Impact of post monsoon rainfall and soil moisture conservation strategies to sustain Coconut productivity

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Introduction

Success of coconut farming is mostly determined by favorable climatic factors, optimum supply of water, nutrients and other inputs. Among the climatic factors, rainfall plays a crucial role in increasing coconut productivity. Millions of families in India depend directly or indirectly on coconut for their livelihood. The annual coconut production in India is 23.90 billion nuts from an area of 2.08 million ha with an average productivity of 11481 nuts/ha (CDB 2016- 17). The four southern states in India viz., Kerala, Tamil Nadu, Karnataka and Andhra Pradesh are the major coconut producing states, accounting for more than 90 percent of area and production. Indian agriculture is mainly dependent on the monsoon rain and 75 % of the rainfall is received during the south west monsoon (June to Sept.), benefiting most of the coconut growing regions. Along the east coast, in the main coconut growing areas of Tamil Nadu and Andhra Pradesh, the north east monsoon (October to December) accounts for major rainfall. Occurrence of both the monsoons are equally important for successful coconut cultivation in the country. This is mainly because of the fact that after the cessation of monsoon there is no rainfall till the receipt of good summer showers during the first fortnight or end of May. Hence normal monsoon followed by few post monsoon showers ensure availability of sufficient soil moisture till January end and thereafter depletion of soil moisture results in soil moisture deficit. The situation gets aggravated after March. Therefore the survival of palms during the period between January to May is mainly dependent on post monsoon rains.

In recent years, sustainable production of coconut is in danger owing to erratic behavior of monsoon and post monsoon rains and frequent droughts result not only in decline in productivity and also mortality of palms in extreme cases. Hence an effort was made to analyze the post monsoon rainfall data for the year 2018. Its effect on coconut yield and mitigation measures for the same are suggested below.

Occurrence of north east monsoon during 2018

Rainfall received during the post monsoon season (October to December) of 2018 in major coconut growing districts of southern states is presented in tables 1 to 4 and depicted in figures 1 to 4.

Tamil Nadu

The rainfall received during October to December, 2018 in Tamil Nadu clearly revealed that 13 districts out of 21(considered districts having >6000 ha coconut area) received less rainfall than the normal which falls under the category of deficit, two districts viz., Kanyakumari and Tirunelveli districts received excess rainfall (Table 1 and Fig 1) and 6 districts viz., Krishnagiri, Namakal, Salem, Thoothukudi, Tirupur and Vellore districts received normal rainfall. (Table 1 and Fig.1).

Table1. Comparison of normal and actual rainfall received during October- December 2018 in the major coconut growing districts of Tamil Nadu

Districts	Area (ha)	Normal RF (mm)	Actual RF (mm)	% Deviation	Category*
Coimbatore	85832	328.9	182.5	- 45	D
Dindigul	30538	436.4	325.1	-25	D
Dharmapuri	7974	330.1	254.7	-23	D
Erode	14301	314.6	196.4	-38	D
Kanyakumari	23988	496.4	611.2	23	E
Karur	6640	314.7	234.3	-26	D
Krishnagiri	15612	289.4	329.7	14	N
Madurai	10876	419.1	286.5	-32	D
Namakkal	8269	291.6	256.6	-12	N
Pudukottai	9456	406.2	207.5	-49	D
Ramanatha puram	8292	491.7	259.1	-47	D
Salem	13635	370.5	341.9	-8	N
Sivaganga	7098	422.7	259.1	-39	D
Thanjavur	36136	550.3	433.7	-21	D
Theni	20931	357.9	280.7	-22	D
Thiruchirapally	6070	391.5	223.7	-43	D
Thoothukudi	6013	427.0	353.7	-17	N
Tirunelveli	16248	467.2	665.4	42	E
Tirupur	60148	314.3	255.6	-19	N
Vellore	20523	348.7	338.8	-3	N
Virudhunagar	10156	419.0	332.3	-21	D

**D = deficit (Percentage deviation of realised rainfall from normal rainfall is between – 20 % to - 59 %.), N = normal (Percentage deviation of realised rainfall from normal rainfall is between - 19 % to + 19 %.), E= Excess (Percentage deviation of realised rainfall from normal rainfall is + 20% or more.)*

Source: IMD, 2019

Kerala

Rainfall received during the post monsoon season of major coconut growing districts of Kerala revealed that except Alappuzha, Ernakulam and Idukki districts, others recorded either less or excess rainfall. The highly affected district is Palakkad. (Table 2 and Fig. 2)

Table 2. Comparison of normal rainfall vs actual rainfall received during October- December 2018 for coconut growing districts of Kerala

Districts	Area (ha)	Normal RF (mm)	Actual RF (mm)	% Deviation	Category*
Alappuzha	33676	572.1	489.4	-14	N
Ernakulam	43079	489.3	539.0	10	N
Idukki	16122	564.2	494.0	-12	N
Kannur	88217	345.1	246.1	-29	D
Kasaragod	65243	337.9	180.1	-47	D
Kollam	50938	638.6	950.0	49	E
Kottayam	25610	535.1	645.0	21	E
Kozhikode	119064	422.2	271.5	-36	D
Malappuram	102836	448.3	343.7	-23	D
Palakkad	59547	428.0	177.4	-59	D
Pathanamthitta	15877	624.2	928.3	49	E
Thiruvanantha-puram	70467	522.7	667.4	28	E
Thrissur	80540	469.4	318.4	-32	D
Wayanad	10322	332.5	165.0	-50	D

*D = Deficit (Percentage deviation of realised rainfall from normal rainfall is between – 20 % to - 59 %.), N = Normal (Percentage deviation of realised rainfall from normal rainfall is between - 19 % to + 19 %.), E= Excess(Percentage deviation of realised rainfall from normal rainfall is + 20% or more.)

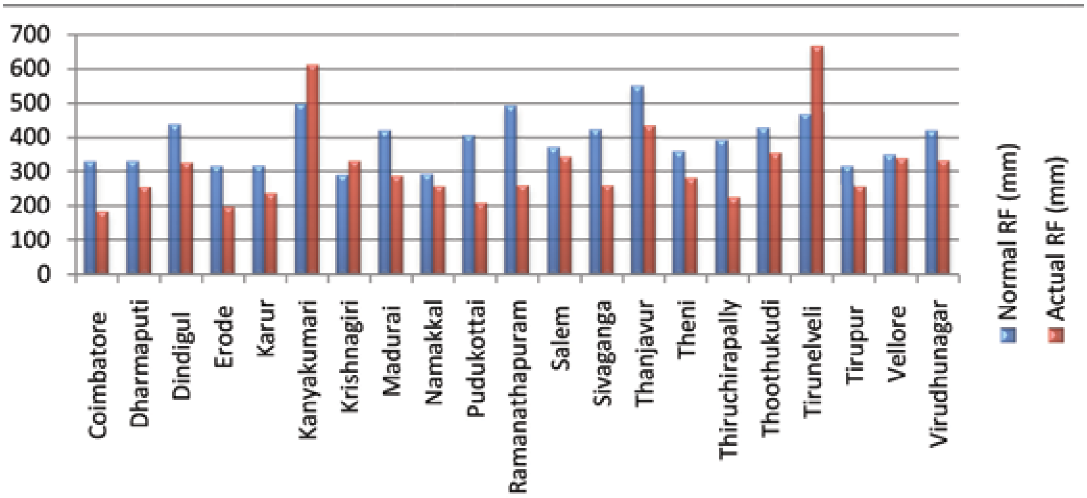

Fig.1

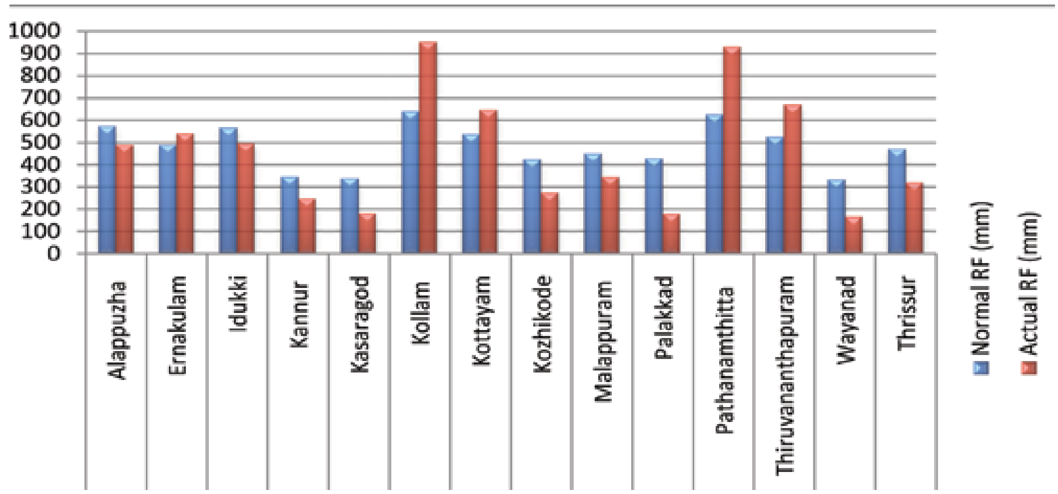

Fig.2

Karnataka

Rainfall received during the post monsoon season in major coconut growing districts of Karnataka (considered districts having >7000 ha coconut area) revealed that except Chamarajanagar, Davangere, Ramnagar, Mandya and Udupi, other districts of Karnataka recorded either less or excess rainfall. The highly affected district is Chikmagalur (- 45) (Table 3. and Fig 3)

Table 3. Comparison of normal rainfall vs actual rainfall received during October- December 2018 for major coconut growing districts of Karnataka

Districts	Area (ha)	Normal RF (mm)	Actual RF (mm)	% Deviation	Category*
Chamarajanagar	9130	244.8	237.3	-3	N
Chikmagalur	41114	238.5	131.7	-45	D
Chitradurga	40576	159.0	196.5	24	E
Dakshina Kannada	18467	334.5	248.4	-26	D
Davangere	10011	176.7	194.7	10	N
Hassan	60472	221.0	131.8	-40	D
Mandya	24629	214.1	198.3	-7	N
Mysore	16712	214.3	142.7	-33	D
Ramanagar	18242	243.1	267.1	10	N
Udupi	17922	317.2	345.8	9	N
Tumkur	152341	205.7	250.0	22	E
Uttar Kannada	7787	210.4	155.2	-26	D

*D = Deficit (Percentage deviation of realised rainfall from normal rainfall is between – 20 % to - 59 %.), N = Normal (Percentage deviation of realised rainfall from normal rainfall is between - 19 % to + 19 %.), E= Excess (Percentage deviation of realised rainfall from normal rainfall is + 20% or more.)

Andhra Pradesh

Rainfall received during the post monsoon season of major coconut growing districts of Andhra Pradesh revealed that except Chittor and Srikakulam, other districts of Andhara Pradesh, recorded less than normal rainfall. (Table 4 and Fig. 4). The worst affected districts are East Godavari and West Godavari (-55 %).

Table 4. Comparison of normal rainfall vs actual rainfall received during October- December 2018 for major coconut growing districts of Andhra Pradesh

Districts	Area (ha)	Actual RF (mm)	Normal RF (mm)	% Deviation	Category*
Chittoor	3465	418.4	362.9	15	N
East Godavari	50490	125.7	276.6	-55	D
Krishna	1872	127.5	242.4	-47	D
Srikakulam	14753	243.2	286.1	-15	N
Visakapatanam	7300	133.2	267.8	-50	D
Vizianagaram	2793	193.5	250.5	-23	D
West Godavari	21818	124.7	276.2	-55	D

*D = Deficit (Percentage deviation of realised rainfall from normal rainfall is between – 20 % to - 59 %.), N = Normal(Percentage deviation of realised rainfall from normal rainfall is between - 19 % to + 19 %.), E= Excess(Percentage deviation of realised rainfall from normal rainfall is + 20% or more.)

It is clear from the post monsoon data that major part of the coconut growing area in the Peninsular India received deficit rainfall. This will adversely affect the coconut productivity under rainfed conditions (no irrigation) and even under irrigated

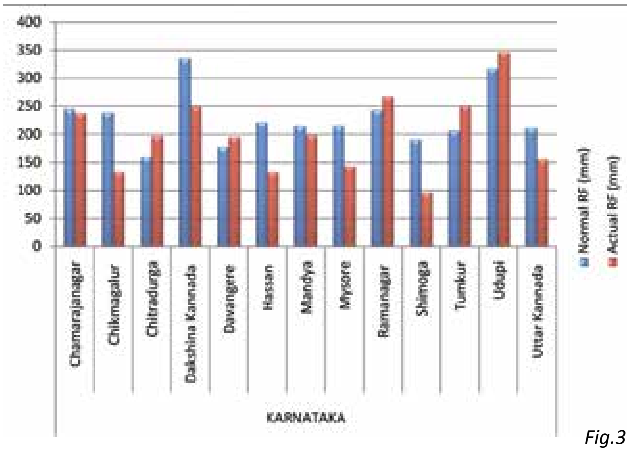

Fig.3

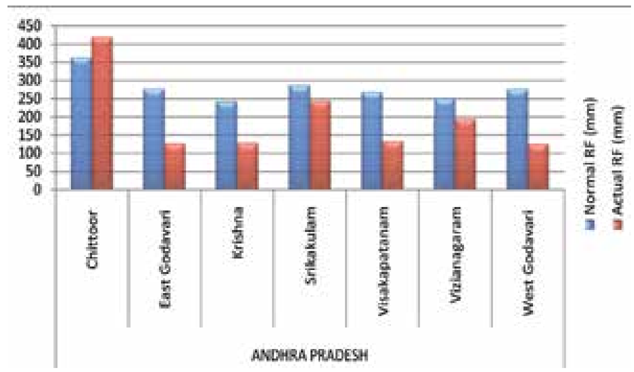

Fig.4

conditions it may pose serious problem during the later part of summer season due to drying up of the irrigation water sources. Hence for sustaining coconut growth and production it is imperative to adopt water conserving and drought mitigating measures including short, medium and long term measures.

Impact of moisture stress on coconut seedlings

A rainless period of more than 10 to 15 days, depending upon the soil type, will cause water stress in seedlings and result in scorching of leaves, followed by wilting of the seedlings. If the duration of stress is prolonged, it ultimately leads to the death of seedling. So in the initial stages of seedling growth (up to a period of three years), life saving irrigation (when grown under high rainfall zone as rain fed crop) or regular irrigation (in dry areas or low rainfall zone) is essential for the survival and successful establishment of the palm.

Impact of moisture stress on adult coconut palms

Deficit soil moisture adversely affects the growth of different parts of the palm to varying degrees, adversely affecting productivity of the coconut palm to a great extent.

Effect on vegetative growth

The absence of adequate moisture in the soil affects the leaf water potential and the absorption of nutrients. Drought conditions cause drying and death of roots which affect the absorption and transportation of water and nutrients from the soil. Inadequate moisture availability in the soil affects solubility and movement of nutrients and absorption of nitrogen and potassium has been shown to be below optimum under inadequate moisture conditions. Moisture stress and poor absorption of nutrients leads to yellowing of lower leaves, drying of leaves and petiole breakage. Breakage of leaf petiole is the typical symptom of the palms affected by drought. The dried leaves then fall off, leaving only a few green leaves on the crown. Subsequently these top leaves also fall off and even a low velocity wind results in to de-topping and death of the palms (Fig. 5)

Effect on yield and yield attributes

Soil moisture availability influences inflorescence initiation and female flower development and water deficiency can result in abortion of spadices. In addition to total absence of the inflorescence in some of the leaf axils, emergence of inflorescences without female flowers, delay in opening of spathes, shedding of fertilized female flowers (buttons) and immature nut fall are also observed to occur due to moisture deficit stress. Further the production of leaves is affected resulting in a reduction in the number of bunches produced. Soil moisture stress also results in bunch drooping and buckling, poor nut set, poor endosperm development and reduction in size of nuts as well as copra content.

Considering the long duration of 44 months from the initiation of inflorescence primordia to nut maturity, there are different stages at which moisture stress can detrimentally affect nut yield. It is noteworthy that about 70 per cent of this period falls in the pre-fertilization phase and only 30 per cent falls in the fertilization and post-fertilization phases. Thus palms affected by drought take at least two to three years to recover completely impacting palm productivity and income to the farmer (Rajagopal *et al.*, 1996).

(Fig. 5) Effect of moisture stress on coconut palm

1. ***Yellowing and drooping of lower leaves***
2. ***Yellowing and drooping of lower leaves Petiole breakage, a typical symptom of moisture deficit stress***
3. ***Drought affected palm, with only central whorl of leaves***
4. ***De-topping and death of drought affected palm***

Deficit post monsoon rains have a negative impact on water availability and it is imperative to use each and every drop of available water more effectively for crop production. Hence the method and system of irrigation along with soil moisture conservation is important and should ensure saving of water, energy and labour and focus on higher Water Use Efficiency (WUE). It is necessary to adopt management practices in a holistic approach on a long term basis owing to the perennial nature of the coconut palm. The principle of CATCH, COLLECT and UTILIZE the rainfall is of paramount importance. The following soil moisture conservation measures could be adopted in the coconut plantation to overcome adverse impact of drought owing to erratic behavior and failure of monsoon rains.

I. Soil and water conservation measures

Mulching coconut basins

Mulching is the simplest and most effective moisture conservation practice for sustainable coconut production. In order to conserve soil moisture in coconut plantations, mulching with various types of organic materials viz., coconut leaves, husk and coir pith can be practiced (Fig. 6). Mulching not only helps in reducing soil temperature and evaporation of moisture from soil surface, it also creates an ambient condition for proper root growth and proliferation of soil flora and fauna. The timing of mulching is crucial for effectively conserving soil moisture. Mulching the area around the base of the palm (1.8 - 2.0 m radius) before the end of monsoon (and before the top soil dries up) will help retain soil moisture and prevent the ground from becoming hard and thus help lessen the adverse effects of drought conditions and promote growth of the palms.

For mulching, coconut leaves should be cut into two or three pieces and arranged in two to three layers in the coconut basins. About 15 to 25 fallen coconut leaves would be required to cover 1.8 m radius of a coconut basin.

Coconut husk and coir pith can hold moisture to the tune of three to five times of their weight and hence are ideal for mulching the basins and promote soil moisture conservation. Besides conserving soil moisture, coconut husk is an important organic material and a good source of plant nutrients. On an average husk constitutes 45% of the weight of nut and on this basis, a nut weighing 1,000 g will have 450 g of husk with 20% moisture. Approximately 250 to 300 husks would be required for one coconut basin. Decomposition of the mulches after a period of time results in enrichment of soil organic matter pool. On dry weight basis, the average composition of husk is 0.23% N, 0.04% P, 0.78% K, 0.08% Ca and 0.05% Mg. For mulching one coconut basin with coir pith to 10 cm thickness, approximately 50 kg coir pith would be required. Due to its fibrous and loose nature, incorporation of coir pith considerably improves the physical properties and water holding capacity of soil and thereby increases the coconut productivity. Mulching of coconut basins can also be done with other organic wastes such as completely dried weeded material.

Dried coconut leaf mulch ***Coconut husk mulch***

(Fig. 6) Organic mulching materials

Timing of mulching as soil moisture conservation measure

Timing of mulching is very important. As a soil moisture conservation measure, mulching should be done before the soil moisture is depleted and preferably when the available soil moisture is at field capacity. If it is not done earlier, then before applying mulches the basin of coconut palm (1.8 m radius) should be fully irrigated (300 to 400 liters of water) to reach field capacity.

Contour trench filled with coconut husk

This measure is to be taken up where the land slope is high (7-22%). Trenches of 50 cm width and 50 cm depth and of convenient length (preferably 4 m length) are to be made (across the slope) in between two rows of coconut palms. The trench should be dug in such a way that it would not come in line with the basin area and will trap the water flowing down the slope from the area in between the coconut basins. These trenches are to be filled with layers of coconut husk, with the bottom layers facing up (concave side up) and top layer facing down. A bund of 50 cm height and suitable width (50 cm) is to be made at the downstream of the trench using the excavated soil. To stabilize the bund, two rows of pineapple plants are to be planted on the bund at a spacing of 20 cm x 20 cm (Fig. 7). Pineapple plants in addition to stabilizing the bund, would also provide additional income to the farmer. The runoff water from the upstream, along with soil particles in the runoff water gets collected in the trenches. The coconut husk retains the moisture for a longer period and makes it available for plants during summer months. Adoption of this intervention in coconut plantations (in farmers holdings), was effective in soil and water conservation, with 98% reduction in the soil loss (0.14 t/ha) as compared to control (10.52 t/ha) and recorded lesser water runoff (0.17%) as compared to control (5.6%). Similar results were obtained in terms of nutrient conservation, with minimum nutrient loss (1.28, 0.20 and 1.15 kg/ha/year N, P_2O5, K_2O, respectively) as compared to control (105, 22 and 167 kg/ha/year N, P_2O5, K_2O, respectively), with a per hectare yearly nutrient saving of 103.7 kg nitrogen, 21.8 kg phosphorus and 166.85 kg of potassium. A positive effect on coconut yield under rain fed conditions was also observed (over a four year period), with a 162 % increase in coconut yield (93 nuts/palm/year), over pretreatment yield (35 nuts/palm/year), as a result of these management practices.

Half moon bund with two rows of pineapple

This is another effective method for conserving precarious natural resources, viz. soil and water and has been successfully demonstrated in coconut plantations. This measure is to be taken up where there is mild slope. Here a flat basin with a slight inward slope in the upstream is made by excavating soil from the upstream side and shifting the excavated soil to the downstream side. A bund of 50 cm height and 50 cm width is made at the downstream side of the coconut palm using the excavated soil. Two rows of pineapple plants are to be planted on the bund, with a spacing of 20 cm row to row and 20 cm plant to plant (Fig. 8). The bund prevents runoff and water gets collected within the basin and percolates down. Roots of pineapple act as a reinforcement to stabilize and protect the bund, in addition to giving additional income to the farmer through fruit yield. About 94% reduction in soil loss (annually to the tune of

Fig. 7. Contour trench filled with coconut husk

Fig.8 .Half moon bund

Fig. 9. Catch pit with pineapple border

0.59 t/ha as against 10.52 t/ha in control) was recorded in farmers gardens, due to adoption of this simple technology. Similarly, less nutrient loss was also observed (3.30, 0.83 and 4.18 kg/ha/year N, P_2O5, K_2O, respectively) as compared to control (105, 22 and 167 kg/ha/year N, P_2O5, K_2O, respectively). Higher soil moisture content was observed even during post monsoon period, up to four months after cessation of rains, in comparison to control wherein the coconut palms reached almost close to permanent wilting point within two months after cessation of rains. Along with the reduction in runoff, soil erosion, nutrient loss, 63% increase in yield (70 nuts/palm/year) over pre treatment yield of 43 nuts/palm/year was also recorded (Mathew *et al.*, 2018).

Staggered catch pit

Catch pit technology is very effective in conserving soil and water resources and can be constructed in all slopes. By adopting this technique, the soil loss was 0.69 t/ha/year and the nutrient loss was 2.71, 0.56 and 3.87 kg/ha/year, N, P_2O5 and K_2O, respectively. Though there are no standard dimensions for catch pits, for convenience catch pits of 1.5 m length x 0.5 m width x 0.5 m depth can be adopted. A bund is to be made downstream of the catch pit using the excavated soil and strengthened by planting pineapple plants (Fig. 9). This pit may or may not be filled with coconut husk. If it is without husk, periodic measurement of the depth of the pit indicates the amount of soil collected inside the pit, a direct measurement of soil erosion. Remarkable impact of catch pit on coconut palm yield was observed at ICAR-CPCRI, with a 96% increase (49 nuts/palm/year) over the pre treatment yield (25 nuts/palm/year).

Coconut husk or leaf burial in interspaces

Husk or leaf burial in interspaces can be undertaken in any coconut plantation, for moisture conservation. Trenches of 120 cm width x 60 cm depth and convenient length can be made in between two rows of coconut palms. These trenches are then filled with coconut husk and/or coconut leaves (Fig. 10). Coconut husks need to be filled in layers with the bottom layers facing up and top layer facing down. The top portion of the trenches are filled with coconut leaves and finally covered with soil.

Efficient water management

Deficit monsoon rains have a negative impact on water availability, resulting in water becoming a critical input. So it is imperative to use each and every drop of the available water more effectively for crop production and hence the method of irrigation and system of irrigation is more important and should ensure saving of water, energy and labour and focus on higher Water Use Efficiency (WUE) and drip irrigation is an ideal method of irrigation for coconut. However to reap the full benefit of drip irrigation, it is essential that sufficient care is taken to ensure proper installation of the system for effective delivery of water in the subsurface and in the active root zone. Studies on root absorption in coconut indicate an active absorption zone 0.75 m to 1.25 m from the bole and hence it is recommended to place the emitter/micro tubes in the centre of that area (about 1 m from bole). Further, loss of water through evaporation can be reduced by adoption of sub surface irrigation, allowing the

Fig.10 . Coconut husk or leaf burrial in interspace

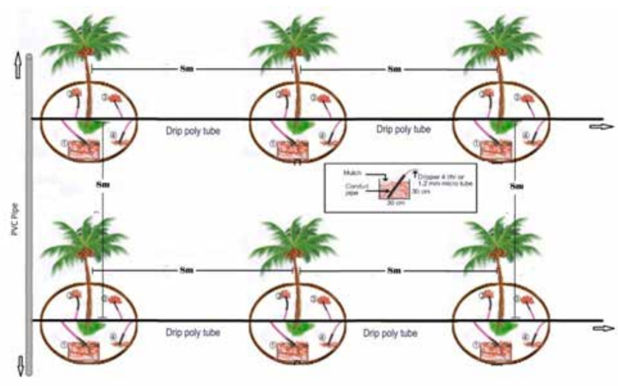

Fig. 11 Layout of drip irrigation in coconut

water to drip at 30 cm depth by making a pit of 30 cm-3. The pit should be filled with locally available mulch or coir pith (if available nearby). To facilitate effective sub surface delivery of irrigation water, a conduit pipe of 40 cm may be placed diagonally and water allowed to drip through that pipe. By this subsurface placement, evaporation is minimized and the volume of wetted soil was 35% more than the surface placed emitters (Fig. 11). Further, fertilizers also can be applied through drip irrigation system, thus ensuring efficient use of both water as well as fertilizers.

Integrated nutrient management

Application of sufficient quantities of organic manure in a regular interval will not only improve soil structure, but also improve its nutrient status to support growth of the coconut palms. Organic matter addition enhances moisture retention capacity and reduces the bulk density of the soils, thereby increasing aeration, drainage and water intake of soils. Farmyard manure, composted crop and animal residues, vermicompost and green leaf manure and other biodegradable wastes can be effectively used in the coconut groves to improve the soil texture and nutrient levels. Application of farmyard manure/compost/green leaf manure @ 50 kg per palm/year along with inorganic NPK (based on soil test value), will improve nutrient availability to the palm for sustained coconut production. Results from the long term manurial experiment at ICAR-CPCRI Kasaragod also indicated higher coconut productivity under integrated nutrient management in rain fed cultivation.

Circular basins of 1.8 m radius and 20 cm depth may be dug and green leaf or compost or farm yard manure @ 50 kg per palm may be spread in the basin. The availability of recyclable biomass from a well-managed coconut garden with 175 trees/ ha. has been estimated as 15 tonnes /ha/year in the form of leaves, spathe, bunch waste and husk. By effective recycling of these biomass in the coconut garden through vermicmposting, mulching and other soil moisture conservation measures would help in improving the physical, chemical and biological properties of soil. The increased organic content in the soil will also enhance its water retention capacity in the sandy soils. In clayey soils, it will help in loosening the structure and make it more porous, thus facilitating better aeration in the root zone and good drainage. It will also help in efficient intake of water and nutrients.

Conclusion

Water becomes a dwindling resource day by day and there won't be any change in future too. Hence it is imperative to use this most important resource in an effective manner. In this context sustainable coconut cultivation heavily depends on the systematic and scientific adoption of soil moisture conservation measures with integrated nutrient management practices

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