48

Drought Management Strategies

Proceedings of the Brain Storming Session

organised by
Kerala Agricultural University
at College of Horticulture, Vellanikkara

3rd March 2003

Edited by
G.S.L.H.V. Prasada Rao

Department of Agricultural Meteorology
College of Horticulture
Kerala Agricultural University, Thrissur - 680 656
Kerala, India

March 2005

Department of Agricultural Meteorology
College of Horticulture
Kerala Agricultural University
Thrissur - 680 656, Kerala

Published and released in connection with "National Workshop on Drought Management in Plantation Crops" held on 22nd and 23rd March 2005

Printed at Lumiere Printing Works, Thrissur

FOREWORD

The occurrence of drought is phenomenal in recent decades all over the world. The recurrent drought and desertification seriously threaten the livelihood of over 1.2 billion people who depend on the land for most of their needs. The 1997/1998 El Nino event, the strongest of the last century is estimated to have affected 110 million people and cost the global economy nearly US$ 100 billion. Statistics compiled from insurance companies for the period 1950-1999 show that major natural catastrophes, which are mainly weather-and climate-related, caused estimated economic losses of US$960 billion. Most of the losses were recorded in recent decades. In fact, the year 1998 was the warmest on record, with 2001 being the second highest. The 1990s were the warmest decade of the 20th century and it is likely that the rate and duration of warming of the 20th century were larger than at any other time during the last 1000 years. Probably, the global warming may be one of the causal factors for recurrent droughts.

Indian economy is mostly agrarian based and depends on onset of monsoon and its further behaviour. The year 2002 was a classical example to know how Indian kharif foodgrains production was dependant on rainfall of July and it was declared as the all-India drought, as the rainfall deficiency was 19% against the long period average of the Country and 29% of the area was affected due to drought. Despite technological advantage to mitigate the ill effects of drought, the *kharif* foodgrain production was adversely affected; fell by a whopping 19.1%. At large, such adverse affect was not seen over Kerala on seasonal as well as plantation crops though the deficiency of monsoon rainfall was the highest (35% less to long period average). However, *kharif* paddy was affected to a certain extent wherever standing water could not be maintained. At the same time, it was the summer drought which affects plantation crops production in the humid tropics like Kerala as witnessed in 1983. Consecutive deficiency of monsoon rainfall since the last four years over Kerala may also have long standing ill effects on major plantation crops and seasonal crops that are grown during Mundakan and Puncha seasons due to shortage of water during summer. In contrast, several districts in Kerala experienced floods during October 2002, which led to floods and devastated plantations in Kannur and Kasaragod Districts. Kannur received 370 mm of rainfall on 14th October 2002, which was the highest and not received since 1924. To quote another example of last week, two thundershowers were noticed on 25th and 26th February in this part of Kerala, which are not common during February. Of course, it was a great relief when people were in search of water. In fact, it was good for plantation crops. All these reveal that weather related disasters viz. droughts, floods, landslides and thunderstorms are of great concern, leading to economic loss to a considerable extent in Kerala. Therefore, the farmers of Kerala are very keen to know the short-and-long term contingency plans for drought management. With this background, the Kerala Agricultural University formed a core group to formulate contingency plans in consultation with similar institutes and assigned the task to Dr.GSLHV Prasada Rao, Professor and Head, Department of Agricultural Meteorology, College of Horticulture. Accordingly, one day 'Brain Storming Session on Drought Management Strategies' was held on 3rd March, 2003.

I am happy to understand that several status papers were deliberated in the sessions and suggested strategies to mitigate the drought effects on short and long term basis. I am also glad to note that the proceedings were brought out in an abridged form. It is hoped that the material is informative and useful to the agencies who are all involved in drought management strategies. I congratulate Dr. GSLHV Prasada Rao for his concerted efforts in editing and bringing out this volume in time.

Professor (Dr.) K.V. Peter
Vice-Chancellor

PREFACE

The uni-model rainfall during monsoon and a long dry spell from November to May is a characteristic feature in the humid tropics like Kerala. It is, more so, in northern districts of Kerala. Erratic rainfall distribution during monsoon coupled with failure of northeast monsoon since last a few years led to drying up of surface reservoirs during summer, which are the major water resources. The meteorological droughts during monsoon and summer droughts are not uncommon across the State during the recent years. Though the erratic rainfall during monsoon may not adversely affect the perennial crops as the rainfall is very high, the summer drought adversely affects most of them in Kerala. Of course, the erratic rainfall during monsoon may adversely affect crops like black pepper and cardamom as their growth, development and reproductive phase may depend on rainfall distribution. Looking at the nature of damage due to dryspells during monsoon, it is felt that there is a need to take up pro-active measures to mitigate the effect of lull monsoon on crops. With this background, one day Brain Storming Session was held to take stock of drought management strategies. A few status papers and recommendations evolved from several research stations were presented and deliberated in length. The proceedings, based on the deliberations, has been brought out in an abridged form in connection with the "National Workshop on Drought Management in Plantation Crops" to be held at the College of Horticulture, Kerala Agricultural University on 22nd and 23rd March, 2005. It is hoped that the plantation researchers and extension workers will be immensely benefited in formulating pro-active drought management strategies for mitigating the ill effects of drought.

As promised, though late, the proceedings of the Brain Storming Session was brought out, for which the services rendered by Dr.Jose Mathew, Associate Professor and Head, Cashew Research Station, Madakkathara and M.V.Sudheesh, Assistant Professor, Department of Agricultural Meteorology, College of Horticulture are greatly acknowledged. It is also placed on record the services rendered by Mr.K.N.Krishnakumar, Mr.C.S.Gopakumar and Mr. Jagadeesh Kayalil for typing the manuscript. The editor is also grateful to the faculty members and other staff members of the College of Horticulture who helped in his editorial work. The financial support extended by the Coconut Development Board, Govt. of India for bringing out this publication is highly acknowledged.

G.S.L.H.V. Prasada Rao
Editor

CONTENTS

Status Papers

Proceedings of the Brain Storming Session on Drought Management Strategies, held on 3rd March 2003, KAU, Vellanikkara, pp. 3-5

ALL-INDIA DROUGHT OF MONSOON 2002 – Is it relevant to Kerala?

G.S.L.H.V. Prasada Rao, K.N. Krishna Kumar, C.S. Gopakumar and M.V. Sudeesh
Department of Agricultural Meteorology
College of Horticulture, Kerala Agricultural University
Vellanikkara P.O, Thrissur

1. All-India drought 2002

The year 2002 was the first all-India drought year after a continuous spell of 14 good monsoons that followed the previous all-India drought year of 1987. The seasonal rainfall (June-September) for the country as a whole was 19% below normal. 29% area of the country experienced drought conditions with 19% area under moderate category and 10% under severe category. July had the worst rainfall deficiency of 49%.

1.1 Definition of all-India drought

The all-India drought is defined as the drought year when the rainfall deficiency for the country as a whole is more than 10% of normal and more than 20% of the country's area is affected by drought conditions.

The total monsoon rainfall deficiency need not necessarily result in agricultural drought, since timely rainfall during critical crop phases may save the crop, or irrigation water may be available. However, in the event of an extreme rainfall deficiency, its agricultural and hydrological impacts are inevitable.

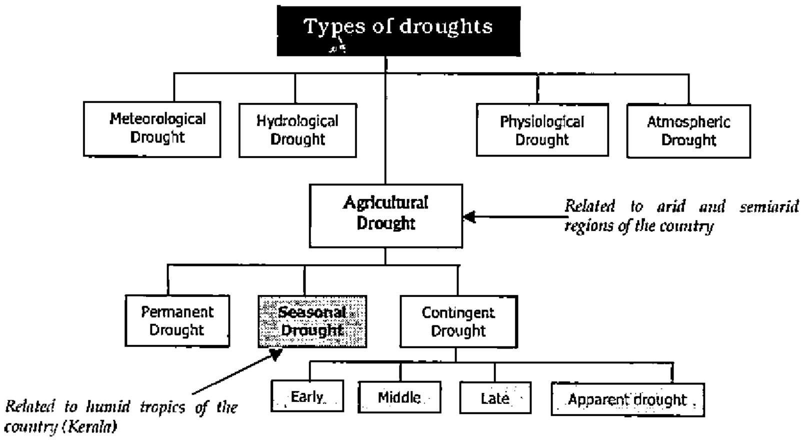
The occurrence of drought is commonly noticed in major parts of India during kharif when monsoon is delayed or it fails partially or due to monsoon break. For example, the all-India drought during 1987 and 2002 was due to monsoon failure.

2. Types of drought

There are different types of drought viz., meteorological, hydrological, agricultural, physiological and atmospheric droughts. The schematic presentation of various types of droughts is as follows:

3. Effect of all-India drought on Indian foodgrains production

The *kharif* foodgrains production across the country is dependant on the monsoon rainfall and its distribution under rainfed conditions. The effect of drought on the



The schematic presentation of various types of droughts total foodgrains production of the country in 1987 was less by about 34 million tonnes (138.41 million tonnes in 1987-88 as against 172.18 million tonnes in 1988-89). The lull monsoon in 2002 also led to all-India drought. It also led to low foodgrain production during 2002-03. The estimated loss in Indian foodgrains production was 13.6% as a whole. It reveals that the Indian foodgrains production was adversely affected significantly whenever all-India drought was noticed (Fig. 1)

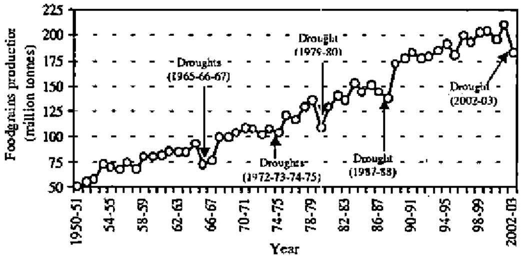


Fig.1. Indian foodgrains production (million tonnes) from 1950-51 to 2002-2003

3.1 Is all-India drought during 2002 relevant to Kerala

The answer is "yes" as per the definition of all-India drought since the monsoon rainfall was less by 35% during monsoon 2002. It is one of the lowest monsoon rainfall years. The water level in major hydel power generating reservoirs of Kerala was very low. To assess the impact of drought on major crops, a field study was conducted among 30 selected farmers from the nearby Grama Panchayaths viz., Pananchery, Madakkathara, Ollukkara and Nadathara of Thrissur District under Agromet Advisory Service.

It reveals that only 23% of farmers advocated different drought management strategies to mitigate the ill effect of drought. However, it is understood that the plantation crops were not affected due to deficiency of rainfall during the monsoon 2002.

Table. Number of farmers experienced drought under various farm activities.

Type of farm activity affected	No. of farmers experienced drought	Percentage of affected
Depletion in irrigation water	12	40
Reduction in crop yield	9	30
Crop acreage reduced	4	13
Experienced drought	12	40
Drought management strategies adopted	7	23

At the same time, the annual coconut production of the State was severely affected due to unprecedented drought that occurred during the summer 1983 (Fig. 2). It revealed that the agricultural droughts with reference to plantation crops of Kerala should be classified based on the distribution of rainfall during summer, but not based on rainfall that is assured during the monsoon. Moreover, most of the plantation crops are never under soil moisture stress during the monsoon as rainfall/soil moisture is assured.

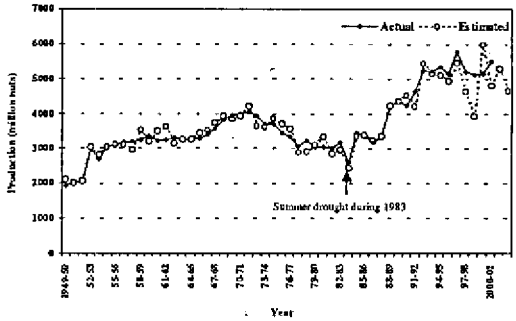


Fig.2. Actual and estimated annual coconut production (million nuts) over Kerala from 1949-50 to 2002-2003

4. Drought characteristics in coconut

Coconut palms show the following characteristics under severe soil moisture stress depending upon the duration and intensity of drought.

- Withering and mortality in the case of young seedlings under poor management
- Drooping, wilting and drying of lower whorl of leaves
- Breakages of leaves at petiole or just above it
- Spindle leaf breaking which lead to mortality in the case of senile palms under conditions of poor management
- Abortion of spadices, starts from October/November onwards
- Button shedding and immature nut fall
- Nut size decline and Finally decline in nut yield in the subsequent year up to fifty per cent depending upon the type of management

5. Can drought effect be alleviated?

There are two ways to alleviate the effect of drought effectively in coconut.

1. Mitigating drought effect through summer irrigation.
2. Mitigating drought effect through better management under rainfed condition.

5.1. Mitigating drought through summer irrigation

The nut yield in coconut can be increased significantly if coconut gardens are irrigated during summer. This is one of the reasons, why, coconut productivity is higher in the neighboring states of Kerala, viz. Tamil Nadu, Karnataka, and Andhra Pradesh, where coconut is grown under irrigated conditions. In coarse textured soils having less available water, better yield response could be achieved through flood irrigation or basin irrigation. Flood irrigation, however, has its own disadvantages as it may lead to waterlogging, salinization and alkalization. As water is scarce, several water saving irrigation methods are being practiced in coconut gardens. Studies indicate that drip irrigation is highly effective and profitable in areas with limited water availability. If there is no water available for irrigation during summer months as the case in many parts of northern districts in Kerala, the question is, how, to mitigate the effect of drought in coconut gardens under rainfed conditions. In, this context, drought management under rainfed conditions plays an important role. An increase in nut yield can be achieved in such conditions through better crop management practices as suggested in package of practices and recommendations: crops (KAU 2002).

References

KAU. 2002. *Package of Practices Recommendations: Crops.* Twelfth edition Directorate of Extension, Kerala Agricultural University, Thrissur, p.278

Mooley, D.A. 1984. Origin, incidence and impact of drought over India and remedial measures for there mitigation. *Sadhere* 19: 597-608

Rao, G.S.L.H.V. P. 2003. *Agricultural Meteorology.* Kerala Agricultural University, Thrissur, p.326

Rao, G.S.L.H.V.P. 1994. Drought Management in Coconut. *Indian Cocon. J.* 24: 6-8

Rao, G.S.L.H.V.P. 2002. *Climate and Cashew.* Kerala Agricultural University, Thrissur, p.100

Rao, G.S.L.H.V.P. 1988. Agrometeorology of Coconut. *Six decades of coconut research.* (eds. Aravindakshan, M., Nair, R.R. and Wahid, P.A.). Kerala Agricultural University, Thrissur, pp. 81-93

Rao, G.S.L.H.V.P. 2003. *Climate Variability and Coconut Production in Humid Tropics.* Kerala Agricultural University, Thrissur, p.38

Rao, G.S.L.H.V.P. and Nair, R.R. 1988. *Agrometeorology of Plantation Crops.* Proceedings of the National Seminar, March 12-13, 1987. Kerala Agricultural University, Thrissur, p.187

Rethinam, P. 1987. Management of Drought Situations in Coconut Plantations. *Indian Cocon. J.* 18: 3-5

Proceedings of the Brain Storming Session on Drought Management Strategies, held on 3rd March 2003, KAU, Vellanikkara, pp. 6-10

DROUGHT AND ITS MANAGEMENT IN PLANTATION CROPS

V. Rajagopal and S. Naresh Kumar
Central Plantation Crops Research Institute
Kasaragod-671 124, Kerala, India

In world more than 80% of the cultivable land area is under rainfed condition (Table 1). In the rainfed areas, drought is the major constraint for the crop productivity, more so in plantation crops since they are widely grown in different soil types such as sandy, sandy loam, laterite and forest soils in the states of Kerala, Karnataka, Tamil Nadu and Andhra Pradesh.

Table 1. Cultivable land in rainfed area in the World and in India

Land	World	India
Cultivable land	1474 m ha	142 m ha
Irrigated area	227 m ha	39.2 m ha
Rainfed area	1247 m ha	102.8 m ha
Irrigated area (%)	17.6%	28%
Rainfed area (%)	82.4%	72%

(Source: II International Crop Science Congress Proceedings (1998)

As these crops are mainly grown under rainfed condition, productivity is affected due to the dry summer months starting from December/January to April/May. During the period the soil water deficits coupled with the changes in atmospheric parameters aggravate the situation leading to soil as well as atmospheric drought. Increasing the crop area under irrigation has several limitations, the major one being the water resources. Being perennial in nature the water requirement of plantation crops is also fairly high. Since the water availability is becoming scarce, further increase in crop area under irrigation is difficult. The approach then has to be to use the available water source with high productivity efficiency. Thus it is important to identify the varieties, which can withstand moisture stress conditions in the field, and to evolve management strategies for conserving available water sources in order to mitigate adverse effects of drought.

1. Agro-climatic variables

Most of the plantation crops grow well in tropical climate with abundant sunlight, well distributed rainfall, with moderate temperature. For coconut the ideal conditions will be an annual rainfall between 130 and 230 cm, mean annual temperature of 27° C and sunlight ranging from 250 to 350 wm^{-2} with annual sunshine of 2000 hrs (at least 120 hrs per month according to child, 1974 and Murray 1977).

Among the meteorological variables, rainfall is one of the important parameters which affect the production of crops. Hence conservation of available soil moisture is important for mitigating the water deficit during prolonged drought periods, at least to a certain extent. Various methods like contour bunding, trenching, pitting and construction of check-dams are used for the conservation of soil water. However for managing the atmospheric drought, crop plants which can adapt to the changing soil and atmospheric conditions and yield satisfactorily have to be recommended. Hence, before crop area expansion, a thorough knowledge of hydro-physical characteristics of soil as well as atmospheric condition of the locality is essential.

As in many crops the microclimatic conditions influence the water relations of coconut (Kasturi Bai *et al* 1988). Based on irrigation levels a soil-water plant relationship in coconut has been worked out (Table 2).

Table 2. Soil-plant water relationship in coconut

Irrigation levels IIW/CPE)	Available soil water mm(0-120 cm depth	Stomatal resistance	Leaf Water Potential(Mpa)	Nut yield (No.)
1.00	51	3.07	-0.90	144
0.75	43.7	5.10	-1.20	125
0.50	14.2	7.60	-1.30	110
0.00	9.5	14.9	-1.45	87

In sandy loam soil a water deficit of 110 mm is the critical level at which coconut suffered most due to moisture stress. During extreme water scarcity, palms shed most of the leaves except the spindle leaf, thus protecting the meristematic region. However, the severity of the morphological symptoms depend on the intensity of drought (Prasada Rao, 1985, Pomer and de Taffin 1982) As the same weather conditions do not always occur in any given location, the yield of coconut fluctuates depending on the intensity of the factor involved. Water deficit caused by the inadequate rainfall with poor distribution deserve special mention. These dry spells vary with the location and year. The influence of varying climate in South and North Kerala on coconut production emphasize this factor. The agro-climatic variables in the tropical areas varied significantly between the non-stress and stress period (Table 3).

Even the rainfall pattern in different parts of same place is found to vary significantly. For example the rainfall in southern Kerala is evenly distributed whereas the northern Kerala, although annual rainfall averages 360 cm, 85% of it is received during the Southwest monsoon (June to September), while 7.5% is received during the Northeast monsoon, (October-November) and the remaining 8.5%. of it is received as non-seasonal rainfall. Thus the rainless period ranges from 5 to 7 months in northern Kerala as compared to 4 to 5 months in southern Kerala due to early cessation of Southwest monsoon or failure of Northeast monsoon. Coconut palms also respond differently to these changing environmental condition in terms of growth and nut production (Table 4).

Varietal differences in nut yield in response to severe stress conditions have been reported by Ramadasan *et al* (1991). Bhaskara Rao *et al* (1991) have explained the performance of same hybrids during good and drought influenced years in which some of the hybrids like LCT x COD and LCT x GBGD maintained high female flower production and high nut set than COD x WCT during drought years. The drought susceptible nature of COD x WCT and drought tolerant nature of LCT x GBGD and LCT x COD were also reported by Rajagoapl *et al* (1990)

Table 3. Agroclimatological variables during non stress and stress periods in Kasaragod range.

Variable	Non-stress	Stress
PAR(pmolm²5⁻¹)	1000-1070	1350-1470
Air temperature (°C)	31.4-34.1	34.7-37.3
VPP (KPa)	1.9-2.8	3.1-3.6
Pan evaporation (mm day⁻¹)	3.3-3.8	5.2-5.5

based on water relation components and cuticular wax content.

2. Drought tolerant characters

Drought tolerant types can be identified by screening the germplasm for specific traits sensitive to stress conditions. Investigations have been carried out on physiological and biochemical mechanism of drought tolerance in plantation crops and identified the varieties with drought tolerant characteristics. Some of the desirable traits identified are Large paranchyma cells, high stomatal resistance, high leaf water potential, low transpiration rate, high epicuticular wax content and higher activities of the stress sensitive scavenging enzymes. The exploitation of the identified varieties, with not only drought tolerance but also with the potential for high yield under limited water availability, in the breeding strategies would be an important step for the overall improvement of crop productivity in drought prone areas. Mechanisms and strategies to be adopted in selection and breeding programmes depend not only on their effect on traits related the productivity, but also on the type of drought likely to be encountered by the crop. Plants adapt to stress condition by the intervention of several inductive phenological, morphological, anatomical, physiological, and biochemical mechanisms.

Naresh Kumar *et al* (2000) have studied the leaflet anatomical adaptation to drought tolerance in coconut and the relation between the anatomical features and physiological parameters. The study indicated marked influence of leaflet anatomy on photosynthesis and transpiration. It is suggested that a leaf anatomy which

Table 4. Response of coconut palms to high (North Kerala) and low (South Kerala) drought intensities

Characters	WCT		COD x WCT	
	Kerala	S. Kerala	Kerala	S. Kerala
No. of days for leaf opening	55	52	57	54
No. of days for spathe opening	72	66	55	77
Nut yield palm⁻¹	78	96	106	116
Copra weight (g)	133	167	135	169

favours high photosynthetic rates also favour high transpirational rates thus the drought susceptible types had higher photosynthetic rates associated with high transpirational rates compared to the tolerant ones. The reason for such trends can be explained on the basis of leaflet anatomy. Based on the physiological and environmental variables a drought index has been worked out in coconut (Table 5).

Table 5. Drought indicators in coconut

Parameter	Critical levels
Air temperature	33°C
Radiation	265 wm^{-2}
VPD	27 m bar
Soil moisture content	9%
Stomatal resistance	9.0 Sec cm^{-1}
Transpiration rate	2.5 ug cm^{-2} Sec^{-1}
Leaf water potential	1.20 MPa

Source: Kasturi Bai and Rajagoapl, 1996

3. Sensitive critical stages to drought stress

Being perennial in nature, production and productivity of plantation crops are considerably influenced by agro-meteorological variables. The sensitive critical stages which affect the yield in many crops are seedling establishment, inflorescence initiation, flowering, fruit set and fruit development stages. In addition to these in coconut and arecanut spike let initiation and female flower primordia formation are also found to be stress sensitive stages whereas in black pepper it is the spiking stage. Sucker and panicle initiation stages are sensitive in cardamom and in tea it is the vegetative growth, which is sensitive to moisture stress. Depending on the severity of the stress yield will be affected. Rajagopal *et al.* (1996) have explained the impact of drought on inflorescence and nut development in coconut by integrating the overall occurrence of dry spell during the ontogeny of inflorescence and nuts.

4. Drought tolerant types

By employing screening techniques for desirable traits for drought tolerance, varieties have been selected and released for planting in drought prone areas. Using tolerant parents, hybrids have also been evolved. The important drought tolerant varieties/hybrids are:

Coconut - WCT, LCT, FMS, WCT x COD, LCT x GBGD, LGTxCOD
Cocoa - NC23, NC29, NC 31, NC 39
Cashew - BPT1, BPT2, H-2/16, H-1608
Black pepper - Arakalamunda, Kalluvally
Cardamom - Malabar
Tea - UPASI-1, 2, 20, 26, 27
Coffee - Sanramon hybrid
Rubber - GI 1, GT1, RRIM 600, RRII 18, RRII 10

5. *Drought management*

Drought occurs once in three to four years with different intensities in major plantation areas. Depending on the length of dry spell and its coincidence with the critical stages of crop growth the yield will be affected. In order to have sustained yields it is important to have strategies to manage drought, which includes the soil, as well as atmospheric droughts.

Drought management strategies mainly include the conservation of available soil moisture and efficient use of available water resources for high production. As the plantation crops are grown under different soil types having variation in hydrophysical characteristics different methods have to be adopted to conserve soil moisture. The following agronomic practices can be used for soil management for conservation of water during drought periods such as adoption of organic farming technologies and tillage practices like summer ploughing, soil mulching and addition of soil stabilizers.

6. Soil management

- Mulching with composted coir dust, 50 kg/palm,
- Burial of husks in 3 or 4 layers
- Application of green manures and organic manures (FYM) - 50 to 100 kg/palm
- Spreading dried coconut leaves and other organic residues (mulching effect)
- Addition of tank silt at 100 to 200 kg/palm (improves organic matter, water holding capacity)
- Spreading of 2 kg NaCl around the palm basin

7. Water management

- Bury 2 or 3 earthen pots/hollow bamboos and fill with water (sub-soil moistening)
- Drip irrigation: 3 or 4 drippers may be placed per palm, (drippers to wet sub-soil layer)
- If adequate water is available, irrigate with 200 lit. water/palm once in 4 days and mulch with dry leaves

- Avoid flooding the basins. If water resources are good, save for facing prolonged drought
- Effective recycling of used water from backyards
- At large scale, some of the following are desirable to follow to conserve soil and water
- In sloppy lands, terracing the palm basins may be undertaken (intercepts run off water and enhance soil moisture)
- Water harvesting devices in mildly slopped area to enable water to collect in between row
- Prepare bunds dividing the field into plots to prevent run off of water
- These measures would help to increase the ground water table and the increase the soil water availability

Crop management also offers scope to reduce drought impact on crop mainly by the removal of senescent leaves to reduce transpiration loss. If late rains occur, pulses or fodder crops can be sown in between coconut rows. After harvest, these plant residues can be used as mulches. So also green manure crops can be raised in the plantations. Application of higher doses of fertilizers (eg. for each coconut palm 1 kg urea, 2 kg Super phosphate, 1.2 kg muriate of potash, 0.5 kg $MgSO_4$, 50 kg green leaf or FYM) will also help in alleviating the impact of water stress on production, by increasing the soil water holding capacity.

8. Drought management in coconut in different agro-climatic zones

Coconut palms are mainly grown as rainfed crop in many parts of India. They are exposed to drought of different intensities and durations, particularly during summer months. This leads to significant reduction in yields thereby resulting in considerable economic loss to the growers. Studies to characterize drought and the nature of drought which differs among the agro-climatic zones, and to evolve soil moisture conservation practices suitable for specific locations were undertaken in past 5 years. Apart from this, survey on the extent of damage to coconut palm in the selected areas and identification of drought tolerant types also formed as one of the objectives in this multi-location project.

In different agro-climatic zones viz., Western coastal area – hot sub-humid-per-humid (Kasaragod – Kerala; Ratnagiri – Maharastra), hot semi- arid (Arisikere – 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 rainfall varied from a maximum of 3337.7 mm in Kasaragod to a minimum of 718.23 mm in Arsikere. Kasaragod, Kidu and Ratnagiri had similar rainfall pattern with peaks during June, July and August, whereas, Veppankulam, 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 centres exhibited 2 or 3 years of consecutive drought as also alternative drought during a 15-year cycle.

Significant reductions in nut yield at each centre during 1 or 2 years either consecutively or alternatively, indicating dependence of yield on the rainfall pattern and length of dry spell. In view of long duration of 44 months between the initiation of inflorescence primordium and ultimate nut yield, with about 70% period of 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.

It is important to identify the palms, which survive and yield highly in drought prone locations. These palms may have desirable traits for drought tolerance, thus able to withstand drought and yield high. Identification of such palms will help in increasing the genetic variability for the crop, which can be used for crop improvement programme. Such field tolerant palms were identified *in situ* during surveys conducted in farmers' plots under rainfed condition at Arsikere, Ambajipeta and Ratnagiri (Naresh Kumar *et al.*, 2002). This field drought tolerant palm 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. The tolerant palms can be used as mother palms in breeding programme for drought tolerance.

Drought management involves soil moisture conservation and plant management. Since plant management practices like removal of old leaves, etc., are common, efforts were made to find suitable soil moisture conservation practice, which vary due to soil type, availability and suitability of material for mulching, method of conservation, etc. In order to identify of location specific soil moisture conservation practices, which can be recommended for adoption in farmers' fields, field trials were laid at each of six centers. In addition to the experimental sites in the Research Farms, a trial also was laid out in the farmer's field at one of the centers (Ambajipeta)

Overall results indicate variations in treatment efficiency to conserve moisture at different centres mainly due to variations in soil type. Conservation practices led to relative moisture retention up to ~60% at Veppankulam (Sandy loam soils) followed by Kidu (~35%; red laterite soils), Ratnagiri (30%; sandy loam soils), Arsikere (20%; black soils) and Ambajipeta (~ 20%; coastal sandy soils). The results infer to the conclusion that the treatment efficiency is mainly dependent on soil type. 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. The soil moisture holding capacity and hydraulic conductivity characteristics play an important role in these situations.

Covariance analysis of yield data indicated that soil moisture conservation practices significantly increased nut yields which was highest at Veppankulum with ~75% increase over rainfed palm yield. At Arsikere, Kidu and Ratnagiri increase was up to the tune of ~ 40%, 20% and 20%, respectively over rainfed yields at respective places. At Ratnagiri local practice of weed heaping in palm basin gave highest increase in yield over pre-treatment yield. Here, other soil moisture conservation treatments increased the yields by 10 % over pre-treatment yields. It indicated that the efficiency of soil moisture conservation varies with soil type and climatic condition.

Drought can be managed by soil moisture conservation practices, which should be imposed just after first spell of monsoon showers. Depending on the availability of material, suitable practice can be adopted as recommended. It is also advisable to conserve the summer rainfall water in similar way. In soil types such as sandy soils, 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.

. The above practices which lead to soil-water-plant management can be synerzised by planting suitable varieties/cultivars which can adapt to the changing environmental conditions.

References

Bai, K.V.K. and Rajagopal,V. 1996. What imparts drought tolerance in coconut?. *Indian Cocon. J.* 27: 2-3

Bai, K.V.K., Voleti, S.R. and Rajagopal, V. 1988. Water relations of coconut palms as influenced by environmental variables. *agri.Forest.Meteorol.* 43: 193-199

Child, R. 1974. *Coconuts*. Second edition. Longman, London, p.335

Chopra, V. L., Singh, R.B. and Verma, A. 1998. Crop Productivity and sustainability - shaping the future. *Proceedings of Second International Crop Science Congress.*

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

Kumar, S.N., Rajagopal, V., Thomas, T.S., Vinu, K., Cherian, M., Hanumanthappa, B., Srinivasulu., Kumar, A. and Nagvekar, D. D. 2002. Identification and characterization of in situ tolerant coconut palms to drought in farmers field. *PLACROSYM XV*, Mysore, Dec 8 - 12

Murray, D.V. 1977. Coconut palm. *Ecophysiology of tropical crops.* (eds. Alvim, T.A. and Kozlowski, T.T.). Academic Press, New York, pp. 384-407

Pomier, M. and De Taffin, G. 1982. The tolerance to drought of some coconut hybrids. *Oleagineux* 37: 55-62

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

Rajagopal, V., Shivashankar, S. and Mathew. J. 1996. Impact of dry spells on the ontogeny of coconut fruits and it's relation to yield. *Plantation Res. Dev.* 3 :251-255

Ramadasan, A., Balakrishnan, T.K. and Rajagopal, V. 1991. Response of coconut genotypes to drought. *Indian Cocon. J.* 21: 2-5

Rao, G.S.L.H.V.P. 1985. Drought and coconut palm. *Indian Cocon. J.* 15: 3-6

Proceedings of the Brain Storming Session on Drought Management Strategies, held on 3rd March 2003, KAU, Vellanikkara, pp. 11-13

DROUGHT OF 2002 – ITS IMPACT AND MANAGEMENT STRATEGIES FOR RUBBER PLANTATIONS

Sherin George, T. Sailajadevi, Mercykutty Joseph and K.I. Punnoose
Rubber Research Institute of India
Kottayam – 686 009

The entire State of Kerala together with parts of Kanyakumari District of Tamil Nadu and South Kannada and Kodaku District of Karnataka forms the traditional rubber growing belt in India. The average annual rainfall in this region ranges from 2000 – 4500 mm, the distribution being more even as we move from north to south.

1. Rainfall distribution over Kerala

About 67 per cent of the annual rainfall is received during the southwest monsoon which extends for four months from June to September and 16 per cent during the northeast monsoon during October-November (Table 1). Thus about 83 per cent of rainfall is received during the rainy season which extends for about 6 months. Only 17 per cent of the total annual rainfall is received during the remaining six months period from December to May. As a result soil moisture stress is generally noticed during this period.

2. Rainfall at RRI farm Kottayam

The rainy season which runs from June to November seldom experience moisture stress due to the regular occurrence of rain. However, during the year 2002 the rainfall received during September was only about 30 per cent of what was being received during previous years (Table 2). This has made the soil moisture situation less luxurious during this period. The total rainfall received during 2002 was less than normal.

3. Impact on rubber plantations

Planting of rubber is done during the southwest rainy season from June to September. The planting materials being used are poly bag plants and budded stumps. A vast majority of growers (85%) use polybag plants whose establishment is generally not affected by a low rainfall received in a particular month within the rainy season. But this will not be the case when budded stumps are used for planting. However, planting of budded stumps is advised to be undertaken immediately after the establishment of the southwest monsoon. Due to the above reasons the establishment problem consequent to the low rainfall experienced during September was noticed only in very few cases. Nevertheless, prolonged drought during any part of the year will have adverse effect on plant establishment.

Table 1. Rainfall distribution (Kerala)

South west monsoon	4 months	67% of annual
North east monsoon	2 months	16% of annual
Total rainy season	6 months	83% of annual
Off season	6 months	17% of annual

Adequate soil moisture is required for the rubber tree to give sustainable yields. The dry months extending from February to May is the low yielding period and accounts for about 20 per cent of the annual yield. The peak yielding period from October to January gives an average share of about 45 per cent. The remaining 35 per cent is usually realised during the rainy season.

A slight depression in yield was noticed in a few cases during the month of September 2002 when the rainfall was unusually low. However, it is seen that this has not resulted in reduction in the total annual yield for 2002. In many other cases no such depression was noticed.

It is thus seen that the below normal rainfall received during 2002 has not resulted in an adverse situation with regard to yield and planting success in rubber. A depression in rainfall in one month during the rainy season cannot be expected to influence the yield of a tree crop like rubber.

However, a drastic reduction in the total annual rainfall may have an adverse effect on the performance of rubber. An even distribution of rainfall has been observed to be more conducive for yield rather than a high total annual rainfall as evidenced by a fairly high annual yield from

Table 2. Rainfall (mm) at RRII Farm, Kottayam (1998-2002)

Month	1998		1999		2000		2001		2002	
	Rain fall	No of rainy days	Rain fall	No. of rainy days	Rain fall	No. of rainy days	Rain fall	No. of rainy days	Rain fall	No. of rainy days
Jan	33.6	2	0	-	6.6	1	23	2	8.6	1
Feb	0	-	41.4	3	45	7	47.6	3	12.4	2
March	38.4	1	13	2	118.2	4	27.6	1	61.7	2
April	115.3	7	204.1	9	97.3	8	367	14	123.1	12
May	150.9	5	565.1	20	57.9	7	240	12	477.1	15
June	733.2	25	612.4	19	582.3	23	657.2	23	458.7	22
July	511.3	24	473.8	25	236.7	15	600.7	18	325.1	22
Aug	402.7	20	214.6	13	666.2	22	284.9	18	343.3	16
Sept	572.7	23	61.1	8	246	15	414.8	10	99.8	6
Oct	390.9	16	795.8	25	155.1	14	353.2	18	450.4	20
Nov	67.4	7	208.9	10	90.0	7	149.6	9	279.6	8
Dec	91.1	6	6.8	1	30.2	2	30	4	—	—
Total	3107.5	136	3197	135	2331.5	125	3221.6	132	2657.8	126

rubber plantations in Kanyakumari District of Tamil Nadu.

4. Agronomic strategies for effective drought management

The Rubber Board has been advocating a number of practices to be followed in rubber plantations for water and soil conservation with a view to minimize the adverse effects of drought during any part of the year. A number of other steps are also taken to protect the young plants from the hot sun. The following activities are being followed by rubber growers and planters to achieve the above objective.

Timely planting: When budded stumps are used as planting materials, planting should be done immediately after the south west monsoon is established, so as to get the full advantage of the rainy season. Poly bag plants also should be planted early in the rainy season although a little more flexibility is allowable.

Planting pits: It is recommended that planting pits of size 75 cm^3 to 90 cm^3 should be opened and refilled with fertile topsoil devoided of gravel and large roots. This results in better moisture availability in the root zone and enhanced root activity leading to greater success in establishment.

Contour terracing: Most rubber holdings and plantations are situated on slopes of varying degrees with an inherent vulnerability to soil and water erosion. It is recommended that planting should be done necessarily along contour terraces when the slope is more than 8 per cent. Contour terracing helps to minimize water and soil erosion and enhance infiltration of rain water down the soil profile contributing to ground water recharge.

Establishment of legume ground cover: The practice of establishment and maintenance of legume ground cover from the year of planting of rubber does a good job in minimizing water and soil erosion and in promoting infiltration of rainwater. It also adds a lot of litter and enriches soil organic matter.

Silt pits: The practice of taking silt pits widely adopted by rubber growers has been observed as an excellent water harvesting technique for the rainy season.

Contour bunds/ Edakkayyalas: In steep slopes construction of contour bunds/ edakkayyalas has been found very effective in complimenting the function of contour terraces.

Shading: Shading the young plants in summer, during the year of planting, using plated coconut leaves or similar materials helps to protect the young plants from sun and gives better establishment and prevents casualities to a great extent.

Mulching: Mulching the plant basins during the initial years help a lot in conserving soil moisture and enriching soil organic matter.

White washing: White washing the main stem of the plant during the initial years help to minimize the impact of sunlight.

5. Conclusion

Droughts of even severe magnitude both in terms of uneven distribution and reduced total annual rainfall can strike the State in future years. For economic reasons rubber is generally considered as a rainfed crop. Irrigating rubber plantations during moisture stress periods will not be either economical or feasible. Adoption of appropriate management practices towards conservation of water and soil as described above can go a long way in addressing drought situations. The total annual yield during 2002 was not affected due to meteorological drought of monsoon 2002 though a slight depression was noticed in a few cases during September when the rainfall was unusually low.

Proceedings of the Brain Storming Session on Drought Management Strategies, held on 3rd March 2003, KAU, Vellanikkara, pp. 14-16

DROUGHT MANAGEMENT STRATEGIES FOR TROPICAL TUBER CROPS

G. Byju and V. Ravi
Central Tuber Crops Research Institute
Thiruvananthapuram - 695 017, Kerala

Drought limits plant growth and crop productivity more than any other single environmental factor (Boyer, 1982). Tropical tuber crops include cassava, sweet potato, yams, aroids etc. In the case of cassava, Kerala stands first with regard to area under cultivation among different states of India. But the total production in Kerala is lesser than that of Tamil Nadu because the average productivity of cassava is only 18 t / ha in Kerala while in Tamil Nadu, it is 46.32 t / ha. Basically cassava is regarded as a drought resistant crop and the mechanisms of drought resistance have been considered in terms of stomatal closure and leaf area reduction (Yano *et al.* 2002).

Though the area under sweet potato cultivation in Kerala is less than 2000 ha only, is a very important crop in States of Orissa, UP and Bihar where natural calamities like drought and cyclone are common. During the super cyclone, which devastated the state of Orissa in 1998, sweet potato was one of the few crops people depended upon for survival (Mukherjee *et al.* 2002). Other major tuber crops like elephant foot yam and taro also thrive well in warm humid climate with temperature ranging from 25 – 35 ^{0} C (Mohankumar and Kabeerathumma, 1994; Kabeerathumma and Mohankumar, 1994). According to the survey conducted in the Asian and Pacific Regions, 76 per cent of sweet potato cultivation is in drought stricken area (Anon. 1982).

1. Root distribution pattern and water requirement

In the case of cassava, the bulk of the root volume is confined to the upper 20 cm soil and the lateral spread of the root extends up to 45 cm under field conditions (Ramanujam, 1984). Cassava needs adequate soil moisture for sprouting of stakes and subsequent establishment. The stage most sensitive to moisture stress is tuberisation, which caused yield loss up to 32 per cent (Conor *et al.* 1981). In a crop duration of 10 months, cassava requires about 18 irrigations given to a depth of 5 cm with a total water requirement of about 900 mm / ha. Up to tuber initiation (3 months), the crop needs irrigation at 10 days interval and thereafter once in 20 days. Moisture stress at the time of root bulking drastically reduces root yield. Supplemental irrigation at IW/CPE ratio = 1.0 increased the cassava yield by 90 per cent over the rain fed crop (Nayar *et al.* 1985).

In the case of sweet potato, 51 per cent of the roots are confined within 45 cm depth in soil and 92 per cent of roots are within 57 cm depth (Ravi, 2000). Maximum rooting depth of all roots go even up to 180 cm. Sweet potato is unique for its abundant vegetative growth in a conducive environment like non-limited water availability, rich sunshine and fertile edaphic condition. The tuber initiation phase, which falls between 10 and 30 days after planting, is critical in the case of sweet potato. Soil moisture stress during this period adversely affects the tuber yield, whereas sweet potato tolerates moisture stress during tuber bulking phase (30 – 50 days after planting) (Nair *et al.* 1996). Sweet potato yields best when irrigated at 25 per cent available soil moisture and there is no increase in storage yield by maintaining soil moisture above 50 per cent. Sweet potato requires 500 mm water for a period of 4 – 5 months. The crop experiences drought stress at less than 50 % available soil moisture.

2. Physiological adaptations to drought

Cassava and sweet potato have indeterminate growth habit and is one of the characteristics that help them overcome drought stress. Under severe moisture stress, cassava adapts to drought by shedding the leaves. Other changes include reduction in leaf area, leaf water content, reduction in photosynthesis and dry matter production and ultimately reduction in tuber yield. Once the crop is relieved off from the moisture stress or remained under drought for a longer period, regeneration of terminal buds with fresh foliage could be noticed. This regeneration is initially at the expense of the stored food materials from the tuber.

Drought tolerant sweet potato cultivars accumulate greater amount of proline in the leaf and fibrous root tissues than the plants under water deficit stress free

Table 1. Effect of moisture stress on net photosynthesis and light interception of cassava

Cultivar	Photosynthetic rate (mg $CO_2/m^2/s$)			Light interception (%)		
	Irrigated	Moisture stress	Mean	Irrigated	Moisture stress	Mean
M4	514	186	350	40.8	15.6	28.2
H165	633	389	486	58.2	16.9	37.5
H226	567	319	442	51.4	16.7	34.0
H1687	506	253	378	80.1	26.3	53.2
H2304	575	317	444	82.4	25.2	53.8
S1315	400	300	350	84.3	50.2	62.2
Sree Prakash	467	311	389	88.4	34.6	61.5
CI590	533	261	397	36.7	10.0	23.2
LSD (P = 0.05)						
Cultivar (Cv)		34			3.27	
Treatment (Tr)		55			1.60	
Interaction						
Tr/Cv		69			4.58	
Cv/Tr		48			4.64	

conditions. Because most of the proline accumulation occurs after growth has ceased, proline doesn't seem to influence sweet potato plant growth during water deficit stress. However, proline accumulation may help the plant for survival through osmotic adjustment. Efficiency in post stress recovery coupled with high sink capacity may lead to better tuber yield in drought tolerant sweet potato cultivars.

3. Drought tolerant cultivars

In Kerala, in the main season of planting cassava (May – June), the dry period coincides with the peak tuber-bulking phase, the potential productivity is not being realized for want of optimum canopy. So it is a major limitation for the rain fed cassava. In the case of the second season (September-October) planting, the usual dry weather coincides with canopy formation and early tuber bulking phases that cause more yield reduction as compared to main season planting. There are varietal differences of cassava plants with regard to drought resistance (Table 1.) and the varieties *H – 165* (high yield under moisture stress due to high photosynthetic rate), *H – 226* and *Sree Prakash* (high yield under moisture stress due to better leaf retention to intercept more solar radiation in addition to inherently high harvest index) are identified as drought tolerant cassava cultivars (Ramanujam, 1990).

In the case of sweet potato, moisture stress during 20 – 40 days after planting significantly reduced tuber yield than moisture stress at 40 – 60 and 60 – 80 days after planting. When the crop faces moisture stress during 20 – 40 days after planting, the tuber initiation and number of tuber producing roots are affected. Drought tolerant cultivars have high leaf area and better tuberous root growth than the drought susceptible cultivars. *Sree Bhadra* is identified as a drought tolerant sweet potato variety.

4. Agronomic practices

Close pruning of the main stem at 30 cm height from the ground level at 8th month stage during prolonged drought period (February) showed some encouraging results (Table 2). This treatment favoured the development of fresh leaf canopy to support storage root growth in the absence of adequate soil moisture (Ramanujam, 1987). Varieties *M-4* and *H-2304* having tubers with distinct neck at the point of attachment to the mother stem are more suitable for pruning treatment when tuber quality is to be restored. Pruning is suitable for drought prone areas and also economical to regulate supply of tubers during off-season.

Instead of the normal sett (stake) size of 15 – 20 cm length bearing 6 – 8 nodes, on an average, in *minisett* technique, single, two or three buds could be used as minisetts for planting material production (Table 3). Experiments conducted at CTCRI, Thiruvananthapuram revealed that

Table 2. Effect of pruning on tuber yield of cassava (t / ha)

Treatment	H - 2304	M - 4	H - 165
Control (10 months)	40.7	29.6	45.6
Control (16 months)	61.7	49.4	80.2
Pruned (16 months)	74.0	59.2	93.8

Table 3. Effect of direct planted and transplanted minisetts on establishment

Treatment	Establishment Percentage	
	Direct planted	Transplanted
1-node	39.6	71.1
2-node	56.2	86.4
3-node	59.7	90.3

establishment of transplanted cassava minisetts was about 90 per cent. The results also indicated that there was no apparent difference between 2-node and 3-node minisetts in overall performance. Plant the minisetts horizontally very close to each other in a nursery. Make nursery under partial shade with sufficient moisture supply. Transplant to main field at 3-leaf stage. In this way the crop can more effectively utilize the short rainy season for growth and yield. This is advantageous in areas having short rainfall period (James George, 2003).

Though many of the high yielding varieties of cassava were of 10 months duration (H 97, H 226, Sree Visakham, Sree Sahya, Sree Harsha, Sree Rekha and Sree Prabha), breeding approaches changed towards developing shorter duration varieties. This has resulted in developing varieties of 6 months duration or less (Sree Jaya, Sree Vijaya from CTCRI and Kalpaka, Nidhi and Vellayani Hraswa from KAU). These short duration cassava varieties can mitigate the drought impact on the yield of cassava.

References

Anonymous. 1982. *Progress Report*. Asian Vegetable Research and Development Centre. pp. 113-115

Boyer, J. S. 1982. Plant productivity and environment. *Science* 218 : 443-448

CIAT. 1984. Cassava Program. *Annual Report*. CIAT, Cali,

Conor, D. J., Cock, J.H. and Parra, G.E. 1981. Responses of cassava to water shortage: Growth and yield. *Field Crops Res.* 4 : 285-296

George, J. 2003. Quality planting material production and storage in tuber crops. *Training Course on Recent Advances in Production and Processing of Tropical Tuber Crops*, February 24 – March 1, 2003, Central Tuber Crops Research Institute, Thiruvananthapuram

Kabeerathumma, S. and Mohankumar, C.R. 1994. (eds. Chadha, K.L. and Nayar, G.G.). *Advances in Horticulture. Vol. 8 – Tuber Crops*. Malhotra Publishing House, New Delhi, pp. 293-311

Mohankumar, C. R. and S. Kabeerathumma. 1994. Agro techniques and nutritional requirements of aroids and minor tuber crops. (eds. Chadha, K.L. and Nayar, G.G.). *Advances in Horticulture. Vol. 8 – Tuber Crops*. Malhotra Publishing House, New Delhi, pp. 233-249

Mukherjee, A., Naskar, S.K., Saravanan, R., Swamy, T.M.S., Byju, G., Satapathy, B.S. and Sahoo, B.K. 2002. Performance of sweet potato in cyclone hit areas of Orissa and its impact on coastal agriculture. *National Conference on Coastal Agricultural Research : Extended Summaries*. April 6-7, 2002. (eds. Manjunath, B.L., Ramesh, R., Faleiro, J.R. and Korikanthimath, V.S.) ICAR Research Complex for Goa, pp. 61-62

Nair, G. M., Nair, V.M. and Sreedharan, C. 1996. Response of sweet potato to phasic stress irrigation in summer rice fallows. *J. Root Crops* 22: 45-49.

Nayar, T. V. R., Mohankumar, B. and Pillai, N.G. 1985. Productivity of cassava under rain fed and irrigated conditions. *J. Root Crops* 11: 37-44

Ramanujam, T. 1984. Water management in cassava. *Advances in Horticulture. Vol. 8 – Tuber Crops*. (eds. Chadha, K.L. and Nayar, G.G.). Malhotra Publishing House, New Delhi

Ramanujam, T. 1987. Effect of pruning on leaf area development and productivity of cassava (*Manihot esculenta* Crantz). *J. Root Crops* 13 : 83-90

Ravi, V. 2000. Physiological aspects of tuber crops. *Production technology of tuber crops*. (eds. Mohankumar, C.R., Nair, G.M., George, J., Ravindran, C.S. and Ravi, V.). Central Tuber Crops Research Institute, Thiruvananthapuram

Yano, K., Kato, Y., Banoc, D.M., Pardales, J.R. and Yamauchi, A. 2002. Comparisons in soil water extraction between cassava cultivars. Proceedings of twelfth Symposium of the International Society for Tropical Root Crops, Sept. 10-16, 2000. (eds. Nakatani, M. and Komaki, K.). Potential of root crops for food and industrial resources, Tsukuba, Japan, pp. 132-135

Proceedings of the Brain Storming Session on Drought Management Strategies, held on 3rd March 2003, KAU, Vellanikkara, pp. 17-18

DROUGHT MANAGEMENT IN THE FORESTRY SECTOR

Jose Kallarackal
Kerala Forest Research Institute
Peechi-680 653, Thrissur, Kerala

According our satellite imageries, forests form 25% of the land area of Kerala. Almost all of this land area is located in the Western Ghats range of hills and valleys. It is well understood that these hills and valleys of the Western Ghats constitute our major watersheds, which form the sources of our 44 rivers. Studies in India and elsewhere have shown that protecting the watershed is the least we can do to manage our water resources and managing them properly is the best we can do to prevent the consequences of a drought. It should be recognized that drought in any part of the world is the result of deficient precipitation. When this is combined with a non-uniform pattern of precipitation, the drought conditions are aggravated. It is this situation that we mostly face in Kerala. We can do little to control the climate. However, if the monsoon rainfall can be suitable conserved, much of the hardships due to drought can be circumvented. It is with this intention that the following suggestions are given:

1. Conservation of the natural forests

Decrease in the land are under forests should not be allowed. This is mainly happening in Kerala because of encroachment by farmers and destruction by fire. Since forests form important watersheds for our rivers, destruction of the tree cover can cause unusually high runoff losses, causing floods in the rivers and thereby deficient streamflow to sustain the flow in the rivers. Forests help rainfall by orographic lifting. Therefore, it is important to have tall trees in the Western Ghat ranges.

Strong decisions should be made to prevent any loss of forest area by encroachment or fire in the future. Awareness should be given to the public about the water storing capacity of the forests and how important is that water to our agriculture.

2. Appropriate management of plantations

The growth of plantations in the public and private sectors has been phenomenal. Overall, 1,55,000 ha of forest land have been converted to plantations by the Forest Department alone. A total of 443,300 ha are available for rubber, 105,700 ha for cashew and 82,400 ha. for coffee and few thousand hectares for other plantations. The total area under plantations, which can be reasonably assumed to be forest land before 50 years or so thus amounts to 786,400 ha. This is nearly 42% of the total land area available in the Highlands of Kerala if we assume that all the above type plantations are in the Highlands.

A plantation differs from a natural vegetation in many ways. Plantations are monocultures, usually in even-aged stands. Many plantation species like rubber, cashew, tea, eucalypts etc. are exotic in origin. Most plantations are harvested periodically and replaced with new crop. They also receive several management inputs like tillage, fertilisers, pesticides, irrigation etc. over natural vegetation.

Raising plantations on lands previously occupied by natural vegetation can have several impacts on the water balance. Although Kerala receives an average annual rainfall of 3000 mm, it is highly seasonal, so that nearly half the year remains dry. Moreover, due to the hilly terrain, instead of infiltrating the soil, 40-90% of the rainfall is lost as runoff from the Highlands (CWRDM). The humus cover in plantations is very poor compared to natural forests, and the laterisation of the ground in many exposed as well as planted areas reduce the infiltration of water. Therefore, less water is available for recharging the water table in areas converted to plantations.

The choice of tree species is an important factor affecting the water yield from a catchment because the evapotranspiration characteristics of the plant species differ very much. There are several reports of planting fast-growing trees on grass and scrublands considerably decreasing the dry season water yield. Based on the studies of several plantation species of Kerala it has been shown that the variation in water consumption, especially the seasonality and quantity, between species, can be immensely great.

Soil erosion is an important disturbance that can occur even in well-managed plantations, during planting, fertiliser application, weeding or harvest. The most obvious physical impact is exposure, leading to heavy soil erosion. Loss of topsoil can expose the hard laterites, which will enhance the surface runoff. Another physical impact is compaction due to the use of heavy machinery and vehicles during harvesting operations. This results in the increase of bulk density of the topsoil, reducing the infiltration and water holding capacity.

It is not possible to bring back plantations to natural forests for the sake of water. However, it is important to ensure that water and soil conservation practices are followed in these plantations. Plantation technology recommended for each species should be carefully followed and choice of species should be carefully done to suit the land.

3. **Building of reservoirs at high elevations**

Reservoirs should be built in the high elevation areas without causing destruction to the forests by consequent encroachment. Traditionally, from a hydrologist's point of view, after the construction of a dam, the forests in the catchments are cleared for promoting maximum runoff into the reservoir. This has been practiced in the management of most of the hydroelectric projects in Kerala. However, presently we know that most of the silting in our reservoirs has happened because of this. Conversion of large areas of the catchments for annual cropping can worsen the situation. Raising plantations also need not solve this problem in the light of the discussion already presented.

4. **Problem oriented research for the tropics**

Much of our hydrological studies have been based on the European system where the precipitation pattern is more or less uniform throughout the year. During our monsoons, probably the soil gets saturated to such an extent that no more water can be held in the soil. It should be known whether recharging of the ground water table is possible in such a situation. If that is not possible, then, reservoirs are possibly the main answer. However, environmental lobbies are against the dams. Is it environmentally wrong to have reservoirs in such a situation? Studies should be undertaken to see how the ground water recharge is occurring in forests and how much water is lost by evapotranspiration, which is the major component in the hydrological cycle.

There could be many more recommendations for the forestry sector. However, the success or failure of these recommendations will depend on the scientific spirit by which they are implemented and the commitment of the people involved in the implementation.

Proceedings of the Brain Storming Session on Drought Management Strategies, held on 3rd March 2003, KAU, Vellanikkara, pp. 19-22

SOIL AND WATER MANAGEMENT STRATEGIC PLANNING FOR PRESENT AND FUTURE DROUGHT SITUATIONS

Dr.M.Subramonia Iyer
NATP on Landuse planning, Dept.of Soil Science &Agrl.Chemistry
College of Agriculture,Vellayani – 695 522, Trivandrum, Kerala

India Meteorological Department declared the year 2002 as "the first-ever all-India drought year" since 1987. In the country 29 per cent of the area recorded drought conditions, with rainfall deficiency exceeding 25 per cent. *The country is said to experience a drought year when the overall rainfall deficiency is more than 10 per cent and more than 20 per cent of its area is affected by drought conditions.* The "2002 became an all-India drought year", with rainfall deficiency for the country as a whole amounting to 19 per cent and drought conditions impacting 29 per cent of its geographical area. Of the 29 per cent area affected by drought conditions, 10 per cent was under 'severe drought' and the remaining under 'moderate drought'.

The 2002 drought situations, among the four major droughts of the century, was mainly caused by the dry spell in July 2002, with the rainfall deficiency of 49 per cent during the month being "the worst in the history of recorded observations". Only on two previous occasions in the past (1911 and 1918) did rainfall deficiency exceed 45 per cent in July. Unlike previous episodes of drought, the rainfall was actually on the positive side of normal in June this year, with precipitation being much better even in August and September (Table).

Table. Performance during drought years

Year	June	July	Aug	Sept	June-Sept
1972	- 27	- 31	- 14	- 24	- 24
1979	- 15	- 16	- 19	- 28	- 19
1987	- 22	- 29	- 4	- 25	- 19
2002	+ 4	- 49	- 4	- 10	- 19

(Percentage departure from long period average)

As drought has hit our State also during the last year/season more practical adjustments in farming from this year/season onwards should be practiced with immediate effect. The impact of drought cannot be assessed well after the harvest. The basic concepts and earlier experiences will certainly help Management Decision Support Systems (MDSS) to increase crop yield chances for the coming seasons.

1. Soil Management Planning

Many soils will be in a different condition after drought. Some will be bare and powdery on the surface, some will be further eroded and some will have higher levels of nitrogen (N) and phosphorus (P) than expected.

Loss of effective ground cover cultivation leaves the soil highly prone to erosion. It has been reported that erosion due to drought-breaking rain can make up 90% of the total soil loss in a 20–30-year cycle.

Available N and P levels in the soil are generally higher following a drought than in a normal season. However, most of the N and P are in the topsoil, so if erosion strips the topsoil, much of this benefit is lost.

A useful strategy is to sow your most erodible fields early to make use of available nutrients. Reserve your less erodible areas for your main crop.

Controlling weeds by spraying, rather than cultivation, will retain some surface ground cover, but you may need to cultivate bare soils initially to create some surface roughness to improve infiltration of water and reduce soil erosion. In this situation, practice as early as you can when the soil is moist but not too wet or too dry. Use a ripper or chisel plough, and cultivate on the contour to catch maximum rainfall and reduce run-off.

Uncontrolled machinery traffic and stock trampling are major factors in causing the structural degradation, and subsequent erosion of wetlands soils. Where necessary, in order to reclaim eroded areas or prevent further erosion, contour furrows or soil conservation earthworks should be constructed. These will reduce and slow run-off, limit the movement of soil and organic matter and decrease the sedimentation and nutrient loss/ contamination to dams and waterways.

In areas that were sown but failed to produce a crop, soil nitrogen levels are likely to be higher than usual for two reasons. The first is that most of the nitrogen incorporated before sowing the crop that failed will still be available, provided the crop was not grazed, or cut for hay. The second reason is that mineralisation of nitrogen (conversion to plant-available forms) increases markedly once it rains.

As a consequence, weeds are likely to grow rapidly after rain and need to be controlled, preferably by spraying. Despite high soil N levels, starter fertiliser and some top dressings may still be required.

Higher soil temperatures and a longer growing season result in greater root exploration and hence the need for less fertiliser. As in a normal season, soil testing for plant-available nutrient is advisable to help you decide how much fertiliser you need. This is an important decision. Conservation farming practices and the efficient management of fertilisers are two important ingredients for long-term sustainable, profitable production. Such measures help to prevent or slow down soil erosion and other soil-degrading processes and are part of precautions against drought.

2. Some important conservation practices

- Use minimum tillage or no tillage
- Retain stubble on the surface for as long as is practicable; if burning is necessary, wait until the main period of high erosion risk has passed
- Use herbicides, rather than tillage, to control weeds during fallows
- Use crop rotations that include well-managed fodder crops and legumes
- For irrigated row cropping, use permanent, raised beds
- Improve grazing management to minimise soil compaction and maintain adequate surface cover, particularly during droughts
- Increase topsoil organic matter levels by, for example, stubble incorporation or mulching, and including fodder in crop rotations
- Judiciously apply lime to acid soils
- Promote vigorous plant growth generally, through sound soil, crop and water management practices
- Degradation leading to compaction further increases drought damage, it increase moisture stress. so locate these areas, plan and correct by
- Fe toxicity management of acid sulphate soils of Kerala (Manorama Thampatty et al,2001) for rice production with potassica

3. Nutrient Management for Drought- *Some Proven realities to act*

- Under drought stressed conditions nutrient deficiencies are more common particularly potassium (K)
- Drought damaged crops grown under conditions of good nutrient availability need starter fertilizers, which are particularly effective
- Crops grown with high soil test P and K are better to tolerate heat and moisture stress
- Higher P availability helps young seedlings establish a good root system early in the season. They may survey better against the moisture stress
- High levels of K improve water use efficiency because losses of water from leaves are reduced and healthier root systems are able to extract more moisture from the soil
- Adequate soil fertility speeds crop maturity and can help a crop pollinate before likely period of moisture stress set in
- Drought underscores the fact that nutrient application in many areas have not kept pace with nutrient removals in recent years when yield and nutrient levels are high

The preliminary trend analysis of soil fertility data (Soil Health change) from soil testing laboratory and KAU research projects for the last ten years in the Kuttanad and pokkali soils in relation to production of rice and fertilizer consumption strengthens above fact (Iyer, 2003)

Drought impact on soil health is to be assessed measuring soil health indicators.Soil physical, chemical, biological, crop, and micro climate indicators(Doran and Parkin,1994) and the specic frequency had been widely used as a base for measuring/monitoring soil health (Lal and Stewart,1995)

4. Water Management

After a drought, it is important to reassess your stock and domestic watering system in the light of what was learnt during the drought:

- Were there sufficient watering points in all fields?
- Were tanks big enough?
- Were catchments/watersheds able to be maintained satisfactorily?
- Were bores, pipelines, pumps and ponds adequate and well maintained?

Adequate ground cover should be maintained in water catchment areas and constructed waterways in order to keep water clean and prevent loss of capacity. The area around the inlet is particularly important, and good cover here can act as a filter and as a silt trap. Limited irrigation water during droughts is best used on perennial crops or the most valuable crop. It is better to adequately irrigate a small area than to under-irrigate a large area. If soil below the root zone is saline, salt may move up the soil profile during drought. Unless rains have been sufficient to flush accumulated salts from the root zones of crops, additional irrigation water should be applied. During drought, irrigators have the opportunity to check over their system so that it is able to be operated efficiently when irrigation water is again available. All the mechanical and delivery components of the system should be checked in all the irrigation systems. After long periods of not being used, check the system carefully for blockages caused by dust, insects etc. in pipes and sprinkler outlets, and flush the system through. After a dry spell, the opportunity should be taken to frequently monitor the infiltration depth of rainfall or irrigation. This will indicate when there is enough water available within the crop root zone. During drought the quality and flow rate of water in unregulated waterways may deteriorate. In tidal regions, the salt can move considerably further upstream than would be the case in a normal dry spell.

After rain, the quality of water in some streams may be variable and should be monitored before using it for stock, garden watering or irrigation of crops.

Palanisami et al (2002) in their watershed development research paper reports that among the soil moisture conservation materials, coir pith@10t per hectare recorded the maximum yield in pure crop of Tapioca as well as tapioca + ground nutinter cropping compared to other treatments. Their study on suitable land configuration measures for *in-situ* water harvesting, the broadbed furrow system registered higher crop yields followed by compartmental bunding. Four micro water harvesting methods viz., pit method; crescent bund, compartmental bunding and basin were tried, among these methods tree seedlings grow faster under basin method when observed after 70 days after planting followed by crescent bund and pit method. Among these methods basin method was superior in conserving moisture from 0-15 cm depth.

To ensure that rice plant roots remain healthy and vigorous, there should be no continuous standing water on the field, at least through the period of tiller growth up to the time of flowering begins. After flowering, a thin layer of water is kept on the field,1-2 cm, and the field is drained 10-20 days before harvesting according to local practice". Practical and critical observation of some of our rice experts of Palghat, Kole and Kayamkulam may have similar agreable realities at least in odd micro locations and environments though may not be documented in research reports. Hence this SRI water management know-how for rice is to be tested and adaptation be evaluated in actuall rice farming situations of our State particularly in Palghat, Chitoor, Kole and Onattukara in comparison with GALASA, KAU-POP, Farmers practice ?

5. Farm management planning

Farm planning should recognise that drought can occur at any time and can cause land degradation, financial hardship, family stress and threats to productivity, especially if it is prolonged and followed by heavy rain and floods. The thought of drought may be unpleasant, but property management planning which recognises the inherent limitations of our environment can maintain productivity and profitability while reducing the impact of drought. Farm management planning includes:

- An assessment of the farm's physical resources
- Goal setting
- An assessment of the human resources available to run the farm business
- Financial management to enable the accumulation of reserves or the implementation of strategies for alternative income generation
- Conservative farming practices (stocking rates, tillage, weed and pest management) to allow flexibility in the face of changing climatic conditions
- Maintenance of the farm infrastructure
- Maintenance of the farm's natural resources including soils, water, pastures, shelter belts and remnant native vegetation
- Monitoring and reassessment of the farm's capability and the management plan
- Determining your future in farming
- Recognition of animal welfare issues and community expectations

6. Long-term strategies to cope with drought

"The authorities should frame policy to deal with drought on a long-term basis," says Dr William D Dar, Director General of ICRISAT. "The issue of considering water efficiency and not merely availability is a recent development."

Now the question is - is the available water being used efficiently? Increasing usage of available water resources becomes quite significant in this context. It is essential to mobilize local participation to work towards implementing soil and water conservation measures developed by scientists for the rainfed areas. For example:

- Integrated watershed management should be adopted for conserving water and using it efficiently through rainwater harvesting. Diversion of rainwater into dugout ponds, mini-percolation tanks, dry wells, sunken gully silt traps, water tanks and checkdams should be taken up under watershed development programmes.
- Soil organic matter also needs to be improved in the long term. Nitrogen-fixing shrubs like *Gliricidia* and Leucaena can be grown on bunds to improve the water-holding capacity of the soil.
- Vermicomposting farm residues and weeds can add valuable organic matter to the soil. Earthworms both improve fertility and increase water-holding capacity of the soil.
- Balanced and integrated use of nutrients and environment-friendly pest management options can increase the productivity of rainfed agriculture through efficient use of conserved soil and water resources.
- Increase green cover with suitable plants.
- Use improved varieties that resist pests and tolerate drought.
- Educate farmers on appropriate soil and water conservation technologies.
- Establish community-based systems for water resources auditing and use at village level to avoid over exploitation of groundwater.
- Desilting existing water harvesting structures to increase storage capacity. The silt can then be used as a valuable source of plant nutrition.
- Good management is best in drought years. Combination of good levels of soil fertility, use tolerant hybrid varieties, early planting, use of moisture conservation tillage systems, and good weed control will help to improve water use efficiency.

7. Conclusion

KAU has to strengthen R&D for Crop Stress Management (CSM)

Refine the KAU-POP with all aspects of the drought and other stress tolerance of our crops with suitable and useful mitigating packages for each crop in English and Malayalam.

Leaflets, Newsletters and awareness programmes in real field situations in mission mode should be given priority. Harvested rainwater should be used effectively during prolonged drought periods or dry spells. Some of the practical methods of rainfall harvesting, such as rooftop harvesting and conservation of small check dams, require the people's participation. In the future, the quest for water will involve community-based rainwater harvesting in both urban and rural areas, which may help us certainly to achieve food sustainability and thereby livelihood security.

References

Doran, J.W. and Parkin, T.B. 1994. Defining and assessing soil quality. *Defining soil quality for a sustainable environment.* (eds. Doran, J.W. and Coleman, D.C.)

ICRISAT. 2002. ICRISAT- Strategies to manage drought situation for Rainfed Crops: Dealing with drought, News 5th August, 2002. Website: www.icrisat.exch.cgiar.org

Iyer, M.S. 2003. *Annual Report of the NATP on Landuse planning for Management of Agricultural resources-Coastal Ecosystem,* Kerala Agricultural University, Vellayani,

Lal, R. and Stewart, B.A. 1995. Managing soils for enhancing and sustaining agricultural production. *Soil Management: Experimental basis for sustainability and environmental quality.* (eds. Lal, R. and Stewart, B.A.). CRC Press, pp. 1-9

Palanisami. K.., Sureshkumar. D. and Selvi, R.K. 2002. Watershed development research in selected watersheds of Tamil Nadu, Watershed based development and management. *Compendium of selected articles on watershed development and management,* Western Ghats Cell, Planning & Economic Affairs Department, Government of Kerala. pp:34-53

Thampatty, K.C.M., Iyer, M.S. and Cherian, M.S. 2001. Management of Iron toxicity by Potassic fertilizer in an Acid suphate soils (Sulphaquent) of Kerala. *Extended Abstracts of the International Syposium of Potassium,* New Delhi, Dec 3-5,2000

Uphoff,N., Fernandes, N. Longping, P., Jiming, P., Rafaralahy, S. and Rabenandrasana, J. 2000. *Proceedings of an International Conference on Assessment of Rice Intensication System* ,Sanya, April 1-4, 2002

The Hindu. 2002. The Hindu Business Line, Internet Edition, Saturday, October 5th, 2002

Presentations from Research Stations

DROUGHT MANAGEMENT IN RICE BASED CROPPING SYSTEMS IN EASTERN PALAKKAD

Cropping Systems Research Sub Centre
Vadakkenchery

In Eastern Palakkad district rice is grown in a total area of 58,300 hectares, distributed in Alathur, Chittur and Palakakad taluks. The rabi crop in Alathur and Palakkad taluks are already over and that in Chittur taluk is almost over. Due to scarcity of water the crop was affected. An yield reduction up to 25% is expected. It is likely that about 25% of the crop in Chittur may get dried due to water shortage.

Contingency crop management measures

For the current year no contingency measures required / possible since there would be no summer crop. However, to avert problems in the ensuing years it is proposed to observe the following pattern.

A. Short - term

- Grow only short and medium duration rice for kharif according to the possibility of taking nursery before harvest or after harvest of kharif crop
- Restrict long duration varieties with less than 140 days in Chittur taluk, that too only for rabi
- Dry-sowing should be promoted wherever possible
- The cropping pattern should be adjusted in such a way to complete rabi crop by January end in Alathur and Palakkad taluks and by February end in Chittur taluk
- Schedule for irrigation to rabi and summer rice
- Supply adequate quantity of seed to farmers
- Direct seeding by dry-sowing during kharif and wet-seeding during rabi has to be encouraged
- Community nursery (normal or mat type) and mechanical transplanting to complete the work in time and to reduce cost of production
- In areas where rice cropping is not possible during rabi, it is better to go for grams, sesame or groundnut. Short-duration vegetables would be another option

B. Long - term

- Renovation of farm ponds and wells
- Improve irrigation conveyance and increase efficiency

MEASURES TO COMBAT DROUGHT SITUATIONS IN THE SPECIAL ZONE OF PROBLEM AREAS

Regional Agricultural Research Station
Zone of problem areas, Kumarakom

During the year 2002, there was a deficit of 23% of rainfall compared to the previous year which lead to the present drought situation. Following measures are suggested to combat the drought situations. Low rainfall conditions have resulted in the early incursion of saline water into the Kuttanad Agro-eco System. This year, the salinity problem has been aggravated due to belated operations in constructing the Kariyarmuttu saltwater prevention dyke and untimely closure of the Thanneermukkam barrier. The barrier is usually closed at highest tide level to enable maximum freshwater impounding in the southern side of the barrier. This has caused lowering of water table particularly in northern Kuttanad. In most parts of Kuttanad, incursion of saline water into the rice fields has resulted in considerable damages to the rice crop that was not ready for harvest. Irrigated banana and vegetables are also affected by the drought and salinity.

Recommendations

As a long term plan, puncha crop is to be sown so as to harvest the crop by the early January every year before the salinity incursions sets in. Considering the recurrent nature of drought in the zone, at least 10% of the total padasekharams may be kept as temporary fresh water storage reservoirs to serve the multi-utilitarian purposes of the locality.

All the channels and ponds may be desilted to enable greater water retention and for water recharge in these potential water reserves. The silt, rich in organic matter, collected from these water resources when applied to the crops will improve the moisture status of the soil and also the water holding capacity.

Water conservation measures like burial of coconut husk, application of coir pith/coir pith compost and mulching basins with aquatic weeds like water hyacinth can be resorted for coconut and other perennial crops.

Lime washing on the basal portion of the trunk of coconut and arecanut may be carried out.

Providing shade will help to reduce transpiration loss and help to withstand drought to a great extent.

In the lateritic midlands where the land is slopy, water harvesting techniques like digging farm ponds, silt pits, percolation tanks and construction of check dams are proposed to conserve water.

Proceedings of the Brain Storming Session on Drought Management Strategies, held on 3rd March 2003, KAU, Vellanikkara, pp. 27-29

DROUGHT MANAGEMENT IN COCONUT AND BLACK PEPPER

Regional Agricultural Research Station
Pilicode, Kasargod

Coconut is mainly grown as a rainfed crop in Kerala. In Northern Kerala, the crop is affected by prolonged drought from December to May unlike in the State. Severe drought was experienced in Kerala during 1982-83 period and another one we are facing now. The mean annual rainfall obtained during the period up to December 2002 is found to be normal (Table 1).

I. Impact of drought on coconut

a. Drought characteristics in coconut

Coconut palms show the following characteristics under severe soil moisture stress depending up on the duration and intensity of drought

- Withering and mortality in the case of young seedlings under poor management
- Drooping, wilting and drying of lower whorl of leaves
- Breakage of leaves at Petiole or just above it
- Spindle leaf breaking which lead to mortality in the case of senile palms under conditions of poor management
- Abortion of spadices, starts from October/ November onwards
- Button shedding and immature nut fall
- Nut size decline and
- Finally decline in nut yield in the subsequent year up to fifty per cent depending upon the type of management

b. Yield loss

The decline in monthly nut yield was noticed from February 1984 to January 1985. The effect of drought on monthly nut yield was noticed in the eight month after the drought period was over (the drought period was over in June 1983). The maximum (64.12%) reduction in nut yield was noticed in July 1984 (ie, 13 months after the drought period was over) and the minimum (23.69%) in January 1985.

II. Drought management

A. Coconut seedlings

Coir dust mulching

Irrigation interval can be increased from 9 to 15 days without affecting the growth and performance of the seedlings if coir dust mulching in coconut nursery bed for 10 to 15 cm is provided (Table 2).

Table 1. Rainfall and number of rainy days during November – May

Year	Nov-May rainfall mm	No. of rainy days	No. of rainy days in April/May	Non-rainy days
1980	290.5	21	11	Jan-Mar(3)
1981	219.6	11	3	Dec,Feb-Apr(4)
1982	152.9	12	6	Dec-Apr(5)
1983	5.0	1	1	Nov-Apr(6)
1984	441.1	20	9	Dec,Feb(2)
1985	377.7	17	13	Dec,Feb(2)
1986	209.5	11	3	Jan,Feb(2)
1987	264.6	10	3	Jan-Apr(4)
2000	593.8	22	16	Jan-Mar(3)
2001	476.4	30	21	Jan,Mar(2)
2002(Up to Dec)	74.3	5	NA	Jan,Feb....)

(November of previous year to May of current year)

Selection of planting material

Choose seedlings with good agronomic traits. Vigorous seedlings can withstand the effect of drought.

Depth of planting

Plant seedlings in pits of one meter depth. Deep planting has the following advantages:

- Produces more number of roots and surface roots are prevented. Nutrient uptake is more.
- Whatever soil moisture is available in root depth during summer, it can be effectively utilized by the roots since the subsurface evaporation is much low when compared to that of surface evaporation
- Soil temperature at that depth will be lower when compared to that of surface depths
- Mechanical damage/ uprooting could be minimized when compared to that of surface depths

B. Adult palms

Mulching: Mulching the basins during October/ November with locally available tree leaves/coir dust @ 50 kg/palms to control surface evaporation and to reduce soil temperature.

Husk burial: If husk buried in linear trenches to a width and depth of 0.5m dug in between rows of coconut palms, it was found that the yield of coconut increased significantly from the third year onwards (Table 3). The beneficial effect of burying husk lasted for six years.

Cover cropping: Grow cover crops and green manure crops to avoid surface run off and to retain soil moisture.

Leaf cutting: Cutting two older leaves every month from January to May reduces transpiration loss without affecting coconut yield. The leaves can be used for mulching the coconut basins.

Soil conservation measures

In sloppy lands, terracing the palm basins also can be done. Short linear trenches across the slopes may be dug in staggered manner which will intercept run-off water and aid percolation. This will help in increasing soil moisture.

In mildly sloppy lands, water harvesting devices like forming slight slope in between the coconut rows can be done. This will help in percolation of water in the palm rows.

If land is out of uniform level, bunds can be formed dividing the field into plots so that the run-off can be prevented. All these soil and moisture conservation methods will help the rainfed palms in getting adequate moisture.

If *rabi* rains are also delayed and if mulching has already been done, life saving irrigation has to be continuted wherever water is available.

Water management

i. If very little water is available, life saving irrigation can be done by burying 2 or 3 earthen pots/hollow bamboos and filling up these with available water. This will help in moistening the sub-soil. The pots are to be covered with lids and in lower portion of the pot, a small hole is made and a wick is inserted in the hole for dripping water

ii. If water is available for drip irrigation, drip system can be laid. 3-4 drippers/palm may be placed and the dripper may be allowed to drip into another tube buried at a depth of 30 cm so that the discharge can be in sub-soil; thus surface loss can be

Table 2. Mulching versus irrigation interval in coconut seedlings

Treatment	Water requirement (mm)	Irrigation interval (days)	Germination (%) at (months)		Dry matter (g)	Plant ht. (cm)	No.of leaves	Diamtr at collar region (cm)
			4	6				
B1 control, No mulching	2096	4	75	79	102	75	6	3.7
B2 5cm Mulching	1521	8	75	83	111	76	6	3.9
B3 10cm Mulching	1389	9	75	83	118	84	6	4.1
B4 15cm Mulching	951	15	75	84	127	91	6	4.1
C.D at P-0.05	-	-	-	-	14.5	10	NS	NS

Table 3. Effect of burying coconut husk in the soil on the growth and yield of coconut cv.West Coast Tall

Year	Nut yield Per palm	C.D (0.05)	Increase over pre-treatment Yield (per cent)	Number of leaves per palm	C.D (0.05)
1937 (Pre-treatment)	38.0	-	-	29.3	-
1939 (Post-treatment)	40.8	-	7.4	31.3	0.9
1940	63.0	7.5	65.8	32.5	0.8
1941	69.6	7.5	83.2	31.1	1.2
1942	54.0	6.7	42.1	30.1	-
1943	64.5	7.1	69.7	30.7	1.3
1944	46.1	3.9	21.3	28.2	0.7

prevented. Yield of nuts under drip irrigation at 30 liters/day/palm was on par with basin irrigation at 600 litres/day/palm

iii. If adequate water is available, basin irrigation with 200 literes/palm once in a week can be done. However, every effort should be made not to waste water. In that case, the basin management by growing green manure crops like sunnhemp, calopogonium and pueraria and incorporation in basins may be done
iv. In backyards and house compounds, effective recycling of used water to coconut basins can be done
v. Irrigation at IW/CPE ratio of 1.0 significantly superior to other treatments with regard to early flowering.

Effect of irrigation is more pronounced in low yield groups (20 to 40 nuts/palm/year) than medium and high yielders

Drought situation may aggravate stem bleeding and Tanjavur wilt disease of coconut

Drought management in black pepper

The characteristic climate requirements for black pepper are high rain fall, uniform temperature, high R.H which is typical of the hot and humid tropical region with little significant variation in day length and humidity throughout the year. The pepper growing area generally requires RF ranging from 1000-3000mm, which is required for proper growth and development of pepper plant, though the crop comes up even in low rainfall areas with uniform distribution of procipitation. The distribution of rainfall, drainage status and moisture holding capacity of the soil are more important than the quantum of total rainfall. A high precipitation will be an advantage if the soil is well drained, if not the plants will be prone to diseases. Long spells of dry period are harmful. It was found that thousands of pepper plants dried up in Kannur district during the drought period of 1973, 1977, 1983, 1987 and 1989. It may be summed up that effective rainfall received during different periods of the year is more vital than the total rainfall received during any particular period of the year, and the effectiveness or otherwise of the rainfall received during any particular period is determined by the texture and depth of the soil,atmospheric temperature and humidity.

Precautions

- Provide life saving irrigation especially to young vines- pot watering, drip irrigation, keeping mud pot with water in the basin of the plant
- Mulching the basins with dried leaves, saw-dust, arecanut husk and other materials have to be resorted to conserve the soil moisture
- Cover the young vines with arecanut leaves or other leaves care should be taken for providing better aeration and light
- Cover the standing older vines with coconut leaves as maximum as possible

OPTIMUM USE OF IRRIGATION WATER

Agronomic Research Station
Chalakudy

1. Irrigation scheduling in rice

   - Rabi (Mundakan) season – Intermittent irrigation with 7cm depth of water, three days after disappearance of ponded water
   - Puncha (Summer) season – Intermittent irrigation with 7cm depth of water. One day after disappearance of ponded water
   - It will help in bringing more area under irrigation by adopting the turn system of irrigation where canal irrigation is practised

2. Pulses and oil seeds

   - Black gram – Summer fallows – Five cm of water at approximate interval of 20days
   - Cow pea - Summer fallows – Five cm of water at approximate interval of 20days
   - Groundnut - Summer fallows – Five cm of water at approximate interval of 11days
   - Sesamum – Summer fallows – Irrigation at four critical stages viz., leaf stage, branching, flowering and pod formation

3. Vegetables

   - Bittergourd - Five cm of water at an interval of three days
   - Bhindi - Five cm of water at an interval of five to six days
   - Ashgourd - Five cm of water at an interval of thirteen days

4. Tuber crops

   - Tapioca – Furrow irrigation with 25mm of water in all the furrows at an interval of three weeks.
   - Sweet potato – Five cm of water at an interval of 11 days
   - Ginger – Five cm of water at an interval of 8-10 days (Mulching is necessary)

5. Banana

   - 200 litres of water per plant at an interval of 13 days (low land)
   - Upland banana – 40litres of water per plant through basin on alternate days in sandy loam soil.

6. Pineapple

   - Five cm of water at an interval of 20 days (Mulching with dry leaves)

Report of the Brain Storming Session - An overview

REPORT OF THE BRAIN STORMING SESSION - AN OVERVIEW

Background

In view of the deficit in seasonal rainfall to the tune of 19%, the year 2002 was declared as an All India Drought Year. Deficiency of monsoon rainfall was to the tune of 35% in Kerala. It was estimated that the all India Kharif foodgrains production during 2002 fell by 19.1%, due to drought. It is necessary to take all precautionary measures to mitigate the ill effects of drought. The Ministry of Agriculture, Govt. of Kerala is very keen to know the contingency plan for drought management. Most of the research institutes located in Kerala have developed very effective technologies for the management of drought in different areas. It is in this context that Kerala Agricultural University took the leadership to organise a Brain Storming Session to pool the information on the ways and means to minimise the adverse effect of drought to the bare minimum.

Altogether eleven papers were presented in the session. The papers were included in the proceedings.

Minutes of the session

The session started at 9.00 AM on March 3rd 2003. Dr. A. Sukumara Varma welcomed the gathering. Dr. A.I. Jose, Director of Extension chaired the session. Dr. R. Vikraman Nair, Director of Research was the Co-chairman. Dr. K.V. Peter, Vice-Chancellor of Kerala Agricultural University, in his keynote address indicated that the deficiency of monsoon rainfall in Kerala was to the tune of 35% but its impact on seasonal and plantation crops was of low magnitude. According to him, the impact of summer drought is more important in Kerala, particularly its long-standing ill effects on perennial crops. He advocated the need to formulate short, medium and long term strategies to mitigate the adverse effect of drought on agriculture.

Dr. GSLHV Prasada Rao, Professor and Head, Dept. of Agricultural Meteorology, in his paper gave an overview of the drought situation and its impact on Indian Agriculture. He suggested that the current definition of drought in the all India context is not appropriate for Kerala and needs to be redefined. Agricultural drought with reference to plantation crops of Kerala should be defined based on the quantum and distribution of summer rainfall and not based on the quantum of rainfall received during monsoon season.

In the ensuing discussion, Dr. John Thomas, Dean, Kealappaji College of Agricultural Engineering and Technology suggested that hydrological drought indicating the position of surface water resources is more important than meteorological drought. He stressed the need for formulation of water and population policy together. The delegates suggested the need for prediction of drought on short, medium and long-term basis with more reliability.

Dr. E.J. James, Director, Centre for Water Resources Development and Management presented a paper on rainfall characteristics, drought and drought management in Kerala. He emphasized the need for collecting reliable data on rainfall to study the pattern of drought in Kerala more accurately. According to him, Kerala is not rich in water resources, in comparison to all India average, as revealed by the data on per day per capita water availability. Since the occurrence of drought is not uniform throughout the State, there is a need for working out the temporal and spatial distribution of drought, to identify the areas and periods prone to drought. Location specific strategies, based on the nature of drought of the location, is to be formulated. He further emphasized the need for renovation of ponds and wells and recharging of ground water to augment the water resources.

Dr. Sherin George presented a paper on the impact of Drought during 2002 on rubber plantations and the management strategies required for rubber plantations.The low rainfall during the year has not affected the establishment of rubber seedlings generally. This is because majority of the cultivators are using polybag plants. Hence the deficit in rainfall during a particular month may not affect the seedling establishment seriously. Regarding the yield of rubber, a slight depression was noticed in the month of September when the rainfall was low but the annual yield for 2002 was not affected by the deficit. She however remarked that a prolonged and drastic reduction in rainfall may have an adverse effect on the performance of rubber in the long run. For minimising the adverse effect of drought, agronomic and structural strategies such as timely planting, contour terracing, establishment of legume ground cover, *edakkayyalas*, silt pits, shading, mulching etc were suggested.

Dr. James Jacob, Rubber Research Institute of India reported that soil moisture deficit is not the only culprit in reducing yield in rubber during the summer months. The high light conditions coupled with low moisture in soil is also a constraints. About 47 percent inhibition in photosynthesis was noticed in unirrigated trees under full sunlight in summer while it was only 23% in trees which were given 70% shade. He also informed that rubber has got higher water use efficiency compared to other trees like acacia, mahogany etc. A 12-year-old rubber tree uses 45-50 litres of water per day while eucalyptus uses more than 90 litres per day. The solar energy use efficiency of rubber is also high. High organic carbon content was observed in the soil of rubber plantations, which was contributed by the cover crop and also by the litter fall.

Dr. Jose Kallarackal, KFRI presented the paper on drought management in the forest sector. He reported that forests cover about 25% of the land area of Kerala which is mostly located in the Western Ghats. Studies in India have shown that protecting the watershed is the least we can do to manage our water resources and managing them properly is the best we can do to prevent the consequences of drought. He stressed that measures are to be taken for conservation of forests by making public awareness on forest fire, water conservation etc. The plantation technologies recommended for each species should be carefully followed and choice of species should be carefully done to suit the land. Studies should be undertaken to see how the ground water recharge is occurring in forests and how much water is lost by evapotranspiration. As far as a forest situation is concerned any crop is suitable to any place, provided right technology of planting is followed. Reservoirs should be built in high elevation areas without causing destruction to the forests by consequent encroachment.

Dr. Nagesh Prabhu, Conservator of Forests, Central Circle, Thrissur suggested that a land use policy is to be put to use in Kerala. Dr. A.I. Jose opined that the Govt. is to be informed of the occurrence of drought in forest areas and all the available information on the land use pattern, policy issues etc are to be compiled for implementation. Dr.E.J. James opined that there is nothing wrong in going for reservoirs, considering the environmental impacts. Sediment lost is only 1/10th from the forests.

Dr. P.J. Joy, Associate Director , RARS, Kumarakom discussed the measures to be taken to combat the drought situations in the special zone. He suggested that, as a long-term plan, puncha crop is to be sown so as to harvest the crop by early January every year before the salinity intrusion sets in. All the channels and ponds may be desilted to enable greater water retention and water recharge in these potential water reserves. Water conservation measures like burial of coconut husk, application of coir pith/coir pith compost and mulching basins with aquatic weeds like water hyacinth can be resorted to coconut and other perennial crops. Lime washing on basal portion of coconut palms and providing shade can also to be adopted. Encouraging water-harvesting techniques like digging farm ponds, silt pits, construction of check dams etc. is also required.

Dr. Harikumar, Asst Director (Agri.) asked whether there is any relation of drought with salt water intrusion in Kuttanad. Dr. P.J. Joy replied that when there is heavy flow due to rain in Vembanad lake, there is no salt water intrusion and vice versa. The mechanical means to prevent salt water intrusion is to make bunds.

Dr. Sashidharan, Assoc. Professor emphasised the need for de silting of channels, canals, ponds etc. to develop the water resources. Dr. Jose Kallarackal suggested rainwater harvesting techniques and development of salinity tolerant crops.

Dr. E.J.James pointed out that a policy has been formulated to close the Thannermukkom bund by Dec. 15th and open again by March 15th to enforce crop discipline so as to minimise ecological imbalances in Kuttanad.

Dr. Subramania Iyer,Associate Professor, suggested that drought management strategies should be implemented through public leadership.

Dr. A.I. Jose pointed out that the impact of sand mining on the availability of water should also be studied.

Dr. Narayankutty, RARS, Pattambi, presented the drought management strategies for Palakkad district. He stated that rainfall was less by 19% in Pattambi, 42% in Malampuzha and 31% in Eruthiampathy. He suggested strategies for standing crops such as mulching, water saving irrigation practices etc. Long term strategies include water harvesting, improving water-holding capacity of soil by organic matter addition, roof top water harvesting etc. Formulation of cropping pattern based on water availability, disciplined cultivation etc. were also suggested particularly for rice crop.

The paper on drought management strategies for cardamom was presented by Dr. Kuruvilla, Indian Cardamom Research Institute. He explained the sepecific characteristics of cardamom in relation to its water requirement. It was suggested to follow measures such as modern irrigation practices, contour planting, contour trenching, conservation pits, mulching, organic manure addition, growing of drought tolerant varieties, afforestation etc. to combat the drought.

Dr. P.C. Balakrishnan, Associate Director, RARS, Pilicode presented the impact of drought on coconut and the different strategies for alleviating drought.

Dr. Subramania Iyer, Associate Professor, College of Agriculture, Vellayani discussed the importance of fertilizer management under drought situations.

Dr. P.C. Rajendran, Associate Professor, College of Horticulture, Vellanikkara presented a paper on drought management at state level and the scope of organising irrigation communes.

Mr. Joshy, a progressive organic farmer from Coimbatore, shared his experience related to drought management from his own experience.

Dr. E.J. James, Director, CWRDM chaired the plenary session. Dr. Jose Mathew, Associate Professor (Agronomy), College of Horticulture presented the recommendations emanated from the Brain Storming Session. The house discussed these recommendations in detail and finalised them. The session came to an end with the vote of thanks by Dr. G.S.L.H.V. Prasada Rao, Prof. and Head, Dept. Agrl. Meteorology and Convener of the Brain Storming Session on Drought Management Starategies.

Recommendations

RECOMMENDATIONS

Long - term strategies

Drought with special reference to Kerala, which comes under humid tropics, is to be redefined considering the crops in the different agroclimatic regions of the State. This is to be done by KAU through R&D efforts.

Spatial and temporal distribution of drought and flood prone areas are to be worked out based on existing database and new studies.

Crop-site matching utilising land use classification is to be chalked out for prescribing crops particularly in drought prone areas.

Appropriate structural and agronomic measures may be adopted as a long term strategy for managing current and future drought situations and a complete package in this line is to be formulated for different crops.

Rice fields should be maintained for water conservation and ecological balance.

Traditional sources of water, including tanks, ponds, open wells, suramgams etc. should be renovated to overcome drought situations of the State depending upon the local availability of resources.

Attempts should be made to recharge the ground water table and avoid over exploitation of ground water sources so as to minimize the water depletion.

An integrated intervention for water resource development including medium, minor and other traditional sources along with soil and water conservation measures is to be followed.

The existing reservoirs for hydel and irrigation purpose may be linked with drinking water projects

Possibility of utilising selected polders for fresh water storage is to be probed in Kuttanadu region.

Considering the impact on drought management, appropriate forest conservation measures will have to be adopted. Plantations which come up in the forest land should follow appropriate management practices to ensure soil water conservation.

Short - term Strategies

Agronomic measures for in-situ soil and water conservation such as mulching, shading, burial of coconut husk, addition of organic manures, white washing of tree trunks etc. may be adopted.

Scientific irrigation scheduling and water saving irrigation practices are to be given emphasis.

Formulation of cropping pattern based on water availability including the use of drought tolerant varieties and disciplined cultivation will help to manage water scarcity, particularly in rice.

Integrated water shed management aiming at sustainable development including water harvesting techniques like construction of farm ponds, silt pits, check dams, contour trenching, conservation pits etc. are to be promoted.

With regard to Kuttanadu, all the channels and ponds may be desilted to enable greater water retention and for water recharge in these potential water reserves.

Sowing of puncha crop in Kuttanadu is to be adjusted so as to harvest it by early January before the salinity intrusion sets in.

With regard to Thanneermukkam bund, the recommendations of the high power committee should be followed to close it for a minimum period i.e. from Dec. 15th to by March 15th so as to minimise ecological imbalance in Kuttanadu.

Efforts may be intensified for the dissemination of viable technologies for the management of drought, with special emphasis on drought prone areas.

Awareness training programmes on drought management strategies should be taken up at various levels. e-and-Print media should be made use of effectively for the above purpose. VCDs may be prepared with different drought situations and their management with reference to cropping systems/crops/homesteads.

List of participants in the one day brain storming session on drought management strategies held at the College of Horticulture on 3rd March, 2003

1. Dr. K.V.Peter, Vice Chancellor, KAU
2. Dr. A.I.Jose, Director of Extension, KAU
3. Dr. R.Vikraman Nair, Director of Research, KAU
4. Mr. Nagesh Prabhu,IFS, Conservator of Forests, Kerala Forest Dept.
5. Sri. P.S.Sasi, Addl.Director of Agriculture(Plg.), Dept. of Agriculture
6. Dr. A.Sukumara Varma, Associate Dean, CoH, Vellanikkra
7. Dr. G.S.L.H.V. Prasada Rao, Professor & Head, Dept. of Agromet, CoH, Vellanikkara
8. Smt. P.Chandramathyamma, Registrar i/c, KAU
9. Dr. James Jacob, Deputy Director (Physiology), RRII, Kottayam
10. Dr. Mercykutty Joseph, Soil Chemist, RRII, Kottayam
11. Dr. Sherin George, Scientist, RRII, Kottayam
12. Dr. S.J. Pillai, College of Agriculture, Vellayani
13. Dr. N. Purushothaman Nair, CRS, Balaramapuram, KAU
14. Smt. T. Sailaja Devi, Agrometeorologist, RRII, Kottayam
15. Dr. K.C. Aipe, ADR, Ambalavayal, KAU
16. Dr. K.M. Kuruvilla, ICRI, Myladumpara, Spices Board
17. Dr. P.C. Balakrishnan, ADR, RARS, Pilicode, KAU
18. Dr. Sam T. Kurunthottikkal, Assoc.Prof.(SS), CoH, Vellanikkra
19. Dr. S. Naseema Bai, Asso.Prof(Ent.), CoA, Vellyani, KAU
20. Dr. John Thomas, Dean, KCAET, Tavanur, KAU
21. Mr. Joshy V Cherian, Organic farmer, Coimbatore
22. Dr. N. Saifudeen, CLRRM, CoH, KAU
23. Dr. K. Gopikumar, Head, Forestry Management, CoF, Vellanikkra
24. Dr. M.S. Iyer, Assoc.Prof, CoA, Vellayani
25. Dr. Reena Mathew, Asst.Professor, WMRU, Vellanikkra
26. Dr. A. Prema, Asst.Professor, RARS, Pattambi, KAU
27. Dr. M.C. Narayanan Kutty, Asst.Professor, RARS, Pattambi
28. Dr. P.J. Joy, ADR, RARS, Kumarakom, KAU
29. Dr. N.K.Sasidharan, Assoc.Professor, RARS, Kumarakom, KAU
30. Sri. P.K. Sureshkumar, Asst.professor, CoH, Vellanikkarara
31. Dr. G. Byju, Scienctist(SS), CTCRI, Sreekaryam, TVM
32. Dr. Jose Mathew, Assoc.Professor, CoH, KAU
33. Dr. Jose Kallarakkal, KFRI, Peechi
34. Sri. K.G.Thomas, Dy.Director, Directorate of Arecanut and Cashew Development, Calicut
35. Sri. Jacob Thomas, Asst.professor, CCB & M, Vellanikkara
36. Sri. A. Sakker Hussain, Asst.Professor, CCB & M, Vellanikkara
37. Sri. E.J. James, Executive Director, CWRDM, Callcut
38. Sri. HabbebRahman, Assoc.Prof, KCAET, Tavanur, KAU
39. Sri. K.P. Harikumar, Asst.Director of Agriculture, Dept. of Agriculture, Govt. of Kerala
40. Dr. (Mrs.) K.P.Visalakshi, Assoc. Professor (Ag.Engg.), WMAU, Vellanikkara
41. Dr. M. Mohandas, Assoc.Dean, CCB & M, Vellanikkara
42. Dr. P.C. Rajendran, Assoc. Professor, CoH, Vellanikkara
43. Sri. M.V. Sudheesh, Assistant Professor, Agromet Department, CoH, Vellanikkara
44. Sri. V.N. Gopi, Farm Supervisor Gr.I, Agromet Department, CoH, Vellanikkara
45. Sri. P.M. Paulose, Farm Supervisor Gr.II, Agromet Department,CoH, Vellanikkara
46. Sri. C.S. Gopakumar, Technical Assistant, Agromet Dept. CoH, Vellanikkara
47. Sri. K.N. Krishnakumar, Research Associate, Agromet Department, CoH, Vellanikkara
48. Sri. A. Anilkumar, Senior Observer, IMD Soil Moisture Station, Vellanikkara
49. Sri. N. Manikandan, MSc (Agromet) student, CoH, Vellanikkara
50. Sri. Sajeesh Jan, MSc (Agromet) Student, Agromet Department, CoH, Vellanikkara
51. Sri. Shamsudeen, BSc (Ag.) Student, CoH, Vellanikkara
52. Sri. M.A. Sudheer Babu, MSc Student, CoH, Vellanikkara
53. Sri. P.K. Sreekumar, Farm Assistant, CoH, Vellanikkara
54. Sri. Jagadeesh Kayalil, Data Entry Operator, Agromet Department, CoH, Vellanikkara
55. Sri. P.K. Velayudhan, Padikkal House, Vellanikkara