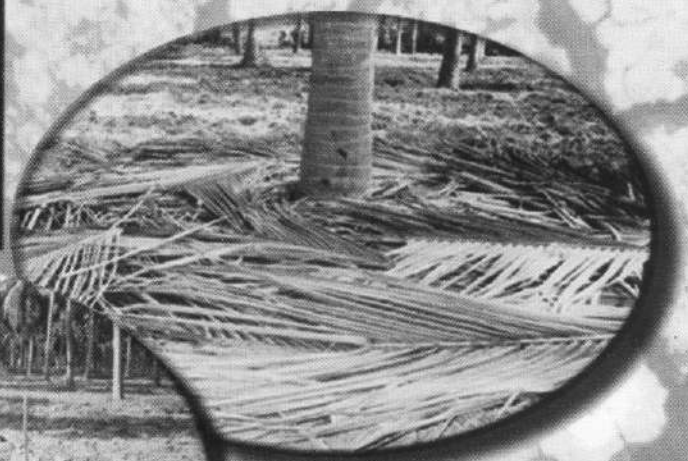
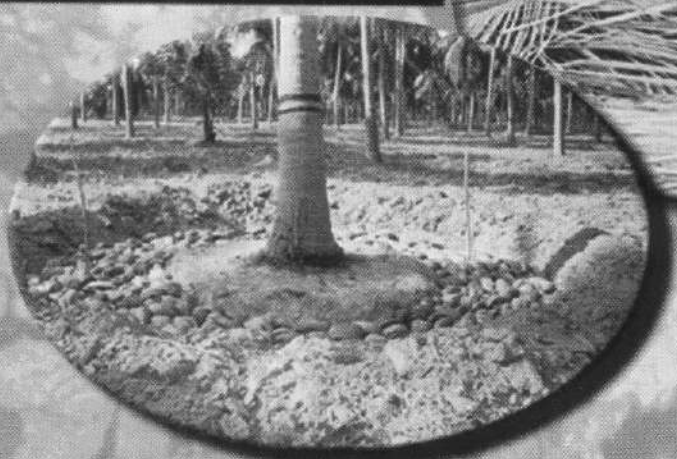
DROUGHT MANAGEMENT IN COCONUT GARDENS





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Technical Bulletin

Drought Management In Coconut Gardens

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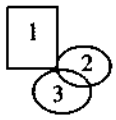
Front: 

1. Drought affected coconut garden
2. Leaf mulching in coconut basin
3. Coconut husk burial in basin

Back : Overview of a coconut garden

Photo credit : **S. Naresh Kumar**

Cover design : **S. Naresh Kumar & Ch. Amarnath**

March, 2004

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INTRODUCTION

Coconut palms, as rainfed crop, are exposed to annual summer dry spells and frequent drought years of different intensities and durations in various parts of the country. The impact of drought on coconut persists for two to three years in view of the indeterminate flowering habit and perennial nature of the crop. As coconut yields are closely linked to favourable weather conditions, occurrence of drought leads to significant reduction in yields thereby resulting in considerable economic loss to the growers. Impact of drought stress and response of palms to tolerate drought was studied in India and abroad. Investigations based on physiological, anatomical and biochemical characters resulted in identification of some of the genotypes capable of withstanding drought conditions. As the nature of drought differs among the agro-climatic zones, where coconuts are cultivated, a sound knowledge on the characterization of drought is an essential pre-requisite to initiate any action on drought management. Investigations were carried out to characterize the nature of drought in different agro-climatic zones and to evolve soil moisture conservation practices suitable for specific locations. Apart from this, identification of *in situ* drought tolerant types also formed one of the objectives in this multi-location project.

Experiments were conducted at CPCRI and AICRP (Palms) centres in different agro-climatic zones viz., Western coastal area – hot sub-humid-per-humid (Kidu – Karnataka; Ratnagiri – Maharastra), hot semi- arid (Arsikere – Karnataka) and Eastern coastal plains- hot sub-humid (Veppankulum- Tamil Nadu; Ambajipeta- Andhra Pradesh), which represent the major coconut growing areas in India. The average annual rainfall varied from a maximum of 3338 mm in Kasaragod to a minimum of 718 mm in Arsikere. Kasaragod, Kidu and Ratnagiri had similar rainfall pattern with peaks during June, July and August, whereas, Veppankulum, Ambajipeta and Arsikere had different patterns for rainfall with peaks during October and November. Dry spell was longer in Ratnagiri (216 days) and Arsikere (202 days) and shorter at Kidu (146 days). Fluctuations in coconut yield during different years could thus be explained on the basis of variations in rainfall, dry spell and day/night temperature pattern. In general, all the centres exhibited either two or three years of consecutive drought or alternative drought year during a 15-year cycle.

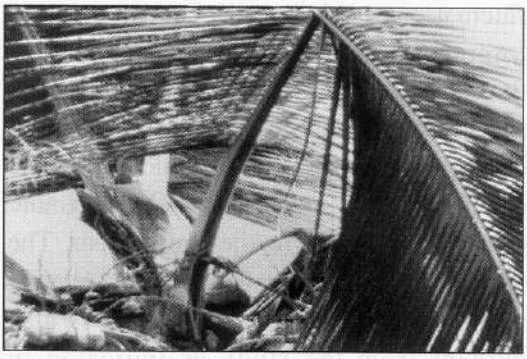
EFFECT OF DROUGHT ON COCONUT

In view of the long duration of 44 months between the initiation of inflorescence primordium and ultimate nut yield, with about 70% period for the pre-fertilization and only 30% represented by fertilization and post-fertilization phases, any fluctuations in dry spell occurring during important stages of floral and fruit development would reflect on nut yield. The study revealed that the rainfall or dry spell during these stages ultimately determine the nut production. Longer dry spell was found to affect nut yield in the fourth year. The impact of day/night temperatures and relative humidity on nut yield of coconut is also evident from the study as indicated in prediction models.

Drought stress affects coconut seedlings: Seedlings need to be protected from high sunlight intensities by providing shade. Regular irrigation should be provided to ensure better establishment. A dry spell of 15 to 20 days make seedlings to experience water stress resulting in leaf wilting and scorching. If stress duration is prolonged, it leads to seedling death.

Drought affected coconut seedlings

Frequent drought stress affects the adult palms: The rainfed coconut gardens face summer dry spells causing drooping of leaves due to low leaf water potentials, shedding of buttons and immature nut fall. In severe stress conditions bending and breaking of leaves occur. Drought occurrence aggravates the situation causing these symptoms early and in severe cases crown gets damaged leading to detopping and death of palms leaving only dead stems in the field. Most of the palms will be without any bearing inflorescence or inflorescences with barren nuts thus affecting the productivity and income to the farmer. Such gardens take three to four years to revive once soil moisture conservation practices are adopted. Hence, it is recommended to follow the drought management practices to mitigate dry spell effects. Soil moisture conservation practices like husk burial in basin, leaf mulching, burial of FYM or composted coir pith or other farm waste, mulching with green leaf manures like *Glyricida* or with other suitable green manure crops should be followed based on the availability of material. Available scarce water resources can be used



Bending and breaking of leaves - a drought stress symptom

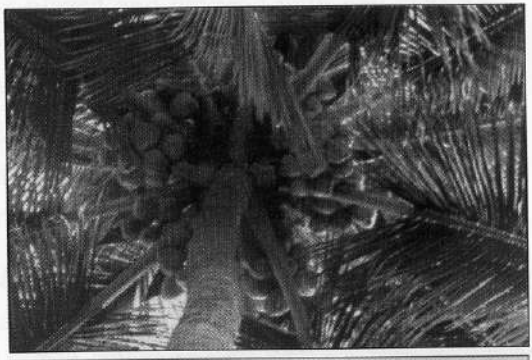
Aborted inflorescence - a common-site in drought affected gardens

Drought affected coconut garden

for providing summer irrigation to all palms in the field even at deficit levels. Old leaves can be cut to reduce the transpirational water loss. Drip irrigation can increase the water use efficiency at field and plant level. *In situ* water harvesting is one of the important methods to increase the soil water table.

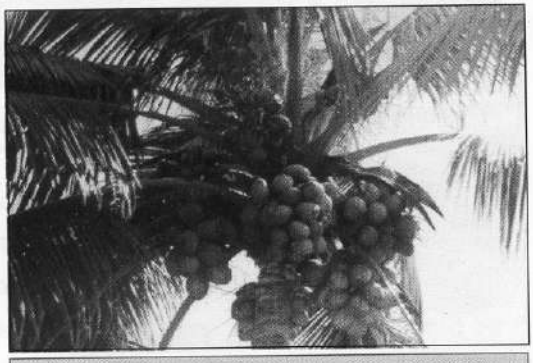
DROUGHT TOLERANCE IN COCONUT

Studies based on morphological, anatomical, physiological and biochemical characters indicated that tall cultivars like

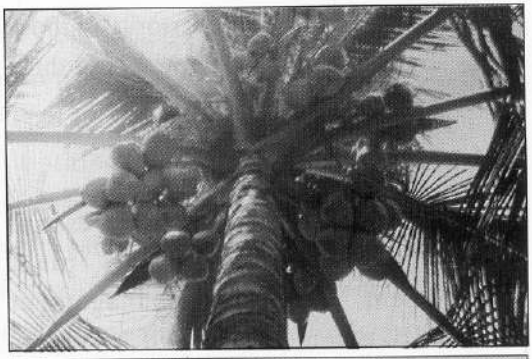


Drought tolerant WCT palm

WCT and LCT are drought tolerant. Among the hybrids LCT x GBGD, WCT x COD and LCTx COD are relatively tolerant. These cultivars and hybrids performed better, in terms of nut yield, even during drought and subsequent years.



Drought tolerant hybrid (LCT x GBGD)



In situ drought tolerant palm in farmer's field

In situ drought tolerant palms

It is important to identify the palms which survive and yield heavily in drought prone locations. These palms have desirable traits for drought tolerance, thus are able to withstand drought and produce high yield. Identification of such palms will help in increasing the genetic variability for the crop, which can be used in crop improvement programme. Such *in situ* field tolerant palms were identified during surveys conducted in farmers' plots under rainfed condition in Arsikere, Ambajipeta and Ratnagiri areas. These field drought tolerant palms had more number of leaves, bunches and mature nuts/ bunch compared to the other palms in the vicinity. These palms also exhibited good water use efficiency. The superiority of these palms in the photosynthetic parameters showed their capacity for drought tolerance and high yield (~ 90 nuts/palm/year) They can be used as mother palms in breeding programme for drought tolerance Conservation and characterization of desirable gene pools present in such palms should be a priority. For marking a palm as field drought tolerant, it is absolutely necessary that the physiological,

morphological and yield superiority of those palms should be monitored for at least three years.

DROUGHT MANAGEMENT

Drought management involves soil moisture conservation and plant management. Since plant management practice like removal of old leaves is common, efforts were made to find out suitable soil moisture conservation practices, which vary due to soil type, availability and suitability of material for mulching, method of conservation, etc.

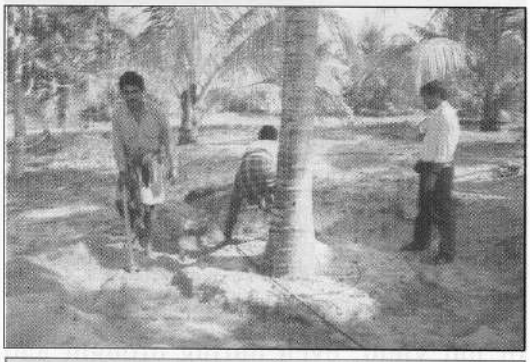
Soil moisture conservation - multilocation experiments

In order to identify location specific soil moisture conservation practices, which can be recommended for adoption in farmers' gardens, field experiments were laid out at five locations representing different agro-climatic zones of major coconut growing areas in India. The experimental locations were situated at Western coastal area – hot sub-humid-per-humid (Kidu – Karnataka; Ratnagiri – Maharastra), hot semi- arid (Arsikere – Karnataka) and Eastern coastal plains- hot sub-humid (Veppankulum- Tamil Nadu; Ambajipeta- Andhra Pradesh). In addition to the experimental sites in the Research Farms, a trial was also laid out in the farmer's field at one of the centers (Ambajipeta). The treatments included ***Control*** (T1 - Fully rainfed, normal management practices); ***Soil moisture conservation treatments*** (T2 - Burial of coconut husk in the basin; T3 - Mulching palm basins with dry coconut leaves; T4 - Application of double dose of potassium than the recommended; T5 - Soil amendment with 'polymer'; T6 - Local practice and T8 - Burial of composted coir pith); ***Absolute control*** (T7 - Fully irrigated, recommended management practices).

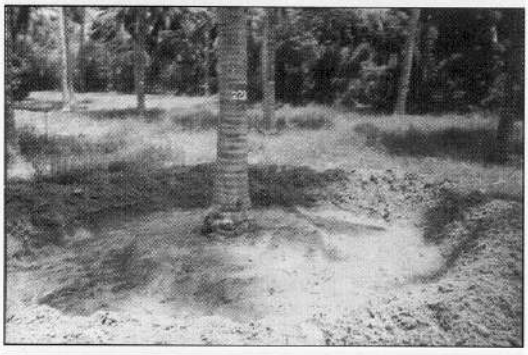
Soil type of experimental site is laterite in Kidu and black loam in Arsikere, whereas Ratnagiri, Veppankulum, Ambajipeta and Konark have different types of sandy soils. All the centres have acidic soil except Arsikere where it is alkaline

Soil moisture conservation practices

Basin opening : Conservation of soil moisture in the root zone is very important for ensuring the moisture availability for



Coconut basin opening



Opened coconut basin

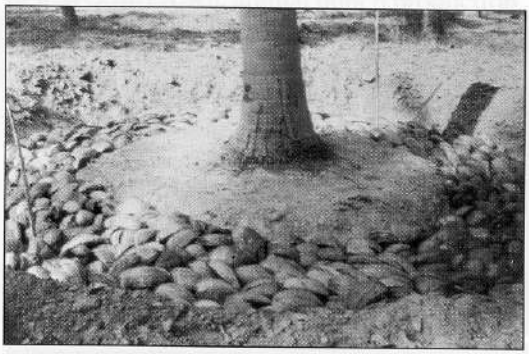
prolonged periods. For imposing soil moisture conservation practices in root zone, coconut basin (1.0 to 1.5m radius from bole) can be opened to a depth of around 20 to 30 cm. Basin opening can be done from base of trunk if sub-surface planting is done and no roots are visible near base or 30 cm away from the base of trunk if roots are exposed near base of palm. In opened basins, materials like coconut husk, farm waste, green manure, composted coir pith, etc. can be placed and covered with soil. The soil moisture conservation treatments should be imposed at the end of the rainy season. If long gap between rainy periods is a common phenomenon, it is advisable to impose the treatments at the end of first rainy spell.

Husk burial : The coconut husks (half pieces) can be buried in opened basin. Half splits of dry coconut husk should be placed in this

Arranging coconut husks in 2 to 3 layers in basin

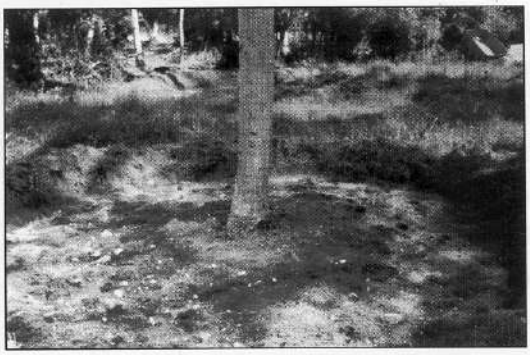
trench with convex side facing up. Husks should be placed closely so as to cover the entire area as a mulch. This can be done in two to three layers. Husk layers should be covered with soil. This will help to retain the husks in trench for longer time and also to absorb the air - moisture or rain-water in side. About 1000 husk pieces per palm are required for this treatment. This method of conservation is very effective and buried husks can remain intact for two to four years depending on soil type. It was observed that in light soils this remained for longer period.

Husk should be compactly buried in basin



Coconut husk burial in palm basin - a durable soil moisture conservation practice

Potassium application : Potassium can be applied at double the recommended dose as per regular fertilizer application schedule. After application of fertilizers in opened basin, it should be covered with soil. Common salt (NaCl) also can be applied @ 2kg/palm.



Potassium application helps coconut palms

Burial of farm waste : Farm waste (fresh and/ or dry material) can be put in opened basin and covered with soil. Materials such as leaves and small twigs of *Casurina, Glyricidia*, organic manures, coconut bunch waste, and other farm waste can be used for burial (50 to 100 kg / palm). This also is a durable treatment. Apart from these, addition of tank silt @ 100 - 200 kg/palm is also useful.

Burial of farm waste in coconut basin

Surface mulching : Mulching can be done by either placing dried coconut leaves or any other leaf material in the entire basin area in three to four layers. Coconut leaves can be cut into two to three pieces before putting for mulching. This treatment is very effective if it is maintained continuously, since strong winds can disturb the mulched leaves leaving the surface exposed for drying.

In some locations, heaping of weeds in palm basins is practiced. Weeds in the farm can be collected or rooted out, cut into pieces

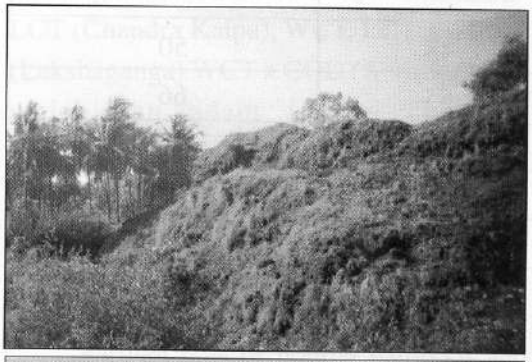
Coconut leaf mulching in basins

and placed in the entire basin around trunk of the palm in a heap. Height of heap can vary from 30-100 cm depending on the availability of material.

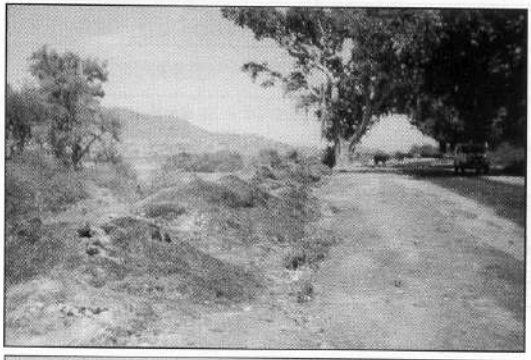
Weed heaping in coconut basin

Composted coir pith : Coir pith is a by-product of coir industry but is wasted by dumping on road-sides. The dumpings are either burnt or left as such forming huge heaps on which grass grows. This wasted product can be converted to a product of potential commercial value by vermicomposting or by using microbial inoculants. Composted coir pith not only can be used for soil moisture conservation but also as potting mixture for raising nursery of garden plants.

Composted coir pith (50-100 kg/palm) can be buried in the entire area of opened basin and covered with soil. Care must be taken to apply only thoroughly composted coir pith.



Coir pith dumpings is a common site in Arisikere and Veppankulum areas



Coir pith dumps burnt-off on road sides near Arisikere

Soil moisture conservation improved coconut growth and yields

Soil moisture conservation practices led to relative moisture retention up to ~60% at Veppankulum (Sandy loam soil) followed by ~35% at Kidu (red laterite soil), 30% at Ratnagiri (sandy loam soil), 20% at Arsikere (black loam soil) and ~ 20% at Ambajipeta (coastal sandy soil) over respective rainfed plots. In general, local practice of soil moisture conservation also gave promising results at all the centres. Soil type played a crucial role in determining the efficiency of treatment. In soils with good water holding capacity, soil moisture conservation practices lead to retention of moisture for longer duration during dry period, on the other hand in soils with low water holding capacity, the moisture retention will be high for short duration only.

Palms receiving irrigation and those with soil moisture conservation treatments maintained relatively high net photosynthetic rates *(Pn)* and transpiration rates *(E)*, and maintained relatively high water use efficiency even during summer period compared to those in rainfed palms.

In general, palms under soil moisture conservation treatments and irrigated palms had higher rate of leaf production, number of leaves on crown, annual bunch production, number of pistillate flowers, particularly during dry periods at all the centers. Nut retention was also higher in these palms, particularly during summer months. Pistillate flower production in rainfed palms was low especially during summer. However, peak production of pistillate flowers also varied with agro-climatic zone.

Drought management increased coconut yields

Table1: Effect of drought management practices on nut yield at different centers (Data from experiment carried out for five years)

Centre/ treatment		Nut yield/palm/year	
		Pre-treatment	Post-treatment
Arsikere	Rainfed	48	50
	Treatments*	55	66
	Irrigated	119	127
Kidu	Rainfed	60	62
	Treatments	62	69
	Irrigated	92	105
Veppankulam	Rainfed	52	70
	Treatments	51	89
	Irrigated	116	130
Ratnagiri	Rainfed	68	68
	Treatments	78	89
	Irrigated	112	115
Ambajipeta	Rainfed	100	97
	Treatments	105	117
	Irrigated	140	152

* Soil moisture conservation treatments

Covariance analysis of yield data indicates that soil moisture conservation practices significantly increased nut yields which was the highest at Veppankulum with ~55% increase over rainfed palms' yield (Table 1). At Arsikere, Kidu and Ratnagiri the increase was up to the tune of ~ 40%, 20% and 20%, respectively, over rainfed yields at respective places. Based on the experimental results and locally available material, location specific recommendation for soil moisture conservation are listed in Table 2

Crop management

Crop management also offers scope to reduce the impact of drought on crop mainly by the removal of senescent (drying) leaves to reduce transpiration loss. If late rains occur, pulses or fodder crops can be sown in between coconut rows. After harvest, the plant residues can be used as mulches. Simultaneously, green manure crops can be raised in the coconut garden. Ploughing back tender *Glyricidia* has given encouraging results in alleviating the impact of water stress

on production by increasing the soil water holding capacity.

The practices which lead to soil-water-plant management can be synerzised by planting suitable cultivars/ hybrids such as LCT (Chandra Kalpa), WCT, LCT x GBGD (Lakshaganga) WCT x COD (Kera Sankara) which can adapt to the changing environmental conditions.

Water management in coconut gardens include

i) In the palm basin, bury two or three earthen pots or hollow bamboos and fill with water.

ii) Drip irrigation at 66% Eo: Four (in laterite soils) or six (in sandy soils) drippers may be placed per palm. Drip irrigation is shown to increase not only field water use efficiency (WUE) but also the physiological WUE of plant.

iii) If adequate water is available, irrigate with 200 lit. water/palm once in four days and mulch with dry leaves.

iv) Avoid flooding the basins. If water resources are good, save them for facing prolonged drought.

v) Effective recycling of used water from backyards.

vi) Give only life saving irrigation at least once in 15 days.

By following soil moisture conservation practices, the frequency of irrigation can be reduced from once in four days to once in 10-12 days.

In undulated terrains, some of the following are desirable measures to conserve soil and water.

i) In sloppy lands, terracing the palm basins may be undertaken (it intercepts run off water and enhance soil moisture).

ii) Water harvesting devices in mildly slopped area enable water to collect in between the rows.

iii) Prepare bunds dividing the field into plots to prevent run off of water.

These measures would help to increase the ground water table and thus enhance the soil water availability.

Fertilizer application method

It is recommended that the soil moisture treatments may be imposed at the end of rainy season and fertilizers can be applied before imposition of treatments. In case where burial of husk or farm waste is practiced, in the first year, the treatments may be imposed after the application of fertilizers or organic manures. In subsequent two years, the fertilizers and organic manures can be applied over the decomposing husk or farm waste material and may be covered with soil. In areas where the gap between rainy spells is too long, it is recommended that the soil moisture conservation treatments may be imposed at the end of first spell of rain. In such a situation, a slight circular gap (without husks) may be provided at about one meter radius to facilitate fertilizer application. Organic manure may be applied in entire basin area.

Table 2: Location specific recommendations for soil moisture conservation (SMC)

Centre	Most suitable SMC practice in decreasing order	Locally available material	Recommendations
Hot semi-arid (Arsikere)	FYM+ *Glyricedia* > composted coir pith> double the dose of recommended K_2O application> husk burial> mulching with leaf	Coir dust, husk, leaf, FYM and green manure	Since a lot of coir pith is locally available, use of composted coir pith may be promoted extensively to conserve the soil moisture in this drought prone area. This will also create a demand situation for coir pith, which other wise is dumped on the road-sides. Apart from this burial of green waste also can be recommended.
Western coastal area – hot sub-humid-per-humid (Kidu)	Husk burial> composted coir pith> double the dose of recommended K_2O application> mulching with farm green waste/weed heaping> mulching with leaf	Husk, leaf, green manure	Here burial of husk in palm basin may be recommended. Apart from this heaping of farm waste also is useful.
Eastern coastal plains-hot sub-humid (Veppankulam)	Double the dose of recommended K_2O application > husk burial> mulching with leaf> composted coir pith> mulching with coir dust	Coir dust, husk, leaf	In this area also, coir pith is locally available. Use of composted coir pith may be promoted extensively to conserve the soil moisture in this dry area. This will also create a demand situation for coir pith. Apart from this, burial of farm-waste and husk also can be recommended.
Western coastal area – hot sub-humid-per-humid (Ratnagiri)	Mulching with farm green waste/weed heaping> double the dose of recommended K_2O application> mulching with leaf> husk burial	Husk, leaf, green manure	Mulching with farm green waste/weed heaping, a local practice has given better results, which can be followed in other areas also. Burial of coconut husk or farm waste in palms basins can be recommended.
Eastern coastal plains- hot sub-humid (Ambajipeta)	Husk burial> mulching with leaf> burial of farm waste in palm basin> double the dose of recommended K_2O application	Husk, leaf, green manure	Here burial of husk or farm waste in palm basin may be recommended.

It is also noticed that mulching of palm basin with coconut leaf can give desired results of soil moisture conservation. However, it requires to be refreshed as and when required, (i.e., more frequently than other practices). Other farm waste or leaves can be substituted for coconut leaf for mulching.

SUMMARY

Coconut palms, as rainfed crop, are exposed to annual summer dry spells and frequent drought years of different intensities and durations in various parts of the country. Fluctuations in coconut yield during different years can be explained on the basis of variations in rainfall and dry spell. Impact of drought on coconut persists for two to three years in view of the indeterminate flowering habit and perennial nature of crop. The study revealed that the coincidence of dry spell with critical stages of inflorescence and nut development is detrimental to the nut production.

Research efforts led to identification of drought tolerant cultivars and hybrids in coconut. Apart from this, *in situ* field tolerant palms were identified during surveys conducted in farmers' plots under rainfed condition, which can be used in breeding for drought tolerance.

To mitigate dry spell effects, it is recommended to follow the drought management practices. These include soil moisture conservation, crop and water management. Soil moisture conservation practices like husk burial, leaf mulching, burial of FYM, composted coir pith or other farm wastes, mulching with coconut leaves, green leaf manures like *Glyricida* or with other suitable green manure crops and organic manures in the basin should be followed either alone or in combination based on the availability of material. Soil moisture conservation treatments helped in soil moisture retention and the efficacy of treatment depended on the soil type. In general, palms under soil moisture conservation treatments had better photosynthetic and water use efficiency, better canopy and inflorescence production. Further, they had more number of pistillate flowers coupled with better nut retention thus have produced higher yields.

Crop management to mitigate drought includes the removal of senescent (drying) leaves to reduce transpiration loss and planting drought tolerant cultivars/ hybrids. Water management in coconut gardens forms an important strategy to mitigate drought. It includes drip irrigation, mulching the irrigated area, avoiding flooding, recycling of water and providing life saving irrigation. Drip irrigation can increase the water use efficiency at field and plant level. Available water resources can be used for providing life saving summer irrigation to all palms in the field even at deficit levels. *In situ* water harvesting in the basin is one of the important methods to increase the soil water table. In undulated areas, terracing the palm basins, construction of water harvesting devices, contour bunds will help in preventing run off of water.

Drought can be managed by soil moisture conservation practices, which should be imposed just after first spell of monsoon showers in the areas where the gap between rainy spells is long. In areas with high rain fall, it is recommended that the soil moisture conservation treatments may be imposed at the end of the rainy season. Depending on the availability of material, suitable practice can be adopted either alone or in combination as recommended. It is also advisable to conserve the summer rainfall water. By practicing soil moisture conservation methods one can reduce number of summer irrigations. Apart from this, available water may be supplied to all palms so that yield/palm can be maintained even during drought years.

REFERENCES

Naresh Kumar, S., Rajagopal, V. and Anitha Karun. 2000. Leaflet anatomical adaptations in coconut cultivars for drought tolerance. *In: Recent Advances in Plantation Crops Research* (N. Muraleedharan and R. Raj Kumar eds.). Proceedings of PLACROSYM XIII. pp. 225-229.

Naresh Kumar, S., Rajagopal, V., Siju Thomas, T., Vinu K. Cherian, Hanumanthappa, M., Anil Kumar, Srinivasalu, B. and Nagavekar, D. 2002. Identification and characterization of *in situ* drought tolerant coconut palms in farmers' fields in different agro-climatic zones. *In: Abstract of papers 'PLACROSYM XV'*, 10-13 December 2002, Mysore. pp. 61-62.

Naresh Kumar, S., Rajagopal, V., Vinu K.Cherian, Siju Thomas, T and Vijaya Kumar, K. 2002. Weather data based descriptive models for prediction of nut yield in coconut grown in different agro-climatic zones, communicated to Journal of Agronomy and Crop Science.

Naresh Kumar, S., Rajagopal, V., Siju Thomas, T. and Vinu K. Cherian. 2003. Influence of soil moisture conservation on the source-sink relationship in coconut (*Cocos nucifera* L.) under different agro-climatic conditions. *In: Abstract of papers Second International Congress of Plant Physiology on Sustainable plant productivity under changing environment'*, 8-12 January 2003, New Delhi. pp. 572.

Rajagopal, V., Kasturi Bai, K.V. and Voleti, S.R. 1990. Screening of coconut genotypes for drought tolerance. Oleagineux 45(5): 215-223

Rajagopal, V., Shivashankar, S. and Jacob Mathew. 1996. Impact of dry spells on the ontogeny of coconut fruits and it's relation to yield. Plantation Research and Development. 3 (4) :251-255.

Rajagopal V. and Naresh Kumar S., 2001. Avenues to improve productivity potential under drought condition-A case study on coconut. *In: Abstracts of papers National Seminar on role of plant physiology for sustaining quality and quanity of food production in relation to environment.* 5-7 Dec., 2001, UAS, Dharwad 31-36.

Rajagopal, V., Naresh Kumar, S., Siju Thomas, T., Vinu K. Cherian, Ratheesh Narayanan, M.K., Ananda, K.S., Nagawekar, D.D., Hanumanthappa, M., Vincent, S and Srinivasulu, B. 2000. Variations in nut yield of coconut (*Cocos nucifera* L.) and dry spell in different agroclimatic zones - A multilocation experiment. *In: Abstract of papers 'National seminar on Recent advances in plant biology'*, 3-5th February 2000, CPCRI, Kasaragod. pp. 37.

Rajagopal, V. and Naresh Kumar S. 2003. Management of abiotic Stresses in coconut, In: *Thematic Papers, National Seminar on Stress Management in Oil Seeds for Attaining Self-reliance in Vegetable Oils*, (Eds.) (Mangala Rai, Havinder Singh and Hegde, D.M.) pp 113-136.

Rajagopal, V. and Naresh Kumar S. 2003. *Characterization of Drought in Different Coconut Growing Areas and Drought Management Strategies: Project Final Report.* p.84