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केरोफअसं
CPCRI

50 Years
of
Research Achievements
of

CPCRI Research Centre, Mohitnagar (1958-2008)

Edited and compiled by :

Dr. Arun Kumar Sit
Dr. Gobinda Ch Acharya
Dr. H. P. Maheswarappa

CENRAL PLANTATION CROPS RESEARCH INSTITUTE
RESEARCH CENTRE,, MOHITNAGAR,
JALPAIGURI-735102, WEST BENGAL, INDIA

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Dr George V. Thomas
Director
Central Plantation Crops Research Institute
Kasaragod-671 124, Kerala

Edited and compiled by

Dr. Arun Kumar Sit
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CENRAL PLANTATION CROPS RESEARCH INSTITUTE
RESEARCH CENTRE, MOHITNAGAR
JALPAIGURI-735102, WEST BENGAL, INDIA
E-mail : cpcrircm@yahoo.com.in
Fax : 03561-250198
Phone : 03561-250698
03561-250115

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FOREWORD

Arecanut, coconut and spices are small holder's plantation crops which provide livelihood security, employment opportunities and sustainable income for the farming community in the tropical regions of the country. The Sub-Himalayan Terai Region of West Bengal also has agroclimatic conditions favourable for cultivation of these crops and they are being grown under homestead condition in this region.

Lack of awareness of scientific cultivation practices is the major limiting factor for the low productivity of majority of the crops in this region. The plantation crop sector offers wide scope for intercropping, mixed farming, organic agriculture, environmental conservation, product diversification, and entrepreneurship development. The Central Plantation Crops Research Institute, Research Centre (formerly Central Arecanut Research Station), Mohitnagar was established in 1958 to undertake research with the objective of developing location-specific and purpose-specific technologies in the field of plantation crops for realization of self-sustainability among the farming community. Over the last 5 decades, the centre has developed a number of viable technologies which include release of improved variety, scientific crop management practices, cropping system models and crop protection technologies, and disseminated the technologies through transfer of technology programmes to farmers. The book entitled “Fifty years of research achievements of CPCRI RC Mohitnagar” will be helpful to the farmers, researchers and entrepreneurs as a ready reckoner for technologies which will be useful for improving the productivity of plantation crops and spices of the region.

(Dr. George V Thomas)
Director
CPCRI

Central Plantation Crops Research Institute, Research Centre, Mohitnagar, Jalpaiguri

Historical Background

The arecanut industry in India was in a serious crisis when the Second World War broke out. The Government of India set up an Ad-hoc committee in 1947 to study the problems and to suggest preliminary measures to bring about improvement in arecanut industry and protect it from crisis. On the recommendation of this committee, the Indian Central Arecanut Committee was constituted. Subsequently the Central Arecanut Research Station (CARS) was established in 1957 by the Indian Central Arecanut Committee at Vittal (Karnataka). The Regional Station, Mohitnagar was established in 1958 to carry out research activities at Sub-Himalayan Terai Region of West Bengal and provide support to the Vittal station.

The Central Plantation Crops Research Institute (CPCRI) was established in 1970 by the Indian Council of Agricultural Research (ICAR) by merging Central Coconut Research Stations at Kasaragod and Kayangulam, and the Central Arecanut Research Station (CARS), Vittal and its five Regional Stations at Palode, Peechi, Hirehalli, Mohitnagar and Kahikuchi. The CPCRI was then assigned additional responsibilities for conducting and co-coordinating research on other crops such as cashew, cocoa, oil palm and spices. The ICAR had taken over these research stations in 1966 from the Central commodity committees on coconut and arecanut following the abolition of commodity committees. When the CPCRI was established with its headquarters at Kasaragod (Kerala) in 1970, the research stations at Vittal and Kayangulam were designated as its Regional Stations and the five regional stations of CARS, (viz., Palode, Peechi, Hirehalli, Mohitnagar and Kahikuchi) as Research Centres. The headquarters is located 5 km north of Kasaragod and 42 km south of Mangalore on the Mumbai-Kanyakumari National Highway (NH 17) in Kudlu Village, Kasaragod district, Kerala. The Research Centre, Mohitnagar is located 7 km north-west of Jalpaiguri town in Jalpaiguri District, West Bengal. It is situated by the side of NH 31 at about 40 kms away from Siliguri and about 35 kms away from the New Jalpaiguri Railway Station. The nearest airport is at Bagdogra, about 65 kms away from this research centre. It lies on 26^0N latitude and 88^0E longitude and at an altitude of 91.3m above mean sea level. The area is a typical representative of Sub-Himalayan Agro-climatic condition and is receiving an average annual rainfall of about 3000-3200 mm, 90 per cent of which is received during South-West monsoon. The mean maximum temperature varies from 18^0C to 38^0C and the mean minimum temperature ranges between 6^0C and 26^0C. The soil is predominantly of alluvial type with a pH range of 4.5-6.0.

Expansion

This centre was established during 1958 with an area of 24.42 acres taken over on a 99 years lease basis from the District Seed Farm, Government of West Bengal under Mouza-Patkata, Khatian No.-19. The centre was started in a rented house at Mohitnagar, 3 km away from the present site and was the then headed by Sri S.C. Paul, Research Officer along with two other associates. The farm area was expanded during the year 2000 by taking possession of additional 39.97 acres of land from the Department of Land and Land Reforms, Govt. of West Bengal (Mouza-Patkata, Sheet no-19, JL No-5, Mouza-Bahadur, Sheet No-6, JL No-4) by depositing an amount of Rs. 61135/- towards *salami*. The process of the transfer of land was initiated by Dr S.P.Ghosh, Former DDG (Hort.), and actively executed by Dr.K.U.K.Nampoothiri, Former Director of CPCRI and Dr. C.R. Biswas, the then Scientist-in-Charge of the centre. At present, the centre has land area of 64.47 acres consisting of two low-lying areas and water-bodies of 4.60 acres and the major crops being grown are coconut, arecanut, pepper (as mixed crop), banana and acid lime (as intercrop).

Present Setup

The centre has one scientific, two administrative, five technical (including one farm superintendent and a driver) and six supporting staff and is headed by Scientist-in-charge. The centre has a well-equipped tissue culture laboratory and all essential equipments like laminar flow, autoclave, incubator, micro-wave oven, digital and electronic balance, TC racks, glass-wares etc. are available. Apart from these, facilities for N and K analysis,UV spectrophotometer, incubator, arecanut dehusker, arecanut drier, stereoscopic microscope, pH meter and magnetic stirrer also exists. During the year 2003, a new laboratory-cum-administrative building has been constructed. The centre has also an old farm office to house the technicals and other staffs, two drying floor, store rooms, one two-bedded guest room, and one Type-IV quarter. For carrying out basic research, a mist house, a two net house with a capacity to accommodate 12, 000 seedlings at a time, has been added in recent times.

This centre has a farm house and facilities such as 7.5 HP power tiller, a weed/bush cutter, a lawn mower, coconut climbing devices, sprayers, 4 diesel-operated irrigation pump sets, 5 electric operated irrigation pump sets, 2 generators of capacity 10 KV and 20 KV, five shallow tube wells, etc. During 2004, a V-Sat system has been set-up for un-interrupted network connectivity among various research organizations. The system is linked to all the three computers functioning at this centre. An EPBAX system has also been installed for smooth communication among the staffs. A dispensary with major essential medicines and a part-time medical officer is available at this centre to cater to the medical needs of the staff members and their families. The centre has a modest library with seating arrangement for 8 persons. The library has strength of about 700 books and 17

periodicals subscribed every year.

Mandate

The centre was started with the following objectives:

1. To tackle agronomical, pathological, botanical and other regional problems
2. To improve the yield and quality of arecanut in the region
3. To formulate, suggest and organize control measures against common pests and diseases affecting areca in the region
4. To evolve suitable manurial, cultural and irrigational schedules for adoption by the areca growers
5. To investigate any other problems of economic importance to areca growers of the region
6. To raise quality areca seedlings out of seed nuts collected from pre-marked mother palms and distribution to areca growers of the region and
7. To serve as an information centre on all matters relating to plantation crops.

However, with the merger of the centre with the Central Plantation Crops Research Institute, the mandate of the centre has been revised as given below;

- To standardize sustainable production and protection technologies for arecanut and coconut for Sub-Himalayan Terai Region
- To maintain and evaluate the germplasm of arecanut for better yield performance
- To evaluate germplasm of coconut suitable for the region
- Production of quality planting materials
- Scope for introducing non-traditional profitable intercrops under arecanut and coconut gardens
- To develop location specific palm based cropping system for better profit and
- To transfer proven technologies to the farming community.

The research achievements made in different crops is summarized below:

1. Arecanut

Crop Improvement

a) Collection, conservation, cataloguing and evaluation of arecanut germplasm

Arecanut (*Areca catechu* L.) is one of the important commercial crops of the country mainly grown in the states of Karnataka, Assam, Kerala, Meghalaya, West Bengal, Tamil Nadu and Konkan region and A&N group of Islands. Genetic variability, longer pre-bearing phase and high initial investment are some of the bottlenecks in realising higher economic returns. It is therefore desirable to have cultivars/varieties with high yielding potentials. Genetic manipulation for higher yield and quality through varietal evaluation and selection is one of the known methods of crop improvement. Arecanut cultivars both indigenous and exotic are being evaluated for economic traits at CPCRI Regional Station, Vittal, CPCRI Research Centre, Mohitnagar and CPCRI Research Centre, Kidu.

Evaluation of germplasms of arecanut under Sub Himalayan Terai Region of West Bengal was started during 1981. At present, a total of 71 accessions are being maintained and planted in a row system consisting of 10 palms for every accession. The initial results showed that among the accessions planted during 1988, Mohitnagar performed well with respect to number of inflorescences, number of nuts produced and fresh weight of nuts. Among the accessions planted during 1990, maximum chali weight (0.68 kg/palm) was produced in Kamrup followed by VTL-21. Among the accessions that planted during 1991, maximum chali weight (1.67 kg/palm) was produced in VTL-13 followed by VTL-13 (in) (1.14 kg/palm). VTL-29(f) performed better producing 0.99 kg of chali/ palm, among the accessions that planted during 1992. Among the accession planted during 1994, maximum harvest was obtained from Nalbari (1.87 kg of chali/ palm) followed by K & J Hills (1.67 kg chali) and Kamalpur (1.46 kg). Among the accessions which were planted during 1997, maximum number of nuts (186.25) was produced by SCRDTC followed by CAL-7 (164.11 nos.). Another 32 indigenous accessions of arecanut was also planted in a randomized block design with three replications for their further evaluation.

b) Release of Arecanut variety "Mohitnagar"

The most outstanding contribution of this research centre towards the farming community is the release of arecanut variety "Mohitnagar" during the year 1991. The evaluation of indigenous accession resulted in identifying high yielding and consistent cultivar 'Mohitnagar' which was

introduced to CPCRI Regional Station, Vittal during 1962 and based on its better performance; it was introduced to Seed Farm Kidu during 1972, 1983 and 1985 in three batches.

Mohitnagar variety is a tall cultivar with long internodes (Table 1). The spread of the crown is higher than Mangala with longer leaves. This cultivar has great potential with high female flowers production. The nuts are comparatively bigger and heavier than other released varieties with a mean kernel weight of 8.96 g. The striking feature of this cultivar is its greater uniformity. The bunches are well placed and nuts are loosely arranged on spikes which help in uniform development of nuts and also aids in efficient plant protection measures. This cultivar has become popular among farmers in coastal districts of Kerala, Karnataka and West Bengal.

Table 1: Growth and yield characteristics of Mohitnagar cultivar

Sl.No	Characters	Range	Average
1	Crown shape	Tall, Partially drooping	
2	Girth above fixed mark	8.6 - 15.5	12.79
3	Internodal length (cm)	7.3 - 26.5	16.60
4	No. of. leaves	8.0 - 12.0	9.90
5	No. of. leaflets	L 29.0 - 49.0	39.70
		R 27.0 - 57.0	40.80
6	Length of the oldest leaf (cm)	135.0 - 240.0	179.50
7	Breadth of oldest leaf (cm)	50.0 - 151.0	83.00
8	Leaf sheath Length (cm)	60.0 - 118.0	93.30
9	Leaf sheath Breadth (cm)	30.0 - 62.0	45.90
10	No. of female flowers/palm	480.0 - 1562.0	1093.10
11	No. of bunches/year	3.0 -10.0	6.60
12	Colour of ripe nut	Orange	
13	Nut shape	Oval - round	
14	Fruit length (cm)	4.7 - 6.8	5.30
15	Fruit Breadth (cm)	3.8 - 5.3	4.40
16	Fresh Fruit wt. (g)	28.1 - 75.4	36.80
17	Husk thickness (cm)	0.4 - 1.4	0.88
18	Kernel length	2.2 - 2.7	2.10
19	Kernel Breadth (cm)	2.2 - 3.5	2.29
20	Dry wt. of kernel (g)	6.2 - 12.4	8.96

The performance of Mohitnagar cultivar was studied at different regions like Vittal, Kidu (Karnataka) (Table 2), Mohitnagar (WB) (Table 3) and Dapoli (Maharashtra). The yield performance at Kidu and Vittal revealed that, the percentage increase in yield over Mangala was 70 and 15%, respectively. Similarly, this cultivar also registered an increase of 17% over Mangala at Dapoli Centre of Maharashtra. The performance at Mohitnagar is superior as it had recorded 75 % more yield over other released varieties.

Table 2: Performance of Mohitnagar cultivar and released varieties at Kidu (Average of 8 cropping seasons)

Characters	Variety/Cultivar			
	Mangala	Sumangala	Sreemangala	Mohitnagar
Cumulative ripenut yield/palm (kg)	70.56	103.44	102.56	120.64
Mean ripenut yield/palm/year (kg)	8.82	12.93	12.82	15.08
Mean Chali yield/palm/year (kg)	2.02	3.28	3.10	3.67
% increase over other varieties	70.98	16.63	17.63	--

Table 3: Performance of Mohitnagar cultivar and other released varieties at Mohitnagar (Average of 9 cropping seasons)

Characters	Variety/Cultivar			
	Mangala	Sumangala	Sreemangala	Mohitnagar
Cumulative ripenut yield/palm (kg)	32.80	35.80	28.62	63.25
Mean ripenut yield/palm/year (kg)	3.64	3.98	3.18	7.03
% Increase over other varieties	92.86	76.67	127.00	--

Variety Mohitnagar in full bearing and individual bunch and fruits

Mohitnagar variety has been released for commercial cultivation in areca growing areas of Karnataka, Maharashtra, Kerala and also North Bengal region during 1991, due to its higher yield potential compared to earlier released varieties viz., Sumangala, Sreemangala and Mangala. Compact blocks of this cultivar have already been established at Regional Station, Vittal, Research Centre, Kidu and Research Centre, Mohitnagar for generation of planting material. *Inter se* mating is suggested in order to produce genetically superior pure planting materials.

Standardization of the nursery techniques in arecanut

The following aspects were studied at the centre to standardize nursery techniques in arecanut through various experiments:

- Determination of optimum depth of sowing nuts in the primary nursery
- Influence of effect of different positions of sowing the seed nuts
- Influence of the age of trees on the seed nut performance
- Determination of the frequency of the seed nuts having different floating habits, factor influencing such habits and their relative merits
- Performance of seed nuts gathered at different stage of maturity for seed purpose
- Effect of different spacing-cum-efficacy of sowing unsprouted and sprouted seeds on seedling performance
- Standardization of media for the nursery
- Effect of weight of the seed nuts on vigor and germination and
- Degree of root damage (at the time of uprooting for transplanting) of areca seedlings and their subsequent establishment.

The results revealed that seed nuts and position of seed nuts in the bunch collected from the bottom and middle portion of the second bunch of middle aged and old aged palms, gave higher percentage of germination. Comparison of seedlings raised from seed nuts collected from young, middle aged and old aged palms proved that, seedlings were superior to those raised from young palms. Slanting and vertical floating nuts gave better germination percentage over the horizontal floating nuts. The experimental results on performance of the seed nuts gathered at different stages of maturity revealed that matured nuts are superior to fully matured and immature nuts in germination. It has also been observed that seed nuts sown horizontally at top depth and slanting at top depth were better than the other treatments, though root development was poor compared to those sown at 1" and 2" depths. Seed nuts sown in sprouting buds gave higher percentage of germination and better quality seedlings than those that were directly sown. Seed nuts sown in soil media were found to be the best. Germination percentage and vigour of seedlings were found to be the best in beds with complete and partial shade over open condition. Seed nuts treated with cow-dung slurry and immediate sowing gave higher percentage of germination.

Effect of soil mixtures on germination and growth of arecanut seedlings in nursery

(a) Primary Nursery Management

Influence of different soil mixtures in seedbeds revealed that, the parameters like plant height, plant girth, leaf production, leaf length, leaf width, root length and root number did not differ significantly. However, root volume and per cent vigorous seedlings produced differed significantly due to influence of seed bed. The root volume ranged between 2.00 in the treatment containing raised soil bed topped with FYM + ALM (arecanut leaf mulch) to 2.55 in the treatment containing raised soil bed topped with sand + ALM and raised soil bed topped with VC + ALM. The treatment, raised soil bed + FYM + ALM supported highest vigorous seedlings (89.88%) followed by 86.3% germination in raised soil bed topped with sand + ALM. About 76.25 % vigorous seedlings only produced in treatment containing raised sand bed with ALM.

Table 4: Germination profile of arecanut influenced by different soil mixtures

Treatment	Per cent germination							% vigorous seedlings
	50DAS	60DAS	70DAS	80DAS	90DAS	100DAS	110DAS	
T1: Raised Sand bed + ALM	0.50 (4.05)	7.63 (16.00)	36.88 (37.41)	58.13 (49.66)	68.25 (55.73)	77.88 (61.96)	79.13 (62.80)	**76.25 (60.87)**
T2: Raised soil bed + ALM	0.38 (3.53)	7.25 (15.56)	31.88 (34.39)	52.00 (46.15)	66.75 (54.82)	80.63 (63.87)	84.13 (66.50)	**82.63 (65.35)**
T3: Raised soil bed + topped with sand + ALM	1.00 (5.74)	16.5 (23.97)	43.38 (41.21)	50.75 (45.46)	70.13 (56.85)	86.00 (68.03)	87.63 (69.38)	**86.30 (68.28)**
T4: Raised soil bed + topped with VC +ALM	0.88 (5.38)	18.88 (25.70)	33.38 (35.30)	55.25 (48.04)	76.88 (61.27)	89.25 (70.91)	91.00 (72.54)	**89.88 (71.47)**
T5: Raised soil bed + FYM + ALM	0.75 (4.97)	15.63 (23.26)	42.50 (40.69)	57.13 (49.08)	70.63 (57.17)	80.13 (63.51)	81.88 (64.82)	**80.50 (63.79)**
CD (0.05)	--	6.33	7.64	--	--	--	7.78	**7.91**

Table 5: ***Growth parameters of areca seedling influenced by different soil mixtures***

Treat.	No. leaf	Plant height (cm).	Leaf length (cm).	Leaf width (cm).	Stem girth (cm).	No. roots	Root length (cm).	Root vol. (ml)	Fresh plant weight (g).	Fresh root weight (g).	Plant dry weight (g).	Root dry weight (g).
T_1	1.50	32.59	21.35	7.95	4.92	7.20	19.16	2.45	5.84	2.15	1.35	0.71
T_2	1.38	35.79	20.23	8.61	5.24	8.28	16.40	2.50	6.77	2.11	1.70	0.58
T_3	1.55	30.95	24.00	8.33	5.21	7.40	18.43	2.55	6.13	2.33	1.24	0.60
T_4	1.60	35.73	20.23	8.28	5.39	8.45	16.03	2.25	5.63	2.16	1.28	0.56
T_5	1.50	33.50	23.20	8.15	5.15	7.75	15.48	2.00	6.03	1.85	1.24	0.56
F-test	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

(b) Secondary Nursery Management

The experimental results on standardization of suitable potting mixture for raising arecanut seedlings in the secondary nursery indicated that, higher number of leaves were produced (4.59) in a potting mixture containing top soil + FYM besides more plant height (57.27 cm), long leaves (44.20 cm), wider leaves (13.2 cm) and more plant girth (7.73). The other parameters viz. root number, root volume, plant and root dry weight under study did not differ significantly (Table 6). Root weight varied significantly among all the treatments from 13.37 cm (T_{14}) to 26.00 cm (T_1). Significant result was obtained in root fresh weight for all the treatments. Maximum root fresh weight (6.32 g) was found in T_3, whereas, minimum weight (3.02 g) was obtained from T_6.

Table 6: Growth of Areca seedlings influenced different potting mixtures

Treat.	No. leaf	Plant height (cm).	Leaf length (cm).	Leaf width (cm).	Plant girth (cm).	Root number	Root length (cm).	Root Fresh wt. (g).	Root vol. (ml).	Plant Fresh wt. (g).	Plant dry (g).	Root dry (g).
T_1	**4.25**	**41.30**	**33.26**	**11.00**	**6.16**	11.53	26.00	5.28	2.20	26.93	5.12	2.04
T_2	**4.59**	**57.27**	**44.20**	**13.20**	**7.73**	12.40	19.09	4.47	2.20	36.07	7.94	2.49
T_3	**3.76**	**37.52**	**31.86**	**10.08**	**5.95**	13.33	25.60	6.32	2.73	22.40	4.70	1.98
T_4	**4.43**	**48.67**	**38.57**	**12.49**	**7.71**	12.07	23.94	5.19	2.23	37.30	6.71	1.71
T_5	**4.32**	**45.64**	**35.10**	**11.06**	**6.58**	11.33	19.87	4.95	1.87	32.47	6.71	2.07

Treat.	No. leaf	Plant height (cm).	Leaf length (cm).	Leaf width (cm).	Plant girth (cm).	Root number	Root length (cm).	Root Fresh wt. (g).	Root vol. (ml).	Plant Fresh wt. (g).	Plant dry (g).	Root dry (g).
T_6	**4.27**	**42.41**	**35.40**	**10.49**	**6.56**	11.60	20.38	3.02	1.60	29.33	6.31	1.35
T_7	**4.25**	**42.37**	**35.47**	**11.21**	**6.58**	12.07	19.02	2.43	1.55	28.03	5.28	1.04
T_8	**4.49**	**46.95**	**36.68**	**10.97**	**6.87**	12.47	22.63	3.13	2.23	41.80	5.05	1.38
T_9	**4.23**	**42.43**	**33.83**	**11.47**	**6.56**	12.33	17.15	4.64	2.37	33.53	7.70	2.00
T_{10}	**4.15**	**42.40**	**32.43**	**10.48**	**6.64**	13.37	23.81	3.67	2.05	31.83	6.65	1.57
T_{11}	**4.15**	**42.41**	**33.13**	**10.22**	**6.43**	12.07	20.17	3.82	2.37	30.30	6.35	1.77
T_{12}	**4.08**	**40.79**	**32.57**	**10.09**	**6.52**	11.33	19.60	3.61	1.96	27.37	5.76	1.63
T_{13}	**4.15**	**42.90**	**32.80**	**11.29**	**6.54**	18.99	18.99	5.79	2.37	32.82	4.79	2.98
T_{14}	**4.03**	**43.13**	**32.74**	**10.20**	**6.37**	13.37	13.37	3.36	1.21	34.23	5.91	1.50
F-test	*	*	*	*	*	**NS**	*	*	**NS**	**NS**	*	**NS**
CD (0.05)	0.26	2.60	3.06	1.00	0.83	--	**4.279**	**2.066**	--	--	**5.650**	--

T1- Top soil, T2- Top soil + FYM, T3- Top soil + sand, T4- Top soil + FYM + sand, T5- Top soil + coir pith + FYM, T6- Top soil + areca husk + FYM, T7- Top soil + vermicompost + sand, T8- sand + FYM, T9- sand + Vermicompost, T10- sand + coir pith + FYM, T11- Sand + areca nut husk + FYM, T12- Sand + coir pith + vermicompost, T13- sand + areca nut husk + vermicompost and T14- control (Traditional seed bed method.

Nutritional requirement of arecanut

The experiment was started with an objective of standardizing the fertilizer requirement for arecanut and was laid out in 3^3 x2 x3 factorial design during 1967 with three levels of N (0,50,100 kg/500 palms), three levels of P_2O_5 (0,20,40 kg/500 palms) and three levels of K_2O (0,70,140 kg/500 palms) as main treatment and two levels of lime (0, 1 kg/palm) as sub-plot treatment, however application of lime was discontinued from 1977 onwards.

a) Impact on morphological characters

Potassium was found to have marked influence on girth at permanent mark, last exposed node, internodal distance below crown, length of oldest leaf and maximum length of leaflet. Nitrogen application increased the number of leaves, leaflets and internodal distance considerably. Internodal distance below the crown, number of nodes and maximum breadth of leaflets were the

only characters significantly affected by lime application. The first two characters also revealed the influence of fertilizers and lime interaction.

b) Impact on reproductive characters

Effect of K was found to have significant effect on number of bunches, nuts harvested and weight of nuts. Application of potassium @K_1 level gave significantly more number of bunches and weight of nuts than K_0 and K_2 levels. Application of lime is found to reduce the value for all the characters, significantly. As regards to the interaction effect, only NL was found to be significant for weight of nuts whereas N_1L_0 found to give significantly more weight of nuts than N_0L_1, N_1L_1 and N_2L_1.

Nutritional requirement of high yielding varieties of arecanut

The Experiment was conducted during the years 1993 to 2005, in a Strip Plot Design with three replications with two years old seedlings of four arecanut varieties planted during 1993. Five fertilizer treatments (No fertilizer, Half of the recommended fertilizer, full dose of fertilizer, $1^{1/2}$ dose of recommended fertilizer and Double dose of recommended fertilizer) were imposed during the experimentation period. A fixed dose of 20 kg FYM was also applied to all the palms. Besides these, 50 g borax was also applied in alternate year after rains. Inorganic fertilizer was applied in two split, one before rain and another after the rain. Yield and yield attributing characters were recorded at post bearing stage. The yield and yield attributing characters of four arecanut varieties differed significantly among the different doses of fertilizer (Table 7). In case of production of inflorescence and productive inflorescence, it was found that maximum number of inflorescence (4.13) was seen in Sreemangala at recommended doses of fertilizer but the productive inflorescence was very less (1.81), which was followed by Mohitnagar (4.12) at the same dose of fertilizer. In all the varieties, at no fertilizer dose, production of inflorescence was minimum than the treatment where fertilizer was applied. Retention of inflorescence (productive inflorescence) was more in Mohitnagar than the other varieties. Significant difference was observed among the varieties and fertilizer doses and there was interaction effect between variety and doses of fertilizers. In case of nut production, it was observed that, with the increase in fertilizer doses, there was increased nut production per palm up to a certain level. In case of Mangala and Mohitnagar, the maximum nut production (254.27 and 377.33 respectively) was observed at recommended dose of fertilizer, whereas in case of Sumangala and Sreemangala, it was at one and half dose of recommended fertilizer and half of the recommended fertilizer dose, respectively. Chali production was increased with the increase in the fertilizer dose up to certain level, and then there was gradual decrease of chali production with the increase of fertilizer dose. Maximum chali

production (3.75 kg/palm/year) was recorded by Mohitnagar variety at recommended doses of fertilizer followed by Mangala (2.20kg) on same level and Sumangala (1.68 kg) and Sreemangala (1.57 kg) at one and half dose of recommended fertilizer and half of the recommended fertilizer, respectively. There was significant interaction effect between variety and fertilizer in this parameter. From the present investigation, it can be concluded that for Mohitnagar and Mangala varieties, full dose of fertilizer (100:40:140 as N:P:K, respectively) and for Sumangala and Sreemangala one and half of recommended fertilizer (150:60:210 as N:P:K, respectively), respectively is require to obtained maximum chali yield per palm per year under sub Himalayan Terai Region of West Bengal.

Treat Ment	No. Inflo.	Number of prod. Inflorescence	Number nuts/palm	Length of Nuts (cm)	Breadth of nuts(cm)	FreshWeight of nuts (g)	Nut vol(ml)	Kernel length (cm)	Kernel width (cm)	Fresh kernel weight (g)	Dry. kernel Wt (g)	Fresh husk weight (g)	Dry husk weight (g)	Chali Yield (kg/palm/year)
V1T0	3.17	1.94	123.67	5.08	4.13	40.00	51.38	2.53	2.9	13.567	6.90	**26.43**	6.37	0.861
V1T1	3.86	2.33	155.87	5.14	4.14	42.73	51.73	2.44	3.05	13.900	7.87	**28.84**	5.83	1.249
V1T2	3.83	2.59	254.27	5.4	4.42	48.00	55.47	2.46	3.03	15.833	8.43	**32.17**	5.70	2.196
V1T3	3.87	1.78	139.80	5.68	4.38	45.17	50.83	2.55	2.85	15.470	7.90	**29.7**	6.60	1.101
V1T4	3.81	2.52	197.77	5.84	4.32	50.13	58.57	2.7	2.92	15.767	8.20	**34.37**	7.13	1.659
V2T0	2.61	1.40	086.70	5.30	4.16	45.73	49.70	2.54	2.66	10.867	6.10	**34.87**	7.10	0.527
V2T1	3.97	2.43	186.60	5.55	4.34	45.67	52.10	2.62	2.87	12.900	8.07	**32.77**	7.17	1.504
V2T2	4.02	2.63	162.33	5.62	4.03	38.33	46.87	2.62	2.84	13.367	7.50	**24.97**	5.30	1.209
V2T3	3.95	2.32	211.77	5.45	4.34	51.40	54.33	2.58	2.84	12.667	8.07	**38.83**	7.03	1.677
V2T4	3.94	2.26	149.00	4.50	3.72	40.03	36.97	2.51	2.37	09.900	7.00	**30.13**	5.90	1.045
V3T0	3.3	1.67	070.90	5.39	4.31	43.83	51.03	2.61	2.95	11.767	8.47	**32.07**	7.00	0.593
V3T1	3.98	2.56	185.67	5.65	3.78	40.27	41.97	3.0	2.48	15.433	8.57	**24.83**	5.83	1.573
V3T2	4.13	1.81	101.57	6.14	4.21	45.90	45.03	2.69	2.91	17.433	8.77	**28.47**	6.87	0.848
V3T3	3.91	1.57	078.20	5.58	4.05	41.60	51.30	2.94	2.9	16.600	9.40	**25.03**	5.93	0.703
V3T4	3.65	1.56	112.00	5.30	4.04	39.90	48.00	2.55	2.68	13.500	7.60	**26.40**	6.47	0.915
V4T0	3.45	2.45	125.70	5.39	4.36	50.63	57.97	2.64	2.85	14.800	8.83	**35.83**	7.53	1.040
V4T1	3.99	2.41	248.70	5.65	4.54	54.57	63.57	2.71	2.94	15.230	9.27	**39.33**	8.30	2.254
V4T2	4.12	2.88	377.33	6.14	4.33	59.33	55.67	2.80	3.37	16.500	9.93	**42.83**	7.83	3.747
V4T3	4.07	2.66	343.80	5.58	4.29	54.67	52.37	2.87	2.97	16.000	9.70	**38.67**	6.63	3.005
V1T4	3.78	2.62	249.00	5.30	4.54	53.60	64.90	2.9	2.92	15.500	8.40	**38.10**	7.73	2.060
CD-V	0.910	0.565*	205.72*	0.738*	0.411*	13.31*	12.41*	0.541	0.455*	5.0051*	2.842*	10.32*	1.85*	2.197*
CD-F	0.680*	0.580*	097.91*	0.347*	0.517	11.90	12.12	0.543	0.217*	2.4631*	1.126*	09.58	2.11	0.784*
CD-VxF	0.173	0.580*	095.85*	0.392*	0.527	08.93	14.59	0.279	0.302*	3.2489	0.775*	07.16*	1.72	0.855*
CV-V	12.09	12.80	57.84	6.66	4.88	14.31	11.95	10.90	7.97	17.460	17.240	16.02	13.80	73.90
CV-F	09.60	14.12	29.21	3.32	6.50	13.56	12.38	10.20	4.04	09.118	07.252	16.23	16.77	27.99
CV-VxF	07.93	15.60	31.95	4.20	7.40	11.37	16.65	06.19	6.25	13.440	05.574	13.19	15.26	34.12

Comparative study of different green manure and cover crops

The investigation on suitable green manure and cover crops in arecanut garden viz., a) *Mimosa invisa*, (b) *Calopogonium mucunoides*, (c) *Pueraria javanica*, (d) *Sesbania speciosa* and (e) *Stylosanthes gracilis* and their organic matter production capacity revealed that, *Pueraria javanica* yielded the maximum amount of green matter among the five green manure crops grown (Table 8). In general *Pueraria javanica* and *Mimosa invisa* were found to the best green manuring crops from the point of view of nutrient addition and yield of green matter.

Table 8: Yield of green matter and nutrient removal from soil for different green manure crops

Name of the crops	Mean yield (t/ha)	Moisture (%)	Nutrient composition			Nutrient removal (kg/ha)		
			N	P	K	N	P	K
Calopogonium mucunoides	7.14	78.37	2.63	0.23	2.80	4.50	3.46	43.12
Pueraria javanica	14.35	79.01	3.30	0.24	1.63	99.33	7.22	49.06
Stylosanthes gracilis	12.81	79.40	2.42	0.23	1.63	63.64	5.91	42.87
Mimosa invisa	12.62	77.63	3.96	0.34	2.00	111.67	9.44	56.40
Sesbania speciosa	5.18	77.50	2.70	0.17	1.12	31.32	1.97	12.99

Arecanut based cropping system

The natural resources such as soil, sunlight and air space are not fully utilized when arecanut is grown as a monocrop. There is ample scope for cultivation of other crops in the interspaces of arecanut gardens for effective utilization of natural resources and to maximize the productivity and profitability from a unit area of plantations. The orientation and structure of arecanut canopy permits 32.7-47.8 per cent of incident radiation to penetrate down depending on the time of the day. In arecanut plantations spaced at 2.7x2.7 m, only 30% of the land area is utilized by roots of arecanut. Cropping system trials conducted in the centre revealed the feasibility of growing different annuals and perennials as inter/mixed crops in arecanut garden. The following crop combinations were tried for SubHimalayan Terai Region of West Bengal:

Model I	Arecanut + black pepper + Banana (Cv Champa) + Cocoa
Model II	Arecanut + black pepper + Banana (Cv Malbhog) + lime (Gandharaj)
Model III	Arecanut + betel vine + Banana (Cv Malbhog) + turmeric
Model IV	Arecanut + black pepper + Banana (Cv Malbho) + Coffee
Model V	Arecanut + betel vine + Banana (Cv Malbhog) + cinnamon
Model VI	Arecanut alone

The economic yield data for 10 years revealed that mean arecanut yield per hectare was highest (1842.41 kg dry chali) in Model V followed by Model II and Model III (Table 9). The mean dry pepper yield was highest in Model I as compared to other models. Mean yield of banana in different models varied between 699.0 to 2059.85 kg/ha. Highest yield of banana was recorded in Model V. With regard to other intercrops, cocoa provided an average yield of 9055 number of pods, lime yielded 6983 number of fruits, turmeric yielded 1966.57 kg fresh rhizome, coffee gave 95.58 kg dry seeds and 65.54 kg dry cinnamon was produced in relevant models. The different economic parameters indicated that the input cost in different models ranged between Rs. 5703/- in Model VI (monocrop) and Rs 25,870/- for Model II. The mean net returns over 10 years in different models varied between Rs 52473/- to Rs 84705 per hectare (Table 10).

Arecanut based HDMSCS Model

Table 9: Yield of arecanut and component crops in different models under HDMSCS per hectare

Model	Produce	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	Mean
Model-I	Areca chali (kg)	838.90	1445.20	1073.00	2130.72	2262.00	1938.00	1153.00	2491.00	1446.00	1395.00	1617.28
	Dry pepper (kg)	801.90	27.26	120.00	361.41	104.00	30.00	270.00	666.00	434.00	78.00	309.26
	Banana fruit (kg)	833.00	---	---	---	---	---	---	804.00	467.00	692.00	699.00
	Cocoa pods (nos)	11967	24417	11923	4210	2760	---	---	---	---	---	9055.00
Model-II	Areca chali (kg)	1364.29	1700.23	1038.00	2592.53	2456.00	2559.00	908.00	2691.00	1392.00	1004.00	1781.60
	Dry pepper (kg)	408.30	136.15	143.00	384.52	44.00	8.00	184.00	752.00	553.00	16.00	262.90
	Banana fruit (kg)	1784.00	1453.60	957.00	751.20	1485.00	1245.00	572.00	807.00	809.00	980.00	1084.37
	Gandharaj lime (nos.)	5469	16857	---	20521	2696	2568	1016	---	685	6050	6983.00
	Banana suckers (nos.)	437	181	---	---	---	---	172	105	---	---	223
Model-III	Areca chali (kg)	1764.35	1759.54	1105.00	2448.60	2053.00	2734.00	1465.00	1784.00	1567.00	1025.00	1770.20
	Betel leaf (nos.)	139595	131569	153354	339417	219518	503533	53680	32796	48738	4922	162711.80
	Banana fruit (kg)	1792.00	1395.12	547.00	1314.00	2846.00	3028.00	2592.00	2065.00	1864.00	462.00	1790.40
	Turmeric fresh (kg)	2397.00	2396.94	2411.00	2746.90	2025.00	1558.00	1471.00	1676.00	1141.00	1843.00	1966.57
	Banana suckers (nos.)	219	---	---	---	---	---	315	213	---	---	249
Model-IV	Areca chali (kg)	1541.02	1387.81	1426.00	2198.70	2092.00	2760.00	1380.00	1503.00	1380.00	1070.00	1673.81
	Dry pepper (kg)	---	---	---	3.99	20.00	---	106.00	90.00	86.00	26.00	55.27

Model	Produce	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	Mean
Model-IV	Banana fruit (kg)	3184.00	3650.91	2304.00	2018.10	656.00	406.00	2358.00	2152.00	2427.00	1442.00	2059.85
	Dry coffee (kg)	255	35.09	30.00	103.78	111.00	128.00	48.00	110.00	69.00	56.00	95.58
	Banana suckers (nos.)	218	1066	---	---	---	---	352	441	---	---	519
Model-V	Areca chali (kg)	2012.82	1570.39	1318.00	2131.25	2054.00	2887.00	1842.00	2182.00	1417.00	1010.00	1842.41
	Betel leaf (nos.)	118471	152600	267211	343591	389194	471018	77660	47313	57587	14445	3669.14
	Banana fruit (kg)	3102.00	2902.55	2983.00	1773.20	656.00	34.00	1820.00	1892.00	2166.00	1652.00	1898.06
	Dry cinnamon (kg)	18.60	6.55	---	---	---	---	62.00	---	175.00	---	276.00
	Banana suckers (nos.)	218	---	---	---	---	---	207	405	---	---	65.54
	Cinnamon layers (nos.)	---	5030	---	5453	1813	4357	---	---	---	4280	4185.60
Control	Areca chali (kg)	598.13	819.48	670.00	1792.49	1668.00	2430.00	993.00	1764.00	1446.00	954.00	1313.551

Model	Parameters	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	Mean
Model-I	Input	19053.00	19861.00	13506.00	14440.00	16397.00	1533.00	25150.00	28592.00	40183.00	21975.00	21152.00
	Net return	31330.00	75247.00	36919.00	55064.00	70726.00	47885.00	57057.00	152235.00	131045.00	168502.00	83601.00
	Percent increase over control	318.78	108.76	45.70	10.91	38.00	-32.23	25.49	197.74	78.13	55.53	19.98
Model-II	Input	24130.00	19709.00	19363.00	18955.00	23669.00	19228.00	28371.00	36882.00	43538.00	24803.00	25870.00
	Net return	23424.00	75542.00	39802.00	77823.00	72762.00	66049.00	37825.00	194733.00	150714.00	108388.00	84705.00
	Percent increase over control	260.00	109.58	23.60	56.75	42.00	-6.52	-16.81	280.86	104.87	0.04	85.44
Model-III	Input	12385.00	11409.00	13680.00	13556.00	19775.00	18609.00	23973.00	15886.00	25528.00	36692.00	20149.00
	Net return	26405.00	80900.00	51190.00	72346.00	68984.00	88547.00	72961.00	51026.00	79418.00	94858.00	68664.00
	Percent increase over control	306.04	124.44	58.90	45.72	64.00	25.32	60.46	-0.20	7.52	-12.44	65.02
Model-IV	Input	15315.00	12456.00	16645.00	14591.00	18840.00	18635.00	26017.00	27940.00	41067.00	27742.00	21924.00
	Net return	18423.00	64635.00	58921.00	58796.00	70560.00	79505.00	71540.00	55999.00	74069.00	120111.00	67256.00
	Percent increase over control	183.30	79.32	82.90	18.43	37.00	12.52	57.34	9.52	0.68	10.86	49.19
Model-V	Input	12480.00	9284.00	10436.00	8951.00	15954.00	15087.00	20232.00	24705.00	27054.00	26993.00	17116.00
	Net return	31808.00	95359.00	88649.00	90291.00	70972.00	104505.00	103544.00	60795.00	85737.00	126454.00	85811.00
	Percent increase over control	389.13	164.56	175.20	81.86	39.00	47.90	127.72	18.90	16.54	16.71	107.75
Control	Input	3777.00	3006.00	4138.00	4269.00	7225.00	5645.00	6719.00	8190.00	7978.00	6086.00	5703.00
	Net return	6503.00	36044.00	32207.00	49646.00	51167.00	70659.00	45469.00	58129.00	73565.00	108340.00	52473.00
	Percent increase over control	----	-----	----	-----	----	-----	-----	-----	-----	-----	-----

Recycling of biomass under arecanut based HDMSCS indicated that a huge quantity of green biomass derived form weeds, leaf and other plant parts can be recycled. It has been estimated that the biomass to a tune of 14154 kg to 25797 kg per hectare is available per year (Table 11).

Table 11: Recycling of Bio-mass in different HDMSCS Models

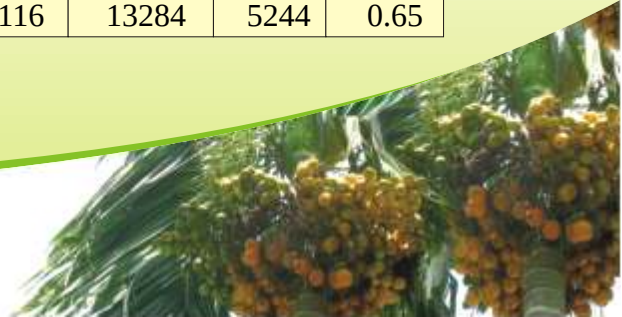
	Biomass (Kg/ha)					
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Control**
Leaf	11656	31071	11255	13925	11219	5711
Weeds	1207	3529	2740	2541	3967	6487
Total	12863	34600	13995	16466	15186	12198

Performance of different annual and perennial intercrops under arecanut garden

The performance of different intercrops was tested under irrigated and un-irrigated conditions. Yield of all the crops grown under irrigated condition was higher than un-irrigated condition. Among the perennials tested, black pepper, cocoa, coffee, banana (cv. Malbhog and Champa), acid lime (cv. Gandharaj) were suitable and most profitable intercrops, which were to be considered to grow under areca based cropping system. Out of the three annual crops, turmeric performed better than the others. The performance of various intercrops under irrigated system were in the order of black pepper> cocoa> acid lime, cv. Gandharaj >banana cv. Malbhog,>banana cv Champa> coffee>turmeric> pineapple> banana cv Cavendish>betel vine> banana cv Kanchakala>elephant foot yam> arrowroot. Best performing and economically viable crops suggested for marginal farmers are black pepper, banana (cv Malbhog and Champa) and acid lime cv. Gandharaj (Table 12).

Table 12: Yield and economics of different intercrops under arecanut based HDMSCS (average of 3 years)

SLNo.	Crops		Input (Rs./ha)	Yield (ha)	Output (Rs./ha)	NR (Rs.)	NR/RI
1.	Black pepper (kg-dry)	IR	4900	481	31664	26764	5.46
		UR	4085	350	21450	19015	4.65
2.	Betel vine (Nos. leaves)	IR	3906	512516	5125	1219	0.31
		UR	3742	366535	3665	-77	-0.02
3.	Lime- Gandharaj (Nos.fruit)	IR	11700	93932	28180	16480	1.40
		UR	11300	79572	23871	12571	1.10
4.	Banana- Malbhog (kg)	IR	8320	16554	24636	16316	1.96
		UR	7928	12048	22704	14776	1.86
5.	Banana- Champa (kg)	IR	8284	13446	22620	14336	1.73
		UR	8040	7116	13284	5244	0.65



SLNo.	Crops		Input (Rs./ha)	Yield (ha)	Output (Rs./ha)	NR (Rs.)	NR/RI
6.	Banana- Cavendish (kg)	IR	9412	9022	13196	3784	0.40
		UR	9044	6744	9594	550	0.60
7.	Banana- Kanchkala (kg)	IR	7424	3582	5372	-2052	-0.28
		UR	7180	3014	4520	-2660	-0.37
8.	Cocoa (Nos.-pods)	IR	4450	32202	25010	25010	4.60
		UR	4334	24160	22560	22560	4.20
9.	Coffee (kg-dry bean)	IR	5136	596	14296	9780	1.90
		UR	4788	380	9500	4712	0.98
10.	Pineapple (kg)	IR	7624	18200	13892	6262	0.82
		UR	6928	12584	9712	2784	0.40
11.	Arrowroot (kg)	IR	9740	8136	2034	-7706	-0.79
		UR	9168	7302	1826	-7342	-0.80
12.	Elephant foot yam (kg)	IR	16567	6206	12422	-4122	-0.25
		UR	16192	5770	11542	-4650	-0.29
13.	Turmeric (kg)	IR	12640	9580	19160	6520	0.52
		UR	11868	8228	16456	4588	0.39

IR- Irrigated **UR**- Unirrigated **NR**- Net Return **RI**- Rupee invested

Comparative study of different turmeric cultivars in areca based cropping system and open field

Among the eleven cultivars/lines namely, Sudarsana (V_1), Prabha (V_2), Prathibha (V_3), Suvarna (V_4), Alleppey (V_5), Kasturi (V_6), CL-24 (V_7), CLS-2A (V_8), CLS-3D (V_9), Suguna (V_{10}) and Local (V_{11}) were planted in 9 m x 1m beds in the interspaces of 35 years old areca garden and in open spaces in the centre. Rhizomes were planted at a spacing of 20 cm plant to plant and 20 cm row to row. The cultivar 'Suguna' gave the highest yield (29.04t/ ha.) followed by CLS-2A (27.41 t/ ha.) and Kasturi (26.22 t/ha.) under areca shade and the cultivar 'Sudarshan' produced maximum fresh rhizomes (44.53 t/ha.) followed by 'Suguna' (38.53 t/ ha.) and Kasturi (38.05 t/ha.) in open conditions (Table 13).

Table 13: Growth, yield and yield attributing characters of different turmeric cultivars/lines under areca nut garden

Sl. No	Cultivars /lines	Days to first emergence of shoot	Days to 90% shoot emer-gence	Plant height (cm)	No. of lvs	No. of primary fingers	No. of secondary fingers	Rhizome weight (g)	Yield per plant (g)	**Yield (t/ha)**
1	Sudarsana **(V_1)**	59.67	88.50	184.50	12.00	6.67	18.33	79.00	323.83	26.09
2	Prabha**(V_2)**	59.50	87.00	151.83	12.00	8.50	19.33	61.50	276.50	21.40
3	Prathibha **(V_3)**	63.33	88.00	160.17	11.17	7.00	10.33	87.00	224.67	25.84
4	Suvarna **(V_4)**	60.17	88.17	171.00	11.33	7.00	17.00	62.67	213.33	22.28
5	Aleppey **(V_5)**	61.83	87.00	175.67	11.50	6.17	11.33	87.33	231.77	22.77
6	Kasturi **(V_6)**	62.50	87.67	154.83	11.83	7.33	15.00	113.00	308.50	26.22
7	CL-24 **(V_7)**	60.50	91.00	162.17	11.83	6.00	12.17	84.67	272.67	26.09
8	CLS-2A **(V_8)**	65.17	91.33	163.83	12.33	7.83	17.17	93.33	332.33	27.41
9	CLS-3D **(V_9)**	62.67	87.00	154.33	11.67	5.83	11.33	94.67	278.33	25.95
10	Suguna **(V_{10})**	79.67	97.33	126.17	11.50	5.50	14.33	83.33	424.50	29.04
11	Local **(V_{11})**	61.67	89.67	149.83	11.50	6.50	13.33	81.67	241.33	23.32
CD (0.05)		1.841	2.087	12.676	NS	1.221	3.492	22.027	89.438	4.558

Table 14: *Growth, yield and yield attributing characters of different turmeric cultivars/lines in open space*

Sl. No	Cultivars /lines	Days to first emergence of shoot	Days to 90% shoot emer-gence	Plant height (cm)	No. of lvs	No. of primary fingers	No. of secondary fingers	Rhizome weight (g)	Yield per plant (g)	**Yield (t/ha)**
1	Sudarsana **(V_1)**	61.00	84.25	162.8	12.3	7.98	19.08	87.90	432.08	44.53
2	Prabha**(V_2)**	60.50	87.00	117.3	11.3	7.55	18.63	62.93	239.13	24.25
3	Prathibha **(V_3)**	59.00	86.75	125.8	10.5	6.78	9.50	92.53	255.40	30.15
4	Suvarna **(V_4)**	59.50	86.00	121.8	11.0	7.18	23.00	57.10	229.60	26.50
5	Aleppey **(V_5)**	61.00	88.00	138.3	11.8	6.25	15.33	86.68	293.75	34.43
6	Kasturi **(V_6)**	60.50	86.25	134.5	12.3	6.68	11.68	117.08	312.00	38.05
7	CL-24 **(V_7)**	58.00	87.25	129.3	12.3	7.00	12.25	112.93	310.83	35.10
8	CLS-2A **(V_8)**	62.00	88.00	138.8	11.8	6.83	11.43	124.68	293.33	33.03
9	CLS-3D **(V_9)**	59.00	86.75	126.8	11.5	6.43	11.33	110.85	302.50	28.90
10	Suguna **(V_{10})**	78.50	92.00	114.0	11.0	5.25	13.50	141.63	382.90	38.53
11	Local **(V_{11})**	59.00	86.25	134.3	12.0	6.58	14.78	135.00	312.50	33.45
CD (0.05)		**3.037**	**2.02**	**13.41**	**NS**	**1.279**	**5.529**	**34.983**	**90.744**	**5.967**

Vegetable intercropping in arecanut garden

Different summer and winter vegetables like *Basella*, lady's finger and different types of gourds like ridge gourd, snake gourd, bitter gourd, bottle gourd, pumpkin and ash gourd and different winter vegetables like radish, carrot, beet, spinach, amaranth, rai sak, cabbage, cauliflower, knolkhol and dolichos bean were raised in arecanut garden (about 36 years old) during 2002-03 to test the feasibility of their successful cultivation. Bower was prepared using arecanut palm as pole to reduce the cost of bower preparation. Cucurbitaceous vegetables were in alternate rows with spacing of 2.7 m plant to plant and 5.4 m row to row. Bowers were made for vine crops using arecanut stem as pole and beds were prepared in between two rows of arecanut (1-1.2 m).

Among the three winter leafy vegetables (palak, amaranth and rai sak (mustard)), maximum yield was obtained from palak (200 q/ha) with a benefit cost ratio of 1.39. The benefit cost ratio of other two leafy vegetables were 0.58 and 0.68, respectively. Among the root crops, radish, carrot and beet, maximum yield was recorded in radish (650.5q/ha) followed by turnip and carrot. Among these three crops maximum crop duration was recorded in turnip, followed by radish and carrot. The benefit cost ratio of radish, turnip and carrot was 2.33, 2.09 and 1.64, respectively. Among the four cole crops, longer crop duration (111 days) was recorded in cabbage whereas in other cole crops it was only 70-80 days. The maximum yield was recorded in cabbage (437.5 q/ha) with a maximum benefit cost ratio (3.44). Among the pulse vegetables, maximum benefit cost ratio was observed in dolichos bean (1.39) followed by french bean (1.08). Among the summer season vegetables, the maximum out put was recorded from pumpkin (Rs. 65480/- per ha) followed by ash gourd (Rs 27225 /- per ha), bottle gourd (25962 /- per ha) and snake gourd (Rs. 24850/- per ha) with a benefit cost ratio of 2.39, 1.59, 1.17 and 1.53, respectively. The present study clearly demonstratedf that the cultivation of almost all the vegetables particularly leafy vegetables like palak and basella, cole crops, gourds and chilli in arecanut garden are profitable.

Cabbage in open and areca shade condition


Palak in open and areca shade condition


Sem in open and areca shade condition


Tomato in open and areca shade condition

Table 15: Input and output cost of different vegetables grown in arecanut garden

Crop	Duration (Days)	Yield (Rs./ha)	Input (Rs./ha)	Output (Rs./ha)	Net return (q/ha)	B:C ratio
Winter Season						
Spinach	107	200.00	33500	80000	46500	1.39
Amaranth	135	119.10	30126	47640	17514	0.58
Rai sak	76	175.00	31250	52500	21250	0.68
Sprouting brocoli	70	97.40	32500	68180	35680	1.10
Knolkhol	80	205.67	32590	82268	49678	1.52
Cauliflower	79	187.00	35400	74800	39400	1.11
Cabbage	111	437.50	29580	131250	101670	3.44
Raddish	101	650.50	19550	65050	45500	2.33
Carrot	92	148.50	22500	59400	36900	1.64
Turnip	130	207.50	20150	62250	42100	2.09
Tomato	104	182.50	32500	82125	49625	1.53
Chilli	175	180.50	31400	108300	76900	2.45
Brinjal	170	270.50	31050	81150	50100	1.61
Capsicum	120	53.90	35250	80850	45600	1.29
Lab lab bean	190	101.50	21200	50750	29550	1.39
French bean	118	134.20	38800	80520	41720	1.08
Summer Season						
Cowpea	120	42.20	22100	25320	3220	0.15
Basella	80	192.30	21000	76800	55800	2.66
Okra	134	150.00	31000	90000	59000	1.90
Bottle Gourd	142	96.20	22150	48112	25962	1.17
Ash gourd	145	74.00	17175	44400	27225	1.59
Snake Gourd	137	51.37	16250	41100	24850	1.53
Pumpkin	155	232.20	27400	92880	65480	2.39
Bitter gourd	136	35.60	20800	28480	7680	0.37
Ridge Gourd	142	42.30	16250	33840	17590	1.08

Traditional vegetables and nutrition security

Many of the traditional vegetables remain underutilized in India. **The Himalayan region is one of the hotspots of biodiversity.** Knowledge of wild edible plants is essential to utilize them as food and in this aspect, attempt was made to report details of 43 species of plants belonging to different families commonly used in Jalpaiguri District located in Sub Himalayan Terai Region of West Bengal. Leaf, tender shoots or flowers of these plants are used as vegetables. Market potential, season of availability, common, vernacular and botanical name of the plants are also described along with a brief note on ethnobotany (Table 16).

Table 16: List of traditional vegetables used for edible purpose

Sl. No	Botanical name	Common name	Vernacular names	Habit	Family	Part used	Season
1	*Allium cepa L.*	Onion	Piyaj koli	Bulbous herb	Alliaceae	Leaves & flowers	Winter
2	*Allium sativum L.*	Garlic	Rasun	Bulbous herb	Alliaceae	Leaves	Winter
3	*Alternanthera philoxeroides (Mart.) Griseb.*	Aligator weed	Bagan Note, Sanche	Herb	Amaranthaceae	Leaves	All the year
4	*Amorphophallus campanulatus Bl.*	Elephant foot yam	Baj/Ool	Tuberous herb	Araceae	Leaves	Summer & rainy
5	*Azadirachta indica A.Juss.*	Neem	Neem	Tree	Melicaeae	Leaves and twigs	All the year/spring
6	*Bacopa monnieri L.*	Brahmi	Brahmi	Herb	Scrophulariaceae	Leaf and twig	Summer & rainy
7	*Bambusa arundinacea*	Bamboo	Bansh	Herb	Poaceae	Young sprout	Spring summer
8	*Benincasa hispida(Thunb.)*	Ash gourd	Chalkumra	Trailing Herb	Cucurbitaceae	Tender shoots & flowers	Summer & rainy
9	*Beta vulgaris L.*	Indian spinach	Palon	Herbs	Chenopodiaceae	Root and leaves	Winter
10	*Brassica juncea L.*	Mustard	Sarson sag	Herb	Brassicaceae	Tender leaves	Winter
11	*Calamus rotang*	Cane	Bet	Shrubs	Arecaceae	Tender stem	Winter
12	*Centella asiaticaL.*	Centella	Thankuni	Herb	Apiaceae	Leaves	Summer & rainy

Sl. No	Botanical name	Common name	Vernacular names	Habit	Family	Part used	Season
13	*Cephalandra indica*	Telakucha	Telapata	Climber	Cucurbitaceae	Twig and leaf	All the year
14	*Chenopodium album L.*	Lamb's quarters	Bathua	Herb	Chenopodiaceae	Leaves	Winter
15	*Cicer arietinum L.*	Bengal gram	Chhola	Herb	Fabaceae	Twig	Winter
16	*Colocasia esculenta(L.) Schoot.*	Colocasia	Kachu Sag	Tuberous Herb	Araceae	Tender leaf/leaf sheath and flower	Summer & rainy
17	*Corchorus olitoriusL.*	Jute	Pat sag	Shrub	Tiliaceae	Tender leaves	Summer & rainy
18	*Coriandrum sativum*	Coriander	Dhania	Herb	Apiaceae	*Leaves*	Winter
19	*Cucurbita moschata*	Pumpkin	Misti kumra	Trailing herb	Cucurbitaceae	Tender shoot and flower	Summer & rainy and winter
20	*Diplazium esculentum Sev., (Plate. 1)*	Fern vegetable	Dhenki sag	Herb	Athyriaceae (Pteridophyte)	Tender leaves (twig)	Summer & rainy
21	*Enhydra fluctans Lour.*	Marsh herb	Helencha	Herb	Asteraceae	Tender leaves	Summer & rainy
22	*Fagopyrum esculentum*	Buckwheat	Dhemsi	Herb	Polygonaceae	Tender leaves	Winter
23	*Gmelina arborea*	Malay Bush Beech	Geema	Tree	Verbenaceae	Tender leaves	Summer & rainy
24	*Hygrophila auriculata (Plate 4) H. spinosa*	Gokulakanta	Kulekhara	Herb	Acanthaceae	Tender leaves	Summer & rainy
25	*Ipomoea aquatica (plate. 3)*	Water Spinach	Kalmi Sag	Herb	Convolvulaceae	Tender shoots	Summer & rainy
26	*Ipomoea batatas*	Sweet Potato	Misti alu	Climber	Convolvulaceae	Tender shoot	Rain to winter

Sl. No	Botanical name	Common name	Vernacular names	Habit	Family	Part used	Season
27	*Lactuca sativa*	Lettuce	letus	Herb	Compositeae	Leaves	Winter
28	Lagenaraia siceraria	Bottle gourd	Lau	Climber	Cucurbitaceae	Twigs	All the year
29	*Leucas aspera Rees*	Gumma	Dandacolus	Herb	Lamiaceae	Tender leaves	Summer & rainy
30	Luffa acutangula	Ribbed gourd	Jhinga	Vines/ shrub	Cucurbitaceae	Tender twig	Summer rain
31	*Marsilea minuta L.*	Dwarf watercloverr	Susuni	Herb	Marcileaceae	Leaves	Summer rain
32	*Mentha arvensis L.*	Mint	Pudina	Herb	Lamiaceae	Leaf	Winter
33	*Moringa oleifera Lam.*	Drumstick	Sajina sag	Short tree	Oleaceae	Leaves & Flowers	Summer & rainy
34	*Musa sp., L.*	Banana	Kola	Herbus perennail	Musaceae	Pseudostem, male flowers	All the yaer
35	*Nyctanthes arbor-tristis L.*	Coral	Seulipata	Shrub	Nyctanthaceae	Twig	All the year
36	*Nymphaea nouchali*	Water lily	Sapla	Herb	Nymphaeaceae	Stalk and flower	All the year
37	*Pandanus amary llifolius*	Indian pandan	Bhog patta	Herb	Pandanaceae	Leaf	All the year
38	*Pisum sativum*	Pea	Matar	Herbs	Fabaceae	Tender leaves	Winter
39	*Raphanus sativus L.*	Radish	Mulo	Shrub	Raphanaceae	Leaves	Winter
40	*Sechium edule Sw.*	Chayote / chow chow	Chow chow	Climber	Cucurbitaceae	Tender leaves	Summer & rainy
41	*Solanum tuberosum L.*	Potato	Alu sag	Shrub	Solonaceae	Tender leaves	Winter
42	*Urtica sp.,*	Nettle	Bichhuti	Climber	Urticaceae	Twigs	Rainy season

Intecropping of Kacholam (*Kaemferia galanga* L.) in arecanut garden and open condition

The vegetative characters as well as yield and yield attributing characters of kacholam were superior when it was grown in arecanut garden than open condition. This indicates that partial shade is required for the growth and yield of this crop. Number of primary fingers, width and weight of primary fingers were more when it was grown in shade condition, whereas only the width of primary fingers was more in open condition. Number of secondary fingers was recorded more (16.5/clump) in shade condition than open condition (13.5/clump). Clump weight and yield/ha was more (62.5 g and 12.5 t/ha, respectively) when kacholam was raised in arecanut shade condition than the open condition where 50 g clump weight and 10.7 t/ha yield was recorded. Higher yield of kacholam in shade condition attributed with the superior performance of yield attributing characters of kacholam in arecanut shade condition. Hence, the cultivation of kacholam as intercrop in arecanut garden is advisable.

Insect and mammalian pest complex under HDMSCS System

Insects associated with different models of arecanut based cropping system have been recorded and monitored every fortnightly. Important insects recorded on cocoa are the defoliator complex consisting of hairy caterpillars and flea beetles. Leaf minor is a serious pest on acid lime from June to December, and the other insects of serious nature are flea beetles, aphids and leaf caterpillars. In case of cinnamon, flea beetles and various types of leaf caterpillars are serious. Scale insects are serious in coffee starting from May to December. In case of banana, leaf caterpillars, lace wing bug, flea beetles and fruit scarring beetle are serious. Thrips are recorded round the year on pepper but are not serious in nature. No insect of serious nature is recorded in turmeric except a rare case of termites.

The control measures are decided depending upon the incidence and severity of the insect and the same is implemented to suppress the insect population. Thiodon on cocoa, cinnamon and banana; Ekalux on coffee and Rogor and Neem oil on acid lime were sprayed for control of insect pests, where as, zinc phosphate baits were used for rat control.

Integrated management of white grub in coconut and arecanut

Different chemicals like Thimet 10g and 20g, Chloropyriphos-4 ml and 8 ml, Carbosulfan 4 ml and 8 ml and Neem cake @ 2 kg per palm were applied to study the control of white grub in the coconut and arecanut basin. It was observed that application of Thimet @ 20g/palm could be able to reduce the grub population most significantly and is followed by the application of Carbosulfan @ 8 ml per palm. However, the highest per cent grub was killed by the application of Thimet 20g followed by Thimet 10g and Carbosulfan @ 8ml per palm.

Table 17: Effect of plant protection chemicals on the grub population

Treatment	Grub population/plot			% grub killed after	
	Initial	*75DAT*	*45DAT*	*75DAT*	*45DAT*
Thimet-10 G	12.33	8.67	7.00	29.2	42.4
Thimet-20G	12.33	7.00	4.67	43.2	61.9
Chloropyriphos-4ml	11.33	10.00	8.67	11.9	23.8
Chloropyriphos-8ml	11.67	8.67	7.67	25.2	33.9
Carbosulfan-4ml	11.00	8.67	7.33	21.2	33.4
Carbosulfan-8ml	11.33	8.00	6.67	28.9	40.6
Neem cake-1 kg	11.00	9.67	8.33	12.2	26.8
Control	11.67	11.33	11.00	3.0	5.8
C.D. (0.05)	NS	1.17	1.18	12.2	14.3

Leaf extracts of locally available weeds/ herbs were tried to see their effect on grub mortality in order to reduce the application of chemicals. It was noticed that leaf extract of *Bombyx sp* gave 100 per cent mortality after 48 hrs of application while leaf extract of an orchid (unidentified) gave cent per cent mortality after 96 hrs, whereas, leaf extract of vanda resulted 100 per cent mortality after 120 hrs of application. After 24 hrs of application 25 per cent grub mortality was observed in *Citrus maxima, Lantana camara, Alstonia scolaris, Cascuda sp and Cajanus cajan,* whereas, 50 per cent mortality was observed in cases of application of *Calotropis* and *Bombyx* sp leaf extract.

Effect of polythene bagging on yield and intensity of scarring beetle of banana

The attack due to fruit scarring beetle in banana not only reduces the yield, but also lessens the consumer preference due to the ugly-look of the fruits, eventually reducing the market value. The experiment was carried out to study the efficacy of the polythene bagging on the incidence of the scarring beetle as well as the yield of three commercially important banana cultivars. It has been observed that variety Malbhog (AAB) was very much susceptible to this pest specifically during rainy season. The results revealed that bagging with polythene packs (200 gauge thickness) at the time of emergence of inflorescence up to the harvesting of the bunch reduces the pest attack to almost zero. This practice also helps in increasing the finger thickness, finger weight, and ultimately the bunch weight. The biochemical characters did not vary much when compared to normal process of ripening.

2. Coconut

a) Survey, collection and conservation of coconut germplasm

In order to enrich the germplasm bank of coconut, an exhaustive survey was carried out over the

coconut growing tracts of North Bengal and South Bengal. A total of 15 numbers of distinct germplasms were identified and collected in phase wise. The germplasms are being maintained at CPCRI, Kasaragod and RC Mohitnagar for further evaluation.

b) Performance of D x T coconut cultivars

A study was conducted during nineties to observe the performance of the D x T coconut cultivars under the region. It has been established that under good management practices the palms performed well giving an average yield of 80-100 nuts per palm per year.

Crown chocking disorder in coconut

The disorder appears first in the spindle whose tip become blunt and necrotic. However, the first observable symptom in young palms of 2-3 years of age is the emergence of shorter leaf with scorching tips in pinna and this is followed by emergence of more smaller leaves. Crowding of leaves around the apex and displacement of petiole of young fronds result in chocking of crown. In palms of 3-10 years of age, the crowding of leaves may not occur immediately after the emergence of the first reduced leaf with scorched tips in its pinna. Distinctive hooks appear at the apex of one or more pinna on subsequent leaves. The laminar tissues of the hook may be folded. The hook may be corrugated, with corrugation affecting both the mid-rib and lamina. Hooks are mostly visible in terminal pinna, although they can occur in any position of the frond. In advanced stage of the disorder there is gradual loss of leaflets, leaves without pinna give stick like appearance. In acute cases of the disorder the reduced and young abnormal leaves crowd around the bud giving a chocked appearance. In chocked condition of the palm, the bud gradually dies.

Comparison of leaf B levels of samples collected from disordered area with that of healthy area indicates that leaf B concentration is much less in disordered area whereas the B concentration is well within the critical limits in palms of healthy area, thereby suggesting that boron might be a limiting factor in crown chocking disorder of coconut. The Ca/B ratio for the leaf rank N/2 or (N+1)/2 is significantly lower for healthy palms when compared to the disordered palms. Analysis of soil samples indicated that the soils of disordered palms had lower pH and lower content of all the available nutrients when compared with the nutrient content present in soils of healthy palms, the differences were significantly only for P, K, Cu, Zn, Mn and Fe.

Management

Application of borax 50g in the soil just after the appearance of the disorder has shown recovery of the palms. In slightly advanced stage of the disorder, two applications of borax at the interval of 3-4 months could result in the redemption of the disorder. The recovery was also facilitated by incising the hardened portion and loosening the crowded leaves. These include inherent deficiency of boron in the soil, acidic nature of the soil, high rainfall and leaching of nutrients during rainy season and planting of coconuts in low-lying areas where water stagnates during rainy season.

Table 18: Leaf nutrient concentration of healthy and disordered palms

Sample	N	P	K	Ca	Mg	Fe	Zn	Mn	Cu	B	Total no of leaves
	(%)					*(ppm)*					
Healthy	1.70	0.13	1.66	0.37	0.18	232	37	153	8.2	7.9	17
Disorderd	1.78	0.14	1.46	0.35	0.22	202	34	180	8.2	6.3	11
't' value	NS	NS	NS	NS	NS	NS	NS	NS	NS	2.288*	3.007**

Table 19: Leaf B concentration of palms in healthy and disordered areas

Sample	Leaf rank	Leaf B content (ppm)
Disorderd area		
Healthy palms	N/2 or (N+1)/2	7.4*
Disorderd palms		5.4*
Healthy area		
Healthy palms	N/2 or (N+1)/2	9.4
	14^{th} leaf	10.2

Table 20: Ca/B ratio of healthy and disordered palms

Sample	Leaf rank	Ca/B ratio in equivalent weights
Disorderd area		
Healthy palms	N/2 or (N+1)/2	95**
Disorderd palms		145**
Healthy area		
Healthy palms	N/2 or (N+1)/2	71

Table 21 : Available nutrient content of soils collected from healthy and disordered palms

Sample	Organic C (%)	Avail P	Avail K	Ca	Mg	Cu	Zn	Mn	Fe	B	pH
		(ppm)		*Exchangable (meq/100g)*		*Available (ppm)*					
Healthy	1.15	128.9	111.4	1.6	0.4	2.3	3.6	5.3	76.8	0.22	5.0
Disorderd	1.11	65.9	53.3	1.0	0.3	0.9	0.8	2.1	43.1	0.19	4.9
't' value	NS	2.37*	2.68*	NS	NS	2.24*	2.16*	2.98**	3.00**	NS	NS

3. Oil palm

Comparative performance of different hybrid combinations of oil palm

Oil Palm is a comparatively new introduction to Sub-Himalayan Terai Region of West Bengal. An understanding of the yield potential of this crop is very much essential for planning future strategies including establishment of processing facilities in this part of the country.

Field evaluation was initiated during 1988 with 8 combinations of *dura* and *pisifera* oil palm. The combinations tried were 128 x 283, 26 x 98, 11 x 1, 41 x 5, 271 x 266, 34 x 1, 3 x 5 and 128 x 1. Pooled data of 4 years revealed, maximum number of bunches (8.27/ palm/ year) in the combination 26 x 98. The interaction effect was found to be non-significant for this character with a maximum 11.50 number of bunches produced by the combination 26 x 98 during 2000. A pooled data on the average bunch weight revealed maximum bunch weight (13.02 kg.) in the hybrid combination 11 x 1 followed by 34 x 1. The maximum bunch weight (14.76 kg/palm) recorded during 2000 from the hybrid combination 34 x 1 led to oil yield of 3.35 t/ha (Table 22). The studies, therefore, showed that oil palm can be successfully grown in Sub-Himalayan Terai Region of West Bengal with an expected yield of 3.0-3.5 mt palm oil per hectare per year, even under rainfed condition. Since moisture stress is one of the main factors in limiting female flower production, the yield can be improved by supplementary irrigation.

Table 22: Total FFB/ palm and estimated oil yield as influenced by different hybrid combinations of oil palm

Hybrid combination	Total FFB/palm/ year (kg)				*Mean*	Estimated oil yield (t/ ha)				*Mean*
	1997	*1998*	*1999*	*2000*		*1997*	*1998*	*1999*	*2000*	
128 x 283	33.10	73.50	129.50	137.51	*93.40*	0.81	1.81	3.19	3.36	*2.29*
26 x 98	46.03	66.26	140.83	144.88	*99.50*	1.13	1.63	4.05	3.56	*2.59*
11 x 1	47.03	61.51	141.88	145.66	*99.02*	1.16	1.51	3.49	3.59	*2.44*
41 x 5	34.22	75.63	112.38	120.59	*85.71*	0.85	1.86	2.77	2.99	*2.12*
271 x 266	51.51	59.03	121.09	128.59	*90.06*	1.27	1.46	2.98	3.11	*2.20*
34 x 1	46.26	74.60	144.61	151.24	*104.18*	1.14	1.84	3.56	3.72	*2.56*
3 x 5	38.50	59.03	126.94	142.31	*91.69*	0.95	1.46	3.13	3.34	*2.22*
128 x 1	35.66	64.49	1236.02	128.49	*88.66*	0.88	1.59	3.10	3.16	*2.18*
Mean	*41.54*	*66.76*	*130.41*	*137.41*		*1.02*	*1.64*	*3.28*	*3.35*	

	Year	Treat	Y x T		Year	Treat	Y x T	
ESm (±)	3.434	NS	NS		0.094	NS	NS	
C.D. (0.05)	10.583	----	----		0.289	----	----	

Insects associated with oil palm

The pollinating weevil (*E. kamerinicus*) was introduced into the oil palm garden to observe their performance. Periodic sampling for its development indicated that weevil population was less during January to March. However, the population was increased during April-June and October-December. The remaining period July-September witnessed relatively low population of weevils. The population of weevil is restricted by the moderate to severe winter prevailing in this region which had a greater influence over the reproductive cycle of the plant itself. Initial studies on the efficacy of the weevil on the per cent fruit set and average fruit weight of bunch and individual fruit indicated that about 40-50% of fruits are additionally recorded in the post-weevil activity period. There was also observance in the increase in the individual fruit weight to the extent of 4-5g as compared to the pre-weevil period.

4. Cashew nut

Varietal performance of Cashew nut Cultivars

Five varieties namely; Ullal-3, Selection-II, H-1608, H-2/16 and Vengruala-4 were collected from AICRP, Cashew Centre, Bhubaneswar for evaluation under Sub-Himalayan Terai Region of West Bengal. The plants were planted during 2000 in a Randomized Block Design with three replications. The initial results revealed that the vegetative growth is almost normal in this condition. The maximum plant canopy was observed in the variety Selection-II. Owing to the extreme winter and rain during flowering, the yield is found to be poor. However, it has been observed that H-2/16 is relatively tolerant to frost injury.

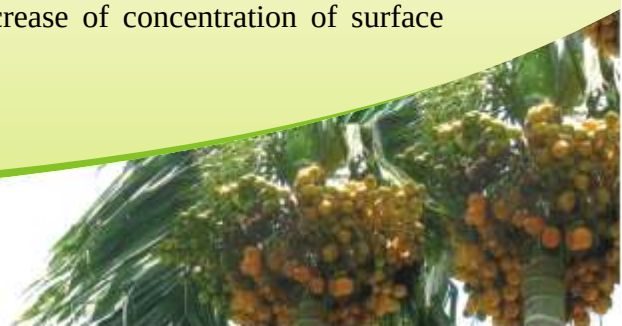
5. Ginger

a) Micropropagation

'Garubathan', a low fibre content popular ginger variety was collected from the fields of Garubathan, Darjelling dist, West Bengal. The rhizomes were treated with fungicide Dithane M 45 @ 0.1% for 30 minutes and were kept on germinating trays under room conditions. The rhizomes sprouted within 4-6 weeks and the sprouts were used as explant.

b) Effect of surface sterilant on shoot and root multiplication

The effect of surface sterilants on duration required for shoot and root initiation and number of shoots and roots produced / explant are presented in Table 23. More number of days were required for shoot and root initiation with the increase of concentration of $HgCl_2$ and in case of shoot and root production per explant the numbers decreased with the increase of concentration of surface



sterilants. Among all the treatments surface sterilization of explants with 0.1% $HgCl_2$ was best for shoot and root initiation and number of shoot and root production /explant. Only 14 and 19 days were required for shoot and root initiation, respectively, and 5.6 and 5.9 numbers of shoot and root/explant were recorded in this treatment which was much more than the other treatments

Table 23: Effect of $HgCl_2$ on the duration for initiation and rate of shoot and root formation

$HgCl_2$(%)	Duration of initiation (days)		Number/explant	
	Shoot	*Root*	*Shoot*	*Root*
0.1	14.0	19.0	5.6	5.9
0.2	24.0	30.0	4.2	4.8
0.3	38.0	48.0	3.1	3.4
0.4	45.0	50.0	1.6	2.2
0.5	60.0	68.0	0.8	1.3
CD (0.05)	3.689	2.144	0.023	0.197

c) Effect of BAP on shoot multiplication

It was observed that, with the increase of BAP concentration number of shoots and roots produced per explant increased considerably, and at BAP 4 mg l^{-1} both the shoot and root production was maximum(6.2 and 6.1/explant, respectively), and shoot production/explant was at par in MS medium containing BAP 3 mgl^{-1} (Table 24).

Table 24: Effect of BAP on rate of shoot and root formation

BAP (mg l^{-1})	Number of shoots/explant	Range	Number of roots/explant	Range
0.0	0.4	0-1	0.8	0-2
1.0	1.6	1-3	2.3	1-4
2.0	3.3[c]	2-7	4.8 [c]	3-12
3.0	5.8[a]	3-9	5.7 [b]	3-12
4.0	6.2[a]	3-11	6.1 [a]	4-13
5.0	4.7[b]	3-7	4.6 [c]	4-7
CD (0.05)	0.403		0.394	

d) Effect of BAP on root and shoot growth

Maximum root growth was observed in all the treatments during first 10 days which decreased in subsequent intervals and thereafter the rate of shoot growth decreased with the increase of BAP concentration. The length of shoot increased gradually with increase in BAP concentrations (Table 25) and it was the maximum at 3 mg l^{-1} level at 10, 20 and 30 days interval. In case of root length, maximum root length was recorded at lower concentration of BAP (1 mg l^{-1}).

Table 25: Effect of BAP on length of shoot and root after sprouting

BAP (mg l^{-1})	Length of Shoot (cm)			Length of Root (cm)		
	10 days	*20days*	*30 days*	*10 days*	*20days*	*30 days*
1.0	1.30	1.58	1.87	2.63[a]	2.97[c]	3.23
2.0	1.93	3.23	4.25[c]	2.44[b]	4.28[a]	5.86[a]
3.0	3.27[a]	5.04[a]	6.59[a]	2.41[b]	3.27[b]	4.29[b]
4.0	3.18[b]	5.05[a]	5.85[b]	2.14[c]	2.76	3.27[c]
5.0	2.79[c]	3.35[c]	3.82	1.64	2.29	2.67
CD (0.05)	0.047	0.049	0.024	0.040	0.054	0.040

It was also observed that the multiplication of shoots from explant increased gradually (Table 26) in subculture and maximum number of shoots/explants were recorded at second subculture in both the cases and then declined in further sub culturing.

Multiplication of ginger and (right) hardening of TC plants

Table 26: Rate of shoot multiplication on primary, 1st, 2nd and 3rd subcultures

BAP (mg l^{-1})	Primary Shoots	Range	Subculture					
			1st	*Range*	*2nd*	*Range*	*3rd*	*Range*
3	3.1	2-4	5.6	3-8	9.2	4-11	5.2	2-6
4	3.4	2-5	6.0	4-8	9.4	7-12	5.6	3-8

The rooted plantlets were transferred to sterilized potting mixtures (top soil and sand in 1:1 ratio) and kept in mist house for hardening and about 90% plantlets survived in potting mixtures during hardening.

e) Field evaluation of tissue culture plantlets

Three types of planting materials viz. tissue cultured plantlets, rhizome derived from tissue cultured plantlet in the field and conventional rhizomes were used as planting material for the present investigation. Recommended packages were followed to all the experimental plots.

The minimum disease infestation (7.5%) was observed in the plants derived from the rhizomes of tissue culture rhizomes from the previous year's harvest while maximum disease infestation (56.66%) was in the conventional planting method. The maximum numbers of shoots/sprouts (10.57), maximum plant height (66.92cm), maximum number of leaves (21.66cm), maximum primary (8.44) and secondary (61.33) fingers were recorded in the plants derived from the rhizome of tissue cultured derived plantlets compared with the plants raised from conventional rhizomes. The total weight of the aerial parts was maximum (250gm) in the plants derived from the rhizome of tissue cultured plantlets while the minimum (120gm) was recorded from the plants of conventional type. The maximum yield of rhizome (0.356g/plant) was obtained with the plants derived from the rhizome of tissue cultured plantlets compared with plants grown from conventional planting materials (0.195 g/plant). General observation revealed that the plants raised through conventional propagating material were affected more by pathogens than the other two propagating materials. The plants derived from the rhizome of tissue cultured plantlets harvested from the field were better than the plantlets derived from tissue cultured plantlets because of *in vitro* and field selection, and greater adaptability to the environment.

6. Black pepper

Effect of rooting media on production of quality black pepper cuttings by rapid multiplication

Black pepper has proved to be a profitable intercrop in arecanut garden under Sub-Himalayan Terai Region of West Bengal. The normal method of propagation, i.e., through cuttings of runner shoot is very slow and there is also involvement of large quantity of mother vines. So, to counteract these problems, multiplication by bamboo method is considered to be fast which otherwise called rapid multiplication method. In this connection, an experiment was conducted to evaluate the suitable soil mixture for rooting of black pepper vines in bamboo method of rapid multiplication.

Bamboo splits of length of 1.8 m and diameter 7-8 cm were placed at an angle of 45^0 on a bamboo support frame. The splits were placed in such a way that the lower portion does not touch the ground. A trench of 1 ft deep, 1 ft wide and convenient length was made and was filled with a mixture of topsoil, sand and FYM (1:1:1). Rooted black pepper cuttings of cv. Panniyur 1 were planted in the trench against each and every splits containing different rooting mixtures viz. top soil -T_1; top soil + FYM (2:1)- T_2; top soil + vermicompost (2:1)- T_3; top soil + coir pith (2:1)- T_4; top soil + sand + FYM (1:1:1)- T_5; top soil + sand + coir pith (1:1:1)- T_6; top soil + sand + vermicompost (1:1:1)- T_7 and top soil + vermicompost + coir pith (1:1:1)- T_8. The treatment, T_1 was considered as control. The experiment was laid out in a Randomized Block Design with three replications. The vine was tied with the bamboo split from time to time with the advancement of its growth in such a way that the newly developed root from each node touches the rooting mixture. The vines were sprayed with 1% Bordeaux mixture regularly to check the *Phytophthora* infestation. All the vines were planted under shade with 75% mesh of netlon. After about 45 days when the vines reach the top of bamboo splits the vine tip has to be nipped and the stem crushed at the third node above the ground. Vines were then allowed to grow for another one week and then each single rooted node was separated from the vine and planted in poly bags containing mixture of topsoil and FYM at a ratio of 1:1 and allowed to grow in the net house. It was found that the mixture containing top soil, sand and vermicompost at a ratio of 1:1:1 to be the best for rooting of black pepper and produced 23.5 numbers of vigorous rooted cuttings within three and half months from each vine followed by the mixture containing equal ratio of top soil and coir pith (21.43 cuttings/ vine) (Table 27) and the mixtures containing equal ratio of top soil and FYM (20.60 cuttings/ vine). The percentage of recovery was maximum (85.00) in the media containing top soil, sand and vermicompost (1:1:1).

Table 27: Growth of pepper vines influenced by various rooting media

Treat-ments	Leaves per vine(no)	Leaf length (cm)	Rooted nodes/vine (no)	Roots per node(no)	Root length (cm)	Root vol. (ml)	Root fresh wt.(g)	Root dry wt.(g)	Percent recovery (Cuttings)
T_1	20.17	10.10	19.60	09.67	11.09	06.33	4.73	1.8	77.87(61.94)
T_2	22.50	10.77	20.60	10.75	11.29	05.75	4.09	2.2	80.07(63.49)
T_3	20.17	10.17	18.67	11.25	12.38	07.92	5.63	2.1	78.07(62.08)
T_4	21.67	10.97	21.43	10.75	12.92	09.17	6.00	1.5	82.03(64.92)
T_5	19.33	11.22	17.10	09.25	09.17	05.50	3.83	1.5	75.50(60.33)
T_6	19.30	10.17	17.33	09.42	09.75	05.00	3.08	1.7	75.37(60.24)
T_7	25.83	12.17	23.50	13.00	15.42	12.67	7.08	3.1	85.00(67.22)
T_8	17.83	09.70	17.00	07.92	09.42	04.17	2.75	1.4	75.27(60.18)
CD (0.05)	**2.17**	**1.42**	**4.34**	**2.70**	**1.97**	**1.87**	**0.917**	**NS**	**1.22**

Figures in parentheses denotes the angular transformed values

[T_1+-Top soil, T_2- Top soil + FYM (2:1), T_3- Top soil + vermicompost (2:1), T_4- Top soil + coir pith (1:1), T_5- Top soil + sand + FYM (1:1:1), T_6- Top soil + sand + coir pith (1:1:1), T_7- Top soil + sand + vermicompost (1:1:1) and T_8- Top soil + vermicompost + coir pith (1:1:1) **]**

Integrated Nutrient Management for the Control of Wilt of Black Pepper caused by *Phyotophthora* spp

The experiment on biological control of quick wilt using *Trichoderma* in combination with different chemicals revealed that the incidence of the quick wilt was practically nil in the treatments *Trichoderma (*TC) alone @ 50g per vine and TC + Ridomil (1.25 g/lit solution). Drenching the basins with 1 % Bordeaux mixture also found to be give good result against this disorder with only 1-2% damage (Table 28).

Table 28: Effect of different control measures against the quick wilt of pepper

Treatments	Per cent vines affected
***Trichiderma* culture (TC; 50 g)**	**0.00**
Ridomil (1.25 g/l)	**1.35**
Akomin (3 ml/l)	**1.37**
Bordeaux Mixture (BM; 1%)	**2.14**
TC + Ridomil	**0.00**
TC + Akomin	**1.29**
TC + BM	**1.37**
Control	**1.39**

Performance of wilt tolerant lines of black pepper 3

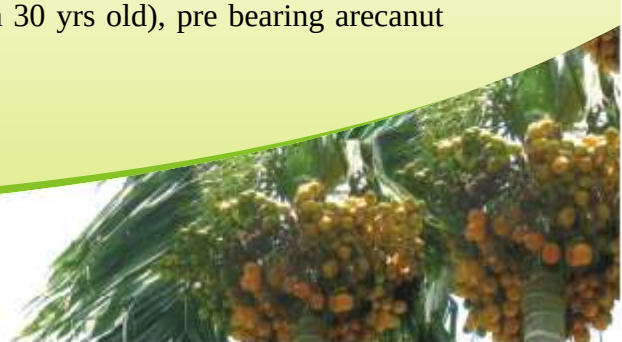
The trial was laid out in a randomized block design with three replications involving 14 black pepper lines collected from IISR, Calicut during 2003. The plants were planted under an existing 35- years old arecanut garden at RS Mohitnagar. The initial results have revealed that the lines Arakalam have the maximum survival percentage (92.3 %) followed by KS-14 (59.1 %) and P-24 (54.5%), whereas, maximum mortality was recorded in the line Narayakodi (5.6%). The data after 4 years of planting revealed that maximum vine length (547.0 cm) was recorded in case of P-339 followed by Panchami (524.6 cm). Maximum laterals were produced by the variety P-24 (60.0) followed by Pournami (40.5). Variety KS-14 produced maximum number of spikes (182.8) in a vine followed by Panchami (134.5) (Table 29).

Table 29: Yield and morphological characters of black pepper lines

Lines/CV	Vine length (cm)	No. of laterals / vine	No. of spikes /vine	Disease incidence
Chumala	466.0	28.5	156.0	----
KS-27	402.0	38.0	218.0	----
Panniyur-1	459.5	34.5	115.33	----
Karimunda	377.0	19.0	98.0	----
Arakalam	387.7	31.3	111.0	----
KS-14	492.5	30.	182.8	----
C-1090	423.5	29.7	28.8	----
P-24	512.1	60.0	106.3	----
Karimunda (s)	452.6	32.8	130.7	----
Narayakodi	320.7	29.0	35.0	----
Pournami	471.5	40.5	33.0	----
C-1047	375.0	35.0	55.0	----
P-339	547.0	39.0	41.0	----
Panchami	524.6	31.9	134.5	----
C.D. (0.05)	90.65	9.23	27.74	----

7. Weed distribution at different plantation garden under Sub Himalayan Terai Region of West Bengal

Five different areas viz. area with coconut (*Cocos nucifera* L), oil palm (*Elaeis guineensis*, Jacq.), bearing adult arecanut (*Areca catechu* L.) (more than 30 yrs old), pre bearing arecanut



garden (3 yrs old) and fallow land were selected for the study of weed distribution. The study was conducted during September in the year 2004 just after rainy season. Quadrates of 10 square meter area were laid down in different locations at a random manner. For, each type of field 10 quadrates was included for weed study. Various species and total number of individuals of each species were noted. Average data of 10 replications/quadrates was considered for statistical analysis.

Among the 24 weed species in fallow land, maximum frequency of weed population (100%) was recorded for *Andropogon aciculate, Boreria alata, Brachiaria sp., Centella asiatica, Clerodendron infortunetum, Cyperus spp., Leucus aspera, Melastoma sp.* and *Oxalis corniculata* (Table 30*)*. About 90 % frequency was recorded for *Cynodon dactylon , Desmodium trifoliatum. Ageratum conyzoides, Boraria sp, Cynodon dactylon, Imperata cylindrica.* In coconut field *Ageratum conyzoides, Borreria sp, Centella asiatica, Gnaphalium sp., Oxalis corniculata, Solanum nigrum, and Vandelia sp.* occurred with 100% frequency. Ninety per cent frequency was observed for *Clerodendron infortunetum, Dryopteris sp., Imperata cylindrica, and Melastoma sp.* The weed cover of the adult areca nut garden was different from the other fields. Weeds like *Colocasia sp., Drymeria sp., Stelaria media* were present only in the adult arecanut field. In case of oil palm field maximum frequency (100%) of weeds like *Ageratum conyzoides, Brachiaria sp., Cynodon dactylon, Desmodium trifoliatum, Digitalis sanginalis, Rungia sp.* and *Spermacocci latifolia* was *recorded. Imperata cylindrica* and *Melastoma sp.* were found to have 90% frequency. About 37.93 %, 80% & 64.28 % weeds were recorded at 81-100% frequency range in fallow, coconut and adult arecanut field, respectively whereas in young areca garden 40% weeds were in 61-80% frequency range. The maximum density of weed in fallow land was recorded for *Bracharia* (59.13) and minimum for *Pteris sp.* (0.4). In arecanut field (3 years old), the maximum density was for *Cynodon dactylon* (71.09) and the minimum for *Melastoma sp.* (0.09) whereas in adult arecanut field, the maximum weed density was recorded for *Oxalis corniculata* (29.26) and minimum for *Colocasia sp.* (0.11). In coconut field the maximum density was recorded for *Selaginella sp.* (14.06) and minimum for *Melastoma* (0.71). In oil palm garden the maximum weed density was for *Digitaria sanguinalis* (79.73) and the minimum for *Triumfetta rhomboidea* (0.09).

The maximum abundance of different weed species in fallow land, young areca nut garden, adult arecanut, coconut and oil palm was recorded as *Cynodon dactylon* (438.2), *Cynodon dactylon* (710.9), *Oxalis corniculata* (292.6), *Selaginella sp.* (234.3) and *Cynodon dactylon* (143.0), respectively whereas the minimum abundance was recorded as *Pteris* (1.33), *Melastoma sp.* (2.3), *Colocasia sp.* (1.8), *Melastoma sp.* (7.9) and *Triumfetta rhomboidea* (1.8), respectively.

Among the 44 weed species, only two weeds (*Ageratum conyzoides and Oxalis sp)* were present in all the field irrespective of crop whereas, seven of the weeds (*Cymbopogon citrate, Drosera sp., Hyptis sp., Mimosa pudica, Polygonum aurantale, Pteridium sp.and Pteris sp.* were

present in fallow land only. Two weeds (*Elicine indica and Linderbergia sp.*) are specific to young arecanut gardens whereas, *Colocasia sp., Drymeria sp., Emelia sonchifolia and Stelaria medica* were present only in adult arecanut plantation. *Selaginella sp.* was present only in the coconut field and *Euphorbia hirta and Scoparia dulsis* were found only in young arecanut garden and fallow land. *Cyprus spp.* was present only in the adult arecanut and fallow land condition. *Spilantes sp.* was present in oil palm garden but *Vandelia sp.* was absent in this garden. The weed species like *Andropogon aciculate, Lygodium sp., Triamfetta rhomboidea and Vernonia cinera* were present only in adult arecanut plantation. The present investigation reveals that different weed species can grow in different shade condition and their growth depends on availability of sun lights along with other growth conditions. Prevalence of dicot weed species was more in all the conditions under study than the monocots. Restriction of some weeds species to some particular area supports that they require some special conditions for their growth, whereas presence of some weeds to all the study areas shows that they can grow in wide variation of light conditions.

Table 30: Number of weeds species in different botanical families in palm gardens under study

Family	Fallow land	Juvenile t Arecanu	Adult areca	Coconut	Oil Palm
Monocotyledons	5	6	5	1	5
Araceae (Ar)	0	0	1	0	0
Cyperaceae (C)	2	1	2	0	1
Poaceae (P)	3	5	1	1	4
Dicotyledons	19	14	10	12	15
Acanthaceae (Ac)	0	0	0	1	1
Apiaceae (Ap)	1	1	0	1	1
Asteraceae (A)	3	2	3	2	4
Caryophyllaceae (Ca)	0	0	2	0	0
Droseraceae (D)	1	0	0	0	0
Euphorbiaceae (E)	1	1	0	0	0
Fabaceae (F)	2	1	0	1	1
Labiatae (L)	2	1	0	0	1
Melastomaceae (M)	1	1	0	1	1
Oxalidaceae (O)	1	1	1	1	1
Polygonaceae (Po)	1	0	0	0	0

Family	Fallow land	Juvenile t Arecanu	Adult areca	Coconut	Oil Palm
Rubiaceae (R)	2	1	0	1	2
Scrophulariaceae (S)	2	3	1	1	0
Solanaceae (So)	0	1	1	1	0
Tiliaceae (T)	1	0	0	0	1
Urticaceae (U)	0	1	1	1	1
Verbenaceae (V)	1	0	0	1	1
Pteridophytes (Pter)	4	0	0	1	2
Total	28	20	13	14	22

8. Transfer of Technology

Establishment of demonstration gardens

The low production and productivity of arecanut and coconut in this region as compared to other states like Andhra Pradesh and Tamil Nadu is mainly attributed to the unsystematic and un-scientific way of plantation management. The problem is further aggravated due to the lack of awareness to the advanced agro-techniques, wayward attitude of the farmers towards the plantation, fluctuating market price and poor processing facilities. It is observed in this part of the state that every household in villages has an average of 12-15 number of arecanut palms in their homestead as a rainfed crop. The production from those palms could be increased by following advanced cultivation practices, growing of mixed/ inter crops and proper inter-cultivation practices which include timely application of fertilizer, pest, and disease management and after care.

Keeping the above facts in view, technology demonstrations and on-farm trials were implemented with the active participation of local farmers with an objective of increasing net return per unit of arecanut plantation. The list of farmers benefited from this scheme in enumerated in Table 31 to 33:

Table 31: List of demonstration gardens

Name of the Farmer	Area (ha)
Md. Saidul Islam, Purba Haihaipatthar	**0.102**
Md. Kader Mohammad, Dhaneswari	**0.133**
Mr. Binoy Kr. Saha, Berubarihat	**0.218**
Amarendra Nath Roy, Uttar Gurudevpur	**0.09**
Debendra Nath Roy, Amguri	**0.09**
Md. Makleswar Rahman, Dakshin Altagram	**0.07**

Name of the Farmer	Area (ha
Mr. Sudhir Burman, Solmari	**0.12**
Biswanath Sarkar, Haldibari	**0.09**
Raben Roy, Mathachulka	**0.13**
Baburam Orao, Fagudhara	**0.10**
Tarani Paul, Kumarpara	**0.09**
Mr. Nagen Barman, Near Engineering College, Jalpaiguri	**0.14**
M/S Handicapped Home, Bakuabari, Jalapiguri	**0.15**
Sri Samaresh Datta, Assam More, Jalpaiguri	**0.40**
Sri Manik Takur, Mohitnagar*	**0.13**

* Coconut based HDMSCS

Demonstration gardens

Table 32: list of On-farm trial

Name and address	Area (ha)	No of Arecanut	No of Banana	Date of start	Treatment Details
Bhabesh Roy, Basilar Danga	**0.09**	**130**	**51**	**02-08-01**	**T_1=Recommended dose of fertilizer**
Manabendra De Sarkar, Mahabari	**0.09**	**130**	**60**	**02-08-01**	**T_2= ½ of Recommended dose**
Md. Samsul Haque, Uttar Dhupjhora	**0.08**	**115**	**--**	**19-10-01**	**T_3= FYM (5kg/palm)**
Subadh Basak, Bhotpotti	**0.11**	**150**	**--**	**19-10-01**	**T_4= No Fertilizer**

This centre is continuously involved in organizing the training programmes in collaboration with Spice Board/Coconut Development Board on the following topics for the benefit of farmers and extension officers.

Table 33: List of training programmes arranged in the reporting period

Sl. No.	Training on
1.	Management of arecanut garden for maximization of profit
2.	Management of arecanut garden for maximization of profit
3.	Plant protection of areca based cropping system
4.	Plant protection of areca based cropping system
5.	Management of arecanut garden for maximization of profit
6.	Plant protection of areca based cropping system
7.	Production Technology of arecanut based HDMSCS
8.	Management of pests and diseases of arecanut
9.	Production technology of coconut
10.	Management of pests and diseases of coconut
11.	Arecanut based cropping system Why and How?

Sl. No.	Training on
12.	Arecanut based cropping system Why and How?
13.	The Kalpavriksha coconut why and its cultivation
14.	The Kalpavriksha coconut why and its cultivation
15.	Arecanut based mixed cropping system
16	Arecanut based mixed cropping system
17.	Black pepper cultivation in North Bengal
18.	Off Farm- Black pepper cultivation
19.	Arecanut based cropping system
20.	Cultivation of plantation crops in North Bengal
21.	Arecanut based cropping system for Toto community
22.	Training on Coconut cultivation in collaboration with CDB, Kolkata
23.	Black pepper cultivation in shade trees of tea garden and raising of planting materials of Black pepper

The personnel of this centre are also constantly participating in farmers-oriented programme which are telecasted on TV and AIR. Till date about 55 programmes have been interviewed and telecast in the E-TV (Bengali) “ANNADATA” programme. About 10 numbers of programme have been aired by AIR, Siliguri, West Bengal.

Kisan melas:

Till date four numbers of Kisan Melas were organized at this centre where about 400-500 farmers took part in each of the programme. This centre is regularly participating in Kisan Melas at other venues to showcase the technologies developed by this research centre.

Dissemination of technology through training programmes and Kisan melas

Production of quality planting materials:

- In the last 25 years the centre has supplied about 25,41,756 arecanut seednuts, 2,15,282 numbers of arecanut seedlings and 34,744 numbers of black pepper rooted seedlings.
- Apart from that a good number of quality planting materials of coconut, banana (mostly Malbhog type), bay leaf, cinnamon and Lemon (both Gandharaj and Assam type) has been produced and supplied to the farmers/ Entrepreneurs.

Quality Planting Material production

Future line of activities of the centre

This Research Centre, Mohitnagar is and will serve as an important research station on major plantation crops and will make all efforts to solve the problems faced by the farming community of Sub-Himalayan Terai region of West Bengal. The main focus of this centre will be on evaluation of coconut and arecanut for varietal development and subsequent use in breeding programmes; development of Integrated Nutrient Management for major plantation crops; refinement of the technologies developed earlier etc. Apart from this incorporation of profitable non-traditional seasonal/ perennial crops as component crops for arecanut/coconut based mixed cropping system will also be evaluated. As an integral part of the research activity, production of genuine quality planting materials of important plantation crops (coconut, arecanut) including other component crops (black pepper, bay leaf, cinnamon, lime/lemon etc.) will remain as an important activity of this research centre. Dissemination of tested technologies through establishment of demonstration gardens, on-farm trials, training programmes, Kisan Melas will also be taken up.

List of Publications

Articles in peer reviewed journals

- Acharya, G. C. and Dash, D. K. (2006). Critical levels of macro and micro-nutrients in coconut leaves in littoral sandy soil. *Journal of Plantation Crops,* **34(1):** 68-70.
- Acharya, G. C., Dash, D. K. and Sahoo, S. C. (2006). Diurnal variations in the mineral composition of coconut leaves. *Journal of Plantation Crops,* **34(2):.**121-124.
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