

PLANTATION CROPS BASED CROPPING AND FARMING SYSTEM OPTIONS FOR ASIA AND SOUTH EAST ASIAN COUNTRIES

K.V.A. Bavappa*

ABSTRACT

Although plantation crops based farming systems in some form or other has been in vogue in different countries, scientific information on the desirability or otherwise of such systems has been meager. Research efforts made during the last two decades have shown that perennial plantation crops offer wide scope for the adoption of cropping and farming systems. Systems designed on sound scientific principles of land, space and solar energy utilization and managed under normal conditions with adequate inputs recorded higher production of both biomass and economic yield. A high and sustainable yield at lower level of nutrient inputs was indicated in coconut based high density multispecies cropping system. The systems had buffering effect against drastic fluctuations in the ecoclimate. There was improvement in root growth, soil fertility and moisture status, microbial activity in the rhizosphere of the component crops and increase in the population of beneficial microorganisms and microbial biomass. The scope for adopting a no tillage farming technology was evident from field observations as well as from the mixed cropping trials laid out in India, Sri Lanka, Malaysia, Thailand, Vietnam and Philippines. It has been observed that cereals, tubers, spices, vegetables, legumes and fruits in varying combinations could be successfully grown in cropping systems in plantation crops. The integrated coconut-grass-cattle system with recycling of cattle waste and production of biogas has high employment potential and income generating capability. In the Mekong delta of Vietnam, a successful high density plant-animal-human ecosystem involving coconut, cocoa, black pepper, banana, fruit trees, pigs, goats, poultry, bee-hives and fish have come to stay. The need to focus the Farming System Research (FSR) in three directions viz., Farming System Analysis (FSA), On Farm System Research (OFSR) and New Farming System Development (NFSD) has been highlighted.

Key words : Cropping/Farming System, Plantation Crops, High Density Multispecies Cropping, Plant-Animal-Human Ecosystem, Pekarangan, System Effect

INTRODUCTION

Cropping and farming systems are dynamic interactive practices aimed at better use of the production components such as soil, water, air space, solar radiation and all other inputs on a sustainable basis. While a cropping system involves only crops, a farming system integrates into it entities like animals, birds and fish. Perennial crops with their large canopy and deep root system can exploit the production components to a much greater extent than

annuals. By and large, these systems have got evolved through innovative efforts of farmers and very successful models have come to stay in different countries. Size of holding, home needs, income spread and stability, easiness of marketing, compatibility of the crops etc. are some of the considerations that have dictated the choice of component crops and animal species of the systems. Plantation crops like tea, coffee, rubber, coconut, cashew, oil palm, arecanut and cocoa offer scope to varying degrees for the adoption of farming and cropping

* FAO Consultant, P.O. Kappur, 679 552, India

systems. The problem which received scientific attention only in the last quarter of the last century is yet to make head way due to the inherent difficulties associated with the experimentation, data generation and interpretation. The available options are presented in the light of the scientific information on hand and future research and development strategies that may prove useful are discussed.

SYSTEM PRINCIPLES

There are a number of factors and principles underlying the evolution of a successful system. They include among other things, the shoot and root architecture of the plant species, their growth pattern, land and air space use potential, shade requirement or shade tolerance of the crops, moisture availability, solar radiation spectrum, climate, social background of the farmers and easiness of access to markets. These interacting factors keep the system in a dynamic state till it reaches a stage of stability.

SYSTEM OPTIONS

The ever-increasing small and marginal farmer settlements, the dwindling of the holding sizes in the plantation crops sector and the observations made in different countries that considerable scope exists for better utilization of soil, air space and solar radiation in different plantation crops during their growth phases attracted the attention of scientists towards FSR in the last quarter of the century. The data generated from field observations and well laid out experiments have opened up new vistas in system research and farm production. Scope for intensive cropping and adoption of cropping systems in plantation crops has been highlighted (Bavappa, 1951, 1975, 1976, 1982, 1985; Nelliat *et al.* 1974; Nair, 1979; Rethinam and Venugopal, 1994).

In the study of the tree crop farming systems of the humid tropics Watson (1980) described rubber, oil palm, coconut and cocoa based systems. Bavappa and Jacob (1981, 1982) and Bavappa *et al.* (1981) developed mixed cropping and crop diversification models suited for home and commercial needs. Nair *et al.* (1975 a, b),

Nair and Bavappa (1975), Jacob Maqthew and Mohamed Shafee, (1979) and Bavappa (1986) reported the coconut based systems under study at CPCRI and Das (1990, 1991) analysed the economics of these systems and discussed their socio-economic implications. Bavappa (1990 a, b, c) presented an up to date research profile on Coconut Based Farming Systems (CBFS), the agronomic desirability of these systems and their management considerations. Among the different CBFSs, cocoa-coconut system of Malaysia (Jamadon and Osman, 1990) and a high density plant-animal-human system of Vietnam (Bavappa 1990 c) and models from Indonesia (Darwis, 1991) have been reported to be highly successful. Reynolds (1995) has discussed the pasture-cattle-coconut systems prevalent world over. Reddy and Biddappa (2000) reviewed the coconut based cropping/farming systems in India. Bavappa and Jacob (1982) and Bavappa *et al.* (1986) made detailed studies of the high density models of Sri Lanka and India. Ray *et al.* (2000) studied the performance of areca based high density systems. Simmonds (1985) reviewed the state of the art of FSR.

Since the component crops and animal species of the systems vary from one plantation crop to the other in different countries in which they are grown, the options are briefly presented crops and system-wise.

TEA

Tea which is by and large grown in higher elevations has rather limited options for cropping on a system basis. In India in the higher elevations (around 2000 m) of Nilgiris, tea is mix cropped with pear on a limited scale. Of late in the high ranges of Munnar (Tata Tea Estates), orange has been introduced in tea but require further observation to establish its compatibility. In Sri Lanka where tea is also under cultivation in lower elevations of even up to sea level, pepper on glyricidia is a proven mixed cropping system of good economic return. Clove, coffee, nutmeg and cinnamon are the other crops cultivated in tea on a system basis. Studies on rooting pattern, moisture and nutrients in tea and clove mixed

Farming systems in plantation crops

cropping (Bavappa, 1982) showed that clove and tea under mixed cropping showed an increase of 19.4% and 12.7% respectively in the total fresh weight of roots. The available phosphorous in the top 30 cm soil was over 600 ppm in the mixed stand of tea and clove as compared to 160 ppm in the monocrop of clove. Compared to the monocrops of tea and clove which had 18% moisture in the first 30 cm soil depth the moisture level was 29% in the mixed stand.

COFFEE

In the coffee industry in India nearly 97 per cent of the growers come under small holder sector. Robusta coffee is becoming less remunerative and farmers are compelled to diversify cropping in such plantations with introduction of crops such as banana, pepper, ginger, turmeric, oranges, sapota, papaya, annona and silk cotton trees. Ramaiah (1990) reported that Arabica coffee planted with pepper gave the highest total income than other combinations. When coffee yields were low in certain years due to seasonal variations and unprecedented drought, the income from other crops such as banana, pepper, orange, etc. covered up the loss.

RUBBER

Multiple cropping in rubber particularly in the first two to three years after planting has been in vogue in many Asian and South East Asian countries. Speirs (1974) reported that in Thailand majority of small holders grow some cash crops in the early years of planting. These included upland rice, banana, water melons, cucumbers, pineapples and mung beans. In Malaysia in the small holder sector pineapples, bananas and soya beans are popularly grown. After rubber canopy has closed over, RRIM has suggested raising of poultry and sheep grazing. In Indoensia upland rice and maize are the more popular crops of the system. In Sri Lanka a wide range of crops (coffee, cocoa, banana, chillie, vegetables, passion fruit, upland rice, soya bean and cowpea) are intercropped with rubber.

COCONUT

Of all the plantation crops coconut is the most widely cultivated in the Asian and South

East Asian region and also mix cropped extensively. The canopy and root architecture of coconut permits introduction of a wide range of crops and animals into coconut based farming systems (Nelliath *et al.* 1974). In India cassava, ginger, turmeric, yams, cowpea, soya bean, banana, pineapple, pepper, cocoa, clove and nutmeg are grown in different combinations and have been found to be economically viable. In Malaysia coconut and cocoa is a well established cropping system, coffee and fruit trees being the other crops. Due to the high pressure on land coconut is intensively mix cropped in Indonesia. The crops include upland rice, maize, cassava, groundnut, beans, ginger, patchouli, chillie, coffee, banana, clove, cinnamon, jack and other fruit trees. In Sri Lanka coconut is mix cropped with pineapple, passion fruit, banana, coffee, cocoa and clove. In Philippines the crops commonly grown are fibre crops like abaca, kenaf and ramie and bevarage and spice crops such as coffee, cocoa and pepper (Aldaba, 1990).

CASHEW

Depending upon the lay of the land and soil conditions pineapple in trenches across the slope, fodder grass, ginger, legumes and vegetables are profitably mix cropped with cashew in early years of the plantation establishment.

ARECANUT

Banana, pineapple, ginger, turmeric, pepper, coffee, cocoa and cardamom (in higher elevations) are grown with arecanut.

OIL PALM

Oil palm is not generally mix cropped. The one promising combination reported from Malaysia is oil palm planted at 10 m x 7 m (143 palms/ha) interplanted with a single row of cocoa at 10 m x 2.5 m (400 trees/ha).

High Density Farming Systems

While cropping systems with varying intensities got evolved and stabilized in different countries efforts were on to integrate animals into the systems and at times even to increase the density of farming. The coconut-pasture-pepper-milch animal system (Jacob Mathew and Mohamed Shafee, 1978; Bavappa, 1986; Das,

1991) with biogas production from cattle waste had high employment potential and income generating capability. Coconut-pasture-cattle system in vogue in many of the coconut growing countries of the world is one of the most popular farming system (Reynolds, 1995). In Mekong delta of Vietnam where fertile soil with assured moisture and sun shine of over 120 hours/month are available, high density systems involving coconut (140), cocoa (640), black pepper (640), banana (150), fruit trees such as citrus, sapota and carambola (40), five pigs, 10 goats in battery system, 200 poultry birds, 10 beehives, all in one ha of land of which one third area is under canals with fish, have been established with considerable success (Bavappa, 1990 c). Large quantities of the biomass are recycled through animals, birds and fish. Banana leaf and pseudo stem and Ipil Ipil loppings are fed to goats, poultry and fish and cocoa pod husk is used in the generation of biogas along with animal wastes which later are applied to the plants. The production efficiency of the system is ensured by a management system involving shade regulation through pruning, recycling of the biomass, fertilizer supplements whenever needed and little or no use of plant protection chemicals.

Concerted efforts to develop and study high density models for commercial and home needs as well as for cropping in the standing crops of coconut and arecanut (Bavappa, 1985, Bavappa and Jacob, 1981, 1982; Bavappa *et al.* 1986; Ray *et al.* 2000) have yielded useful results. A high density multispecies cropping system laid out in coconut gave a mean annual yield of 150 nuts/

palm during 14 Years of experimentation against 129 nuts obtained from monocrop of coconut. The yield of coconut in the same trial was not adversely affected even when the fertilizer input was reduced to 1/3rd (Table 1).

At the micro level a critical study of the 'Pekarangan' plant-animal- human-agro-ecosystem of Indonesia (Bavappa, 1991) characterized by parcels of land surrounding a permanent living house, usually planted densely with diverse crops and practicing associated animal husbandry and fishery activities alone or in combinations, was found to be one of the most sustainable agricultural systems evolved so far by the innovative actions of farmers spread over hundreds of years. The biological load per ha of Pekarangan consisted of 575 trees, 24 types of vegetables, 18 species of medicinal plants, 311 poultry birds, 12 cattle and 985 kg fish.

DISCUSSION

Study of the response of component crops and the environment of the farming system under a given situation using various parameters is of utmost importance for understanding the dynamics of the systems and making mid-term corrections for their improvement. Though the yields obtained from the tropical perennial plantation crops are high, further yield increases could be achieved by improvements in light interception, conversion efficiency and harvest index (Corley, 1985). He also indicated that minimizing stress with irrigation or fertilizer application increases conversion efficiency in oil palm, coconut, cocoa and rubber.

Table 1. Manurial input and yield of crops under the coconut based high density multispecies cropping system - CPCRI, India.

		HDMS	MONOCROP	
Total nutrients applied to the system - N,P,K kg/ha	792.7	534.2	276.6	317.1
Crops yields				
Coconut (mean 14 years) nuts/tree	151	149	151	129
Clove (g/tree)*	419	614	327	
Banana kg/bunch*	5.54	5.1	4.54	
Pineapple kg/tree*	0.82	0.79	0.7	

* Mean of 5 years

Increase in planting density to achieve early ground cover, careful management of shade and use of varieties with greater tolerance of exposure to full sun light, reduced maintenance respiration and better harvest index are the other factors suggested by Corley as pathways for increasing yield. The high intensity multispecies model involving 14 crops of which 7 had large canopy, 6 medium canopy and one small canopy planted in Sri Lanka in 1978 had taken into account the advantages of early ground cover by increasing planting density, right choice of crops having differential canopy architecture, their proper placement and canopy training with a view to maximize the per unit area productivity (Bavappa and Jacob, 1982).

In rubber, various crop rotations tried in comparison with standard legume covers and also with natural covers with and without ploughing, a common practice in Thailand showed that legume and non-legume crops can both be included in the rotation, preferably alternating and that there should not be more than two non-legume crops consecutively during the first two years of intercropping and that intercropping did not harm the growth of the replanted rubber. This finding is confirmed by the work of Rubber Research Institute of Malaysia (Pushparajah and Chellapah, 1969). The importance of adopting a correct rotation in the farming system is thus apparent.

The evaluation of the coconut and arecanut based HDMS after three years of their establishment had shown that there was no marked yield differences of the crops in the full, two-third and one-third levels of fertilizers. In general there was build up of P and K nutrients and improved microbial activity in the systems. The mean yield when considered for the entire 14 years of experimentation (Table 1) showed that there was no difference in the yield of coconut at the three levels of manuring and there is an increase of about 20 nuts per palm over the monocrop. There was marginal decrease in the yield of other crops due to reduction in level of fertilizers. The fact that coconut under the one-third manurial dose gave 22 nuts more than monocrop which received full dose, presents

interesting discussion. While the monocrop received 317.1 kg NPK/year/ha in its full dose coconut in the HDMS at one-third dose level received only 105.7 kg. Even assuming that coconut in the system has foraged at least partially on the nutrients, applied to the other crops of the system which all put together received only 276.6 kg nutrients there is a response factor outside the nutrients which is the 'system effect'. It should be the effort of researchers to discern this highly cost effective mechanism and exploit the same in further research and system development. A study of the nutrient profile of the system adopting the technique suggested by Biddappa *et al.* (1984) would be highly rewarding. Published data on the HDMS of Sri Lanka are not available excepting for a personal communication in 1986 that the income from the plot had gone beyond 100,000 SRL Rs. (US\$ 4000), exceeding the estimates made.

FUTURE OUTLOOK

The continued increase in the small and marginal holdings in the plantation sector as well as in farmer settlements is on one hand locking up otherwise productive arable land in the form of homesteads and farmsteads and on the other reducing their production efficiency due to a wide range of factors. Since the plantations or arable area in a given agro-ecological zone is fairly constant and the number of rural households being on the increase the size of such holdings is steadily on the decrease. Daw (1991) reported a decline of 14% in mean Pekarangan size and an annual 2.2% increase in their number in Indonesia. The sudden fall in price of almost all the plantation crop products (barring cashew) arising out of the WTO agreement, increased cost of inputs and labour and difficulty in marketing some of the crops like coconut are new problems that would shatter the economic viability of these systems. The role of plantation crops as cash crop components of the system is becoming insignificant. The FSR has to quickly take into cognizance these changes and modify the research strategy to make the system agronomically efficient, socially acceptable, ecologically balanced and economically viable.

The integration of animals, fish and birds completely recycling the organic wastes of the system through a biogas plant generating the energy required for lighting, cooking and pumping as practiced by the farmers of Java (Indonesia) and Vietnam could make farming a self generating system in every term of its operation.

On the research front an indepth technical and socio-economic analysis of the ongoing potential farming systems and their dynamics should enable intervention for refinement and further follow up. This would accelerate the FSR gains, generating information at field level far more acceptable to farming community. Incidentally these plots would also serve as living demonstrations for transfer of technology. Research on varietal suitability for mixed cropping is an area in which no efforts has been made so far. Multipurpose varieties having high light use efficiency, compact canopy and root architecture, shorter juvenile phase and high biomass productivity are to be evolved for use in the systems. Continued monitoring of the coconut and arecanut based HDMS in terms of biomass generation, its recycling, soil nutrients and microbial load, soil moisture status, solar radiation spectrum of the system and other worthwhile parameters should be made and midterm corrections done so as to upgrade the performance of the system. Information on rooting pattern and partitioning of the applied nutrients has great relevance in the management of the system. The FSR should receive the focused and continued attention of a multi-disciplinary team as dynamic as the system itself concentrating on Farming System Analysis, On-Farm System Research and New Farming System Development.

ACKNOWLEDGEMENT

The author wishes to express his thanks to Dr. K.U.K. Nampoothiri, Director; Dr. H. Hameed Khan, Project Co-ordinator (Palms) and Dr. D.V. Srinivasa Reddy and Dr. Dhanapal, Scientists of Crop Production Division of CPCRI, Kasaragod for providing facilities for the preparation of the paper and making available some of the unpublished data. His thanks are also due to Mr.

PA Radhakrishnan for word processing.

REFERENCES

- Bavappa, K.V.A. 1951. Some common intercrops in arecanut gardens. Indian Central Arecanut Committee, *Monthly Bull.* 2(2): 16-17.
- Bavappa, K.V.A. 1975. Intensive cropping possibilities in plantation crops. *Planters Chronicle*, 69(9): 260-262.
- Bavappa, K.V.A., Jacob, V.J., Premaratne, H.E. and Rusttimann, R.A. 1981. Minor export crop models from Mixed cropping and crop diversification. Tech. Bull. 9, UNDP/FAO. Research Project, Matale, Sri Lanka. pp. 15.
- Bavappa, K.V.A. 1976. *J. Plant. Crops* 5(1): 1-10.
- Bavappa, K.V.A. 1982. Expert Report on Spices Research and development in Sri Lanka. UNDP/FAO Project SRL/79/010. Research Station, Malale, pp. 144.
- Bavappa, K.V.A. 1985. *J. Plant Crops* 13(1): 1-10.
- Bavappa, K.V.A. 1986. Research at Central Plantation Crops Research Institute (CPCRI), Kasaragod, Kerala, India. pp. 82.
- Bavappa, K.V.A. 1990a. Agronomic desirability of coconut based farming systems. In: Coconut Based Farming Systems (ed., Silva, de S.). Proceedings of the XXVII COCOTECH Meeting, 25-29 June, 1990, Manila, Philippines, 57-68.
- Bavappa, K.V.A. 1990 b. In: *Coconut Based Farming Systems* (ed. Silva, De S.), Proceedings of the XXVII COCOTECH Meeting, 25-29 June, 1990, Manila, Philippines, 90-102.
- Bavappa, K.V.A. 1990c. In: *Coconut Based Farming Systems* (ed. Silva, de S.), Proceedings of the XXVII COCOTECH Meeting, 25-29 June, 1990, Manila, Philippines, 491-502.
- Bavappa, K.V.A. 1991. In: *Proc. Seminar in Pekarangan Land Development Possibilities and their contribution to farmers' welfare.* (ed. Daw, M.E., Bavappa, K.V.A. and Parandaram), FAO, Rome. 18-28.
- Bavappa, K.V.A. and Jacob, V.J. 1981. A model

Farming systems in plantation crops

- for mixed cropping, Ceres No. 81, 14(3) May-June, 44-46, FAO Rome.
- Bavappa, K.V.A. and Jacob, V.J., 1982. *World Crops*, **34**(2): 47-50.
- Bavappa, K.V.A., Kailasam, C., Khader, K.B.A., Biddappa, C.C., Khan, H.H., Kasturi Bai, K.V., Ramadasan, A., Sundararaju, P., Bopaiah, V.M., Thomas, G.V., Misra, L.P., Balasimha, D., Bhat, N.T. and Shama Bhat, K., 1986. *J. of Plantation Crops* **14**(2): 74-87.
- Biddappa, C.C., Hameed Khan, H., Joshi, O.P., Manikandan, P. and Bavappa, K.V.A., 1984. Integrated nutrient management in perennial based high density cropping through system approach. A critical consideration, PLACROSYM VI, 299-310.
- Corley, C.H.V., 1985. Yield potentials of plantation crops. 19th Colloquium of the International Potash Institute-Potassium in the Agricultural Systems of the Humid Tropics. International Potash Institute, Bern, Switzerland. 35-53.
- Das, P.K., 1990. In: *Coconut Based Farming Systems* (Ed. Silva, De S.), Proc. of XXVII COCOTECH Meeting 25-29 June, 1990, Manila, Philippines, 539-554.
- Das, P.K., 1991. *J. Plant. Crops*, **19**(2): 191-201.
- Daw, M.E., 1991. In: *Proc. Seminar on Pekarangan land: Development possibilities and their contribution to farmers' welfare* (eds. Daw, M.E., Bavappa, K.V.A. and Pasandaran, E.), FAO, Rome, 1-17.
- Jacob Mathew and Mohamed Shafee, 1979. Mixed farming in coconut gardens. In: *Multiple cropping in coconut and arecanut gardens* (ed. Nelliath, E.V. and Shama Bhat, K.), Tech. Bull. 3, Central Plantation Crops Research Institute, Kasaragod. pp. 42-46.
- Jamadon, B. and Osman, Y., 1990. In: *XXVII COCOTECH Meeting*, 25-29 June, 1990, Manila, Philippines, 263-276.
- Nair, P.K.R., 1979. Intensive Multiple Cropping with coconut in India : Principles, programmes and prospects. International Council for Research in Agroforestry, Nairobi, Kenya, Verlag Paul Parich, Berlin.
- Nair, P.K.R. and Bavappa, K.V.A., 1975. *J. Root Crops* **1**(2): 93-94.
- Nair, P.K.R., Bavappa, K.V.A. and Nelliath, E.V., 1975a. Intensive farming programmes for small-sized coconut plantations. IV FAO Technical Working Party on Coconut Production, Protection and Processing, Kingston.
- Nair, P.K.R., Varma, R., Nelliath, E.V. and Bavappa, K.V.A., 1975 b. *Indian J. Agric. Sci.* **45**: 165-171.
- Nelliath, E.V., Bavappa, K.V.A. and Nair, P.K.R., 1974. *World Crops*, **26**: 262-266.
- Pushparajah, E. and Chellappah, K., 1969. *J. Rubb. Res. Inst., Malayai*, **21**: 126-139.
- Speirs Andrew, J. 1974. Towards an understanding of rubber smallholders. A socio-economic survey of some rubber villages in Thailand. Document No. 41, Rubber Research Centre, hat Yai, Thailand.
- Ramiah, 1990. In: *Plantation based Multiple Cropping Systems* (Eds. Bandhopadhyay, A.K., Michel Raj, S., Gangwar, B. and Dagar, J.C.), CARI, Port Blair, 744001.
- Ray, A.K., Srinivasa Reddy, D.V. and Sairam, C.V., 2000. *J. Plant Crops* **28**(2): 110-116.
- Reddy, D.V.S. and Biddappa, C.C., 2000. *J. of Plantation Crops* **28**(1): 1-18.
- Rethinam, P. and Venugopal, K., 1994. In: *Advances in Horticulture - Plantation and Spices Crops* (Eds: K.L. Chadha and P. Rethinam), Vol. 9(1), Malhotra Publishing House, New Delhi.
- Reynolds, S.G., 1995. Pasture cattle-coconut systems. Food and Agriculture Organization, Rome. pp. 668.
- Simmonds, Norman, W.C., 1985. Farming system Research - A review World Bank Tech. Paper No. 43, The World Bank, Washington DC. pp. 97.
- Watson, G.A., 1980. A study of tree crop farming systems in the low land Humid Tropics. Vol. II, The World Bank, Washington DC. pp. 80.