AGRO-TECHNIQUES FOR HIGHER COCONUT PRODUCTIVITY UNDER COASTAL SANDY SOIL

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In India, coconut is being grown in different soil types. However, alluvial, laterite, sandy and red sandy loam form the major soil types occupied by coconut. The coastal sandy soil, which occurs all along the coastal tract of the West and East coast of the Peninsular India lying mostly in Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Orissa and Maharashtra is the most predominant soil type with respect to coconut cultivation. The general weather prevailing along the coast is conducive for growing coconut. However, coconut productivity is very low in the coastal sandy soils due to poor physico-chemical properties of the soil (Table 1). The major reasons for lower productivity of coconut under coastal sandy soil are: 1) Poor water holding capacity, 2) High infiltration rate (due to the porosity of sands), 3) Easy leaching of nutrients, 4) Small specific surface area (due to low clay and organic matter), 5) Low major nutrient/ micronutrient content, 6) Low cation exchange capacity and 7) Low organic carbon content.

Table 1. General Physico-Chemical properties of coastal sandy soils

Content	Range
Clay (%)	0.6-10.8
Silt (%)	0.0-7.8
Sand (%)	87.2-95.4
pH	5.52-8.3
Organic carbon (%)	0.00-0.46
CEC (m.e/100g)	0.4-5.4
Available nitrogen (kg ha^{-1})	30 - 60
Available phosphorus (kg ha^{-1})	10 - 25
Available potassium (kg ha^{-1})	5 - 25
Physical constants	
Field capacity (%)	3.8 - 7.2
Permanent wilting point (%)	0.42 - 2.12
In situ bulk density g.cm-3	1.56 - 1.82

Under these conditions, sustainable crop production in such soil requires quality improvement in terms of soil physical, chemical and biological environment. Following are the agro-techniques standardized at CPCRI, Kassaragod to increase and sustain the productivity of coconut under coastal sandy soil.

Agro-techniques for Coastal Sandy Soil Management

1) Use of husk/coir pith for growing different intercrops in coconut gardens

Coconut is highly amenable for cultivating intercrops because of its wider spacing (7.5m x 7.5m) used for planting. However, the physical and chemical properties of coastal sandy soil are not conducive for growing intercrops without fertilizer and crop management practices. Under this situation waste/usufructs materials from coconut palm viz., husk and coir pith come handy for rectifying the constraint. From a well-managed coconut garden about 14-16 tonnes/ha/year of dry material is available in the form of leaves, spathe, bunch waste and husk. In this half the contribution is from husk coir pith. These waste/ usufructs available *in situ* can be used to as moisture conservation materials and a source of nutrients for coconut other crops. Results based on the experiments conducted at CPCRI revealed that fodder grass and vegetable crops (amaranthus, pumpkin and ash gourd) and fruit crops (banana and pineapple) could be successfully grown as intercrops in coconut gardens under coastal sandy soil by adopting appropriate soil moisture conservation measure viz., husk and coir pith application in the planting zone. In addition to the extra income realized by intercropping, it has a complimentary impact on coconut productivity. This leads to the overall improvement in the productivity of the system as a whole.

a) Fodder grass

Trench of 30 cm width and 30 cm depth and suitable length are taken 50 cm apart in the interspaces of coconut palms. While taking trenches a minimum of 2 m radius around each palm has to be left undisturbed. One layer of coconut husk is spread out in the bottom of this trench with its concave surface facing up. Husk from 10 coconuts are required to cover 1 meter length trench. In the case of coir pith incorporation, similar trench is opened and raw coir pith is applied to a height of 5 cm. Application of farm yard manure @ 5 tonnes/ha and vermicompost @5 tonnes/ha is to be adopted for both the husk and coir pith trenches. The trenches are then filled with the excavated soil and are ready for planting. Hybrid Bajra Napier Co 3 fodder grass can be planted by rooted slips or by stem cuttings. Cuttings of moderately mature stems and preferably from the lower two thirds of the stem length sprout better than the older stems. Cuttings with two nodes are pushed into the soil with the basal end down, either vertically or at an angle to such a depth that one node remains within the soil and above the soil surface. The cuttings are planted at a spacing of 50 cm x 50 cm. For one hectare of coconut garden, approximately 30,000-stem cuttings/root slips are required. The best time of planting is June for the areas benefitted by South West monsoon and September-October for the areas benefitted by North East monsoon. A basal dose of 50 kg N, 40 kg K and 40 kg P/ha is to be applied at the time of planting. Thereafter, only nitrogen @ 75 kg need to be applied after each harvest is made. However, application of NPK should be repeated once in a year for sustained higher yield of fodder. Sprinkler system of irrigation is to be practiced once in four days. Drip irrigation also can be practiced where acute shortage of water is felt. First cutting of grass can be done 80 days after planting and subsequent cuttings can be done at 45 day-interval. Cutting should be done 10-15 cm above ground level. Six or seven harvest can be made every year.

Performance of Hybrid Bajra Napier Co 3

Findings of the study prove that the grass Co 3 can be successfully grown as an intercrop in coconut garden under coastal sandy soil. From one hectare coconut garden around 96 tonnes of green fodder can be produced. This is sufficient to supply green fodder 8-10 milch animals.

Economics

A farmer integrating coconut + grass (1 ha) and dairy (6-8 milch animals) in the coconut based mixed farming system under coastal sandy soil situations can realize a net profit of approximately Rs 1 lakh/ha/year. The maximum profit that could be realized is from dairy followed by coconut. Besides, the farmer can get 30 to 35 tonnes of cow dung, cowshed washings and urine that could be effectively recycled for biogas production and later the slurry pumped to the garden for increasing the productivity of the system.

b) Pumpkin/ash gourd

Pumpkin/ash gourd can also be grown successfully as intercrops in coconut garden using husk/coir pith as amendments. For husk burial, a pit of 60 cm diameter and 30-45 cm depth is opened, and one layer of husk applied with the concave surface facing up. Husks from 10 coconuts would be sufficient to fill one pit. In the case of coir pith treatment, a pit of the same dimension is opened and 10 kg of coir pith per pit is applied. Application of Farm Yard Manure @ 2.5 tonnes and vermicompost @ 2.5 tonnes/ha is to be applied along with N (17.5 kg), P_2O_5 (25 kg) and K_2O (25 kg). The pits are then covered with soil and the sowing is taken up. Four to five seeds can be sown per pit. Unhealthy plants are removed after two weeks so that only three plants are retained per pit. Irrigation is given once in three to four days during the initial stages of growth. Later irrigation may be done on alternate days during flowering and fruiting periods. Dried twigs are spread on the ground for easy trailing of these creepers. Weeding and ranking of the soil are to be done at the time of fertilizer application. Another dose of N (17.5 kg) could be applied in two equal splits at the time of vining and at the time of full blooming.

Performance of pumpkin/ash gourd by incorporation of husk/ coir pith

Pumpkin and ash gourd respond well to husk and coir pith application. Fruit yield of pumpkin and ash gourd increased substantially when soil is incorporated with coconut husk/coir pith, compared to the control where no soil amendments were used (Table 2). Higher fruit yield was obtained under coir pith application and it was on par with husk application and significantly different from the control. Higher yield is mainly due to the beneficial effect of coir pith and husk in the pits viz., higher soil moisture and increased nutrient availability and enhanced biological activities in the rhizosphere.

Table 2. Effects of different treatments on pumpkin and ash gourd yield (t/ha)

Treatment	Pumpkin	Ash gourd
Coconut husk burial	9.46	8.92
Coir pith application	10.12	9.37
Control	6.21	4.89

Economics

By growing vegetables such as pumpkin and ash gourd, farmers could realize an additional net income of Rs. 35,000/ha/season with the adoption of soil conservation measures.

c) Pineapple

Trench Planting

Pineapple can be grown successfully as an intercrop in coconut gardens under coastal sandy soil by adopting husk/ coir pith incorporation technology. The best planting season is May-June. Planting should be avoided during periods of heavy rain.

Preparation of Trenches

Trenches of 1 m width and 30 cm depth are to be opened 1.5 m apart. In the bottom of the trench one layer of husk is to be spread out with concave side facing upwards. In the case of coir pith it shall be incorporated to a thickness of 5 cm. Then vermicompost / compost /

farmyard manure is to be applied at the rate of 10 tonnes/ha as basal dressing. Fertilizers are to be applied at the rate of 8:4:8 g N, P_2O_5 and K_2O, respectively. Full dose of P_2O_5 is to be applied at the time of planting, while Nitrogen and K_2O may be applied in four splits, during May-June (at planting), August-September, November and May-June (2nd year). After application of fertilizers, they may be covered with soil by scraping the sides of the trenches.

Planting

In each trench, two rows of pineapple slips/suckers should be planted 15 cm inside from the edge of the trench. There can be two trenches in between two rows of coconut. Triangular method of planting may be adopted in each trench so that the plants in two adjacent rows are not opposite to each other. Healthy suckers of uniform size weighing 500-1000 g are to be selected. Suckers have to be kept in open space under shade in a single layer for about seven days for drying. After a week, a few of the old and dried leaves have to be stripped off and the suckers should be allowed to dry and cure for another seven days. The cured suckers should be dipped in 1% Bordeaux mixture at the time of planting.

Irrigation

During summer months, pineapple should be irrigated wherever possible at 0.6 IW/ CPE ratio (50 mm depth of water). It requires five or six irrigations during dry months at an interval of 7 to 10 days. Mulching the crop with coconut dry leaves at 6 tonnes/ha will help to conserve moisture.

Induction Flowering

For induction of uniform flowering, 25 ppm ethephon (2-chloro ethyl phosph) is to be applied in acqueous solution containing 2% urea and 0.04% calcium carbonate. The aqueous mixture (50 ml/plant) is to be poured into the heart of 12-17 month old plants (39-42 leaf stage) during dry weather. For treating 1000 plants, 50 liters of the solution would be required. The aqueous is prepared by taking ethepon 1.25 ml, urea 1 kg and calcium carbonate 20g, and making to 50 liters with water. Flowering will commence from the 40th day after application and will be completed by the 70th day.

Performance

Pineapple suckers grown in coastal sandy soil under husk/coir pith incorporation produced higher yield of fruit. The result revealed that a yield of 16 tonnes of pineapple could be produced from the interspaces available in one ha. coconut garden with soil moisture conservation measures by applying husk/coir pith technology.

Impact of cropping systems on coconut productivity

The impact of intercropping on coconut productivity revealed complementary effect of growing vegetable and pineapple intercrops. Higher coconut yield was recorded under coconut + vegetable intercropping system compared to monocropping of coconut. Cropping systems and soil conservation measures have a positive impact on coconut productivity (Table 3). Adopting intercropping systems viz coconut + pineapple, coconut + vegetable and coconut + fodder grass resulted in increased productivity of coconut compared to monocropping of coconut under coastal sandy soil situations. Similarly soil moisture conservation measures play beneficial role on coconut productivity.

Economics of coconut based cropping system

The economic analysis performed for different coconut based intercropping system under coastal sandy soil indicated that all the cropping systems had realized higher net returns as compared to monocrop. The net return had ranged from Rs. 45,771/ ha/ year in case of coconut monocrop to Rs. 103,010 / ha / year in case of coconut + pineapple intercropping system. The percentage increase in case of net returns over coconut monocrop ranged from 128% in case of coconut + pineapple intercropping system to 40% in case of coconut + ash gourd intercropping system (Subramanian et.al., 2009).

Table 3. Effect of croppinf system and soil moisture conservation measures on coconut yield

Treatment	Coconut productivity (nuts/palms/year)
Cropping Systems	
Coconut + Vegetable intercropping	96
Coconut + Pineapple intercropping	100
Coconut + fodder grass intercropping	89
Coconut monocropping	91
Soil Conservation Measures	
Coconut husk burial	108
Coir pith application	100
Control	72

2) **Alleycropping/intercropping of glyricidia in coconut gardens**

Even though coconut is a widely spaced crop, the interspace cannot be utilized economically for growing commercial intercrop in coastal sandy soils without adopting proper soil and water conservation measures and irrigation. Therefore, permanent coconut-tree legume intercropping may be well suited under coastal sandy soils with minimum water for establishment in the beginning. Glyricidia has great potential as a multipurpose tree in agro forestry, which fits well in marginal and submarginal soils.

Experimental results from CPCRI have proved that glyricidia can be successfully grown as intercrop in coconut gardens in coastal sandy soil (where no other green manure crop can establish), and supply green manure permanently.

Glyricidia in Coconut Garden

Method of planting

A fast growing, multi-purpose tropical leguminous tree, *Glyricidia Sepium* is well adapted in coastal sandy soil. The tree is propagated through vegetative cuttings or seeds. One meter long stem cutting or 3 to 4 month old seedlings raised in poly bags/raised beds can be used for planting. It is preferable that the planting season coincides with the monsoon (South West monsoon/ North East monsoon) for better establishment. Spacing of 1 m x 1 m can be adopted. Two or three rows of glyricidia can be planted in between two rows of coconut. Planting can be done as depicted in the schematic representation of glyricidia in coconut gardens. Plant stem cuttings or seedlings in an upright position in pits of 30 cm^3. For better establishment, a basal dose of 50 kg of P_2O_5/ha may be applied. Height of the plant should always be maintained at 1 m by pruning. Glyricidia intercropping suppresses the weed growth and hence weeding may not be a major problem. Pest and disease of glyricidia is not a major problem and hence no plant protection measures are required.

Pruning can be started one year after planting. For good management, plants should be pruned at the appropriate time. Pruning should be done at least thrice a year (February, June and October). Three rows of glyricidia in between two rows of coconut with three prunings per year resulted in higher biomass yield of 7,970 kg/ ha. The lopping is cut into small pieces and the chopped material is incorporated into the soil as green manure. The coconut growth is not affected by intercropping with glyricidia. Application of glyricidia prunings from the interspace of one hectare of coconut garden to the coconut palms could meet a major portion of nitrogen (88%), part of phosphorus (27%) and potassium (13%) requirement of coconut palms (Table 5). The *in situ* planting of nitrogen fixing tree species like glyricidia between coconut rows can even supply micronutrients such as Copper, Zinc and Boron. Further advantages are *in situ* availability, easy decomposability and low cost of the green manure. In addition to this, the microclimatic conditions in the coconut garden is also improved.

3) Glyricidia green manure

The poor soil fertility status of coastal sandy soil can be improved by addition of green leaf manure of glyricidia. The results of a field experiment on substitution of nitrogenous fertilizer with glyricidia green manure in coconut under coastal littoral sandy soil at Central Plantation Crops Research Institute, Kasaragod revealed that incorporation of glyricidia green manure added valueable nutrients such as nitrogen, phosphorous, potassium, calcium and magnesium to the soil (Table 6). Application of glyricidia along with inorganic fertilizers was found to increase the nut yield of coconut. When 50% of N was

Table 4. Nutrient substitution through glyricidia in coconut

Nutrient	N	P	K
Coconut			
Fertilizer recommendation (g/palm/year)	500	320	1200
Total fertilizer needs (kg/ha)	87.5	21.0	210
Glyricidia			
Nutrient content of loppings (%) (on dry wt. basis)	3.38	0.247	1.165
Nutrient availability through glyricidia biomass	77.74	5.68	26.80
From 1 ha of glyricidia intercropped coconut garden (kg)			
Fertilizer nutrient substitution by glyricidia (% nutrient substitution)	88.0	27.0	13

substituted by Glyricidia (25 kg of glyricidia green leaves) along with 50% of N and 100% of P and K through chemical fertilizers, higher coconut yield of 52 nuts / palm / year was recorded (44 percentage increase over control). The cost benefit ratio was also most favorable in this treatment (1:1.82).

For glyricidia green leaf manure incorporation, 1.8 m radius basin should be opened at a depth of 20 cm around the bole and 25 kg of green manure and the required inorganic fertilizers are applied and covered with the excavated soil during the first fortnight of September.

Table 5. Effect of Glyricidia green manuring on organic carbon content and available soil nutrient status in coconut basin at different depths

Treatment	Organic carbon (per cent)		Available Nutrients (ppm)					
			N (ppm)		P (ppm)		K (ppm)	
	0-25 cm	25-50 cm	0-25 cm	25-50 cm	0-25 cm	25-50 cm	0-25 cm	25-50 cm
T1: Control (Chemical fertilizer alone)	0.25	0.24	39.4	31.2	88.82	85.21	35.77	23.08
T2: 25% N by glyricidia + 75% N and full PK by chemical fertilizers	0.46	0.25	44.5	33.4	107.96	46.5	42.68	27.68
T3: 50% N by glyricidia + 50% N and full PK by chemical fertilizers	0.43	0.26	46.3	36.4	107.88	28.62	41.54	25.36
T4: 75% N by glyricidia + 25% N and full PK by chemical fertilizers	0.44	0.33	47.0	37.0	104.24	48.08	43.84	35.77
T5: 100% N by glyricidia + full PK by chemical fertilizers	0.56	0.31	49.0	36.2	95.88	33.62	43.84	30.00
SEd	0.08	0.06	1.56	7.68	23.906	19.813	4.682	5.312
CD (P=0.05)	0.17	NS	3.40	NS	NS	NS	NS	NS

4) Coconut basin management with leguminous crops

Growing a green manure crop *in situ* and incorporating it into the soil is probably the easiest and most economical method of augmenting the organic matter in the soil. The following are the benefits of growing legume crops in the coconut basin (2 m radius).

- Prevention of soil erosion.
- Smothering of weeds, thus reducing weeding costs.
- Addition of organic matter to the soil and thus maintaining the structure of the topsoil.
- Improving the aeration of the soil.
- Protecting the soil and roots of crops from excessive heat of the sun.
- Conservation of fertility by using available plant food, which might otherwise be leached away.
- Fixing of atmospheric nitrogen from the air in the case of leguminous plants.

The technique of utilizing leguminous cover crops as green manure to supply biologically fixed nitrogen and easily decomposable biomass to coconut was standardized at CPCRI. It involves cultivation of crops such as cowpea (*Vigna unguiculata*), and sun-hemp (*Crotalaria juncea*) in coconut basins during the monsoon period from June to August and incorporation of the biomass in respective basins under coastal sandy soil conditions. Sowing of green manure cowpea should be carried out the month of June by broadcasting 125-150 g seeds in 2 m radius basins after application of fist dose (1/3rd) of inorganic fertilizers recommended for coconut palm. When cowpea and sun hemp attain 50% flowering, it should be uprooted and incorporated in the basins during second fortnight of August along with 2/3rd fertilizer application. Cowpea and sunhemp yields about 23 and 25 kg of green biomass, respectively. Nutrient substitution obtained by incorporating cowpea/sunhemp in coconut basin is given in Table 7.

5) Vermicomposting of coconut plantation wastes

The availability of fallen dried coconut leaves from a coconut garden with 175 palms/ha has been estimated at 6 to 7 tonnes / ha / year. The natural decomposition of these coconut leaves and the nutrient release are very slow due to high lignin content and the nature of lignocelluloses complex of coconut leaf materials. Substantial saving in terms of fertilizer input is possible through effective reclycling of the waste of the waste biomass. Studies conducted at CPCRI, Kassaragod have revealed that coconut plantation wastes could

Table 6. Nutrient substitution through cowpea/sunhemp growing and incorporating in coconut basins

Particulars	N	P_2O_5	K_2O
Coconut			
Fertilizer recommendation (g/palm/year)	500	120	1200
Cowpea			
Nutrient Content (%)	2.87	0.22	2.14
Nutrient availability through biomass from one basin of coconut palm when cowpea is grown in the basin (g)	145	11	108
Fertilizer nutrient substitution by cowpea % substitution	29	9	9
Sun hemp			
Nutrient Content (%)	2.94	0.18	1.43
Nutrient availability through biomass from one basin of coconut palm when sun hemp is grown in the basin (g)	142	28	37
Fertilizer nutrient substitution by sun hemp			
% Nutrient substitution	29	8	3

be effectively converted into rich vermicompost using epigeic earthworms or compost worms such as *eudrilus* spp.They can fully convert the wastes into vermicomposts, leaving behind only mid ribs of the leaves.

Experiments were conducted for vermicomposting coconut leaves by cement tank method/trench method in the coconut sandy soil situations. For cement tank method, a tank of dimension of 4 m x 3 m x 1 m was constructed in the interspaces of coconut garden. Coconut leaves weathered for 2 to 3 months are preferable as they can be used without chopping, thereby saving lot of labor.

As the earthworms need composted organic matter as feed in the initial stages of composting, the collected coconut leaves are to be treated with cowdung slurry @ 100 kg per tonne of leaves and allowed to further decompose for 2 to 3 weeks. Sufficient moisture is to be ensured by sprinkling water. Earthworms @ 100 worms per tonne of coconut leaves are to be introduced. It should be mulched with available organic wastes such as dry grass, straw or coconut leaves. Depending on the extent of weathering of leaves used for composting, 70 per cent recovery of the compost is obtained within a period of 75-90 days.

The average nutrient composition of the vermicompost recovered was : N 1.84%, P 0.22%, K 0.28%. Organic carbon 17.84% and C:N ratio 9.95. From one ha of coconut garden around 4.2 to 5.6 tonnes of vermicompost can be produced every year. With this an amount of 25 to 32 kg of vermicompost can be applied to each palm every year. This could meet the entire requirement of nitrogen, 39 to 49 per cent of phosphorus and 4 per cent of potassium. This clearly indicates that the nitrogen and phosphorus requirement could be met through vermicompost. For potassium, the balance should be met through chemical fertilizers. The same technology for vermicomposting was found to work well when tested in large trenches taken in the inter spaces of four coconut palms in sandy loam and coastal sandy soils. As composting is done in the field itself, lot of labor required for transportation of the biomass and compost can be saved.

6) Soil moisture conservation measures with coconut wastes

Most of the organic wastes from the coconut garden have high moisture holding capacity and can very profitably used as moisture regulators and conservators. This gains more practical significance in the light of the fact that soils cannot be rejuvenated with organics in the absence of sufficient moisture. Similarly the full benefits from irrigation can be obtained only if there is sufficient quantity of soil organic matter. Keeping in mind the complementary roles of soil organic matter and moisture conservation, coconut leaves, husks, coir pith and weeded material from the plantation can be utilized directly for mulching.

a. Mulching

Mulching is the application of a layer of organic/inorganic material to the top layer of soil. The objective of applying mulch are, generally, four fold: to conserve soil moisture in the immediate root area by preventing rapid evaporation; to prevent sudden fluctuations in the soil temperature; to restrict weed growth and to supply food for the plant. It is an important agricultural practice that should be routinely done in the base of the palm especially in coastal sandy soil.

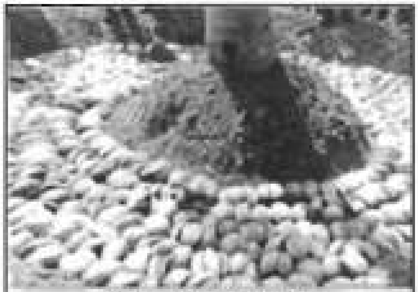
i) Coconut leaf

Mulching coconut basins with dried coconut leaves during September-May ensures soil moisture conservation and restricts weed growth. In addition, the leaves gradually release nutrients to palms they contain when they decompose. Coconut leaves can be cut into two or three pieces before using them for mulching. The mulching is best done the end of the monsoon and before the topsoil dries up. To cover one basin (2 m radius) 20 to 25 coconut leaves are required. Experiments conducted at CPCRI revealed that mulching with coconut leaves combined with irrigation treatments recorded significantly higher yield as compared to irrigation without mulching. Unlike husk and coir pith, leaves cannot hold much moisture before they become composted. Leaf mulch prevents the topsoil from getting heated up and this reduces the evaporation from the basin area. The leaves once applied as mulch could last for 1 to 2 years.

Coconut Leaf Mulching

ii) Coconut husk

Coconut husks are also used as surface mulch around the base of the palm. It can hold moisture to the tune 3 to 5 times of its weight. Approximately 250 to 300 husks will be required for mulching one coconut basin. Mulching is usually done up to a radius of 2 m leaving approximately 30 cm near the palm. Two layers of husk may be



Coconut Husk Mulching

buried in the coconut basin with the concave side facing upwards. These layers facilitate absorption of moisture. Above this another layer of coconut husk is placed with convex side facing upwards to arrest evaporation. Effect of this mulch lasts for about 5-7 years.

iii) Coir pith

Coir pith, a waste product obtained during the extraction of coir fibre from husk, is very light, highly compressible and highly hygroscopic. Coir pith when applied at 10 cm thick (approximately 50 kg/ palm) around coconut basin is an ideal medium to conserve moisture. The mulch may be applied during the end of the rainy season. Coir pith can hold moisture upto 5 times of its weight. Due to its fibrous and loose nature, incorporation of coir pith into the soil improves the soil's physical properties and water holding capacity considerably and thereby increases the coconut productivity.

Further, by spreading coir pith in the basin, increase in soil temperature and evaporation is arrested. However, it is better to use composted coir pith rather than raw coir pith. The applied material may last for about 4 to 5 years.

Other organic wastes

Mulching of coconut basin could also be done with other organic wastes as weeded materials etc. The weeded materials should be properly dried and then applied.

b. Husk burial

Husks, if buried in the soil act as a water reservoir and also supply palms with small amount of potash present in it. A fully soaked husk is able to retain about 5-6 times of its weight of water and make it available to the palm during summer season. Besides, on an average 100,000 husks contain potash equivalent to 1 tonne of muriate of potash, which is also made available to the palm.

c. Burying Husks in pits around the coconut palm

Coconut husk can be buried in circular trenches taken around the palm at a distance of 2.5 m away from the trunk. The trenches may be of 0.5 m in width and depth. The husks are to be placed in layers with concave surface facing upwards and covered with soil.

7) Drip irrigation

Poor soil moisture retention characteristic of coastal sandy soils makes irrigation very essential. Good irrigation practices are needed to sustain productivity in this soil. In the traditional system of irrigation, irrigation efficiency is only 30 to 50 per cent due to considerable wastage of water. In addition, cost of inputs like labor and energy is quite high for these irrigation systems. Under these circumstances, drip irrigation is the most suitable system for coconut. The system has an overall application efficiency of around 90%. Some of the major advantages of drip irrigation are: it saves water, enhances plant growth and yield, save energy and labor, is most suited for soils having low water holding capacity and undulating terrain, reduces weed growth and improves efficiency of fertilizers. Drip irrigation is an efficient method of providing water directly to the root zone of plants. It provides irrigation closely to the crop water requirements. It is a boon for the very porous soils like coastal sandy soils where any other type of irrigation will lead to wastage of water and energy. A minimum of 15 to 20 percent of the active root zone should be wetted to absorb the required amount of water by the palms.

Drip Irrigation for Coconut Planting

Table 7. Influence of irrigation, mulching and their interaction on coconut yield (pooled data for 6 years) in litoral sandy soil

Treatments Irrigation	Nut Yield/palm/year		
	No Mulch	Mulch	Mean
T1: 66% of Eo through drip	59	76	68
T2: 100% of Eo through drip	65	80	72
T3: 133% of Eo through drip	56	78	67
T4: 100% of Eo through basin irrigation	58	74	66
T5: Rainfed	28	28	28
Mean	53	67	

CD for Main plots (P=0.05)=12.3 CD for sub plots (P=0.05)=4.5 CD for sub plot at the same level of main plot (P=0.05)=12.1 CD for main plot at the same or different levels of subplot (P=0.05)=18.2

Results of irrigation experiments conducted at CPCRI have shown (water spread from a single point source) that at least six emitters are required for sandy soil. Studies on the water absorption by coconut roots indicate that the active absorption zone lies from 0.75 m to 1.25 m away from the bole. Hence, it is recommended to place the emitter/micro tubes in the center of that area i.e. 1 m away from bole. If water is allowed to drip on the surface it leads to evaporation losses and a good amount of water is lost. Therefore, it is advisable to allow the water to drip at 20 cm depth since it helps to prevent evaporation. This is achieved by making a pit of 20 cm^2. A conduit pipe of 30 cm is placed diagonally and the water is allowed to drip in that pipe. The pit should be filled with locally available mulch including coir pith if available nearby. Under Kasaragod conditions, 32 to 40 liters (66% of open pan evaporation) of water/palm/day can be applied through drip irrigation. Irrigation should be started in the month of November when the soil moisture depletes to 50% available soil moisture. In other parts of India especially Tamil Nadu and Andhra Pradesh, water should be provided throughout the year except during rainy season.

The response of coconut to combined effect of drip irrigation and mulching was studied under coastal sandy soil at the Central Plantation Crops Research Institute (CPCRI), Kasaragod, during non-rainy seasons with West Coast Tall variety. Pooled data on nut yield for six years (1993-99) showed no significant difference among drip irrigation treatments (at 200 liters once in 4 days). All irrigation treatments were on a par with each other but superior to the rainfed control (Table 8). The highest nut yield (72 nuts) was observed in the drip irrigated treatment at 100 % of Eo and was on par with treatments of drip irrigation with 66% or 133% of Eo (67 nuts).

Table 8. Nutrient substitution through cowpea/sunhemp growing and incorporation in coconut basins

Particulars	N	P_2O_5	K_2O
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Cowpea Nutrient Content (%)	2.87	0.22	2.14
Nutrient availability through biomass from one basin of coconut palm when copea is grown in the basin (g)	145	11	108
Fertilizer nutrient substitution by cowpea % substitution	29	9	9
Sun hemp Nutrient content (%)	2.94	0.18	1.43
Nutrient availability through biomass from one basin of coconut palm when sum hemp is grown in the basin (g)	142	26	37
Fertilizer nutrient substitution by sun hemp			
% Nutrient subsitution	29	8	3

Conclusion

To make coconut cultivation economically viable and sustainable under coastal sandy soil, more emphasis should be given to improve soil conditions physically and chemically. In this regard, CPCRI has successfully developed a number of agro techniques viz.: moisture conservation practices using husk/coir pith for growing different intercrops, alley cropping of glyricidia, green manuring with glyricidia loppings, basin management with leguminous crops, direct utilization of coconut wastes for soil moisture conservation measures, vermicomposting of coconut plantation wastes and recycling and micro irrigation for increasing the yield of coconut palm. All these techniques need to be adopted in an integrated manner to improve the productivity of system. By adopting such agro techniques in the coastal sandy soil, a significant improvement in yield could be achieved as evident from the results of the experiments conducted at CPCRI.

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