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Coconut - Real *Kalpavriksha* to Raise Farmers' Income

V. V. Shinde*¹, P. J. Kshirsagar², J. M. Talathi², S. L. Ghavale¹, S. S. Wadkar², P. B. Sanap¹, V. K. Patil³, A. D. Rane³, S. M. Wankhede¹, A. D. Hake², S. B. Dodake⁴, P. M. Haldankar⁵ and T. Bhattacharyya⁵

¹Regional Coconut Research Station (DBSKKV), Bhatye, Ratnagiri, Maharashtra (India) 415712

²College of Agriculture (DBSKKV), Dapoli, Ratnagiri, Maharashtra (India) 415712

³College of Forestry (DBSKKV), Dapoli, Ratnagiri, Maharashtra (India) 415712

⁴Kharland Research Station (DBSKKV), Panvel, Raigad, Maharashtra (India) 410206

⁵Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri, India. 415712

Abstract

Various research experiments have been conducted at Regional Coconut Research Station, Bhatye, Ratnagiri under All India Co-ordinated Research Project on Palms from early 1960's to till date. Coconut is crop of small and marginal farmers in Konkan region. Nearly 90 per cent of the total coconut area is with small holders with less than 0.1 ha area. Productivity of coconut in Maharashtra state is 6670 nuts ha⁻¹ (43 nuts palm⁻¹ year⁻¹) and farmers are getting approximately ₹ 53,360 ha⁻¹. But sole crop does not provide adequate employment to the family members. Multi-storied coconut-based cropping system is one of the alternative to increase the income from same piece of land. The multi-storied/multi-species cropping model consisting of tree species like nutmeg, cinnamon, black pepper and few annual fruit crops like banana, pineapple have been developed by DBSKKV, Dapoli. This model has potential to earn profit of more than ₹ 1.0 lakh acre⁻¹ has become popular as '*Lakhi baug*' and has increased the productivity up to 100 nuts palm⁻¹ year⁻¹. Large number of coconut growers in Konkan region are following this technology and it has played a major role in doubling farmer income in Konkan region. A review of development of this technology, its various aspects, supporting research findings and post-application benefit analysis through success stories is presented in this article.

Keywords: Coconut, multi-storied cropping, *lakhi baug*, Doubling Farmers' Income, DFI.

Introduction

Coconut (*Cocos nucifera* L.) is cultivated in over 95

*Corresponding author: vaibhavvilasshinde@yahoo.co.in

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countries around the world, predominantly in developing countries and the cultivation is more concentrated along the coastal regions. Coconut is cultivated in the tropical belt of world over an area of about 12,196 million ha with production of 69,836.36 million nuts and productivity of 5726 nuts ha⁻¹. India, Indonesia, Philippines and Srilanka together account for nearly 80 per cent of total world production (Table 1). Indonesia ranks first, while India ranks third with respect to worlds hectareage. India has secured first position in production (21,665 million nuts) in year 2014-15 followed by Indonesia (16,354 million nuts) and Philippines (14,696 million nuts). Interestingly, highest productivity (10,119 nuts ha⁻¹) of coconut is also observed in India highlighting importance of Indian coconut in the world.

In the West Coast of India, coconut is an essential component in the homestead system of farming. In India, coconut is closely related with the socio-economic life of large number of small and marginal farmers, which provides regular income once it commences fruiting. The farms are mostly village based small holder size, mostly under one hectare. Coconut is a crop of small and marginal farmers, since 98 per cent of about five million coconut holdings in the country have less than two hectares land holding. Traditional areas of coconut in India are the states of Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, Orissa, Goa, West Bengal, Pondicherry, Maharashtra and Islands of Lakshadweep and Andaman and Nicobar among these, Kerala, Karnataka, Tamil Nadu and Andhra Pradesh contribute about 88 per cent area and 90 per cent production. However, several states like Assam, Gujarat, Madhya Pradesh, Bihar, Tripura, Manipur, Nagaland and Arunachal Pradesh have emerged as non-traditional areas for the cultivation of coconut (Table 2).

In Maharashtra, 95 per cent area under coconut is concentrated in Konkan region and most of the orchards are situated near the seashore and majority of them are sole coconut orchards. It is a major irrigated

Doubling Farmers' Income (DFI) through DBSKKV Interventions**Table 1.** Area, production and productivity in major Coconut growing countries. (Source: Singh 2016)

Sr. No.	Country	Area ('000 ha)	% Share in Area	Production (million Nuts)	% Share in production	Productivity (Nuts ha ⁻¹)
1	India	2141	17.55	21665	31.02	10119
2	Indonesia	3610	29.60	16354	23.42	4530
3	Philippines	3502	28.71	14696	21.04	4196
4	Brazil	251	2.06	2919	4.18	11630
5	Srilanka	440	3.61	2870	4.11	6523
6	Papua New Guinea	221	1.81	1483	2.12	6710
7	Vietnam	159	1.30	1246	1.78	7834
8	Mexico	169	1.39	1119	1.60	6620
9	Thailand	206	1.69	1001	1.43	4859
10	Tanzania	128	1.05	546	0.78	4264
11	Others	1369	11.22	5938	8.50	4338
	Total	12196	100.00	69836	100.00	5726

Table 2. Area, production and productivity of Coconut in India in 2014-15. (Source: Singh 2016)

State	Area ('000 ha)	% Share in Area	Production (million Nuts)	% Share in production	Productivity (Nuts ha ⁻¹)
Kerala	649.85	32.89	4896.61	23.96	7535
Karnataka	515.03	26.07	5141.15	25.15	9982
Tamil Nadu	465.11	23.54	6917.46	33.84	14873
Andhra Pradesh	105.99	5.36	1463.56	7.16	13808
Odisha	50.68	2.57	324.89	1.59	6411
Gujarat	31.63	1.60	295.03	1.44	9328
West Bengal	29.41	1.49	372.23	1.82	12657
Maharashtra	28.10	1.42	187.44	0.92	6670
Goa	25.79	1.31	127.72	0.62	4952
Andaman Nicobar	21.91	1.11	129.77	0.63	5923
Assam	21.14	1.07	237.49	1.16	11234
Bihar	14.90	0.75	141.38	0.69	9489
Tripura	6.93	0.35	28.41	0.14	4100
Lakshadweep	2.57	0.13	70.91	0.35	27591
Pondicherry	1.88	0.10	21.90	0.11	11649
Chhattisgarh	1.71	0.09	27.85	0.14	16287
Telangana	1.69	0.09	25.34	0.12	14994
Nagaland	1.45	0.07	16.32	0.08	11255
Mizoram	0.04	0.00	0.16	0.00	4000
Daman & Diu	Negligible	--	13.99	0.07	--
All India	1975.81	100.00	20439.60	100.00	10345

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horticultural crop in Konkan region of Maharashtra, where agro-climatic conditions are very much congenial for its cultivation. The Government of Maharashtra had launched an ambitious Employment Guarantee Scheme (EGS) for fruit crop cultivation in 1990, which led to the expansion of the total area under coconut cultivation to 28,100 ha by 2016-2017 with an annual production of 187.44 million nut and productivity of 6,670 nuts ha⁻¹. At national level, Maharashtra contributes about 1.42 per cent share in area and 0.92 per cent in annual production (Table 2).

Problems of coconut cultivation in Konkan region

The major problems of coconut cultivation in Konkan region of Maharashtra State are fragmented holdings, scattered production, homestead nature of cultivation, lack of skilled manpower for climbing and harvesting, incidence of pest and diseases, lack of adoption of scientific cultivation practices, lack of appropriate mechanization for harvesting and for home-scale processing.

Regional Coconut Research Station in Bhatye, Ratnagiri

To address the problems faced by farmers, the Indian Central Coconut Committee established a Regional Coconut Research Station (RCRS) in Bhatye. The objective of this station is to carry out research in coconut for catering to the needs of coconut growers in this region. The Research Station is situated on the coast of the Arabian sea in village Bhatye near Ratnagiri town and is located at 17.00° N Latitude and 73.40° E Longitude and 3 m above MSL. This station was established on 1st July, 1955 under the administrative control of the State Department of Agriculture. The centre was under Mahatma Phule Krishi Vidyapeeth, Rahuri up to 1969 and presently it is under Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. The station has an area of 25.84 ha for conducting research on mandate crops i.e. coconut and spices. This station undertakes research and extension programmes under ICAR- All India Coordinated Research Project (AICRP) on Palms and National Agricultural Research Project (NARP). This research station has contributed to the farming community through development of improved varieties of coconut along with evaluation and dissemination of location specific crop production and protection technologies.

Technological Interventions of RCRS, Bhatye under DBSKKV, Dapoli

Coconut varieties/hybrids released

Pratap: A high yielding tall coconut variety, pratap was released in the year 1987, which was a selection from Banawali. It is having green coloured, round shaped nuts with an average yield of 140-145 nuts palm⁻¹, dry copra yield of 120-160 g nut⁻¹ and 68 per cent oil content. This variety is recommended for cultivation in Konkan region of Maharashtra.

Konkan Bhatye Coconut Hybrid 1 (GBGD x ECT): This hybrid was released in the year 2007, with an average yield of 120-122 nuts palm⁻¹ and copra content of 160-169 g nut⁻¹ with 67.1 per cent oil content. Nuts are green coloured, oval shaped with tender nut water content of 330 ml nut⁻¹. The hybrid is resistant to stem bleeding disease and is moderately resistant to leaf blight and bud rot. This hybrid is also recommended for cultivation in Konkan region of Maharashtra.

Recommended varieties / hybrids of coconut for cultivation in Maharashtra

Based on the performance, varieties / hybrids like Chandra Kalpa (Laccadiv ordinary), Kera Sankara (T x D), Kera Chandra (Philippines ordinary), Chandra Sankara (DxT), Kera Bastar (Fiji Tall) and Godavari Ganga (ECT x GBGD) have been recommended for cultivation in Maharashtra.

Nucleus seed gardens for released varieties: Nucleus seed gardens for released varieties were established in the centre for ECT, Gautami Ganga (GBGD) and Kera Bastar, which will cater to the needs of quality planting material in the region.

University recommendations in coconut crop management

Nutrition

Fertilizer dose of 1000 g nitrogen, 500 g Phosphorous and 1000 g of Potash palm⁻¹ year⁻¹ in three split doses (June, October, and February) was recommended for coconut cultivation in sandy soils of the Konkan region of Maharashtra state (Maharashtra SAUs 2007, Maheswarappa and Kumar 2014).

On the basis of cumulative yield and economics following dose is recommended for coconut hybrid palm. The dose should be applied in three splits. 1/3 N and K₂O, full dose of P₂O₅ and FYM should be applied in the month of June and remaining 2/3 N and K₂O in two splits (October & February) (Nagwekar *et al.* 2004, Maharashtra SAUs 2008; Maharashtra SAUs 2010).

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Application of 1 kg N, 0.5 kg P₂O₅ and 1 kg K₂O palm⁻¹ year⁻¹ (recommended dose) is recommended through drip irrigation in eight splits from October to May (Anon. 2002).

Application of recommended dose (1:0.5:1 Kg NPK palm⁻¹ year⁻¹) with 1.5 kg Ormichem Micronutrient (Zn 3.15 %, Mg 1.8 %, Cu 0.65 %, Fe 1.97 %, Mn 2 %, Mo 0.05 % and B 0.68 %) recorded maximum yield (129 nuts palm⁻¹ year⁻¹) in coconut and also the percentage increase in yield was higher in post treatment period yield when compared with pretreatment period yield. Therefore the application of recommended dose of fertilizer with 1.5 kg Ormichem micronutrient in three splits is recommended for adult coconut palm (Nagwekar *et al.* 2004, Anon. 2002).

Irrigation

An experiment was conducted to assess the influence of quality of irrigation water on growth of one year old newly planted “West Coast Tall” coconut seedling in coastal sandy soil. Irrigation with sea water had detrimental effects, at any growth phase throughout the duration of the experiment, due to primary salt stress, which was responsible for membrane disintegration and disturbance in metabolic process. The dilution of sea water with sweet water reduced the extent of primary stress injury but imposed salt injury causing decrease in uptake of mineral elements, which resulted into poor growth of seedling (Patil *et al.* 2001, Anon. 2002).

Drip irrigation with 30 liters water palm⁻¹ day⁻¹ during October to January and 40 liters during February to May with six drippers placed at a distance of 1.25 m away from the bole in sandy loam soils of Konkan region and recommended for adult coconut palm (Maharashtra SAUs 2005, Nagwekar *et al.* 2006, Maharashtra SAUs 2010).

For getting higher yield in coconut, application of recommended dose of 1 kg N, 0.5 kg P₂O₅ and 1 kg K₂O per palm per year is recommended through drip irrigation in eight splits from October to May (Anon. 2002).

Coconut based Cropping System

The cultivation of Chillli (variety “Jwala” and “Konkan Kirti”) is recommended due to their higher yield and best net returns as inter crop in coconut orchard (Anon. 2002).

On the basis of economic returns obtained man day⁻¹ ha⁻¹, Dolichos bean could be rated as the most remunerative

vegetable crop, whereas, tomato cultivation provided better employment opportunities and gave attractive yield (Patil *et al.* 1995).

Rainfed vegetables such as ridge gourd, cucumber, snake gourd and bitter melon is recommended in coconut plantation during rainy season (Nagwekar *et al.* 1997).

Excellent growth and good bearing capacity of cinnamon, nutmeg, black pepper and clove planted in coconut as intercrops proved that these crops can be cultivated on commercial scale in the Konkan region of Maharashtra (Patil *et al.* 1991, Anon. 2002, Maharashtra SAUs 2005).

After planting spice crops as intercrops in coconut plantation, the average yield of coconut per palm has increased from 25 to 93 per cent at the end of 26th years as compared to the average yield of previous 4 experimental years. Nutmeg (at 22 years age) proved as the best intercrop in coconut plantation. Nutmeg and coconut together gave ₹ 93,578 as net returns per ha whereas, coconut as a monocrop recorded net profit of ₹ 25,987 ha⁻¹. On the strength of net economic returns released, it is recommended to interplant nutmeg, cinnamon and clove in well spaced coconut garden in the Konkan region of Maharashtra (Khandekar *et al.* 2014).

Four intercrops *viz.* turmeric, banana, pineapple and tapioca are recommended in coconut plantation in Konkan region of Maharashtra for getting more economic returns (Maharashtra SAUs 2010).

The biomass productivity of coconut ranged from 3.4 to 5.1 t ha⁻¹ while it ranged from 161 kg to 4450 kg ha⁻¹ in different spices. Vermicompost productivity of coconut ranged from 2 to 3 t ha⁻¹ where as it was 48 kg to 1.5 t ha⁻¹ in different spice crops. Nutrient recycling rate of 43.62 kg N, 9.64 kg P, 30.13 kg K, 21.81kg Ca and 16.56 kg Mg ha⁻¹ in coconut can be achieved through proper utilization of available biomass. In organic fertilizer substitution of about 33% N, 3.67% P₂O₅ and 22.96% K₂O in coconut and 20.40% N, 2.7% P₂O₅ and 20.67% K₂O in spice tree species can be achieved by organic recycling (Maharashtra SAUs 2003).

Considering the performance of different medicinal crops as a intercrop and market demand, the arrowroot, lemongrass, shatavari, adulsa and citronella have been recommended as a intercrops in coconut plantation for Konkan region of Maharashtra (Maharashtra SAUs 2010).

It is recommended to retain 5 sprouts after coppicing

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in regular harvesting season (October to May) to get maximum yield of cinnamon bark and leaves.

For getting the higher yield and returns in coconut based cropping system, it is recommended to cultivate lily flower crop as an intercrop under Konkan agro-climatic condition.

Lakhi Baug

On the basis of mixed cropping experiment on spices, DBSKKV has promoted the '*Lakhi Baug*' concept. That is intercropping of spices particularly Cinnamon, Nutmeg and Black pepper in the coconut orchard and from one acre of this kind of system farmer can get one Lakh rupees, thus it is called as '*Lakhi Baug*' which includes Model-I.

Crop Protection

Rhinoceros Beetle (*Oryctes rhinoceros*)

a) Release of Baculovirus infected adults of rhinoceros beetle @ of 10 to 15 acre⁻¹ was recommended for biological control of the rhinoceros beetle.

b) False breeding material traps @ of 10 ha⁻¹ should be included in integrated pest management programme for rhinoceros beetle.

c) Integrated pest management technology for rhinoceros beetle has been found to be very effective and economical to control this pest. It consists of:

1) Sanitation method: The dead and decaying organic debris in the coconut gardens may be properly disposed off since this acts as prolific breeding ground for the beetle.

2) Mechanical method: Removal of beetles with iron or aluminum hooks from the palm crown without causing injury to growing point particularly during peak period of population build up.

3) Attraction and trapping: False breeding material trap: Digging of ten pits per hectare of the size 2 x 2 x 2 feet and to be filled with breeding material should be done in coconut gardens. These pits should be sprayed with 0.1 per cent Carbaryl 50 WDP at the interval of two months.

4) The breeding sites of the beetle such as cow dung, compost and other decaying organic debris may be treated with 0.1 per cent Carbaryl 50 WDP at the interval of three months.

5) Prophylactic control: The innermost 2nd and 3rd leaf axils may be filled with Lindane 1.3% @ 50 g

+ equal quantity of sand and Phorate 10G @25 g, Methyl parathion 2% @ 50 g, Endosulfan 4% @ 50 g, Endosulfan 12.5 g and Lindane 1.3% @ 12.5 g plus equal quantity of sand at the interval of three months.

6) Biological control: Release of Baculovirus infected beetles at the rate of 10-15 beetles acre⁻¹ in plantation should be done.

Black Headed Caterpillar

This pest's intensity is severe in Thane and Raigad districts of Konkan region. The intensity of incidence was 50.95 per cent. The infestation was also observed in bottle palm, Khajur and toddy palm. For the control of coconut black headed caterpillar, release of larval parasite *Goniozus nephantidis* at the rate of 20.5 per cent in the pest population or 3,500 adult parasites ha⁻¹ is recommended.

The Integrated pest management strategy should be adopted in endemic outbreak of the pest. IPM consists of:

1. Mechanical control: Cutting and burning of badly infested leaves and dried 2-3 outermost leaves will reduce the infestation.

2. Biological control: For the control of black headed caterpillar a larval parasite *Goniozus nephantidis* should be released at the rate of 20.5 per cent of the pest population or 3,500 adult parasites ha⁻¹ (when 20 per cent leaves are infested with the pest).

3. Chemical control:

i. Need based spraying with 0.1 % Carbaryl, or 0.05 % Endosulfan or 0.05 % Dimethoate or 0.05 % DDVP in severe outbreaks of the pest would give satisfactory control of the pest. Care should be taken to spray lower surface of the leaves so as to get effective control. If chemical control felt necessary after release of parasitoids, spraying should be done after 15 days after release of parasites.

ii. Root feeding with systemic insecticides viz. Monocrotophos 36 EC @ of 10 ml or Azadirachtin 10000 ppm @ 10 ml in 10 ml of water palm⁻¹ were effective in controlling black headed caterpillar.

For root feeding, select pencil size, sweet potato coloured root from 1-1.5 feet depth. Slanting cut should be given to the selected root. Then take polythene bag of the size 12 X 8 cm and pour 10 ml Monocrotophos + 10 ml water in it. This root should be kept in

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polythene bag with having containing insecticide solution and tighten mouth of the bag with the help of thread. Care should be taken to dip the tip of the root in the insecticide solution. In this case, all mature nuts may be harvested before treatment and plucking of tender coconuts or harvesting of nuts should be strictly avoided for forty days after treatment.

Mass rearing of parasites: The multiplication of potential larval parasite *G. nephantidis* is done supplied to the farmers at the rate of ₹ 500 per 1000 parasites.

Red Palm Weevil

The use of PO29 Ferro lure 400 mg trap at an interval of three months is recommended for the management of coconut red palm weevil.

Eriophyid Mite

Drenching of Eriophyid smash (Azadirachtin 0.03 per cent plus micronutrients) @ 250 ml in 20 litres of water palm⁻¹ three months interval is recommended for the management of coconut Eriophyid mite (Maharashtra SAUs 2007).

Mechanized harvesting

The continuous increase in the yield and production rate of coconut orchards has urged the need for mechanization of coconut harvesting in India. The average yield, production and area of coconut is increasing since the last 34 years. The drudgery in manual coconut harvesting, lack of climbing labours and the operational and safety problems in availing manual climbers have necessitated the need for mechanization of coconut harvesting. Coconut growers are facing practical difficulty in coconut harvesting due to the height of tree. The Tractor Mounted Hydraulic Elevator (TMHE) developed by DBSKKV is a fully automatic harvesting device for harvesting tall coconut orchard. The coconut harvesting field capacity of the developed TMHE is observed as 4,524 coconuts day⁻¹ (Shinde and Chavan, 2016).

Important features of hydraulic climber:

- 1) The TMHE is suitable for harvesting of coconut up to a maximum height of 14 m using traditional harvesting pole,
- 2) It takes very less lifting and lowering time for coconut harvesting, spraying and cleaning operations.
- 3) The machine can be operated by any agricultural worker with training.

4) The efficiency of this machine is much more than the manual harvesting.

Economics and Marketing

Area under coconut as well as production has been showing a steady increase during the last five decades. Area under coconut was 0.63 million ha during 1950-51 which increased to 1.91 million ha during 1998-99. During the same period, production increased from 3,282 million nuts to 14,925 million nuts and productivity from 5238 nuts ha⁻¹ to 7821 nuts ha⁻¹. Growth over the period 1950-51 to 1998-99 was 204.58 per cent in area, 354.79 per cent in production and 49.31 per cent in productivity. An analysis of percentage shows that the decade 1985-86 to 1994-95 was the peak period (Veerkar 2004). The country is still deficit in coconut production and consequently, resorts to import of copra from abroad. Therefore, coconut development assumes importance in conserving the crores of foreign exchange. In view of this, the Central and State Government have launched an intensive programme for coconut development so as to make India self-sufficient in coconut production.

The strategy to increase area, enhance production and set up yield by way of improved technology is no doubt essential. Yet this would not be sufficient to sustain the growth of coconut industry. An efficient marketing system, a pre-requisite for stable and remunerative prices to producers can alone provide the necessary stimulus and an incentive to increase production. It is prevailing fact that on an average the farmer receives

Table 3. Identified coconut based cropping systems in Maharashtra

Sr. No.	Cropping system	Share %
1.	Coconut sole	26.67
2.	Coconut + Arecanut	45.00
3.	Coconut+Arecanut + Black pepper	13.89
4.	Coconut+Arecanut + Black pepper + Banana	3.33
5.	Coconut + Arecanut + Banana	2.78
6.	Coconut + Banana	1.67
7.	Coconut + Arecanut + Nutmeg	2.22
8.	Coconut + Arecanut + Black pepper + Nutmeg	3.89
9.	Coconut + Arecanut + Black pepper + Nutmeg + Clove	0.55
Total		100.00

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only about 40 per cent of the prices paid for food product by the consumer. There is a consensus among the agricultural circle that the middleman grabs too large profit, disproportionate to the services rendered by them. It is not uncommon for the price of agricultural products to get almost doubled on the way from the producer to the consumer. The abundant documentary evidence collected by agricultural experts in this regards may be deficient in certain reports but certainly they draw our attention to some genuinely disturbing features (Talathi and Kshirsagar, 2016).

Coconut based cropping systems:

In Maharashtra, different coconut based cropping systems adopted by the coconut growers are grouped into nine types of coconut based cropping systems. Out of these, majority (45%) of the respondents to adopted Coconut + Arecanut cropping system (Table 3). Sole cropping of coconut was adopted by 26.67 % with total area under the system was to the tune of 27.11 ha with average area of 0.56 ha per farm. Another major system identified as Coconut + Arecanut + Black pepper, adopted by (13.89%) growers and average area per orchard is 0.75 ha (Talathi and Kshirsagar 2016).

University Technology Component

Research on various aspects of coconut plantation in Konkan region is mainly carried out at DBSKKV and RCRS, Bhatye (Ratnagiri). Based on the research findings on mixed cropping in coconut, DBSKKV introduced concept of *Lakhi baug* i.e. systematic plantation of spices crops (Cinnamon, Black pepper and Nutmeg) in coconut orchard for maximizing returns per unit area (₹ One lakh acre⁻¹) in the year 2001. The university has developed various types of *Lakhi baug* models for coconut growers to get more than ₹ One lakh

per acre net profit (Talathi and Kshirsagar 2016) (Table 4).

Case study of Lakhi baug success

In Dapoli taluka of Ratnagiri district, a study was conducted to assess the adoption and profitability of different *Lakhi baug* models. Four different coconut based cropping system models (Table 4) were observed in the study area; all the systems were mixed with banana, nutmeg, cinnamon and pineapple.

Production and Return

On the basis of per farm valuation of main and by-product together per hectare returns were estimated and presented in Table 5 and Table 6.

It is evident from Table 6 and Table 7 that in cropping system-I the per hectare total returns worked out to ₹ 1.97 lakhs of which 43.14 per cent was from Arecanut (₹ 82,250) and 41.62 per cent (₹ 8,28,409) was from coconut. In system-II wherein coconut was grown along with arecanut, black pepper and banana, the total returns ha⁻¹ estimated to ₹ 2.16 lakh. Out of total returns 41.31 per cent received from arecanut, 38.31 per cent from coconut, 9.92 per cent from black pepper and 6.90 per cent from banana and 3.86 per cent were received from by-products. In cropping system-III were coconut grown along with arecanut, black pepper, nutmeg, cinnamon and pineapple, the per hectare total returns received were ₹ 3.17 lakhs. Out of total returns, maximum returns were received from Nutmeg (₹ 1.18 lakh). The proportion of returns from coconut was 27.40 per cent and arecanut was 17.95 per cent. The returns received from black pepper, cinnamon and byproducts was estimated to 13.12 per cent, 1.27 per cent and 2.98 per cent respectively (Talathi and Kshirsagar 2016).

In cropping system-IV where more than three crops were grown along with coconut, the per hectare total returns estimated was ₹ 3.63 lakhs. Out of which, returns received from Nutmeg was maximum (₹ 1.48 lakhs). Next to Nutmeg the returns share was maximum in coconut (23.58%), followed by arecanut (16.34%), black pepper (13.07%), by-products (3.00%), pineapple (2.07%) and cinnamon (1.05%). In case of sole coconut orchard the per hectare total returns estimated to ₹ 0.98 lakhs out of which 91.54 per cent was from coconut and remaining 8.46 per cent was obtained from by-products of coconut. The analysis of the return structure indicated that as the number of crops in the cropping system increased, the gross returns also maximized.

Profitability in cropping systems

Table 4. Identified coconut based cropping system in Konkan.

Sr. No.	System	Crop combination	No. of growers
1	I	Coconut + Arecanut + Black pepper	(20%)
2	II	Coconut + Arecanut + Black pepper + Banana	(20%)
3	III	Coconut + Arecanut + Black pepper + Nutmeg	(30%)
4	IV	Coconut + Arecanut + Black papper + Nutmeg + Cinnamon + Pineapple	(30%)

Doubling Farmers' Income (DFI) through DBSKKV Interventions**Table 5.** Plant population ha⁻¹ in coconut based cropping systems in Dapoli, Maharashtra.

Sr. No.	Crops	System I (No. plants ha ⁻¹)	System II (No. plants ha ⁻¹)	System III (No. plants ha ⁻¹)	System IV (No. plants ha ⁻¹)	Sole coconut (No. plants ha ⁻¹)	Recommended Plant population for <i>Lakhi baug</i>
1	Coconut						
a	Bearing	170	165	169	165	204	175
b	Non bearing	4	12	5	-	-	
2	Areca nut						
a	Bearing	625	620	370	401	-	615
b	Non bearing	125	130	35	52	-	
3	Black pepper	45	42	85	97	-	350
4	Banana	-	48	-	-	-	307
5	Nutmeg	-	-	43	54	-	135
6	Cinnamon	-	-	-	22	-	307
7	Pineapple	-	-	-	75	-	8662

Table 6. Production ha⁻¹ in coconut based cropping systems in Dapoli, Maharashtra.

Sr. No.	System component	I	II	III	IV	Sole
1	Coconut (No.)	11,748	11,832	12,424	12,248	12,852
2	Areca nut (q)	7.75	8.12	5.18	5.40	-
3	Black pepper (kg)	110.25	102.90	208.25	237.65	-
4	Banana (q)	-	7.20	-	-	-
5	Nutmeg (No)	-	-	23650	29700	-
6	Cinnamon (kg)	-	-	11.50	11.00	-
7	Pineapple (kg)	-	-	-	503.00	-

Table 7. Gross returns (₹ ha⁻¹) in coconut based cropping systems in Dapoli, Maharashtra. (Figures in parentheses are percentages to total)

Sr. No.	Item of cost	Type or system of lakhibaug				
		I	II	III	IV	Sole
1	Coconut	82,409 (41.62)	82,825 (38.31)	86,974 (27.40)	85,735 (23.58)	89,964 (91.54)
2	Areca nut	85,250 (43.14)	89,320 (41.31)	56,980 (17.95)	59,400 (16.34)	-
3	Black pepper	22,050 (11.66)	20,580 (9.92)	41,650 (13.12)	47,530 (13.07)	-
4	Banana	-	15,120 (6.99)	-	-	-
5	Nutmeg	-	-	1,18,250 (37.72)	1,48,500 (40.85)	-
6	Cinnamon	-	-	4,050 (1.27)	3,850 (1.05)	-
7	Pineapple	-	-	-	7,545 (2.07)	-
8	by-products	8,037 (4.06)	8,343 (3.86)	9456 (2.98)	10,936 (3.00)	8,313 (8.46)
	Total	1,97,577 (100)	2,16,188 (100)	3,17,360 (100)	3,63,496 (100)	98,277 (100)

Special Section

The profit received per hectare at each cost level in different cropping systems was worked out and the information is presented in Table 8.

It was observed that, the per hectare cost of maintenance in sole coconut plantation worked out to be ₹ 51,120. Regarding mixed coconut of orchards, per hectare cost of maintenance estimated as ₹ 80,274 in system-I, ₹ 87,717 in system II, ₹ 1,09,285 in system-III and ₹ 1,23,392 in system-IV. The per hectare profit received in sole coconut cropping at Farm business income, Family labour income and Net farm income level worked out to ₹ 71,380, ₹ 52,250 and ₹ 47,157 respectively. The benefit cost ratio at Net farm income level came to 1.92. In case of System-I per hectare profit at Farm business income level was ₹1,61,693, at Family labour income level ₹ 1,24,494 and that of at Net farm income level, it was ₹ 1,17,203, with benefit cost ratio of 2.45 at Net farm income level. The net income received in cropping system-II at Farm business income, Family labour income and Net farm income level worked out to ₹ 1,77,412, ₹ 1,37,041 and ₹ 1,28,471 respectively, whereas the benefit cost ratio at Net farm income level was found to be 2.46. The net profit received in system III at Farm business income, Family labour income and Net farm income level was ₹ 2,72,820, Rs. 2,18,702 and ₹ 2,08,075 with benefit cost ratio at Net farm income level found to be 2.90. In cropping system-IV, per hectare profit at Farm business income level was ₹ 3,15,957, at Family labour income level was ₹ 2,51,044 and at Net farm income level it was ₹ 2,40,104 with benefit cost ratio of 2.94 at Net farm income level (Talathi and Kshirsagar 2016). The profitability analysis indicated that, in the mixed cropping system, higher and higher profit was realized at each cost level than sole cropping of coconut. It was also realized that in gross return structure, the profit was also directly related to number of crop species grown in the cropping system.

Relative economics of cropping systems

The relative economic analysis was carried out by computing ratio of additional returns to additional cost and results of analysis are presented in Table 9.

It is observed from Table 9 that in system-I by incurring additional cost of ₹ 29,254 ha⁻¹ over sole cropping of coconut, and the coconut grower obtained additional benefit of ₹ 99,300 ha⁻¹. This indicated that by addition of one rupee, a coconut grower was receiving ₹ 3.39 as additional benefit. Among the different identified cropping systems, the system-III and System-IV was most profitable as indicated by highest ratio of additional

return over additional cost.

Impact on income and employment

The effect of mixed cropping in coconut on net income and employment generated over sole cropping of coconut were worked out and presented in Table 10.

It was observed from Table 10 that, the per hectare net income generated in various cropping systems varied from ₹ 70,046 in system-I to ₹ 1,92,947 in system-IV. This addition of income was due to addition of high value crops as mixed crops in coconut based cropping system. The total human labour employment goes on increasing with the addition of crop species in the cropping system. It was 89 human days in sole cropping and it increased to about 161 human days in system-IV. This increase in employment was to the extent of about 41 per cent in system-I, 63 per cent in system-II, 72 per cent in system-III and 81 per cent in system-IV. This additional generation of employment was mainly due to post-harvest activities and mixed crop cultivation in coconut orchards (Talathi and Kshirsagar 2016).

Disposal Pattern and marketing of coconut

Coconut growers in the study area grew coconut along with important mixed crops as arecanut and black pepper on commercial scale. Majority of farmers performed coconut farming as main source of income. Therefore, there is considerable marketable surplus with the coconut grower. Per farm disposal pattern of produce is presented in Table 11.

It is seen from the Table 11 that in all the identified cropping systems the *Lakhi baug* grower has more than 90 per cent marketable surplus of coconut, arecanut, black pepper, Nutmeg and Cinnamon. But in case of banana and pineapple the marketable surplus was 82 and 88 per cent. Therefore, it is revealed that disposal pattern of produce obtained from the crops grown in the identified coconut based cropping system, the maximum quantity of all crops was disposed in the market as marketable surplus, this indicates that the coconut growers in the study area cultivate these crops exclusively for marketing purpose (Naik 2000).

Farmers Success Stories

Shri. Abdul Rasid Hasan Majgaonkar, Village –Karla, Dist-Ratnagiri. Cell: +918888318410

A progressive farmer who had a 1.5 unit area land on which he planted 120 coconut palms in 1980 and adopted *Lakhi baug* concept for utilization of inter-space on advise from Regional Coconut Research Station, Bhatye.

Doubling Farmers' Income (DFI) through DBSKKV Interventions**Table 8.** Profitability in cropping systems (₹ ha⁻¹)

Sr. No.	Particular	Type or system of <i>lakhi baug</i>				Sole
		I	II	III	IV	
I	Gross income	1,97,577	2,16,188	3,17,360	3,63,496	98,277
II	Total cost	80,374	87,717	1,09,285	1,23,392	51,120
III	Net income at					
	a) Farm business income	1,61,693	1,77,412	2,72,820	3,15,957	71,380
	b) Family labour income	1,24,494	1,37,040	2,18,702	2,51,044	52,250
	c) Net farm income	1,17,203	1,28,471	2,08,075	2,40,104	47,157
IV	Benefit cost ratio at					
	a) Farm business income	5.50	5.57	7.64	7.64	3.65
	b) Family labour income	2.70	2.73	3.21	3.23	2.13
	c) Net farm income	2.45	2.46	2.90	2.94	1.92

Table 9. Comparative profitability of (*lakhi baug*) coconut based cropping system over sole cropping of coconut

<i>lakhi baug</i> Cropping system	Total cost	Total return	Add. cost over sole coconut	Add. return over sole coconut	Ratio of add. benefit to add. cost
Sole coconut	51,120	98,277	-	-	-
I	80,374	1,97,577	29,254	99,300	1:3.39
II	87,717	2,16,188	36,597	117,911	1:3.22
III	1,09,285	3,17,360	58,165	219,083	1:3.77
IV	1,23,392	3,63,496	72,272	265,219	1:3.77

Table 10. Income and employment in *Lakhi baug* over sole coconut. (₹ ha⁻¹) (Figures in parentheses are per cent increase over sole coconut)

<i>lakhi baug</i> Cropping system	Net income (₹)		Employment (Human days)	
	Total	Add. over sole crop	Total	Add. over sole crop
Sole coconut	47,157	-	89	-
I	1,17,203	70046 (148.53)	126	37 (41.57)
II	1,28,471	81314 (172.43)	145	56 (62.92)
III	2,08,075	160918 (341.23)	153	64 (71.91)
IV	2,40,104	192947 (409.15)	161	72 (80.89)

Table 11. Disposal pattern of farm produce (0.23 ha)

Particular	Coconut (No.)	Arecanut (kg)	Black Pepper (kg)	Banana (q)	Nutmeg (No.)	Cinnamon (kg)	Pineapple (kg)
Total production	2,810.78 (100)	152 (100)	37.89 (100)	165 (100)	6,135 (100)	2.58 (100)	115.69 (100)
<i>Disposal</i>							
Home consumption	155 (5.51)	2.5 (1.64)	0.23 (0.60)	12 (7.40)	12 (0.19)	0.25 (9.69)	5.50 (4.75)
Wages payment	120 (4.27)	3.7 (2.43)	-	-	-	-	-
Gift	-	3.77 (2.48)	-	17 (10.30)	25 (0.40)	-	8.50 (7.35)
Used as seed	-	4.23 (2.78)	-	-	-	-	-
Marketable surplus	2535.70 (90.21)	137.80 (90.65)	37.66 (99.39)	136 (82.42)	6098 (99.27)	2.33 (90.31)	101.69 (87.90)

Special Section

He planted 70 nutmegs, 25 black peppers, 15 cloves and produced an average 300 fruits of nutmegs, 2 kg black pepper and 5 kg clove from single plants with near about 120 nuts palm⁻¹ produced every year. According to him, management to intercrops will help in improving the health and yield of coconut. He has attended workshop, training, *melavas* etc. organized by Regional Coconut Research Station, Bhatye. His farm was selected for important of experimental research trials. He is having 40 years farm experience. In the year 1980 he actually started farming by getting the knowledge from Regional Coconut Research Station, Bhatye. Now he is having 1.5 acre land under coconut cultivation with *Lakhi Baug*

Shri. Digambar Kamlakar Kane, Dist-Ratnagiri. Cell: +919422508504

A well-known progressive and innovative farmer who has adopted multi-cropping to perfection and profitability after resigning from teaching job due. He has a 40 year farm experience during this period only on farm income, he purchased 20 acre land. He purchased coconut seedlings from Regional Coconut Research Station, Bhatye. Now he own a total 40 acre farm in which he planted 220 coconut. His space utilization strategy is marvelous and his garden is eye catcher for a beginner who wishes to practice systematic cropping system. He is producing many by-products of coconut mostly through local dealers or on farm marketing. According to him, in cropping systems attention to individual crops and management of key inputs in every crop is essential for the sustained yield of main and component crops. Overall he has generated more than 25 lakh income from farm and allied business every year. His field was selected for experimental trials particularly effectivity of pheromones traps against rhinoceros beetle and red palm weevils.

Mr. Hemant Yadnyeshwar Phatak, Dist-Ratnagiri

Cell: +919545639715

Aged 55, this sincere learned farmer has tremendous farming experience of about 30 years. He is an active member in all research farmer activities of the RCRS, Bhatye. He strongly believes that inclusion of mixed crops is necessary for enhancing the productivity and profitability from unit area using locally available resources. According to him, black pepper, pineapple, banana are ideal intercrops in coconut garden as they are perennial and suits to coconut eco-system. These crops are maintained with minimum investment for realizing additional income regularly over the year. Soil fertility is maintained by effective recycling of the

biomass generated within the farm through mulching, composting, vermicomposting, husk burial techniques etc. He is able to manage the farm with fewer incidences of pest and diseases in coconut and component crops. He is producing elite and quality coconuts. Productivity of coconut realized from his farm is 125 nuts palm⁻¹ year⁻¹. He has attributed his success in coconut farming to intercrops and involvement of family. He is producing coconut oil for his family consumption. He is having vermicomposting pits and a dairy enterprise. He is resource person for training, *melavas*, workshops.

Way forward

The farmers have adopted the technology of *Lakhi baug* and have taken various intercrops which could help the doubling of farmers income. The research station disseminated the University technology through various extension activities such as short term training, vocational training, Scientist farmer forum, one day training programme, method demonstration, farmer field visit, radio talks, TV talks, newspaper, folder publication and published articles etc.

Scope for increasing area under coconut cultivation

There is a great scope for increasing area under coconut cultivation due to the small irrigation reservoirs and fresh river water is available for irrigation of coconut in all four districts of Konkan region. Productivity of coconut is high in the Konkan region but this productivity can be increased to about 20,000 nuts ha⁻¹ with intensive care and management, intercropping, and pest control. Product diversification is need of hour like tender coconut water, coconut powder, coconut charcoal, virgin coconut oil, tender ball copra, coconut chips, coir industry etc. Use of multispecies cropping system to increase yield per unit area of orchards is required.

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