight different basal medium incorporated with either 2, 4-D or picloram as auxin and BAP or TDZ as cytokinin. To isolate microspores, anthers were split into small bits and blended in 8% sucrose solution at 500-600 rpm for two minutes aseptically. The extract after filtering with 80 µm mesh was inoculated into ten different combinations of Y3 liquid media with 2, 4-D (2mg/l), picloram (100 µM), BAP (1 mg/l) and TDZ (1 mg/l). Callusing percentage in anthers was more in media supplemented with picloram alone or along with BAP. Pretreatment of anthers at heat or cold did not show significant difference for callus induction. The callus initiated from anthers did not proliferate upon sub culturing. Microspore culture did not result in callus induction or growth. However success was achieved in isolation of microspores from anthers without contamination. Further modifications are warranted, both in anther and microspore culture, for sustainable results.

Abstract

S2P-03

Effect of different media, auxins, sugars and calcium chloride in callus induction from plumular explants of coconut

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Experiments have been conducted independently to find the effect of media, auxins, sugars and calcium chloride in inducing embryogenic callus in plumular explants of coconut. In the first experiment, plumules were inoculated in MS, Y3, B5, M72 and WPM media with the auxin picloram at concentrations of 100, 250 and 400 µM/L and 1mg/L TDZ. The maximum number of embryogenic callus was observed in Y3, MS and M72 supplemented with 100 and 250 µM/L picloram. In the second experiment, the auxins and herbicide forms (IAA, NOAA, NAA, Atrazine, DICAMBA, 2,4,5-T, and IBA) at concentrations of 100, 200, 400 and 600 µM/L were used in Y3 media with 1mg/L TDZ .Callus initiation was noticed in 2,4,5-T, NAA and NOAA at various concentrations (2,4,5T-400µM, NAA 200 and 400 µM and NOAA 100 and 200 µM). The third experiment which was designed to find the effect of sugars in coconut plumule culture, different sugars (glucose, fructose, trehalose, maltose, sucrose, sorbitol and filter sterilized fructose) at concentrations of 1%, 3%, 5% and 7% were added to Y3 media with 1mg/L TDZ. Callus initiation and multiplication was observed with 1% and 3% fructose and sucrose, 1%, 3% and 7% trehalose, 1% maltose and 1% sorbitol. Calcium which included in tissue culture medium as calcium chloride is an integral component of plant cell wall and helps in formation of pectin that binds cell wall together. Hence the effect of calcium chloride at concentrations of 440, 880, 1320, 1760 and 2200 mg/lit was studied in the fourth experiment. The media used was Y3 supplimented with 1mg/L TDZ. Even though callus initiation was noticed in lower concentrations (440, 880, 1320 mg/lit), the plumules germinated at higher concentrations.

Abstract

S2P-04

Genome wide comparison of miRNAs and their target transcripts in embryogenic and non-embryogenic calli of coconut

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MicroRNAs (miRNAs) are 21-23 nucleotide (nt) long non coding post-transcriptional regulators of gene expression, which include developmental regulation, hormone response and adaptation to stresses. *In vitro* propagation to enhance production of high yielding, disease-free planting material in coconut has remained a distant reality since coconut is recalcitrant to *in vitro* culture. In order to decipher the controlling mechanisms of somatic embryogenesis in coconut, we have carried out small RNA sequencing of embryogenic and non-embryogenic calli of coconut using high-throughput Illumina HiSeq2000 platform. We have identified a total of 1579 conserved miRNAs from 26 miRNA families in both types of calli. In addition, 79 novel miRNAs in embryogenic and 53 novel miRNAs in non-embryogenic calli also identified. Among the conserved miRNAs, 289 miRNAs were differentially regulated between the two types of calli. Two of the miRNAs *viz.* miR156 and miR166 were found to be abundantly expressed. By a combination of computational methods and coconut embryogenic transcriptome data generated earlier, a total of 9604 and 548 targets were predicted for embryogenic and non-embryogenic calli respectively. Gene Ontology and KEGG pathway analyses were performed to predict the functions of the target genes of the conserved and novel miRNAs. The biological network of the miRNA and their targets were also generated. It is hoped that this study would provide new clues for recalcitrance exhibited by coconut *in vitro* cultures and help to design better strategies to improve somatic embryogenesis in coconut and subsequent regeneration and also the role of miRNAs.

Abstract S2P-05

Cloning and characterization of genes involved in gibberellic acid biosynthesis in coconut (*Cocos nucifera* L.)

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The phytohormone gibberellic acid (GA) performs essential functions in plant growth and developmental processes like seed germination stem and root growth, cell division, flower initiation and fruit setting. There is little information available about GA metabolism and the evolutionary history of genes invovled in GA biosynthesis in coconut. To enhance our understanding of GA metabolism in coconut, we have isolated the ORFs of seven GA metabolic enzymes *viz*. ent-copalyl diphosphate synthase (CPS), ent-kaurene synthase (KS), ent-kaurene oxidase (KO), ent-kaurenoic acid oxidase (KAO), GA 20-oxidase (GA20ox), GA 3-oxidase (GA3ox), and GA 2-oxidase (GA2ox) in coconut using a comparative genomics approach. Evolutionary analysis of all the seven genes involved in GA metabolism in coconut indicated negative selection in comparison with similar genes in oil palm and date palm. On the basis of phylogenetic analyses and characteristic motifs of these genes, we have identified a rapid expansion and functional divergence of these genes between the monocot and dicots. We have also carried out secondary structure analysis and three dimensional modeling of these seven enzymes. The results of this study will facilitate further functional characterization and analysis of GA biosynthetic genes in coconut.

Abstract

S2P-06

Molecular dynamic simulations of interactions of fatty acids from virgin coconut oil on nsP2 protease of Chikunguniya virus

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Chikungunya, caused by Chikungunya Virus (CHIKV) belonging to the *Togaviridae* family of *Alphavirus* genus, has re-emerged as a tropical infection which has been creating a huge impact throughout the world in the recent years The nsP2 protease of CHIKV constitutes an essential component of the viral replication since it plays an important part in the cleavage of polyprotein precursors for the viral replication process. It is, therefore, gaining attention as a potential drug design target against CHIKV. Based on the recently determined crystal structure of the nsP2 protease of CHIKV, the present study was carried out to identify the potential of fatty acids, present in virgin coconut oil, as inhibitor of nsP2 protease using structure-based approaches with a combination of molecular docking and molecular dynamics (MD) simulations. Among the fatty acids, oleic acid showed the peak affinity with extra precision glide score -5.069 and exhibited favorable docking energy -32.99 Kcal/mol towards nsP2 protease with two hydrogen bonds being involved in the complex formation. Caproic acid as well as palmitic acid was found to have a notable affinity values for the target protein after oleic acid in that order. The stability of nsP2 protease–oleic acid complex was validated through MD simulations. The analyzed simulation trajectory was found to be in stable root mean square deviation (RMSD) with favorable conformational changes. These results reveal that a superior inhibition of nsp2 could be achieved by oleic acid, which therefore possesses pharmaceutical significance.

Abstract S2P-07

Identification and characterization of novel TIR-NBS-LRR type Resistance Gene Analogues (RGAs) in coconut

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Plant resistant genes (R genes) constitute one of the most important gene families which play key roles in detection of phytopathogens and activation of a repertoire of defense pathways in responses to phytopathogen invasion. The majority of plant R genes belong to a large family of nucleotide binding site-leucine rich repeat (NBS-LRR). Based on whether they also encode an N-terminal Toll/interleukin-1 receptor (TIR) domain, NBS-LRR genes can be further divided into two subclasses, the TIR subclass and the non-TIR subclass genes that can be classified into two TIR domains have been rarely reported from monocot genomes. We had previously identified and distinguished two classes of NBS-LRR in coconut, based on their N-terminal TIR or non-TIR domains. In the present study, using comparative genomics, we have isolated two families of TIR domain containing RGAs *viz.*, TIR-X(TX) and TIR-NBS(TN). The TX family of proteins lack both the conserved nucleotide-binding site (NBS) and the variable leucine rich repeats (LRR), that are attribute of the R-proteins, while the TN proteins contain much of the NBS, but lack the LRR. We have investigated the full coding region and the three dimensional structure of TIR domains of TX and TN proteins. Moreover, the expression patterns of four TIR genes, in response to exogenous application of salicylic acid and jasmonic acid, were evaluated by quantitative RT-PCR.

Abstract

S2P-08

Validation of pollen cryopreservation in coconut accessions

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Pollen is an important source of variability with respect to breeding as well as conservation point of view. Coconut pollen shows desiccation and cryo-tolerance. These unique attributes of coconut pollen can be utilized for its long term storage for conservation purpose or for the production of variability in breeding programmes and also for controlled pollination for the production of hybrids. In the present study, pollen from various coconut accessions were tested for its germinability after cryopreservation to study the variability of pollen from coconut accessions to cryopreservation. Pollen from 11 coconut accessions coconut (Cochin China Tall, Java Tall, Tiptur Tall, Laccadive Ordinary Tall, West Coast Tall, Andaman Giant Tall, Chowghat Orange Dwarf, Malayan Yellow Dwarf, Malayan Orange Dwarf, Chowghat Green Dwarf and Gangabondam Green Dwarf) were cryostored for a period of two years of storage. There were no significant differences observed between desiccated and cryopreserved pollen for germination and pollen tube length.

SESSION 3

ENHANCING INPUT USE EFFICIENCY

Abstract S3L-01

Biochar as a soil amendment: Potential role of coconut byproducts

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Biochar is a soil amendment and nutrient source, the use of which is becoming increasingly popular in agricultural and environmental management. It is produced via pyrolysis or gasification processes that heat plant biomass or agricultural wastes in the absence or under reduced oxygen conditions. Biochar can be an important tool for increasing food security and cropland diversity(by supporting more crops of varying types in nutrient-poor soils) in areas with severely depleted soils, scarce organic resources, and inadequate water and chemical fertilizer supplies. Biochar also improves water quality by increasing soil retention of nutrients and agrochemicals for crop utilization. By enhancing nutrient retention in soils, biochar produced from coconut shells with a large surface area, for example, could reduce nutrient-leaching loss and groundwater contamination. The moisture holding capacity of biochar from coconut byproducts would be important in locations with inadequate and unpredictable rainfall, and with minimal irrigation facilities.

Designing a biochar for a specific use by mixing with other soil amendments or mixing biochar feedstocks could make the product more efficient as a soil amendment by altering the physical and chemical properties of soils. The wood-based and/or straw based biochar such as biochar prepared from coconut shell, husk, or coir might help retain more water and nutrients in soil and remove heavy metals and thus minimize environmental risks such as eutrophication of nearby water bodies. While land-applying large quantities of biochar may not be desirable, the feasibility of using biochar from coconut byproducts for removing excess nutrients such as P and N from water (a sand-bag effect?) need to be further explored.

Although several benefits of biochar have been demonstrated, there are still some "unknowns" about its use. The behavior and performance of biochars produced from various feedstocks and the risks involved, if any, in their continued use over a period of time in agricultural production systems have not been adequately understood. Several questions need to be addressed for exploiting the potential benefits of biochar for successful land application for enhanced agronomic productivity, environmental sustainability, and economic profitability. These include:

i. What would be the ideal rate of a given biochar application for a soil type for maximizing agronomic returns while minimizing environmental risks?
ii. Wouldrepeated biochar addition during each cropping season cause and exacerbate negative effects in the long run?
iii. What would be the impact of adding biochar from varying feedstocks in different agro-ecological settings such as humid tropics, arid and semi-arid regions; and
iv. What is the impact of aging of biochar, i.e., the differences between "old" and fresh biochar when applied to soils?

Abstract S3L-02

Bio-resources based biological soil fertility management for sustainable coconut production

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Bio-resources based strategies to strengthen biological foundations of soil health and soil fertility are of vital importance to achieve sustainable coconut productivity in the light of critical challenges posed by declining production base and climate change. Appropriate recycling of lignin-rich biomass from coconut palm could form the foundation of long term soil health and coconut productivity. Additionally, locally adapted microbial, plant and animal resources need to be integrated into the production system to harness the synergistic and complementary biological interactions and nutrient transformations to play a major or sole role in the production process. Many years of R&D work at ICAR-CPCRI has resulted in identification of potential bio-resources and development of simple and low cost bio-resource technologies capable of making a difference even in resource-constrained coconut growing regions. Research efforts on harnessing the rich microbial resources associated with coconut palm resulted in the development and release of two talc based bio-formulations of plant growth promoting rhizobacteria (PGPR) *viz.* 'CPCRI Kera Probio' and 'CPCRI Cocoa Probio' based on efficient strains of Bacillus sp. and Pseudomonas sp. for application to coconut and cocoa. KerAM, a soil based Arbuscular Mycorrhizal (AM) formulation, containing *Claroideoglomus etunicatum*, as the dominant AM species isolated from coconut agro-ecosystem with high potential to increase the growth parameters of coconut seedlings, is another innovative resource made available as a bio-inoculant for coconut farmers. The technology

for bioconversion of lignin rich crop residue biomass available abundantly in coconut gardens to value added organic resource using local epigeic strain of earthworm through vermicomposting added a new dimension to biological soil fertility management in coconut. The technologies developed to convert recalcitrant coir pith, a byproduct of coir fiber processing, to a valuable resource by co-composting with poultry manure / vermicomposting / using biopolymer degrading microorganisms, have the potential to substantially contribute to sustainable crop production. The vermicompost produced from coconut leaves and coir-pith compost produced using the poultry manure technology at ICAR-CPCRI is now available by the trade name 'Kalpa Organic Gold' and 'Kalpa Soil Care', respectively. Basin management with leguminous crops such as *Mimosa invisa, Pueraria phaseoloides, Calopogonium muconoides* or *Vigna unguiculata* in symbiosis with Rhizobium endowed high nitrogen fixation efficiency is a simple and easily adoptable agri-resource management strategy for biological soil fertility management. Increasing above ground diversity through crop diversification and integration of animal enterprises and their synergistic interactions contributed to sustainability by improving below ground diversity, microbial biomass, and biological interactions. Integrated nutrient management involving resources *viz*. biofertilizers, vermicompost and green manures had a superior edge than chemical fertilizers alone in improving coconut productivity to a higher level with soil ecological benefits. Organic farming methods through an integrated package of 'biologically derived nutrient sources' focusing on biofertilizers, crop residue recycling and application of N2 fixing leguminous crops promoted biological systems of regulation through 'ecological engineering' to achieve sustainable productivity in coconut.

Abstract S3O-01

What ails coconut production in Kerala?

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Kerala state with highest area under coconut plantations returns abysmally low productivity figures, just around 40 nuts per palm per year. Many reasons are cited; low spread of HYV's, neglect of palms in the largely small grower holdings, debilitating diseases, low price realisation for coconut and even climate change. Assessment of climate and soil qualities in the major coconut-growing regions of the state, *viz.*, (1) Central and Eastern Palakkad, (2) Northern Kerala, (3) Central Kerala, (4) Southern Kerala, (5) Onattukara Sandy Plain, and (6) Coastal Sandy plain, however, pointed to the decline in soil qualities as the primary reason for the low productivity of the palm in the state. The overhead climate is in no way limiting the crop, except for Central and Eastern Palakkad wherein irrigation is an absolute necessity. Soil qualities in terms of physical and chemical properties and plant available nutrient content are favourable only in Palakkad and Southern Kerala constituting just around ten per cent of the area under coconut in the state. The effect is reflected in palm health and productivity in both the regions. Soil qualities are severely constraining in the rest 90 % coconut-growing areas with Central Kerala and Onattukara Sandy Plain worst affected. Major soil related constraints are (1) strong surface and subsoil acidity, (2) Al in soil solution in toxic concentration, and (3) extensive and acute deficiencies of potassium, calcium, magnesium, copper, zinc, and boron. Though the constraints are few and their alleviation rather simple, lack of focussed action meant gradual decline of palm health and emergence and spread of debilitating diseases. The green revolution model adopted in the state in 1970's did not exclude coconut palm. The model with emphasis on high yielding crop varieties, NPK fertilizers, irrigation and chemical pest control seldom took into consideration the limitations of the highly weathered, low activity clay soils of the state developed under humid tropical climate. In order to regain soil health, and thereby to enhance palm productivity, we recommend building up of soil organic matter through recycling of palm waste and zero tillage, alleviation of surface and subsoil acidity through application of lime (or dolomite) and gypsum, and external inputs of necessary macro, secondary and micro-nutrients in adequate quantities.

Abstract

S3O-02

Coconut based cropping system with organic and integrated nutrient management for Southern dry region of Karnataka

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To elucidate the possibility of supplementing nutrients to coconut and intercrops (cocoa, lime, drumstick, and banana) by recycling waste biomass in coconut garden three nutrient management treatments were imposed in the coconut based cropping system at HRS, Arsikere during 2012. The coconut cultivar was Tiptur Tall in the age of 40 years. Spacing was 10 m x 10 m. The nutrient management treatments in the cropping system were compared with the monocrop of coconut applied with only recommended quantity of NPK (Rec-NPK). The nutrient treatments for the cropping system were T1: 75% of Rec- NPK + organic recycling with vermicompost (Org-VC); T2: 50% of Rec-NPK + Org-VC + vermiwash (VW) + biofertilizer (BF) and in situ green manuring (GM); T3: Fully organic (Org-VC + VW + BF + GM + Composted coir pith and mulching with coconut leaves).

The nut yield of coconut (average for three years) in the cropping system under different nutrient management treatments (9903-10860 nuts/ha/yr) was maintained as that of monocrop of coconut (9943 nuts/ha/yr). Slight reduction in the yield of intercrops was observed in the fully organic treatment (T3). The earthworm and microbial population were higher in the cropping system compared to monocrop of coconut. The net returns were higher in the cropping system under all the three nutrient management practices compared to monocrop of coconut. Among the nutrient management practices, the net returns were higher in T-3 (Rs. 224078/ha) followed by T-2 (Rs. 215477/ha) and T-1 (Rs. 207515/ha). The monocrop of coconut recorded the lowest net returns of only Rs. 74747 per ha.

Abstract

S3O-03

Effect of drip fertigation on growth and productivity of coconut (*Cocos nucifera* L.) and soil fertility in humid tropical Kerala

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The productivity of coconut in Kerala is very low, when compared to the neighboring states. Lack of irrigation, low fertility of soils and incidence of diseases are the major reasons attributed to this Adoption of drip fertigation is an option for efficient use of water and nutrients through improvement in crop yield per unit volume of water and nutrients used. Field level observations in Kerala reveal that drip fertigation has not become popular among farmers. In this context, a demonstration project of drip fertigation was undertaken in 22 farmers' plots in different districts of Kerala for creating awareness among farmers. The results obtained from a plot in Kozhikode are presented here. The influence of drip fertigation on coconut (Cocos nucifera L.) var. West Coast Tall was analysed in the plot, in comparison with control (farmer's practice of conventional basin irrigation). Under drip fertigation, nutrients were supplied based on soil testing. The recorded data from 2013-2016 on growth and yield of coconut revealed that the canopy development and other yield parameters were higher under drip fertigation than control. The number of leaves, spathe length, number of inflorescence, number of bunches/palm/year and number of nuts/bunch were higher under drip fertigation. Yield per palm was 108 nuts/ palm/ year under drip fertigation, with 76 nuts/ palm/ year under control. Soil moisture and soil fertility parameters were better under drip fertigation than control. The study emphasised that adoption of drip fertigation increases the productivity in coconut, besides ensuring higher efficiency of water and nutrients in coconut. However, since coconut is perennial crop, it is too early to conclude that the yield difference of coconut is mainly due to fertigation, and hence, it needs to be monitored for more years to have a definite conclusion. The major reasons for adoption by farmers, who have adopted drip fertigation on their own, include savings in labour/ fertilizers and the possibility of higher production. The constraints in adoption reported by farmers include high cost, fear of clogging of emitters, difficulty in getting subsidy etc.

Abstract

S3O-04

Coconut residue composts as soil-less medium for raising quality arecanut and cocoa seedlings

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Soil-less media have been successfully employed in production of quality transplants which has revolutionized vegetable and floriculture production. An attempt was made to raise healthy arecanut and cocoa seedlings on urea-free coir-pith compost along with recycled coconut biomass residues such as coconut leaf vermicompost and plant growth promoting rhizobacteria (PGPR). The soil-less substrates were first assessed for raising seedlings of tomato, chilli, papaya and black pepper. After getting positive results, seednuts of arecanut (Mohitnagar *var.*) and seeds of cocoa (Forastero *var.*) were used in the study. Four treatments *viz.* i) soil + coir-pith compost (control), ii) coir-pith compost, iii) coir-pith compost + coconut leaf vermicompost and iv) coir-pith compost + coconut leaf vermicompost + PGPR + *Trichoderma harzianum* were included as different treatments in the study. The study was conducted in polybags. No fertilizer application was carried out. Six months after sowing of the nuts/ seeds, the plant growth parameters and the rhizosphere microbial communities were recorded. It was observed that stem girth, number of leaves and total dry weight of seedlings were higher for both the crops in soil-less medium compared to control. Addition of PGPRs along with *Trichoderma* to soil-less medium improved the growth parameters of the seedlings. Microbial analysis of the soil-less medium also indicated a positive response in terms of higher populations of different general and function specific microbial communities for both arecanut and cocoa. A significant feature observed was the higher root biomass of seedlings grown in soil-less media as compared to control. The abundant coconut biomass wastes can thus be recycled to form an ideal substrate for soil-less cultivation of arecanut and cocoa seedlings and become an important technology in nursery management of horticultural crops.

Abstract S3O-05

Impact of long term organic cultivation practices on soil heath and productivity of coconut

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The perennial growth habit of coconut and the wider spacing adopted for its cultivation, enabling crop plurality, besides production of large quantity of biomass makes the crop highly amenable to follow organic farming. Two long term field experiments (in 35 years old West Coast Tall and hybrid Chandrasankara) were conducted to evaluate the production potential of coconut under various organic cultivation practices (2003-04 to 2013-14). The experiment was conducted in RBD with five organic cultivation treatments *viz*., vermicomposting (VC) in coconut basin, application of biofertilizers (Phosphobacteria and Azospirillum) (BF) and cover cropping in the interspace (T1); VC in the trenches, application of BF and leguminous cover cropping in the basin (T2); VC in the basin, application of BF and growing vegetables in the interspaces (T3); VC in the trenches, application of BF and raising vanilla in interspaces and trailing black pepper on coconut (T4), and control (T5) without any of these treatments

The overall mean yield indicated significantly higher nut yield IN all the organic cultivation treatments compared to the control for both the genotypes. Treatment T2 recorded a mean annual yield of 96 nuts/palm for West Coast Tall, which was 75 % higher than control. In the case of Chandrasankara again highest yield of 108 nuts/palm was obtained in T2 which was 59 % more than control. By adopting various organic cultivation practices, 6.9 to 8.8 and 7.1 to 9.7 ton of organic biomass could be produced in West Coast Tall and Chandrasankara, respectively through which 142-207 kg N, 14-21 kg P and 49-74 kg of K could be added to the soil. There was higher microbial population, soil organic carbon, available nitrogen, and leaf nutrient status under organic treatments compared to control. The results of the eleven years of study suggest that organic cultivation of coconut is possible from the point of view of soil health, however, management of potassium needs further investigation.

Abstract

S3P-01

Influence of long term application of green manure on the productivity of coconut in Reddish Brown Latosolic soils in Sri Lanka

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Organic matter contributes in maintaining soil fertility in agriculture. Green leaf biomasses of *Gliricidia sepium* and *Tithonia diversifolia* are high in nutrients and recognized as a potential sources of nutrients for many crops. A field experiment was carried out in a coconut plantation with Reddish Brown Latosolic soil with two green manure crops to study their abilities to grow and establish in coconut avenues and to evaluate their effect on nut yield. *In situ* green manuring, especially with legumes, had the most beneficial effect on soil properties. The use of green biomass alone has improved soil properties. *Gliricidia* and *Tithonia* biomasses decomposed rapidly after application to the soil, and incorporated biomass would be an effective source of N, P and K for crops. According to the results of this study, coconut yields were significantly increased with the incorporation of green biomass of *Gliricidia* and *Tithonia* than with commercial inorganic fertilizer application especially at the latter stage of this study. Mean nut yield for five years in the green manure applied plots was (37-46%) significantly ($P < 0.05$) higher, compared to that of the inorganic fertilizer applied plots towards the latter part of the experiment. Soil parameters were subsequently collected. Addition of green manure has significantly ($P < 0.05$) improved the soil parameters i.e. soil N (by 75 %), and soil microbial activity (by 52%). Soil bulk density has been reduced by 20% which enhances the root growth. The improvement of soil moisture content by 92% is of great importance for coconut in withstanding the frequent dry spells which are in increasing trend with the present climatic changes. There was no significant effect of green manures on soil pH and P but P content was improved with the use of *Gliricidia* and *Tithonia*.

Abstract S3P-02

Effect of *Arbuscular Mycorrhizal Fungi* based biofertilizer on coconut seedlings growth

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The success of a coconut plantation, in terms of its field establishment as well as its future performance, is heavily dependent on the quality of the seedlings used. Coconut nurseries adopt different agronomic practices to produce good quality seedlings. Applying *mycorrhizal* inoculants is becoming an increasingly common practice in plant nurseries as it facilitates healthy seedling growth resulting in healthy and vigorous seedlings in the nursery, helps to reduce mortality rates of seedlings in the field and reduce water and fertilizer consumption. In this study effects of *mycorrhizae* based biofertilizer were evaluated for the growth of coconut seedlings in the nursery and field. The experiment was conducted at the Makadura Research Center in Sri Lanka.

The nursery experiment treatments were, the presence of AMF based biofertilizer (50g) and absence of *mycorrhizae* based biofertilizer. In the field experiment, five treatments with 500g of AMF biofertilizerwith 25 % recommended inorganic fertilizer mixture for young coconut palms (YPM), 500g of AMF biofertilizerwith 50 % YPM, 500g of AMF biofertilizer with 75 % YPM, 500g of AMF biofertilizer with 100% YPM and with only YPM. Root and shoot growth of seedlings were measured at monthly intervals in the nursery. Leaf production rate, stem girth and height of the seedling were measured at six months interval in the field. The application of biofertilizer increased the number, volume and dry weight of primary, secondary, tertiary and quaternary roots in seedlings in the nursery significantly. A significantly higher leaf production rate and stem girth was observed in the field seedlings treatment with 500g of AMF biofertilizerwith 100 % YPM. The experiment concluded that application of biofertilizer is beneficial for coconut seedlings in the nursery for the production of good quality seedlings with well-developed roots resulting in better field establishment and for fast and vigorous growth in the field.

Abstract

S3P-03

Intercropping of medicinal and aromatic plants in adult coconut garden

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Coconut intercropping system ensures maximum resource capture and use, leading to higher yield per unit area of soil, water and light. In order to realize, an experiment was conducted at Coconut Research Station, TNAU, Aliyarnagar to study the performance of medicinal and aromatic plants as intercrop in coconut garden between 2007 and 2011 under AICRP (Palms). To develop an appropriate cropping system with medicinal and aromatic plants as intercrops compatible with main crop, three medicinal plants Siriyanangai (*Andrographis paniculata*), Sitharathai (*Alipinia galanga*), Karisalankanni (*Eclipta prostrata*) and two aromatic plants Patchouli (*Pogostemon patchouli*) and Lemongrass (Cymbopogon flexuosus) were planted in the coconut garden. Among the three medicinal plants, Sitharathai (*Alipinia galanga*) recorded highest rhizome yield of 5860 kg/ha with a net income of Rs.27966/ha (B:C ratio 2.51). Lemon grass recorded highest leaf yield of 7335 kg/ha with a net income of Rs.21129/ha and B:C ratio (2.28) than Patchouli aromatic plant. The highest nut yield/palm/year recorded in coconut intercropped with Sitharathai (130) and Patchouli (122) followed by Lemon grass (116). Lemon grass (Cymbopogon flexuosus) and Sitharathai (Alipinia galanga) recorded the highest oil content of 0.68 % (rhizome oil) and 0.58 % (leaf oil), respectively when compared to other three medicinal and aromatic crops. The medicinal plant, Sitharathai and the aromatic plant, Lemon grass were found to perform better in adult coconut garden.

Abstract S3P-04

Performance of flower crops under coconut based cropping system in Maharashtra

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In coconut garden, growing suitable intercrops provides additional income and sustains the productivity of the system. The comparative performance of commercial flower crops was carried out at All India Coordinated Research Project on Palms, Regional Coconut Research Station Bhatye, Ratnagiri during 2013 to 2015. The flower crops combinations were T1: Coconut+Jasminum sambac, T2:Coconut+Jasminum multiflorum,T3:Coconut+Lily spp., T4: Coconut+Heliconia spp.,T5 : Coconut+Michelia champaka and T6 : Coconut alone (Monocrop). Average yield of flower crops for two years (2014 to 2015) revealed that, lilly crop recorded 168381 numbers of spikes per hectare, Jasminum multiflorum recorded 48656 kg per hectare, Heliconia spp., recorded 96982.5 number of spikes., Jasminum Sambac recorded 1123.2 kg per hectare follwed by Michelia champaka recorded only 12690 number flowers. In respect of economics, Coconut +Lily spp., system recorded the highest net return of Rs. 12,19,962/- per hectare followed by Rs. 7,63,197/- in Coconut + Jasminum multiflorum system, Coconut +Heliconia spp., recorded Rs. 6,37,495 Coconut +Jasminum sambac recorded Rs. 553102/-, Coconut+Michelia champaka Rs. 12690/-, net income realised in the monocropping of coconut was Rs. 65,025/- per ha only. coconut nut yield realised during 2014-15 in the intercropping garden was 165 nuts per palm per year whereas in monocropping it was 96 nuts per palm per year. Thus study indicated the possibility of growing lily Jasminum multiflorum as intercrops to get additional income depending uppon market.

Abstract

S3P-05

Intercropping of commercial flowering crops in adult coconut garden under Brahmaputra valley region of Assam

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A field experiment was conducted at Horticultural Research Station, Kahikuchi of Assam Agricultural University under All India Coordinated Research Project on Palms during 2012-13 to 2015-16 to study the performance of commercial flowering crops grown as intercrops in 40-year-old Assam Green Tall coconut garden with an objective to develop an appropriate cropping system with flower crops as intercrops compatible with coconut that would give maximum returns to the farmers. The experiment consisting of five commercial flowering crops *viz.*, Tuberose (*Polianthes tuberosa*) var. Single, Gerbera (*Gerbera jamesonii*) var. Red Monarch, Bird of Paradise (*Strelitzia reginae*) var. Glauca, Gladiolus (*Gladiolus grandiflorus*) var. Oscar, Marigold (*Tagetes erecta*) var. Siracole along with a control (coconut alone) was laid out in randomized complete block design with four replications taking four palms per treatment. All the flowerings crops performed well in terms of yield (coconut equivalent yield) and economics. The results revealed that the highest intercrop yield in terms of coconut equivalent yield (Rs. 49,546 nuts/ha), copra content as well as per cent increase in nut yield were recorded in coconut + gerbera followed by coconut + tuberose and the lowest in coconut as monocrop. The soil fertility status in respect of N, P and K in the interspaces of coconut and the leaf nutrient content (N, P, K) of the main crop were found to be higher in intercropping of all the flowering crops as compared to monocropping of coconut. Similarly, higher soil microbial population (bacteria, fungi and actinomycetes) was observed in intercropping of various flower crops than the control (coconut alone). The highest net income and benefit cost ratio (2.14) was recorded in intercropping system of coconut + gerbera followed by coconut + tuberose (B: C ratio of 1.68).

Abstract S3P-06

Permanent manurial experiment on coconut in sandy loam soil (Typic Haplustalf) of Thanjavur district

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A permanent manurial experiment on coconut was initiated during June 2010 to study the long term effect of fertilizers, manures and microbial inoculants on coconut (ECT) productivity and soil health. The experiment was laid out at Coconut Research Station, Veppankulam in sandy loam soil and age of the palms was 38 years. The experiment was carried out in RBD, replicated five times. The periodical observation on growth, yield parameters of coconut, annual nut yield were recorded, in addition to the rhizosphere soil and index leaf sample analysis annually for its nutrients content. The permanent manurial experiment on coconut proved that the integrated nutrient management comprising 560:320:1200 g NPK per palm along with 50 kg FYM, 50 g each of Azospirillum, Phospobacteria in two equal splits ie., during January - February and September - October every year recorded the highest yield attributes *viz.*, number of functional leaves, number of bunches/palm, number of female flowers/bunch and the mean annual nut yield (114 nuts/palm). Besides, the soil available nutrients (major and minor), availability of leaf nutrient content were also highest under integrated nutrient management. The total omission of organic manure and fertilizers except irrigation over the period of five years resulted in significant reduction of yield attributes and mean annual nut yield of coconut (-9.8 % over base yield). The fertilizers alone ie., recommended NPK, without organic manure over a period of five years resulted in poor nut yield increase (2.2 % over base yield) which reveals the importance of balanced nutrient to coconut.

Abstract

S3P-07

Design and development of coconut harvesting machine

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It is very difficult to climb on coconut tree manually due to the constant cylindrical structure and single stem. In other type of trees there will be branches for holding and to support the climber. India alone needs about 2 lakh coconut climbers that present a huge opportunity for the idea of using manual controlled machine for harvesting coconut. Due to the risk involved nowadays very less people are coming forward to climb on coconut trees. As the educational background of Indian youth is increasing, most of the people may hesitate to come in climbing profession. Considering this scenario, a device which will help the user to climb coconut tree easily will be useful for the people who is having large coconut cultivation as well as residents who is having less coconut trees. This kind of devices will encourage more people to come forward to agricultural sector which reduces the high cost, increasing labor wages, cost of production and time of processing. The device consists of climber and harvester; climber is made in curve shape so that all the wheels will have the contact with the tree. Springs are attached to have flexibility, once the climber climbs to the top position, harvester (robotic arm) which has cutter at the end, which can be manually controlled at the bottom by remote, for visibility of bunch of coconuts (harvesting stage) a camera is attached at the end of cutter. Entire movement of the harvesting mechanism is controlled using remote controll.

Abstract S3P-08

Assesment of soil fertility status of coconut based cropping systems of Kasargod – A general view

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A study was conducted to asses soil fertility status of coconut based cropping systems of Kasargod district. A total of 487 soil samples were collected from coconut growing fields of selected 25 panchayath of Kasargod district. The samples were analysed for pH, E C, Organic Carbon, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, zinc, copper and boron in the soil testing laboratory of College of Agriculture, Padannakkad. The analytical results revealed that coconut growing soils were very strongly acidic to neutral in pH. Which shows that coconut survive well in acidic soil condition. Electrical conductivity of these soils were observed to be normal. High organic carbon and available phosphorus content was observed in almost all the soils. This shows high rate of application of organic manure and phosphatic fertilizer in the coconut growing soils. Potassium and sulfur content of analysed soils recorded medium to high values. Although exchangeable calcium content of the soils were high, exchangeable magnesium recorded alarmingly low values. This indicates the necessity of application of magnesium containing fertilizers for proper growth and yield of coconut. The micronutrient status except boron were found to be sufficient in the coconut growing soils. Boron content of the analysed soils were very low, which also corroborate with appearance of crown chocking and other nutrient related disorders in coconut. Hence it is suggested to encourage, the proper and timely application of boron containing fertilizers such as borax by the coconut growing farmers to sustain the growth and yield of coconut.

Abstract

S3P-09

Evaluation of different sources of organic manures on yield attributes of coconut under coastal conditions of Andhra Pradesh

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Coconut is a perennial palm with flowering habit throughout the year, hence nutrients are to be replaced continuously. However, continuous use of chemical fertilizers will result in soil acidity, imbalances in soil nutrient levels and decrease in availability of micronutrients. Organic nutrient management is the alternative. Keeping this in view, a field experiment was initiated to evaluate the impact of organic manures on yield attributes of coconut at Horticultural Research Station, Ambajipeta during 2007 in 30 years old East Coast Tall garden. Eight treatments *viz* T1 : Coir pith compost @ 50kg/Palm/year, T2 : Neem cake @ 10kg + Bone meal @ 2 kg + Ash @ 20 kg/palm /year, T3 : FYM @ 50 kg/palm/year, T4 : Vermicompost @ 25 kg/palm/year, T5 : Poultry manure @ 25kg/palm/year, T6 : Green leaf manure Glyricidia @ 30kg/palm/year, T7 : Green manure crops - sunhemp @ 25 kg/palm/year, and T8 : Control i.e.,500gN:320gP:1500gK through inorganic means were replicated thrice in RBD. Average of seven years (2007-14) data on coconut yield indicated that application of poultry manure @ 25kg/palm/year recorded significantly the highest yield of 82.6 nuts/palm/year and copra out turn (11.9 kg/palm/year) and it was on par with application of vermicompost @ 25 kg/palm/year (78.5 nuts/palm/year) and copra output of 11.14 kg/palm/year.T8 i.e control recorded yield of 72.5 nuts/palm/year. The oil content of coconut did not differ significantly among the treatments and it ranged from 63.0 to 65.5 per cent.

Abstract

S3P-10

Effect of potassium and boron content of leaf and soil on copra yield of coconut (*Cocos nucifera* L.) in sub-Himalayan tract of West Bengal

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The wide spread deficiency of potassium and boron in coconut is a limiting factor for increased production. The ongoing experiment on potassium-boron interaction conducted in terai soils of sub-Himalayan tract of West Bengal with available potassium of 87.45 kg/ha with an aim to study the effect of leaf boron and potassium on copra yield of coconut. The experiment was carried out in a 7.5 m x 7.5 m spaced coconut plantation cv.ECT and laid out in Factorial randomized block design having 9 treatments replicated four times with graded levels of potassium (900, 1200 and 1500 g of K2O per palm) and boron (25, 50, and 100 g borax/palm). Soil samples from effective root zone at 0 to 30 cm depth and the leaf samples from the index leaf (14th frond) was taken for analysing boron and potassium at 6th and 12th months after soil application of potassium and boron. The results of the experiment revealed that both the soil and leaf boron and potassium content increased significantly with the intermediate dose of both the nutrients and decreased with the maximum dose. The interaction effect also showed the same trend. The nut and copra production showed a positive correlation with increased content of leaf and soil potassium and boron. Both the nutrients registered negative effect at their doses.

Abstract

S3P-11

Impact of potassium-boron interaction on leaf nutrient content and nut setting of coconut (*Cocos nucifera* L.)

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The experiment was conducted for two consecutive years during 2014-15 and 2015-16 at the Instructional Farm of Uttar Banga Krishi Viswavidyalaya, West Bengal located at 43 m above mean sea level with 26°19/86//N latitude and 89°23/53// E longitude. The study was aimed to evaluate the effect of potassium-boron interaction on leaf nutrient content and nut setting of coconut in the boron deficient soils of terai zone of West Bengal. The experiment was carried out in a 7.5 m x 7.5 m. spaced 11 years old plantation planted with cv. ECT and laid out in Factorial randomized block design having 9 treatments replicated four times with 3 different levels of Potassium (900, 1200 and 1500 g of K2O per palm) and Boron (25, 50, and 100 g borax/palm. Soil samples were collected from 0 to 30 cm depth within a radius of 1.5 m of the trunk of each palm of the entire experimental area of the plantation and the leaf samples from14th frond was taken for analysing boron and potassium at 6th and 12th months after soil application of potassium and boron. The results revealed that the leaf potassium content showed an increasing trend for the intermediate levels of boron. However, higher leaf boron content recorded with higher rate of boron application. The treatment receiving intermediate dose of potassium and boron registered highest leaf potassium content leading to production of higher number of bunches, female flowers and fruit setting.

Abstract S3P-12

Prevalence of potassium solubilizing bacteria in rhizosphere of coconut palms (*Cocos nucifera* L.) growing in different soil types

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Plant nutrition is closely associated with the activity of rhizosphere microflora, which plays an important role in supplying plants with available nutrients as well as growth promoting substances. Potassium nutrition is an important factor in regulation of plant productivity as far as coconut is concerned. Coconut flowers and fruits throughout the year and has a heavy demand for potassium, which at times, is not met easily from the K pool in the soil. As potassium gets depleted from the feeding zone at a faster rate, the K pool cannot keep up to restore the much needed K available to the coconut palms. In such situations, presence and activities of microorganisms greatly influence the availability of K in soil for plant growth. Hence, investigations were carried out to assess the prevalence of potassium solubilizing bacteria in rhizosphere of adult coconut palms growing in two different types of soil i.e., laterite and sandy loam. The results of the study revealed higher load of potassium solubilizing bacteria in sandy soil as compared to laterite soil. A total of 88 morphologically distinct isolates of potassium solubilizers were obtained using three different media based on Aleksandrov medium. Clearing zones of K-solubilization of upto 7 mm were obtained when potassium alumino silicate was used as the insoluble source of potassium. A maximum of upto 5.4 µg/ml potassium could be solubilized by the selected potassium solubilizing bacteria. The potassium solubilization potential of bacteria isolated from sandy soil was higher as compared to those from laterite soil. *Acinetobacter* sp., *Alcaligenes* sp. and *Micrococcus* sp. were found to be the predominant and efficient potassium solubilizing bacterial genera in coconut rhizosphere soils.

Abstract

S3P-13

Performance of Multiple Cropping Systems in Godavari Alluviums of Andhra Pradesh

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A survey was conducted in Atreyapuram and Ravulapalem mandals of East Godavari district of Andhra Pradesh to assess the profitability of different coconut based cropping systems .East Godavari district is highly potential area for coconut where the farmers are used to grow coconut as monocrop with a spacing of 8.0 m x 8.0 m. The soils in the surveyed areas are deltaic alluviums rich in organic matter. During recent years there is a shrink in coconut yields mainly due to frequent cyclones, pest and diseases. Apart from that due to repeated fluctuations in coconut prices also the farmers are forced to explore the possibility of growing other income generating crops like banana, elephant foot yam, dioscorea and turmeric etc. Different intercrops like banana + elephant foot yam, banana + dioscorea, turmeric + dioscorea are usually followed in different locations of coconut orchards. The yield of coconut varied from 90 to120 nuts/palm/year in monocropping system where as it is 165-180 in different intercropping systems. The yield of banana variety grand naine ranged from 23.5-29kg/plant. Per plant yield of elephant foot yam cv. Gajendra ranged between 1.8-2.2 kg /plant, greater yam (Purple Yam, locally known as Bombai pendalam) yield ranged from 2.1 to 2.9 kg/plant and the yield of aromatic turmeric cv. Kasturi ranged from 280-300 gm/plant. Among all the intercropping systems, highest net income was obtained with coconut+ banana+ Elephant foot yam cropping system where as the B:C ratio is highest in coconut + turmeric + greater yam due to high export potential of turmeric and greater yam.

Abstract S3P-14

Assessment of major and secondary nutrient profile of coconut palms grown in different Agro Ecological Zones of South Kerala

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Coconut is a perennial plantation crop with exhaustive depletion of nutrient s such as K, N, Ca, Mg, S and B. As the productivity of the palm increases, the quantity of nutrient removed per palm also increases. Nutrient exhaustion from the soil has its impact on the foliar nutrient levels which may affect the yield and productivity of the palm. Hence it is imperative to understand the leaf nutrient profile of the palms. In order to assess the leaf nutrient profile of palms, from Agro Ecological Unit-1, 3 and 9, thirty palms were identified from each AEU and leaflets were taken from the first and fourteenth leaf. Results of the study indicate that sufficient partitioning of phosphorus to the leaf tissues of the palms growing in AEU-1 and AEU-3 with an average content of 0.158% and 0.163% respectively. In AEU-9, the average leaf phosphorus content was 0.141. this emphasizes the strategy to skip phosphatic fertilizer application in the area. Sufficient K concentration was observed for the palms in AEU-1 and 3, but the average content was 1.2% for AEU-9. Sixty one per cent of the palms tested less than 0.30 % Ca content in the leaves of the palms from AEU-1 and 3. The average Ca concentration for the palms in AEU-9 was 0.17%. Forty four per cent of the samples had less than 0.2 per cent magnesium in the leaf tissues in AEU-1 where as eighty five per cent of the samples tested less than 0.20 per cent in the leaf tissues in AEU-3 indicating the severity of Mg deficiency in the zone. In AEU-9, forty seven percentage of the samples tested less than 0.2% Mg in the leaf tissues. Analysis of leaf samples from the three AEUs indicated calcium and magnesium as the major nutrient constraint. Considering the acidic soil reaction and the deficient levels of Ca and Mg, dolomite and lime each@1 kg per palm and magnesium sulphate@1 kg per palm in two splits can be recommended in the area along with other management strategies such as addition of palm residues in the basin and soil test based nutrient application.

Abstract

S3P-15

Robust Spatial Regression and its Application in Field Data Analysis

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Outlier detection and robust estimationare the integral part of data mining and has attracted much attention recently. Generally, the data contain abnormal or extreme values either due to the characteristics of the individual or due to the errors in tabulation, data entry etc. The presence of outliers will badly affect the data modeling and analysis. A robust nonparametric method is proposed to fit the spatial/surface regression which is not influenced by the presence of outliers in the data. Robust M- kernel weighted local linear regression smoother is used tofit the spatial regression function. The proposed method is useful to estimate/eliminate the spatial effect and to identify the high potential trees in an orchard, which is useful for the breeding programs. The method is illustrated through simulated and field data. The method is applied to the annual yield data of 225 coconut palms in a field to eliminate spatial effect and to identify the high potential trees.

Abstract S3P-16

Integrated nutrient management in coconut based cropping system

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Among the production constraints, optimal nutrition to coconut still plays the vital role for enhancing productivity. The effect of integrated nutrient management in coconut based integrated cropping system (Coconut (ECT) + Black pepper (Panniyur 1) + Banana (G9) + Cocoa (F1 hybrid)) was studied at Coconut Research Station, Veppankulam farm under AICRP on Palms, on 37 years old coconut in non replicated trial with four treatments @ 24 palms/ treatment *viz.*, T1 - 75% of recommended NPK + 25% organic (vermicompost), T2 - 50% of recommended NPK + 50 % organic (vermicompost + vermiwash + biofertilizer + in situ green manuring) , T3 – 100% organic (vermicompost + vermiwash + biofertilizer + in situ green manuring (sunhemp at basin) + green leaf manuring (Glyricidia leaves) + composted coir pith and mulching with coconut leaves) and T4 – Check (recommended NPK and organic manure) were evaluated. Among the treatments, T2 – 50% of recommended NPK + organic recycling with vermicompost + vermiwash + biofertilizer + in situ green manuring recorded more number of functional leaves (30 per palm per year), number of bunches (12 per palm per year) and number of nuts (118 per palm per year). The average earthworm population (25 nos./m^2) and soil microbial population counts (fungi, 18.27 10-3cfu/g of soil and bacteria 13.25 x 10-5cfu/g of soil) were also more in T2. Intercrops yield was also higher in T2 treatment where in yield recorded in cocoa beans (dried) was (262 kg/ha), banana was (24,125 kg/ha) and pepper was (47 kg/ha). The net income and B:C obtained was also the highest in the T2 treatment. Mono cropping of coconut with recommended NPK and organic manure registered the lowest earthworm, fungi and bacteria population. These observations proved the positive effect of integration of inorganics with organics especially vermicompost generated out of coconut biomass and microbial inoculants assumes significance for better productivity of the system.

Abstract

S3P-17

Design and Development of Coconut Basin Digger

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Opening of basin around coconut palm is a recommended practice on coconut cultivation. The coconut basin could act as a pit for collecting rain water during monsoon and irrigation water in other seasons. It also helps to store organic trashes and manures, cowdung, chemical fertilizers etc. for the overall growth of palm. But due to scarcity of laboures and escalating labour charges in manual basin opening, farmers are not giving much attention on regular maintenance works of coconut farms especially, the opening of palm basin. Considering the effectiveness in opening of coconut palm basin, Agricultural Research Station, Mannuthy has developed a device made up of Galvanized Iron material to attach power tiller with coconut palm to make basin around the palm. The device consists of a palm attaching frame, tail wheel mounting frame and chain attaching frame. For ease in operation, some modifications are also made in the power tiller. Rotavator blades are arranged in such a way that throwing of tilled soil from basin to outside has made easy. Track width is adjusted to a minimum of 600 mm in tune with tilling width. Balancing of power tiller, by fitting of additional metal wheels with both traction wheels helps the power tiller to move out easily after finishing each basin of about 300 mm depth. For forming the basin and smooth throwing out of tilled soil, the power tiller is operated in reverse direction. Other modification is the shifting of tail wheel from rear to front side which in turn gave more steady movement in reverse operation of power tiller. The power tiller attached with the palm by this device has made a circular basin of 150 to 300 mm depth and 1800 mm radius. It makes 8 basins in one hour with diesel fuel consumption of 1.5 litres. Total cost of this device is Rs. 15,000/- and the cost involved in making one basin is Rs.46/-. Also it is found economical with an output of 64 basins against manual opening of 12 basins in a day of 8 hours of operation.

Abstract S3P-18

Properties of biochars produced from coconut residues and their impact on humid tropical soils

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Coconut plantations and coconut-based cottage industries generate about 25 MT of biomass residues annually in India. They make an ideal feed-stock for producing biochar owing to high lignin content and provide an alternative to their direct soil application. We converted i) mature coconut husk, ii) tender (immature/green) coconut husk with shell, iii) coconut leaf petiole and iv) coir-pith, after initial sun-drying, to biochar through pyrolysis in a simple charring kiln. Resultant product was black, light weight and porous in nature. Chemical analysis showed small variations in the different biochars produced depending upon the type of coconut residue used. However, several characteristics were found consistent. Primary among them were i) alkaline pH ii) high potassium content, and iii) low organic carbon content, thus, making them a Class 3 category of biochars. Microbial analysis of the biochar immediately after its production did not show any microbial load. However, upon storage, a very low bacterial load was detected which indicated their recalcitrance to degradation. Two critical tests, *viz.*, seed germination using cow pea seeds and earthworm avoidance assay using *Eudrilus* sp., an earthworm species used for vermicomposting of coconut leaves, proved coconut biochars to be highly suitable for use in agriculture. Addition of these biochars in graded doses, alone or in combination with coconut leaf vermicompost, increased the pH, organic carbon and potassium content, and promoted plant-beneficial microbial communities and enzyme activities in the soil. In addition, coconut biochars are also expected to sequester carbon as a result of solidification of carbon structure of the biomass brought about by their thermal modification, thus, making them a stable soil constituent. Our studies highlight the potential of coconut biochars as soil catalyst for re-invigorating the health of nutrient-poor tropical humid soils, particularly those with low pH.

Abstract

S3P-19

Feasibility of flowers as intercrop in coconut by different agro techniques under coastal sandy soil system

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Experiment was conducted at ICAR-CPCRI, Kasaragod, Kerala, during 2015-16 to study the performance of different flower crops grown as intercrop in coconut with in-situ moisture conservation materials in littoral sandy soils of west coast. Flower crops viz., C1-Marigold (Arka Agni), C2-Gladiolus(Arka Kesar), C3-China aster(Arka Kamini) and C4-Gomphrena(Local variety), (C1 and C2 grown in kharif ; C3 and C4 grown in rabi) were grown with moisture conservation materials *viz.*, M1-Coconut husk, M2-Coir pith, M3-Shredded coconut leaf and control(M4). Vegetative, physiological and bio-chemical parameters of flower crops grown in kharif season recorded significantly higher growth in M3-treatment with the maximum flower yield (6.70 tons/ha of marigold and 78,026.95 spikes/ha of gladiolus) when compared to control (3.69 tons/ha of marigold and 63,788.43 spikes/ha of gladiolus). However, significantly higher growth of flower crops grown in rabi season were observed in M1-treatment with maximum flower yield (2.50 tons/ha of china aster and 40.17 tons/ha of gomphrena) when compared to control (1.36 tons/ha of china aster and 14.81 tons/ha of gomphrena). The higher soil moisture retention capacity of shredded coconut leaf and coconut husk throughout the growth period of kharif and rabi crops resulted in higher growth and yield attributes. Studies on soil properties showed that there was no significant influence of moisture conservation materials on soil pH, EC, OC, total N, available P and K. The coconut equivalent yield under intercropping of flower crops with in-situ moisture conservation materials was significantly highest under gladiolus (52,926 nuts/ha) intercropping over gomphrena (27,836 nuts/ha), marigold (13,537 nuts/ha) and china aster (12,584 nuts/ha).

Abstract

S3P-20

Mapping soil related constraints for coconut in the major coconut growing districts of Tamil Nadu

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Soil constraint maps for coconut cultivation were prepared for four major coconut growing districts of Tamil Nadu (Coimbatore, Tiruppur, Tanjavur and Dindigul) using the soil map at 1:50000 scale developed by TNAU. Thematic maps on soil depth, drainage, soil texture and soil reaction related constraints for coconut were developed using ArcGIS software. Subsurface soil reaction and soil texture properties were considered to identify the constraints. Based on the soil requirements of coconut, each soil property was classified in to four constraints classes *viz.*, highly suitable, moderately suitable, marginally suitable and not suitable. The soil depth related constraints (under marginal or not suitable condition) for coconut cultivation were observed in 22, 19, 17 and 36 per cent of the total geographical area of the districts Coimbatore, Tiruppur, Tanjavur and Dindigul respectively. Similarly, pH related constraints were observed in 55, 64, 41 and 28 per cent, soil texture related constraints were found in 17, 18, 19 and 6 per cent, and soil drainage related constraints were observed in 20,16,14 and 12 per cent of the total area in the Coimbatore, Tiruppur, Tanjavur and Dindigul districts of Tamil Nadu respectively. Majority of the area is having soil pH related constraints for coconut cultivation in these districts. Soil depth was found to be highly or moderately suitable for coconut cultivation in 72, 79, 76 and 60 per cent of the total geographical area of the Coimbatore, Tiruppur, Tanjavur and Dindigul districts of Tamil Nadu respectively. Likewise, the soil pH in 40, 33, 52 and 68 per cent area, soil texture in 77, 80, 74 and 89 per cent area and soil drainage condition in 74, 81, 78 and 83 per cent area were found to be highly or moderately suitable for coconut cultivation in these districts. The spatial information developed, is useful for planning location specific management strategies for overcoming the limitations in order to improve the coconut productivity further.

Abstract

S3P-21

Effect of inoculation of arbuscular mycorrhizae on the *ex vitro* establishment of embryo-derived coconut plantlets

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Tissue/organ cultured plants grown under aseptic conditions are devoid of the mutualist microbes present in rhizosphere and once transplanted to external environment, they face several biotic and abiotic challenges which impair their survival and growth. Embryo cultured coconut seedlings too face similar challenges. Arbuscular mycorrhizae (AM) fungi are key rhizosphere symbionts that form mutualistic association with more than 80% of the plant species known growing on earth. They offer several critical plant-beneficial functions such as nutrient and water absorption, pathogen and drought tolerance, etc. Inoculation of AM is also known to reduce the transplantation shock and improve the acclimatization of tissue/organ cultured plants. *Glomus etunicatum* and *Glomus boreale*, isolated from rhizosphere of coconut and tested earlier for their efficacy in promotion of growth of coconut seedlings, were chosen for this study. Embryo- derived coconut plantlets growing in pots in green house were de-potted and transplanted into poly-bags containing 10 kg non-sterilized soil-sand mixture. For AM inoculation, 100 g soil containing 100 spores of *G. etunicatum* and *G. boreale* per 10 g of soil, were added to the respective treatments individually. Control seedlings were grown without any AM inoculation. No fertilizer was added to any of the treatments and all were irrigated uniformly. Six months after AM inoculation, plant growth parameters measurements indicated longer shoot and leaf length and larger collar girth in AM inoculated seedlings. Fresh and dry weights of the AM inoculated seedlings were significantly high compared to uninoculated seedlings indicating better water absorption and biomass accumulation by the former. AM spore count and root association were also significantly higher in AM inoculated seedlings. This study clearly indicated the scope of integrating arbuscular mycorrhizae with embryo cultured coconut plantlets for better establishment under *ex vitro* conditions.

Abstract

S3P-22

Response of graded levels of boron application on the recovery of boron deficient coconut palms (*Cocos nucifera* L.) under terai zone of West Bengal

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The investigation was carried out during 2014-15 and 2015-16 in terai zone of West Bengal located at 43 m above mean sea level with 26°19/86//N latitude and 89°23/53// E longitude to study the effect of the application of graded levels of boron on the recovery of boron deficient coconut palms. The experiment laid out in RBD with 12 treatments, each replicated 4 times, comprised soil application of boron at 4 levels (0, 25, 50 and 100 g per palm per year) in the form of borax (10.5% B) to 4 to 5 years old coconut palms. The experiment was preceded by a preliminary study based on the results of which the palms were categorized into two stages of the degree of severity of boron deficiency *viz.* Incipient and Advance stages. The available boron contents of the soils with healthy and boron deficient palms were in the range of 0.26 to 0.39, and 0.51 to 0.54 mg/kg, respectively. Leaf tissue of the index leaf analysis revealed that the leaf boron contents (3rd leaf) of the deficient and healthy palms were in the range of 4.28 to 6.75, and 8.36 to 9.94 mg/kg, respectively. Application of boron to the affected palms at incipient stage improved the condition of the palms within the following six months. Complete recovery of the palms however, required not less than 9 months. Palms in advance stage of deficiency however, could not be recovered, despite the application of borax even at the highest rate (100 g/palm/year). The results further revealed that with no borax application, the healthy stage palms gradually changed to incipient stage of boron deficiency after 9 months, while the palms already in incipient stage required only 6 months to change to advance stage of the deficiency. The palms in advance stage of boron deficiency that could not be recovered by boron application died within 4 months. Though, boron content of the leaf tissue was increased correspondingly with increasing boron application in advance stage palms were in the range of 9.48 to 19.41 mg/kg.

Abstract

S3P-23

Screening of cocoa clones for their performance as intercrop in coconut gardens under South Gujarat condition

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Field investigation on "Screening of cocoa clones for their performance as intercrop in coconut gardens under South Gujarat condition" was carried out during the year 2009-10 to 2015-16 at Regional Horticultural Research Station, ASPEE College of Horticulture and Forestry, Navsari. The five clones *viz.*, VTLCC-1, VTLCH-1, VTLCH-2, VTLCH-3 and VTLCH-4 were planted during the year 2009-10 under 45 years old coconut garden with four replications by using Randomized Block Design. The results revealed that, growth attributes like plant height (4.52 m), stem girth (41.70 cm) and number of branches/plant (7.00) were significantly maximum in VTLCC-1, whereas, the minimum height at first branching (16.00 cm) were significantly recorded with same cocoa clone. Looking to the canopy spread, the VTLCH-3 clone showed significantly higher spread at both E-W (5.18m) and N-S (4.78 m) followed by VTLCH-1 (E-W 4.72 m and N-S 4.49 m) as compared to rest of cocoa clones. Regarding pod/yield characteristics, significantly maximum number of pods/tree/year (45.2), weight of single dry bean (1.15g) and dry bean yield/tree/year (1.59 kg) were recorded in VTLCC-1 of cocoa clone. In case of weight of pod, significantly maximum weight (42.51 g) was recorded in VTLCH-3 whereas, minimum value was recorded in VTLCC-1 (28.21 g). However, the maximum number of beans/pod (20.38) was recorded in VTLCH-4 followed by VTLCC-1(20.00) as compared to rest of cocoa clones moreover; minimum value was count in VTLCH-3 (14.27) of cocoa clone. In respect of coconut yield, the initial yield of coconut (WCT) was 60 nuts/palm and it was increased to 74 nuts/palm in the year 2015-16 (23.33 per cent increase over initial yield).

SESSION 4

MANAGEMENT OF PESTS AND DISEASES

Abstract S4L-01

Threats of invasive and emerging pests and diseases of coconut

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The emergence and spread of pests and pathogens pose a serious threat to global food security and natural vegetation. The increasing flow of free trade and movement across the globe has increased the attention of every country to protect their biodiversity of the crop plants. Coconut is a perennial tree crop cultivated globally in more than 90 countries by small and marginal farmers for its versatile use to human beings. It has vast morphological and genetic diversity which is vulnerable to invasive pests and diseases. Pests like *Brontispa longissima*, *Aspidotus rigidus* and diseases like lethal yellowing, foliar decay virus, cadang–cadang viroid, red ring nematodes are the major pests which are not present on coconut in some countries. However, these pests and diseases are causing huge loss to coconut and wiped out coconut plantations in other countries. Invasion of some of the exotic pest like coconut eriophyid mite, *Aceria guerreronis* Keifer in India from 1998 onwards caused economic loss to the tune of several crores of Indian rupees. Ever since the pest was first reported in Kochi, Kerala during 1998, it had spread like a forest fire affecting all major coconut growing areas of the country. Other non-native insects like Asian grey weevil-*Myllocerus undatus*, inflorescence moth-*Batrachedra arenosella*(nuciferae), Spiralling whitefly - *Aleurodicus* disperses also causing significant damage to coconut production in India in recent years. Presently the coconut leaf beetle, *Brontispa longissima* and the armored scale insect, *Aspidiotus rigidus*, which caused huge damage to coconut in our neighbor countries like Myanmar, Maldives, Indonesia, Malaysia and Philippines poses a great threat to Indian coconut. The spread of the coconut leaf beetle is mainly through the movement of infested seedlings. Shipments of ornamental palms from countries having the pest infestation have been the main source of spread within the Asia-Pacific region. Hard scale, *A. rigidusis* ravaging Philippines incurring huge loss to coconut growers in that country. The mobile stage being the crawlers and males are easily drifted away by wind or passively carried through any inert packaging materials, nuts etc. A close relative of the chysomelid beetle, *B. longissima*, *viz.*,

Wallacea sp. feeding on the spindle region of coconut seedlings was recently recorded from South and Little Andaman. Among the diseases, lethal yellow disease caused by Phytoplasma, coconut cadang-cadang caused by viroid, foliar decay caused by virus and red ring disease caused by nematode are not present in India. However, entry of these pathogens to India may pose a severe threat to coconut sector in India. Strict quarantine laws for movement of coconut or other ornamental palms, regular monitoring for these diseases and pests in India, creating awareness among the farmers and policy makers about these invasive pests and diseases, and preparedness to manage the pest or disease in case of accidental entry are essential.

Abstract S4L-02

Emerging trends In the sustainable management of coconut pests

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The coconut (*Cocos nucifera*) palm is a major plantation crop in Asia, with India, Indonesia and Philippines together accounting for more than 86% of the total 61.5 million whole nuts produced in the world in 2014. One of the constraints in increasing the production of coconut palm is a long list of insect pests that inflict severe damage and reduce the nut yields substantially. Classified as the important pests are Eriophyid mite, Aceria guerreronis Keifer, Coconut rhinoceros beetle, *Oryctes rhinoceros*, Red Palm Weevil, *Rhynchophorus ferrugineus* Oliv., Black Headed Caterpillar, *Opisina arenosella*, and Coconut Hispid Beetle, *Brontispa* longissima. Eriophyid mite that affects directly the nuts is still a major obstacle in the production as the available management methods are not adequate and there is a pressing need to find newer sustainable methods of management to alleviate the losses suffered by the farmers.

Coconut rhinoceros beetle is still a menace in young farms in many countries and for the management of it, apart from light traps, other kinds of effective trapping methods with pheromone baits were developed. In some countries especially with Islands, the classical biological control with *Baculovirus* sp. was tried with variable results and other putative pathogens are being attempted for the control of this pest.

The Red Palm Weevil in coconut farms has been kept under control to some extent with suitable and sustainable integrated management techniques like mass pheromone trapping, novel early detection methods, effective pesticides,phytosanitation and a few modern methods. Though many Asian countries like Vietnam, Thailand, Indonesia, Maldives and others were suffering from the attacks of coconut Hispid beetle for more than a decade, the Indian subcontinent was free till now. However, one has to keep a close watch on this quarantine pest as it may reach India through some planting materials. An effective biocontrol agent *Asecodes hispinarum* was mass multiplied and

released in the field to control this pest.The Black headed caterpillar more specific to Indian sub-continent occurs in some seasons in certain eco-zones and biological control through scheduled release of parasitoids is available for implementation besides other methods. Among other pests is soil borne coconut Root Grub, *Leucopholis coneophora* for which integrated pest control methods are well developed.

In recent times greater emphasis is being laid on the use of more ecofriendly, sustainable, economical, less labor-intensive methods of pest management. For this purpose more knowledge has to be generated on the insect and host plant interactions through cutting edge biotechnological studies and molecular techniques. In this paper the new trends in sustainable management of coconut pests are discussed with focus on future research.

Abstract S4O-01

Lufenuron-induced growth and morphogenetic modulations in red palm weevil infesting coconut

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The insect growth regulatory effect of a new generation biorational chitin synthesis inhibitor, lufenuron on the grubs of red palm weevil is reported in this study. Six different doses of lufenuron *viz.*, 0.00054%, 0.0011%, 0.0054%, 0.0065% and 0.0081% were exposed to uniform-sized grubs and the growth and development abnormalities was recorded at regular time intervals. Twenty grubs were used in the laboratory bioassay experiment and number of grubs that transformed into malformed/dead pupae was calculated. The data was subjected to probit analysis and homogeneity of data was confirmed through chi-square test. A total of ten larval instars could be demarcated in this study using Dyar's law with linear increase of head capsule width with one instar to the next in the ratio of 1.16 ($Y=0.541x$ with $R^2 = 0.9244$). More larval instars in RPW led to enhanced susceptibility to lufenuron. Malformation of RPW grubs shot up from 25% to 70% when exposed to lufenuron @ 0.00054% and 0.0081%, respectively indicating a dose-depended effect of lufenuron on treated grubs. The cuticle became soft and fragile with boil-like pustules; lesion turn brown and sometimes eruption of fluid was observed. Pupating insect were busted at certain points and the fibrous cocoon formed was not well-woven with low tensile strength. Emerged adults were malformed and could not initiate flight. Median effective dose of lufenuron against red palm weevil was found to be 0.00779% and at this concentration fifty per cent of the RPW grubs turn malformed. Grubs-treated with lufenuron pupated in 16 days, whereas the healthy insects pupated only after 44 days. Furthermore, lufenuron-treated insects attained a maximum weight gain of 2.75 g in 10 days and healthy insects reached >4.5 g after 17 days. The study indicated that lufenuron interfered with larval-pupal transformation of RPW grubs resulting in abnormal pupation. Accelerated feeding and diminished weight gain of RPW grubs were observed in lufenuron-treated grubs leading to precocious pupation and morphogenetic aberrations.

Abstract

S4O-02

Biological suppression of coconut black headed caterpillar Opisina arenosella outbreak in East Godavari district of Andhra Pradesh

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The leaf eating black headed caterpillar, *Opisina arenosella* is a serious pest of coconut palm causing significant yield loss in all the coconut growing tracts of India. It attacks coconut of all age groups and is a prolific feeder of coconut leaves. Among the coconut growing states, Andhra Pradesh occupies fourth place in the country with 5.50 per cent of area and 6.15 per cent of production. In 2015, starting from October, a high infestation of black headed caterpillar was observed in the coastal districts (East Godavari, West Godavari, Srikakulam, Visakapatanam and Krishna districts) of A.P and incidence ranging from 42.82 to 62.86 per cent was recorded. An outbreak of black headed caterpillar was recorded during this period in Allavaram mandal of East Godavari district in 675 ha. From October 2015 to April 2016, innundative releases of about 37.88 lakhs of *Bracon hebetor, Goniozus nephantidis* larval parasitoids was carried out in pest affected gardens in this mandal. To study the impact of parasitoid release randomly 10 leaflets/ palm were collected from 10 sample palms from the gardens in the seven villages from lower whorl of leaves. After parasitoid release in the affected gardens, the larval population of *O. arenosella* decreased by 34.1 to 75.9 per cent, pupal population by 33.4 to 94.5 per cent and paralysed larval population recovered was 8.30 to 26.92 per cent after three months. After six months the larval population decreased by 59.65 to 100.00 per cent the pupal population up to 92.8 to 100.0 and paralysed larval population recovery increased ranging from 18.68 to 34.6 per cent. After six months of release of parasitoids, the impact of inundative release of bio agents in the suppression of the leaf eating caterpillar was prominent providing impetus to the role of biological control in pest management.

Abstract

S4O-03

Controlled delivery of ethyl 4 methyl octonate, the pheromone of coconut rhinoceros beetle, Oryctes rhinoceros linn.

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Rhinoceros beetle, *Oryctes rhinoceros* Linn. (Coleoptera: Scaraebidae) is a key pest of coconut, *Cocos nucifera* in India and South East Asia. Polymer membrane /polypropylene tubes are used in delivery of rhinoceros beetle pheromone (ethyl 4 methyl octonate) for mass trapping of the beetles. Though effective, the polymer membrane dispensers have high release rate ranging from 10-30 mg/day. This warrants replacement of the lure in 3-4 months interval which adds up to the cost of the labour and chemistry. Nanoporous materials are a novel carrier/dispenser for the volatile signaling molecules with controlled spatiotemporal release rates. A nano dispenser made of mesoporous sieves with ordered pore channels was developed for loading the rhinoceros beetle pheromone. Characterization by Field Scanning Electron Microscopy (FESEM) and X - ray Diffraction (XRD) confirmed the ordered structure of the pores on the matrix. Pheromone when loaded in nanomatrix showed delayed dissipation as compared to pheromone alone when assayed by Thermal gravity analysis (TGA). Fourier transform infrared (FT-IR) measurements confirmed the presence of pheromone in the nanomatrix. Further, studies on release rate of the entrapped pheromone in the nanomatrix using the Gas Chromatography revealed lower release rate of volatiles compounds as compared to the commercial lures having polymer membrane. The release rate from the nanomatrix was sufficient to cause physiological response that was ascertained by electrophysiological techniques (electroantennogram). Field test of pheromone loaded in nanomatirx captured more beetles than unbaited traps. Its longevity is more: While the commercial lure containing 800 mg pheromone was exhausted in three months, same quantity pheromone loaded into nanomatrix lasted for six months.

Abstract

S4O-04

Coconut water, an efficient medium for *in vitro* mass culturing of Trichoderma

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The *in vitro* mass culturing of *Trichoderma* is done in sugarcane molasses or Potato Dextrose Broth. Lack of sugarcane industries at Kasargode makes availability of molasses difficult, and use of Potato Dextrose Broth involves high cost. The district has plenty of Copra processing units where large amount of coconut water is getting waste daily. *In vitro* studies were conducted for evaluating coconut water and other liquid growth media such as rice gruel, potato extract etc using dextrose, sucrose and jaggery as the carbon sources. Each treatment was replicated thrice. The results indicated that coconut water with 2% jaggery gave the highest mycelial dry weight of *Trichoderma* followed by coconut water with 2% sucrose. Sporulation of *Trichoderma* was also highest in coconut water with 2% jaggery.

Abstract S4O-05

An outbreak of stem bleeding affecting dwarf coconuts in the State of Sergipe, Northeast Brazil

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The coconut stem bleeding disease was first detected in Brazil, causing the death of several plants, in 2004 in a small area of the State of Sergipe. Later was found widespread in other regions affecting dwarf and as well hybrids plants. Studies were conducted in order to investigate the spread of the disease, insects involved in the *T. paradoxa* transmission, the interaction with other pathogen as ways of disease control. The spatial pattern of stem bleeding spread varied over time, with initial infections presenting random pattern and then evolving to aggregate pattern during evaluations. Stem bleeding was responsible for large aggregations of diseased coconut palms, indicating that individually infected plants were the outbreak source for subsequent infections. This fact also showed that secondary inoculants were spread over short distances, dissemination from plant to plant by contact between roots, or by water splashing. *Thielaviopsis paradoxa* was internally and externally in the insects: *Rhynchophorus palmarum* and *Metamasius hemipterus* in the region where the disease was present while in region where the disease was absent, the insects where also fungi free. The pathogenicity of the isolates was confirmed in coconut plants, it is very probable that both insects are vectors or agent of dispersal of pathogen. An epidemiological study revealed a constant association between *Bursaphelechus cocophilus* and *Thielaviopsis paradoxa* in all cases of stem bleeding examined in Sergipe. These observations lead to the conclusion that nematode is a predisposing agent to subsequent invasion by Thielaviopsis. Treatment with Bordeaux paste significantly reduced the progress of stem bleeding in 66.4% in affected plants, and 84.2 % remained symptomless during the experiment, demonstrating mainly the preventive capacity of the Bordeaux paste.

Abstract

S4P-01

Cultural and molecular characterization or grey leaf spot pathogen of coconut

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Preponderance of minor diseases in coconut emerging in sporadic outbreaks is well documented. Grey leaf spot is a minor disease infecting coconut and occasionally reported as a major limiting factor in certain cultivars in different agro-ecological conditions. Surveillance surveys indicated moderate incidence of grey leaf spot disease in juvenile palms of Niu Leka variety in Kayamkulam, Kerala during 2015-2016. Diseased leaflets showing oval spots with greyish white centre, reddish brown margin and yellow halo were collected and the pathogen was isolated. Based on the cultural and morphological characters the isolated fungus was identified as *Pestalotiopsis sp.* and the pathogenicity was established. The colony of *Pestalotiopsis sp.* appeared to be white, fluffy with brown to black fruiting bodies which often formed black conidial masses. The fusiform conidia were five celled with four conspicuous septa. The three median cells of conidia were brown coloured while the apical and basal cells were hyaline with appendages. The apical cells of the conidia showed two to three hyaline appendages whereas the basal cells possessed a single pointed appendage. In order to characterize the *Pestalotiopsis sp.* through molecular techniques, multi-locus sequencing using primers for ITS region, β-tubulin and elongation factors was undertaken. Studies on the influence of temperature on the growth of *Pestalotiopsis sp.* under in vitro condition showed that the pathogen could grow over a temperature range of 20-30 °C and attained maximum growth at 25 °C. Under *in vitro* conditions the fungus could grow in a pH range of 5.0 to 8.0 with the optimum pH range near neutral pH 6.0 to 7.0. The inhibitory effect of water extracts of different oilcakes was tested *in vitro* against *Pestalotiopsis sp.* and significant reduction in radial growth of the pathogen was obtained in PDA fortified with neem cake extract. Out of the fungicides tested, carbendazim 50% WP and tebuconazole 25.9% EC inhibited the mycelial growth of *Pestalotiopsis sp.* at 100 ppm concentration. The study confirmed the presence of *Pestalotiopsis sp.* on Niu Leka coconut variety through morphological and molecular techniques and the pathogen could be suppressed by carbendazim and tebuconazole in laboratory bioassay.

Abstract S4P-02

Integrated management of white grubs, *Leucopholis* spp. (Coleoptera: Scarabaeidae) in palm gardens

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Three species of white grubs belongs to genus *Leucopholis viz.*, *Leucopholis burmeisteri*, *L. lepidophora* and *L. coneophora* are associated with palm based cropping system in Southern and North eastern parts of peninsular India. Larvae damage the palms and intercrops by feeding on subterranean parts, resulting in yellowing, nut shedding, and decline production of inflorescence and yield. Integrated Pest Management is a holistic approach wherein all components of compatible management strategies are integrated harmoniously as possible so as to prevent the insect population attaining economic threshold level. Ethology of *L. coneophora* indicated that en-masse emergence commenced with the setting of south west monsoon in June and active swarming prolonged for 21 days. The daily emergence occurred when illuminance fell down to 124.37±75lx in the evening and prolonged up to 1.2±04lx. The beetles congregated during activity period and they did not attract to light traps. Hand picking is highly significant over light trapping. Field biology revealed the presence of first and second instar larvae in the interspaces up to August, and presence of third instar larvae in the root zone during August-February. The third instar larvae were targeted by number of natural enemies including parasitoids (*Prosena sp.* nr. *Siberita* and *Campsomeriella collaris collaris*) and pathogens (*Beauveria, Metarhizium* and *Serratia*). Toxicological studies showed that, imidacloprid (LC50 at 120h = 47.605 on III instar larvae) and bifenthrin (LC50 = 63.052 ppm) were toxic insecticides. As per field efficacy evaluation, two round (Aug. and Sept.) application of bifenthrin @ 2kg ai/ ha (74.26 % reduction in grub population) or imidacloprid @ 0. 24kg ai/ ha (75.84 %) were as much good as recommended insecticide chlorpyriphos @ 2kg ai/ ha (69.15 %). Bifenthrin was long persisting and compatible with *Trichoderma harzianum*. Based on these findings IPM package was fine-tuned which will be discussed.

Abstract

S4P-03

Evaluation of botanical formulations and chlorantraniliprole for management of coreid bug infestation in coconut

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The coreid bug, *Paradasynus rostratus* Distant (Hemiptera: Coreidae) has attained the status of a potential emerging pest of coconut palms in South Kerala in recent years. The adults and nymphs puncture and desap the developing buttons by inserting the stylet through the perianth region. The pest infested buttons shed down and those buttons that remain in the palm develop into undersized nuts with incomplete kernel formation or barren nuts. Objective of the present study was to evaluate botanical pesticides (Neem oil, nimbidine, plant products (combination of neem oil+palm oil) and green labeled pesticide (Chlorantraniliprole) in reducing coreid bug damage on coconut. Two sprayings were carried out at bimonthly interval during February and May 2015. Each treatment comprised of ten palms and each palm was designated as a replication in a completely randomized design. Initial coreid bug damage on nuts ranged from 24.8 to 34.0%. After imposing treatments, significant reduction in coreid bug incidence was recorded in palms treated with 0.5% neem oil+soap (7.10%) and 0.018% chlorantriniliprole (7.73%) than control (18.66%). Highest per cent reduction in coreid damage over pretreatment was observed in palms treated-with chlorantraniliprole (75.55%) followed by neem oil (73.89%). The palms were further monitored for button shedding so as to ascertain the influence of different botanicals as well as chlorantraniliprole in the suppression of button shedding. Button shedding ranged from 56.57 to 58.28 % initially, which got reduced significantly in various treatments (21.14 to 28.15%) than control (40.71%) after superimposition of the treatments. All the treatments were found significantly superior than control in reducing button shedding due to coreid bug damage. Highest reduction (63.72%) in button shedding was observed in palms treated with plant product extract (2%) followed by Chlorantraniliprole 0.018% (57.57%). Results of the present study clearly indicated that neem oil or chlorantraniliprole could be used for field management of coreid bug infestation in coconut.

Abstract

S4P-04

Pathogenicity of entomopathogenic nematodes against coconut rhinoceros beetle, oryctes rhinoceros (scarabaeidae: coleoptera)

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The coconut rhinoceros beetle (*Oryctes rhinoceros*) is one of the most damaging insect pest to coconut palms in India. Safety and environmental issues surrounding the chemical insecticides has led to an alternative control measures such as use of entomopathogens and their products. Entomopathogenic nematodes (EPNs) (Rhabditida: Steinernematidae and Heterorhabditidae) are one such entomopathogens which occur naturally in soil environment. Several EPN species and their isolates exhibit considerable variations in terms of pathogenicity. The present study was thus conducted to evaluate the efficacy of two strains of EPNs, *Steinernema carpocapsae*, and *S. abbasi* on eggs and larvae of rhinoceros beetle. Infective juveniles (IJs) at various levels/concentrations *viz.*, 0, 5, 10, 20 and 40 IJs per cm^3 against eggs and neonate larvae and 0, 20, 40, 80 and 160 IJs per cm^3 against second and third instar larvae were inoculated in vermicompost and kept at 28 °C under laboratory condition. The number of dead larva and inhibition of egg hatching (%) were observed at 24 hours intervals. Under laboratory conditions, both the egg and larval stages were susceptible to infection by these two nematode species, but *S. carpocapsae* had lower LC50 than *S. abbasi*. Similarly, *S. abbasi* had lower concentrations of IJs required than *S. carpocapsae* to attain the same larval mortality under micro-plot trials. Nematode emergence from the infected grubs was found to be higher in *S. abbasi* than *S. carpocapsae* which indicates its potential to reproduce and recycle in the vermicompost. Ovicidal activity up to 90 % was observed at 40 IJs per cm3. This is the first report of entomopathogenic nematode pathogenecity against coleopteran eggs. In the current scenario, EPNs could be efficient sustainable method for reducing rhinoceros grubs in breeding points.

Abstract

S4P-05

Management of coconut rhinoceros beetle *Oryctes rhinoceros* (L.) (scaraebaeidae: coleoptera) through IPM intervention

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Rhinoceros beetle, *Oryctes rhinoceros*(L.) is one of the serious pests in South East Asia, infesting young coconut palms in the age group of one to six years. The adult beetle causes injury to the young palms by boring into the spindle leaf, spathe and young petioles. An estimated yield loss of 10% is attributed to spathe damage by rhinoceros beetles. The present study was attempted to evaluate and validate IPM measures for the management of rhinoceros beetles in large scale field conditions from 2012 to 2014 at AICRP centres *viz.*, Aliyarnagar (Tamil Nadu) and Ambajipeta (Andhra Pradesh). An Integrated Pest management Module was followed incorporating all the components in the selected gardens in the age group of 4 -5 years in a minimum of 5 ha area. The IPM practices included setting up of Rhinolure(PCI®) pheromone traps @ 1/ha, field release of baculovirus suspension treated adults @ 15/ha, placement of naphthalene balls once in 45 days, and application of green muscardine fungi, *Metarhizium anisopliae*@ 5 x 10^{11} spores/m^3 to the manure pits. The intensity of coconut rhinoceros beetle damage on leaf and spindle was recorded prior to imposing the IPM measures and at six monthly intervals. The data obtained were subjected to paired t test and analysed statistically. At Aliyarnagar centre, upon following the IPM measures, the leaf and spindle damage reduced gradually from 37.50 to 6.97 per cent and 25.0 per cent to 6.97 per cent, respectively after 18 months of imposing treatments. Similar trend was observed at Ambajipeta centre also, wherein, the leaf damage reduced from 65.46 to 4.40 per cent and spindle damage from 30.0 per cent to 2.0 per cent. Thus, adopting IPM strategies showed significant reduction of rhinoceros beetle damage in coconut ecosystem.

Abstract S4P-06

A modified method for mass multiplication of the fungal biocontrol agent, *Trichoderma*

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The currently used method for the *in situ* mass multiplication of the bio-control agent, *Trichoderma* involves use of neem cake and farmyard manure in the ratio 1:9. Adulteration of neem cake with common salt leading to poor growth and multiplication of *Trichoderma* and often the multiplied inoculum was found to be contaminated by the dreaded fungus, *Aspergillus flavus*. Unavailability of quality neem cake led to search for other alternate substrates for mass multiplication of the fungus. Coconut cake and farm yard manure at different proportions were used for mass multiplication of Trichoderma. *Trichoderma* was initially multiplied in coconut cake for 5 days and the multiplied inoculum was later mixed with farmyard manure and allowed to grow for 10 more days. Coconut cake and farmyard manure at the ratio 2:8 yielded the best results.

Abstract

S4P-07

Eco - friendly management of coconut eriophyid mite *Aceria guerreronis* (Acarinae: Eriophyidae)

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The efficacy of different typesof botanicals were tested against coconut Eriophyid mite, *Aceria guerreronis* under field conditions .The botanicals like Calotropis leaf extract(*Calotropis gigantea*) -5%, black pepper extract -10%, neem seed kernel extract -5%, neem azal -1%, turmeric –ash powder solution (one kg each in 100 liters of water), malathion 50 EC@ -2ml/litre as a standard check along with a control. The experiment was carried out with seven treatments and three replications. It was noted that neem seed kernel extract recorded highest percentage (58.99%) reduction of mite population followed by black pepper extract (49.50%), and turmeric-ash powder solution (39.99%) respectively. Lowest percentage of population reduction was shown by Calotropis leaf extract (2%).

Abstract

S4P-08

Evaluation of susceptibility of Rhinoceros larvae *Oryctes rhinoceros* to botanicals

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The susceptibility of rhinoceros larvae, *Oryctes rhinoceros* to different botanicals were tested under *in-vitro* conditions. The botanicals used were leaf extract of Clerodendron (*Clerodendron infortunatum*) -10%, finely powdered flower buds of clove -10%, black pepper extract -10%, castor cake slurry @1kg/liter. The experiment was carried out using completely randomized design with five treatments and four replications. Each treatment included two rhinocerous larvae. Clove extract showed highest mortality (68.83%) when compared to the others followed by castor cake slurry (42%). Lowest mortality was shown by Clerodendron leaf extract (25.87%).

Abstract

S4P-09

Morphological characterization of the entomopathogenic fungus, *Ophiocordyceps neovolkiana* on coconut root grub (*Leocopholis coneophora*)

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The entomopathogenic fungus, *Ophiocordyceps neovolkiana* observed to be sprouting from the specimens of coconut root grub (*Leocopholis coneophora*) from the sandy soils at the instructional farm, College of Agriculture, Padannakkad, Kasaragod during June-July month every year, was morphologically characterized. From the buried infected grubs, dark brown stalks of about 0.3 - 0.6 cm thickness emerged, the tip of which later became bulged and developed bright orange colouration. The bulged portion showed numerous holes representing the ostioles of the perithecia. The entire stalk measured around 6 -14 cm length and the orange coloured stromatic portion measured about 1 - 4 cm. The length of perithecia ranged from 85 - 100 µm whereas the width varied from 82.5 - 137.5 µm. The ascus measured about 135 -188 X 6.25^{-10} µm and the ascospores were filiform, having around 30 - 85 µm length with a width of 2 - 2.5 µm. The thickness of the perithecial wall ranged from 17.5 - 25 µm. In later stages, the stromatic region became dark brown to black and numerous white colored thread like sporulating structures developed representing the conidial stage of the pathogen. Further studies need to be focused on the possibility of using the entomopathogenic fungus as a biocontrol agent in controlling coconut root grub.

Abstract S4P-010

Field management of basal stem rot disease of coconut using native bio control agents

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Coconut is one of the important plantation crops that plays significant role in Indian economy. Basal stem rot or Ganoderma wilt caused by *Ganoderma species* is the most destructive disease accounting to reduced net returns. Biological control with antagonistic microorganisms such as *Trichoderma species* and *Pseudomonas fluorescens* was found promising in managing the disease. So, a field trial on management of basal stem rot was conducted at P. Gannavaram village of East Godavari District of Andhra Pradesh during 2014-16 for standardization of dosage, frequency and method of application of bioagents. Soil application of talc based formulation of *Trichoderma reesei* or *Pseudomonas fluorescens* or both along with neem cake was tested in the trial. The doses and frequencies of bio agents tested were 125g of bio agent along with 5kg of neem cake at yearly interval, 125g of bio agent with 2.5kg neem cake at half yearly interval and 125g of bio agent with 1.25kg of neem cake at quarterly interval. Root feeding of 1 ml of Hexaconazole /100 ml water thrice a year and integrated disease management including bio agents, root feeding of hexaconazole and nutrient management were included as positive controls. Height of bleeding patches on the stem, number of leaves and reduction in leaf size of each treated palm was recorded at regular intervals. Based on these observations, disease index of each treated palm was calculated. Average disease index before treatment application in all the treatments except one was found decreased by March 2016. Soil application of 125g of *Trichoderma reesei* and *Pseudomonas fluorescens* along with 5 kg of neem cake/ palm/year was found effective among all the treatments and showed the lowest disease index of 6.2 by the end of March 2016. This treatment was on par with soil application of talc based formulation of 125g of *Trichoderma reesei* along with 5 kg of neem cake/ palm/year.

Abstract

S4P-11

In vitro screening of fungicides against the growth of *Ganoderma lucidum* causing basal stem rot disease on coconut

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Basal Stem Rot (BSR) disease in coconut incited by the fungus, *Ganoderma lucidum* is the deadly disease of coconut. It is severe in India and in some cases; the incidence goes as high as 31 per cent. The disease is responsible for significant yield reduction every year in India and few Asian countries. The inhibitory effect of twelve systemic fungicides *viz.*, Azoxystrobin 23% SC, Kresoxim methyl 44.3% SC, Tebuconazole 25.9% EC, Tetraconazole 3.8% EW, Tebuconazole + Trifloxystrobin 50% + 25% WG, Difenoconazole 25% EC, Hexaconazole 5% EC, Propiconazole 25% EC, Thiram + Carboxin 37.5 + 37.5 WS, Thiophanate methyl 70% WP, Pencycuron 22.9%SC and Famoxadone 16.6% SC + Cymoxanil 22.1 % SC) at 0.1 per cent concentrations on the growth of *Ganoderma lucidum*, causing basal stem rot disease on coconut under *in vitro* condition was evaluated by poisoned food technique. Among the 12 fungicides tested, Tebuconazole 25.9% EC, Tetraconazole 3.8% EW, Tebuconazole + Trifloxystrobin 50% + 25% WG, Difenoconazole 25% EC, Hexaconazole 5% EC, Propiconazole 25% EC, Thiram + Carboxin 37.5 + 37.5 WS were found superior recording 100 per cent inhibition of *Ganoderma lucidum* and showed superior over the other fungicides tested under *in vitro*. Based on the results of *in vitro* evaluation, Tebuconazole 25.9% EC, Tetraconazole 3.8% EW and Propiconazole 25% EC were selected along with standard check, Hexaconazole 5% EC for *in vivo* evaluation as root feeding @ 2 ml in 100 ml of water for the management of basal stem rot disease at Avanam village of Pudukkottai district in Tamil Nadu.

Abstract S4P-12

Morphological and molecular characters of *Lasiodiplodia theobromae* (Grifon and Maubi) isolates causing leaf blight disease in Coconut

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Leaf blight of coconut is caused by the fungus *Lasiodiplodia (Botryodiplodia) theobromae* (pat.) grifon and maubl. and it's an emerging and serious problem in Pollachi tracts of Tamil Nadu. The disease causes reduction in nut yield to an extent of 10 to 25 % in adult palms. The affected leaflets start drying from the tip downwards and exhibit a charred or burnt appearance. The main objective of the study is to characterize the *L. theobromae* isolates from coconut at morphological and molecular level. Twenty five isolates were collected from severely infected leaf blight symptoms containing leaflets of the farmer's field from different coconut growing areas of Tamil Nadu, India. Based on morphological characters, the pathogen was identified as *Lasiodiplodia theobromae (Botrydiplodia theobromae)* and all twenty five isolates were tentatively identified as amplicon of 560 bp corresponding to the region of the 18S-28S rRNA intervening sequence for *L. theobromae*. All the isolates were artificially inoculated on one year old palm grown in glass house conditions and maintained at 85 per cent relative humidity. The initial infection started from 20 days after inoculation of the pathogen. The observations on disease severity revealed differences in the virulence between isolates were observed on 30 days after inoculation. The molecular variability among isolates of *L. theobromae* were genetically analysed through random amplified polymorphic DNA (RAPD) by using 20 random primers. Analysis of the genetic coefficient matrix derived from the scores of RAPD profile showed a minimum of 22.15 and a maximum of 87.56 per cent similarities among the L. *theobromae* isolates. The polymorphism in each case was documented and grouping was done using Jaccards similarity coefficient. Molecular phylogenetic grouping obtained by RAPD analysis did not correlate with morphological characteristics and virulence patterns. Thus genetic study of pathogen will help in determining their genetic diversity, adoptions to different environments which will further help in developing improved methods of sustainable disease management.

Abstract

S4P-13

Ecological safety of newer insecticides against larval parasitoids, *Bracon brevicornis* and *Goniozus nephantidis* of Coconut black head caterpillar, *Opisina arenosella*

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Augmentative release of larval parasitoids *viz.*, *Bracon brevicornis* and *Goniozus nephantidis* is established as one of the effective management of coconut black headed caterpillar, *Opisina arenosella* Walker (Lepidoptera: Oecophoridae). However, due to the easy availability and quick results, chemical insecticides play a vital role in pest management especially when the pest reaches Economic Threshold Level (ETL). Thus, selection of a suitable insecticide is very crucial not only depends on its efficacy against the target pest but also on its toxicity to beneficial insects. Safe waiting periods for the release of bioagents after insecticidal application need to be determined as the residual toxicity of insecticides has greater influence on parasitoids dispersal and their searching activities of the hosts. The potential toxicity of insecticides *viz.*, Spinosad, Imidacloprid, Flubendiamide and Chlorantraniliprole against adults of *Bracon brevicornis* and *Goniozus nephantidis* were tested under laboratory conditions by glass vial residue method. Results of this experiment would be useful in choosing the insecticide with lower risks towards parasitoids. The order of toxicity in the descending order was found as Imidacloprod > Spinosad > Flubendiamide > Chlorantraniliprole. Based on the classification by IOBC/WPRS working group on Pesticides and non-target invertebrates, Chlorantraniliprole and Flubendiamide were classified as harmless to *Bracon brevicornis* and *Goniozus nephantidis*, as the recommended dose caused less than 50% mortality in the laboratory conditions. Imidacloprid and spinosad were found as slightly harmful and moderately harmful category, respectively. Diamides, Chlorantraniliprole and Flubendaimide were found to have a safer profile towards these parasitoids compared to other chemicals. However, under field conditions, the insecticide may have less impact on parasitoids and thus, further studies to be carried out to assess the insecticidal toxicity against natural enemies under those environmental conditions.

Abstract S4P-14

Management of mite in coconut

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A study on management of coconut mite was carried out in farmers' field at Bagharpara Upazila in Jessore District from May 2011-June 2014. The mite attacking the coconut in Bangladesh remained unidentified till 2008. It is tiny in size. Field and laboratory studies on morpho-anatomy revealed that 2-3 month old nuts hosted colonies of mites. No mite was found on unfertilized flowers and nuts of more than 7 months old. Colonization was found maximum in younger nuts of 2-3 month old. Triangular yellowish brown patches were observed extending distally on the fruit surface from beneath the perianth of young developing button. It resides under the perianth near the stalk of young coconut and sucks sap from the tender portion of the nut. Based on the above findings, treatments were applied: T1- removing of infected young nuts and foliar application of Omite @ 0.2% adjacent to the bunch region of crown; T2 - removing of infected young nuts and foliar application of Neem-oil @ 0.3% adjacent to the bunch region of crown; T3- T1 and soil incorporation of Neem-cake at root zone @ 250g/palm; T4-T1 & soil incorporation of Tricho-compost at root zone @ 1kg/palm; T5-T2 & soil incorporation of Neem-cake at root zone of palm @ 250g/palm; T6-T2 and soil incorporation of Tricho-compost at root zone 1kg/palm. All the treatment were effective in controlling mite attack in coconut. Treatments containing Neem-cake (T3 and T5) found to increase kernel production of nuts. At the onset of the study, 32 nuts/palm were counted of which 55% were damaged. The rest 45% had longitudinal fissures and reduced size having no market value. Before treatment intervention, the income from infested palms was estimated at Taka 143.00. After intervention, an average of 77 nuts were harvested/palm/year and their market value was estimated at Taka 1540 .00 with BCR value 605.

Abstract

S4P-15

Trichoderma harzianum (CPTD28) - Effective in controlling diseases in coconut based cropping system

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Indiscriminate use of chemical pesticides for disease management has resulted in emergence of resistant pathogen strains over time and also increased the risk of environmental pollution and health hazards. Thus, there is an increasing demand for alternative measures for the control of diseases. *Trichoderma spp.* have gained wide acceptance as effective biological control agents against several important phytopathogens. The aim of the present study was to identify effective and potential *Trichoderma species* and substrate for easy multiplication in order to assist economical and effective management of diseases. Out of 16 Trichoderma isolates (13 from phytofura depository and three native), two were confirmed as *T. harzianum*, 13 as *T. asperellum* and one as *T. longibrachiatum* by sequencing ITS rDNA region. Among 16 Trichoderma isolates tested against *Phytophthora palmivora* of coconut and cocoa and also other major pathogens coconut *viz.*, *Thielaviopsis paradoxa* and *Ganoderma lucidm*, *T. harzianum* (CPTD28) expressed highest mycelia growth inhibition and cellulase enzyme activity. Formulations consisted of *T. harzianum* (CPTD28) *viz.*, Trichoderma coir pith cake found effective in the management of coconut bud rot and cocoa stem canker diseases and Trichoderma enriched neem cake in the management of basal stem rot disease of coconut.

Abstract S4P-16

Evaluation of olfactory pre conditioned larval parasitoid *Goniozus nephantidis* Muesebeck against Opisina arenosella Walker under field condition at Tumkur district of Karnataka

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Coconut black headed caterpillar, *Opisina arenosella* is one of the major pests of coconut and about 1.6 million palms are affected by this pest in Karnataka alone. Severe incidence of the pest was observed in Tumkur district (20.84%) throughout the year followed by Hassan (12.41%), Mysore (12.33%) and Mandya (04.61%). A field trial was carried out during 2014-15 and 2015-16 in a farmer's field of Kaidalu, Tumkur District, Karnataka state where a severe outbreak of coconut black headed caterpillar was observed to study the effectiveness of conditioned and unconditioned *Goniozus parasitoids*. Larval parasitoid was mass multiplied in the laboratory for field release. Parasitoids were pre-conditioned in the laboratory prior to release in the field. For olfactory conditioning, the parasitoids were exposed to odour of larval frass for about 72 hours. Before releasing the parasitoid, number of larva per leaflet was recorded. Then, parasitoids were released at the rate of 20 adults per palm. Four releases were made at 10 days interval during the experimental period. Each treatment was replicated on 10 palms. An untreated check was also maintained simultaneously. The observations were recorded at monthly intervals up to three months after release of parasitoids from treated and control palms. Two years mean data indicated that there was a higher initial black headed caterpillar population ranging from 21.08 to 21.72 numbers per ten leaflets which gradually decreased to 1.55 numbers per ten leaflets in treatment T1(Conditioned parasitoid) and 4.69 numbers per ten leaflets in treatment T2(Unconditioned parasitoid). In control palms, a larval population of 21.40 to 25.03 numbers per ten leaflets was recorded which indicated an increase in the larval population during the experimental period. Conditioned parasitoids were found to be more effective in reducing black headed caterpillar population below economic threshold level compared to un-conditioned parasitoids.

Abstract

S4P-17

Characterization of symptoms and pathogens associated with coconut leaf spot/blight disease

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Severe outbreaks of Leaf blight disease caused by *Lasiodiplodia theobromae* has been reported in Pollachi tract of Tamil Nadu and presently, disease is spreading at a faster rate in neighboring districts. Symptoms caused by *Pestalotiopsis palmarum* and *Lasiodiplodia theobromae* are also be distinguished clearly. The present study is to assess disease severity, characterization of symptoms and associated pathogens. Random survey on coconut leaf blight disease revealed highest incidence in Tirupur district of Tamil Nadu. Small brown or grayish color spots and grey color blighted patches either in middle or margin of *leaf lamina* has been observed in *Pestalotiopsis palmarum* infection while in Lasiodiplodia theobromae, burnt type appearance from the tip to downwards. A total of 23 *L. theobromae* and 5 *P. palmarum* isolates were recovered from diseased samples and characterized through morphology and molecular PCR based marker. Nucleotide sequences of ITS region of the ribosomal DNA of twenty three *L. theobromae* isolates had 100% homology with *L. theobromae* isolates available in the NCBI. The polymerase chain reaction (PCR) assay with the *L. theobromae* species-specific primer yielded a single band of 397 bp. Twenty Lasiodiplodia theobromae isolates were recovered from diseased samples and characterized through morphology and molecular PCR based marker. Nucleotide sequences of ITS region of the ribosomal DNA of all isolates had 100% homology with *Lasiodiplodia theobromae* isolates available in the NCBI. The polymerase chain reaction (PCR) assay with the *Lasiodiplodia theobromae* species-specific primer () yielded a single band of 450bp.

Abstract S4P-18

Occurrence and characterization of *Lasiodiplodia theobromae* causing nut rot in coconut

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A severe outbreak of malformation and cracking of nuts in coconut palms (*Cocos nucifera L.*) was reported in Tamil Nadu State, India. Based on reports from coconut farmers, a survey was conducted in the coconut plantations of Dharmapuri, Salem, Erode, Thanjavur, Thiruvarur and Coimbatore districts of Tamil Nadu state during 2015. The symptoms appeared as brown lesions covering the entire nut surface, later turning into whitish grey colour having shrivelled appearance. In advanced stages all nuts were malformed and developed hardness. The symptoms were observed in both eriophyid mite inested as well as healthy nuts. In some cases, gummosis were also observed.

The dehusked nuts with rotting symptoms were also observed under storage conditions in most places of survey. The incidence ranged from 4 to 16 %. Fifteen isolates of *Lasiodiplodia theobromae* (Pat.) Griffon & Maubl. (Lt) from symptomatic tissues were isolated and identified. In PDA, *L. theobromae* produced whitish grey aerial mycelia initially that turned dark brown later. Pycnidia were dark brown to black. Immature conidia were subovoid to ellipsoid, apex rounded; truncate at the base, thick walled, hyaline and one celled. Matured conidia were dark brown, two celled with irregular longitudinal striations. The average length of conidia was 20.28 µm and 9.28 µm wide. Pathogenicity tests were conducted on both healthy and eriophyid mite infested detached nuts with 9 mm mycelial disks from 8days old pure cultures grown in PDA. Coconuts were kept in a humid chamber using plastic bags for fifteen days under laboratory conditions. Untreated controls were inoculated with PDA disks only. The fungus invaded the kernel through the monocarp resulting in decay of the endosperm. Untreated controls did not show any symptoms and no fungi were reisolated from tissue thus fulfilling Koch's postulates.

Abstract

S4P-19

Cluster approach for assessing status of pests and diseases - A case of coconut in Northern Kerala, India

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The most basic requirement for any pest and disease management programme is the availability of a cost-effective sampling method for assessing the status of incidence and intensity from minimum effort. Coconut, a perennial tree crop, is attacked by a number of debilitating and lethal pests and diseases, of which, individual assessment require technical expertise and involve time consuming operations. In this study, a sampling strategy and measures of severity and crop loss for simultaneously assessing the major pests and diseases of coconut were formulated and implemented in northern districts of Kerala.Important factors considered were the practical feasibility of selecting the gardens in absence of a sampling frame; proportion of incidence could be very small at least for some of the pests or diseases; and the simplicity of the procedures. Accordingly, sampling methodology involved a cluster approach from each of the selected panchayaths, four clusters of at least 500 bearing palms from a minimum of 10 households, representing the geographical strata of the panchayath, were scored visually for incidence of major pests *viz.*, rhinoceros beetle, red palm weevil, eriophyid mite and coreid bug and diseases *viz.*, bud rot, stem bleeding and Thanjavur wilt. Palm-wise severity were recorded following standard pest/ disease severity indices in two randomly selected clusters out of four selected in the first round survey. District level estimates were derived incorporating area under coconut in each panchayath as the weight. Lat-long information was also collected utilized for preparation of thematic maps using Arc-GIS. Further, crop loss due to the major pests and diseases were also estimated under certain scenarios.

The study revealed that the diseases like stem bleeding and Thanjavur wilt are more prevalent in areas with high temperature and low rainfall whereas incidence of bud rot disease is significantly higher in hilly areas wherein low temperature and high humidity prevails. Incidence of pests like Eriophyid mite and coreid bug is high in coastal areas of the districts.

SESSION 5

CLIMATE CHANGE: EFFECTS AND MITIGATION

Abstract S5L-01

Climate change, carbon sequestration, and coconut-based ecosystems

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Climate change, the most widely talked-about global environmental issue of the day, refers to the gradual increase in temperature of the Earth's atmosphere. It is believed to be caused by the increase in atmospheric concentration of carbon dioxide and other greenhouse gases (GHGs). Concerned by the serious consequences of climate change, several global initiatives have been launched to address the issue. They fall under two broad categories: climate-change mitigation and adaptation, aimed at reducing GHG emissions and their negative impacts, respectively. Carbon sequestration, the prominent mitigation strategy, refers to capturing atmospheric carbon and securing it in long-lived pools, such as through photosynthesis by plants. Climate smart agriculture is the rallying theme for adaptation strategies. Both sets of strategies, i.e., for mitigation and adaptation, involve a combination of site-specific management activities. Most climate-change M & A studies in agriculture so far have focused on annual crops, with little attention being paid to perennials such as coconut. Coconut-based ecosystems offer good possibilities for enhancing carbon sequestration through crop combinations involving a variety of plants including food crops, tubers, vines, and tree crops. For climate-change adaptation, the annual intercrops planted under coconuts could be managed for optimum benefits for the whole system. Unlike during the early part of the first century of coconut research (in India) when the emphasis has been on enhancing the productivity of the palm itself, future research efforts should adopt a holistic approach focusing on the overall productivity and sustainability of the coconut-based agroecosystem as a whole, to cope with the increasing threats posed by climate change.

Abstract

S5L-02

Climatic risks and coconut: India's status paper on research

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Coconut plantations, owing to their perennial nature, live through the cycles of several types of stresses. Abiotic stresses such as droughts, dry spells, high and low temperatures, floods significantly affect the growth, development and yield of the plantations. In climate change scenario, frequency and magnitude of these stress is projected to increase, further challenging the sustainability of plantations. At Central Plantation Crops Research Institute, Kasaragod, India, research efforts were initiated in 1980's to analyse the response of coconut to drought stress, subsequently studies also included high temperature, high light intensity stresses as well. These efforts resulted in delineation of tolerance mechanism on coconut to drought and photo-oxidative stresses. Anatomical, physiological and biochemical markers were used for screening and identification of drought tolerant genotypes. Studies on characterization of drought and its management in plantation crops led to identification of in situ drought tolerant palms and drought management strategies in different agro-climatic regions of India. In 2004, climate change studies on plantation crops were initiated at CPCRI. The open top chamber studies quantified the physiological, biochemical and anatomical response of plantations to elevated CO_2 and temperature. Development of process based coconut simulation model by CPCRI opened many opportunities for studying the climate change impacts, adaptation strategies and also for larger management strategies providing important policy support. These studies were reported in India's National communication to UNFCCC as well as IPCC reports. Studies also provided an estimate of carbon sequestration potential of coconut. Apart from these, the studies also focussed on root (wilt) disease leading to physiological trait based identification of root (wilt) affected plants. Coconut germplasm was characterized for oil fatty acid profile. These studies helped in release of variety 'Kalpashree'. This chapter summarizes the major research achievements so far under climatic stress related studies.

Abstract 5L-03

Climate change: Modelling impacts, adaptation and mitigation strategies for coconut plantations

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Coconut farming demands perennial commitment for land, investment and labour. Any adverse impact on plantation causes perennial loss to the farmers, due to it's long recovery time. Coconut palms face climate change effects during it's economic life span. In view of the projected increase in climatic risks in climate change scenarios, it is essential to know the spatio-temporal impacts on coconut productivity. Further, deriving adaptation and mitigation strategies become essential to not only minimize the adverse impacts but also to exploit conducive weather conditions for improved resilience in productivity. Studying climate change effects on plantation crops is challenging due to size and duration of crop. Thus, methods such as statistical modelling and surveys have been used initially to quantify the relationship between yield and weather variables. But these methods have inherent limitations. Effects of climate change major parameters such as temperature and CO_2 on coconut, arecanut and cocoa seedlings were quantified in open top chamber (OTC) experiments. Anticipated yield performance was derived based on established seedling characters in these conditions and coconut yield. However, growth and yield is dependent oncrop physiological status, soil characteristics, management level, daily weather, CO_2, pests and diseases, etc. Dynamic simulation models integrate all these to mimic the crop performance in field. Uses of crop models are multi-dimensional, including i) decision support system for crop management ii) environmental characterization and agro-ecological zoning iii) estimating potential production and yield gap analysis, iv) strategic and anticipatory research and decision making support tool v) developing breeding strategies vi) crop potential zones for land use planning vii) in-door crop management, hi-tech horticulture viii) developing crop insurance products ix) weather-based crop-advisory x) local

and regional planning, xi) climate change studies, xii) defining research priorities xiii) prioritizing technology transfer and xiv) use as policy support tool and so on.

Development of InfoCrop-COCONUT, a dynamic simulation model, has opened opportunities to study the above. The model was used to quantify the spatio-temporal impacts of climate change, region specific adaptation gains and also quantify the mitigation potential. Prior to its application for climate change studies at regional level, the model was calibrated using high quality experimental data including OTC experiments. It was validated using multi-location experimental data. Climate change is projected to exhibit spatio-temporal variations in impact on coconut yield. Adaptation options and gains also vary spatio- temporally. Analysis indicated that in current climates, all India coconut yield can be doubled with optimal management, while it can be improved up to 35% towards the end of the century despite climate change. The carbon sequestration potential of coconut plantations in India was assessed using real time estimates and InfoCrop-Coconut model. Simulation results indicated that the carbon sequestered in stem in coconut plantations in four states *viz*., Kerala, Karnataka, Tamil Nadu and Andhra Pradesh is likely to be influenced by climate change. In states like AP and Tamil Nadu, the sequestration is projected to reduce by about 10 and 31%, respectively in PRECIS A1B 2030 scenario. On the other hand in Karnataka and Kerala it is projected to increase by about 28% and 3%, respectively. However, at all India basis, carbon sequestration is projected to increase marginally in future.

Abstract S5O-01

Influence of temperature, germination duration and cultivar on *in vitro* pollen germination and pollen tube growth in Coconut (*Cocos nucifera* L.)

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Temperature, germination duration and cultivars are important factors influencing pollen germination and pollen tube length of plants and thereby effecting fruit set and yield. To quantify the influence of nine temperatures from 10 °C to 50 °C at 5 °C intervals, four germination durations of 1, 3, 5 and 7 hours and five coconut cultivars *viz.*, WCT, CGD, MGD, MOD, MYD on in vitro pollen germination and pollen tube length, an investigation was carried out during 2014 and 2015 at CPCRI. Regional Station, Kayamkulam, India. Maximum pollen germination (71%) and pollen tube length (243µm) was observed at 30 °C and least at 50 °C. Pollen germination required 5 hours at 10 - 20 °C, 3 hours at 25-35 °C and 1 hour at 40-50 °C for reaching maximum value. Pollen tube growth required 7 hours at 10 °C, 5 hours at 20 and 30 °C, 3 hours at 15, 25, 35 and 40 °C and 1 hour at 45 and 50 °C to reach maximum value. WCT cultivar was found to have significantly more pollen germination percentage than the other cultivars. The cultivars which would perform better in predicted future climate change scenario are presented. Mean cardinal temperatures estimated for pollen germination and pollen tube length were Topt 28.5 °C and 29.5 °C , Tmin 4.3 °C and 8.5 °C , Tmax 52.8 °C and 51.2 °C respectively.

Abstract

S5O-02

Impacts of climate change on the main coconut diseases in Brazil

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Studies on impacts of climate change on coconut plant diseases has been limited, with most work concentrating on the effects of a single atmospheric constituent or meteorological variable on the plant, pathogen, or the interaction of the two under controlled conditions. It is understood that climate change could alter stages and rates of development of the pathogen, modify host resistance, and result in changes in the physiology of host-pathogen interactions. In the future with a warmer climate, heavy rainfall will increase and produce fewer more intense events. This could lead to longer dry spells and a higher risk of floods. There are recognized in the world various diseases that affect the coconut palm, specially in Brazil, varying the importance from one region to another, depending on the environmental conditions. The more important are: leaf spot, small and largeverrucoses, leaf blight, stem bleeding, bud rot, red ring, hartrot and dry bud rot. Some of the diseases, will probably increase but others have a probability to have its incidence less important. Perennial crops are particularly important in the reduction of CO_2 and coconut oil could be also widely use as biofuel . So we concluded that in Brazil, coconuts are an important crop in the fight against global warming.

Abstract S5O-03

Carbon sequestration potential of coconut based cropping systems with different cropping sequences and INM practices

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Carbon sequestration play a major role in mitigating climate change by converting atmospheric carbon into long lived wood biomass and soil carbon pool. The present investigation emphasizes above ground and soil carbon sequestration potential of coconut based cropping systems with integrated nutrient management practices. The experiment consisting of three cropping sequences of vegetable crops grown as intercrops in coconut garden, four integrated nutrient management (INM) practices was carried out in FRBD with five replications during 2012-14 at Horticulture Research Station (HRS), Arasikere, Hassan District, Karnataka. The above ground carbon sequestration in coconut palms in the intercropped plot was 18.77 t/ha during 2013-14 which was higher than the monocrop plot (16.19 t/ha). The incremental C sequestration in the intercropped plot was 5.65 t/ha compared to coconut monocrop plot (4.01 t/ha) in a two year period. The soil carbon sequestration potential as influenced by different cropping sequences was not differed significantly at 0-15cm depth but it was differed significantly during both the years at 15-30 cm soil depth. M3-baby corn-gherkin sequence recorded significantly the highest soil carbon sequestration ie., 19.17 Mg C/ha & 20.43 Mg C/ha at 0-30 cm depth during 2012-13 and 2013-14, respectively. Among the INM practices, soil carbon sequestration was significantly the highest in S4 treatment (5 tonne FYM+50% N by Vermicompost+50 % N by CCP+ vermiwash spray +Azatobacter) (21.16 Mg C/ha and 20.95 Mg C/ha at 0-30 cm, during 2012-13 and 2013-14, respectively) and it was the lowest in S1 treatment (Inorganic fertilizer alone-100 %)(17.94 Mg C/ha and 17.96 Mg C/ha at 0-30 cm, during 2012-13 and 2013-14, respectively). Interaction of the cropping sequence and INM practices recorded significant difference in the soil carbon sequestration potential and it was the highest under M2S4 sequence at 0-30 cm depth (21.49 Mg C/ha and 19.81 Mg C/ha during 2012-13 and 2013-14, respectively).

Abstract

S5P-01

Interaction effect of elevated CO_2 and elevated temperature with water deficit stress on coconut seedlings

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An experiment was conducted at ICAR-CPCRI, Kasaragod to study the response of coconut seedlings to elevated CO_2 [ECO_2] and elevated temperature [ET] and the interaction effect of climate change variables with water deficit stress in open top chamber facility. Seedlings were exposed to ambient (Shade net condition), OTC control (atmospheric CO_2 and temperature), [ECO2] (550 and 700ppm), [ET] (3 °C above ambient) and [ECO_2+ET] (550ppm CO_2 + 3 °C). In each OTC, two set of seedlings were maintained at 100% and 25 % field capacity, respectively. Seedlings in [ECO_2] treatments had a positive effect on plant height, leaf area and biomass production. [ECO_2] increased photosynthesis (PN), stomatal conductance and decreased osmotic potential (OP) but there was no significant change in stomatal resistance, leaf water potential (LWP), Fv/Fm ratio and transpiration rate. This shows improved water use efficiency in coconut seedlings. [ECO_2] led to higher carbonic anhydrase (CA), peroxidase (POD) and polyphenol oxidase (PPO) activity and increased the amount of Chlorophyll content and index (CI), total and reducing sugar, soluble protein, and phenolic content, and lipid peroxidation (LP), SOD and epicuticular wax accumulation was significantly less. [ET] decreased biomass by 27% and caused reduction in leaf area and PN. The seedlings under [ET] had the least LWP, chlorophyll content, CI, and Fv/Fm ratio. Total and reducing sugar, protein and phenolics got accumulated in leaves. CA activity was low and LP was higher, so the POD and PPO were higher under [ET]. [ECO_2 + ET] stimulated plant height, leaf area, PN and biomass. It reduced Fv/Fm ratio, total soluble sugar content and CA activity and enhanced soluble protein. Water deficit stress decreased plant PN, so it caused reduction in biomass and with leaf area under [ET] and no significant difference was observed in OP. [ECO_2] stimulated the growth of plants under water deficit stress to certain extent and [ET] induced low growth of coconut seedlings under water deficit was compensated by [ECO_2].

Abstract

S5P-02

Climate change on coconut: Thrusts and prospects

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Coconut is almost exclusively grown as rainfed crop. Climate change is associated with rise in temperature, CO_2 concentration, uncertainities in precipitation, intensifying drought and floods around the world. Being in rise in temperature of Earth in current year, variation in temperature and rainfall pattern affect the production through functional LAI, dry matter production, photosynthetic rate, pistillate flower production, pollination etc. The amount of impact of climate change on coconut is challenging. The coconut productivity on tri-decaded basis was high during 1951-80 when compared with 1981-09 in most coconut growing states of India. The percentage of decline was 1.6%. Increase in temperature, acidity index, number of severe summer drought, decline in rainfall and moisture index were the major factors for a marginal decline are stagnation in coconut productivity over a period of time. There is a threat to coconut productivity in the ensuring decades due to climate change. Coconut being a C3 crop, is likely to benefit due to increase in CO_2 concentration. The carbon sequestration potential in coconut plantation vary ith season, age of the plantatation, variety and management. The potential role of coconut plantation in mitigating climate change is not adequately addressed by researchers. Intensive genetic and agronomic adaption to climate change substantially benefit the coconut production in India. Improved management can provide higher productivity in areas projected to have positive impact of climate change, while intensive management can reduce the negative impact in parts of Tamil Nadu, parts of Maharashtra, Andhra Pradesh, West Bengal, Orissa, Gujarat. In view to the above, there is a urgent need for proactive measures as a part of climate change adaption to sustain coconut productivity in India.

Abstract

S5P-03

Screening of coconut varieties for tolerance to high temperature stress using pollen germination test

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Temperature is the major factor that limits the growth and production of coconut in the humid tropics. Due to the current accelerated climate change, temperatures are expected to rise at the rate of 0.2°C per decade. Coconut pollen, since they have to stay viable under field conditions from anthesis to pollination, are more vulnerable to the effects of high temperature. The present study evaluates the impact of high temperature stress on coconut through in vitropollen germination technique and attempts to screen the selected genotypes for tolerance to high temperature stress. Pollen samples collected from palms belonging to 11 genotypes were allowed to germinate on an in vitro germination medium containing 8% sucrose and 0.01% boric acid at the temperatures 20°C, 25°C, 30°C, 35°C and 40°C for a duration of two hours. Percentage pollen germination and pollen tube length were assessed after this period. The tall variety WCT had highest percentage germination at all temperatures, followed by the hybrid COD x WCT. Generally for all genotypes, germination decreased drastically at 40°C. On an average, COD had much higher germination than the rest of the dwarf varieties studied, while MYD had the lowest germination of all the genotypes. Mean pollen tube length also showed a significantly low value (41.55µm) at 40°C. Highest mean pollen tube length was recorded for the hybrid COD x WCT (408.9µm). All talls and hybrids showed significantly higher pollen tube lengths compared to dwarfs. Optimum temperatures for pollen germination and pollen tube length for all genotypes were calculated.Tall variety LMT (29.31°C), hybrid MYD x WCT (29.02°C) and dwarf MYD (29.11) had high optimum temperature for germination. The mean optimum temperature for pollen germination was 2°C greater than that for pollen tube length. WCT among talls and COD among dwarfs were found to be tolerant to high temperature stress.

SESSION 6

VALUE ADDITION AND PRODUCT DIVERSIFICATION

Abstract S6L-01

Research and Development for Value added products from coconut - Present status and Future prospects

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In this presentation, the R&D that has been carried out at CFTRI with latest developments are presented. The major endeavor is to introduce and adopt technologies in coconut processing sector to provide technical impetus for transformation of traditional coconut dependent rural economy into a vibrant commercially viable economy. Another objective is development of technologies/process for consumer based products from by-products in coconut processing in order to increase the consumption of coconut. Further, the process is on exploitation of by-products in coconut processing for production of value-added, shelf-stable, convenient products. From coconut refinery, several value added products, byproducts, co-products can be obtained (as shown in figure 1) improving the economical viability.

Realizing the importance of the integrated processing and value addition to the by-products and co-products for the economical viable coconut processing industry, the Coconut Development Board, Kochi has provided financial support to continue the efforts in this direction to develop coconut based diversified products. The highlights of the R&D work in this regard are presented here in a nutshell. A process for the production of tender coconut beverage (Coconut lassi) and mature coconut-water concentrate (Coconut honey) has been developed. A process for the production of coconut spread based on mature coconut-water concentrate and coconut dietary fiber has been developed and the same also being jointly patented. The method of preparation of coconut soufflé by involving two different methods such as baking or refrigeration has been studied in order to standardize these methods. Efforts are made to develop the dry mixes. Differential partitioning studies of coconut whey proteins using aqueous two-phase extraction have been conducted. Ultrafiltration in combination with spray drying was employed as a method of preparation of coconut whey protein powder. Formulations are prepared for coconut chutney powder.

Abstract

S6L-02

Dietary coconut oil and cardiovascular health

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Relationship of statured fat and cardiovascular diseases has been focus of discussion many years. There is consistent and strong evidences from randomized clinical trials that reduction of saturated fats in diet translate into reduction of cardiovascular events.

Coconut oil is considered as a source of saturated fat and has been recommended to reduce its intake in order to reduce the cardiovascular diseases.

The literature in this highly controversial topic of impact of coconut oil on cardiovascular health is limited. The observational studies as well as interventional studies are not supportive for a conclusion because of their inherent limitation such as low sample size, short period of consumption, biased samples and the confounding nature.

Scientific view differs in opinion regarding the inclusion of fatty acids present in the coconut oil into median chain or long chain saturated fats. lauric acid the main content in coconut oil can be classified as either medium chain or long chain but few of the scientist believe that biochemically it behaves like long chain fatty acid as 75% of lauric acid is absorbed with chylomicrons.

The clinical studies conducted with coconut oil in past mainly looked into intermediate outcomes like the lipid profile after a short intervention for weeks to months.

Previous works showed that there were no difference in lipid profile (serum total cholesterol, triacylglycerols, and cholesterol in lipoprotein fractions) between persons taking coconut oil or sunflower oil.Higher intake of coconut oil did not cause any significant increase in the concentration of lauric acid in blood among coconut oil consumers. Moreover, serum lipid values did not show significant variation between animals (New Zealand white rabbits) fed coconut oil or sunflower oil. Coconut oil intake did not cause hypercholesterolemia or oxidative

stress in rabbits. In another study, the fatty acid content of the coronary plaque (endartectomy specimen) did not show any difference between coconut oil consumers versus sunflower oil consumers. Since these studies were done in free living subjects many confounding factors like eating outside, quantity of oil, duration of consumption and physical activity were could not be assessed correctly. Another large study involving 200 coronary artery disease patients on medical treatment with 2 yrs long follow up did not reveled any significant difference in anthropometry, lipid profile, vasomotor function, antioxidant levels and cardiac events at the end of 2 yrs.

The main limitation of the studies involving human are 1) the lack of control over other nutrients which affect the serum lipids positively or negatively 2) non dietary factors like physical activity, life styles and the genomic factors are likely to Influence the outcomes 3) most of the physician driven small clinical studied included specialized patient population like coronary artery diseases or patient with diabetes mellitus 4) few of the data in humans using medium chain triglyceride are controversial as the commercially available MCT is different as it contain very small amount of lauric acid which is the main content in coconut oil hence it is difficult to extrapolate these results with coconut oil studies 5) small duration intervention with either coconut oil or virgin coconut oil is insufficient to test the hard outcomes of cardiovascular system as it requires a long time for the metabolites to produce a favourable or unfavourable effect 6) VCO is not tested in long term human clinical trials or observational studies7) most importantly the clinical hard end points death, myocardial infarction, stroke were not considered as end point in these studies.

To have clarity on coconut oil's effect (as dietary) on cardiovascular outcome we need a) long term longitudinal follow up study of a cohort or families without cardiovascular diseases or other comorbidities b) Globally accepted clinical as well as biochemical out comes should be monitored periodically c) can compare with one of other commonly used oil d) different ethnic population should be included in the study to assess genomic and epingenomic influences.

Such a study will definitely help the medical, scientific, heart-health, governmental and intergovernmental, and professional authorities to formulate the dietary recommendations

None of the clinical trials in the past assessed the exact occurrence of cardiac events in community living normal individuals while consuming coconut oil as

their oil sources for food. Also the ethnic variation in the outcome while using coconut oil is yet to be studied To address the above issues a large, randomized population based study to assess the exact occurrences of cardiac events as well as to measure the intermediate outcome like lipid profile is highly warranted.

Abstract S6O-01

Production of fibrillated coconut fibre reinforced epoxy composites

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Nowadays reinforced polymer composite are used in numerous industrial applications. However environmental challenges, toxicity and biodegradability issues associated with fibres of petroleum origin and mineral fibers lead the researchers to focus on exploring the natural fibres as fillers in polymer composites. The advantages of natural lignocellulosic fibres over traditional reinforcing materials such as carbon fibres, glass fibres, talc and mica, are high specific strength properties, low cost, low density, non-abrasive, good thermal stability, enhanced energy recovery and bio-degradability. Coconut fibre is an important lignocellulosic fibre obtained from coconut fruit, and available abundantly in tropical countries like India and Sri lanka. Though the coconut fibres are being evaluated as fillers in polymer composites, its low tensile strength, Young's modulus and very high extensibility made it in-compatible with many of the polymer matrices. To improve its performance in polymer composites, the present research focused on fibrillation of coconut fibres by mechanical means and evaluated as reinforcement in epoxy composite. The fibrillated fibres were characterized using X-ray diffraction (XRD), scanning electron microscopy (SEM), Differential Scanning Colorimetry (DSC) and Fourier Transform Infrared Spectroscopy (FTIR). The raw coconut fibre reinforced and fibrillated fibre reinforced epoxy composites were prepared and analyzed for mechanical properties. The tensile and impact strengths of fibrillated fibre reinforced epoxy composites increased by 53% and 22%, respectively.

Abstract

S6O-02

Optimization and evaluation of ready to eat extruded snack from virgin coconut oil cake

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The effect of extrusion variables was evaluated on the physical properties and sensory attributes of extrudates prepared using virgin coconut oil (VCO) cake, maize grits and broken rice. Experiments were designed using Box and Behnken method with independent variables such as level of VCO cake (20-30%), feed moisture (14-18 % wb) and screw speed (300-350 rpm). Responses such as expansion ratio (ER), bulk density (BD), pasting viscosity (PV), browning index (BI), hardness (H), water absorption index (WAI), water solubility index (WSI), and overall sensory acceptability (OAA) were analyzed to obtain optimized extrusion parameters. All the models were found to be statistically significant ($R2 > 0.85$). Results indicated that, increasing VCO cake level significantly ($p \leq 0.05$) reduced the ER, PV, WSI and WAI and increased the bulk density and hardness of the extrudates. However, OAA increased with increase in the level of VCO cake. The maximum sensory score obtained was 8.55 with addition of 25% VCO cake and lowest score was obtained for extrudates with least concentration (20%). The optimized conditions obtained for the extrudates were 28.7 % VCO cake, 14 % feed moisture, and 300 rpm screw speed with maximum desirability of 0.88. Protein, fat and carbohydrate content in the optimized samples were 11.14%, 5.07 % and 74.19% respectively.

Abstract

S6O-03

Studies on the production of virgin coconut oil (VCO) from coconut/ball copra

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The process for the production of Virgin coconut oil is entirely different than commercial coconut oil. Many methods were present for the production of VCO. Depending on the raw material (coconut and copra) used for the production of VCO it was grouped in to two; wet and dry methods. In dry methods, VCO was extracted from ball copra by using three mechanical equipments (Hydraulic Press, Rotary/ Power Ghani, Table Expeller). In wet methods, VCO was produced by Low Temperature Method (LTM) (<50 °C), Centrifugation Method (CM), Chilling and Centrifugation (C&C) method, Natural Fermentation Method (NFM) (uncontrolled), Induced Fermentation Method (IFM) uncontrolled and controlled conditions. Induced fermentation method was carried out with six probiotic species of Lactobacillus collected from NDRI (National Dairy Research Institute, Karnal). The study was carried out in the computer controlled bioreactor for different parameters like temperature, pH, inoculums concentration, fermentation end time, oxygen requirements and optimized for all six species of organisms to obtain higher yields. All VCO samples produced from wet and dry methods were analyzed to determine physico-chemical and microbial quality and compared with the APCC (Asian Pacific Coconut Community) standards. Studies were carried out to determine the quality control parameters of partially deoiled cake and deoiled meal were obtained during the production of VCO by dry and wet methods respectively and compared with standards.

Abstract

S6O-04

Innovations in the utilisation of coconut fractions in dairy foods with special reference to coconut milk

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Coconut is a crucial ingredient in many of the traditional cuisines of South East Asian countries. Among the coconut fractions, coconut milk is used as a major or essential ingredient in the preparation of a wide variety of dishes. Scientists and physicians have attributed several nutritional and medicinal properties for coconut. Efforts have been taken to develop new dairy products using a combination of skim (cow's) milk and coconut milk. Coconut water and milk extracted from coconut gratings also used in the preparation of dairy foods.

In 1994, Asian and pacific coconut community proposed certain definitions for different aqueous coconut products. The term coconut water should refer exclusively to the natural aqueous liquid endosperm of the drupe of *cocos nucifera*, while the term 'coconut cream' should refer to the aqueous products, essentially free from fibre extracted from solid coconut endosperm but which optionally may include some coconut water. Coconut cream contains 18.5% coconut fat and maximum 77.6% water and it should have a minimum of 25% total solids. On other hand coconut milk have 11.5, 86.1 and 15.0 percentage of fat, water and total solids respectively. The Malaysian Food Regulations differentiate between coconut milk and coconut cream as follows: coconut milk shall contain not less than 30% fat and 3% protein and not more than 35% water while the cream, recovered through separation of the coconut milk emulsion by standing or centrifugation shall contain not less than 50% fat and 5% protein derived from coconut.

Abstract

S6O-05

Coconut value addition and product diversification

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Itegrated coconut processing for maximum value addition, impact on value addition due to size of the factory, latest technological developments available to produce good quality coconut products without the change in natural taste. Process flowchart for high value products like coconut water concentrate, coconut milk, wet process virgin coconut oil and dry process virgin coconut oil etc., comparssion study with existing similar competiting products like soya and almond . Study on various products produce with coconut milk . Growth through health and wellness. Growth drajectory on coconut milk. Carbon foot print comparison . Environmental comparrison. Coconut water and its new market . Coconut water concentrate (cwc) and its applications. key players in different markets . Coconut water with consistence growth.

Abstract

S6O-06

Construction of fishing canoes with coconut wood - a techno economic analysis

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Wood from the coconut palm (*Cocos nucifera*) is a by-product from the senile coconut trees. Coconut wood is hard, durable, strong and versatile and is widely used for various purposes in most of the coconut growing island countries around the world. In the context of the increasing scarcity of conventional wood species in our country as a boat building material, the coconut wood can be used as a suitable substitute especially for the traditional fisheries sector. The hydrophilic nature and susceptibility to bio deterioration are the major drawbacks of this wood. However studies revealthat preservative treatment can increase the service life of wood in marine environments. This communication deals with the chemical preservative treatment of coconut wood with Copper-Chrome- Boron (CCB), a water-borne preservative, through vacuum pressure impregnation method and its successful utilisation in the construction of fishing craft. The physical and mechanical properties of the wood and the resistance of treated wood to bio deterioration were studied. The fabrication of fishing canoes was done following the localmethod of construction of plank built canoes. Two canoes were constructed of dimensions respectively 9 m LOA and 9.75 m LOA for operation of gill nets, seine nets and hook and lines. The cost of construction was found to be 20 -30% lesser than that of the canoes built with conventionally used wood species like wild jack (Artocarpushirsutus). Performance monitoring carried out showed that the canoes were free from physical damage and deterioration caused due to weathering and biological agents.

Abstract

S6P-01

Coconut shell pyrolytic oil as Wood preservative - A value added product from coconut (*Cocos nucifera* L)

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Coconut trees (*Cocos nucifera* L.) are grown in India and many South Asian countries and coconut shells are available in large quantities. Current research work focuses on developing a marketable botanical wood preservative formulation from coconut shell pyrolytic oil. The efficacy of coconut shell pyrolytic oil in protecting wood against termites, wood decay fungi and wood borers were assessed as per BIS standards. The results indicate that coconut shell pyrolytic oil imparts significant protection against the wood deteriorating agents both in laboratory and field conditions and has considerable wood preservative properties. Since coconut shell pyrolytic is a dark viscous liquid, it can be recommended only for outdoor applications. To improve the aesthetic value and efficacy of coconut shell pyrolytic oil, it was modified by various methods. Of all the formulations developed, coconut shell pyrolytic oil distillate (CSPOD), which is a more or less colour less liquid, was found promising in terms of efficiency and aesthetic value. Identification of the active components of the CSPOD was done using GC-MS. Efficacy of CSPOD was further improved by introducing metals namely, Zinc, Copper and Boron. Copper incorporated CSPOD, (CSPOD-Cu) was found to offer better wood protective effects compared to other metals. To avoid leaching of metals from the treated wood and its adverse effects on environment, the CSPOD-Cu treated wood was further coated by linseed oil. As coconut shell pyrolytic oil is a waste by-product of coconut shell charcoal industry, its utilization as a wood preservative will expand the reach of such industries by increasing their operations and income sources. Commercialization of the wood preservative formulation will depend on the cost of commercialization, market requirement, treated wood disposal and challenges in the registration policy.

Abstract

S6P-02

Effect of feed composition and processing parameters on physical properties of coconut milk residue-corn-rice based ready to eat extrudates

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Physical properties of extrudates are useful for process design and production of high nutritive value foods with desirable quality. The effect of feed composition [10-20% coconut milk residue (CMR) and 20 - 30% corn flour)], screw speed (200 - 300 rpm) and extrusion temperature (100 - 140 °C) on important physical properties such as expansion ratio, bulk density, piece density, true density and porosity were investigated. Increased CMR level decreased the expansion ratio significantly ($P<0.001$). Highest expansion (3.58) was found at highest extrusion temperature (140 °C) and lowest screw speed (200 rpm). Bulk density of extrudates varied from 0.06 to 0.12 g cm^{-3} and it was positively correlated with CMR level ($P<0.001$), however it decreased with increase of screw speed and extrusion temperature. Increase in coconut milk residue resulted in increased piece and true density, and decreased porosity of the extrudates, whereas screw speed caused the opposite trend. Based on the given criteria for optimization in mixture process design, the basic formulation for production of CMR-based extruded snack with desired quality was obtained by incorporating 15% CMR, 25% corn flour and 60% rice flour.

Abstract S6P-03

Effect of osmotic solution and soaking time on quality characteristics of coconut chips

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Investigations were carried out to optimize the soaking time of coconut slices in two osmotic solutions (cane sugar and neera based) in order to get the optimum reduction of moisture content and enhance the nutrition level of coconut chips. The coconut slices were immersed in two types of osmotic solution for 15, 30, 45 and 60 minutes. Sugar and Neera based coconut chips were made following CPCRI technology for the production of coconut chips. The TSS, moisture loss and solid gain of coconut slices were measured at 15, 30, 45 and 60 minutes during osmotic dehydration. Then, osmotic dehydrated coconut slices were dried in tray dryer at 60 °C for 6 hours. The final moisture content and hardness was also determined for all the treatments. The sensory evaluation based on nine point hedonic scale was conducted for both sugar and neera based chips. Then, the biochemical parameters such as available carbohydrate, proteins, fat content, ash content, phenolics content and antioxidant activity were determined for all the treatment samples. Among all the treatments, 15 minutes soaked cane sugar and neera based coconut slices exhibited more moisture loss, less solid gain, less hardness and insignificant change in TSS. Similarly, 15 minutes soaked neera based coconut chips had more ash, carbohydrate, protein, phenolics, antioxidant activity and less fat than other treatments. But, 15 minutes soaked cane sugar based coconut chips contained less ash, carbohydrate, protein, phenolics and more fat and antioxidant activity than 60 minutes soaked coconut slices. Based on the sensory evaluation, neera based chips scored more than cane sugar based chips in terms of crispiness, flavor, taste and overall acceptability whereas color and appearance of cane sugar based chips scored more than neera based coconut chips. Hence, coconut inflorescence sap or neera is a potential osmotic solution for enhanced nutritional level of coconut chips.

Abstract

S6P-04

Studies on shelf life extension and quality evaluation of fresh coconut grating

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The aim of present work is preservation of fresh coconut grating. The effect of different storage temperatures (2.5, -13.5 and -20 °C) and salt concentrations (0, 0.5, 1 and 2% w/w) on physico-chemical, microbial, sensory, and structural characteristics of coconut grating were analysed. Coconut grating samples were stored for a period of one month and withdrawn at selected intervals of one week for analysis. The density and color (lightness) of coconut grating samples was observed to decrease at all storage conditions over storage period. There was no any significant difference in moisture content and water activity of coconut grating during storage. The variation in pH of coconut grating revealed significant difference at different temperatures over the storage period. The total plate count and yeast and moldcount of coconut grating were analysed. The salt treated coconut grating showed lower values of total plate count as compared to control (without salt), Yeast and mould count of salt treated coconut grating significantly reduced at -13.5 °C and -20 °C. Coconut grating with 2% salt, indicated the least increase in microbial count (2.69 to 4.20 log cfu/ml) at -13.5 °C storage temperature.The scanning electron microscopic images of coconut grating showed retention of microstructure intact during storage. The sensory analysis of coconut grating after one month storage at -13.5 °C and -20 °C, showed higher overall acceptability score of 7.0 and 6.9, than that at 2.5°C (5.5). Coconut grating stored for a period of one month at -13.5 °C and -20 °C was used for the preparation of an end product, namely, coconut chutney, which was found to be acceptable. There were no any significant difference in aroma pattern (Electronic Nose)between coconut grating samples stored at different conditions.

Abstract S6P-05

Value added processed products from coconut

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In beauty and utility no other tree can surpass the coconut tree. It is the most extensively grown nut in the world, the most important palm.There are more than 50 unprocessed, semi processed or processed coconut products entering the international markets in small and big quantities. Aside from copra and coconut oil, other nutritionally important processed products likenutties, coconut roll, tender coconut pudding and tender coconut jam were prepared and standardized their nutritional value.The primary fatty acid of coconut oil is lauric acid, which is present at approximately 45–53%. The metabolic and physiological properties of lauric acid account for many of the properties of coconut.There is an urgent need for intense research and commercialization of the technology so as to provide an additional source of income and to improve the economic status of the farmers and the country.

Abstract

S6P-06

Biochemical changes in coconut haustorium during different developmental stages

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Coconut (*Cocos nucifera* L.) is essentially a seed propagated crop, contains two distinct endosperms (nut water and kernel). The nutrients present in both endosperms are utilized during the germination and further growth. Haustorium, a spongy tissue formed form the basal part of embryo during germination, mobilizes the nutrients from nut water and endosperm and nourishes the growing embryo. The objectives of the study was to determine the biochemical changes in the haustorium at different maturation stages. Fully matured coconut cultivar West Coast Tall was used in the study. The nuts were kept for germination in poly bag and the haustorium was collected at different intervals from 20 to 120 days after germination (DAG), and analyzed for various biochemical parameters *viz*. total sugar, reducing sugar, starch, soluble protein, fat, dietary fibre, phenolics and antioxidant potential. The fresh weight of the haustorium increased from 63.8 g to 138 g during the developmental period 20 DAG to 120 DAG. Among the biochemical parameters studied, soluble sugar was found to accumulate more (2.18-5.28 g) in the haustorium followed by starch (0.76-2.16 g) and protein (0.25-0.67 g). At 20 DAG the percentage of reducing sugar was about 54.3 % which increased to 85 % at 120 DAG. This indicated that the carbohydrates in endosperm were hydrolyzed to simple sugars like glucose and fructose which was then utilized by the growing shoots and roots. Phenolic content and antioxidant potential were also increased from 20 DAG to 120 DAG. But no significant differences were observed for the parameters studied per unit weight. There was a gradual reduction in kernel and complete disappearance of liquid endosperm was noticed. The results indicated that the nutrients present in the both liquid and solid endosperm was gradually hydrolyzed and absorbed by the haustorium, and an equilibrium maintained between the absorption of nutrients from endosperms by the haustorium and assimilation of nutrients by the growing shoots and roots.

Abstract S6P-07

Protein rich powder from coconut skim milk by spray drying

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During the production of virgin coconut oil (VCO) one of the by-products, namely, coconut skim milk containing 2-3% protein, is underutilized at present. Alternate process was developed to obtain value-added products, namely, Concentrate Coconut Skim Milk powder (CCSM) and Coconut Skim Milk powder (CSM). When coconut milk emulsion was subjected to centrifugation, three phases, namely, fat phase (coconut cream), aqueous phase (coconut skim milk), and solid phase (insoluble protein) were obtained. The coconut skim milk was subjected to ultrafiltration (UF) to concentrate the protein while removing the sugars and then to spray drying. The process parameters of UF were standardised with respect to transmembrane flux, protein retention efficiency and removal of sugars. The stirred cell and tangential filtration system equipped with UF membrane having 300 kDa MCO was used and CSM was concentrated to 1/5th of initial volume. The protein content was found to increase in CCSM (from 21 to 46%) and sugar content to reduce (from 59 to 34%). The lightness (L*) of CSM and CCSM powders was found to be 83.81±0.33 and 80.70±0.47, a* to be −0.74±0.01 and 0.54±0.89, and b* value was 12.68±0.93 and 15.21±0.63, respectively. Polyphenol content of CSM and CCSM powder was found to be 2.56 and 1.84 mg/g GAE, respectively, while no significant difference was observed in phytate content (~2.1mg/g). Powders were found to be microbiologically safe as per water activity index for CCSM (0.27) and CSM (0.26). Carr index values of CCSM (32.95) and CSM (33.14) powders indicated fair flow properties. CCSM protein powder with high protein content can be used as a multifunctional dietary food supplement. Further, the powders have high potential usage as new source of vegetable protein or as an ingredient in the food processing.

Abstract

S6P-08

Optimization of pasteurization temperature to improve the shelf life of 'Kalparasa' (Coconut inflorescence sap)

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Kalparasa, the natural sweet sap of immature inflorescence of coconut palm, deteriorates under room temperature within an hour or more. In the present study freshly collected sap using ICAR-CPCRI developed coco sap chiller was subjected to pasteurization at different temperatures *viz.* 60, 70, 80 and 90 °C for 5 minutes. The pasteurized samples were placed in both room temperature (30±2 °C) and refrigeration temperature (5 °C) for a period of 4 and 10 days respectively and the observations were recorded at 24 hrs and 48 hrs interval respectively. pH of the fresh sample was 7.0 and it declined to 4.0 in room temperature and 4.4 in refrigeration temperature within a day. On the other hand in pasteurized sample placed under room temperature changed gradually, while under refrigeration condition did not change. Even sap heated at 60 °C for 5 min did not alter the pH and biochemical properties of the sample,suggesting that 60 °C temperature is optimum to improve the shelf life of sap to be kept in the refrigerator. However, to be kept under ambient condition for a day or two then pasteurizing at 80-90 °C is found to be better.

Performance evaluation of semi-automatic coconut de-husking machine for West Coast Tall variety of coconut

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Coconut de-husking is the first postharvest operation in coconut processing industry, but it is regarded as the most time consuming, cumbersome and difficult operation to perform and involves much human drudgery. De-husking with traditional hand tools like sickle or a spike depends on the skill of worker and involves training. Nowadays, there is a shortage of such skilled workers. Keeping this in mind, a semi-automatic coconut de-husking machine was developed at ICAR-CPCRI, Kasaragod and evaluated for different sizes of WCT (West Coast Tall) variety coconut. There are two de-husking units in this machine i.e. primary de-husking and secondary de-husking unit and are used for primary de-husking and tail fibre removing respectively. For primary de-husking, there are two rollers with pins on their surface and rotates at 35 rpm each. A leather conveyer belt is provided to hold and convey the coconuts of different sizes, but minimum space is fixed for easy feeding of coconuts. For tail fibre removing, two blade type rollers rotating at 28 rpm and one helical type roller rotating at 56 rpm is provided. Developed de-husker was tested for three sizes of WCT coconut variety based on their circumference i.e Large (50-55 cm), medium (45-50 cm) and small (40-45cm). De-husking capacity of large, medium and small size coconuts were observed as 193 nuts/h, 155 nuts/h and 94 nuts/h with de-husking efficiency of 98%, 97% and 35% respectively. There was significant difference in de-husking capacity of all three sizes of nuts. In case of de-husking efficiency, large and medium size nut exhibited insignificant difference but small size revealed significantly lower efficiency.

Abstract

S6P-10

Coconut sap 'Neera' and its value added milk based Bengali sweets – Prospect and possibilities in West Bengal

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Coconut is a crop of small and marginal farmers which plays an important role in the national economy. But coconut farming is gradually becoming non-profitable due to frequent fluctuation in price, severity of pests and diseases, higher input cost, land fragmentation etc. To make it profitable, neera and neera based milk sweets, coconut sugar are the latest value additions which holds the potential to revitalize the prospects of coconut sector. Neera is the sweet, brown or honey colored unfermented sap, which is a rich source of sugars, minerals and vitamins and delicious in taste. Recently, on a pilot scale neera collection has been started in W.B. with the technical support of CPCRI and BCKV. An inflorescence on an average produces 2.25 liter sap/day. By selling neera a farmer could earn at least 10 times more income than selling the nuts. Further, fresh neera based value added products like Bengal sweets *viz.* Neera Sandesh, Neera Peda, Neera Kanchagolla, Neera Kalakand, Neera Rabri etc were prepared and marketed in W.B. These sweets are rich in vitamins, minerals and amino acids and healthy as compared to sugar based sweets. As per an estimate in W.B. even if 1% of the total plants (non-productive) are tapped for Neera would generate return around Rs. 6175.2 lakh, besides employment generation of 3431 numbers /day. Thus, large scale tapping of neera and its processing into value added products would generate good daily return to the coconut farmer, the tappers and sweet makers which will ultimately contribute to the GDP of the state.

Abstract S6P-11

Phenolics, flavonoids and antioxidant potential of different solvent extracts of coconut (*Cocos nucifera* L.) haustorium

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Coconut (*Cocos nucifera* L.) haustorium is a rich source of phenolics and have considerable amount of antioxidant potential. Since the phenolics and flavonoids are exist in complex forms in the haustorium, routinely used solvent system may not able to extract all the compounds. In the present study we used seven solvent systems (water, 100% & 80% methanol, ethanol and acetone) with and without acidification with 0.3M HCl. Four different methods viz. CUPRAC, FRAP, DPPH and ABTS were used to determine the antioxidant activity (AOA). Significant differences were observed for the parameters studied using different solvent systems. Acidification of solvents significantly increased the yield of phenolic content from the haustorium. Among the solvent systems used, 100% acetone extracted less amount of phenolics (0.98 mg GAE/g) and 100% acetone acidified with 0.3M HCl extracted maximum amount of phenolics (10.16 mg GAE/g). Aqueous forms of the solvents used yielded more phenolics compared to their pure form. This indicated that methanol, ethanol and acetone it their pure form are not an appropriate solvent system for phenolics extraction. In case of flavonoids, solvents acidified with 0.3M HCl extracted lesser amount of flavonoids compared to their aqueous form followed by their pure form. Acidification caused significant increase in AOA measured by CUPRAC, FRAP and DPPH, but significantly reduced AOA measured by ABTS except 100% acetone. The AOA measured by CUPRAC method ranged from 13.61 μM TE/g (100% acetone) to 76.42 μM TE/g (acidified 100% acetone. The AOA measured by FRAP method ranged from 3.38 μM TE/g (100% acetone) to 52.83 μM TE/g (acidified 100% acetone. Similar trend was observed for DPPH method also.

SESSION 7

AGRIBUSINESS AND ENTREPRENEURSHIP

Abstract

S7L-01

Strategic solutions for making the coconut industry globally competitive

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Coconut, *Cocos nucifera* L., known as Tree of Life, Tree of Heaven, Nature's Super Market and Kalpavriksha , grown in 12.196 million ha in more than 93 countries with a production of 69 836 million nuts or 11.818 million tons of copra equivalents as on 2014 is a great source of lively hood and social security to millions in the coconut growing regions, besides providing nutritional , health and wellness as well as environmental security. Low level of productivity due to various reasons, not changing the mind set from the traditional concept of coconut-copra to coconut oil , very limited value addition , product diversification and by product utilisation, still not able to come out of the myth that coconut oil and coconut products are not good for health , inadequate market promotional activities , inability to meet the demand on a continuous basis etc. are some of the problems pulling down the competitiveness of coconut.

Always the price of coconut depends on coconut oil and the farmers could not get fair price for coconut. Coconut tree as a whole provide ample opportunities to produce large number of value added products. Coconut products like coconut oil, virgin coconut oil, coconut milk, milk powder , desiccated coconut, defatted desiccated coconut powder, coconut dietary fibre, coconut jaggary/sugar and jaggary powder, coconut water based drinks, vinegar, activated charcoal, coir and coir based products, geo textiles, coconut husk chips and coconut coir pith , coco wood based furniture and handicrafts are having good market potential. Coco oleo chemicals and coco bio diesel, bio lubricants in some of the Asian and Pacific countries are gaining importance. The price for value added products are much more than coconut oil at any point of time. .However , many countries are still going on slow space on value addition and export except probably Philippines.

A change in the contest of coconut industry is a must and that change can be

brought out with short, medium and long term strategies. Change should start from increasing the productivity and production , value addition, byproduct utilisation, capitalizing the emerging new application of value addition, market promotional activities, consumer preferable packaging ,brand name and labelling and making available at competitive prices. To ensure both economic and ecological access to food and nutritional security, high profitability, reduced production cost at farm level and to take full advantage of globalization and trade liberalization through advanced preparedness for the WTO regime. Strategic planning and implementation for free flow of proven technologies which have not reached the farmers, strong Public - Private - Farmers' partnership approach with needed technical back stopping, strong market promotional and marketing network , bilateral ,regional and international collaborations with strong political will and commitment from government side and determination of farmers for increasing productivity and thereby production as well as farm level processing are essential to make the coconut industry competitive.

Global Coconut Trade

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It is a prestigious moment for all coconut farmers and stakeholders around the globe during this Centennary Year of Coconut Research. Hearty congratulations to the Government of India, the Central Plantation Crops Research Institute and to the Coconut Farmers of India for the excellent and eventful commemoration of the establishment of this prestigious institution.

It is wise as coconut stakeholders to focus on our strengths, the positive trends and sustainable outcomes as we collectively share our visions, mission and goals for the development of the coconut sector going forward. When we unite in our efforts, the burden of our challenges becomes manageable and our objectives and outputs are achievable in real time. The global market demand has increased so dramatically for coconut and its products in the recent years that it is time for the sector to accelerate production to meet the demand.

The coconut sector is maturing in many ways nationally and internationally through the APCC network. The Sector recognises and therefore is making genuine efforts in addressing the key challenges that include:

Many countries look towards examples set by leading producers like India and Philippines to learn and improve their position on managing the negative environmental and biological impacts on coconuts caused by pests, diseases and adverse climate change effect to name some. Farmers however continue their best efforts of planting coconuts utilising local material available as reesearchers continue to seek more elite planting material to give farmers.

The positive market outlook continues for all products of coconut:

- Coconut oil prices are at USD 1446/MT which is over 26% higher than prices during December 2015;
- Dessicated Coconut market maintaining its position with large producing countries in the Philippines, Sri Lanka and Indonesia realsing a price of USD 2000-2400/MT;

- Virgin Coconut Oil market surging up with prices in the range of USD 4000-6000/MT. Increasing awareness among consumers on health benefits of VCO is expected to increase the demand;
- Coconut water emerging as the fastest growing beverage with over 20% annual increase in production in the recent years;
- Coconut sap based products consolidating and developing the market position; and
- By-products like coconut shell charcoal, activated carbon and coir fibre products experiencing growing market demand.

The challenge facing suppliers of both the traditional and non-traditional products of coconut is not being able to meet the volumes required now by the global market. This is caused by inadequate and inconsistent supply of raw material from coconut growers of which smallholders are attributed with 80%-90% of coconut production.

Only in the last 10 years the private sector and industry has seen growth in six digits numbers in monetary value by the coconut and coconut products as new scientific knowledge and improved technology is applied in both the process and type of machinery and equipment developed for greater efficiency and effectiveness in meeting quality standards of the various products for the global market.

In recent months coconut water craze has entered large populous markets such as in China and recently in Japan apart from the large Western markets in USA, Brazil, Canada, Europe and through to New zeland and Australia. Virgin Coconut Oil consumption has risen sharply in the last 5 years globally with more awareness on the health benefits of the products as indicated by positive market trends for VCO. These non-traditional products of coconut are the new impact lines the coconut world will veiw as the improved products emerge on the gobal scene. The greater benefit would be seen at farm level as many processing centres are placed as close as possible to the points of origin where increasing efforts would be made to maximise the economic benefits to the growers of coconut.

Over the last decade it is clearly evident the coconut sector in India has developed quite rapidly beginning with the growth of institutional capacity in important organisations such as Central Plantation Crops Research Institute, Coconut Development Board and the Coir Board of India. The mobilisation of

growers at farm level and through marketing cooperatives is also an important ingredient for sustainable development as the absorption of new knowledge and technology by growers and producers is maximised in an organised and structured setting. New innovative programs involving youth and women improves implementation of the many programs instituted for the development of coconut.

The important message to our coconut farmers is to continue to replace old senile coconut palms, plant new coconut lands and improve viability of farms through improved farming practices including intercropping with economic crops as well as production of small livestock. Development of micropropagation techniques to meet the demand for quality planting materials is the need of the hour. Life under a coconut tree needs to become an increasingly exciting, healthy and profitable life. This life needs to attract our young generation to easily chose to go back to the farms not only as a viable business proposition but a better way of life. The future for coconut is promising, progressive and positive.

When we plant a coconut it is one step towards sustaining the livelihood for the next generation of our people as the Minister for Agriculture from the small Pacific island nation of Kiribati once quiped with reference to the Chinese proverb that "if you give a man a coconut, you feed him for a day but if you teach a man to plant coconut, you feed him for a lifetime."

Abstract

S7L-03

Nurturing innovations and entrepreneurship development through Business Incubation approach

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Agribusiness takes place in a complex environment with many defining characteristics that involves farmers, crop yield dynamics, government policies and market implications.With the increasing importance of market context in Indian agriculture, enhancing business skills of agri-preneurs assume greater significance. The development of a competitive and sustainable agribusiness community needs an effective innovation and entrepreneurship ecosystem, which fosters the growth of agribusiness ventures.This needs different stakeholders in the agricultural sector to work in collaboration to provide services such as adequate infrastructure, access to finance and resources such as technologies, along with supportive policies and regulations to make the ecosystem more responsive. For such an ecosystem to thrive, a platform must exist to enable linkages between research and business that can translate into actionable initiatives that nurture innovations and develop entrepreneurship. Hence Incubation approach is the need of the hour. Involvement of agribusiness incubators in an entrepreneurial ecosystem shall strengthen areas of weakness and can lead to major impacts in agriculture. Agribusiness incubators can take the form of comprehensiveoccupational schools, offering rural producers andworkers sufficient knowledge, experience, infrastructure, andmeans to become agribusiness entrepreneurs. This can have far-reaching effects, promoting theoverall modernization of primary production, industrialization,and marketing and development of rural areas.

Agribusiness and Innovation Platform (AIP) is an initiative of ICRISAT to act as one such platform for fostering agro-business to bring Research for Development (R4D) innovations of ICRISAT and its partners to the market for faster, wider-scale impact. AIP provides prototype innovations, knowledge and expertise, training

and co-location with researchers for close interaction; while the entrepreneurs fine-tune the prototypes and take them to market, bearing the risks and reaping the rewards.

AIP includes three programs; Agri-Business Incubation (ABI), Innovation and Partnership (INP) and NutriPlus Knowledge (NPK). With a strong contextual understanding of the Agribusiness domain, AIP offers high level of customized business incubation support that includes R&D, business planning, business development and access to capital. It's a pioneering initiative in India that maximizes the success quotient of start-up enterprises by offering them best opportunities with minimum risk.

Over the past years, the program has successfully developed an ecosystem that nurtures entrepreneurship in the sector by technology transfer as well as supporting innovations from the grassroots level, using an array of business support services. With more than 160 ventures supported and which has benefited more than five lakh farmers, this initiative from ICRISAT has indeed shown that market-oriented development can have better results for the benefit of all the stakeholders of the sector.

Abstract

S7L-04

Coconut based ventures for rural uplift

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Coconut had a very important role in the rural economy of Kerala. But economical returns from the crop declined drastically over the past two decades. Role of value added and product diversification is a topic of discussion in all forums concerned with revival of the coconut sector. Despite the efforts of extension and developmental agencies, progress in this regard is not up to the desired levels. The major limiting factor for the expansion of coconut based enterprises is their marketing. Unilateral export orientation of coconut entrepreneurs without giving adequate attention to the vibrant domestic market is a worrisome factor. For instance, as of now, a meager 3 per cent of the domestic population consumes coconut. From this scenario, even an increase of one percent in the consumer base will require an additional supply of 127 lakhs nuts. Further, if this sort of a demand is created, better price for coconut farmers can be ensured. It should be kept in mind that, the above mentioned demand creation is not possible through promotion of conventional coconut products like coconut oil. Reorienting the value addition according to the need of the potential consumers is the plausible option in this context. The surging market demand, as realized by the Kerala Dinesh for the novel products like coconut milk, coconut cream and quality desiccated coconut are to be explored and further expanded. To conclude, coconut farming community is sitting on treasure and searching it around.

Abstract S7O-01

Intellectual property management, commercialization and incubation

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Conventional extension interventions were observed to be inadequate to enhance the level of adoption of coconut production and protection technologies required to make an impact on productivity in a region as reported in several studies. As an alternative, at ICAR-CPCRI, the participatory approach of technology transfer was experimented in seven extension projects since 1999. These projects were having one or more of the following aspects as the objectives: (i) enhancing level of adoption of technologies; (ii) augmenting income of farmers; (iii) increasing level of participation of farm women in coconut farming; (iv) utilization of natural resources for sustainable production; and (v) evolving appropriate extension delivery mechanism. The operational area of these projects varied from 20 to 2100 ha and number of farm families from 106 to 7068. The primary objective of achieving increased level of technology adoption was achieved in all these projects; almost three times more when compared with conventional extension approaches. The percentage difference between pre- and post-project yield of coconut was nearly 100%. The first study of this kind was the National Agricultural Technology Project on Participatory Technology Transfer (PTT) of integrated root (wilt) management technologies (1999-2003). Its major outcome was the paradigm shift in extension delivery mechanism for perennial crops. The need of augmenting farm income through value addition and participation of women farmers in scientific management of coconut were felt and addressed in subsequent projects. It was convincingly proved that Inclusiveness of all family members and market linking would have catalyzing effect on technology adoption. Improved level of farmer-scientist interaction, exposure to farmers on research findings and methodology, appreciation of farmers on activities of the Institute etc. are some of the intangible benefits. Some of the problems encountered while implementing technological interventions are non-availability of skilled workers, lack of awareness and experience of farmers on certain technologies/ critical components, and inefficiency of farmers in monitoring the interventions. There are also issues related with assessment of impact of these programmes, as it will take three to four years since implementation to measure the effect on coconut yield.

Abstract

S7O-02

Context and challenges of coconut FPCs in Kerala

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During the last four decades, Kerala witnessed several structural changes in society and economy. Construction and service industry reduced the role of agriculture. The steep increase in wages, fertilizers and fuel resulted in huge increase in agriculture production cost. The state lost one third of coconut palms and half of its productivity during this period. The crops that once made the region the richest now resulted in the opposite, farmers are the poorest in the contemporary society. This had wide implications for the society, economy and environment especially because the state is existing on a highly fragile eco system.

The task at hand is increasing and stabilizing the income of coconut farmer. But there is no short cut to it. Coconut value addition by private and government sectors are yet to make a significant impact on the prices. The one and only one remedy is the large scale value addition facilities at the ownership of farmers.

But severe socio - economic constraints exists on this. Historically the farmers in Kerala were never organised as farmers. It is remarkable that the present initiative of Coconut Producer Societies as building blocks overcame these obstacles and coalesced in to a fledgling group. There are thousands of CPSs, 500+federations, 29 Coconut FPCs as on today. The had enrolled 55% of coconut famers of the state, raised a capital of Rs 40 crore from the members and initiated value addition facilities worth about Rs 105 crores. There are 22 major value addition centres under them which are processing millions of (effective) nuts per day in to about 18 value added products. This resulted in an unprecedented wave of vibrant and dynamic farmer centred entrepreneurship. t is true that lot of gaps exist – lack of technocrats, technology, marketing organisations, professionals, capital, etc. There are huge delays related to industrial permits and approvals, sanctioning and disbursing of capital subsidies, taking critical decisions on procurement etc. But still the present initiative has a potential to put back Kerala in to its rightful place – a model of economically and environmentally sustainable society based on equity and justice.

Abstract S7P-01

Agri Business Incubation Centre of ICAR-CIRCOT: An Opportunity for sustainable entrepreneurship

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Agribusiness Incubation (ABI) Centres are fast gaining importance due to changing paradigm of global economy, decreasing agricultural yield, dearth of employment opportunities and increased emphasis on entrepreneurship and skill development by Indian Government. These centres promote entrepreneurship by providing technological knowledge; capacity building and incubation facility to facilitate success establishment of competitive agribusiness enterprises. The Indian Council of Agricultural Research (ICAR), New Delhi hosts 27 ABI Centres across different institutes in diverse areas as agricultural engineering, horticulture, fisheries, forestry, and dairy technology. The ICAR-CIRCOT has decades of experience in the field of technology innovation, incubation and entrepreneurship development and has nurtured and promoted entrepreneurs in fields of ginning & pressing and cotton processing technologies leading to successful establishment of their own enterprise resulting in saving of foreign currency by manufacturing products which are import substitutes. The institute was awarded 'Best performing NAIP-BPD Unit Award for Technology Commercialization' at Agri-tech Investors Meet 2013, New Delhi in field of entrepreneurship development and incubation. An Agri Business Incubation (ABI) Centre was sanctioned at the institute by ICAR, New Delhi in 2015 on competitive basis. The ICAR-CIRCOT-ABI Centre facilitates incubation of new enterprises for innovative technologies by providing physical, technical and networking support, facilities and services to test and validate the venture before their successful establishment. Presently this ABI centre is promoting entrepreneurs in fields of antimicrobial textile finishing, degossypolised cottonseed meal for poultry feed, cotton rubber composite batons for police force, various application of nanocellulose in paper and composites.

Abstract S7P-02

Farmer's perception and awareness in establishing a feasible farmer producer organization – A case study of Meenakshipuram Farmers Producer Company Limited

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Indian agriculture over the last decade is facing lot of problems and it has been declining and all those stakeholders associated with agriculture is to look this as a serious concern . 40 per cent of the farmers wish to leave agriculture (Murray, 2009) which was reported by National Sample Survey Organization (NSSO). Lack of better price, low productivity, access to credit, input, market and below-par adoption behaviour are the major challenges faced by the farmers in the current scenario. The price spread among the intermediaries in the structure of agricultural market limits the farm gate price realized by the primary producers to the lowest possible in the supply chain. It indicates that the Indian agriculture is at imminent crisis and only radical and innovative policies will help to pull the country out of this situation. There is always a discussion in Indian agriculture is that how to integrate the farmers, especially the small farmers; with the value chain so that the net return at the farmers end is remunerative enough for the farmers to remain interested in agriculture. The only way is Farmer Producer Company which integrates the finance, technology, infrastructure, marketing and management and work for the rural betterment which will contribute towards the alleviation of rural poverty. The present study focus on the perception of farmers about establishing successful FPO, to study the attitude of farmers in working in a group, to predict the awareness about Farmers Producer Organisation, to study the benefits obtained by the farmers on establishing an FPO, to study the problems faced by farmers regarding an establishment of an FPO.

Abstract

S7P-03

Production of coconut hybrid seedlings at Umapathy Farms, India

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The Coconut Hybrid Centre of Umapathy farms was started in 2004 with the production of Ramganga hybrid seedlings, which is a hybrid between Gangaibondam Green Dwarf and West Coast Tall (GBGD X WCT). The breeding program is 100% software-monitored and the nursery is one of the most advanced coconut nurseries in India. Controlled pollination is practiced on selected mother palms. The seedlings are in polybags with pencil drip irrigation so as to ensure that each seedling is given equal opportunity to grow. This helps in rejection of the seedlings which do not satisfy the prescribed quality standards. Polybag planting is advantageous since it helps in better monitoring of growth of seedlings, makes it easy for farmers to plant and makes it less stressful for the seedlings during planting. Seedling selection is made at the stage of 8 months after sowing. Umapathy farms is the first coconut nursery in India to use bar code for seedlings. The bar code is an extension of the software. Through scanning of bar code it is possible to trace back the seedling to its mother palm, pollen tree, pollinator, inspector, harvest date etc. This has significantly improved the quality and transparency of the coconut breeding program.

The key features of Gangaibondam Green Dwarf like high yield, high brix level, high copra, comparatively low growth and dense leaf and the key features of West Coast Tall like high yield, increased quantity of coconut water, high copra and round nuts could be effectively combined in the hybrid. It has an optimal nut size which results in high yield. There is less buckling noticed in comparison to other varieties. The high brix and high copra content is advantageous and the palm has a low height per year ratio.

SESSION 8

RESEARCH - EXTENSION INTERFACE AND POLICY ISSUES

Abstract S8L-01

Yield gap analysis of coconut production in India

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India, like other developing countries, is undergoing a demographic and economic transformation that stands to change the quantity and types of food demanded. With an annual population growth rate of about 2.8 % and an urbanization rate of 52 % in 2010, coconut production is likely to face numerous challenges, including competition for land with other uses, an increase in the total amount of coconut demanded and changes in dietary preferences. Coconut production in India is still largely in the hands of small-holder farmers who make up about 70 % of the farming population. Cultivation practices continue to be characterized by the use of old generation tools, small farm size, low capital input, high labour inputs, limited management of coconut pests and diseases, and low yields. The challenges of producing coconut under such constrained conditions are mounting. One has to question the ability of small-holder farmers to cope with the evermore complex, multi-level, socio-economic factors that have implications on coconut production at the farm scale. The challenge of coping with this dynamically changing socio-economic context is further compounded by global environmental changes that affect crop yields and production. Key among them are the impacts of climate change and soil resources degradation which negatively affect the attainment of food security, reduction of poverty, and meeting developmental challenges in the developing world. The country's potential for increasing coconut crop yields and coconut production to ensure the sustainability of coconut sector is examined here.

Based on the situation analysis in India, it could be inferred that crop management and policies are likely to be the primary reasons for the large yield gaps. A key challenge to be addressed in bridging the yield gaps is that of

replenishing and properly managing the available resources. The problems and needs of the farmers are to be identified through purposeful interactions with them and results of such studies should form the basis for conducting research and developing technologies aimed at reducing the research gap and achieving sustainability in crop production concurrently enhancing the economic status of the farmer and overall improvement of national GDP.

Growth of agriculture both in terms of GDP and livelihood security with social equity has been ever challenging and more so in the present context of inadequate public sector investment and services and pressure of globalization of agriculture leading to a greater demand for highly knowledge-intensive services. Investments in agriculture need to be rationalized and appropriate knowledge driven institutional reforms have to be brought in. Appropriate framework for technology development and dissemination would be very much needed for transforming agriculture in the developing countries from the present approach of its sustenance as a way of life to a vibrant economic activity with a sense of pride for future generations. We must begin the process of imparting dynamism and optimism in the farm sector. Accelerated agricultural progress based on the enhancement of productivity, sustainability and profitability through farming systems diversification, sustainable intensification, quality upgradation and value addition, is vital not only for food security and poverty eradication, but also for national sovereignty. The prospects of coconut farmers in sustainable agriculture oriented towards market economy will then be bright.

Abstract

S8L-02

International trade and India's coconut economy: An outlook on the R & D efforts

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Coconut is grown in more than 90 countries in the world with an area of 19.99 million ha and a production of 69836.36 million nuts. Indonesia, Philippines, India and Sri Lanka account for 80 per cent of the global acreage and production of coconut. The competitiveness of the industry in the international market depends upon three major things-the first, being the inherent ability to produce the coconut. Coconut grows well in coastal areas where soil and agro climatic conditions are much better suited. The second factor, which contributes significantly to enhance the bargaining power in the market, is the ability to develop comparative advantage by adopting better methods of production or to come up with better varieties and so on. Then we can actually enhance the comparative advantage which is basically the quickness with which we can streamline the systems such as post harvest system so that we are able to deliver the product to the consumer effectively and efficiently. The Research & Development efforts made since 1976 placed the country the major supplier of coconut in the world. India ranks first among all the coconut producing countries followed by Indonesia and Philippines. The crop is currently grown in an area of 1.97 million ha which is spread over in 18 States and 3 Union Territories having varied agro-climate. Growing of coconut along the coastal region protects the coastal eco system and provide micro climate for the successful growing of other crops as intercrops. The dependence on the coconut sector is high in southern states *viz*. Kerala, Tamil Nadu, Karnataka and Andhra Pradesh. These four states accounts for 88% of the area and 90% of coconut production in the country. The rest is shared by the states of Orissa, West Bengal, Maharashtra, Assam, Gujarat and Andaman and Nicobar Islands, etc. The crop significantly contributes to the agricultural economy of these states. The third factor that helps the industry to grow faster is its presence in the international markets. An analysis has also been made to know the performance of India's foreign exchange earnings through the trade in coconut based products particularly

during the post liberalization period. Coconut contribute considerably to India's economy by way of export earnings, improving the income of the rural people, ensuring livelihood and nutritional security and creating forward and backward linkages in developments. The crops alone contributes to 6% of the vegetable oil pool of the country, earns foreign exchange to the tune of rupees 3352 corers per annum (2015-16) out of which 56.73% by the export of coir and coir productions and 43% from coconut products and contribute considerably to National GDP.

Abstract

S8L-03

Research Extension Interface in the Coconut Sector in Sri Lanka: The Role of Coconut Research Institute

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Research is a systematic investigation to establish facts and reach new conclusions in order to fill the gaps in knowledge. This new knowledge must be transferred to the enduser through effective communication links. In the sphere of coconut in Sri Lanka, this sector comes under the purview of the Ministry of Plantation Industries. The Ministry directs and supervises the activities of Coconut Research Institute (CRI), Coconut Cultivation Board (CCB) and Coconut Development Authority (CDA). The mandate of the CRI is to generate new knowledge and develop technologies related to cultivation, farming systems and processing in coconut and transfers them to stakeholders. The main stakeholder of the CRI is the CCB since it is the mandated organization for extension and advisory services of the sector. This is unique compared to the other sectors where research and extension are carried out by one organization. The extension activities of the CCB are carried out by an island-wide network through its regional stations. The CDA on the other hand, is responsible on policy formulation and the coordination of different agencies in the sector. A diagnostic survey carried out by the CRI revealed a considerable gap in knowledge on scientific cultivation of coconut amongst growers. Considering the present challenges, the extension activities of the CRI have been strengthened to maintain effective linkages and to develop strategies to promote technology transfer and adoption. In technology transfer activities the CRI is conducting collaborative activities with the CCB to update the technical knowledge and skills of Community Development Officers (CDOO) and farmers and ensure effective feedback. These activities involve, awareness and educational programmes, research and extension dialogues, training of trainees in different organizations operating at the village level, series of one-day educational programmes with field demonstrations, field days, seminars, workshops and crop clinics, farmer field schools, advisory and consultancy services for stakeholders, improvement of knowledge and understanding of

school children and teachers. The CRI also issues detailed advisory circulars, various other research and advisory publications, flash cards, leaflets, posters, stickers, banners and display boards. Mass media and electronic toolshave beenless extensively used in the past in coconut sector. Therefore recently TV advertisements and spots were started. Production of video documentaries and making them available for the growers in the form of CDs and the production of Interactive Multimedia CDs is also done. As recent initiatives, the CRI uses mobile phone alerts to disseminate important and timely information to the stakeholders. To further improve the overall performance of the coconut sector, it is important to maintain an effective linkage among the sub sectors in coconut growing areas. This interaction facilitates sustainable technology generation, development and transfer. Coconut growers, processors, millers, dealers, brokers and exporters play major roles as sub sectors in the coconut sector. Strengthening the linkage mainly among research, extension and grower activities could be identified as the major focus of the technology transfer plan for the future.

Abstract S8L-04

FPOs facilitated by Coconut Development Board

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Farmer Producer Organization is formed with the main objective of socio economic development of farmers through productivity improvement, cost reduction, efficient aggregation, processing for value addition, better by-product utilization and efficient marketing of the produce. It aims at providing a fair, steady and reasonable income to farmers by organizing the unorganized coconut sector through farmer collectives. The Coconut Farmers Producer Organizations thus formed have a three tier structure consisting of Coconut Producers Society (CPS), Coconut Producers Federation (CPF) and Coconut Producers Company (CPC).

CPS is formed by associating 40-100 coconut growers in a contiguous area with range of 4000-6000 yielding palms. Farmers with a minimum of 10 palms are only eligible to be a part of this society. Once the society is formed, it is registered under charitable societies act and also with Coconut Development Board. All the societies have a common bye - law. CPF is formed by combining 8-10 CPS. A CPF would have around 1, 00,000 palms under it. CPF is also registered as a charitable society and further registered with CDB. 8-10 CPFs would join together to form a CPC. A CPC would consist of around 10, 00,000 yielding palms. The Producer Company is wholly and fully owned by the farmers.

Coconut Producer Company is one of the most important points under CDB's vision of 12th five year plan. CDB has taken up the task of facilitating formation and hand holding of FPOs during

its initial stages. There are various fronts in which CDB is currently supporting FPOs. Being a zero wastage product, the product basket from coconut is enormous. Some of the value added products from coconut are Desiccated Coconut (DC), Virgin Coconut oil, , Coconut chips, Coconut milk, coconut milk powder, Coconut Vinegar, Coconut oil, Tender Coconut water, Coconut wood

products, Ball copra, Husk and Coir products, Coconut ice cream, Coconut body lotion and so on. Another unique product named 'Neera' is a sweet, oyster white coloured juice obtained from the unopened inflorescence of coconut palm. Neera is a rich source of sugars, minerals and vitamins which makes it an excellent health drink.

Technology Mission on Coconut (TMOC) supports FPOs for establishment of coconut processing unit, market promotion, brand building, product processing and diversification. CDB Institute of Technology (CIT), CDB's in-house research centre is set up for providing technical support, consultancy and efficient technologies for integrated coconut processing. Capacity building is also done by conducting leadership and other trainings for directors of the companies. Various schemes of CDB such as Laying out of demonstration plots, Replanting and Rejuvenation schemes etc are being implemented through CPCs. For production of Quality planting materials CPCs are encouraged to establish own nurseries. This would invoke among the farmers a sense of ownership and thus give way to better productivity and quality.CDB has proposed formation of Consortium of Producer Companies to take over the abovementioned role played by CDB and to establish itself as an independent entity which addresses the common needs of Producer Companies and act as a powerful force to build a more favorable business climate.

Going forward, CDB plans to form 100 Producer Companies, 1000 CPFs and 20,000 CPS' in the country. The purpose behind the same is that at least 10% of total production and value addition happening in coconut sector should be through Producer Companies. Only in such a situation would the actual bargaining power reside in hands of farmers. Besides, this would also encourage new entrepreneurs to establish business in this sector as the issue of aggregation and organized availability of raw materials would be addressed through FPOs.

Abstract S8O-01

Frontline extension programmes for sustainable growth in coconut sector

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Indian agricultural sector in general and plantation crop sector in particular has realized significant growth during the past four decades. Coconut is the major small holder's plantation crop widely cultivated in the peninsular India has also exhibited higher growth rate during the same period. In order to sustain this, maintain higher rate of technology adoption at the farmer field level is crucial.

Technologies evolved in laboratory and or experimental fields, often under controlled conditions are influenced by various biotic, abiotic and socio-economic factors prevailing in a district. In order to assess their performance in farmers field conditions under the influence of these factors, Krishi Vigyan Kendras carry out frontline extension programmes like technology assessment, frontline demonstrations, capacity development, extension activities and production and supply of technology products etc. The successful technologies evolved based on these processes in which farmers act as partners, they are up-scaled in convergence mode through Development Departments for achieving growth in coconut sector. This paper highlights few of those processes carried out by Krishi Vigyan Kendras in India for achieving sustainable growth in coconut sector at district level. District level implementation of frontline extension programmes implemented in coconut followed by the dissemination of successful technologies through innovative technology delivery mechanisms has improved the profitability and livelihood security of small holding coconut farmers and farm women.

Abstract

S8O-02

SWOT Analysis of Indian coconut sector with respect to production sphere and trade competitiveness

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There are umpteen reasons for the right kind of preparedness in the international spectrum of coconut and value added products of coconut. It is pertinent to note that the failure to respond to changing patterns in the world trade in coconut products can have adverse effects on employment and revenue in the Indian coconut sector. Competitiveness analysis of coconut and coconut products to export destinations revealed that competitive advantage of India is lower than major coconut exporting countries like Philippines, Indonesia and Sri Lanka. Moreover the analysis of demand-supply scenario using stock-use ratio revealed that there is a declining demand for coconut oil from 2012-13 onwards and the wedge between demand and supply has been narrowed down. This has, of late reflected in realization of low prices for the commodity. It was observed that there is huge price wedge between domestic and international prices. As the prices will tend to integrate there is a possible price crash in the near future. Indian coconut sector has huge domestic demand, comparatively higher productivity, strong R & D support, and technology delivery systems. In spite of these positive aspects, concerted efforts are lacking to effectively utilize the possible linkage between them for increasing the production and marketing efficiencies and enter the high value global chains. Sustainable coconut economy could only be achieved through integrated development of cultivation and industry coupled with a stable market. We have found that, as far as the export markets of coconut value added products are concerned, India is comparatively a very small player with paltry export market shares. Having said that, in recent times due to the fast pace in urban life, there is considerable growth in the Indian confectionery industry (25 percent/ year). It is an indubitable fact that products like Desiccated Coconut and neera are high potential breakthrough products, which can bring in a paradigm shift in domestic coconut sector of India. Hence, there is tremendous potential in the domestic market as well wherein a meticulous plan to tap this potential would benefit the Coconut industry in a big way.

Abstract

S8O-03

Stakeholder analysis of action oriented participatory research program on mite management in coconut

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Participatory Research Appraisals (PRA) was conducted at BagharparaUpazila in Jessore in October 2011 to understand farmers' perception about mite attack in coconut. The area has been known for coconut farming where men, women and children have been involved in coconut production and processing. The participants of FPRA identified coconut as the leading species among the 22 fruit species in the homesteads of the surveyed area. They were not aware about mite attack in coconut and could not perceive the reason of cracks on nut surface. Farmers used different chemicals, fertilizer and exorcisms which were not related to mite control. As a result of continuous yield loss of coconut, many farmers cut down coconut palms and shifted farming to other fruitsor field crops. The FPRA matrixes revealed that coconut contributed around 32% of the total homestead income which reduced to 4% due to mite attack. Estimated yield loss was 80-90%. Stakeholder analysis and literature review on mite guided the research team to develop a coconut mite management program which was implemented in the community from May 2011 to June 2014. Farmers were directly involved in implementing the intervention. The study area comprised of around 1000 hectares involving six adjacent villages which represented an ecosystem. Miticide, Neem-oil, Neem-cake, Tricho-compost, Tricho-leachate each alone or their combinations were used as treatments. After the intervention, the farmers were able to understand the actual cause of coconut damage which was inflicted by coconut mite.

Abstract

S8O-04

Evolving sectoral innovation system of 'Neera': The apprehensions, potential and strategies

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This paper addresses the present operating-environment of 'neera' production in the state of Kerala. Though government of Kerala has come out with a pro-farmer policy frame for the production and promotion of neera, still it is partially under the control of excise department. This clearly indicates the policy blurredness at the institutional helm. In a span of three years, a total of 220 licenses have been granted for neera production. Barring few public sector agencies, the licensees are mostly the Coconut Producer Federations (CPFs) of Coconut Producer Societies (CPSs). Only 57 CFFs are continuing the neera production though 94 CFSs initiated the production activities, which point towards the already experienced commodity problamatique in the sector. The farmer share in the value chain in 17% of the consumer price and neera-tapper's share is 20%. Issues concerned with neera production at policy level include ceiling for the number of coconut palms to be tapped/day, the selling controls on the product, the registration formalities etc. In the production front, scarcity of skilled tappers and lack of adequate infrastructure for processing are the major problems. Marketing of neera also poses challenges as consumer perception and buyer segment studies are completely lacking and profit analysis are based only on projections without any structured marketing studies. Further to compete with other similar product, it has to be appropriately positioned for its nutritional edge. Since it is an evolving product, lack of product uniformity may hamper the market penetration. Howver, the unexplored markets and preparedness to meet the demand are the opportunities. Above all, from April 2017 onwards ASEAN products may flood the Indian market because of the phasing out of customs import duty as per the trade agreement, and the real competition will be set in then onwards.

Abstract

S8O-05

Farmer participatory action research experiences in coconut-homesteads

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Conventional extension interventions were observed to be inadequate to enhance the level of adoption of coconut production and protection technologies required to make an impact on productivity in a region as reported in several studies. As an alternative, at ICAR-CPCRI, the participatory approach of technology transfer was experimented in seven extension projects since 1999. These projects were having one or more of the following aspects as the objectives: (i) enhancing level of adoption of technologies; (ii) augmenting income of farmers; (iii) increasing level of participation of farm women in coconut farming; (iv) utilization of natural resources for sustainable production; and (v) evolving appropriate extension delivery mechanism. The operational area of these projects varied from 20 to 2100 ha and number of farm families from 106 to 7068. The primary objective of achieving increased level of technology adoption was achieved in all these projects; almost three times more when compared with conventional extension approaches. The percentage difference between pre- and post-project yield of coconut was nearly 100%. The first study of this kind was the National Agricultural Technology Project on Participatory Technology Transfer (PTT) of integrated root (wilt) management technologies (1999-2003). Its major outcome was the paradigm shift in extension delivery mechanism for perennial crops. The need of augmenting farm income through value addition and participation of women farmers in scientific management of coconut were felt and addressed in subsequent projects. It was convincingly proved that Inclusiveness of all family members and market linking would have catalyzing effect on technology adoption. Improved level of farmer-scientist interaction, exposure to farmers on research findings and methodology, appreciation of farmers on activities of the Institute etc. are some of the intangible benefits. Some of the problems encountered while implementing technological interventions are non-availability of skilled workers, lack of awareness and experience of farmers on certain technologies/ critical components, and inefficiency of farmers in monitoring the interventions. There are also issues related with assessment of impact of these programmes, as it will take three to four years since implementation to measure the effect on coconut yield.

Abstract

S8P-01

Impact of training programmes on bee keeping

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A total of 11 vocational training programmes were conducted at KVK, Kasaragod for the last three years (2012 to 2015) with the participation 254 trainees out of which 37 were ladies. An apiary was established at KVK to serve as resource unit for practical demonstrations during the on campus training programmes. The present study among 60 sample trainees with pre and post evaluation tests and questionnaires as tools was conducted to assess the impact of these training programmes. More than 20% increase in crop yield has been observed by 11.67% or entrepreneurs whereas 43.33% and 35% of them have noticed an increased crop production ranging from 11-20% and 5-10% respectively. Around 11.67% entrepreneurs could harvest more than 100 kg of honey. The other ranges were more than 50kg (53.33%), 10-50kg (31.67%) and less than 10 kg (3.33%). It was a great achievement that 1.67% of the ex trainees could earn more than Rs. 150000 additional income annually through sale of honey and divided colonies. Around 5% could earn in a range of Rs. 50000 to 100000. Others also could make a commendable additional income of Rs. 15001 to 50000 (38.33%), Rs. 3000 to 15000 (48.33%) and upto Rs. 3000 (11.67%) respectively. The results of the study show that there has been significant impact among the respondent trainees in terms of knowledge gain, skill, self confidence and overall income via bee keeping enterprise. There was increase in the production of cultivated crops, especially coconut, cashew and vegetables through enhanced pollination. In fact, bee keeping can be seen as a social commitment for generation after generation in the point of view of sustainable yields from plant species and enhanced agricultural production.

Abstract S8P-02

Impact analysis of capacity building programme on coconut: The case of SMSs of KVKs in south India

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Technological innovations and diffusion of new technologies are the key drivers to enhance the profitability of coconut farming. Field level integration of improved technologies at the grass root level should be strengthened through institutions like KVKs. In this context, for enhancing and updating the knowledge levels of Subject Matter Specialists (SMSs) of KVKs, ICAR–CPCRI in collaboration with ATARI, Bengaluru organized training on improved technologies of coconut for SMSs from different states during February, 2016. Impact analysis was done on gain in knowledge, level of satisfaction of trainees, usefulness of the topics covered and overall grading of the training. Data were collected using structured interview schedule before and after the programme. Data was tabulated and analyzed using SPSS software ver. 19. Majority (67.6 %) of the trainees belonged to middle age category, sixty five per cent were male respondents, about 60 per cent were having doctorate, fifty per cent were having specialization in horticulture, fifty three per cent trainees were from Kerala and fifteen per cent trainees attended the training on coconut. Paired't' test conducted for testing the statistical significance of difference in scores in pre and post evaluation revealed that training had significant impact on enhancing the knowledge level of the respondents in all subjects of coconut technologies. Average gain in knowledge was estimated to be 18.36 per cent. There was a difference in knowledge levels in pre evaluation and in knowledge gain among age groups wherein, youngsters were having high knowledge gain. Similarly, knowledge gain was higher among respondents who had undergone training earlier. Majority (79 %) of the respondents were highly satisfied with the course contents and training delivery methods. Sixty one per cent of the respondents graded training course as excellent. After the training, about 38 per cent of KVKs initiated OFTs and FLDs on coconut technologies for better technology integration. Impact analysis indicates that, it is highly effective to conduct such type of capacity building programmes for enhancing the competency level of SMSs of KVKs.

Abstract

S8P-03

Persuasion of farmers about IPM strategy in rhinoceros beetle management

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Application of chemical pesticides for the control of Rhinoceros beetle, *Oryctes rhinoceros* (L) in coconut is an expensive method and cause environmental pollution. A survey was conducted during 2015, among the farmers in Peravurpanchayat of Kannur dist and KallarpanchayatKasargod district of Kerala statefor the intensity of rhinoceros beetle attack.The observations from this area were that, farmer's practice of leaf axil filling of common salt @ 2kg/palm was ineffective and finally they were trying heavy doses of chemicals for the management. The coconut basins where the decaying organic matter present were the main breeding places of this beetle. Persuasion of the farmers to follow an Integrated Pest Management Approach in these panchayats werefollowed. First step was giving awareness about the symptoms of beetle attack, life cycle of beetle and finally the ill effects of high doses of pesticides in coconut. Later IPM strategy wasrecommended which included sanitation of leaf axils, coconut basins, leaf axil filling with naphthalene balls + sand and incorporation of ClerodendroninfortunatumLin.@10% w/w basis in manure pits and application of Metarhiziumanisopliae@ 5 x 1011 spores / m3in manure pits and coconut basins and other breeding sites in wet conditions. Observations after three weeks of treatment showed 100% mycosis of grubsand after 6 months, showed a reduction of pest attack from 88% to 24%. Therefore IPM strategy for the management of this pestis quite easy and economical, compared to insecticides. The farmers were immensely benefited by this IPM approach, as the rate of damage was significantly reduced.Therefore persuasion of the farmers about the IPM strategy for the control of rhinoceros beetle attack was a successful mission in these pachayats.

Abstract

S8P-04

Prediction of coconut yield in Goa state of India

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Goa is a small state in Konkan coast of western India where coconut occupies 25,750 hectare of land area. Coconut is described by 51 Konkani words and used as major ingredient of traditional cuisines of Goa along with toddy from inflorescence and handicrafts from shells. Objectives of the study are to predict annual nut yield by the weather data of past 10 years and to perform a sample statistics survey to forecast the yield in 2015-16. Annual nut yield data of North Goa during 2002 to 2015 from Directorate of Economics and Statistics figures was used after filling the gaps with missing values. Step wise multiple regression was attempted with weather data. Significant regression (P=0.003) of annual nut yield Yield = 5739.14 + 0.68*(weighted Tmax* RHmin) was found with maximum temperature and minimum relative humidity recorded one year before harvest with R2 value of 0.66. A state wide production sample survey supported by Coconut development Board Cochin was carried out during Oct-Dec 2015. About 102 village panchayats each represented by one random farm with minimum 40 coconut palms were surveyed. In each holding basic data of the farm was collected. All the buttons and nuts were counted in ten randomly chosen bearing palms in each farm and the data of last harvest was enquired from the farmers. Annual nut yield of Goa state (2015-16) was forecasted as 69 nuts/palm from the survey. The average coconut farm size was 0.59 ha. Most coconut gardens (64%) were small in size (0.2 to 0.4 ha). Only one-fourth of coconut farmers practised inter/mixed cropping. Farmers plant coconut either in homesteads or in Kulaghar systems along with jack fruit, banana, arecanut and many perennial crops. Our results have implications in forecasting the yield by sample survey and predicting the future coconut yield by weather data.

Abstract

S8P-05

'e Kalpa'-Cloud based interactive mobile Application for coconut farmers and stakeholders

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Knowledge and information are also considered as among basic factors of agricultural production. One of the big challenges of present era is to understand and harvest data, information and knowledge equitable, to promote knowledge based decision in farming. Reaching out to farmers requires linkages, networking, localising content, adapting to resource situations, skill level of intended customers and higher level of commitment from research and extension partners. E kalpa - a digital initiative - is a mobile based app in Android, demand driven, real time customised facilitation, multimode communication, for farming community, students, farmers' groups/ communities, researchers, extension agencies and NGOs. This integrated App encompass five major services namely 'farmer's issue reporting and support system', 'Synchronised farming', digital online 'farmer diary'' Knowledge base' and 'Notifications'. Farmers issue reporting and support service could be utilised for reporting field problems on real time basis in the form of audio/text/image or video directly to scientists. The multi disciplinary team of scientists would be able to provide advisories within a short period. Online chatting facilities are also available in the application. Synchronised farming application would enable the user to receive information right from the time of planting. It also could cater the needs of individual farmers or community based groups to manage area-wide pest and disease problems. The farmer diary facilitates recording of details of farming for scientific facilitation. Knowledge base encompasses documentation and integration of information. Supportive web facilities also designed to support users and for widening reach out span of users. The analysis of information needs for using ICT tools, trends in pilot testing of the mobile app among coconut farmers and profile of the field problems will be presented in the paper. This App got potential for analytics, archiving of data, mapping GPS enabled individual data for pattern analysis. This could also facilitate impact analysis and contribution of research for enabling returns and progress of farming community.

Abstract

S8P-06

Assimilating agrarian changes in extension strategies for coconut farmers: the promise and prospects from the Kerala experiment in India

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Low productivity and high cost of production is often cited as the major factor behind the low level of economic profits from coconut farming. Though enhanced technology adoption can address the issue, a deeper understanding the socio-economic context of technology dissemination is needed to deploy effective strategies for enhancing technology uptake, reduce cost of production and create a viable business proposition for coconut farming in the state, especially among the small holder producers. This study describes the insights on socio-economic profile of the coconut farming community in the State. Data from 180 coconut farmers across six major agro-ecological coconut production regions in Kerala was collected using pre-tested structured questionnaire. The study presents the rationale and approach of the innovative extension service delivery model initiated in the project area with special emphasis on promoting soil health management practices evolved to address the soil related constraints for enhancing productivity and income from coconut farming in different agro-ecological units. The rising share of non-farm income sources, shifts in demographic pattern affecting availability of family labour and hired labour, inefficiencies in input delivery system, predominance of small holder producers, etc. were found to influence the production effort and consequently, technology adoption. The extension approach adopted involved restructuring of crop management practices and concurrent monitoring to address the low level of management inputs and the constraints arising out of changes in agrarian structure. The study, while highlighting the role of understanding agrarian socio-economic profile in determining the choice of extension strategies, also makes a case for adopting similar approach for streamlining extension service delivery in other plantation crops.

Abstract

S8P-07

Community based bioresource management under coconut based coastal agro-ecosystems: Success from Kanjikuzhy block of Kerala, India

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Effective utilization of biowastes is one of the important tools for sustainable production in sandy soil tracts. Kanjikuzhy block of Kerala is the major organic farming tract in the coastal belt of Kerala having sandy soils characterised by low organic matter content and poor water holding capacity, making farming less profitable. Farmers of eight coconut federations under the block were sensitized and trained through participatory action management mode on crop residue recycling including different composting techniques, production and mass multiplication of bioagents, evaluation of locally available substrates / substrate formulations for multiplication of bioagents, production and use of microbe-enriched organics, production of bioprimed coconut seedlings, soil test based nutrient application – integrated management and organic management, mulching and crop diversification for climate resilience by Central Plantation Crops Research Institute (CPCRI), Regional Station, Kayamkulam under a NABARD funded project on bioresource management. The interventions resulted in 45% improvement in the setting percentage and 26% improvement in the yield of coconut. The average area under intercrops increased by 80% and income from intercrops doubled over the project period. Isolated eight native strains of Trichoderma from Kanjikuzhy Block Panchayat area and Trichoderma isolate KKT-6 showed highest antagonistic activity to leaf rot and stem bleeding pathogens of coconut under in vitro conditions. Field evaluation of the organic manure combinations enriched with Trichoderma harzianum (CPCRITD 28) and native isolate KKT- 6 revealed higher growth rates in case of both CPCRITD 28 and KKT-6 in Coir pith compost + Neem cake (4:1) combination, but on soil application, the highest growth rate was observed in Cowdung + Neem cake (4:1) treatment. However, highest yields were obtained from chilly plants treated with Coir pith compost + Neem cake + Poultry Manure + Cowdung (2:1:1:1), but sustainability in yield was observed for Cowdung + Neem cake (4:1) treatment on enrichment with CPCRITD 28.

Abstract

S8P-09

Economic impact study on technology adoption in coconut farming

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A study was conducted to analyze the economic impact of technology adoption in coconut farming in Kannur and Kasaragod districts of Northern Kerala. Hundred respondents/farmers were covered in the study and the data has been collected with a structured schedule. Mainly the study concentrates on field level adoption of improved coconut varieties/hybrids, coconut based cropping systems, and vermicomposting. It was observed that the adoption of technology is highly individual centric and thereby reflects a scattered pattern of adoption. Though the awareness on beneficial aspects and economic advantages of the technology adoption is well known among the farmers, the proactive adoption and experimentation is quite lacking. It was revealed that majority of the respondents adopts cropping systems in their own convenience and not in tune with the recommended scientific pattern. even though Farmers unequivocally expressed the comparative yield benefits and higher economic returns of the improved coconut varieties vis a vis local varieties, the comparison is mostly based on the few numbers of improved palms scattered in the field with that of senile local palms cultivated in large area, which turns out to be erroneous. With regard to the adoption of organic farming, farmers are quite apprehensive on the low yield in the initial years, high labour costs and rudimentary marketing system. The results of the study indicate the need of further strengthening the participatory research approach for effective utilization of technologies in the field.

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