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CROP WEATHER RELATIONSHIP OF CARDAMOM

SEMINAR REPORT

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ABSTRACT

Weather is a dominant factor determining the success or failure of agriculture enterprises. Farmers have no control over this natural force, but they can get good in good monsoon years and minimize the losses in bad monsoon years through better management practices, if the seasonal weather forecast is known ahead.

Cardamom (*Elettaria cardamomum* Maton), the queen of spices is one of the important spice crops grown in India. It's production is highly influenced by weather parameters like rain fall, temperature, light intensity, relative humidity, wind velocity, soil moisture etc. (Jacob *et.al*, 1995).

Rainfall has a positive correlation with cardamom production showing significant relationship for number of rainy days (Murugan *et.al*, 2000). Rainfall during January to April is the most critical factor deciding the cardamom production if normal rainfall situation prevails during southwest monsoon. In a lull monsoon year like 2002, the cardamom is likely to be affected due to poor rainfall during tillering and flowering stages.

Cardamom survives within a temperature range of 10 – 35 °C and prefers a mean annual temperature around 26 °C. Filtered sunlight of 50 – 60 per cent is the optimum for better performance of the crop (Korikanthimath, 1991), which could be provided under Red cedar, Korangati, Plavu, and Athi.

Deforestation processes around the cardamom belts may lead to warming and high wind speed. This may result to poor cardamom production. Those parameters also influence the crop indirectly by means of favouring insect pest and disease incidence.

Introduction

Weather-A natural resource is the important basic input in agriculture. It is a dominant factor determining the success or failure of agricultural enterprises. Farmers have no control over this natural force but they can get good in good monsoon years and minimize the losses in bad monsoon years through better management practices, if the seasonal weather forecast is known ahead. According to World Meteorological Organization weather induced variability in crop production was found to range 10-50 per cent and is not a surprise eventually if it reaches 100 per cent.

Cardamom (*Elettaria cardamomum* Maton), the Queen of Spices is one of the important spice crops grown in India. From time immemorial it is cultivated in evergreen forests of Western Ghats comprising Kerala, Karnataka and Tamilnadu states. The total area under cardamom in our country over 72,000 ha (Korikanthimath, 2002). Cardamom is a perennial herbaceous crop and any disturbance in the environmental conditions especially climatic conditions definitely affect the growth, development and yield.

Geographical distribution of cardamom – World

India and Guatemala are the major cardamom producing and exporting countries in the world. Besides these two countries, cardamom also cultivated in El Salvador, Honduras, Costa Rica, Tanzania, Sri Lanka, Thailand, Laos, Vietnam and Papua New Guinea.

Even though cardamom has been cultivated in all these countries Guatemala is major competitor for India in international market. Up to 1970 India was top in the international market but after 1970 Guatemala emerged as keen competitor for India and India has been pulled down from its first position.

GEOGRAPHICAL DISTRIBUTION OF CARDAMOM :WORLD

GEOGRAPHICAL DISTRIBUTION OF CARDAMOM :INDIA

Geographical distribution of cardamom – India

In India both large cardamom (*Amomum subulatum* Roxb.) and small cardamom (*Elletaria cardamomum* Maton.) is cultivated. Large cardamom is cultivated in northeastern states, like Sikkim and West Bengal. Sikkim ranks first both in area (23484 ha) and production (3710 ton) followed by West Bengal with area and production of 2874 ha, 500 ton respectively.

Small cardamom is native to the evergreen forests of Western Ghats of South India. In India small cardamom tracts lies between 8 ^{0}30'N and 15 ^{0}N latitude and between 75 ^{0}E and 77 ^{0}E longitude, which includes Kerala, Karnataka and Tamil Nadu. Among these threes Kerala occupies rank first both in area and production followed by Karnataka.

Table No.1 Area, production and productivity of small cardamom in India (2000-01)

Sl. No.	States	Area (Ha)	Production (m.ton)	Productivity (Kg/ha)
1	Kerala	39802	7580	257.5
2	Karnataka	25013	2100	112.5
3	Tamil Nadu	4902	800	225.0

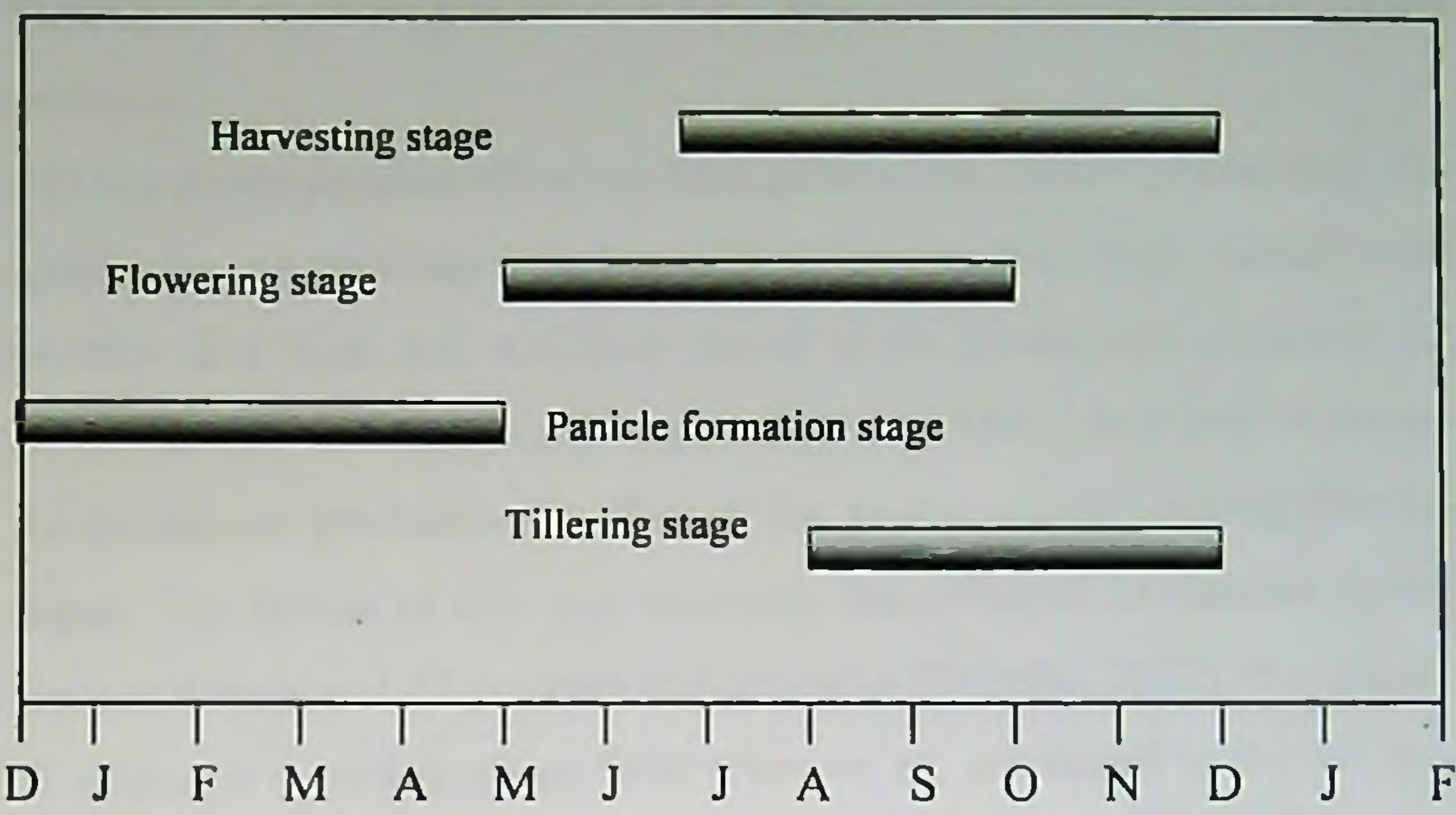
(www.cardamomcityindia.com)

Important phenological phases of cardamom

Phenology is the science that relates climate to periodic events in plant life. Phenological data include such facts as dates of germination and emergence of seeds, dates of budding, flowering and ripening.

The characteristic mode of reproductive phase in cardamom commences with tillering phase. It is seen between August and December. The maximum panicle formation is between December to May. The flower production is between May and October. The harvest period is from July to December.

Fig No.2 Phenological phases of cardamom



Weather factors affecting cardamom production

1. Direct effects

- Rainfall
- Air temperature
- Relative humidity
- Light intensity
- Soil temperature
- Wind speed
- Evaporation
- Soil moisture

2. Indirect effects

- Pest
- Diseases

Effect of rainfall

Weather factors are known to influence production under rainfed condition. Of all the weather factors rainfall has maximum influence on variation in yield. Nearly 75 per cent of cardamom area in India is still rainfed (Korikanthimath, 2002). Cardamom growing tracts in India received the rainfall of 1500-4500 mm per annum

(Hegde, 1996). Cardamom tracts receive most of the rainfall during southwest monsoon season (June-September).

Rainfall has direct positive effect on tiller production, flower production and fruit set. These processes are maximum during high rainy months. High rainfall with high relative humidity and high soil moisture status gives conductive situation for production of tillers, flowers and fruit set (Vasanthakumar, 1986). In a bad monsoon year like 2002, the cardamom production is affected due to poor rainfall during tillering and flowering stages. The failure of this year monsoon has affected cardamom output by about 40 per cent in Kerala and 25 per cent in Karnataka (Rebello, 2002). Production in the 2002-2003 season is therefore about 7500 tones or so, compared to the all time record of 11,000 tones in the previous season. So rainfall during southwest monsoon period is important.

Importance of January-April rainfall

About 90-95% of rainfall is received during the period of May to November (George and Mathew, 1996). Remaining part of year mainly dry with few summer showers. The cardamom crop in a particular season depends mainly on the rainfall received during the initial growth period of panicles till they come into flowering stage. Cardamom is extremely sensitive to drought conditions in its environment. Failure of summer showers during panicle initiation and subsequent growth stage result in poor growth and yield. The drought that was occurred during 1982-83 greatly affected cardamom plantations throughout the cardamom tracts.

Table No.2 Cardamom production during 1981-85

Sl.No.	Year	Production (ton)
1	1981	4100
2	1982	2900
3	1983	1600
4	1984	3900
5	1985	4700

(George and Mahew, 1998)

The above table shows the drastic reduction in production during 1982, 1983 was due to unprecented drought. Practically there was no rainfall for the period of first four months during 1983.

Table No.3 Monthly and annual rainfall (mm) during 1981-85.

Year	January	February	March	April	Total annual rainfall
1981	12.0	2.1	24.3	29.9	1250.9
1982	0.7	0.0	5.6	26.6	976.5
1983	0.2	1.6	3.1	5.2	1247.9
1984	19.2	80.2	62.6	51.9	1072.6
1985	44.8	4.6	11.3	27.3	1054.2

(Parthasarathy *et al.*, 1995)

From the above table we can conclude that though the total annual rainfall was more during 1983, the production was very low. So rainfall during January-April is decisive important in cardamom production. Moisture stress will result in drying of panicles. Unlike tea or coffee, cardamom is a fragile plant and prolonged drought affects the plant itself and not just the production. It was estimated that 30-70 per cent of the plantation was affected in the year 1983 (Korikanthimath, 1987).

Mitigation of drought through summer irrigation

Summer irrigation forms an important package for boosting cardamom production. Failure or delay in irrigation severely grips the production of panicles and ultimately the yield (Sulikeri, 1986). From the following table we can know the effect of time of irrigation on the yield of cardamom. The study was conducted by Gurumurthi *et al.*, (1996) in Regional Research Station, Madikeri, Karnataka.

Table No.4 Effect of time of irrigation on yield of cardamom

Dates of commencement of irrigation	Yield (dry capsules) kg/ha)
Dec 15	244.2
Dec 30	204.6
Jan 15	240.0
Jan 30	217.2
Feb 15	204.0
Feb 28	172.2
Mar 15	160.2

(Gurumurthi *et al.*, 1996)

Thus it is most appropriate to commence irrigation from December 15th followed at every 15 days interval till the onset of monsoon instead of commencing irrigation from January. Commencement of irrigation later than February 15th affects the yield.

Study conducted at Cardamom Research Station, Pampadumpara by Murugan *et al.*, (2000) reveals that the characters of rainfall like total rainfall, total rainy days, per cent of summer rainy days and per cent of summer rainfall were positively correlated with the production of cardamom. But a significant correlation was observed only between total number of rainy days and yield. It was observed that during 1998-99, the production was 20 per cent of the average when there was no rain for 93 days in summer.

Hence, total annual rainfall of 2000 mm with uniform distribution was considered as ideal for cardamom cultivation.

Effect of temperature

Cardamom is sensitive to temperature fluctuations. It survives within a temperature range of 10-35°C. The mean annual temperature of 26°C is preferable for better growth and development of cardamom (Jacob *et al.*, 1995). The germination of cardamom significantly affected by variations in temperature. Maximum germination can be achieved by sowing in September and least in January.

Experiments conducted at Regional Research Station, Mudigree, Karnataka by Gurumurthy *et al.*, (1987) reveals that, germination percentage of 53-78.4 was achieved when mean minimum temperature and mean maximum temperature was 18°C and 34°C respectively. It was only 5-11.5 per cent, when mean minimum temperature of 10°C and mean maximum temperature of 30°C. There were positive significant correlations between minimum temperature and maximum temperature with germination. The regression equations obtained by their were

Y (germination) = 9.5 x min. temp. (°C) - 103.37

Y (germination) = 15.72 x max. temp. (°C) - 467.05

In hilly area, temperature is limiting factor for germination. The temperature of seedbed could be increased by polythene structure (spreading of polythene sheet on a wooden frame placed six inches above the ground) or polythene cover (spreading of polythene sheet on bed), over control (Gurumurthy *et al.*, 1987). The increment in maximum and minimum temperature in polythene structure seedbed over control was 5.1°C and 3.7°C respectively. There is a significant difference in germination between seedbed with polythene structure (48.4 per cent), seedbed with polythene cover (42.3 per cent) and control (10.1 per cent).

Temperature has a great influence on panicle initiation and flowering processes in cardamom. Panicles are getting initiation during December to January. A high temperature coupled with moisture stress and low relative humidity favours the panicle initiation. If the moisture stress prolongs, affect the subsequent panicle formation. A distinct dry spell is needed for panicle initiation (Vasanthakumar, 1986).

Flowering initiation occurs during May month. A high temperature during onset monsoon triggers the flowering.

Effect of light intensity

Light intensity is a very important factor that determines the growth and production efficiency of cardamom. Both high light and low light intensity detrimental to growth. Excessive sunlight during growth of seedlings in the nursery, which causes breakdown of chlorophyll, is one of the main reasons for leaf scorching in cardamom.

Study conducted at Regional Research Station (ICRI), Thadiyankudisai, Tamil Nadu by Ravindran and Kulandaivelu (1998) indicated that growth and biomass were adversely affected in leaf scorched seedlings grown under full light (100 per cent of total sunlight), when compared to healthy seedlings grown under medium light (45-55 per cent of total sunlight). The results are shown in the following table.

Table No.5 Effect of light intensity on growth and biomass of cardamom seedlings

Growth parameters	Medium sunlight	Full sunlight
Fresh weight (g/pl)	28.40	21.51*
Dry weight (g/pl)	3.20	2.40*
Leaf area (cm^2)	476.00	310.00*
Shoot length (cm/pl)	31.00	22.00*
Root length (cm/pl)	45.00	42.00
Internode length (cm/pl)	7.80	5.70*

(Ravindran and kulandaivelu, 1998)

Medium sunlight - 675-825 $\mu Em^{-1}S^{-1}$ (45-55 per cent sunlight)

Full sunlight - 1500 $\mu Em^{-2}S^{-1}$ (100 per cent sunlight)

*Significant at 5% level

Ravindran and Kulandaivelu (1998) reported that optimum light level necessary for the maximum growth and yield of cardamom plants. For this study they had taken five year old cardamom plants in three plots. The plants of the three plots received three different light regimes viz., full light (1600 $\mu E.m^{-2}.S^{-1}$), medium light (720-980 $\mu E.m^{-}2.S^{-1}$) and low light (320-480 $\mu E.m^{-2}.S^{-1}$).

The results on the performance of growth and yield of cardamom plants growing under three different light levels are given in table.

Table No.6 Effect of light intensity on growth and yield of cardamom

Parameters	Full light	Medium light	Low light
Number of suckers	24.8	45.2	32.3
Total length of suckers (cm)	119.0	189.0	154.0
Number of panicle/ bearing sucker	1.16	4.0	2.5
Number of panicles/clump	6.5	29.5	16.0
Length of panicles (cm)	23.0	40.0	32.0
Internode length of panicle	1.53	1.2	1.8
No. Of capsules/clump	22.0	75.0	36.0
Fresh weight of 100 capsules (g)	51.12	89.26	75.42
Dry weight of 100 capsules (g)	17.65	26.67	20.10

(Ravindran and kulandaivelu, 1998)

About 40 per cent reduction in growth characters and 60 per cent reduction in yield characters were observed under full sunlight when compared to those of medium sunlight. The plants under low light showed values, which are intermediate between those of full and medium light. The reduction in the yield components of cardamom under full light may be attributed to excessive sunlight during summer months, combined with high temperature and low humidity and soil moisture. The decrease in yield under low light may be due to reduced photosynthesis during winter months. Though cardamom is regarded as shade loving plant, low light condition is not conducive for optimum growth and productivity.

Effect of wind

Wind is an important feature of the mountain environment. Wind is not only involved in heat and mass transfer by forced convection but also it is important to plants in many other ways including the dispersal of pollen and seeds. Wind is very variable both in direction and velocity. Wind affects plant mechanically by its pressure, physiologically by increasing the evaporation of moisture from the soil and transpiration from plants. In recent years wind velocity is increased as there is no windbreak in absence of trees after deforestation (Korikanthimath, 1999). Moisture stress will be more in wind prone areas, especially during summer. Cardamom being a moisture loving plant is affected by dry winds. With the onset of dry season the cool humid microclimate in cardamom plantations has rapidly changed as the hot wave of air from hinterland pass across the cardamom tracts without much hindrance due to deforestation all around the cardamom pockets, with the consequence cardamom has to grow in a hostile environment resulting in poor growth and yield.

Plants can be protected by growing tree as wind break/shelter belt along the contours on western aspects. A windbreak is a vegetative barrier for protection from wind while a shelterbelt is usually a longer barrier than a windbreak consisting of a combination of shrubs and trees intended for protection of field from soil and moisture conservation point of view.

They aid in arresting wind damage, including erosion control, reduce evaporation loss from and adjoining cropped areas which alone is estimated to increase crop production by at least 15 per cent (Jacob *et al.*, 1995).

In selecting species the chief consideration to the climate and soil, value as wind break/shelter belt, rate of growth, case of establishment and possibility of serving dual role of subsidiary income to the grower and shelter belt. Windbreaks particularly in western aspects provide better protection from desiccating wind in summer (Cherian, 1977).

Effect of microclimate

The microclimate is the climate in which plants and animal live. It differs from the macroclimate, which prevails above the first few meters over the ground, primarily in the intensity of the changes with elevation and the changes with time that occur there.

Cardamom is considered as **"Sciophyte"** i.e., shade loving plant. Being a shade loving plant cardamom does not tolerate direct sunlight. Shade trees have a great role to play in the healthy growth and development of cardamom. Shade acts as a moisture and temperature regulator thus creating a microclimate, which favours vegetative growth and root development. As soon as the soil is directly exposed to the sunlight, soil moisture content and soil temperature fluctuate. Thus root development becomes restricted if there is no proper shading (Abraham *et al.*, 1979).

Although cardamom is a shade loving plant, excess shade is quite detrimental (Kololgi, 1976). In areas where well-distributed and adequate rainfall is received cardamom plants can afford less shade. Sufficient research findings are available that 50-60 per cent shade is required for cardamom for successful cultivation (Korikanthimath, 1991).

To get favorable microclimate, we should regulate shade trees. In areas where the trees are too much over crowded with a packed canopy casting dark and dense shade, looping of excessive and undesirable branches so as to allow sufficient light penetration.

Successive crop failures coupled with the oscillating price fluctuation in the international market have created a sense situation among the cultivators and considerable area has been put to other crops like coffee, pepper etc. These crops requires more light when compare to cardamom plant. To get more light penetration they are cutting shade trees. This affects the microclimate, which is favorable to cardamom.

Ideal shade trees

An ideal shade tree in cardamom plantation is expected to have the following characteristics.

- Wide canopy
- Minimum side branching to provide diffused light to cardamom plants.
- No shedding of leaves during the flowering phase of cardamom so that the pollination in not affected by the leaves falling on the panicles.
- Shedding of leaves during monsoon and production of flush or new growth before the commencement of dry season.

(George *et al.*, 1984).

It is rather difficult to get trees, which have all the desirable characteristics in a cardamom plantation. Tall tree having well distributed branching habit and small leaves are ideal for cardamom. The shade trees like red cedar (*Cedrella toona*), which shed their leaves in monsoon, provide natural shade regulation. Apart from red cedar, some other trees are recommended for cardamom plantations. They are following

- Korangati - *Acrocarpus fraxinifolius*
- Pali - *Palaquium ellipticum*
- Plavu - *Artocarpus integrifolius*
- Cholavenga - *Bischotia javanica*
- Athi - *Ficus gibbosa*

(Dandin, 1980)

Bad shade trees are those which have

Large broad leaves with dense canopy, which prevent light.

Slow growing nature with lower canopy.

Shallow root system with surface feeding nature which competes for plant nutrients.

Deciduous nature with shedding their leaves in summer thus unable to provide on adequate shade.

Soft heartwood, which is more susceptible to wind.

Some of the undesirable shade trees showing above characteristics are

- Vadiplavu - *Cullenia excelsa*
- Nanku - *Mesua ferrea*
- Vattilaipatta - *Calicarpa lanata*
- Karimuruthu - *Terminalia tementosa*

Indirect effect of weather on cardamom production

Weather indirectly affect the cardamom growth, development and yield by influencing the pest and diseases. The pest and disease damage differ according to the microenvironment condition of the plantation.

Important pests and season of damage

(1) Cardamom thrips - *Sciothrips cardamomi*

Thrips population attained two peaks annually. One during January-February and another during September-October. As a result capsules harvested during October showed higher infestation. It was observed that building up of thrips population during dry months (December-April) and then decreased with the onset of monsoon rains. According to Chakravarthy *et al.*, (1993) moistened and enclosed niches such as space between leaf sheath and pseudostem, favoured thrips for feeding and breeding.

(2) Shoot and fruit borer - *Conogethes punctiferalis*

Borer infestation generally attained peak during October-November when the weather is clear and sunny especially after monsoon period.

(3) Scolytid beetle - *Poecilips cardamomi*

The damage due to this pest was found to be very high in July-August and particularly in the thickly shaded, dark and damp regions of the plantation. The pest development favoured by the high humidity i.e., more than 80 per cent.

(4) Hairy caterpillar - *Eupterote canariaca*

The population of hairy caterpillar more during June-July months.

(5) Root grub - *Basitepta fulvecorne*

Adult beetle number peaked during April-May and during September-October. Soil moisture of 30 per cent and soil temperature of 30°C proved to be the most optimum for egg hatch, larval and pupal development. It was observed that there were a significant and positive correlation between sunlight area and the number of beetles. Kumaresan *et al.*, (1989) reported that root grub population favoured whenever soil moisture is found more to the field capacity.

Important diseases and season of damage

(1) Azhukal disease - *Pytophthora nicotianae* var. *nicotianae*

This disease is serious in Kerala, causing up to 30 per cent loss under favourable conditions. The disease is found during May and it reaches its maximum during August coinciding with the southwest monsoon. During May-August the ambient temperature range of 21-26°C was ideal for infection. Disease incidence is directly correlated to soil moisture, relative humidity and the amount of rainfall (Arjunan *et al.*, 1999).

(2) Katte or Marble Mosaic disease

This disease of cardamom is limiting the cultivation of this crop in India. It occurs in severe form in Karnataka, Kerala and Tamil Nadu states and it is roughly estimated that nearly 75 per cent of the area under cardamom is already invaded by the disease (Rangaswami and Mahadevan, 1999). Cardamom aphid, *Pentalonia nigronervosa f. caladii*, transmits this disease. So whenever aphid population is more, damage is also more. The pest population is more during dry season.

(3) Leaf rot - *Conithyrium* sp.

This disease commonly found in the nursery. It affects the crop during wet seasons.

(4) Centhal disease - *Colletotrichum gloeosporiodes* Penz.

It has been observed in many cardamom plantations in Karnataka, Kerala and Tamilnadu. The plants, which are in improper shaded area, affected more by this disease.

Conclusion:

The effects of various weather parameters on cardamom growth, development and production were dealt so for. Cardamom productivity in India is comparatively low because of over dependence on monsoon, unprecedented recurring of drought, inadequate shade management, inadequate irrigation and deforestation. One of the important reasons for low productivity of cardamom in India is poor understanding of weather parameters. Hence, it is necessary to understand the weather parameters and manipulate the crop microclimate in a better way by providing additional irrigation, proper shade management, and providing wind breaks for getting higher productivity.

Discussion:

Q: What is the reason for high cardamom productivity in Guatemala?

A: India's average yield of cardamom is 150 kg ha^{-1}.It is very low compared to that of Guatemala, which is having more than 367 kg ha^{-1}. One of the main reason for high productivity in Guatemala is bimodal type of rainfall with well distribution throughout the year secondly, they are cultivating in virgin soils which are rich in organic matter content and also there is no problem of katte disease.

Q: whether the failure of this year (2002) southwest monsoon rainfall affects the production of this year?

A: yes. The failure of southwest monsoon rainfall definitely affect the production of this year because, low rainfall during southwest monsoon season affect tillering, flowering and fruit set processes in cardamom.

Q: How does soil moisture stress affects the cardamom production?

A: cardamom is very sensitive to moisture stress especially during summer. Moisture stress during summer affects the panicle formation, which in turn affects the production.

Q: what are all the optimum climatic conditions for cardamom cultivation?

A: The ideal climatic conditions are (1) annual mean temperature of 26 ^{0} C. (2) annual rainfall of 2000mm with well distribution. (3) Relative humidity 60-80%. (4) 50-60% filtered shade. (5) Medium light intensity 720 – 980 $\mu E.m^{-2}.s^{-1}$

Q: Is it possible to cultivate the cardamom in plains?

A: Cardamom fails to establish and come up satisfactorily in plains. The survival of plants itself very difficult and even the surviving plants will not produce any flowers.

Q: How does weather influences the quality of cardamom?

A: Inadequate rainfall during fruit set will affect cardamom fruit by making shrinkage of fruit. Size of the capsule is important factor in fixing the price of the cardamom.

Q: What is the effect of climate on spread of katte disease?

A: The cardamom aphid, *Pentalonia nigronervosa f.caladii.* is the vector of katte disease. Summer climate favours the growth and spread of the cardamom aphid. Likewise summer climate increases katte disease in cardamom indirectly.

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CROP WEATHER RELATIONSHIP
OF
COCONUT

844

SEMINAR REPORT

Submitted for the partial fulfillment of the course
Agromet. 651 Seminar

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ABSTRACT

Weather plays an important role in determining agricultural enterprises. In the case of coconut, it not only has a long phenology of three-and-a-half year but also has crop growth and development in different stages at a given point of time. Hence, it makes complex to understand influence of weather on growth, development and yield of coconut.

The mean annual rainfall over Kerala indicates that the contribution of rainfall during the southwest monsoon is high (68%), followed by post monsoon (16%) and summer (14%), while least (2%) in winter. The distribution of rainfall varies from bimodel (in south Kerala) to Unimodel (in north Kerala).

Coconut yield in a particular year is affected by January to April rainfall two year prior to harvest together with rain in January to April of the year of harvest (Patel 1938).

The effect of unique disastrous drought during summer 1983 that occurred in Kerala resulted in heavy decrease in nut yield of the following year. The decrease in yield started from 8^{th} month with maximum reduction in 13^{th} month after the drought was over (Prasada Rao 1994). Prolonged dryspell at three stages viz., initiation of primordium, ovary development, button size nut could also adversely effect the productivity of the palm (Rajagopal 1996).

Weather also plays an important role in nut development, starting from female flower fertilization to the final harvest. The second phase of nut development appears to be much more influenced by adverse weather aberrations.

The thermal unit which is a function of surface air temperature influences the second phase of nut development. Whenever thermal units exceed 2100- day degree Celsius during the second phase of nut development, the final nut size may be low (Prasada Rao 1988).

It is evident that high rainfall during Southwest monsoon together with prolonged dryspell during summer will influence the final output of the crop under rainfed conditions in Kerala

CROP WEATHER RELATIONSHIP OF COCONUT

Introduction

Coconut is a versatile crop, which is considered as '*Kalpavriksha*' as it provides all required amenities for human life. It is the most important horticultural crop grown in more than 92 countries. More than 5 million-farm house holds that depend upon coconut in one-way or other. India is a major coconut producing country with an annual production of over 1225 million nuts and its percentage share is 22.36% after Indonesia, 27.59% and Philippines, 22.81% (APCC 2000 - Indian Coconut Journal April 2002). Kerala is the land of coconut it contributes very much to the economy it has the production of 5496 million nuts and 5870 nuts/ha.

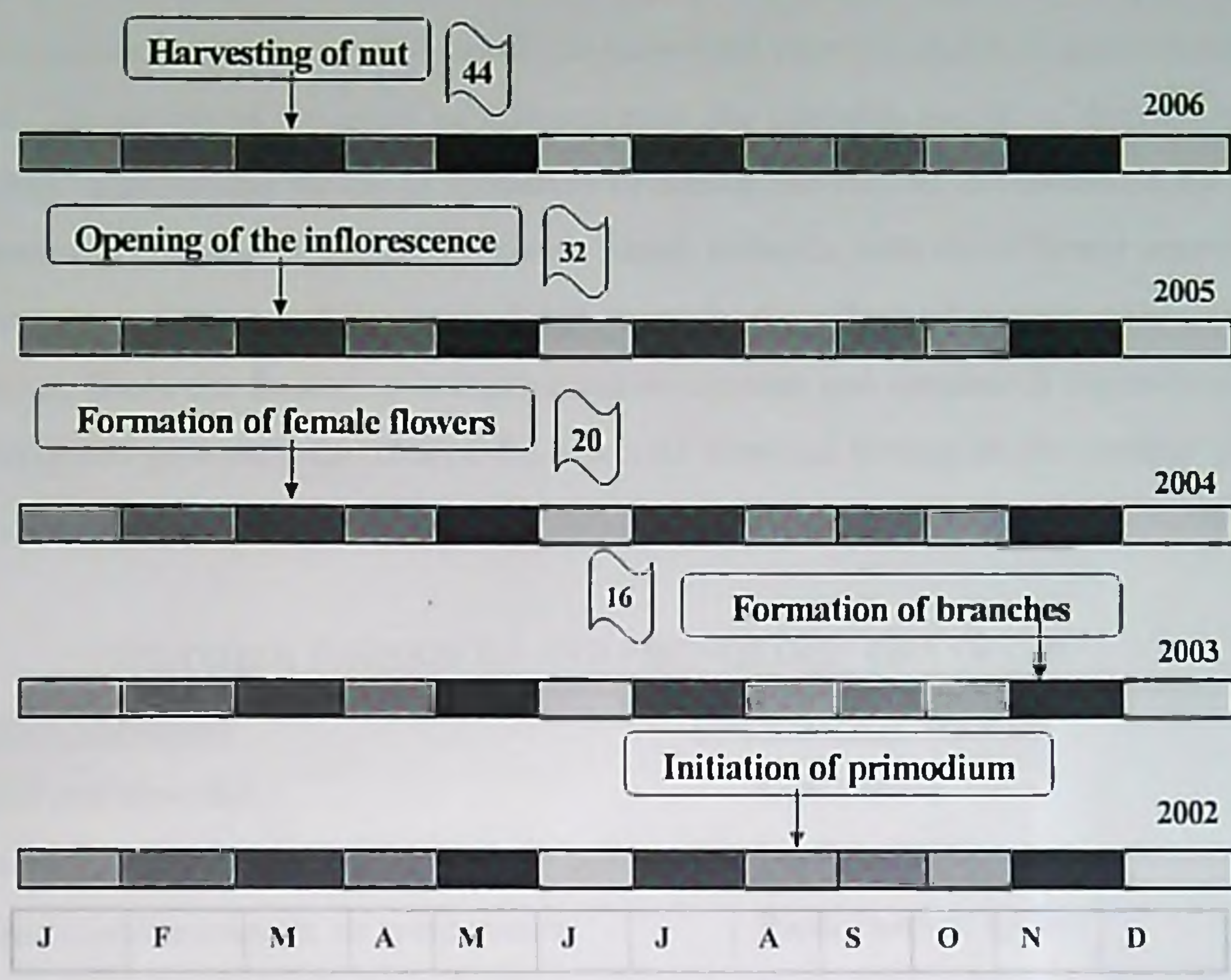
Crop productivity is mainly depending upon Genotype-Soil-Technology-Weather-Farmer. Weakest link in the chain decides the final productivity. From this we can see that except weather, others are manageable. Literature says in general, about 50% variation in final crop output due to weather aberration. The present monsoon behaviour across the country is the best example - how kharif crop production depends on monsoon behaviour.

Weather effects can be broadly divided into two viz., 1) Direct effects including drought and floods, heat and coldwaves, cyclones, thunderstorms, hailstorms and dust storms which leads to soil fertility loses and ultimately crop loses. 2) Indirect effects - water balance, nutritional balance and incidence of pest and diseases.

CROP WEATHER RELATIONSHIP OF COCONUT: A COMPLEX PHENOMENON

The effects of seasonal factors on the yield of perennial crop like coconut cannot be assessed as easily as in the case of annual crop mainly due to longevity of crop and lag period between weather effects and final crop output. Which clearly stated by Salter and Goode (1967) as "*with so great time lapse between the initiation of leaf, inflorescence primordia and flowering and with many other inflorescences in various stages of development present at the same time, It has been found difficult to relate accurately growth, flowering or yield responses to any particular climatic condition*".

EVOLUTION AND DEVELOPMENT OF INFLORESCENCE IN COCONUT



Inorder to study the effect of season on yield of nut in coconut, the evolution and development of inflorescence and female flowers during different season of the year has to be traced.

The primordium of inflorescence is reported to develop 32 months before opening of the inflorescence. The primordium of the branches of the inflorescence develops in about 16 months and male and female flowers in about 11 and 12 month respectively before the opening of the inflorescence. The ovary is first differentiated about 6-7 months before the opening of the inflorescence. Seasonal factor prevailing during the development of stages during the period of 32 months before the inflorescence open do affect the yield of nut and quality and quantity of copra in different ways.

To study the effect of seasonal factors on yield, the development of inflorescences initiated in every month till they open after 32 month is approximately traced. The month of initiation of inflorescence the probable month of formation of branches, approximate month of formation of female flowers on the inflorescence and the month of opening of the inflorescence which coincide with the different season of the year have been carefully worked out to study the effect of season on the yield attributes. Since the flowering is continuous in coconut and weather is unpredictable, the study can give only the idea of the effect of seasonal factors on the various yield attributes of the palm.

WEATHER VARIABLES AND PHENOLOGY OF COCONUT

Weather variables	Phenology of coconut
Rainfall and dew fall	Leaf production
Sunshine and solar radiation	Leaf shedding
Maximum and minimum air temperature	Production of spikes
Diurnal range of temperature	Production of female flowers
Soil temperature and soil moisture	Duration of male phase
Wind speed and direction	Shedding of button
Vapour pressure deficit	Female phase
Relative humidity	Yield
	Oil content
	Copra content

Phenology is the science that related climate to seasonal events in plant and animal life. Each weather variables are determined by geographical co-ordinates i.e., latitude, altitude and longitude.

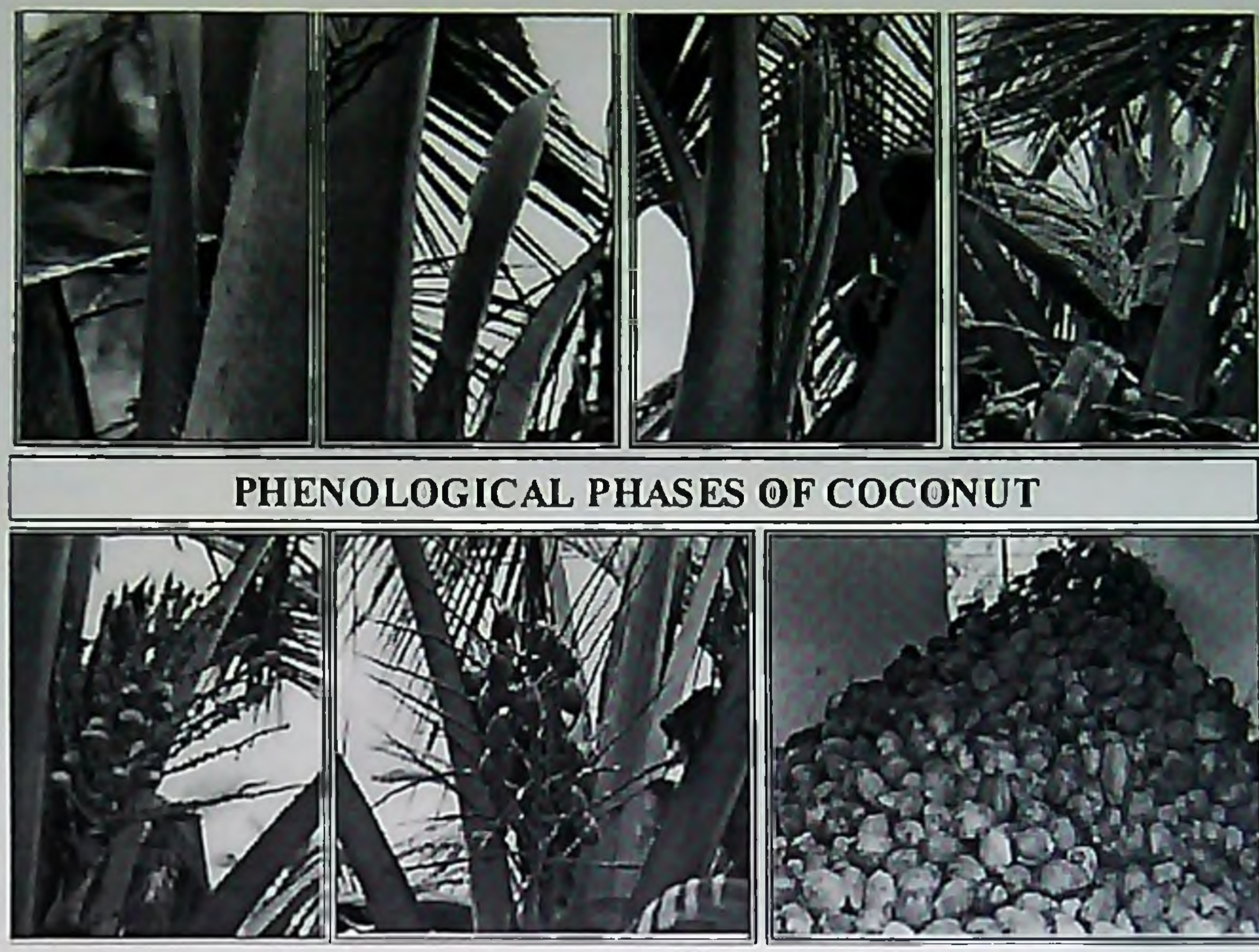


Figure.1: Phenological phases of coconut

SEASONAL EFFECTS ON BIOTIC EVENTS

Considerable data on the effects of season on different characters of the palm have been gathered as a result of detailed investigations carried out at CPCRI, Kasargod and have been published by Patel (1938), Sayeed and Narayanana (1953), Gangolly and Chathukutty Nambiar (1953) and Sayeed (1955) have been referred here.

1) **Rate of leaf production:** In the adult coconut palms, leaves are produced in successive but the interval between the openings of the successive leaves is found to be influenced by seasonal conditions. Leaves are produced at shorter intervals during September-November than in other part of the year it can be seen in the data summarised below:

Table No.1: Rate of leaf production

Quarter	Mean interval in days between the opening of two successive leaves
March - May	29.2
June - August	28.9
September - November	26.0
December - February	27.4

2) **Rate of leaf shedding**: Shedding of leaves is found to be influenced by season. It is least during the southwest monsoon season.

3) **Production of spadices:** Larger numbers of spadices are produced in the hot weather season than in the other seasons. This also substantiated by the fact that the mean interval in days between the openings of successive spadices is least in hot weather when compared to that in other seasons. The pertinent data are summarised below.

Table No.2: Production of spadices

Quarter	% Production of spadices to the yearly production	Mean interval in days between the opening of successive spadices
March - May	29.8	24.5
June - August	23.7	27.2
September - November	23.2	29.9
December - February	23.3	27.4

4) Abortion of spadices:

Table No.3: Abortion of spadices

Quarter	Percentage of aborted spadices to the total for year
March - May	9.0
June - August	46.6
September - November	42.1
December - February	2.3

Though every leaf axil is capable of producing an inflorescence. It is not uncommon to see leaf axils without spadices. This phenomenon is found to be more in the case of spadices that are to open in the rainy season (June-November) is seen from the data mentioned above.

5) Duration of male phase: The inflorescence of the coconut palm is a much-branched spadix with a few female flowers towards the base and numerous male flowers above. The interval between the opening of the first male flower and the shedding of the last is termed the male phases. The mean duration of the male phase is given below.

Table No.4: Duration of male phase

Quarter	Duration of male phase in days
March - May	16.7
June - August	20.2
September - November	18.9
December - February	17.9

The male phase is completed in the shortest period during hot weather season (March - May).

6) Production of female flowers: This is an important character as it influences largely the final yield of ripe nut from the palm. The data summarised below will show that number of female flowers is, in general, more in inflorescence that are produced in hot weather than in the other season of the year.

Table No.5: Production of female flowers

Quarter	Percentage to the total female flower produced in a year
March - May	30.8
June - August	24.4
September - November	17.1
December - February	20.5

7) Female phase: About three weeks after the opening of the spadix the female flowers in a inflorescence commence to open and the interval between the onset of stigmatic receptivity in the female flowers first to open and the drying up of stigma in the flower hast to open is termed the female phase. The seasonal effect on this character is not very pronounced.

8) Interval between the male and female phase: The interval between the end of male phase and beginning of the female phase in the same spadix, or that between female phase of one spadix and the commencement of the male phase of the next one has an important bearing on the nature of the pollination that is likely to take place. The data shows the seasonal effects of this character.

Table No.6: Interval between the male and female phase

Quarter	Mean interval in days between the male and female phases	Proportion of spadices when the phases overlapped
March - May	2.6	8.5
June - August	2.4	14.2
September - November	2.0	8.4
December - February	2.6	9.4

The possibility is only for cross pollination though chances for self pollination to occur to a limited extent through intra spadix pollination are there particularly in the spadices that open in the south west monsoon season. Self-pollination is also likely in the hot weather season through inter spadix pollination because the female phase of an inflorescence would not have been completed before the commencement of the male phase in the subsequent one.

9) Shedding of button:

Table No.7: Shedding of button

Quarter	Percentage shedding to the total
March - May	24.0
June - August	34.8
September - November	22.0
December - February	19.2

Shedding of button or female flower is an inflorescence is a common phenomenon in the coconut and has great economic bearing on the yield of the nut. Shedding is found to be high in the southwest monsoon season and low in cold weather, as can be seen from the data summarised above.

10) Yield: Considerable variation is noticed in the yield obtained in the different season of the year. This is found to follow a regular pattern every year irrespective of the magnitude of the yield obtained. The percentage of the total annual yield accounted for by the different seasons of the year is given below.

Table No.8: Yield

Quarter	Percentage of the annual yield
March - May	35.6
June - August	25.7
September - November	18.6
December - February	20.1

11) Copra (g/nut)

Table No.9: Copra (g/nut)

March - May	182
June - September	136
October - November	119
December - February	153

-(Nambiar and Rao, 1991)

12) Oil in copra (%)

Table No.10 Oil in copra (%)

June - September	67.7
October - November	68.5
December - February	71.2

13) Oil g/nut

Table No.11: Oil g/nut

March - May	121
June - September	92.1
October - November	81.4
December - February	109

From above, it is clear that seasonal effect is significant in coconut. All the above events related to climatic factors, which may influence independently or collectively.

SEASONAL EFFECTS ON BIOTIC EVENTS-A SUMMARY

Biotic events		Seasons			
		March-May	June-August	September-November	December-February
Leaf production interval		High		Low	
Production of spadices		High			Low
Abortion of spadices			High		Low
Duration of female phase		Low	High		
Production of female flowers		High		Low	
Shedding of buttons			High		Low
Yield component	Good nut	High		Low	
	Barren nut		High	Low	
	Oil in copra	Low			High
	Copra/nut	High		Low	

- (Krishnamarar and Pandalai, 1957)

- (Nambiar and Rao, 1991)

WEATHER VARIABLES

The profound influence of weather condition on agricultural crops, particularly raised under rainfed conditions, is well known. The climate decides as to what types of crops can be raised successfully in a given area but also influences directly and indirectly the performance of the crops themselves. Though man has no control over the climate there is no doubt that a clear idea of the action and interaction of the different factors characterising it and its effect on the crop will enable suitable measured to be formulated in time to derive the maximum advantage from, or to mitigate the ill effect of, a prevailing situation.

Climatic requirements of the coconut palm:

Coconut is essentially a crop of the humid tropics, which is clearly shown by its distribution over the world. Its latitudinal distribution is well defined between the tropic of Cancer and Capricorn. But within these boundaries, the coconut palm shows a fairly wide adaptation to various climatic factors. A review of the conditions under when the palm is new found grown has given some indication of its probable requirement for successful growth.

1) Rainfall: Of all the factors affecting the coconut, rainfall appears to be the most important. This is so because the water requirement of the palm is high and it is being grown in the different countries of the world mainly with the help of rains. A well-distributed rainfall is an important requisite with regard to tract suitability for coconut cultivation. As the palm stores little moisture and as it has no tap root it is not suitable for regions with long and pronounced dry spell during which the water table goes considerably down. Though Kerala is endowed with plentiful rainfall (1479 mm at Parasala in the south to 3562 mm at Hosduring in the month), the crop is affected by a prolonged drought from January-May. This is particularly true of the northern districts of Cannore and Kasaragod where a dry spell prevails from November through May. This adversely affects the crop growth and production. It is due to this season that nut production per unit area is less in the northern parts of Kerala when compared with that of the southern districts, where the rainfall is evenly distributed. The West Coast of India, the major coconut belt of the country, the rainfall varies from 2500 to 3500 mm or more per annum. Still the condition are not quite good for the crop because of its unsatisfactory distribution.

2) Temperature: This is another important weather factor, which has got profound influence on the distribution and performance of coconut palms. In fact it is temperature that sets a limit to the latitude and altitude unto which coconut can be successfully cultivated. The further the one goes from equator the more is the palm confined to low land. According to Child (1974), the ideal mean annual temperature is usually put at around 27°C and the average diurnal variation between 5°C and 7°C. the coconut palm likes equable temperature neither very hot nor very cold.

3) Humidity

The coconut palm likes a warm and humid climate. On the West Coast of India the mean monthly humidity recorded at 0730 IST seldom fall below 70 per cent. The prolonged high humid conditions adversely affect the transpiration and nutrient intake. This condition is also said to be congenial to disease and pest attack on the coconut palm. Too cloudy region or too shady places are unsuitable for coconuts.

4) Proximity to the sea

The humid nature of sea-shore atmosphere and its being less subject to wide fluctuation of temperature are the probable reason for this sea side growth tendency in the coconut palm. It has however to be said that flourishing coconut garden has now been established in the interior, far away from the sea-in Mysore, 200 miles away from the sea and in Tanganyika 4500 feet above sea level. But the fact also has been reported that yields are comparatively low in such region. The other advantage of the seacoast is high soil fertility. Advantages of the coconut palm derive from proximity to sea, therefore, conditioned by a number of factors.

5) Sun shine: The avidity of the coconut palm for sunlight is very well known. It does not grow well in shade or in too cloudy region. Copeland has made extensive observations on the effect of sunlight on transpiration, which is the vital growth process in plant. He has established that cloudiness arrests the rate of transpiration considerably. Sun light has also been shown the raise the temperature of the leaf surface and thereby to promote better activity in the tree.

6) Windiness: According to Copeland the effect of wind on the palm depends upon soil moisture conditions. A dry and windy atmosphere conduces the best growth of the palm provided soil moisture condition is favourable. If the soil is dry, only little wind is desirable. Windiness will accelerate transpiration and thus help in the uptake of more nutrients in the soil solutions. Strong winds are not desirable as they do considerable damage to coconut plantations. Heavy and extensive damages to coconut palms due to cyclones have been reported from Philippines, South India and Jamaica.

RAINFALL AND COCONUT YIELD -A CHRONOLOGICAL REVIEW

1936 Anandan, A.P,Patel,J.S. - Yield in particular year is effected by January-April year of two year prior to harvest together with rain in January-April of the year of harvest. Heavy rainfall during SouthWest and early part of NorthEast monsoon adversely affect the yield.

1963 Abeywardena - current crops is decided by rainfall during the previous year and first quarter of current year.

1968 Abeywardena - heavy rainfall during January-April has no harmful effect. September-December excess of 355 mm was harmful in May-August showing no harmful effect due to heavy rain.

1980 Henry Louis and RS Annappan - heavy rain prevent pollination in coconut.

1982 Prasada Rao GSLHV - rainfall during hot weather and other part of North East monsoon season favourable to coconut i.e., January-April of one year prior to harvest and January-April at year of harvest. Number of dry spell during rainy season (low) appears no effect on yield.

1982 Thampan - beyond a certain maximum rainfall precipitation may not be useful and increase in yield may not be manifested.

1988 Vijayakumar *et al.* - identified that 7-lag phase from (6-46) month. Rainfall during opening of spadix has positive correlation and during initiation of primordial has negative influence.

1988 Prasada Rao G.S.L.H.V. - Positive correlation between button shedding, amount, and intensity of rainfall.

1988 Pankajakshan and Unnithan, V.K.G. - High rainfall in the second lag of first season (March,April,May) had adverse effect on yield while higher amount of rainfall during first lag(Dec,Jan,Feb) of 4^{th} season appeared to influence yield.

1993 Sathees Babu *et al.* - March and May rainfall had significant positive correlation and during January-November had significant negative influence on coconut productivity.

1993 Pairis (Sri Lanka) rainfall exceeding 460 mm in a bimonthly period depressing effect and is not utilized by the palm

IMPACT OF SOUTH-WEST MONSOON ON COCONUT IN KERALA

It was proved that any rain in excess of 35.56 cm in a month was significantly harmful to the crop. But normal rainfall during the period of January-April was not found harmful probably due to the accelerated transpiration facilitated by high temperature and low humidity prevailing under South Indian conditions. Research indicated that nut yield increase in years succeeded by high rainfall years. Very high rainfall interferes with pollination thus affecting the nut yield. Beyond a certain maximum rainfall the precipitation may not be useful and increase in yield may not be manifest. In general, very active South West monsoon in Kerala exert only negative influence on the plantation crop industry due to.

- Losses due to leaching and surface runoff of valuable surface soil and organic matter.
- Poor oxygen supply in the soil and consequent suppression of growth to root system.
- Prolonged cloudy weather in June-July during the Southwest monsoon and consequent reduction of photosynthetic activity.
- Reduced evapotranspiration and consequent nutritional starvation, especially of nitrogen.
- Damage to soil structure due to surface runoff.

Southwest monsoon has positive effect in the incidence of various diseases of coconut especially caused by fungi. Diseases like budrot, leaf rot etc. appears in a sporadic manner during the south-west monsoon period. The high disease incidence is due to humid atmospheric condition conducive to the growth and multiplication of fungi.

EFFECTS OF SUMMER RAINFALL ON COCONUT

In Kerala perennial crop like coconut depend upon summer showers during March, May for higher yield. Higher nut yield per palm is obtained in the southern districts despite the prevalence of root (wilt) disease of coconut when compared to northern district viz. Kannur and Kassaragod. This is due to even distribution of rainfall received in the southern districts. Following are the some of the favourable effect of summer rainfall on coconut.

- Help to obtain high yield during hot weather season in each year.
- Help to control immature nut fall during development in the current year.
- To control button shedding during the previous year.
- Fuvours the development of female flowers and branched of inflorescence during the earlier years.

Following are the some other classical examples of summer rainfall.

Good year in 1926, because in 1925 rainfall was uniform during March, April and continuous light showers from middle of April to outbreak of south west monsoon.

The unpredicted drought that occurs is Kerala during 1982-1983 took a heavy toll on nut production. During that year there was no rainfall from 6th November to 13th June. In contrast, significant amount of rains was received in March-April in 1984, which lead to higher nut production in 1985. If clearly indicated that the effect of soil moisture stress on not yield in the field condition is seen immediately in the following year though the phenology of coconut is 3 ½ years.

DROUGHT CHARACTERISTICS IN COCONUT

Coconut palms show the following characteristics under severe soil moisture stress depending upon the duration and intensity of drought (like 1982 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 leads to mortality in the case senile palm under condition of poor management
- Abortion of spadices starts from October, November onwards
- Button shedding and immature nutfall
- Nut size decline and
- Finally decline in nut yield in the subsequent year up to 50% depending upon the type of management

(Rao, 1994)

EFFECT OF MOISTURE STRESS-A CHRONOLOGICAL REVIEW

1960 Pandalai - period of drought occurring 15-16 month before the opening of spadices may lead to abortion of spadices, so abortion take place in rainy season.

1969 Nambiar *et al.* - moisture stress at the second phase (4 months after fertilization) adversely affects the size of nut and copra content.

1975 Cooman – Water stress results in lower leaf production and consequently less number of inflorescences.

1981 Thampan - severe drought during early formation period may kill inflorescence. 1988 Jacob Mathew *et al.* and Bhaskara Rao *et al.* - indicated that duration drought period affect the yield of coconut in the succeeding year. Also stressed length of the dry spell is more important than the total rainfall, which affects the yield of coconut.

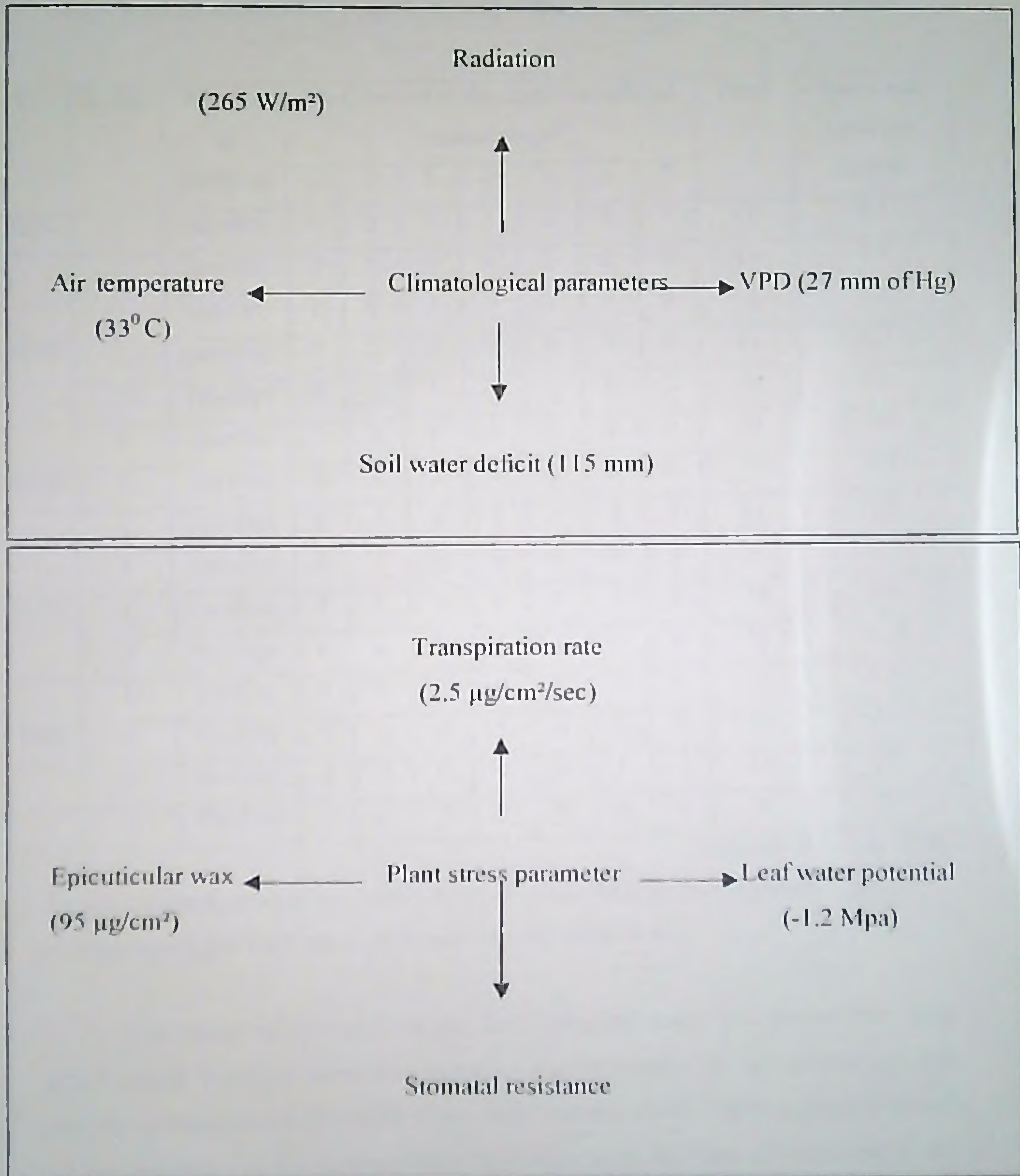
1989 Prasada Rao and Nair - Decrease in yield started from eighth month with maximum reduction in the 13^{th} month after drought was over.

1996 Rajagopal - Prolonged dry spell at three stages viz. initiation of primordium, ovary development, button size nut could adversely affect the productivity of coconut.

1996 Kasturi Bai - Nonavailability of adequate soil moisture result not only in restricting the photosynthesis at the source (leaves) but also impairs the translocation of the photosynthates to the developing sink, also low net photosynthesis during stress period as compared to non stress period. Empty bunches noticed during some periods of harvest is due to weak sink.

SCHEMATIC DIAGRAM SHOWING THE CRITICAL LEVEL OF PARAMETERS FOR FIELD STRESS

Fig.no.2: Schematic diagram showing the critical level of parameters for field stress



(Bai, 1993)

IMPACT OF DRY SPELLS DURING DIFFERENT STAGES OF NUT DEVELOPMENT

Table No.12:Impact of dry spells during different stages of nut development

Yr.	Group	Months of initiation	Max. Period of dry spell (months) at various stage*							Total	Mean nut yield per month
			1	2	3	4	5	6	7		
1976	1	Jan-May	4	3	4	1	2	3	1	18	4.5
	2	Jun-Sept	0	3	0	4	3	2	2	14	6.3
	3	Oct-Dec	1	0	2	0	0	1	0	4	4.3
1977	1	Jan-May	4	2	5	2	3	4	1	21	3.7
	2	Jun-Sept	0	3	1	2	1	0	3	10	8.1
	3	Oct-Dec	1	0	1	1	0	0	0	2	7.6
1978	1	Jan-May	4	3	3	1	2	3	0	16	4.8
	2	Jun-Sept	0	2	0	3	2	1	3	11	7.0
	3	Oct-Dec	0	1	2	0	0	0	0	3	5.7
1979	1	Jan-May	5	3	4	1	2	3	1	19	4.0
	2	Jun-Sept	0	2	0	3	2	1	4	12	11.8
	3	Oct-Dec	0	0	2	0	0	0	0	2	8.9
1980	1	Jan-May	4	2	4	1	2	3	0	16	4.2
	2	Jun-Sept	0	2	0	4	3	2	1	12	7.9
	3	Oct-Dec	1	0	2	0	0	0	0	3	7.0

(Rajagopal *et al.*, 1996)

*Stage1: Primordium initiation; 2:Male &Female phase; 3:Ovary development; 4:Spathe opening; 5:Fertilisation; 6:Button size nut; 7:Mature nut

The impact of dry spell on the developmental stages of coconut fruit from inflorescence initiation upto fruit maturity and its relation to nut production was studied by Rajagopal *et al (1996)*. The rainfall pattern 1976-1980 was super imposed on the ontogeny of the coconut fruit beginning from the time of initiation of the inflorescence primordium up to maturity of nut. Based on the total annual rainfall and on the ontogeny of the coconut fruit beginning from the time of initiation of the inflorescence primordium up to maturity of nut. Based on the total annual rainfall and monthly precipitation, the degree and duration of dry spells corresponding to each stage of nut development was deduced.

For the sake of convenience, 12-month period in a year is grouped as (1) January to May, (2) June-September, (3) October-November. The following points emerged from table.

Group 1 is characterized by dry month at almost all stages of nut development, the maximum dry spell being 21 month in 1977-1981 blocks. It may be noted that the primordial stage itself passes through 4 to 5 months (1979) of dry spell.

Group 2 tree of dry spell at two stages namely PI and ovary development (OD), the total dry period ranging from 10 (1977) to 14 (1976).

Group 3 has a total dry spell of only 2 to 4 months and most of the growth stages did not experience drought.

The significance of the above trend is evident from yield data.

From the foregoing account, the following conclusions are drawn.

- The length of dry spell influences coconut production under rainfed conditions significantly at critical stages.
- The availability of adequate moisture in the field on primordial initiation, ovary development and button size nut in that order are most crucial for the production of nuts and
- Nut production can be sustained at relatively high level by giving life saving irrigation during summer months by reducing the ill effects of dry spells, especially on the development of the inflorescence primordium.

EFFECTS OF HEAT UNIT OR GROWING DEGREE DAYS IN COCONUT

The nut development of coconut is influenced by air temperature. Nambiar *et al.* (1969) point out that any abnormal weather factor coinciding with critical phase of development (4-7 months after fertilization) adversely affected the rate of growth and final size of nut and copra content. The correlation coefficients between the heat unit, function of temperature and second phase of nut development and husked nut weight showed a high significant negative correlation. Based on the above relationship the quadratic equations were worked out in estimating nut weight of test varieties (Prasada Rao and Nair, 1986).

The heat unit or growing degree day (GDD) is delivered as follows.

$$GDD = \frac{T(max) + T(Min)}{2} - Tb$$

T (max) = maximum temperature (°C)

T (min) = minimum temperature (°C)

Tb - Threshold or base temperature

There was a marked decline in nut size from July to December in response to an increase in total heat units, indicating that total heat units above 2100 day °C were not congenial for nut development. Out of all the weather parameters studied, the heat unit, which is a function of air temperature has a distinct influence on the final nut size.

According to Rao and Nair (1986) though the copra content was more during summer, the percentage of oil content was less. This was probably due to the effect of the higher maximum temperature, which prevails during the final stage of nut developments.

CROP WEATHER MODELS

Crop weather relationships were worked out using the simple agroclimatic index viz., the index of moisture adequacy (IMA), which is the ratio of actual evapotranspiration to potential evapotranspiration and nut yield data of west coast tall palms. The data from 1946-1971 available at Regional Agricultural Research Station, Pilicode were made use of. The data indicated that nut yield of coconut was high (more than 45) when IMA was more than 30 percent in the previous year. A moisture index of less than 15 per cent indicated severe moisture. Stress leading to very poor yield (30 nuts and below) in the subsequent year.

The correlation coefficients between the monthly index of moisture adequacy in a particular year and nut yield in the succeeding year showed that the index during

December to April had a highly significantly value (positive) when compared to those of. Other periods viz. January-April and March-April. The availability of soil moisture for the cumulative period from December to April seemed to be more important than for period of two to three months. Based on this relationship, a multiple linear regression was fitted for estimating nut yield of the following year.

$$Y = 18.7212 + 0.284 X_1 - 0.1367 x_2 + 0.5906 x_3 - 0.3245 x_4 + 0.2733 x_5$$

Where Y is the nut yield of the following year (nuts/palm) x_1, x_2, x_3, x_4, x_5 are the indices of moisture adequacy for December, January, February, March and April, respectively. The equation had a multiple correlation coefficient of 0.7087 and was significant at 1% level.

Forecasting pests and disease incidence

Stem bleeding of coconut is a serious disease in coconut, prevalent in most part of the northern districts of Kerala State. Drastic moisture changes are known to aggravate the intensity of disease. It was found that the disease in incidence was more in the year of drought when mean aridity indices were higher than 90 per cent. The following equation was developed for estimating the disease incidence

$$N = 243.0155 + 2.4895 x_1 - 8.8681 x_2 + 3.7445 x_3 + 1.6488 x_4 + 0.2550 x_5$$

N = Estimated number of palms affected due to stem bleeding and x_1, x_2, x_3, x_4 and x_5 are the monthly aridity indices for January, February, March, April and May respectively. The equation has a multiple correlation coefficient of 0.8995 accounting for 80 per cent of disease incidence.

CONCLUSION

Of all the climatic factors affecting the coconut, rainfall appears to be most important. The studies revealed that the second years yield was positively correlated with October-April rainfall while it was negatively correlated with June to August rainfall. Nut development of coconut is influenced by air temperature any abnormal weather factor coinciding with (4-7 months after fertilization) adversely affect the rate of growth, final size ot nut and copra content. Coconut production under rainfed condition is influenced significantly by length of dry spell at critical stages. Nut production can be sustained at relatively high level by giving life saving irrigation during summer months by requiring ill-effects of dry spell especially on the development of the inflorescence promordium.

DISCUSSION

1) In what way drought condition of this year affect coconut in Kerala?

In Kerala rainfall during the summer season mainly decides the yield, in this year summer rainfall was enough even though the rainfall during monsoon in low. It will not much influence the yield became appreciable soil moisture was maintained during the monsoon. High intensity rainfall adversely affect the yield. So in this year there will not be much problem for coconut.

2) How weather influence the incidence of pests?

In the rainy season abundance of white grub can be seen in the root environment of coconut palm. Reason shows that the population was higher during June and July than during February to May. The population of coconut mite is found to be low during rainy season.

3) What are all the reason for low productivity of coconut in Kerala?

In Kerala coconut is mainly cultivated on rainfed crop but in other states it is cultivated as irrigated crop. In Kerala during summer occurrence of moisture stress is common. Moreover is other states area under cultivation is low when compared to Kerala.

4) How weather influences the incidence of diseases?

Stem bleeding is common in the area where soil moisture stress continue for long period, because it leads to production of cracks on the stem through which fungi can enter. Bud rot and leaf rot is common during monsoon season due to high RH (>95%) and low temperature when furrows the growth of fungi.

5) What is the difference between PET and AET?

PET is the amount of water transpired in unit time by a short grass crop completely shading the ground, of uniform height and never short of water. Thus PET is maximum possible moisture loss. Where as AET is observed amount of soil water loss by evapotranspiration for a given soil moisture under the prevailing weather. The difference between PET and AET is the water need of crop.

6) Generally all the tall varieties are cross-pollinated weather has any role for this?

So far no research has been conducted on this direction.

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PRECISION AGRICULTURE

By

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SEMINAR REPORT

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ABSTRACT

Food security has been threatened by declining productivity, soil salinity, micronutrient deficiency, water logging, ground water depletion and development of resistance and resurgence in pests. To alleviate the ill effects of excess and under application of inputs a new form of farming, Precision Agriculture, is on the way. Precision agriculture is one of the most scientific and modern approaches to sustainable agriculture that has gained momentum in 21st century. It aims to improve crop performance and environmental quality. The real value from precision farming is that the farmer can perform timely farming operations, adjust seeding rates, fertilize according to soil conditions, plan precise crop protection programs and know the yield variation within a field.

Variations occurring in a crop or soil properties are noted and often mapped in this technique. Then management actions are taken as a consequence of the spatial variability within a field. Important technologies involved in mapping are Remote Sensing, GIS, GPS, manual mapping during field operations etc.

Moran *et al.* (1997) in their review paper summarised the applications of remote sensing for precision farming. Three approaches for the use of remote sensing for precision farming were identified (Barner *et al.*, 1996). According to Bregt (1997), GIS has got specific roles in precision agriculture. It is widely practiced in developed countries though it is at a nascent stage in many of the developing countries even now.

INTRODUCTION

Agriculture is the backbone of our country and economy, which accounts for almost 30 per cent of GDP and employs 70 per cent of the population. Though this is a rosy picture of our agriculture, how long will it meet the growing demands of the ever-increasing population? This is a difficult question to be answered, if we depend only on traditional farming. Agricultural technology available in the 1940s could not have been able to meet the demand of food for today's population, inspite of the green revolution. Similarly, it is very difficult to assume that food requirement for the population of 2020 AD will be supplied by the technology of today. To meet the forthcoming demand and challenge we have to divert towards new technologies, for revolutionizing our agricultural productivity.

Green revolution succeeded in India to increase the farmer's income, yield of major crops and made India self reliant in food production, with the introduction of high-yielding varieties and use of synthetic fertilizers and pesticides. In the post green revolution period agricultural production has become stagnant, and horizontal expansion of cultivable lands became limited due to burgeoning population and industrialization. In 1952, India had 0.33 ha of available land per capita, which is likely to be reduced to 0.15 ha by the end of year 2000 (Singh *et al.*, 2000). As the availability of land has decreased, application of fertilizers and pesticides became necessary to increase production. The major effect is that our agriculture became chemicalised. To alleviate the ill effects of excess and under application of inputs a new form of farming, precision agriculture, is on the way.

Precision Agriculture is based on the fact that land is heterogenous in nature. Consider the state of Kerala. It is divided into twenty agroclimatic zones. This has identified by super imposing soil moisture availability regimes over seven soil groups (KAU, 1996). For all these agroclimatic zones, there is only a single blanket recommendation. The variability in soil type, fertility status, soil moisture availability etc. among these agroclimatic zones is not considered. Soil fertility status i.e., nutrient content varies from one place to another even in the same field. Work conducted in Vellanikkara Horticulture College Campus revealed that within an area of 380 ha itself, wide variability can be seen in soil physical properties, fertility status etc. (Sajnanath, 2000). The population of weeds is never uniform throughout the crop field and the population dynamics of insect pests also shows a variable pattern. When a pathogen attacks a crop, the disease intensity may not be same throughout the field. Sometimes disease appear in pathches leaving many disease free zones. But in conventional agriculture, without considering these variables, fertilizers, herbicides, insecticides and fungicides are applied at a uniform rate through out the crop field. Precision agriculture emphasizes on this aspect and deals with judicious crop management at microlevel wherein only required amount of inputs are applied (Biswas and Subba Rao, 2000).

Precision agriculture - its meaning and adoption.

Precision agriculture is also referred to as precision farming, site specific farming, prescription farming, GPS based farming etc. It is a management philosophy or approach to the farm and is not a definable prescriptive system. It identifies the critical factors where yield is limited by controllable factors and determines intrinsic spatial variability. It includes the application of technologies and principles to manage spatial and temporal variability associated with all aspects of agricultural production (Pierce and Nowak, 1999). The variations occuring in crop or soil properties within a field are noted, mapped and them management actions are taken as a consequence of continued assessment of the spatial variability within that field. It is a paradigm shift from conventional management practice of soil and crop in consequence with spatial variability. It is a refinement of good whole field management, where management decisions are adjusted to suit variations in resource conditions. Statistically, the precision farming P = 1-SD, where, SD is standard deviation; P = 1, indicates highly homogenous field and P = 0, is a complex system, which describes maximum variability of field (Mandal and Ghosh, 2000).

U.S. is considered the birth place of precision agriculture. In the U.S. precision agriculture is "coming of age" - and in a few years may become a routine part of day - today farming operations. The environment also is a driving force in South America, where there is increasing pressure for natural resource conservation and less soil pollution. Adoption in Europe has been driven by environmental pressure as well as spatial variability. In the united Kingdom, fruit and vegetable producers are using precision farming data to better meet the needs of the supermarket chains with which they contact (Nicola McIntosh, 1997).

Scientists in Europe are investigating how precision can help reduce or eliminate agrochemical inputs, while research in Brazil has focussed on analysis of variability and correlation between soil fertility, soil particles, and yield. While site-specific techniques may become a part of routine crop management in the U.S., that may not be the case in Brazil, where cost may hinder farmer adoption. In Europe and Australia, however, precision is likely here to stay with probable long-term ramifications for the agrochemical and fertilizer industries (Reetz, 1998).

Precision farming in Asia is in its infancy, but there are numerous opportunities for adoption. Many Asian countries have begun to integrate geographic information systems (GIS) and remote sensing in their crop inventory statistics programs and as the basis for crop forecast. Recently, the governments of certain Asian countries initiated special efforts to promote precision farming. In Japan, the Ministry of Agriculture has allocated special funds for research on precision farming. In Malaysia, the Malaysian Agricultural Research and Development Institute is promoting research on precision farming of upland rice. In India, a few researchers in the private sector initiated studies on precision agriculture in high-value crops such as cotton, coffee and tea. In Sri Lanka, researchers at the Tea Research Institute are examining precision management of soil organic carbon. The most relevant crops for precision farming in Asia are rice, wheat, sugarbeet, onion, potato, sugarcane and cotton among the field crops, and apple, grape, tea, coffee and oilpalm among horticultural crops. Testing of precision farming technologies for paddy rice at the research farm level is in progress. Researchers at Kyoto University recently developed a two-row rice harvester for determining yields on a microplot basis (Srinivasan, 1998).

TECHNOLOGY FOR PRECISION AGRICULTURE

Spatially variable crop production or precision farming to a large extent is technology driven. The new tools applicable to this precision farming are advances in electronics and computers such as remote sensing, Global positioning System (GPS) and geographic information systems. Technologies used in precision farming cover three aspects such as data collection, analysis or processing of recorded information and recommendations based on available information.

Technologies required are as follows:

Mapping

The generation of maps for crop and soil properties is the first and foremost important step in precision farming. These maps will measure spatial variability and provide the basis for controlling spatial variability. Data collection occurs both before and during crop production and is enhanced by collecting precise location coordinates using the GPS. The data collection technologies includes grid soil sampling, yield monitoring, remote sensing etc. During crop production, the data are collected through sensing instruments on soil moisture status, organic matter content, weeds etc. Then these data generated through mapping are recovered and stored in a computer system for future action and generated maps used for acquisition of information and for making strategic decisions to control variability. Mapping can be done by remote sensing, GIS and manually during field operations.

Remote sensing

Remote sensing is a technology to sense on object from a distance without coming into contact with the same. It is referred to as sensing or observing any object on the surface of the earth either from an aircraft or aerial platform, or from a satellite or satellite platform, wherein a sensor/camera is mounted that observes and enables producing a pictorial view (Narayan, 2000). Satellite based remote sensing is of recent origin, beginning in the early seventies, whereas aerial sensing has been in use for over 60 years. Remote sensing became a versatile tool as an information system for studying various natural resources from satellite altitude by recording the observed details. These include all type of renewable and non renewable natural resources such as agriculture, water resources, forest cover, land use/land cover pattern, coastal resources, geology, geomorphology and such other details as could be found on the surface of the earth continuously. Barnes *et al.* (1996) identified three approaches for the use of remote sensing in precision agriculture.

In the first approach, the multi-spectral images can be used for anomaly detection. These anomalies can be in the form of disease/pest, weed growth, water stress etc. using the reflectance measurements in the visible part of the spectrum, it has been made possible to detect diseases and identify weeds from crops. The difference between remotely sensed surface temperature and ground-based measurements of air temperature has been established as a method to detect water stress in plants. However, such type of anomaly detection needs regular observation of the crop through remote sensing sensor. The next approach is based on correlating variations in spectral response to specific variables such as soil properties or crop yield. soil physical properties such as soil water, organic matter, soil texture can be correlated to spectral reflectance. Vegetal spectral response has also been used to infer other soil conditions. Crop yields for many crops like rice, wheat etc. have been found to be highly correlated with spectral vegetation index during maximum vegetative cover. Thus, the yield map generated from spectral images can be used to form management units. The third approach is to integrate biophysical parameters (such as Leaf Area Index or temperature) derived from high resolution satellite based remote sensing data, with physical crop growth modelling towards an operational decision support system for precision farming. For example, Moran *et al.* (1995) utilized remotely sensed estimates of LAI and evapotranspiration as inputs to a simple alfalfa growth model. To derive biophysical parameter, the remote sensing system need to have high spectral resolution, covering the whole range of optical and thermal region. To find out within field variability, the remote sensing data should have high spatial resolution. With current satellites, one can see areas that are 30 meters x 30 meters, 23 meters x 23 meters, 10 meters x 10 meters and 5 meters x 5 meters.

Geographic Information System (GIS)

Use of GIS in agriculture began in 1960 and has grown rapidly in 1990s. It is a principal technology used to integrate spatial data coming from various sources in a computer. It deals with the management of spatial information of soil properties, cropping systems, pest infestation and weather conditions. It will help the farmers and scientist in decision making and adopting control strategies. GIS range from relatively simple to highly sophisticated and are adopted for use on a variety of computer platforms. Each of these system includes the following capabilities

(1) The ability to enter or capture spatially referenced information from existing among maps or remote sensors.

(2) The ability to store, retrieve and edit spatial data and attribute information.

(3) The ability to perform spatial analysis such as map overlay, spatial buffer analysis attribute reclassification and spatial summaries. Many systems also have the ability to lack models with spatial data bases.

(4) The ability to display crops and generates tabular reports of attributes data.

A GIS consists of three major components (Reddy and Anand, 2000).

1) Computer hardware, (2) Computer software and (3) Digital geographic data.

According to Bregt (1997), GIS has two different roles in precision farming vehicles. First, a combination of GIS and simulation models which is highly relevant for precision farming. GIS helps in integrating geographical data on various aspects such as soil, crop, weather and field history along with simulation models. Another aspect of GIS support to precision agriculture is the engineering component, in which the research findings are translated into operational systems for use at farm level. Many farm information systems are available, which use simple programmes to create a farm level data base. One example of such FIS is LORIS (Schroder *et al.*, 1997).

Manual mapping during field operations

Measurements may also be taken during field operations by the farmers. The most common measurements during field operation are yield recording and soil properties during tillage. Manual measurement has also been done for soil sample, pest infestation and other crop problems. Accurate and reliable sensors are needed for the conversion of physical and biological quantities into electronic value. Based on the extent of variability, control strategies are adopted.

CONTROL STRATEGIES

The documented spatial variability in maps is used to control the variability of soils, crops or pests through field operations. The common response to soil variability within fields is the control of fertilizer application in a spatially variable manner. In the same way, soil moisture map is used to control irrigation. The crop yield and pest infestation maps are also used to control the application of irrigation, fertilizer and patch spray of pesticides. Field operations in a spatially variable manner will need the following equipments (Ghosh, 2000). Control computer - to co-ordinate field operations based on the maps on the memory.

Locator - to determine the current location of the equipment.

Actuator - to receive the command from the control computer.

1) Fertility aspect

a) Variable rate technology

Variable rate application equipments attached to the tractors have sensors which can monitor the soil as the tractor ploughs the field and apply the required quantity of fertilizer at the appropriate place, thus avoiding wastage. There are two types of technologies available: (1) map-based and (2) sensor based. In the map-based technology, fields are grid-sampled, analysed and mapped (Fraisse, 2000). Based on the status of the individual grid in the field, fertilizer application rate is varied. In sensor-based approach, real time sensors are used to measure the properties in the field in spatial-temporal context and the feed back mechanism is used to apply the input through variable rate application machinery (Roloff, 2002).

b) SOILECTION and FALCON

Instruments that are used for the application of fertilizers and pesticides in a spatially variable manner according to digital maps.

c) SPADMETER (chlorophyll meter)

Used for the determination of nutrient content in plants. The leaf nitrogen concentration, photosynthetic rate and the crop yield in rice are closely related since nitrogen is an essential constituent of chlorophyll. Poor nitrogen management strategies lead not only to low recovery of the applied nitrogen but also results in pollution of the environment (Johnkutty *et al.*, 2000). To decide the nitrogen requirement based on crop demand and nitrogen supply power of the soil, it is necessary to estimate accurately the crop nitrogen status. Spadmeter (Soil and Plant Analysis Department, Japan) is used for taking instant and quick estimate of crop nitrogen status in rice (Peng and Cassman, 1995; Johnkutty and Palaniappan, 1996).There is a threshold value for normal growth and development of the plant. If the value shown by the instrument is less than the threshold value, it indicates deficiency of N and we have to apply nitrogenous fertilizers to the crop. The high cost of the equipment prohibits its wide adoption by farmers in developing countries.

d) Leaf colour chart (LCC)

A leaf colour chart (LCC) developed from a Japanese prototype (Furuya, 1987) by IRRI, Philippines is a simple, easy to use, and in expensive tool to determine the time of nitrogen top dressing in rice (IRRI, 1998). The relationship between the leaf colour intensity and nitrogen concentration in rice leaves may differ markedly depending on genotype and environment (Takabe and Yoneyama, 1989). In the leaf colour chart, six colour charts indicating different shades of green are there. By placing the leaf over this leaf colour card, we can find out whether the leaf colour matches with the threshold value. If there is any deficiency, we have to correct it by fertilizer application.

2) Weed control aspect

a) Patch sprayer

The precision agriculture concept has great potential for reducing herbicide application because of the patchy nature of weed distributions in aerable fields (Stafford, 2000). Research at Silsoe Research Institute throughout the last 10 years has resulted in a research sprayer with a boom divided into 2 meter,and with separately controllable sections. With onboard GPS and a weed treatment map held in a cab-mounted PC, the injection metering system as controlled to vary herbicide dose and mix according to a pre-recorded field weed map. Reductions of up to 80% in application of selective grass weed herbicides were observed in trials.

b) Banded spraying

Helps in the directed application of crop protectant chemicals in row crops and saving of the product. Banding is usually done along with the seeding of crops and is practiced in crops like sugarbeet, maize etc. The band nozzle is placed behind the seed drill at a height so as to produce a band width of 16-20 cm. Band nozzles will be equal to the number of seed drills. Banding using special equipment is possible in vines and tree crops. Here herbicides are applied to control the grasses and weeds within the rows. The driving equipment is mounted in front of a tractor.

c) Optical scanners

To detect the soil organic matter and to recognise weeds.

3) Plant protection aspect

a) BBRC's prototype driverless sprayer (Biotechnology and Biosciences Research Council)

Researchers in the United Kingdom have developed a prototype spray rig that can operate without a driver to facilitate site-specific application. So it is also called as hands off approach. It is widely used in row crops. This new development is described as "plant scale husbandry" because the prescribed dose is applied on a plant specific basis. The system can distinguish between plant and soil, and ignores weeds. If a weed comes up in place of a plant, it will be treated, but in the future it might be possible to distinguish weeds from crops by differences in texture. A front-mounted camera, which is sensitive in the near infrared, views the ground ahead. On-board computers analyze the pictures and give the necessary commands to the spraying equipment. Field dimensions must be input into the computer system so the machine "knows" when it reaches the end of a row. Control by the camera is augmented by a process described as "sensifusion" where information originating from the wheels helps to maintain the correct track. Two hydrostatic motros provide the steering system. The rig must be driven to the selected field, but thereafter it can work without an operator, except for refilling the spray tank (Pierce, 1997).

4) Yield monitoring

a) Yield monitors

Used to estimate the yield/acre by measuring the flow rate of the crop through the combine and the area covered by the harvester. From this yield data, the yield variation between various fields can be understood. With the help of GIS, this yield data can be integrated with other biophysical parameters and can find out the causes for yield variation. Based on this, suitable control measures have to be adopted.

5) Water management aspect

The traditional flood or ridges and furrow method of irrigating farms suffers from numerous problems such as poor drainage causing salinity, considerable seepage, conveyance and evaporation losses, higher energy costs, faster soil erosion, greater wastage of fertilizers and other nutrients, higher weed population, increased operational difficulties and costs, uncontrolled (or) unmeasured and uneven water supply etc. But now, irrigation techniques are improving day by day. Important advancement in this techniques are

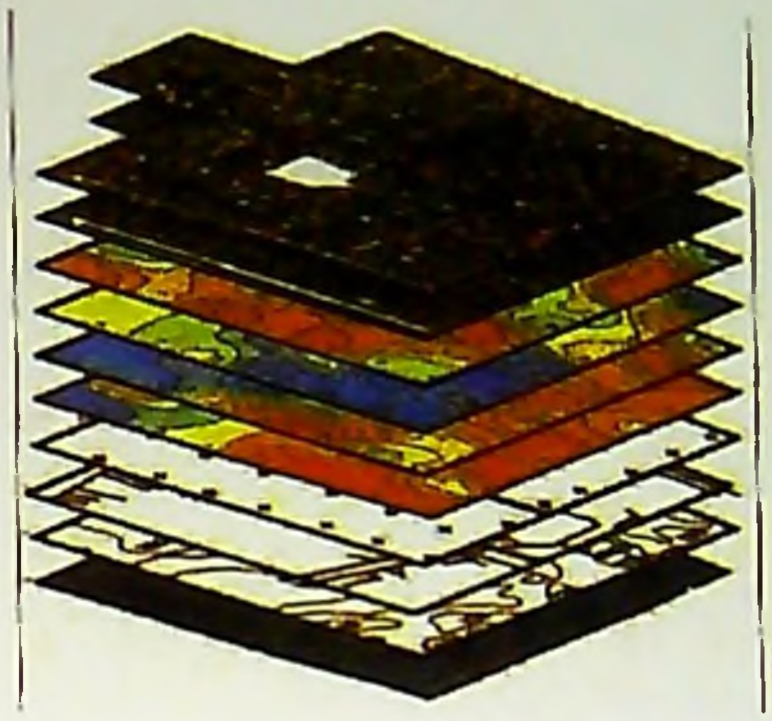
a) Microirrigation system - Microirrigation method is not merely an irrigation technology, it is an integrated management tool in the hands of the farmer (Jain, 2002). It is a method of irrigation where water is applied to the root zone of the crop or plant at a slow speed, low pressure and at measured rate. Here the soil will be having an optimum moisture content throughout the period. Ordinary drip is an example for this. Fertigation is also widely practiced now a days where fertilizer is supplied along with water through the drip. This will increase the yield of crops as well as save more water.

b) Automatic irrigation system - One can control the irrigation values, pump and fertilizer injectors automatically in this system. Controller is the heart of this AIS and it takes just a few key strokes to schedule irrigation. It is programmed to run for a required duration or required volume based on the feed back it received from the seasons in the field.

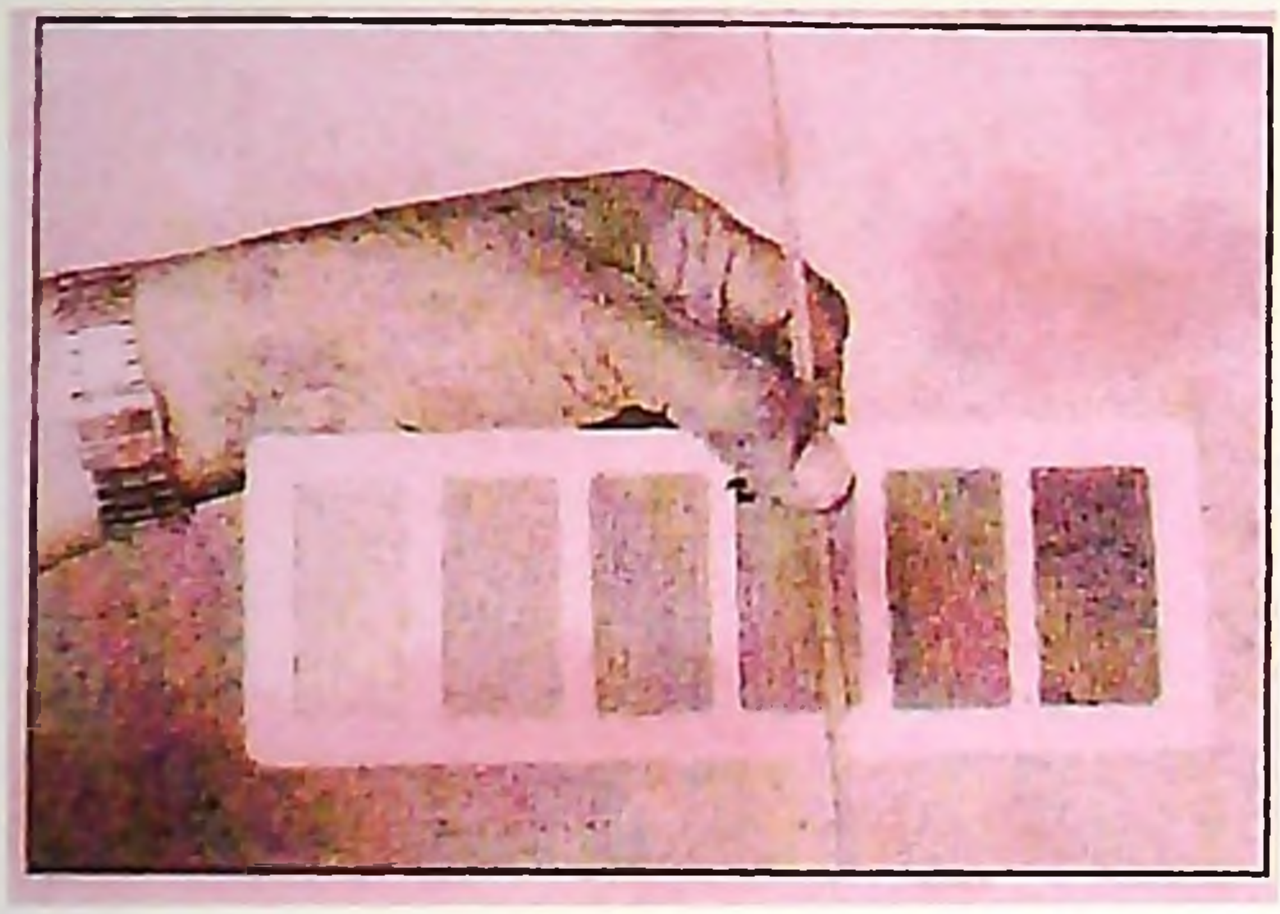
Benefits of automatic irrigation system

- Conservation of water, labour and energy - No need for manual operation to open or close valves, especially in intensive irrigation process.
- Flexibility - Possibility to change the frequency of irrigation and fertilization process.
- Precision and ease in operation.
- Adoption of advanced crop systems and new technologies especially new crop systems that are complex and difficult to operate manually.
- Use of water from different sources, increased efficiency of water and fertilizer use.
- Time saving process - It can be operated at night also. So day time can be utilized for other agricultural operations.

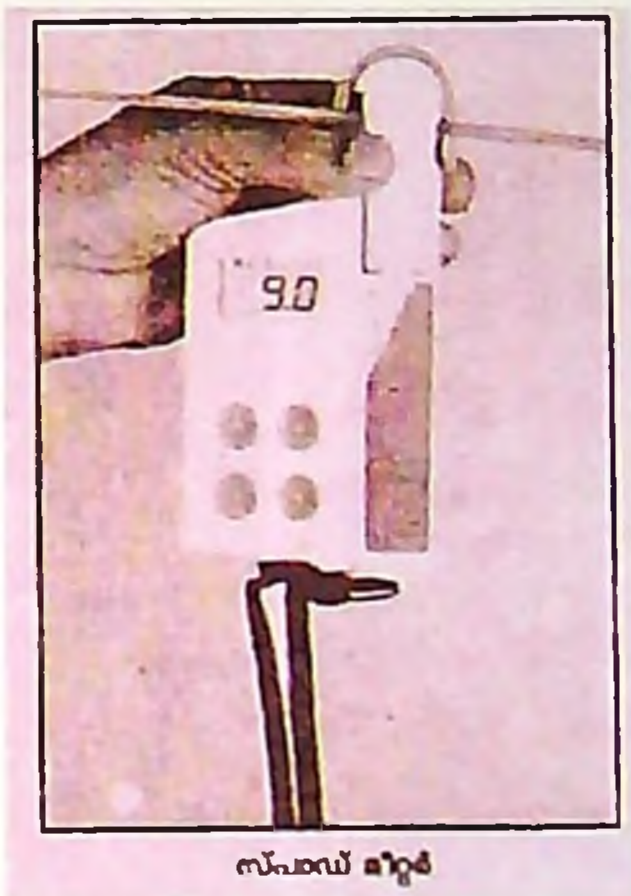
Remote sensing



GIS



Leaf colour card



SPAD meter
(Chlorophyll meter)

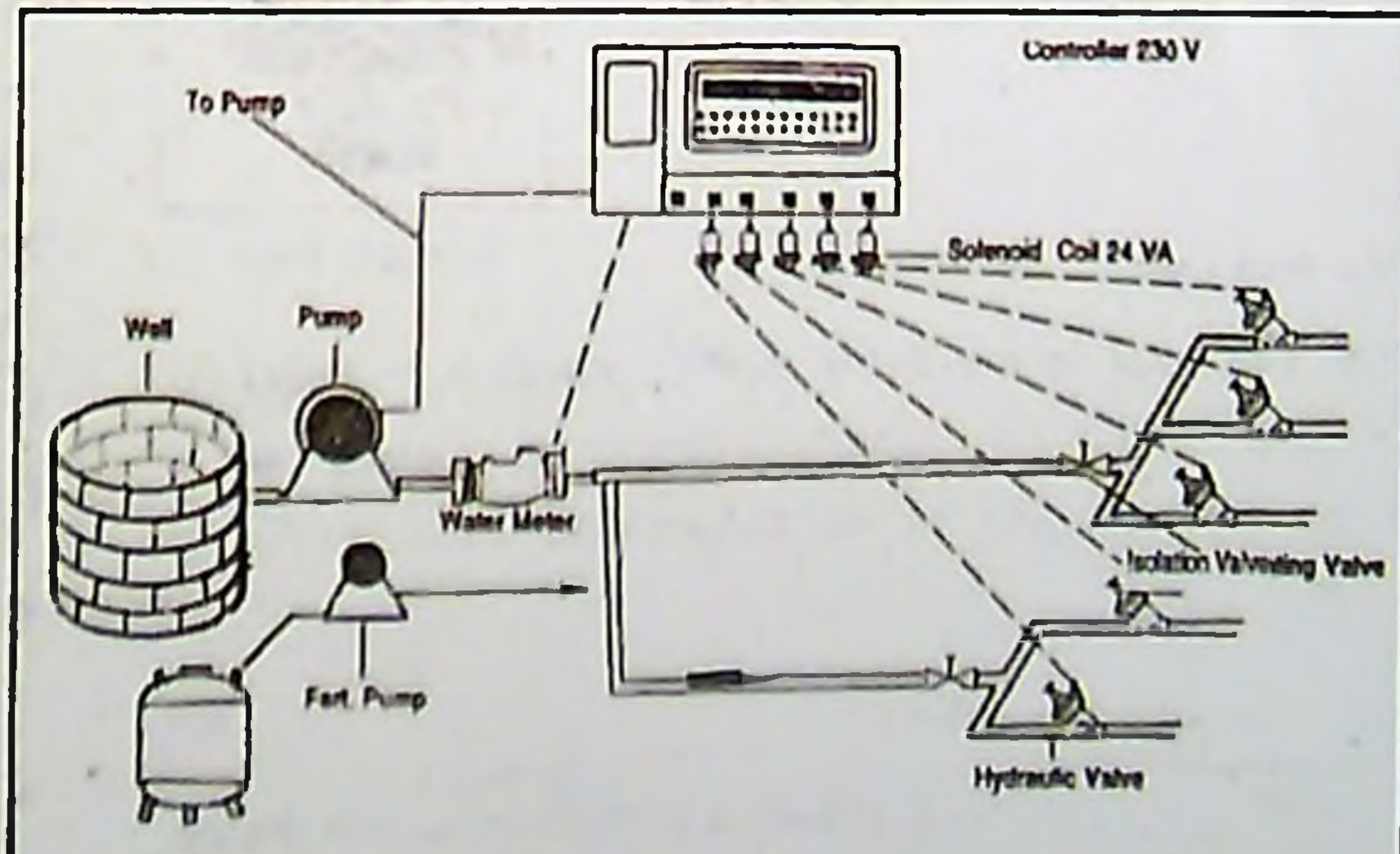
Variable rate applicator

Patch Sprayer

Banded spraying

Band treatment
in orchards

BBRC's prototype
driverless sprayer



Schematic Layout of Jain Automatic Irrigation System

Type of automatic irrigation system

- Time based system - Here time is the basis of irrigation. Each value opens up at a specified time and closes at the end of time duration.
- Volume based system - Here a preset amount of water can be applied in the field by means of automatic volume controlled metering values.
- Real time feed back system - This is a sensor based irrigation system where tensiometers, soil moisture sensors, R.H. sensors, rain sensors etc. are used to control irrigation scheduling. These sensors provide feed back to the controller and controls its operation.

Advantages of precision farming

- Judicious utilization of resources - Here we are applying pesticides, fertilizers, herbicides, fungicides etc. at localized points or only at points where control measures are needed. Thus the cost of cultivation can be reduced.
- Environmental hazard is less.
- It provides precise package of practices at microlevel of cultivation.
- Better management through improved decision and effective and site specific control measure of weeds, pests and diseases.
- Precision farming is aimed for sustainable development of agriculture in cost-effective way.
- Balancing production aspects against environmental threshold values using information technology.
- Using simulation models to fix the optimal timing of management practices.

Limitations of precision farming

- High initial investment for the development of assessing and monitoring system.
- Sampling is cumbersome and cost-intensive.
- Needs modern electronic and computer system for data recording and analysis.
- Expertise is needed for handling high-tec and knowledge-based techniques.
- Small farm size.

In India more than 57.8% of operational holdings has size less than 1 ha with the field size, it is difficult to adopt the techniques of PF at individual field level. For PF to be successful, instead of individual fields, contiguous fields with same crop, under similar management practices are needed.

- Lack of success stories.
- Market imperfections.
- Infrastructure and institutional constraints.
- Knowledge and technology gaps.

INDIAN PERSPECTIVE

Cost is the major problem as far as India is concerned. The cost of full fledged technology was as high as 21050 U.K. pounds as on 1997 out of which 13000 pounds is for mapping devices alone. This cost is too high considering the economic status of Indian farmers. In this context, R.S. data provides a cheaper mapping alternative (Ray *et al.*, 2001).

IKONOS data (1 m resolution) cost is Rs.1600 per sq.km. IRS pan (5.6 m resolution) data is available at a cost of Rs.15/sq.km which is much cheaper than IKONOS. With the launching of Resource Sat-1, one can expect to get 6 m multispectral data at less than Rs.100/sq.km. Even after adding up the analysis and the ground truth data cost, the remote sensing based mapping will be far less than the on field mapping devices and thus can be affordable at Indian condition.

The implementation of PF in India should have two different strategies: One for low input subsistance agriculture and the other for input intensive profit making agriculture. In the 1^{st} case, increase in productivity is the major concern. Here the system has to be converted to a manner, where farmers can use spatial information for efficient input application. Since the field sizes are small, here individually bunded field or a group of fields can be considered as a unit for variable rate application. In the 2^{nd} case, rice and wheat of Indo-Gangetic belt, horticultural crops like grape (Maharashtra), potato (Punjab), tea (assam), the field sizes are large and the farmers are rich. Here input use efficiency is given importance , R.S. data can be used to identify spatial and temporal variability and necessary actions can be adopted using sophisticated instruments like variable rate applicators.

CONCLUSION

PF is essential for serving dual purpose of enhancing productivity and reducing ecological degradation. Though it is widely practiced for commercial crops in developed countries, it is still at a nascent stage in most of the developing countries. Remote sensing can provide a key input (variability map) for the implementation of PF (at lower cost). The study on PF has already been initiated in India, in many research institutes such as space applications centre of ISRO, MS Swaminathan Research Foundation - Chennai, Indian Agricultural Research Institute- New Delhi, Project Directorate of Cropping Systems Research- Modipuram. In coming few years, PF may help the Indian farmers to harvest the fruits of frontier technologies without compromising the quality of land and thereby turning the green revolution into a evergreen revolution.

DISCUSSION

1) What is GPS?

GPS (Global Positioning System) is a space-based navigation system designed originally to provide highly accurate navigational capability to the u.S. military. The GPS receiver allows the co-ordination of latitude, longitude and altitude and correlate the infomation with data obtained from a specific site on the field.

2) Is there any specific growth stage to take L.C.C. and SPAD meter readings?

Yes. Reading has to be taken from second week onwards in transplanted rice and third week onwards in broadcasted rice. This has to be continued upto booting with an interval of 10-15 days.

3) Whether precision farming is practiced in India?

It is not widely practiced in India, but the study on precision agriculture has already been initiated in many research institutes such as Space Applications Centre of ISRO, MS Swaminathan Research Foundation- Chennai, Indian Agricultural Research Institute- New Delhi, Project Directorate of Cropping Systems Research- Modipuram etc.

4) On which aspect IARI is concentrating?

IARI is concentrating their work on phytotrones. Here plants are grown in a controlled atmosphere (humidity, temperature etc.). Yield obtained is very high.

5) Whether the low input subsistance agriculture in precision farming and LISA are same?

These two are different. In precision farming, low input means limited use of fertilizers, pesticides etc. inorder to increase the efficiency of inputs. Here cost involved is very high. But in LISA, low input means the use of low cost technologies. Here importance is given for low cost and not for environment pollution.

6) Whether Kerala government is providing any loans to adopt this technique?

Kerala government is not providing any loans. In Kerala, farmers are not using any sophisticated technologies for farming. Farmers and researchers are using only low cost technologies like LCC for determining the time of nitrogen top dressing.

7) For adoption of precision agriculture, what is the minimum area required?

Minimum area required is 1 ha.In Kerala, majority of the farmers are small scale farmers. So to adopt this technology, they have to integrate their fields or a group of fields have to be considered as a single unit.

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904

FORECASTING THE YIELD OF CROPS BASED ON WEATHER PARAMETERS

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ABSTRACT

Crop yield is related to number of interacting factors like climatic,physical, and biotic factors. Among these, weather plays an important role as it directly affects crops and indirectly acts through factors like insect, pest and diseases, soil moisture and management and cultural practices etc.

Hendrick and Scholl(1943) has done pionerring works in crop forecasting with the help of generated variables.The use of generated variable can give rise to models which require small number of parameters to be estimated, by taking care of the distribution pattern of weather over the crop season.The method suggested by Hendrick and Scholl(1943) and later modified by Agrawal *et.al* (1980) has been tried and found successful to obtain a model for forecasting the grass yield of Lemongrass variety 'Sugandhi'. The yield is obtained from comparative yield trails conducted at the Aromatic and Medicinal Plants Reserch Station, Odakali from 1966-1990. The meterological variables inculed in the study areNumber of rainydays (X_1), Totalrainfall (mm (X_2), Maxmiumtemperature (^{0}C) (X_3), Minimum temperature (^{0}C) (X_4),Relative humidity (%)) (X_5).

The study of forecast model reveals that the 68% of variation of yield can be predicted by the weather parameter. So it is useful model for forecasting the yield.

FORECASTING THE YIELD OF CROPS BASED ON WEATHER PARAMETERS

INTRODUCTION

Crop forecasts are useful for getting reliable estimates on crop production prior to harvest. Such forecasts are needed by the government, agro-based industries, traders and agriculturists. Hence there is a need for developing an objective methodology for pre-harvest crop forecasting. This involves building up of suitable forecast models which should reflect the impact in crop yield due to changes in factors that affect crop yield.

Factors that influence crop yield

Factors affecting crop yield can be classified as

1. Technological change
2. Weather variability

Technological change

Technological change includes the impact of increased fertilizer application, improved management practice and pest control, improved genetic qualities of seeds and other man controlled factors designed to increase yield. It can be assumed that the technological factors will increase yield smoothly through time and therefore, years or some other parameter of time can be used to study the overall effect on yield.

Weather variability (Crop –weather relationship)

Weather variability is an important source of variability in yield. Weather variables affect the crop differently during different stages of development.

These effects are manifested through plant characteristic like height, number if tillers, leaf area etc. which ultimately affect the yield. Further, weather may also create conditions which may be favourable or unfavourable for the growth of disease and pests there by affecting the crop yield. The effect of weather parameters at different growth stages of the crop may help in understanding their response in terms of final yield and also provide a forecast of crop yield in advance of harvest.

Weather variables

The extent of weather influence on crop yield depends not only on the magnitude of weather factors but also on the distribution pattern of weather over the crop season. This calls for the necessity of dividing the whole crop season into fine intervals. This will increase the number of variables in the model and in turn a large number of parameters will have to be estimated from the data. This will require a long series of data for precise estimation of the parameter which may not be available in practice.

The problem of large number of variables can be tackled by increasing the sample size or decreasing the number of variables. The first approach viz, increasing the sample size is generally not feasible. The other approach is to decrease the number of variables. The number of variables can be decreased by taking weather variables which are correlated with yield. But in this method complete information is not utilised in the model. Also the model will not represent the distribution of weather factors over the crop season.

Multiple linear regression

Most commonly used forecasting models are based on multiple linear regression analysis. The technique of multiple linear regression deals with the problem of predicting a dependent variable from a set of 'p' independent variables.

The functional form of multiple linear regression is given by

$$Y=\beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \dots\dots\dots + \beta pXp + e$$

Where

'Y' is the dependent variable

$X_1, X_2, \dots, Xp$ are independent variables

'e' is the error term which are iid normaly distributed with mean zero and common variance.

$\beta_1, \dots\dots, \beta p$ are the parameters to be estimated by the principle of least squares.

β_0 denote the intercept

β_i, i=1,2,3,... gives the average change in the dependent variable per unit change in the independent variable 'X_i' keeping other independent variables at fixed levels. They are termed as partial regression coefficients.

The dependent variable 'Y' represents the yield and independent variable 'X_i', i=1,2,3,...,p represents the factor which affect the yield. These variables should be quantitative in nature. We can predict the mean response at a particular point by substituting the value of independent variables expressed in the model.

The coefficient of determination R^2 which is the square of multiple correlation coefficient is an indicator of fitness of the model. R^2 X100 gives the percentage of variation in 'Y' explained by the regression equation.

The Significance of over all regression is tested by the technique of Analysis of variance. Where the total variation is split into two sources viz 'regression' and 'deviation from regression'. Partial regression coefficients are tested using t – statistic.

Use of generated variables as explanatory variables.

The problem of increased number of variables can be tackled by the use of generated variables. The method was first suggested by Handrick and Scholl (1943) and later modified by Agrawal *et al.* (1980). In this method the crop season is divided into 'n' weeks.

The generated variable corresponding to the ith weather factor

$$Z_i = \sum r_{iw} X_{iw}$$

Where 'X_{iw}' denote i^{th} weather factor in the w^{th} week.

'r_{iw}' is the simple correlation coefficient between 'X_{iw}' and yield (adjusted for trend effect). Thus 'Z_i' takes into consideration the changes in the i^{th} weather factor over the crop season end also its correlation with yield.

Using generated variables as independent variables, the forecast model for studying the effect of weather on yield is given by

$$Y = Ao + A_1Z_1 + A_2Z_2 + \ldots\ldots\ldots\ldots + ApZp + C\ T + e$$

Where 'T' is the time variable and

'e' is the error component it is assumed to be independently and identically distributed normal variables.

The single effect of i^{th} weather factor in w^{th} week on yield can be obtained as

$$\partial y / \partial X_{iw} = A_i * r_{iw}$$

Illustration of the model

The data utilized for the present study were collected from the available records of the meteorological observatory of the Aromatic and Medicinal Plants Research Station, Odakali .Observation on grass yield of the largely cultivated variety of Lemongrass 'Sugandhi' were obtained from the comparative yield trails conducted at the Station, from 1966-1990 (data for 1968,1973,1979,1981and1987 were not available). Lemongrass is a rain-fed crop, and the grass is harvested at periodic intervals of 6 weeks . Yield of grass (Kg/ha) for the harvest during second fortnight of May for various years is taken for the study. Data for 18 years were available for the analysis after leaving missing values. The weather factor considered for the study are

1. Number of rainy days (X_1)
2. Total rainfall (mm) (X_2)
3. Maxmium temperature (^{0}C) (X_3)
4. Minimum temperature (^{0}C) (X_4)
5. Relative humidity (%)) (X_5)

The crop season is divided into 6 weeks prior to the week of harvest 'w' denote the week number prior to the week of harvest. The observation on w^{th} week is denoted by X_{iw}: i= 1,2,3,4,5; w=1,2,3,4, 5,6

The time series data was first tested for the presence of any upward or downward trend. A linear equation was fitted taking "yield" as the dependent variable and 'year'as the independent variable. The data did not reveal any significance trend over years. So 'year' was not included in the model.

Simple correlations r_{iw} of each X_{iw} with yield 'Y' were calculated and are presented in the following table.

Table1:

Simple Correlation Coefficients of weather variable with yield.

Weather factor	Week Number					
	1	2	3	4	5	6
X_1(Number of raindays)	0.158	0.168	-0.211	-0.291	0.556*	0.199
X_2(Rainfall)	0.556*	0.135	0.165	0.335	0.033	-0.353
X_3(Maximum temperature)	-0.459	0.415	-0.165	-0.103	0.012	0.048
X_4(Minimum temperature)	0.431	0.490*	0.362	0.510*	0.364	0.404
X_5(Relative Humidity)	-0.143	-0.266	-0.402	-0.302	-0.462	-0.246

* denote the 5% level of significance.

The table of generated variable as shown below

Year	Z_1	Z_2	Z_3	Z_4	Z_5
1	3.897	128.629	-6.751	68.526	-157.525
2	3.569	166.317	-6.623	63.431	-155.068
3	1.691	41. 521	-7.114	68.724	-148.216
4	5.027	120.072	19.372	70.660	-142.248
5	2.982	107.049	-6.740	66.376	-153.025
6	2.223	53.127	-6.940	66.389	-152.161
7	1.297	28.511	-6.836	64.301	-163.749
8	-0.720	11.681	-9.015	57.845	-155.283
9	6.065	151.194	-7.510	57.496	-159.734
10	-0.201	154.000	-6.074	58.829	-157.403
11	3.510	180.528	-7.113	60.324	-157.572
12	1.805	268.786	-7.326	59.337	-164.484
13	3.181	134.319	-6.978	58.876	-166.783
14	0.052	4.455	-7.913	60.868	-159.873
15	5.001	150.744	-6.995	57.767	-166.999
16	2.624	-2.709	-7.522	58.451	-164.191
17	2.314	30.917	-7.731	59.772	-160.166
18	3.294	38.774	-7.389	58.795	-163.952

The multiple regression analysis was carried out taking the generated variable as independent variable.

Result of regression analysis

Variable	Partial regressions		t
	B	Standard Error	
Constant	4346.793	11922.996	0.365
Z_1	204.515	135.672	1.507
Z_2	8.065	3.017	2.673*
Z_3	9.624	45.745	0.210
Z_4	95.480	74.121	1.288
Z_5	31.098	54.125	0.575

The following eqation was obtained

$$Y = 4346.7993 + 204.515*Z_1 + 8.065*Z_2 + 9.624*Z_3 + 95.48*Z_4 + 31.098*Z_5$$

These equation reveals a significant (at 1% level of significance) regression with the coefficient of determination, $R^2 = 0.682$

ANOVA TABLE

Source	Sum of Squares	Degrees of Freedom	Mean Square	F-Ratio	Significance
Regression	18606946.871	5	3721389.374	5.151	0.009
Residual	8669797.856	12	722483.155		
Total	27276744.727	17			

Change in yield , per unit increase in weather variable are shown in the following table

Weather Factor	Week Number					
	1	2	3	4	5	6
X_1(Number of raindays)	0.467	0.494	-0.062	-0.858	0.164	0.059
X_2(Rainfall)	0.267	0.065	0.079	0.161	0.015	-0.169
X_3(Maximum temperature)	-0.022	0.019	-0.008	-0.005	0.001	0.002
X_4(Minimum temperature)	0.141	0.161	0.119	0.167	0.119	0.133
X_5(Relative Humidity)	-0.023	-0.043	-0.065	-0.049	-0.075	-0.040

Conclusion

Weather variable affect the crop at different stages of development. Hendrick and Scholl(1943) have done the pioneering work in crop forecasting with the help of the generated variables. The use of generated variable can give rise to models which require small number of parameters to be estimated, while taking care of the distribution pattern of weather over the crop season. The method suggested by Hendrick and Scholl(1943) and later modified by Agrawal et al(1980) has been tried and found successful to obtain a model for forecasting the yield of Lemongrass using 18 years data from the Aromatic and Medicinal Plants Reserch Station, Odakali.

DISCUSSION

1. What is regression?

   Ans: The relationship between the independent and the dependent variables may be expressed as a function such functional relationship between two variables is termed as regression.

2. What is the difference between simple regression and multiple regression?

   Ans: when only two variables are involved the functional relationship is known as a simple regression.

   When there are more than two variables and one of them assumed to be dependent upon others the functional relationship between the variables is known as multiple regression.

3. What is the difference between Weather and climate?

   Ans: Weather can be defined as the instantaneous physical state of the atmosphere at particular places.

   Climate is defined as the generalized weather or statistical average of day to day weather condition computed from long term data for a given region or place.

4. What is the relationship between F and R?

   $F = R^2/1-R^2 * n-p-1/p$, $F \sim F_{p,n-p-1}$

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INTERPRETATION OF PRECIPITATION DATA

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ABSTRACT

By the word precipitation we mainly mean rainfall. Rainfall is one of the most important weather parameter which is highly variable in nature. It is well known that the distribution of rainfall contributes more towards crop production than the intensity of rainfall. Quantitative information on the occurrence of seasonal rainfall is highly useful for suggesting suitable methods for reducing the risk in agriculture.

Precipitation data can be interpreted in several ways. The commonly used methods are discussed here. The methods are

- Graphical method
- Ranking order method
- Markov chain probability model

The first two methods fail to provide any useful information with respect to the occurrence or non occurrence of rainfall during a particular period .

Markov chain probability models are widely used for describing the long term probability behaviour of seasonal rainfall during specific periods of the crop season. The model has been applied to characterize the seasonal rainfall occurrence by several workers (Gabriel and Neuman, 1946 ; Bharagava *et al*, 1972 ; and Prabhakaran,1991).

Daily rainfall data required for the present study were gathered from the available records of the Meteorological observatory at Vellanikkara of Thrissur district in Kerala , for a period of 22 years from 1982 to 2001. Using the data the above three methods are discussed here.

INTRODUCTION

The repetitive behaviour of seasonal weather has always been a fascination for meteorologists and statisticians of all time. The meteorologists are interested in the physical explanation for such phenomena whereas the statisticians interest centers around exploring the possibilities of model building for explaining the observed phenomena by way of utilizing the deductive power of mathematics to reach conclusions that could not have reached otherwise.

Weather plays an important role in the agriculture of a country, particularly of India. In tropical countries water is the controlling factor for crop growth and development, the main source of water being precipitation.

The purpose of precipitation measurement is to obtain as much information as in time and space of this precipitation. Of the various forms of precipitation, rainfall is the one which is of more concern for agriculture. As rainfall is the main source of water, decisions on water management are often based on rainfall analysis. From past data, it is possible to get some insight into the availability of water in a region. For that, one must know the stochastic process underlying the sequence of rainfall data. This process is very complicated as it usually exhibits seasonal variations and when working with small increments, one encounters the problem of serial correlations.

Precipitation is measured by means of a rainguage on a daily basis in the field. Field reports are usually summarized weekly or every 10 days. These reports are further summarized in the central offices of the Meteorological services into monthly totals. After a standard period of time, average monthly rainfall data are published, which is the arithmetic mean for a certain number of years. These data are generally available for reference.

Mean monthly rainfall data give only trends of certain climatic patterns. They are useful as a tool to indicate agroclimatic homogeneous zones.

Monsoon rainfall exerts a significant effect on the productivity of almost all crops in Kerala.

Rainfall, which can be considered as one of the most important of the different weather variables, is highly variable and hence sometimes unpredictable. In a given season, the rainfall at a certain location may be too much or too little and hence in either case affects the crop of the region adversely. Interpretation of available rainfall would be of great use in planning development program of a given region, especially of agriculture. A study of rainfall probabilities will help in sound planning against the hardships caused by large variation in rainfall.

Irrigation scheduling and design and operation of the irrigation systems are directly dependent on the input of rainfall. The three main characteristics of rainfall - the amount, the intensity and the frequency-have wide spatial and temporal variations in arid and semi-arid regions. Therefore, accurate prediction of the rainfall over the entire season and at the peak period, as well as its distribution over the growing season of a crop are of great importance for the rational design and management of irrigation systems.

Fisher (1924) established that it is the distribution of rainfall during a season, which influences the crop yield rather than its total amount. Since the distribution of rainfall depends on the sequence of wet and dry spells over a period of time, it is important to investigate the pattern of occurrence of such spells during the period of the growth of a crop. The occurrence of a sequence of wet and dry spells can be regarded as a series of Bernoulli trials in the language of probability.

The pattern of the occurrence of rainfall can be best investigated by fitting a stochastic model to the rainfall data over a period of time. This gives information on various characteristics of the pattern of rainfall i.e., expected length of wet and dry spells during the period of the growth of a crop. Such information is very useful to crop planners and agronomist in planning various crop operations. Markov chain models were used for describing the occurrence of rainfall at a place by several research workers [Bhargava *et al.* (1972) and Prabhakaran (1991)].

Precipitation data can be interpreted in several ways. Of the commonly used methods, three important methods are discussed here. For illustration purpose, daily rainfall data for a period of 22 years from 1980 to 2001 collected from meteorological observatory at Vellanikkara are used.

DEFINITIONS

Stochastic process:

A stochastic process can be considered to be a set of random variables $X(t)$ depending on a real parameter 't' which varies in a certain set I of natural numbers. It is denoted by $\{ X(t), t \in I \}$.

State space:

A real number x is said to be a possible value or a state of a stochastic process $\{ X(t), t \in I \}$ if there exists a time 't' in I such that the probability $P\{x(t-h) < X(t) < x(t+h)\}$ is positive for every $h>0$. The set of possible values of a stochastic process is called its state space.

Transition probability matrix:

Imagine a finite stochastic process with n states with state space 1,2,...,n and assume that at time t, the process is at state 1. Then at time (t+1), let the probabilities of the process being in states 1,2,..., n be denoted by $P_{11}, P_{12}, \ldots, P_{1n}$ respectively with $P_{11}+P_{12}+\ldots+P_{1n} = 1$. Similarly if the process is in state 2 at time t, let the probabilities of the process being in states 2,3,...,n at time (t+1) be $P_{22}, P_{23}, \ldots, P_{2n}$ with $P_{22}+P_{23}+\ldots+P_{2n} = 1$. This is true for every state of the stochastic process. If P_{ij} denote the probability of moving from state i to j in one step, we can note that $\sum P_{ij} = 1$ for all j. The probabilities P_{ij} are called transition probabilities and $P = (P_{ij})$ is the transition probability matrix.

Markov process:

A stochastic process $\{ X(t) \}$ is said to be a Markov process if for any set of n time points $t > t-1 > t-2 \ldots > t-n+1$ in the index set of the process, the conditional distribution of $X(t)$ for given values of $X(t-1), X(t-2), \ldots, X(t-n+1)$ depends only on $X(t-1)$, the most recent known value. More precisely, for any set of real numbers $x_1, x_2, \ldots, x_n$,

$$P\,[X(t) = x_n \,/\, X(t-n+1) = x_1, \ldots, X(t-1) = x_{n-1}] = P\,[X(t) = x_n \,/\, X(t-1) = x_{n-1}] \qquad \text{------------ (1)}$$

Markov chain:

A class of Markov processes in discrete time whose state space is discrete is called a Markov chain. The equation (1) holds good in the case of Markov chains and the conditional probability is independent of the states occupied at times prior to (t-1).

Order of a Markov chain:

A Markov chain $\{X_n\}$ is said to be of order 's' (s = 1,2,...) if for all n,

$$P\{X_n = k / X_{n-1} = j, X_{n-2} = j_1, \dots, X_{n-s} = j_{s-1}, \dots\}$$
$$= P\{X_n = k / X_{n-1} = j, \dots, X_{n-s} = j_{s-1}\}$$

A Markov chain $\{X_n\}$ is said to be of order one if,

$$P\{X_n = k / X_{n-1} = j, X_{n-2} = j_1, \dots\} = P\{X_n = k / X_{n-1} = j\}.$$

MATERIALS AND METHODS

Daily rainfall data spread over a period of 22 years (1980 to 2001) collected from Meteorological observatory at Vellanikkara are used for describing the three methods. The methods are as follows.

1. Graphical method

Graphical representation gives a general idea of the rainfall pattern at a place. Graphs can be plotted for each year separately with daily rainfall data, weekly rainfall data, monthly rainfall data or pooled data over the years. Rainfall of a particular season can be plotted against different years. Graph can be plotted with period on X-axis and corresponding rainfall total on Y-axis.

For illustration, winter rainfall (December to February), summer rainfall (March to May), south-west monsoon rainfall (June to September), post-monsoon rainfall (October to November) and annual rainfall graphs are drawn.

2. Percentile rank method

The method was described by Doorenbos and Pruitt (1977) and Frere, Rijks and Rea (1975). The method involves ranking of the rainfall data of a particular period over several years and calculating the corresponding probability based on the rank. The assumption in this method is that rainfall is normally distributed. Method is as follows:

Take rainfall records of a number of years (say, n). Then, arrange these records in descending order. Each record is assigned a rank number 'm'. The ranking numbers are then given probability levels Fa(m) , which is calculated as

$$Fa(m) = \frac{100m}{n+1}$$

where n is the number of records.

No test of significance of the various probabilities is applied.

For illustration, weekly rainfall data pooled over 22 years was made use. If n=22, for rank number 20, Fa(20)=86.96 which means that in the respective year assured rainfall probability is 86.96 per cent. In other words, we can say that on that year we can expect a minimum amount of rainfall with 86.96 per cent probability.

Again by drawing a graph with Fa(m) on the X axis and corresponding rainfall on Y axis, we can find out amount of assured rainfall corresponding to a given probability. The method fails when the distribution of rainfall is not normal.

3. Markov chain probability model

Two state Markov chain model is widely used for studying the pattern of occurrence of wet and dry days. Daily rainfall data during the period of 22 years (1980 to 2001) were used to characterize the weekly rainfall distribution. One whole year was first divided into 52 standard meteorological weeks. Rainfall data from the 14th standard week (April 2nd-8th) to the 48th standard week (November 26th to Dec. 2nd) were used for fitting Markov chain model. During the remaining weeks rainfall was very infrequent and those weeks were not included.

Classification

Each of the day in the given period is classified as wet or dry depending upon the amount of precipitation received during the day. A wet day is defined as a day on which the amount of rainfall received is greater than or equal to 2.5 mm and if it is less than 2.5 mm is termed as a dry day. By this classification a sequence of dry and wet days are obtained. One of the following four possibilities may occur while classifying each day of such a sequence.

1. A dry day preceded by a dry day.
2. A wet day preceded by a dry day.
3. A dry day preceded by a wet day.
4. A wet day preceded by a wet day.

In each of the 22 years, this classification was made for the period considered.

Evaluation of probabilities

For each year, April 2[nd] is classified as one of the four possibilities depending on whether April 1[st] is dry or wet. Repeating this process each year, cell frequencies for the above four possibilities are obtained. Let these be denoted by a, b, c and d respectively with $a+b = n_1$ and $c+d = n_2$.

Given that the previous day is dry, let the probabilities of a day being dry and wet be respectively P_{11} and P_{12} with $P_{11} + P_{12} = 1$. Similarly, given that the previous day is wet, let the probabilities of a day being dry and wet be respectively P_{21} and P_{22} with $P_{21} + P_{22} = 1$. It is obvious then that two parameters, say P_{12} and P_{22} can be estimated by b/n_1 and d/n_2.

The sequence of wet and dry days over a given period strictly follows a two state Markov chain model, the states being dry and wet. Now the probabilities P_{11}, P_{12}, P_{21} and P_{22} can be expressed in a matrix form say P such that

$$P = \begin{bmatrix} P_{11} & P_{12} \\ P_{21} & P_{22} \end{bmatrix}$$

In order to test whether the occurrence of dry and wet days assumes a first order Markov chain model, the normal deviate test can be applied. The test statistic, Z is given by

$$Z = (P_{12} - P_{22}) / SE(P_{12} - P_{22})$$

Where $SE(P_{12} - P_{22})$ is estimated by $PQ(1/n_1 + 1/n_2)$ with

$$P = (n_1 P_{12} + n_2 P_{22}) / (n_1 + n_2), \quad Q = 1 - P.$$

A significant value of Z reveals that the occurrence of rainfall on a particular day depends on the immediately preceding day's rainfall, which is evidently the property of a first order Markov chain model.

It has been seen that after a long period of time, the system settles down to a condition of statistical equilibrium in which the state occupation probabilities (Π_1 , Π_2) are independent of the initial conditions . The number of days after which the state of equilibrium is achieved is equal to the number of times the P matrix is powered till the diagonal elements of the powered matrix becomes equal to the equilibrium probabilities π_1 and π_2, where $\Pi_1 = (1-P_{22})/(1-P_{22}+P_{12})$ and $\Pi_2 = P_{12}/(1-P_{22}+P_{12})$

In the sequence of wet and dry days, there are possibilities of the occurrence of wet days in succession. A number of successive wet days followed by a dry day are regarded as the length of a wet run (W). Then the expected stretch of wet runs is given by,

$E(W) = 1/(1-P_{22})$ and expected stretch of dry runs is calculated as

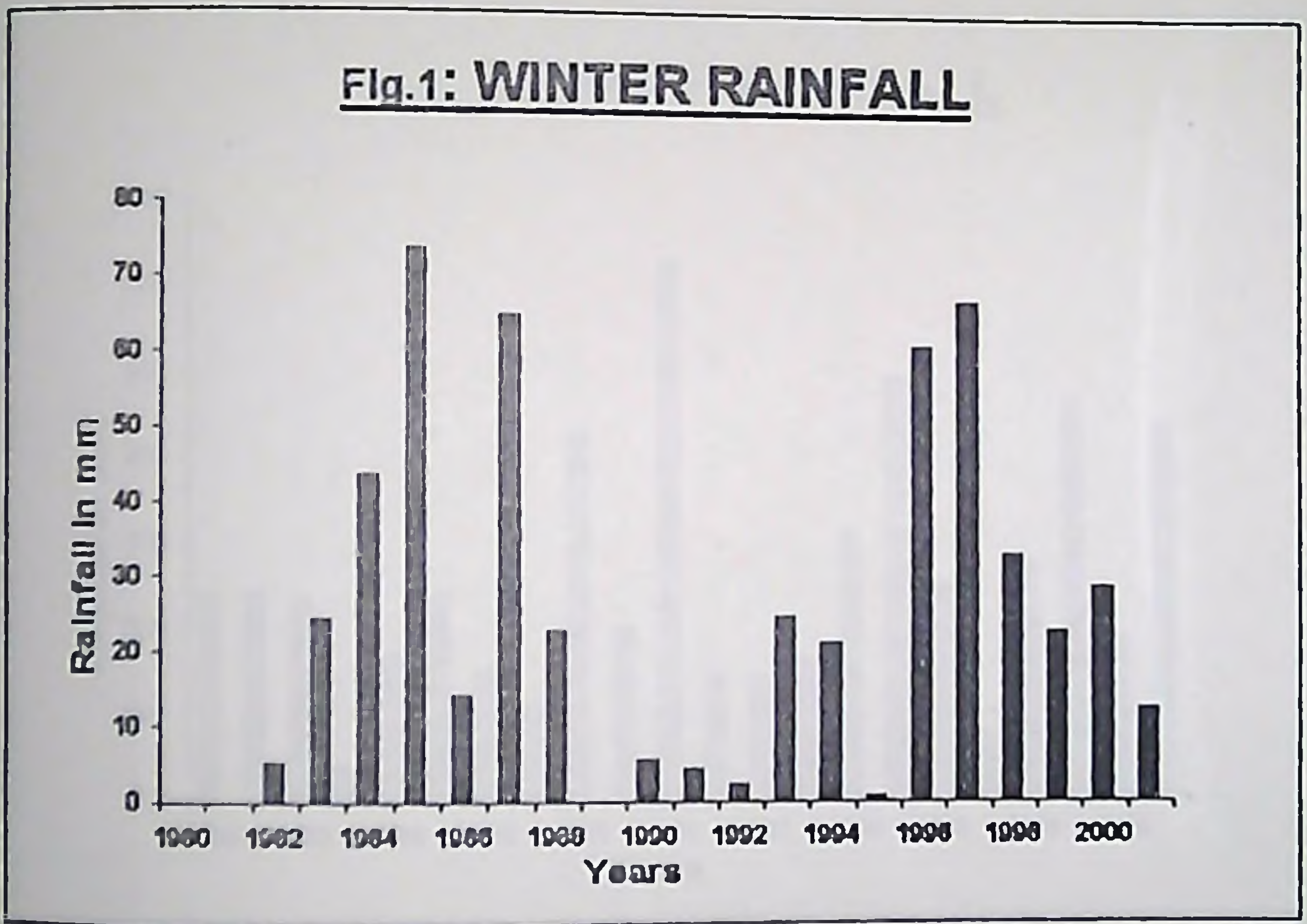
$E(D) = 1/P_{12}$

The expected number of dry and wet days in a standard week is obtained as

Expected no. of dry days $= n\Pi_1$ and

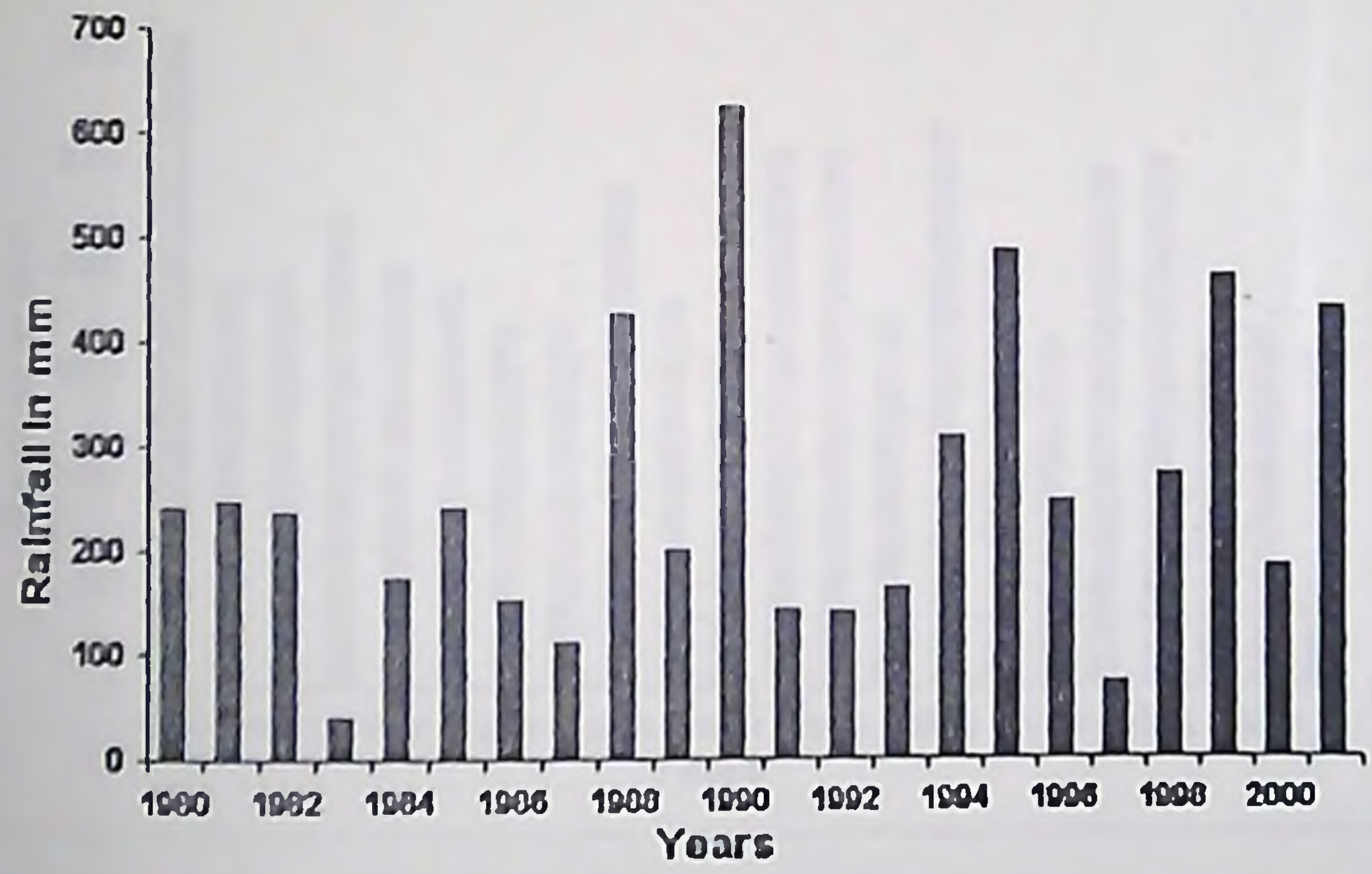
Expected no. of wet days $= n\Pi_2$

Where 'n' is the days constituting the standard week under study.

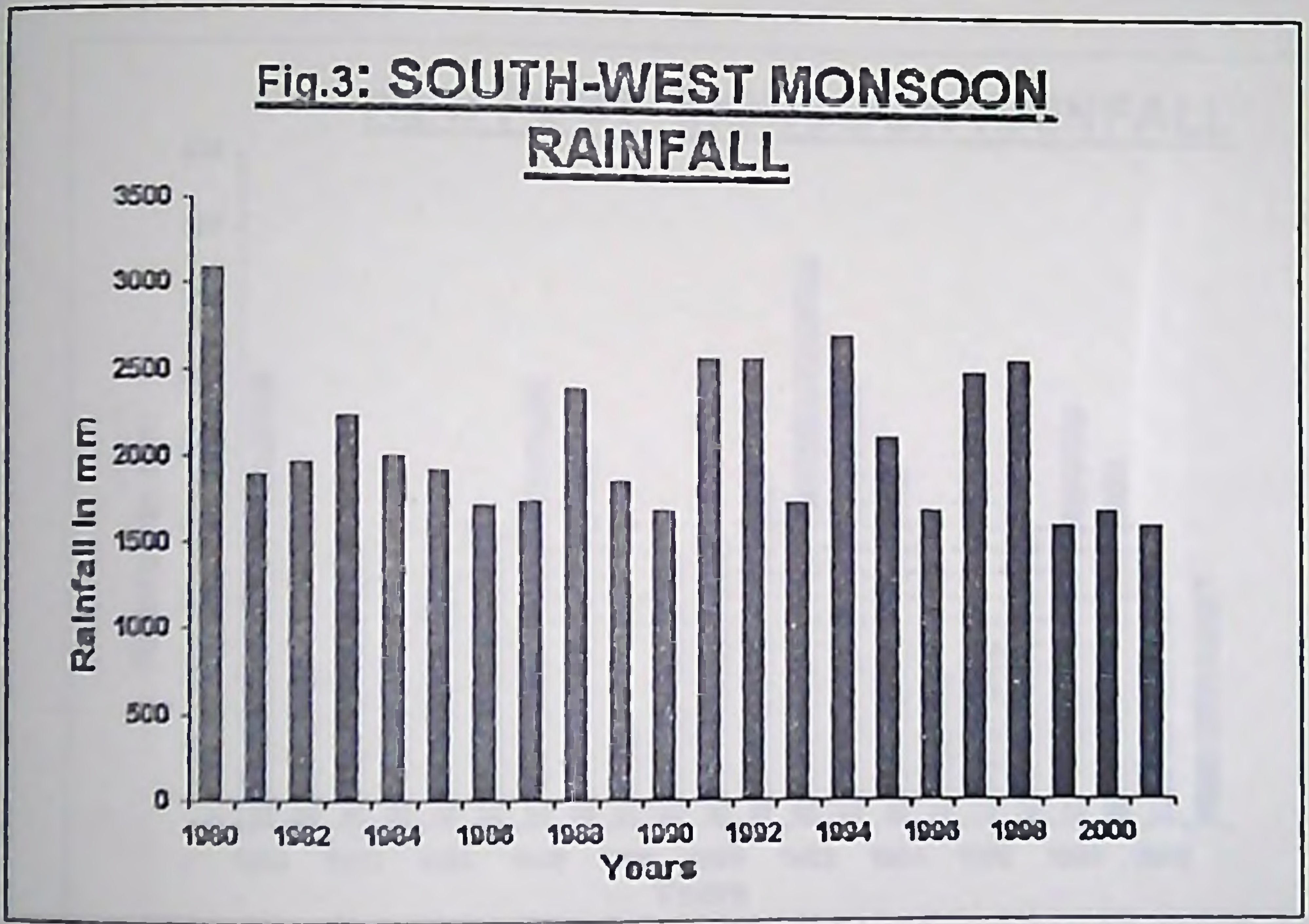


WINTER : DECEMBER - FEBRUARY

Fig.2: SUMMER RAINFALL



SUMMER : MARCH - MAY



SOUTH WEST MONSOON : JUNE - SEPTEMBER

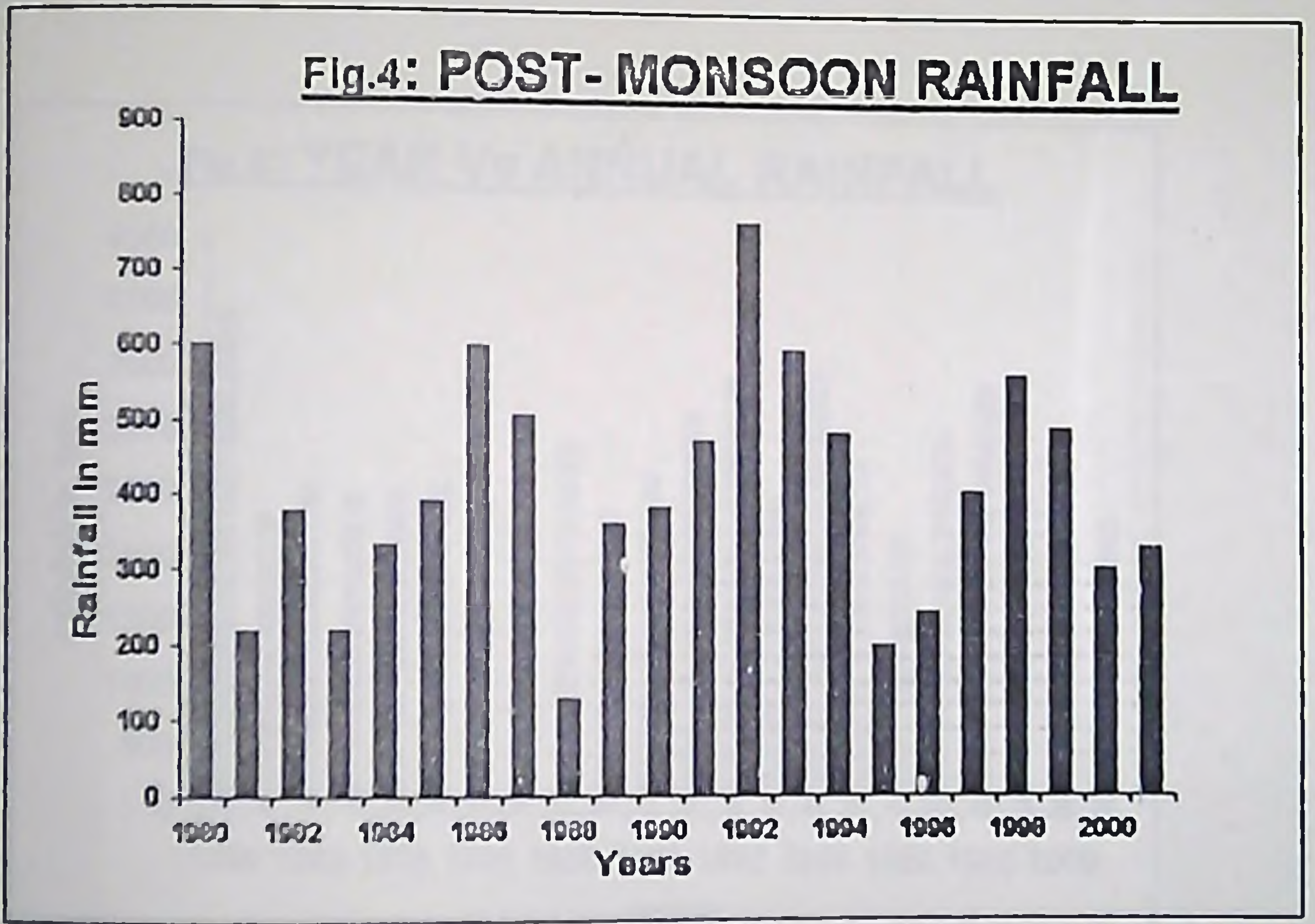


Fig.4: POST- MONSOON RAINFALL

POST MONSOON : OCTOBER - NOVEMBER

Fig.5: YEAR Vs ANNUAL RAINFALL

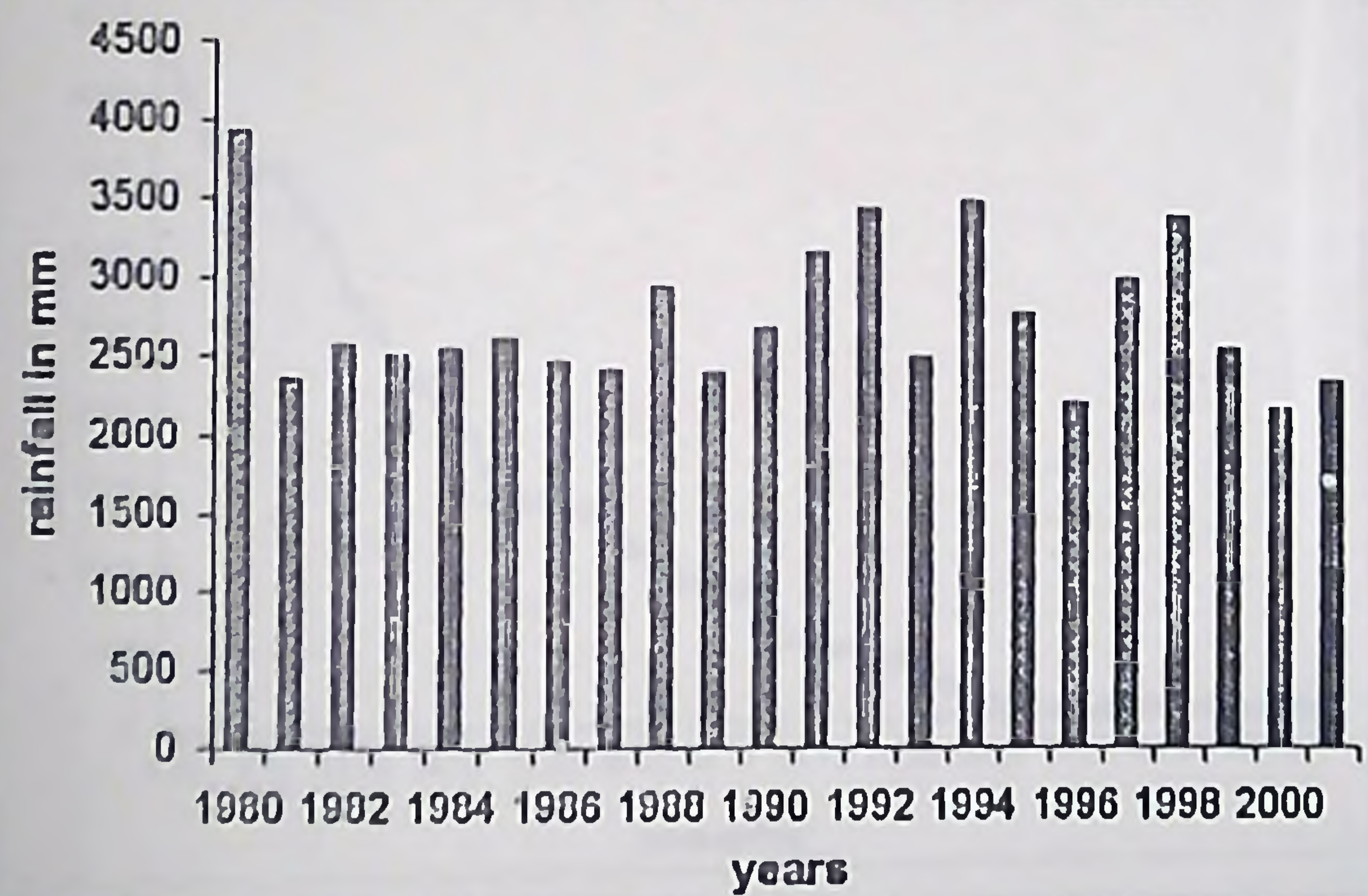


Fig.6: Probability Vs Weekly rainfall graph Using Percentile rank method.

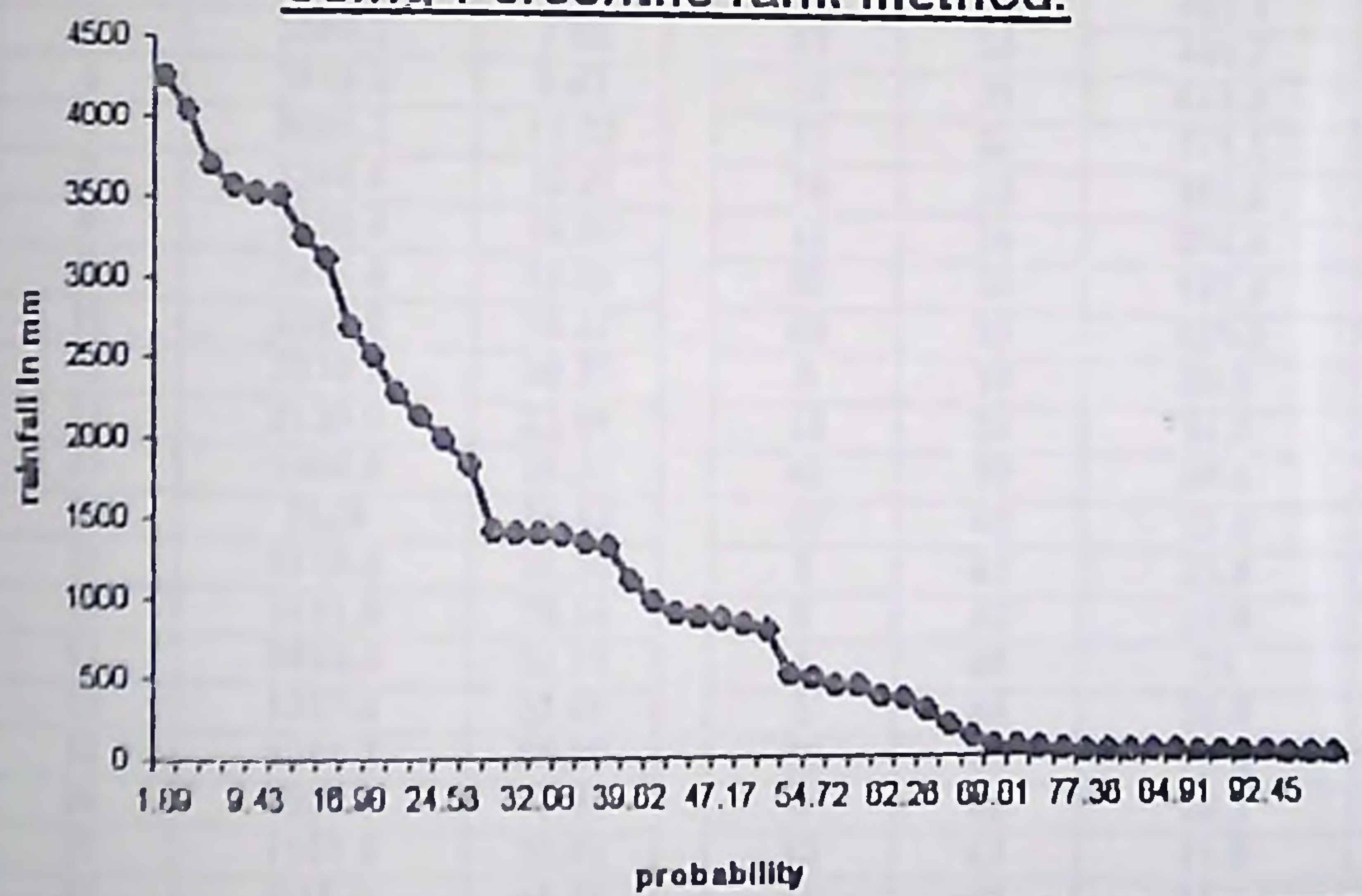


Table 1: Probability and the corresponding annual rainfall in Percentile rank method

WEEK	RANK(m)	TOTAL RAINFALL(mm)	Fa(m)	WEEK	RANK(m)	TOTAL RAINFALL(mm)	Fa(m)
24	1	4251.4	1.89	21	27	798.8	50.94
26	2	4036.2	3.77	46	28	511.4	52.83
28	3	3893.5	5.66	15	29	493.1	54.72
23	4	3566.2	7.55	47	30	446.7	56.60
25	5	3515.8	9.43	16	31	440.8	58.49
29	6	3506.3	11.32	17	32	371.1	60.38
27	7	3249.4	13.21	18	33	356.5	62.26
30	8	3100.4	15.09	14	34	284.4	64.15
33	9	2684.8	16.98	50	35	187.8	66.04
31	10	2502.6	18.87	49	36	121.2	67.92
32	11	2270.7	20.75	9	37	59.8	69.81
22	12	2130.8	22.64	13	38	54.9	71.70
34	13	1988.6	24.53	48	39	49.4	73.58
41	14	1826	26.42	10	40	32.9	75.47
43	15	1418.3	28.30	8	41	23.6	77.36
38	16	1411.6	30.19	6	42	22.8	79.25
39	17	1409.4	32.08	1	43	21	81.13
40	18	1397.4	33.96	3	44	20.6	83.02
42	19	1349.7	35.85	52	45	19.6	84.91
35	20	1323.3	37.74	5	46	12.2	86.79
44	21	1101.9	39.62	12	47	11.9	88.68
36	22	978.4	41.51	11	48	10.6	90.57
37	23	907	43.40	7	49	10.1	92.45
45	24	879.7	45.28	51	50	3	94.34
19	25	860.6	47.17	2	51	1.1	96.23
20	26	832.1	49.06	4	52	0	98.11

Table 2: Transition probabilities, Equilibrium probabilities, ...

Weeks	Probabilities				Equilibrium probabilities		Expected stretch		Expected no. of days	
	P_{11}	P_{12}	P_{21}	P_{22}	Π_1	Π_2	E(D)	E(W)	Dry days	Wet days
April 2^{nd} – 8^{th}	0.891	0.109	0.688	0.313	0.863	0.137	9.20	1.45	6.04	0.96
9^{th} – 15^{th}	0.925	0.075	0.550	0.450	0.881	0.119	13.40	1.82	6.16	0.84
16^{th} – 22^{nd}	0.846	0.154	0.792	0.208	0.837	0.163	6.50	1.26	5.86	1.14
23^{rd} – 29^{th}	0.840	0.160	0.826	0.174	0.837	0.163	6.24	1.21	5.86	1.14
30^{th} – 6^{th} May	0.873	0.127	0.800	0.200	0.863	0.137	7.88	1.25	6.04	0.96
7^{th} – 13^{th}	0.882	0.118	0.481	0.519	0.803	0.197	8.47	2.08	5.62	1.38
14^{th} – 20^{th}	0.783	0.217	0.615	0.385	0.739	0.261	4.60	1.63	5.17	1.83
21^{st} – 27^{th}	0.844	0.156	0.533	0.467	0.774	0.226	6.41	1.88	5.42	1.58
28^{th} – 3^{rd} June	0.735	0.265	0.254	0.746	0.489	0.511	3.77	3.94	3.42	3.58
4^{th} – 10^{th}	0.319	0.681	0.290	0.710	0.299	0.701	1.47	3.45	2.09	4.91
11^{th} – 17^{th}	0.458	0.542	0.062	0.938	0.102	0.898	1.85	16.25	0.71	6.29
18^{th} – 24^{th}	0.381	0.619	0.128	0.872	0.171	0.829	1.62	7.82	1.20	5.80
25^{th} – 1^{st} July	0.538	0.462	0.148	0.852	0.243	0.757	2.17	6.76	1.70	5.30
2^{nd} – 8^{th}	0.553	0.447	0.138	0.862	0.236	0.764	2.24	7.25	1.65	5.35
9^{th} – 15^{th}	0.467	0.533	0.129	0.871	0.195	0.805	1.88	7.75	1.36	5.64
16^{th} – 22^{nd}	0.607	0.393	0.135	0.865	0.256	0.744	2.55	7.41	1.79	5.21
23^{rd} – 29^{th}	0.659	0.341	0.164	0.836	0.324	0.676	2.93	6.11	2.27	4.73
30^{th} – 5^{th} Aug	0.556	0.444	0.174	0.826	0.282	0.718	2.25	5.74	1.97	5.03

6th – 12th	0.475	0.525	0.202	0.798	0.278	0.722	1.90	4.96	1.94	5.06
13th – 19th	0.723	0.277	0.121	0.879	0.305	0.695	3.62	8.23	2.14	4.86
20th – 26th	0.709	0.291	0.192	0.808	0.397	0.603	3.44	5.21	2.78	4.22
27th – 2nd Sept.	0.714	0.286	0.243	0.757	0.460	0.540	3.50	4.12	3.22	3.78
3rd – 9th	0.811	0.189	0.339	0.661	0.641	0.359	5.28	2.95	4.49	2.51
10th – 16th	0.808	0.192	0.417	0.583	0.684	0.316	5.20	2.40	4.79	2.21
17th – 23rd	0.787	0.213	0.246	0.754	0.536	0.464	4.68	4.06	3.75	3.25
24th – 30th	0.694	0.306	0.420	0.580	0.579	0.421	3.27	2.38	4.05	2.95
1st Oct – 7th	0.686	0.314	0.412	0.588	0.567	0.433	3.19	2.43	3.97	3.03
8th – 14th	0.674	0.326	0.435	0.565	0.572	0.428	3.07	2.30	4.00	3.00
15th – 21st	0.659	0.341	0.391	0.609	0.534	0.466	2.93	2.56	3.74	3.26
22nd – 28th	0.703	0.292	0.468	0.534	0.615	0.385	3.43	2.15	4.30	2.70
29th – 4th Nov	0.816	0.184	0.431	0.569	0.700	0.300	5.42	2.32	4.90	2.10
5th – 11th	0.798	0.202	0.511	0.489	0.717	0.283	4.95	1.96	5.02	1.98
12th – 18th	0.878	0.122	0.652	0.348	0.842	0.158	8.19	1.53	5.90	1.10
19th –25th	0.935	0.065	0.750	0.250	0.920	0.080	15.33	1.33	6.44	0.56
26th – 2nd Dec	0.980	0.020	0.500	0.500	0.962	0.038	50.00	2.00	6.73	0.27

RESULTS AND CONCLUSION

Graphical method

Four graphs have been drawn with the rainfall data of four seasons, viz; winter (December to February), summer (March to May), south-west monsoon (June to September) and post- monsoon (October to November) and is presented in figures 1, 2, 3, & 4 respectively. Another graph is drawn with total annual rainfall for 22 years from 1980 to 2001 and is presented in figure 5.

Winter rainfall (December to February) was maximum in the year 1985 followed by 1997 and 1987. The same was zero in 1980, 1981 and 1989. The year 1995 had a small amount of rainfall in winter. The pattern of rainfall was very irregular over the 22 years during winter.

The years, which had high rainfall in winter season, got very low summer rainfall (March to May). Summer rainfall was lowest for 1983 which also had low amount of rainfall in winter season. Summer rainfall was maximum in 1990 for which winter rainfall was comparatively low. In general, those years which got low amount of rainfall in winter showed an increase in summer season.

For the year 1990, which had maximum rainfall in summer season got comparatively low rainfall during south-west monsoon (June to September). During this season for the 22 years under consideration (1980 to 2001) the amount of rainfall was more than 1500mm. South-west monsoon rainfall was minimum in 1999 and 2001, but these years got better summer rainfall. In the year 1990, for which south-west monsoon rainfall was maximum had very low summer rainfall. Those years, which got small amount of rainfall in summer season, got more rainfall during south-west monsoon.

Those years which got maximum rainfall during south-west monsoon had low rainfall in post-monsoon (October to November) season. Post-monsoon rainfall was maximum in the year 1988 which had minimum south-west monsoon rainfall

From the graph of annual rainfall for the 22 years from 1980 to 2001, it is clear that in the year 1980, the rainfall was maximum and was minimum in 1996. Also, it is evident that in all the 22 years the amount total annual rainfall was more than 2000mm.

Thus, from graphical representation of rainfall data we get a general picture of the amount of rainfall during different periods.

Percentile rank method

Each year was first divided into 52 standard weeks and for each standard week, total rainfall was worked out. Again for each standard week, the average rainfall was estimated over the 22 years from 1980 to 2001. Weeks were then ranked based on the amount of rainfall in each week. The probabilities Fa(m) corresponding to the respective ranks(m) were calculated and presented in table 1. A graph with these 52 probabilities on the X-axis and the corresponding rainfall amount was plotted on Y-axis and presented in figure 6.

From the graph, the amount of rainfall assured at a particular probability level can be obtained. The corresponding weeks can be noted from the table 1. The assured rainfall with 25 per cent probability is around 1826mm and the same with 50 per cent 75 per cent probability are respectively 798.8mm and 32.9mm.

Markov chain probability model

Using transition probabilities equilibrium probabilities, expected stretch for dry and wet runs and expected length of dry and wet days were calculated and presented in table 2. From this table, we get the following information. For the week May 28th to 3rd June it could be observed that, the dry stretch starting from 28th May lasts on the average of 3.77 days whereas the wet stretch lasts for 3.94 days. As the period approaches the south-west monsoon, the dry stretch gradually decreases in the peak of south-west monsoon and the wet stretch increases. In the week July 16th to 22nd under observation, the dry stretch is only for a length of 2.55 days whereas the wet stretch has a length of 7.41 days. The wet-dry cycle phenomena could be conspicuously observed during the monsoon season with the dry stretches intermitted frequently by wet stretches from the onset of the south-west monsoon; the wet stretch goes on increasing and is intersected by short dry stretches in the peak of south-west monsoon – the phenomenon gradually limping to the same pattern as that in the early monsoon season.

In the early periods under observation, the dry stretch extends for a length of even 13.4 days as in the week under reference April 9th to 15th whereas the wet stretch is only for a length of 1.82 days. This means we can normally expect around 14 dry days starting from April 9th. This is an indication that the intermittency of the dry stretch by a wet stretch is to the bare minimum – the wet stretch may only be a pre-monsoon phenomenon, which is most beneficial to the crops.

In graphical method and percentile rank method, total amount of rainfall is used whereas in the first order Markov chain probability model occurrence or non- occurrence of rainfall is taken into account. So a Markov chain model is an effective model in studying the rainfall pattern of a region. Also, this model is suitable to describe the long term probability behaviour of seasonal rainfall during the specific period of the crop season. The graphical method and percentile rank method are very easy, but Markov chain probability model method is quite time consuming and involves complicated calculations.

DISCUSSION

1. Of the three methods described the third method is given more importance. Why is it so?

Ans. Graphical representation and percentile rank method are dealing with total amount of rainfall whereas the Markov chain model is based on the occurrence or non-occurrence of rainfall of a region. This means that, only the third method deals with a probabilistic approach. This is the reason.

2. What is the null hypothesis under study?

Ans. The null hypothesis is that the transition probabilities are independent of each other.

3. What you mean by transition probability?

Ans. The transition probability P_{ij} is the probability of system moving from a state 'i' to a state 'j' in one step.

4. What are the two different states under study?

Ans. The two different states are dry and wet respectively.

5. Of the four seasonal graphs, in which season the rainfall is minimum?

Ans. The rainfall is minimum in the winter season.

6. The probability for rainy day is 0.7 and that for a dry day is 0.3. How can this be explained to a farmer?

Ans. The given probability shows that in a week there is a chance of getting 4 to 5 rainy days and the remaining 3 or 2 days would be dry.

7. Are there existing different probability models for different crop seasons?

Ans. No, there are not different probability models for different crop seasons.

8. Is there any software available for doing Markov chain probability model?

Ans. In my knowledge there is no such software available in our campus.

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DRY FLOWERS - A PROSPECTIVE AVENUE IN FLORICULTURE

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SEMINAR REPORT

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THRISSUR

ABSTRACT

Floriculture has become a profitable industry in many parts of the globe. Cut flowers are one of the main components in floriculture trade. These flowers have very short vase life. These prospects of dry flower industry are to be viewed in this background. Dry flowers are near natural, dried, preserved and processed, having beauty as well as an everlasting value. Dehydrated flowers and foliage can be used for designing distinctive and artistic greeting cards, wall plates, landscape etc (Dutta, 2001).

Dry flower industry was introduced to India by British in West Bengal. Tuticorin of Tamil Nadu is another hot spot for dry flower production. Now India has become a leading exporter of dry flowers to various countries. India's share in world market is less than 5 per cent, which, however, is more conspicuous, compared to fresh flowers (Singhwi, 2001).

Processing of dried flowers involves drying, bleaching and colouring (Lourduswamy *et al.*, 2001). The most important step is drying and the different techniques are air drying, embedded drying, press drying, glycerin drying and freeze drying (Bhutani, 1995).

Dry flowers and plant materials have a tremendous potentiality to supplement fresh flowers and foliage. Dry flower industry is labour intensive and provides employment to many sections of people. Plant diversity existing in the humid tropical regions of Kerala can be well exploited to develop a dry flower industry in Kerala.

DRY FLOWERS - A PROSPECTIVE AVENUE IN FLORICULTURE

Introduction

The world floriculture business is expanding rapidly and it has become a profitable industry in many parts of the globe. It has tremendous potential for export besides home consumption. Among the various components of this industry, cutflowers is a major segment and its demand is increasing day by day. Flowers though exquisite in their beauty are expensive, short lived and sensitive to heat and cold. Non-availability of flowers at times and places where one wants them very much is an additional problem. In this context dry flowers provide a better alternative. Anything from flowers, to petals, to buds, stem, roots, fruits and leaves in a dried form come under the domain of dry flowers.

Dry flowers should retain colour, artistic shape and decorative values. They can be used in natural, dyed, bleached or preserved forms. In these flowers, microbial activity comes to a stand still and can be stored in dry atmosphere for a longer period without losing its colour, texture, quality etc. Dry flowers are put to many beautiful and varied uses. Apart from bouquets and flower arrangements, their flexibility enables them to be made into long lasting collages and flower pictures, flower cards and covers, pomanders and festive decoration candles and sweet Smelling Pot-Pourri and many more things.

Dry flower industry is about four decades old and it was introduced to India by British in West Bengal. At first, it was confined only to West Bengal due to its close proximity to the North Eastern States where the climate is very much congenial for the cultivation of flowering plants. Dry flowers and plants are exported from India for the past 30 years. At present dry flower industry is growing very fast with more than 60 per cent share to the floriculture industry in India. India has a share of 1.5 per cent in European export of dry flowers. India is one of the leading producers of dry flowers in the world with an annual export turn over of 10,000 tonnes of dried flowers worth Rs.75 crores. At present Tuticorin area of Tamil Nadu is concentrated by the dry flower units. United States, United Kingdom, Germany, Italy are the major importers of dry flowers from India. Moreover, this industry is labour intensive and provides self-employment and employment opportunities to more than 10 lakh people, both directly and indirectly.

Advantages of dry flowers

1. Dry flowers are cheaper
2. They are not easily perishable
3. They are ecofriendly and bio-degradable
4. Year round availability of raw materials
5. Transport can be by surface, reducing the transport cost
6. Range of products from dry flowers is many
7. Not dependant on weather or season
8. The raw material is cheap and available year round.

9. Their shelf life is much high compared to fresh flowers
10. Dried flowers are more versatile and they suit modern times.
11. Risk of production is rather less.
12. For export, phytosanitary certificate or quarantine measures are not required.

Selection of materials

- Generally plant/plant part should contain low moisture content and fibrous tissues.
- It should have attractive shape and pattern.
- Stage of the plant at the time of harvest is very important. Early morning or later evening harvest is good.
- The flowers with mass of petals are harvested before fully opened.

Time and season of harvest

Early morning or late evening harvest is more desirable. Mid afternoon harvest has to be avoided because wilting occurs before the process of drying is initiated. Brightest colours are produced during monsoon or winter season, but the plants are susceptible to diseases. Materials harvested during dry or summer months give excellent results.

Steps in dry flower production

Basically these are 3 steps in the dry flower production. They are drying, bleaching and dyeing.

Drying

Since flowers and foliage consists of more water, dehydration is necessary for getting dry flowers. The different methods for removing water from plants are:

1. Air drying
2. Embedding
3. Sun drying
4. Oven drying
5. Microwave oven drying
6. Press drying
7. Freeze-drying

Air-drying

Air drying requires warm, clean dark and ventilated area. Here flowers are simply tied in loose bunches and hang upside down until they are dry. This method is ideal for grasses and many flowers having more of cellulose material. Crisp textured flowers like *Helichrysum* and *Limonium* could be easily dried either by hanging or positioning them errect in containers for 1-2 weeks (Bhutani, 1990). Lourduswamy (1998) reported that Gomphrena flowers from half to full maturity took 7-9 days for air-drying and rose took 5-10 days.

Majority of the upright growing flowers dry their best upside down (Thomler, 1997). Small bunches of a few stems are made, that provide good air circulation and stagged in a way that they do not touch each other. According to Barton (1997) Celosia, *Helichrysum* and Marigold could be dried by hanging them at fully opened stages. Perry (1996) and Rothenberger (1997) studied harvesting techniques and drying methods employed for dry flowers.List of plants suitable for air drying is given in Table.1.

Table 1. Plants suitable for air drying

Botanical name	Common name	Parts to dry
Acacia dealbata	Mimosa	Flowers
Anthemis nobilis	Chamomile	Flowers
Arundinaria spp	Bamboo	Stems
Calendula officinalis	Pot Marigold	Flowers
Callistemon lanceolatus	Bottle brush	Flowers
Celosia cristata	Cocks comb	Flowers
Delphinium ajacis	Larkspur	Flowers
Gypsophila paniculata	Baby's breath	Flowers
Gomphrena globosa	Globe amaranth	Flowers
Helichrysum bracteatum	Straw flower	Flowers
Liatris	Gay feather	Flowers
Limonium sinuatum	Sea Lavender	Flowers
Protea sp	Protea	Flowers
Salvia splendens	Salvia	Flowers
Solidago canadensis	Golden Rod	Flowers
Zea mays	Sweet corn	Seed heads
Zinnia elegans	Zinnia	Flowers

Though air-drying is very cheap, shrinkage of petals is considered to be a major disadvantage. It is also weather dependent and thus cannot be suited for all conditions.

Embedded Drying or Embedding

The method of embedding, choice of the container and the embedding medium are to be taken care during drying flowers. The method of embedding has to be varied to suit the structure of the plant material to be dried. Sand, borax, silica gel, sawdust, perlite and combination of these are used as media for embedding. Among these, sand and borax are cheap but it takes more time and labour for drying. Silica gel is an ideal drying agent for delicate flowers like roses, carnation, dahlia etc. and it takes less time. For the flowers, which have a weak stem, such stems are cut about 2.5 cm from the base of the flower. If the stem is too soft, a thin but strong wire of about 5 cm length is inserted from the back in the centre after removing the flower stalk. About 5 cm layer of desiccants like sand, borax or silica gel with fine particles is made at the bottom of the container and the flower stems are pushed into it so that flowers remain intact. Desiccant is poured slowly, carefully and gently so that all gaps in between petals and other floral parts are properly filled up and the original shape of the flower is kept intact. According to Lourduswamy (1998) French Marigold took 4 days for drying by silica gel embedding.

The embedded plant material is kept at room temperature in a well ventilated room till the plant material gets completely dried. The drying materials should have following properties.

- It should be very fine (0.02-0.2 mm)
- Light weight powders are not suitable for embedding
- It should not react with water vapour released during drying, as well as with the floral parts.
- It should be cheap and easily available.

Champaux (1997) reported that silica gel is the best medium for getting excellent dried flowers that retain colour and shape. According to Naeve(1996) flowers of daffodil,larkspur,aster may be dried using silica gel.

Under Embedding, comes the different types of drying, viz. sun drying, oven drying and microwave oven drying.

Sun drying

Plant materials which are embedded in the drying medium in a container are exposed to the sun daily to facilitate rapid dehydration. This method is also very cheap and also weather dependant. Containers are shifted under a roof during the evening hours. Flowers like zinnia, marigold, pansies, chrysanthemum, etc are embedded in sand in an upside down fashion and kept in the sun, will dry within 2 days. It is reported that flowers of Gomphrena and French Marigold took 3-4 days for drying by this method.

Silhol and Denis (1994) reported that for drying flowers, and herbs, solar drier could be used. Since this method of drying is weather dependant, the quality of the product will be inferior and it fetches little price in the market.

Oven drying

Electrically operated hot air oven at a controlled temperature of 40-50°C is used for drying flowers in an embedded condition. The most important advantage is that drying is faster and the product quality is superior. Standardisation of drying time and temperature were done at NBRI. For drying Helipterum, chrysanthemum, Gerbera and Limonium took 48 hours at a temperature range of 45-49°C. French Marigold took 72 hours, African Marigold took 96 hours and Nymphea took 120 hours at this temperature. China aster, Delphinium, Rose buds and Zinnia took 48 hours, medium and large roses took 72 hours and very large flowers took 96 hours at 40-44°C (Bhutani,1990). According to Raju and Jayanthi (2002) oven drying of China Aster flowers using white sand as the medium is the best for the retention of colour, shape and texture of the dried flowers.

Microwave oven drying

Here, drying is based on the principle of liberating moisture by agitating water molecules in the organic substances with the help of microwaves. Drying is exceptionally fast and gets completed within a few minutes (2-3 minutes) and generates little heat. Quality of the product is superior and fetches premium price in the market. The flowers have to be kept embedded in the silica gel medium in a microwave safe open container for few minutes. The containers after taking out of the oven should be left at room temperature for a particular period so as to evaporate the moisture of the container and the plant material gets fully dried. This is called 'setting time'. Setting time varies from plant species to species. For *Antirrhinum majus* the setting time is 3 minutes where as for Limonium it is 2 minutes. Setting time for Combretum Comosum is 3 hours and that of Nymphaea and Gladiolus is 5 hours.

Time taken for drying specific flowers in a microwave oven is given in Table 2:

Bull (1997) reported that combination of silica gel and microwave oven as the fastest and latest method to obtain truer colour flowers. Microwave drying i.e., the most suitable for clusters of mass florets such as golden rod, gypsophilia and corn flowers (Thomler, 1997). Microwave dried flowers look fresher and more colourful than those obtained by other methods.

Press drying

In this method, fresh flowers and leaves are placed between the folds of blotting sheets or newspaper sheets giving some space in between. The sheets are kept one above the other and corrugated boards of the same size are placed in between the fold so as to allow the water vapour to escape. The whole

Table 2. Time taken for drying flowers in a microwave oven

Flower	Heating time (minutes)	Setting time (Minutes)
Aster	2.5	10
Calendula	2.5	10
Carnations	1.0	10
Chrysanthemum	3.0	10
Daffodils	1.5	10
Dahlia	5-7	36
Dianthus	3.0	10
Larkspur	4.0-5.0	10
Marigold	3.0	10
Orchids	1.5-2.5	24
Rose	1.5	10
Zinnia	4-5	10
Snap dragon	3.0	3 hours
Compretum comosum	1.0	3 "
Delonix regia	3.0	2 "
Bougainvillea	3.0	2 "
Gladiolus	2.5	5 "
Tulip	3.0	15 "

bundle or stack is then placed in the press. These flowers are kept at room temperature for 24 hours and after which it is shifted to hot air oven at a temperature of 40-45°C.Flowers of candytuft, grasses and ferns like Adiatum sp. Nephrolepis sp. and silver fern can easily be press dried.(Kher and Bhutani,1976)

Rothenberger (1997) reported that pressed flowers are suited for the preparation of greeting cards, flower picture etc. The flowers listed in Table.3 produce good results when pressed. However there are many others that may be used and experimentation with those available is suggested.

Freeze-drying

Freeze dried flowers are fresh flowers that have been specially dried to preserve their natural shape, colour and beauty. Freeze drying is based on the process of sublimation. It requires a Freeze drying machine. It involves first freezing flowers at -10°C for at least 12 hours. A vacuum pump slowly pulls water out of the flowers as vapour in one chamber, then vapour condenses in another chamber. Because of this process the natural colour and shape of flower is retained. High vacuum and low temperature are necessary for freeze-drying. For Roses, it takes 15-17 days and for other flowers, 10-12 days.

Freeze dried flowers should be put in to trays of corrugated papers for storage until they are required for further design work. The storage space should be climatically controlled as under,

Table 3. Flowers for pressing or press drying

Common name	Scientific name	Family
Ageratum	*Ageratum mexicanum*	Compositae
Anemone,Wind flower	*Anemone coronaria*	Ranunculaceae
Bleeding heart	*Clerodendron thomsonae*	Verbenaceae
Candy tuft	*Iberis umbelleta*	Cruciferae
Celosia	*Celosia cristata*	Amaranthaceae
Chrysanthemum	*Dendranthema grandiflora*	Compositae
Bachelors button	*Gomphrena globosa*	Amaranthaceae
Cosmos	*Cosmos bipinnatus*	Compositae
Crocus, saffron	*Crocus sativus*	Iridaceae
Daffodil	*Narcissus sp*	Amaryllidaceae
Daisy	*Bellis perennis*	Compositae
Hydrangea	*Hydrangea macrophylla*	Saxifragaceae
Larkspur	*Delphinium ajacis*	Ranunculaceae
Ladys Lace	*Pimpinella monoica*	Umbelliferae
Pansy	*Viola tricolor*	Violaceae

Temperature: -22°C approx,Relative humidity: 45%RH.

Care should be taken during handling and storage.

Freeze dried flowers are finally used to make open baskets, open wreath, open bouquets etc. Freeze dried flowerS are very common in the European countries. It is not popular in India because of its high cost. Major flowers dried by this method are roses, carnations etc. Freezing time and temperature varies with flowers.

Special preservation techniques

Glycerin drying or Glycerining

It is the term used in the ornamental cut flower and foliage industry to describe the treatment of fresh plant materials with a hydroscopic chemical to retain the suppleness of the plant materials. Foliage treated with glycerin keeps almost indefinitely. Fresh and fairly matured foliage is ideal for glycerining. The difference in glycerin treatment is that the flower is actually preserved and not dried. The glycerin concentration varies with plant materials (Table 4).

Table 4. Glycerin concentration for different plant materials

Foliage	Glycerin solution at 60°C
Thick textured foliage	1 part glycerin to 2 parts of H_2O
Medium textured foliage	1 part glycerin to 2 ½ part H_2O
Thin/fine textured foliage	1 part glycerin to 3 parts H_2O

Materials should not be allowed to stand in the solution any longer than necessary, as this will result in

DRY FLOWERS PRODUCED FROM COMMERCIAL PLANT SPECIES 'glycerine bleeding' from these and this can cause a black sooty mould to form as well as being very messy.List of plants suitable for glycerining is given in Table.5

Skeletonizing

Leathery and fibrous textured leaves are skeletonized by treating in soda, acetic acid for a few days. Leaves become slimy and the lamina portions can be removed leaving the vein skeleton. Skeletonizing is difficult and tedious process, and great patience and care are essential for success with this method of preservation.

Skeletionized leaves are also used in the preparation of post cards, paintings and greeting cards. Ficus leaves and Maple leaves are used for this purpose. Glass shades of night lamps and table lamps can also be decorated with dried flower arrangements.

Bleaching

Bleaching is an important step in the processing of plant material to be marketed. This process allows the use of dyes for colouring. For this both oxidative as well as reductive bleaches are used. Oxidative bleaches include sodium chlorite, hypochlorite, peroxides and the reductive bleaches include sulphites.

According to Lourduswamy (1998) and Mirunalani (1999) sodium chlorite 10 per cent solution at 70°C is ideal for

Table 5. Plants suitable for glycerining

Botanical Name	Common name	Parts to glycerinize
Anthurium andreanum	Anthurium	Leaves
Briza sp	Quaking grass	Seed heads
Camellia japonica	Camellia	Leaves
Codiaeum variegatum	Croton	Leaves
Continus coggygria	Umbrella grass	Leaves
Cyperus alternifolius	Umbrella plant	Leaves
Digitalis purpurea	Fox glove	Seed heads
Eryngium sp	Sea holly	Flowers
Eucalyptus sp	Gum tree	Leaves
Fagus sylvatica	Beech	Leaves
Grevillea robusta	Silver oak	Leaves
Gypsophilla elegans	Babys breath	Flowers
Hydrangea macrophylla	Hydrangea	Flowers
Iberis umbellata	Candy tuft	Leaves, flowers
Ilex sp	Holly	Leaves
Iris foetidissima	Stinking Gladwyn	Seed pods

complete colour removal of pink *Gomphrena* flowers into pure white coloured flowers at 7 hours of immersion.

Hydrogen peroxide 30 per cent also take 7 hours for complete colour removal of Gomphrena flowers. Sodium chlorite 15 per cent or hydrogen peroxide 30 per cent in 60°C water recorded complete whitening in dried rose flowers (Yogitachari, 2000). According to Lourduswamy (1998). Sodium chlorite (15%) takes 9 hours for bleaching celosia flowers. Although sodium hypochlorite (15%) took less time (4 hours) at PH 10 for bleaching Gomphrena flowers, cellulose damage and yellowing were observed. Calcium hypochlorite at 3-5 persent at 70 C is economical for bleaching reeds , grasses, ear heads, barks etc.

In reductive bleaches, hydrosulphites (Sodium or zinc) are cheap and have maximum bleaching action at Ph,5.5 to 6.0.

Main problem in using oxidative or reductive chemicals is yellowing. To avoid this, we have to perform multistep bleaching, that is alternating oxidative bleach with a reductive bleach.

Dyeing and colouring

The decorative value of dried flowers can be increased by dyeing. Dyeing dried flowers/plants is a creative fun and they are highly adoptable to the home and the phase of flower arrangement is more popular among women who enjoy using colour and plants for home decoration.

Natural and artificial dyes are used. Booth (1997) suggested a number of dye items for flowers. Systemic dyes are also available. They are acidic-anionic dyes that are combined with water and glycerin to form a preservation solution that is absorbed by cut flowers and foliage through the stem of the plant. Commercial dyes are used for colouring bleached dry flowers for their cheapness and easy colour uptake.Among the twelve colour groups in the dye industry, vat colours and direct colours are found ideal for Gomphrena flowers at .25 per cent concentration and 10 minutes immersion in cold water(Lourduswamy, 1998). For bleached aerva flowers and roses, basic colours are ideal at 0.3 per cent concentration and 15 minutes dipping in 75°C water.

Due to environmental risk of the spent liquids from dyeing process, natural dyes of plant origin are used for dyeing dry flowers. Natural dyes used are dyes from marigold petals, juice from stewed black berries, mulberries, raspberries etc. Artificial dyes include acid yellow, brill red, turquiose blue, methylene blue, acid violet, basic red etc. Westland (1992) reported that commercial dyes can also be used.

To acidify the dye solution for better dye uptake, acetic acid 2.5 ml per litre of dye solution is added. Wetting agents like arbyl, Tween etc is added to heighten tones and colouring. Fragile products, addition of magnesium chloride is essential. Sometimes dye paste prepared using waier is added to diluted methanol to be used as dye solution for dipping flowers. After dyeing the flowers have to be redried.

There are several methods for dyeing plant materials.

- **Dip dyeing**

Ink or food colouring should be mixed in water to which 1-tablespoon alum per gallon has been added. Fabric dye should be mixed with water to desired strength. Dip either fresh flowers or easily re-dried dry materials in solution until desired colour is obtained.

- **Spray dyeing**

Commercial floral sprays, which are not harmful to even the most delicate materials, are used. Ordinary house paints sold in aerosol cans can be used only on heavy textured material such as branches, thick or large leaves, seedpods and cones.

- **Absorption dyeing**

This method of dyeing is used only in the case of fresh materials. Florist absorption dyes can be used. Water-soluble dyes are mixed with glycerin and water, which results in causing both the glycerin and dye to be taken up simultaneously.

- **Gloss treatment**

Spray heavy textured materials with lacquer or varnish to add a shine or permanent finish. Lacquer may be also thinned and brushed on or the materials may be dipped into it.

Packaging

Since dry flowers are made of cellulose materials of plant origin it invites lot of pests. They are hygroscopic in nature, if allowed to absorb moisture, problem of mould infection will occur. The dried flowers should be treated with a suitable biocide and packed in water proof containers. Selection of proper packaging gives proper cushioning and use of moisture barrier packaging materials are of prime consideration.

Dry flowers are fragile and require careful handling. Cardboard boxes, thermocol packing, poly lined or wax paper lined cartons are normally used for packing dried flowers. Boxes must be free from insects otherwise it will cause disintegration of the petals. The dried flower arrangements are to kept in transparent poly propylene boxes (100-200 gauge for display. Moth balls and silica gel pouches should be kept inside the packing to avoid insect and moisture damage.

When the plant parts have to be preserved care should be taken to prevent their damage. Champoux (1997) suggested that storage of dry flowers in boxes after covering with loose tissue paper. According to Dutta (2001) the flowers dried through silica gel are stored by sprinkling some of the crystals on the bottom to prevent moisture from being picked up by them.

Potpourri, bouquet, flower arrangements wreath and handicraft items are packed in card board cartons and robust plant materials are packed in sacks and HDPE trays.

Value addition

Dehydrated flowers and foliage can be used for designing distinctive and artistic greeting cards, landscapes, interior decorative items with dry flowers sealed in glass containers etc. It can be also used in the preparation of pot-pourri, flower baskets, twig baskets, front facing arrangements, mirror frames, table centres etc. Glass shades of night lamps and table lamps can also be decorated with dried flower arrangements. List of exotic dry flower products are listed in Table 6.

One of the most important uses of dry flowers is in the preparation of potpourri. It can be used in bathrooms, kitchens, and cupboards to refresh the air. It provides both fragrance and attraction. Dry and moist potpourri can be made. Dry method is quicker and easier but it won't last long.

Potpourri

Potpourri is usually a mixture of dried, sweet scented plant parts including flowers, leaves, seeds, stems and roots. The basis of a potpourri is the aromatic oils found within the plant. Two kinds of pot pourri can be made-dry and moist. Both methods require a fixative which is responsible for absorbing aromatic oils and slowly releasing them. Common fixatives include finely ground non iodised salt, orris root (dried rhizomes of iris plant), sweet flag (calamus root), gum benzoine, storax and amber gris. The fixatives are to ground finely so that they can better absorb aromatic oil.


Basket
Table centre
Moss tree
Easter chick
Topiary
Floral Crafts
Garland
Wall arrangement

Table 6. Exotic Dry Flower products from India

Exotics	Exotics	Exotics	Mini exotics	Nuts and botanicals
Artichoke	Hibiscus pods	Pine cone	Arjuna fruit	Amra nut
Ata fruits on stem	Jacaranda pods	Pine needle Screw	Arrow leaves	Angel wings
Badam on stem	Jackfruit	Pods	Ata fruit mini	Arjun large
Banana stick	Land lotus	Reed spadix	Cedar rose	Baby wood rose
Bell cup on stem	Land lotus petals	Sorghum head	Coco flower	Casuarina pods
Black berry	Leather fruit	Spider grass	Dew cups	Cedar rose
Blue pine on stem	Lily on stem	Triangular beans	Dew pods	Coco curl
Browny Raffia	Lotus pods	Sponge mushroom	Grass ball	Coco flower
Buddha nut	Luffa	Step fruit	Lotus mini	Coco strips
Cedar rose	Maize cob	Suri spear	Skeleton leaves	Cotton petals
Coco boat	Maize on stem	White bush	Palm cord ball	Curly pod
Corn cob long cut	Palm blute	Wood rose	Pear pod	Mahagony
Curly pods	Palm caps		Skeleton leaves	Pear pod
	Palm male special		Spoon leaves	Star flower
	Palm spear			
	Palm spear round			

Potpourri can be made by blending together 2 to 3 cups of dried flowers, roots and leaves (herbs and flowers), 2 to 3 tablespoons crushed cinnamon, star anise and cloves, ¼ cup dried orange or lemon peel, 2 tablespoons of a fixative and 5 or 6 drops of an essential oil. Mix this in to flowers, cones etc. By doing this the fixative has time to really absorb aroma and oil. Add the essential oil to the fixative and allow that to blend and age for about 4 weeks. Mix this into the flowers, leaves, cones etc.

Herbs such as Artemisia, Thyme, Sage, Rosemary, Basil, Achillea (yarrow), Lavender, Scented geranium, Mint, Verbena and Anise and fennel can be used for scent. The herbs and fruits should be thoroughly dried to prevent mildew.

Potpourri is designed in a glass bowl or a ceramic jar or in muslin or in satin sachets. It is used as a decorative peace and room freshner.

Future thrust

- Educating and training people to understand the concept and product range.
- Market surveys and information both at domestic and international level.
- Puiblicity through multimedia highlighting value additions, export potential and new possibilities for self employment.
- Packaging techniques are to be standardised for dry flowers to meet the international requirements.

- New techniques like freeze drying, vacuum drying etc should be standardised to preserve the natural colour and shape.

Research programmes needed to strengthen the industry.

1. Survey and assessment of native plant species for dry flowers and plant materials.
2. Standardising the appropriate drying techniques for flowers and plant materials.
3. Standardisation of bleaching and dyeing processes using natural and artificial dyes.
4. Assessment of different desiccants and their cost effectiveness to produce bulk quantities of dry flowers of exquisite quality.
5. Standardisation of packaging materials and packing techniques.
6. Standardisation of storage conditions.
6. Development of basic concept on design and contents.

Problems and prospects in Kerala

Dry flowers and plant material have tremendous potentiality as substitute for fresh flower and foliage for interior decoration as well for a variety of other aesthetic and commercial uses. However in Kerala, the potential of dry flower industry on commercial scale has not been exploited so far. Kerala being a humid tropical high rainfall zone, diversity in plant species is quite high. It is one of the very few locations in the world blessed with highly diversified agro climatic conditions. The available technology is generally related to the flora of temperate zone and hence a systematic assessment of the vast wealth of tropical species suitable for drying and further preservation would add to the list of species and types suited for this trade. There is also an immediate need to develop proper base of raw material production in the state to initiate and further the industry. The processing techniques should be standardised so as not to loose colour, firmness and shape of flowers or foliage. Appropriate packing technology also should be developed.

Dry flower production is labour intensive, provides self employment and job opportunities for a large number of workers and aids in the development of subsidiary industries. There is large potential to develop the dry flower industry in Kerala for employment generation, besides providing self employment. It also has potential for earning foreign exchange in view of its universal demand. Even though the value of dry flowers has increased much in the recent years there is relatively little reports on this especially in Kerala. Therefore there is an imperative need to identify plant species/materials for dry flower production and to develop technologies to dry, bleach and dye flowers and other plant parts for commercial exploitation.

Conclusion

The future growth of this industry depends on a combined effort of farmers, growers, manufacturers, exporters of fresh and dried flowers. This industry is labour intensive and associated with subsidiary industries. The sector enjoys the benefit of comparitively low production cost on account of cheap unskilled labour and the availability of divergent plant produce in abundance. The margin of profit is very lucrative, often raising to 100 percent. Sea shipment and road are possible for dry flowers which make the transport much cheaper. Thus this industry as a whole can contribute immensely to area development which in turn lead to the overall development of the nation.

DISCUSSION

1. What is Potpourri?

Potpourri is usually a mixture of dried, sweet scented plant parts including flowers, leaves, seeds, stems and roots. The basis of a potpourri is the aromatic oils found within the plant. Two types of potpourri are there, dry and wet types. Potpourri can be made by blending together 2 to 3 cups of dried flowers, roots and leaves, 2 to 3 tablespoons crushed cinnamon, star anise and cloves, ¼ cup dried orange or lemon peel, 2 tablespoons of a fixative and 5 o 6 drops of an essential oil. It is usually displayed in decorative bowls or sewn into fine linen to scent the rooms or ward robes and to mask unpleasant odours. Potpourri is also used as a air freshner in kitchen, toilets and bathrooms.

2. What is skletanization?

Leathery and fibrous textured leaves are treated with soda, acetic acid and water mixture for few minutes. As a result of this, the lamina portion of the leaves get dissolved and only the veins alone are retained. Usually this technique is practiced in Ficus leaves. Skeletanized leaves can be used for making paintings, post cards and greeting cards.

3. Is it possible to retain the fragrance of dry flowers?

No. Fragrance can be retained only in potpourri preparation. Individual flowers won't retain fragrance.

4. Is there any private company exporting dry flowers in Kerala?

Yes, Synthites, Kolenchery. Its main office is at Karamada near Mettuppalayam in Tamil Nadu.

5. Which are the major competitors of export for India?

Australia, Singapore, Japan, Thailand, Sri Lanka and Netherlands.

6. What are the different types of dyes used in dry flower industry?

There are both natural as well as artificial dyes. Natural dyes include dyes extracted from marigold petals, black berries and synthetic dyes like methylene blue, turquinose blue, basic red, acid yellow, garnet, brill red, direct yellow etc.

7. Does the natural flower retain during drying?

Flowers dried in silica gel retain good colour because silica gel is the fastest acting drying agent. Microwave drying also provides material that look fresher and more colourful than that obtained by other methods. Some colour changes noticed during drying are given below:

1. Yellow and orange are usually well presented
2. Magenta turns to lavender
3. Pure blue acquires a lavender or purplish colour
4. Red generally becomes more purplish or bluish.

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CUT FOLIAGE:
AN UPCOMING AVENUE IN FLORIBUSINESS

SEMINAR REPORT

Submitted in partial fulfillment for the course

Hort 651- Seminar

By

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15.ABSTRACT

Rapid urbanization the world over has resulted in a definite cultural shift in the urban masses and flowers and foliage fit perfectly in the changing social genre. Modern cut flower industry cannot survive without the cut foliage industry and this has emerged as a booming industry in many countries.

Cut foliage refers to the leaves or part of leaves along with stems, branches with or without decorative fruit or other parts of the plant. This can be fresh, or dried and are intended for decoration on its own or in association with flowers in bouquets. Crops selected for cut foliage production should produce foliage with good vase life, colour, texture, stem length and presentation, thus resulting in a viable profitable investment.

Humid tropical and the sub-tropical conditions are considered best for cut foliage production. Globally, more than 140 countries are engaged in the business. India is endowed with diverse agro-climatic conditions suitable for growing a large number of foliage plants. Besides, during the peak demand period in November-March, the weather in India is very conducive for top quality production when the rest of Europe is at a handicap of not being able to grow tropical foliage plants. India also has a competitive edge in the availability of labour and energy at low costs. The foreign exchange earning ability of the industry also compels India to enter international trade (Sharma *et al*, 1999). Indian floricultural industry has identified Kerala as a potential place for cut foliage industry. Known for its natural beauty, Kerala still remains a virgin state with its rich reserve of native flora. Foliages have enough potentiality as an alternative of flowers particularly during lean period but foliage remained unexploited so far (Roy, 2001). A vacuum exists in the export-oriented production of cut foliage in India. Careful allocation of resources can be made by intensive research in this area. Developing domestic markets will impart strength and resilience to the export sector and simplification of import procedures help in exploring new markets. Global potential is vast and Indian industry can tap the substantial share of the same (MNS, 1996). Thus a co-ordinated action of entrepreneurs, technical experts, growers and traders will have a big impact on the cut foliage industry.

CUT FOLIAGE: AN UPCOMING AVENUE IN FLORIBUSINESS

1.INTRODUCTION

Often overlooked in the agricultural sector are the products that enhance the quality of life either through aesthetic properties or environmental enhancing properties. Rapid urbanization the world over has resulted in a definite cultural shift in the urban masses and flowers and foliage fit perfectly in the changing social genre. The potential and scope that the modern protected cultivation technology presents, offer for furthering the floriculture industry.

Floriculture is a billion-dollar industry worldwide and as the traditional strong hold of the west it has projected itself as a worldwide phenomenon in the recent decade. The think-tank of the Indian agricultural sector considers the industry profitable for the developing economy. Of late, floriculture business has taken momentum in India and is gradually being transformed into a profitable business. In the recent past, lots of commercial activities have started in the floriculture sector in the form of joint ventures with leading foreign companies to boost the export of floriculture products. In the sphere of agro-exports, cut foliage trade is identified as an extreme focus segment for rejuvenating the stagnant economy.

Cut foliage industry is an integral part of the green industry, which goes hand-in-hand with the cut flower industry. Modern cut flower industry cannot survive without the cut foliage industry and this has emerged as a booming industry in many countries. In sub-tropical countries like India, it is difficult to get flowers round the year unless artificial conditions are created in the greenhouse, which is a costly affair. The huge demand of flowers, particularly in off-season or lean period, created a vacuum and a real problem for the flower user. Cut foliage has enough potentiality as an alternative for flowers particularly during lean period but they remained unexploited.

2.WHAT IS CUT FOLIAGE?

According to the UN/ECE standards for cut foliage, it refers to the leaves or part of leaves along with stems, branches with or without decorative fruit or other parts of the plant. Foliage of different herbs, shrubs and trees are attractive and are suitable for arrangement. This can be fresh, or dried and are intended for decoration on its own too or in association with flowers in bouquets.

3.RELEVANCE OF CUT FOLIAGE

Cut foliage is used as a filler, lining and background material in various flower arrangements. They are also used for bringing life to the bouquets, wreaths and garlands, which would otherwise look dull. They find their use in interior decoration and make an office, home or a public restaurant look lively with colours. These aesthetic products are in high demand during the annual events and festive time (Naqvi, 1999).

Cut foliages, when compared to the popularly known cut flowers, have the following advantages:

- Lesser cost of production because most of them can be grown in open conditions and this eliminates the additional cost of construction of green houses.
- Year round production of a particular crop compared to cut flowers which are seasonal.
- No strict time limit for storage.
- Lesser risk of damage to quality while transport.
- Longer shelf life.

4.CHARACTERS WE LOOK FOR IN CUT FOLIAGE

Crops selected for cut foliage production are those that are acceptable to the end user and provide an economic return to the grower. According to John Elgar (1998), consumer's preference depend on certain characters like,

- Fresh appearance.
- Longer keeping quality.
- Attractive colours, shape, texture, stem length.
- Freedom from pests and diseases.
- Freedom from external damage.
- Strength to withstand transport and handling conditions.
- Good presentation.

Plants chosen for cut foliage production should have:

- The capability of rapid regeneration after cutting.

Araucaria excelsa

Thuja orientalis

Juniperus excelsa

Codiaeum variegatum

Asparagus setaceus

Monstera deliciosa

- Lower susceptibility to pests and diseases.
- Greater leaf producing capacity.

The final choice for commercial plantings are based on whether a particular variety when grown in a locality will produce foliage that,

- Has the capacity to travel.
- Possesses good vase life, colour, texture, stem length and presentation.
- Is available at high demand periods.
- Is a viable profitable investment

Table 1. Important cut foliage crops of global trade

The horticultural classification of ornamental foliage plants can be as follows:

Sl.No	Categories	Examples
1	Trees	*Araucaria, Pinus, Thuja, Eucalyptus*
2	Shrubs	*Acalypha, Cordyline, Aralia*
3	Creepers	*Asparagus, Monstera, Scindaspus, Philodendron*
4	Annuals	*Coleus, Cosmos*
5	Grasses	Emu grass, Fountain grass, Bear grass, Pampas grass
6	Herbaceous perennials	Golden rod, *Anthurium*
7	Palms	Christmas palm, Chinese fan palm, Areca palm
8	Ferns	Leather leaf fern, Sharon fern, Asparagus fern
9	Other	*Duranta, Callicarpa, Callistemon*

In Florida, most of the cut foliage crops are produced under shade; however there are numerous plants that grow in full sun. A study conducted at the University of Florida showed that the vase life of Milky way and Ruscus increased linearly with increasing shade levels, but was more than adequate at the lower shade levels (Stamps,1997). Some of the foliage plants grown in shaded condition are Milky Way aspidistra, Holland ruscus (*Ruscus hypophyllum*), Vittatus (*Ophiopogon jaburan*) etc. Some of the full sun requiring crops are dogwood (*Cornus florida*), myrtle (*Myrtus communis*), magnolia (*Magnolia grandiflora*) etc.

Foliage plants for cut foliage production are also categorized based on the condition in which they grow. The dry land dwellers are caladiums, red top (*Photinia glabra*), cherry


Anthurium grande


Hosta spp.


Aglaonema spp.


Dieffenbachia spp.


Calathea insignis


Coleus blumei

laurel (*Prunus caroliana*) etc. The wetland dwellers include umbrella plant (*Cyperus alternifolius*), hatpins (*Eriocaulon decangulare*), soft stem bulrush (*Scirpus validus*) (Stamps, 2001). The success of any of these crops will depend on whether they prove to be popular with florists. Furthermore, even if a crop becomes popular, it may not be profitable to produce.

Various new species of plants have been experimented on for use as cut foliage. Among them are *Fabiana imbricata*, which was evaluated at Pescia. Stem cuttings, were taken each month from February to October from plants growing in full or 70per cent sunlight. There was less variation from month to month in the rooting of cuttings taken from shade plants than in that from plants grown in full sunlight. (Mariano et al, 2000)

Pteris tremula is another plant evaluated for cut foliage. It was found that this could be grown in greenhouses with a maximum irradiance of 25000 lux in summer. Minimum vase life was 15 days even after dry storage at 18° and 90-95per cent RH for 3 days or after dry storage at 5° for 5 days. (Farina et al, 1996).

A large number of tropical plants could be used as potential cut foliage, provided they could be produced and handled economically, and has suitable post-harvest characteristics. A study was conducted at the University of Florida for evaluating 57 species of tropical ornamental plants for cut foliage use. Foliage from them was harvested and placed under a controlled indoor environment to determine its post harvest life. Containers were placed on a bench with PPF at container level of 6mols $^{-1}$ m^{-2} from cool-white fluorescent lamps. Photoperiod was 24 hr, temperature was maintained at 23° ± 1°C, and relative humidity averaged 80 ± 10%. Foliage bases were recut with clippers within 1hr of harvest and five replicates of each species were placed in each of the following solutions:

a) deionized water,

b) a 4-hr pulse in 2mM silver thiosulphate (STS) and transfer to deionized water,

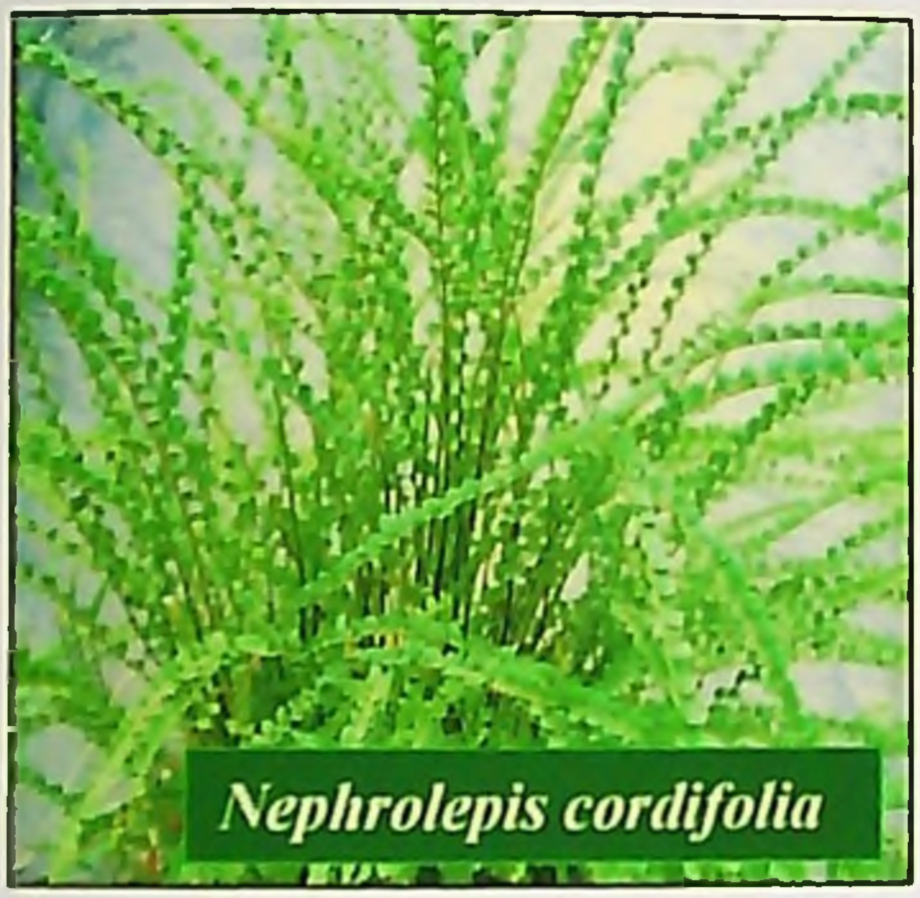
c) a 4-hr pulse in 800 mg l^{-1} 8-HQC plus 20 g liter $^{-1}$ sucrose and transfer to deionized water, and

d) 200 mg liter $^{-1}$ 8-HQC plus 20 g liter $^{-1}$ sucrose for the duration of the experiment.

Leaves were examined daily and those showing signs of wilting, yellowing, or other discolouration, or abscission or necrosis was removed and the number of days from


Licuala grandis


Caryota urens


Nephrolepis cordifolia


Rumohra adiantiformis


Coconut palm leaf cones


Baby blue painted

harvest recorded. The experiment was terminated after 150 days, even though some leaves remained in excellent condition after that time.

Foliage post harvest life in deionised water exceeded 2 weeks for 47 out of the 57 species tested, 20 days for 40 species, and 30 days for 28 species. Deionised water alone was as good as or better than other treatments for 46 species. Post-harvest life of *Asparagus densiflorus* 'Sprengeri', *Calathea rufibarba, Chamaedorea elegans, Cordyline terminalis, Heliconia stricta* 'Dwarf Jamaican', *Philodendron* 'Red Emerald', *Polyscias filicifolia* and *Schefflera* sp was extended beyond that for deionized water when leaves were pulsed for 4 hr in STS and held in deionized water. STS is known to inhibit ethylene activity in plants. However, ethylene does not appear to be the primary cause of senescence in cut foliage for the majority of species tested. Leaves of *A. densiflorus* 'Sprengeri', *Eucalyptus shirleyi* and *Schefflera arboricola* pulsed for 4hr in 800 mg litre^{-1} 8-HQC plus 20 g liter $^{-1}$sucrose lasted longer than those held in deionised water alone, whereas leaves of *Cordyline terminalis, Dasylirion lonissimum* and *Dracaena marginata* held continuously in 200 mg liter $^{-1}$8- HQC plus 20 g liter $^{-1}$ sucrose lasted longer than control leaves in deionised water.

This study shows that foliage of many attractive tropical ornamental plants potentially could be used in the cut foliage industry, although, within a species, many preharvest factors can have significant effects on post harvest lives of cut foliage (Broschat et al. 1987).

Table 2. Top ten plot plants

PLANT	STATUS (X 1,000,000)
Kalanchoe	26
Hedera	19
Ficus	17
Saintpaulia	14
Pot chrysanthemum	12
Dracaena	11
Pot rose	10
Hyacinth	10
Primulas	9
Begonia	8

(Choudhary and Prasad, 2000)

5.PRODUCTION TECHNOLOGY FOR CUT FOLIAGE

According to Elgar (1998), production technology for cut foliage encompasses the following aspects;

- Green house production/out door production, which will include location, aspect, microclimate and wind exposure.
- Labour requirement and availability.
- Distance to market.
- Availability of transport facilities for carrying the produce to auction centers, wholesalers and brokers.
- Consumer demand.
- Level of financial input required.

5.a Climate

Humid tropical and the sub-tropical conditions are considered best for cut foliage production. Temperature is one of the most important factors in the production of cut foliage. Neither high temperatures nor freezing points are preferred. Optimum temperature range is from 25°C to 28°C during day and 18°C during night.

Pittosporum. tobira is a subtropical plant that can be cold damaged in Florida during winters when temperatures dip into the low 20s or colder, especially if cool weather has not proceeded the freezing event(s) and the plants have not become cold acclimated. Some producers freeze-protect pittosporum with water, but using water can lead to ice buildup and broken limbs. If the water supply is interrupted for any reason or if not enough water is applied, cold damage can be more severe than if water was not used.

Ruscus. hypophyllum will tolerate a wide range of temperatures; however, immature stems may be damaged if temperatures drop below freezing and mature stems may be injured during severe freezes. In addition, *R. hypophyllum* will not produce new stems if it does not experience cool temperatures in the fall or winter.

Light is another important factor for cut foliage production. The requirements for light of different foliage plants are different. Most of the cut foliage crops grow well in 50-75per cent shade condition. In Florida, some of them are found to give better foliage in open sun, thus reducing the cost of construction of shade houses. A new technology of growing foliage plants under oak tree hammocks has been followed in Florida. This has also reduced the cost of construction of polypropylene shade fabric covered structures.

A study was conducted by Chen-RiYuan and co-workers at the South China Agric.Univ., Guangzhou, China, to evaluate the shading treatments on growth and physiological effects in *Rumohra adiantiformis*. The results indicated that 70per cent shading promoted leaf growth, increased market yield, and increased the contents of chlorophyll a, b and total chlorophyll, catechol oxidase activity and leaf K content, compared with 50per cent shading.

The effect of different shade levels on the vase life of *Rumohra adiantiformis* (G.Forst.) Ching fronds were evaluated by visual wilting and mass loss measurements. According to visual wilting measurement, fronds from 70 per cent shade net had a significantly shorter vase life than fronds from 70per cent shade net with additional 70 per cent shade net strips. Also a similar one was conducted simultaneously with 80per cent shade net and 80per cent shade net with additional 70per cent shade net strips. However, all the four shade treatments could be used successfully to produce fronds with a long vase life (Van et al, 1996).

A study was conducted to evaluate the effect of shade level on the growth and vase life of 'Milky Way' (*Aspidistra elatior* 'Milky Way' [*A. elatior* 'Minor'], 'Milky Way' cast iron plant), 'Vittatus' (*Ophiopogon jaburan* 'Vittatus', variegated mondo grass), and I/H ruscus (*Ruscus hypophyllum*, Israeli/Holland ruscus). They were grown in the open (0 % shade) and under panels of shade fabric designed to provide 30per cent, 50per cent or 80per cent shade. Plant growth, as determined by estimating percentage plot coverage, was recorded monthly for one year to assess plant establishment/survival, growth and susceptibility to cold damage. After the year of establishment, leaves of 'Milky Way' and 'Vittatus' and stems of I/H ruscus were harvested for vase life evaluations. At each harvest, leaf/stem lengths and weights were determined prior to storage at 40°F [4°C] for two weeks. Shade level only affected the survival of 'Milky Way', which essentially died in full sun. Growth of 'Milky Way' and I/H ruscus increased linearly with increasing shade level, whereas 'Vittatus' grew equally well at all shade levels. Immature foliage of all three crops was damaged during freezes, but in the case of 'Vittatus' only the mature foliage was damaged. Cold damage to 'Vittatus' increased with decreasing shade level. For all three crops, the response of leaf/stem lengths and weights to shade level peaked in the 50– 80per cent shade range. Vase life averaged across three harvests was 52, 33 and 121 days for 'Milky Way', 'Vittatus' and I/H ruscus, respectively. Vase life increased linearly with increasing shade for 'Milky Way' and I/H ruscus, but was the same at all light levels for 'Vittatus'. All three of these perennials are durable florists' greens (Stamps, 1997).

Relative humidity plays a very important role in cut foliage production. Both high relative humidity (RH) and low temperature are important in reducing moisture loss from foliage. At 0°c and 80per cent RH, moisture loss is twice that at 0°c and 90per cent RH (Elgar, 1998).

5.b Soil

Cut foliage crops are very sensitive to soil pH and a slightly acidic soil is preferred. A free draining soil is essential. Inadequate aeration will create a favourable soil environment for the soil-borne fungus diseases. The incidence of such diseases is lower in light, sandy, very free-draining soils (Elgar, 1998).

Pittosporum tobira is not particularly sensitive to soil pH, but it is suggested that the pH should be slightly acidic. Fertile and well-drained soils are preferred, especially to reduce the incidence of *Pythium* root rot.

Ruscus hypophyllum thrives in moist, loamy soils but tolerates a wide variety of soils and soil less growing media. In an experiment conducted under shade house conditions, yield (on a fresh weight basis) was 12per cent higher from pots containing a Florida sedge peat: builders' sand mix (3:1, volume) than from those containing a commercial soil less container mix. The difference in yield may have been due to the greater water-holding capacity of the peat: sand mix and might have been eliminated if watering had been more frequent for plants in the commercial mix.

5.c Planting

Planting can be either in pots or in open field condition. Planting requires investment if done in pots. In the open field condition compacted ground should be sub-soiled to break up any pan that could impede drainage. Where annual weeds and grasses are a problem, spray a 0.6-1 m strip with a desiccant herbicide. Problem perennial weeds such as couch, paspalum, and similar should be sprayed with a suitable non-residual herbicide. If weed problem is widespread, the entire block should be sprayed off.

The strips where the shrubs are to be planted should ideally be rotary-hoed. This enables the roots to spread out quickly into the surrounding soil. When planting out into rotary-hoed ground, the bushes should be planted slightly deeper than appears necessary to allow for the soil to sink and compact. Digging holes for planting often slows down the growth of the plant, because the roots have to penetrate the harder surrounding ground. (Elgar. 1998).

For cut foliage production, pots of three-gallon [11-L] size are most often used when establishing plantings. Optimum plant spacing depends mostly on how large the plants will be allowed to grow in size and how much they will be cut back at each harvest. Pittosporum is sometimes planted too close together initially making it hard for cutters and pesticide applicators to get through the field when the plants reach harvestable size. A spacing of 1.2-meter × 1.8 meters has worked well for many growers (Stamps, 2001)

5.d Irrigation

The irrigation system chosen should be based on

- the crops grown
- method of production
- area of production
- method of application
- water quality
- Cost

If foliar wetting poses itself is a problem, micro irrigation (drip/trickle/spray-jet), rather than overhead irrigation, should be used. Examples of bacterial diseases that are aggravated by foliar wetting are *Pseudomonas* leaf spot of Florida/Holland/Israeli ruscus *(Ruscus hypophyllum)* and *Xanthomonas* leaf spot of English ivy *(Hedera helix)*.

Most cut foliage crops that are grown in containers are big in size and are held long enough to warrant the use of micro irrigation. These systems conserve water, energy and nutrients and, as mentioned above, may help reduce foliar disease problems. However, micro irrigation systems are more costly to install and maintain.

It is necessary to have high quality water and to perform regular maintenance for these types of systems to be successful. Many cut foliage growers are unaccustomed to container production and may forget to take into consideration tho limited water holding capacity of the restricted growing medium volume in containers. Containerized plants may need to be watered more frequently than in-ground grown plants that have more extensive root systems.

Water is used to cold protect crops like leather leaf fern *(Rumohra adiantiformis)* and sword fern *(Nephrolepis exaltata)* that are often grown under artificial shade. Because of this, overhead irrigation systems with low angle sprinkler trajectories must be used to apply water so that ice does not build up on the shade fabric and structure and cause mechanical damage due to its weight. Further, fertilizer and pesticides are applied using irrigation systems for these and many other cut foliage crops. Therefore, it is critical that these overhead irrigation systems apply water uniformly.

A study on the uniformity of 148 overhead irrigation systems used for cut foliage production revealed that only 16 systems (11%) had distribution uniformities (DUs) of 80per cent, the recommended minimum or greater. DUs are a measure of how evenly the water is distributed in the space between a set of adjacent sprinklers and does not address uniformity of the entire irrigation system. Orifice size varied from 13/128" to 20/128" (5/32") for the most uniform systems. Orifice size is only one factor used to design irrigation systems. On the better performing systems, the orifice sizes were appropriate for the sprinkler types, spacings, operating pressures and riser layouts used. While most cut foliage crops are currently irrigated using impact sprinklers with large diameter orifices, those using and/or planning systems with small orifice emitters should pay particular attention to concentrations of bacteria, carbonates, dissolved and suspended solids, hydrogen sulfide, iron and manganese in their water (Stamps, 2000).

Based on all the considerations the irrigation systems are competently designed, installed and well maintained. Micro-irrigation systems conserve water, energy and nutrients, which may help, reduce foliar disease problems. Containerized plants may need to be watered more frequently than in-ground grown plants. Most in ground production occurs on sandy soils with low water- holding capacities and relatively little lateral water movement (Stamps, 2000). Drip irrigation has proven to be the best in the case of plants grown in field condition since it avoids weeds, which in turn reduces pests and diseases.

5.e Nutrition

Nutrition in foliage plants in the field condition depends on the soil tests. When soil tests are carried out it is necessary to look for low nutrient levels. High levels of nutrients were found to destroy the root system (Elgar, 1998). Slow release fertilizers have proven to be the best.

A study was conducted for evaluating the effect of fertilizer along with shading on the foliage quality and yield of *Chrysalidocarpus lutescens*. Application of 1440 kg compound fertilizer (N: P_2O5: K_2O ratio of 20:5:10) per year, resulted in significantly better leaf length, leaf width and yield than when fertilized with 480 and 0 kg per year. Leaf length, leaf width, vase life and yield were improved with 1440 kg fertilizer per year, compared to 480 kg per year. Foliage yields were 19, 23, 25, and 27 slices and the vase life was 12, 14, 15 and 16 days, respectively, with applications of 0,480,960 and 1440 kg fertilizer per year. Although foliage quality was worse under outdoor conditions, fertilizing treatments improved quality and also foliage yield and vase life.

5.f Pruning

Pruning is a controversial subject. Pruning is important in certain plants like leucadendrons in order to replenish foliage growth. On vigorous hybrids like safari-sunset it is desirable to thin some shoots to encourage longer stem. Proteas only need to be shaped, with straggly branches eliminated and unpicked. Leucospermums and banksias need little pruning (Elgar, 1998).

5.g Weeding

Weeding is necessary to control the pests and diseases, which might otherwise find a harbour in them. Weed control is usually practiced by mulching, herbicide application and by hoeing the inter row spaces.

5.h Plant protection

1. Pests

Commonly found pests include the scales, mites, leaf miners, mealy bugs and psyllid. Generally a prophylactic method of constant monitoring is recommended for pest control.

Pests

Leaf roller caterpillars (*Ctenopseutis obliquana; Epiphyas postvittana*):

Regarded as the most significant insect pests of proteaceous plants. The typical symptoms are holes in the leaves or bracts, or chewing damage around the margins. The formation of webbing on leaves or leaves webbed together is also indicative of these pests.

Scale insects (*Phenacaspis eugeniae* - 'waratah scale'; *Parlatoria pittospori*; *Coccus longulus*):

These are white or brown limpet-like insects, usually found on the underside of leaves. Severe infestations result in yellowing or browning of the upper leaf surface - corresponding to the point of attachment of the insect on the underside, and stunting of plant growth can result.

Mites (*Tetranychus urticae* - two-spotted mite; *Panonychus ulmi* - European red mite):

Mites cause silvering and mottling of host leaves or flowers, rendering them unsuitable for export.

Other pests of less significance recorded on proteaceous plants include aphids, cicadas, leaf miners, mealy bugs, and psyllids, all of which should be controlled by regular preventative insecticide application. (Elgar, 1998).

2. Diseases

Commonly occurring pathogens are those causing leaf spot, root rot and blackening. A protective type of fungicide like mancozeb is used for fungal problems.

In the case of proteaceae both root diseases and leaf and stem diseases are common. Root diseases include;

Phytophthora root rot (*Phytophthora cinnamoni*):

The fungus occurs naturally in all soils, particularly those that are poorly drained. PRR is usually first observed as wilting and collapse of plants. Infected roots show browning and rotting.

The best means of control is prevention. Ensure that any proposed sites are adequately drained and that surface ponding does not occur following heavy rain. Where the disease occurs, obviously infected plants should be removed and destroyed. Other plants in the vicinity should have a soil drench of metalaxyl ('Ridomil MZ'), 'Terrazole', or fosetyl-Al ('Aliette'), applied around the root zone. Ensure the soil is thoroughly soaked around each plant to ensure the chemical reaches the roots. Alternatively, foliar sprays of a potassium phosphite-based compound (e.g. 'Foliafos') can be used.

Other soil fungi of less significance occasionally found associated with root rots of proteaceous plants are *Cylindrocladium* and *Fusarium* species. These fungi are generally only a problem when induced by poor drainage.

Leaf and stem diseases include,

Grey mould (*Botrytis cinerea*):

Recorded in NZ and overseas, causing stem lesions and infecting flowers of *Leucospermum* species. Usually seen as a grey-coloured fungus on the infected areas. Ensuring good air circulation within the crop can reduce infection.

Wilt (*Verticillium dahliae*):

This soil-borne fungus has been recorded in NZ on *Protea compacta*. *Verticillium* infects the vascular system of plants, causing wilting and dieback. The recommended method of control is to remove the infected plants.

Silverleaf (*Chondrostereum purpureum*):

Recorded on *Protea* species and on *Leucadendron* 'Safari Sunset' and 'Red Gem' in New Zealand, causing silvering and, in severe cases, yellowing of foliage on affected stems. Entire plants may eventually become infected. The silverleaf fungus enters through pruning wounds or injury sites. To help prevent infection, pruning should be carried out during dry weather and a fungicidal spray such as captafol ('Difolatan') applied to pruning cuts. Only major pruning cuts or injury are considered to be at risk, not normal cuts associated with the removal of flower stems.

Bacterial leaf spot (*Pseudomonas syringae*):

Recently identified as causing a leaf spot on *Protea cynaroides*, where it is usually observed as small (up to 5 mm diameter), occasionally sunken, dark-brown or black well-defined spots. Bacteriocides used for control of *P. syringae* in fruit trees could be tried where the incidence of the disease is of concern.

Leather leaf fern (*Rumohra adiantiformis*) is grown for the cut foliage markets in Europe, the United States and Canada. Warm, moist weather promotes production of the fern, but also favors development of several diseases of leatherleaf fern. Despite the favorable environment, relatively few diseases are common or economically important on this crop grown in Florida.

Anthracnose or Colletotrichum Blight

The disease affects newly emerging fronds most severely by causing them to become blackened preventing development. Older fronds (mature) do not appear to be easily infected. In some nurseries the affected beds look as though a blowtorch has been used on them. Fungicides which may work on this disease include Chipco 26019, Cleary's 3336, Daconil 2787, Dithane F-45, Dithane M-45, Domain, Fore, Systec and Thalonil. Growers should be very careful not to bring in cut fern from the tropics or Florida growers with this disease.

Cylindrocladium Leaf Spot

Spots are pinpoint to inch long and are reddish to grayish brown. They can be water soaked and coalesce to encompass much of the frond. Disease is most severe in the summer but can occur during warm winters. . Irrigation early in the day allows rapid drying of the foliage and can reduce disease spread.

Pythium Root Rot

Plants are grayish-green or chlorotic in color and may wilt. Roots are brown, mushy and reduced (stunted). Disease is rarely severe unless the fernery has poor drainage and excessive winter rains or applications of water for freeze protection are common. Aliette, Banrot, Banol, and Subdue are labeled for this disease on leatherleaf fern. Provide good drainage to avoid development of Pythium root rot.

Rhizoctonia Aerial Blight

Spots occur all over the plants and are dark-brown to grayish, sometimes covering entire fronds. The web-like mycelium of the pathogen frequently spreads up the stipes onto the fronds especially in the center of the plants where the moisture levels are high. Disease is most common in the summer. The fungicides mentioned for anthracnose should aid in control of Rhizoctonia aerial blight. Keep fern cut to allow good air circulation and reduce disease development. Many other cut foliage crops are hosts of Rhizoctonia spp. and disease can readily spread from one crop to another (Chase, 1994)

Spraying of chemical insecticides and fungicides do not ensure the marketability of the produce. Frequent inspections should be made to check for the presence of pests and diseases. Chlorothalonil fungicides are useful in controlling a number of fungal pathogens but heavy applications of the same were found to decrease the vase life of leatherleaf fern fronds (stamps et al, 1997).

The general causes for occurrence of pests and diseases are

- Poor drainage of the soil
- Flourishing weed hosts harbouring the pests and pathogens
- Variability in the pH of the soil
- Irregular pest and disease management
- Improper conditions of growth
- Lack of timely care and monitoring

6. HARVESTING

Harvesting has a considerable influence on the keeping quality of the produce. Atmost care is given to the stage of development and time of harvest to secure the vase life of the produce. Harvesting should be completed in cool conditions either early morning or late in the afternoon when carbohydrate reserve in the leaves are expected to be higher (Elgar, 1998). Certain precautionary measures are also taken to prevent bruises or damage and to prevent the harvest of unwanted materials along with the fresh produce.

Post harvest leaf blackening

"Post harvest leaf blackening" often hampers storage of protea foliage. A few days after harvest, leaves on the flower stem become limp, and within a week develop large deep brown to black areas, especially in the tip regions and around the leaf edges, making the flower stems unsaleable.

The extent of the disorder appears to vary widely between species (particularly affecting *P. neriifolia* and *P. eximia*), individual clones within species, the time of year (higher during summer), maturity of the inflorescences (higher in immature stems), weather conditions at harvest, and the time of day that the stems are harvested (lower when stems are harvested in the late afternoon). It can also occur rapidly during shipping when flowers are packed dry in shipping cartons. Methyl bromide fumigation can accelerate leaf blackening in some species.

Evidence has suggested that the depletion of leaf carbohydrate is the more likely cause. The respiration rate of protea inflorescences is very high. In the field this demand is met by ongoing carbon assimilation via photosynthesis from the surrounding leaves. Once harvested, the stems are shipped in darkness and then placed under light conditions too low for active photosynthesis. Because of the high respiratory demand, leaf starch is rapidly hydrolyzed to sucrose, which is then rapidly transported out of the leaf to the inflorescence. Because of this depletion, the leaf looks to other glucose sources for its energy demand, such as the phenolic glycosides. An enzyme hydrolyses phenolic glycosides to release glucose and toxic phenolics. The highly reactive phenolics can then be oxidised non-enzymatically by free oxygen in the cells, leading to leaf blackening. Blackening is partially retarded by inhibitors of that enzyme such as Zn^{2+} and Cu^{2+} ions, and ethanol (1 minute dip in 30 - 50% ethanol).

Supplying 0.5-1per cent sucrose in the vase solution can retard blackening but the effect is small and unreliable. Continuous treatment with higher concentrations of sucrose tends to aggravate leaf blackening. The efficiency of sucrose supplementation depends on when the stems are given the treatments. Stems packed and shipped immediately and not supplied with added sucrose will lose up to 70per cent of their leaf starch reserves within the first 24 hours. If leaf blackening has already been initiated by this decline, then application of sucrose at a later stage will not have much effect. Therefore, sucrose needs to be supplied as soon after harvest as possible. CA storage of *protea* stems can retard the onset of blackening, but once the stems are removed to air, the leaves blacken within 3-6 hours (Elgar, 1998).

7. POST-HARVEST HANDLING

Post harvest handling includes precooling, conditioning, grading, storage, packing and transport.

7.a Precooling

Cooling is adopted to preserve the harvested produce in a favourable condition. The temperature of foliage at harvest is normally close to that of the ambient air. At this temperature respiration activity is very high temperature, respiration activity is very high. It is done to reduce the moisture loss from the produce by reducing the temperature. According to Aileen Reid and Kevin Seaton (2001) plant material should be cooled as soon as possible after harvest to minimize deterioration. Cooling does this by reducing:

- respiration rates;
- water loss;
- ethylene production;
- sensitivity to ethylene; and
- microbial development (spoilage).

Some of the common cooling methods are.

- Room cooling
- Cold walls
- Vacuum cooling
- Pressurised cooling
- Enhanced cooling.

Rapid cooling technology and forced air-cooling technology offers for better preservation of the produce (Elgar, 1998). This is practiced in the major cut foliage producing countries like USA and Germany.

7.b Conditioning

Conditioning involves the preparation of plant material prior to its arrangement, to ensure that its life is not unduly shortened once it is severed from the parent plant or tree. Correct conditioning will make sure that your foliage last for the maximum time, so that you will get the most value and enjoyment from them. One of the most common causes of wilting in cut flowers and foliage is the presence of an air lock in the stem. The air lock usually forms as the flower is cut, when atmospheric pressure forces air into the water ducts of the stem in which there is normally a partial vacuum.

Containers should be filled to about ¼ full with warm water, to which flower food has been added at the appropriate rate. This will prolong the life of the flowers, and helps to prevent bacterial growth. Using warm water allows the water to enter the stem more rapidly, so conditioning is quicker. However, use cool water for bulb flowers, unless you want them to open quickly. Flowers and foliage should be left in the water for at least two or three hours, and preferably overnight, before arranging them.

One important thing to remember is that stem ends should never be hammered, as this causes damage to the tissues, which leads to a build up of bacteria, thus shortening the life of the material.

Plant material should be conditioned according to its stem type and conditioning varies with different stem types.

Woody Stems (Roses, Mimosa, Eucalyptus, Beech, Yew, Pittosporum, etc.)

Stems should be cut at a sharp angle, and the stem ends split for about ½". Remove all the lower foliage, which will be below the level of the water, and place the stems in a bucket about ¼ filled with warm water, to which flower food has been added at the appropriate rate.

Semi-Woody Stems (Chrysanthemums, Lilies, Carnations, Leatherleaf, Asparagus Fern, etc.)

These should be conditioned by cutting the stem ends at a sharp angle, removing all the lower foliage which will be below the level of the water, and placing the stem ends in a bucket about ¼ filled with warm water, to which flower food has been added at the appropriate rate. Special flower food is available for Lilies, and this should be used if possible.

Soft Stems (Freesia, Hellebore, Anemone, etc.)

Condition as above, but deeper water should be used so that the flowers are immersed up to their necks. After a good overnight drink, the flowers can then be arranged.

Hollow Stems (Delphiniums, Lupins, etc.)

Hollow stems are notorious for forming air locks, as air enters the stem as soon as it is cut. Cut the stems at an angle and remove lower leaves as usual. Turn the stems upside down, and fill the hollow stem with tepid water. Plug the stem with cotton wool, or hold your thumb over it until it is placed in the bucket.

Milky Stems (Poppies, Euphorbias, Poinsettias, Ficus, etc.)

The stems of some flowers exude a milky substance, called latex, when cut. This can be messy, and also can be an irritant if it comes into contact with the skin. Therefore, plant material in this category should have the stem ends cut, and then the end should be burnt in a flame for a few seconds, to seal it. The cut stem ends can also be rinsed under running warm water to remove excess latex, before placing into warm water for conditioning.

Bulbous Stems (Daffodils, Tulips, Bluebells, Hyacinths, etc.)

Most bulbous stemmed flowers are pulled, not cut, from the plant by the grower. This means that the end of the stem is often white and firm. The stem will often not drink from this white area; therefore, it should be removed completely, by cutting at an angle, as water can only be absorbed through the green part of the stem. Bulb flowers should be conditioned in cool to tepid water, unless the flowers are wanted open, as warm water speeds up the development of bulbous flowers. Special flower food for bulb flowers is available, and should be used if possible. Therefore, they should always be conditioned separately. If they are being arranged in water, they should be arranged separately, but if being arranged in floral foam, this is not necessary, and they can be arranged together with other flowers.

Special notes for certain types of material

- Shiny or smooth foliage should always be washed, as this removes any dirt and dust, thus enhancing the appearance
- Single leaves can be completely immersed in water to condition them.
- Grey foliage such as Santolina or Senecio, or woolly foliage such as *Stachys lanata* should never be fully immersed to condition it, as the water is absorbed by the grey covering and the colour of the foliage would be spoiled. Also, these leaves, creating pools of water outside the container, can siphon absorbed water.
- Very new growth, such as spring foliage, should not be used, as it is very difficult to condition, and does not last well.
- Flowers which sometimes wilt even after conditioning, (roses, for example), should have their stem ends re-cut, and the stems placed in very hot or near-boiling water. This destroys the air lock, and enables the plants to take up water again. The heads of the flowers should be wrapped in newspaper to protect them from the steam. When the flowers have revived, (usually after ¼ to ½ hour) re-cut the stem ends, as the boiling water will have damaged them, and continue to condition overnight.
- Carnations and pinks should have their stems cut between the nodes or joints, as they cannot take up water if cut or broken on the node.
- Tulips should be wrapped in newspaper when conditioning, to keep the stems upright, as Tulips tend to "do their own thing" when being conditioned. Tulips continue to grow after being cut, and can grow up to 1" per day. They will always turn towards the light as well, and the flowers will turn upwards if arranged horizontally or almost horizontally. This should be taken into account when using tulips (Harten, 2002)

7.e Storage

Storage is done in waxed corrugated fiberboards or plastic sleeves. Floral preservatives are also used during storage. Flower preservative solutions normally contain carbohydrate, usually in the form of sucrose, plus a bactericide, fungicide, and a wetting agent. These latter chemicals prevent organisms developing in the water and blocking the cut stems, and improve water uptake. The carbohydrate sustains flowers placed in such solutions, but it also tends to speed up their development (Elgar, 1998). There are various formulations for making flower solutions and ready-made concentrates are available for adding to water. These solutions can be used between harvesting and packing at the florists shop, in the customer's vase, or in stem tubes during export.

The effect of floral preservative solution and transportation conditions on the keeping quality of cut stems of Cyperus papyrus was examined. A floral preservative solution consisting of 8-hydorxyquinoline sulfate (8HQC) at 200 ppm, sucrose at 3per cent and BA (benzyl adenine) at 20 ppm (8HQCsolution) affected the opening of bracts and bracteoles of *C.papyrus* and extended its vase life. Vase life was not extended with the pre-treatment with a floral preservative AVB.The addition of 1000 ppm Ca $(No_3)_2$ to 8HQC solution did not have an effect, whereas the addition of 1000 ppm NH_4No_3 effectively suppressed yellowing and wilting in bracts, bracteoles and stems. In addition, supplementing with 0.1per cent bamboo vinegar led to an increase in fresh weight and promoted the opening of young, unexpanded bracts. The results of simulated experiments indicated that a transportation temperature of 5°C tended to induce low temperature injury, observed as browning at the base of stems, but at 10°C the same injury was avoided (Hasegawa et al, 1998).

7.d Grading

Grading is done based on the uniformity and quality of the final produce. The parameters considered for grading are,

- the size and shape of the produce,
- texture of foliage,
- strength, straightness and length of the foliage,
- free from pest and disease attack,
- Development and condition of the foliage.

A study at the Botanic garden laboratory, NBRI, on the vase life of some of the important foliage was conducted to find out their suitability for vase arrangement. Selected foliage was placed in the vase containing plain tap water and kept in room temperature. A few foliage plants stood well and depending upon their vase life, they were graded.

Table 3. Vase life of some ornamental foliage

Sl.No.	Name of foliage	Vase life (days)	Grades
01	*Epipremnum aureum*	15-20	Excellent
02.	*Epipremnum aureum Wilcoxii*	15-20	Excellent
03.	*Setcreasea purpurea*	06-07	Good
04.	*Melaleuca decora*	06-07	Good
05.	*Hibiscus liliflorus 'Variegatus'*	05-06	Good
06.	*Acalypha wilkesiana 'Hoffmanii'*	05-06	Good
07.	*Polyscias balfouriana 'Marginata'*	04-05	Good
08.	*Polyscias balfouriana 'Pennockii'*	04-05	Good
09.	*Melaleuca genistifolia*	02-03	Moderate
10.	*Duranta repens 'Variegata'*	02-03	Moderate
11.	*Russelia juncea*	02-03	Moderate
12.	*Acalypha wilkesiana 'Ceylon'*	02-03	Moderate
13.	*Graptophyllum albomarginatum*	02-03	Moderate
14.	*Pedilanthus tithymaloides*	02-03	Moderate
15.	*Euphorbia cotinifolia*	01	Poor
16.	*Aerva tomentosa*	01	Poor
17.	*Pseudoeranthemum nigrum*	01	Poor

(Roy, R.K., 2001)

7.e Packaging

Packaging is done based on the uniformity of the produce. Each unit of presentation (whether a bunch/bouquet/box) should have a fairly uniform quality. Ultimately the visible part of presentation should be a representative of the entire contents of the unit. All the containers should be marked with the grade and quantity they contain, and the quantity per container should be kept constant. Damage while transit is likely to occur when the container is not firmly packed (Elgar, 1998). The packing material used should be of a high quality, which will avoid causing any internal or external damage.

7.f Marketing

Every grower should visit the markets regularly to be familiar with demand and the standards prevailing. This is essential so that the growers know how their products compare with those of other growers. Marketing of the produce is mainly done through auction houses, wholesalers, and retailers. Presentation of the produce plays a major role in auctioning. It is best to keep foliage in bunches and in containers, when very large consignments are involved i.e.. a limited colour range should be the criteria. Buyers are often looking for a specific colour and less damage may result if such bunches can readily be taken out of the container.

For easy auctioning, containers with one particular grade, marked with the grade and quantity are used. Important strategies for marketing include,

- Continuous supply
- Constant high quality
- Best possible assortment.

8.CRITERIA FOR ECONOMIC PRODUCTION

It is a clear gamble to start a not so popular industry. Some of the significant production criteria are:

- Resource based production.
- Diversification of the crops
- Higher proportion of crops meeting the export criteria
- Selection of plants with longer productive life
- Value addition

At present, there is no market of foliage and availability is remote in the florist shop as the people are not much aware of foliage arrangement. Once the popularity of the foliage arrangement is increased, the availability will also increase in the market. Fascinating arrangements are possible with foliage plants. Selection of foliage is most important because the beauty and display of the arrangement is entirely dependent on the type of foliage used. The criterion to be considered are – colour, texture, shape and suitability of the leaves for arrangement. Dark green, glossy and coloured leaves are preferred. Texture of the leaf is another character, which should be considered. As the leaves are not attractive like flowers the containers used are of immense importance. Selection of the containers depends on the type of the foliage used, their colour, length, texture etc. Long neck flower vases are ideal for having a desired effect.

There are also leaves other than the foliage used in the vase arrangement and are placed in between spaces in order to enhance the elegance of the arrangement. The main considerations are their colour, texture and, most critically, compatibility with the main foliage used is the main consideration. Leaves of the following plants are used as fillers – *Asparagus spp, Chlorophytum comosum* 'Variegatum', *Chorophytum comosum* 'Vittatum', *Microsorium punctatum, Nephrolepis biserrata, Ophiopogon jaburan 'Variegatum', Solidago nemoralis* (Roy, 2001).

9.STATUS OF CUT FOLIAGE INDUSTRY IN THE WORLD

Globally, more than 140 countries are engaged in Floribusiness. Nearly 54 countries are major importers and 50 countries are major exporters of floricultural products. US is the largest producer of floricultural products. It has also proved to be a competitive market. Latin American countries like Costa Rica, Guatemala are important producers together with Columbia, Spain, Kenya and Zimbabwe (Sharma et al, 1999).

Australia is another exporting giant of cut cultivated greens. In 1999, Australian export was around $ 2.6 million. Major importers from Australia include Japan, Netherlands and Spain. Australia imports foliage worth $ 2,00,000. Australia's suppliers are Singapore, New Zealand, Spain, Malaysia, Philippines and Sri Lanka.

Among the importers countries, Norway, Germany, Denmark, U.S.A., France, U.K., Netherlands, Italy, Switzerland, Austria, Sweden, Japan are the major countries and they together account for 85 per cent of the total world import.

Among the Asian producers Sri Lanka is the major one. A wide range of foliage plants produced to buyer's specifications is exported to the Netherlands, Germany, Italy, Japan, and France and to the Middle East.

Table 4. Top ten destinations of Indian floriculture produce in 1997-98

Country	Export value, Rs. crores
U S A	19.79
Netherlands	17.73
Germany	10.44
Japan	8.31
UK	6.57
Italy	3.56
France	2.12
Australia	1.75
Singapore	1.72
Spain	1.55

(Source: APEDA)

10.SCOPE IN INDIA

India is endowed with various agro-climatic conditions suitable for growing a large number of foliage plants. Abundant sunshine throughout the year especially in autumn and winter is very advantageous for the year round production without depending on artificial light. India also has a wide range of soil types suitable for growing different varieties of foliage plants. There is a relative nearness to the new emerging markets like Japan, Australia and the Middle East. Besides, during the peak demand period in November-March, the weather in India is very conducive for top quality production when the rest of Europe is at a handicap of not being able to grow tropical foliage plants. For the markets for Indian cut foliage, Europe is identified as an emerging one. Along with Europe other Asian countries like Japan, Hong Kong, Singapore, and others are also emerging as important ones because Netherlands, one of the acknowledged world leader in exports is planning to target East European markets. This will lead to a vacuum in the coun.ries for floricultural products.

The potential for exports from India is enormous and the Indian industry can have a competitive edge in the international markets for reasons of availability of labour and energy at a low costs, favourable investment environment, availability of critical inputs and climatic conditions. Apart from this the compelling reason for India to enter the world trade of cut foliage is the abundant foreign exchange earning ability when compared to cereals and other farm products. The global floricultural trade is expanding @ 15per cent per annum, whereas in India the annual growth is around 7-8per cent.

After the advent of protected cultivation technology in India, ICAR, CSIR and SAU'S have initiated a number of projects to evolve indigenous cost-effective production technology. Protectnet, a comprehensive research programme launched by the ICAR nearly 4 years ago to address some of the problems, is at its fag end and the final results are awaited. In continuing its efforts the ICAR has also launched a multilocational, multi-disciplinary research programme under the aegis of NATP to develop production modules suitable for protected cultivation in different agroclimatic conditions. Similarly the results obtained from other projects of different organizations are slowly pouring in and the technologies can be harnessed for future growth of the industry. The future lies in exploring new emerging markets like Australia, Japan and Middle East, which can be reached faster due to geographical locational advantage.

Government of India and various governmental organizations are providing considerable support to develop commercial floriculture in India. With the liberalization of industrial and trade policies, export oriented production of floricultural products have boosted up. Floriculture is been identified as one of the thrust areas for setting up of Export oriented units. The National Horticulture Board has made provision for loans at 20 per cent subsidy up to a maximum limit of Rs.1.25 crores for setting up of infrastructural facilities like cold storage, pre-cooling units, packaging and grading facilities and refrigerated transport. Refinance assistance is available from NABARD to a number of hi-tech units at reasonable interest rates. The ministry of Agriculture through APEDA is implementing a project, which provides for the setting up of infrastructure for promoting exports. Subsidies are provided up to 50 per cent for the infrastructural facilities. Nine model floriculture centers have been set up in the public sector and 8 more in the private sector. Along with this 20 small tissue culture units have been established by the Ministry of Agriculture with an allocation of 10 crores. Model markets with cold storage facilities are proposed to be established in various centers like Delhi, Mumbai, Chennai, Calcutta, Hyderabad, Pune and Bangalore by APEDA in collaboration with central and state governmental agencies.

The import duty has been decreased from 55 per cent to 10 per cent for the floricultural products. Import duty on machinery has also decreased to 25 per cent.

Table 5. Export of floriculture products from India (1998-99)

Product group	Quantity	Value	
		Rs. in crore	%
Bulbs, tubers, tuberous root corms, rhizomes chicory dormant, growing, in flower etc.	1889.69 (000 No.)	1.11	1.05
Other live plants incl. Rooted cuttings, slips, mushroom spawn, etc.	2971.96 (MT)	10.51	9.92
Cut flowers flower bulbs, suitable for bouquets/orna-mental purposes -fresh, dried, dyed, bleached, impregnated	11017.78 (MT)	76.16	71.87
Foliage, branches, other plants parts, mosses for bouquets/orna -mental purposes – Fresh, dried, dyed, bleached etc.	3076.19 (MT)	18.18	17.16
Total (000 No.) (MT)	1889.69 17865.93	105.96	100.00

Table 6. Imports of floricultural products from India by selected countries

Cut flowers/foliage (value: US $ million)

YEAR	1990	1991	1992	1993	1994
Germany					
Total Imports	1186.84	1415.60	1503.87	1037.27	1102.80
Imports from India	1:61	1.94	1.99	2.28	3.11
India's Percentage Share	0.14	0.14	0.13	0.15	0.28
USA - Puerto Rico					
Total Imports	459.73	450.86	488.35	525.09	573.92
Imports from India	1.52	2.15	2.78	3.17	5.02
India's Percentage Share	0.33	0.48	0.57	0.60	0.37

Netherlands					
Total Imports	244.05	275.02	349.25	327.32	375.57
Imports from India	0.45	0.44	0.62	0.77	1.34
India's Percentage Share	0.18	0.16	0.18	0.24	0.49
United Kingdom					
Total Imports	324.04	331.38	342.38	315.83	336.07
Imports from India	0.04	0.17	0.25	0.78	0.99
India's Percentage Share	0.01	0.05	0.07	0.25	0.29
France					
Total Imports	324.79	350.90	335.42	258.68	285.13
Imports from India	0.27	0.49	0.12	0.15	0.27
India's Percentage Share	0.08	0.14	0.04	0.06	0.09
Japan					
Total Imports	126.97	155.54	140.17	174.35	215.48
Imports from India	0.13	0.13	0.16	0.11	0.24
India's Percentage Share	0.10	0.08	0.11	0.06	0.11
Italy					
Total Imports	114.76	143.84	143.45	144.05	134.06
Imports from India	0.71	0.99	0.96	1.04	1.34
India's Percentage Share	0.62	0.69	0.67	0.72	1.00
Austria					
Total Imports	97.80	101.54	103.39	96.46	106.22
Imports from India	0.05	0.05	0.10	0.13	0.15
India's Percentage Share	0.05	0.05	0.10	0.13	0.14
Canada					
Total Imports	51.89	47.19	50.99	55.61	59.82
Imports from India	0.03	0.04	0.07	0.11	0.11
India's Percentage Share	0.06	0.08	0.14	0.20	0.18

Denmark					
Total Imports	36.86	39.10	41.39	49.30	49.90
Imports from India	0.00	0.04	0.13	0.19	0.12
India's Percentage Share	0.06	0.18	0.31	0.39	0.24
Spain					
Total Imports	26.75	37.77	44.53	30.45	29.35
Imports from India	0.20	0.22	0.26	0.19	0.16
India's Percentage Share	0.75	0.58	0.58	0.62	0.55
Mexico					
Total Imports	2.49	4.09	10.29	14.15	17.13
Imports from India	0.00	0.00	0.00	0.00	0.72
India's Percentage Share	0.00	0.00	0.00	0.00	4.20
Australia					
Total Imports	7.56	5.54	5.05	4.18	5.50
Imports from India	0.06	0.11	0.09	0.08	0.14
India's Percentage Share	0.79	1.99	1.78	1.91	2.55
Oman					
Total Imports	2.20	2.24	3.03	2.64	2.39
Imports from India	0.06	0.12	0.32	0.01	0.03
India's Percentage Share	2.73	5.36	10.56	0.38	1.26
Sri Lanka					
Total Imports	0.01	0.00	0.06	0.27	0.51
Imports from India	0.001	0.00	0.06	0.12	0.27
India's Percentage Share	0.00	0.00	0.00	44.44	52.94

Total value	3394.64	3777.84	4033.42	3184.41	3739.21

11.OPPORTUNITIES IN KERALA

Indian floricultural industry, standing on the verge of commercialization has identified Kerala as a potential place for cut foliage industry. The agro-ecological situations prevalent in the state, provides great potential for flourishing of a strong floriculture industry in the state. Known for its natural beauty, Kerala still remains a virgin state with its rich reserve of native flora. These have not yet been systematically harnessed for evaluation, large-scale production and income generation. The humid tropical climate prevailing in the state is very congenial for cultivation and production of a variety of foliage plants. The zonation of Kerala with respect to commercial floriculture also gives due importance to foliage plants in the state. In order to exploit the diversity in landforms and agro-ecology, the state can be divided into four zones.

Table 7. Floriculture zonation of Kerala.

SL.NO.	ZONE	FEATURES	SUITABLE CROPS
1.	Palakkad district	Low rainfall, low humidity areas with cheap labour.	Jasmine, crossandra, marigold, tuberose
2.	Hill zone I	Up to 1500 meters above MSL	Anthurium, rose, carnation, gladiolus, gerbera.
3.	Hill zone II	More than 1500 meters above MSL. Poly house condition will be necessary for certain crops.	Cymbidium orchid, lilies, bird of paradise, alstroemaeria.
4.	Other areas	Plane land, including coastal areas.	Orchid, anthurium, foliage plants.

(Rajeevan, 1999)

Considering the potentiality of Kerala, the Government of India has established a Model Floriculture Center and tissue culture unit at the capital city.

12.CONCLUSION

A vacuum exists in the export-oriented production of cut foliage in India. In order to fill this vacuum certain strategies are to be employed. India is lacking in hi-tech post-harvest handling technology. The export enhancement programme, Therefore should envisage following basic strategies;

- A high-tech export oriented post-production needs of Importation of technologies such as pre-cooling cold storage/refrigerated/transport facilities,
- Up-gradation of growing structure, technology and increasing the number of EOU's at a faster rate, construction of auction houses in the important metropolitan cities,
- Developing domestic markets within the country will impart strength and resilience to the export sector,
- Diversification of crops for export,
- Raising trained man power on operational and managerial aspects,
- Intensive location specific research on production aspects,
- Co-ordinated action of entrepreneurs, technical experts, growers and traders.

14.DISCUSSION

1. Why don't people in Kerala take up the business on a commercial scale?

The production is presently taken up on a very small scale and the supply is only to the local markets of Kerala. There is localized production of certain foliage plants like Aralia, Evergreen, Crotons, Palms and Ferns. Mostly the production is taken along with cut flower production.

2. Is the packaging practices the same as that for cut flowers?

Packaging practices are similar to that of cut flowers. The advantage over cut flowers in packaging is that foliage can be packed in greater numbers than flowers. When flowers are packed in large numbers there is a possibility of loss in quality and luster but this does not happen in the case of foliage.

3. Kerala is rich in its native flora. But when they are exploited for cut foliage, will there be any acceptability?

New introductions of foliage plants as cut foliage will help in increasing its popularity. Kerala is at a greater advantage of having a diverse collection of foliage plants still left untapped. Acceptability of these foliage plants will depend upon the cost, quality and the innovative parameters, which is the basis for profitability and feasibility of the business.

4. Is there any export from Kerala?

There is a very negligible export of cut foliage from Kerala. Rather than cut folinge, foliage plants are exported. Most of the cut foliage production in Kerala is restricted to the domestic markets.

5. About 95% of the flowers come from TamilNadu. In such case how profitable will it be when cut foliage production is taken up here?

The 95%flowers from Tamilnadu are loose flowers. Flowers are more sensitive to weather parameters than foliage. Foliage plants do well in humid tropical conditions, which is experienced in Kerala. The production of foliage plants cannot be taken up in TamilNadu because the weather is not congenial for the growth of the foliage plants.

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1017

ANTI CANCEROUS MEDICINAL PLANTS

Submitted by,
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2001-11-19

SEMINAR REPORT

Submitted in practical fulfillment of the requirement for the course

Pbgen. 651 SEMINAR

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ABSTRACT

Though we live in computer or space age sadly enough, still we struggle for our survival. Cancer is one which appears to be an unconquerable danger facing mankind. Even million of Rupees cannot cure the sudden and shocking growth of billions of killing tissues. The cancer is one which rank first among the human ailments that still seem to elude effective treatment and it is tragic that the incidence of this dreaded disease is on the increase in India.

The major form of cancer treatment relies on surgery and radiation, even though both have toxic side effects resulting in damaging immune defense system. As an end to this, molecules must be provided which are able to activate the normal cells with out enhancing the cancer cell multiplication. This can be expected only from biological molecules. In this context anti cancerous medicinal plants are gaining more importance.

Plants have been used in treatment of cancer for over 3500 years. It was from a plant called *Vinca rosea* that a drug controlling cancer was first isolated and marketed in 1961. This wonder drug was vincristine. The anti cancer drug paclitaxel was first isolated from the stem bark of pacefic yew and this is the first choice drug for tumours. Other important plant derived anticancer drugs include camptothecin, podophyllotoxin, colchicine etc.

Apart from this there are many plants indigenous to our state which have potent anticancer property. This include Withamia, Ophiorrhiza, Plumbago, Emilia, Oleander and also many common weed plants which are menace to agriculture. Eventhough innumerable plants possessing anticancerous properties have been identified only seven drugs get the approval of FDA. In the coming days systematic research effort should be oriented towards the screening, selection and improvement of these plants wild relatives and other members of the family which already possess and may possess antitumour principle.

ANTI CANCEROUS MEDICINAL PLANTS

1 INTRODUCTION

Man has depended on herbs for curing diseases Since ancient times, almost as ancient as the orgin of human race. Mention curative herbs in the Regveda seems to be the earliest written record of use plants in medicine. The growing realisation of the toxic effect of Synthetic drugs and antibiotics has led to the popularisation of herbal medicine and their derivatives not only in the developing countries but also in USA and Europe. Among the many human ailments that still seem to elude effective treatment Cancer ranks for most and it is tragic that the incidence of this dreaded disease is on the increase in India.

'Cancer' is a general term applied to a series of malignant diseases, which may affect different parts of the body. Most forms of Cancers are characterised by repeated divisions of a cell that become abnormal, defying the normal control system of the cell. A sudden abnormal activity in the midst of normally growing cells leads to serious cosequenus. If the disease is not detected in the early stage, the problem aggrevates. It is also possible that some cells get detached and float through the blood stream or lymph to other parts of the body where they start resting, eventually spreading the disease to other parts of the body. Thus Cancer is basically due to uncontrolled division of cells and a control of this menace should be related to the control over the prouss of cell division.

2 IMPORTANCE OF ANTI CANCEROUS MEDICINAL PLANTS

The major form of cancer treatment even today, primarily relies on Surgery and radiation, Even though every one is aware of the high cell toxicity of drugs and ionising radiation commonly used for conventional cancer therapy. The two main immediate dangers are chromosome breakage and destruction of the bonemarrow cells, As result immune defences are highly impaired or even destroyed. To this end, molecules must be provided which are able to activate the necessary genes in the cells at risk so as to maintain normal physiological count with out enhancing Cancer cell multiplication. The difficulty lies in finding such highly specific molecules, capable of knowing precisely where to go and act in the body. Such a feat can be expected only from biological molecule. Here comes the importance of medicinal plants.

Plants ha been used in treatment of cancer for over 3500 years (Hartwell, 1967) but it is since 1959, that a concentrated systematic effort has been made to Screen crude extracts of plants for their inhibitory activity against animal tumour system. The plants have provided with wide range of anti tumour active principles which falls under alkaloids, terpenoids and flavonoids. Herbal medicines are gaining popularity day by day and recently Scientist are suggesting simple herbal based recepied for the benefits of the ailing humanity, specially in primary health care programme. Today there are at least 120

distinct chemical substance derived from plants that are considered as important drugs, currently used in one or more countries in the world.

3 IMPORTANT PLANTS YIELDING ANTICANCER DRUGS

PLANT NAME	RELEVANT MEDICINAL COMPOUND
Perwinkle	Vinblastine, Vincristine, Vindesine, Vinorelbine
Podophyllum,Golden flux	Podophyllo toxin
Taxus sp.	Taxol or paclitaxel
Chineese Happy tree	Camptothecin
Nothapodytes *Tabernae montana*	
Colchicum, *Glory lily*	Colchicine
Lapacho tree	B-lapachone & lapachol
White birch tree	Betulinic acid
Arnebia sp.	Arnebin - I&III
Three wing nut	Tripdiolide & triptolide
Japaneese plum yew	Harring toxine, deoxy harring tonine isoharringtonine and homoharringtonine
Garlic	Diallyl trisulphide, Diallyl disulphide
Turmeric	Curcumin
Ixora	Ursolic acid
Plumbago	Plum bagin
Oleander	Oleandrin
Solanum trilobatum	Sobatum
Podocarpus	Nagilactone
Liquorice	Isoliquiritigenin
Viscum album	Mislatolectin

4 (a) *Catharanthus roseus*

Common name : Periwinkle.

Family : Apocynaceae.

Malayalam name : Savamnari, Nithya kalyani.

Constituents : Vinblastine, Vincristine and Vinorelbine.

Periwinkile of family Apocynaceae has been recognised as one of the most important plant for cancer therapy. It was from this plant, a common weed on waste land with pink or white flowers exuding a milky juice on injury that a drug controlling cancer was first isolated and marketed in 1961. This wonder drug is effective in arresting the cell division. Common supplies of drug are obtained from wild as well as cultivated sources. Plant accumulate more than 125 alkaloids of the two alkaloids vincristine and Vinblastine are active in human system. They are together called as Vinca alkaloids.

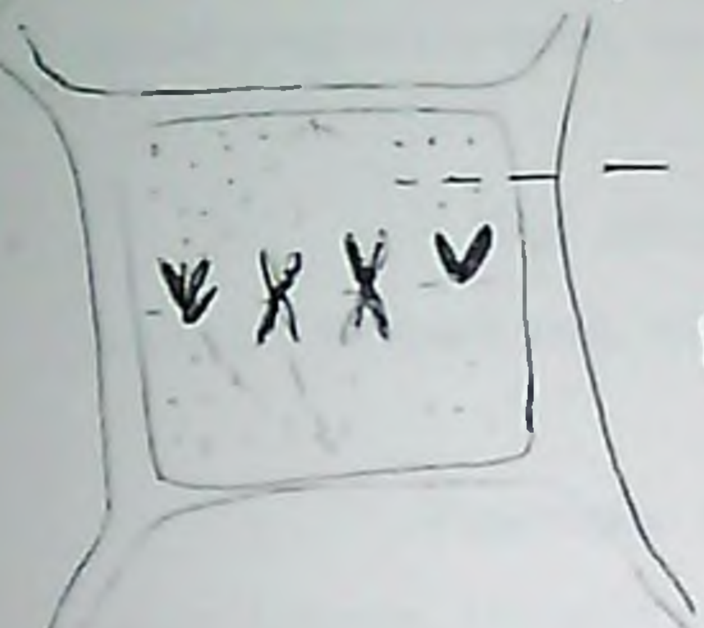
4 (b) ACTION OF VINCA ALKALOIDS

Vinca alkaloids work by inhibiting mitosis in meta phase. These alkaloids bind to tubulin, thus preventing the cell from making the spindles it needs to be able to move its Chromosomes around as it divides. These alkaloids also seem to interfere with cell's ability to Synthesise DNA+RNA.

They are all administered intravenously in their Sulphate form once a week, these solutions are fatal if they are administered any other way, and can cause lot of tissue irritation if they leak out of vein.

NORMAL MITOSIS

PROPHASE



METAPHASE

Metaphase withou
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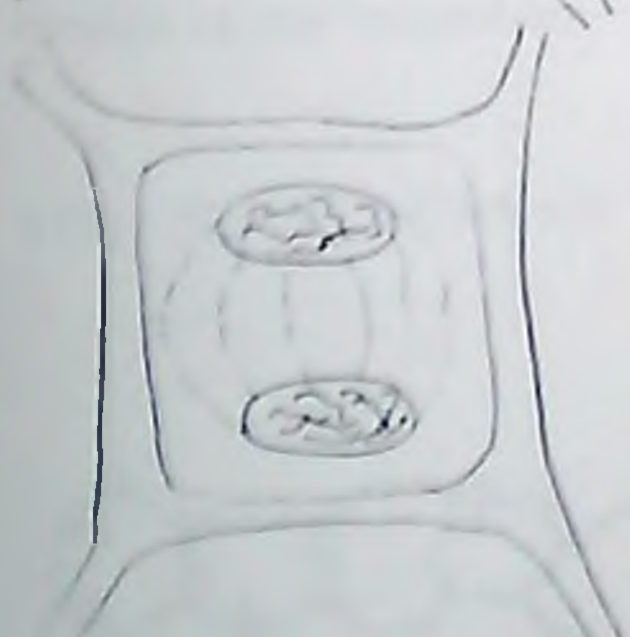
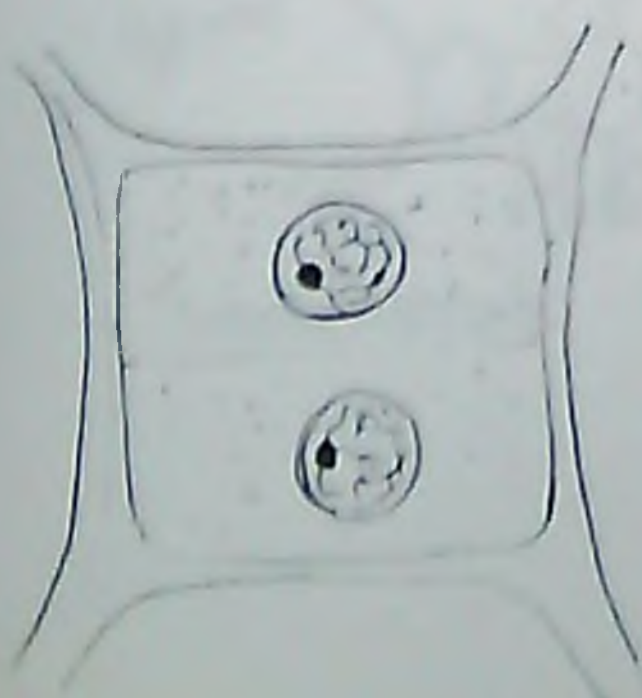
ANAPHASE



TELOPHASE



CYTOKINESIS

4 (c) CLINICAL USE

Vinblastine: It is mainly useful for treating Hodgkin's disease, lympocytic lymphoma, histiocytic lymphoma, advanced testicular cancer, advanced breast cancer, Kaposi's Sarcoma and Letterer Siwe disease.

People with bacterial infections should not be given this drug, nor should pregnant women, since it caused severe birth defects in animal studies.

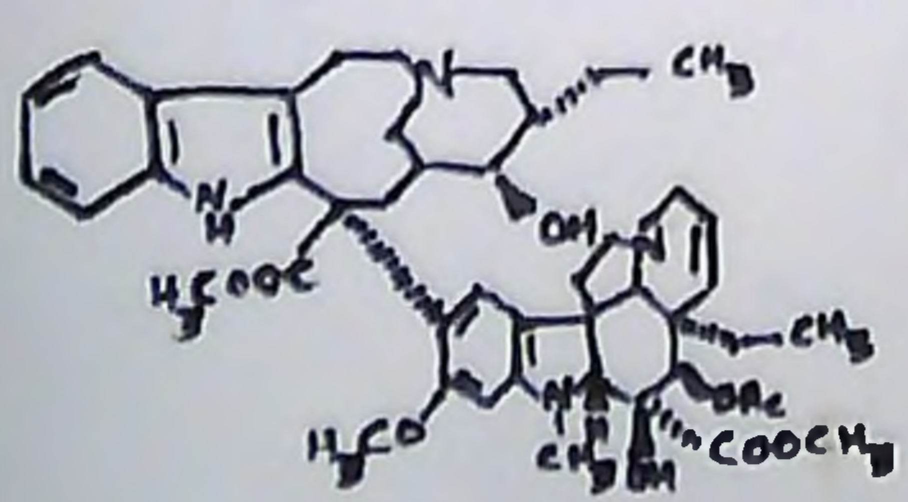
Side effects includes hair loss, nausea, lowered blood cell counts, headache, stomach pain, numbness, constipation and mouth sores.

Vincristine : It is used mainly to treat acute lukemia, rhabdomysarcoma, neuro blastoma, Hodgkin's disease and other lymphomas.

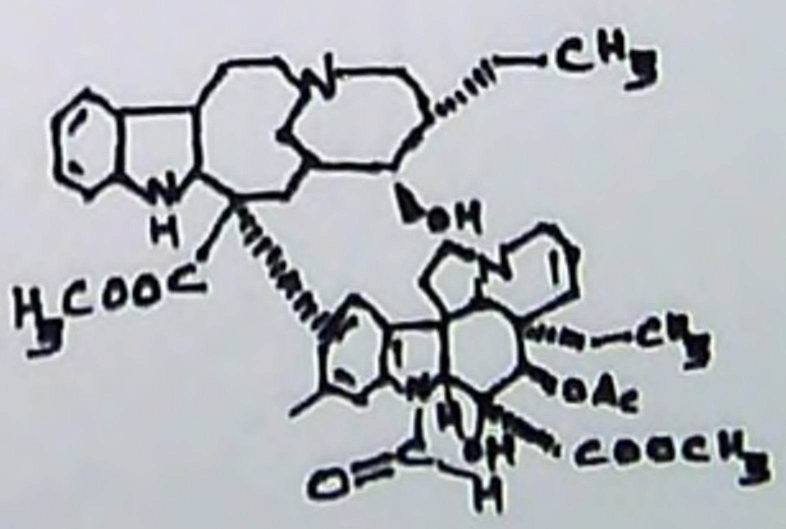
Side effects include those found with vinblastine, plus nervous system problem such as Sensory impairment.

Vindesine and Vinorelbine : They are semisynthetic derivatives of vinblastine. They are mainly used in the treatment of lung cancer, melanoma and overian cancer respectively.

4 (d) STRUCTURE OF VINCA ALKALOIDS



VINBLASTINE



VINCRISTINE

5 (a) PODOPHYLLUM

Scientific name : *Podophyllum peltatum* (American podophyllum)
Podophyllum hexandrum (Indian podophyllum)

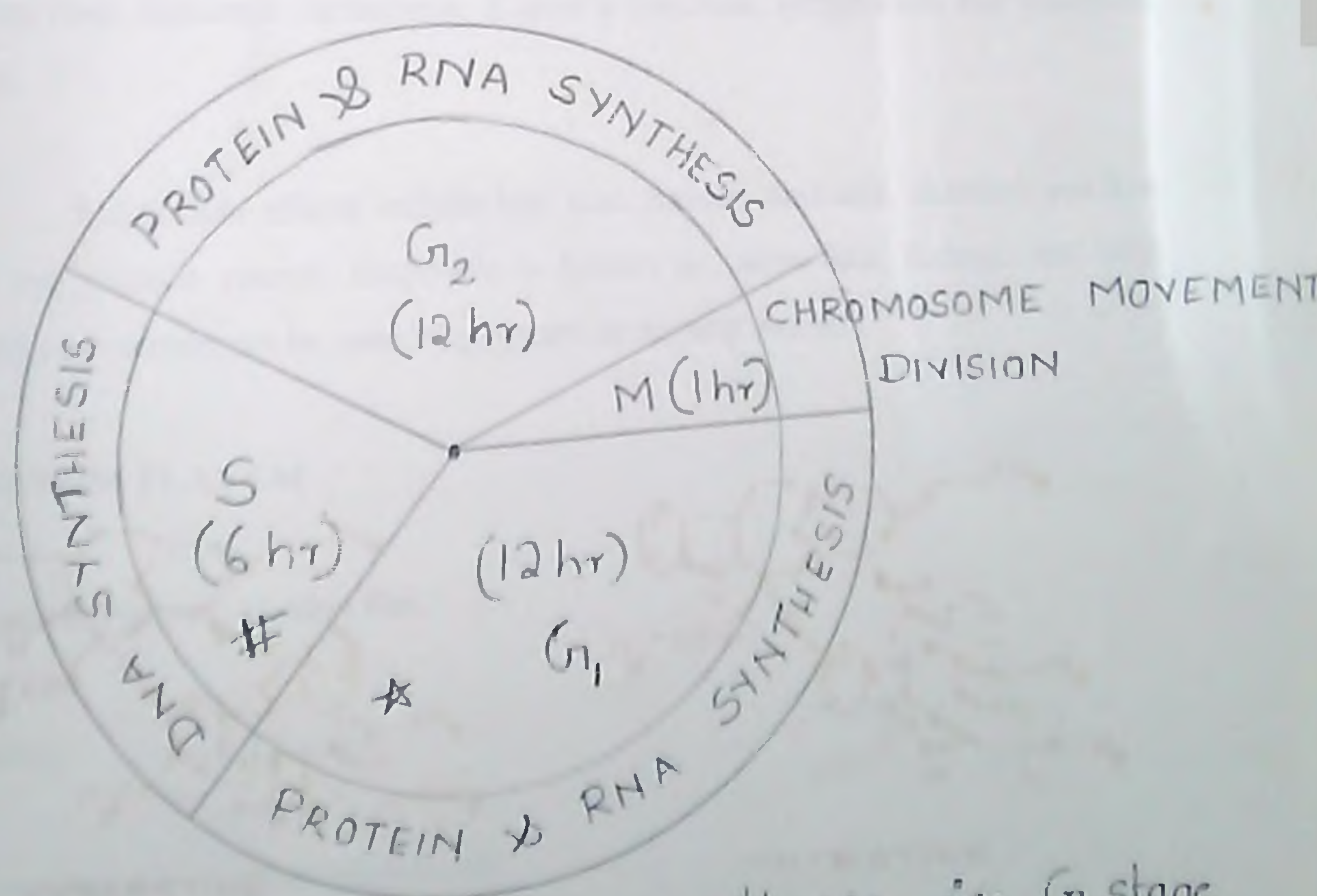
Common name : May apple

Family : Berberidaceae.

Constituent : Podophyllotoxin.

It is a rhizomatous herb that grows in the deciduous forest of North America and Himalayas. The rhizome contains podophyllotoxin that can be extracted with alchol. Indian podophyllum contain more resin than the American and the percent of podophyllotoxin in the resin is much higher.

5 (b) ACTION OF PODOPHYLLOTOXIN



☆ Inhibit protein and RNA synthesis in G_1 stage
DNA replication is prevented in S stage

MITOTIC CELL CYCLE

Podophyllotoxin (podofilox) and its derivatives, etoposide and teniposide are cytostatic glucosides. It generally act as cell poison which cells under going mitosis are particularly Vulnerable to. They block the cell cycle in two specific places: they block the phase between the last division and start of DNA replication (G_1, phase) and they block the replication of DNA (S phase).

5 (c) CLINICAL USE

Podofilox : It is not itself used as Chemotherapy agent, instead it is used in Creams such as Oclassen's Condylox as a treatment for genetical warts. Genetical warts, which are caused by human papillomavirus (HPV), have been associated with cancers of the genitals.

Side effects include nausea, mouth ulcers, fever, diarrhea, nervous system problems, kidney damage, etc.

Etoposide and *teniposide* : Mainly used to treat testicular cancer. It is also used to treat chorionic carcinomas, Kaposi's Sarcoma, lymphomas and malignant melanomas.

Major side effects include hair loss, nausea, anorexia, diarrhea and low leukocyte and platelet counts. Etoposide is known to cause fetal damage and birth defects, and so it should not be used by pregnant or nursing women.

6 (a) LINNUM FLAVUM

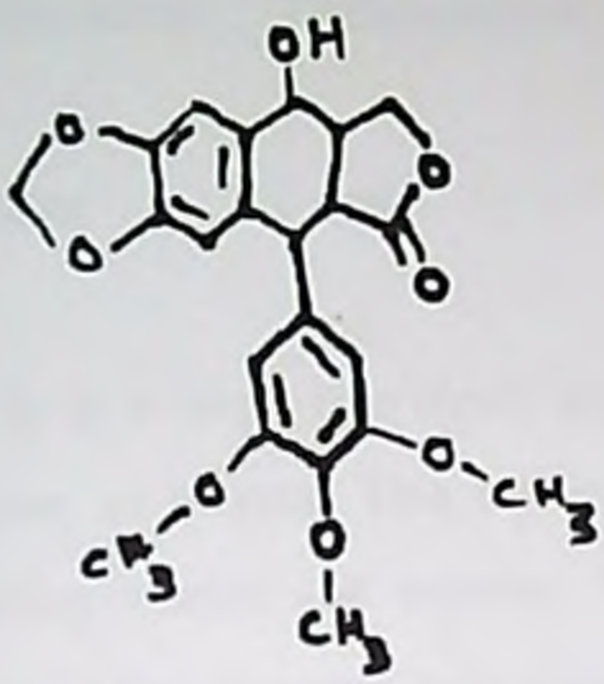
Common name : Golden flax.

Family : Tiliaceae.

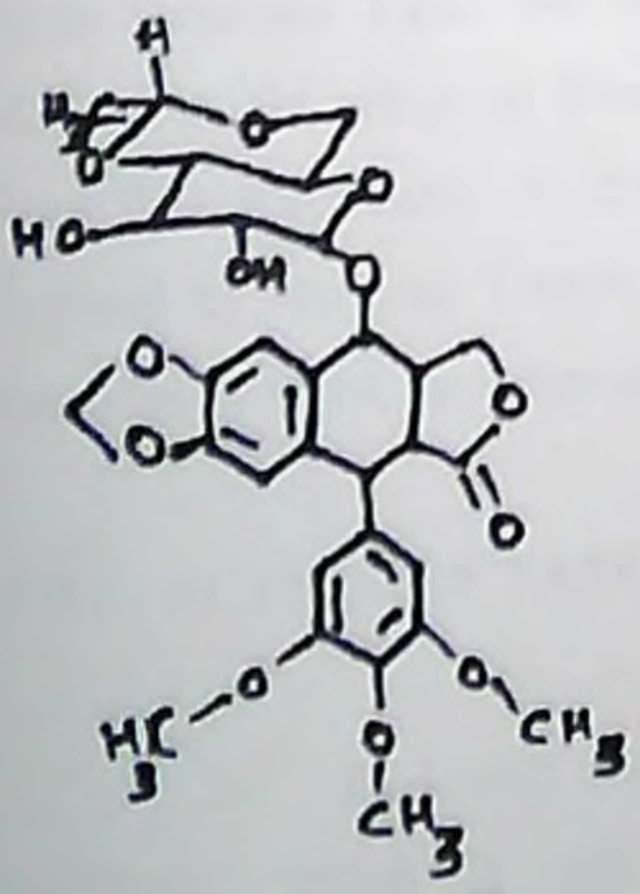
Constituent : Podophyllotoxin.

Roots of this plant also contain 3.5 to 4.1 dry weight of 5-methoxy podophyllotoxin that are capable with the levels of podophyllotoxin present in the *podophyllum hexandrum*. The level of podophylotoxin in the tissue culture was quite high for *Linum sp* suggesting it as a suitable system to achieve production.

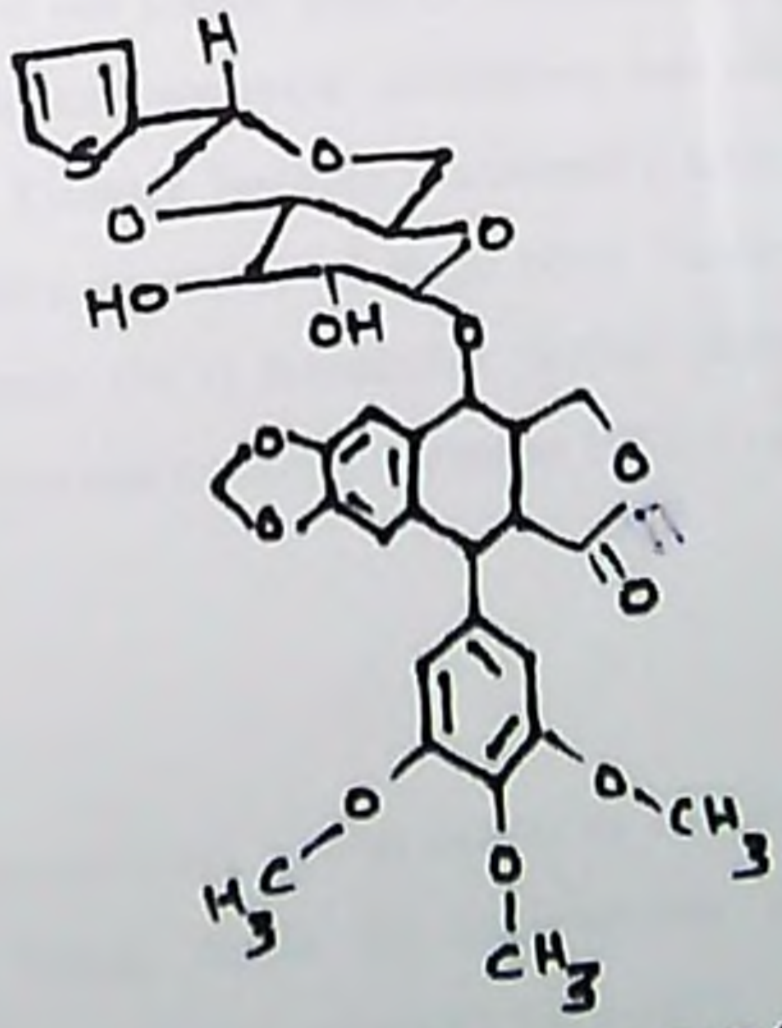
6 (b) STRUCTURE OF PODOPHYLLOTOXIN, ETOPOSIDE AND TENIPOSIDE



PODOPHYLLOTOXIN



ETOPOSIDE



TENIPOSIDE

7 (a) TAXUS

Taxus wallichiana **and** ***Taxus baccata***

Common name : Himalayan yew. Common name : European yew.

Family : Taxaceae

Malayalam name : Thalisapatram.

Constituent : Taxol.

It is a large tree/shrub growing on either sides of Himalaya stretching from Afghanistan to Burma. This has long history of medicinal use apart from being used as colouring matter and incense. The plant has received considerable attention world wide due to the presence anticancer drug paclitaxel or Taxol in the stem bark and leaf needle. The anticancer drug paclitaxel was first isolated from stem bark of pacefic Yew *Taxus brevifolia* and then from the other taxus SP including Taxus wallichiana. The stem bark of the *Taxus baccata* contain highest concentration of paclitaxel (Taxol).

Taxol is a member of the taxane class of diterpenes which occur in the family taxaceae. Taxol has been isolated structural elucidation was carried out by Dr. Monroe Walls group at Research Triangle Institute. Paclitaxel's anticancer properties were first discovered in the 1960's as result of huge plant Screening programme initiated by National Cancer Institute (NCI) Researcher further identified its specific functions in 1979, and clinical trials to test its safety started in 1983.

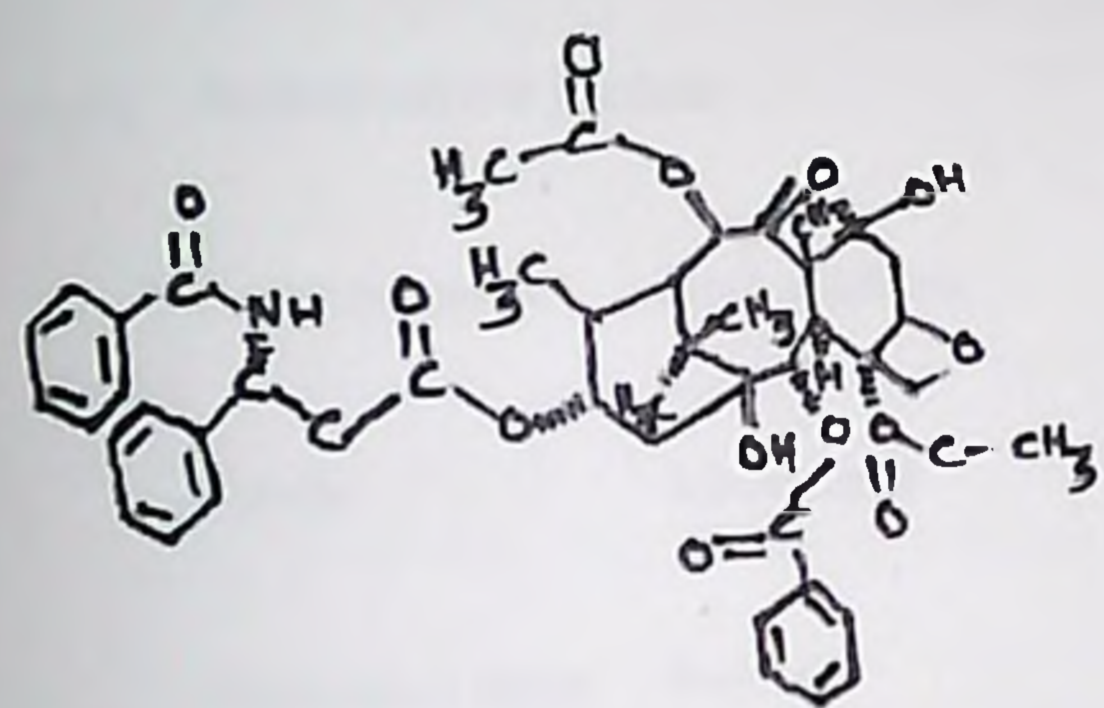
7 (b) ACTION OF TAXOL

Paclitaxel and docetaxel work against cancer by interfering with mitosis, paclitaxel, which is sold as Taxol, binds to microtubules and inhibit their depolymerisation in to tubulin. This means that it blocks cell's ability to break down the mitotic spindle during mitosis with the spindle still in place the cell cannot divide in to daughter cells.

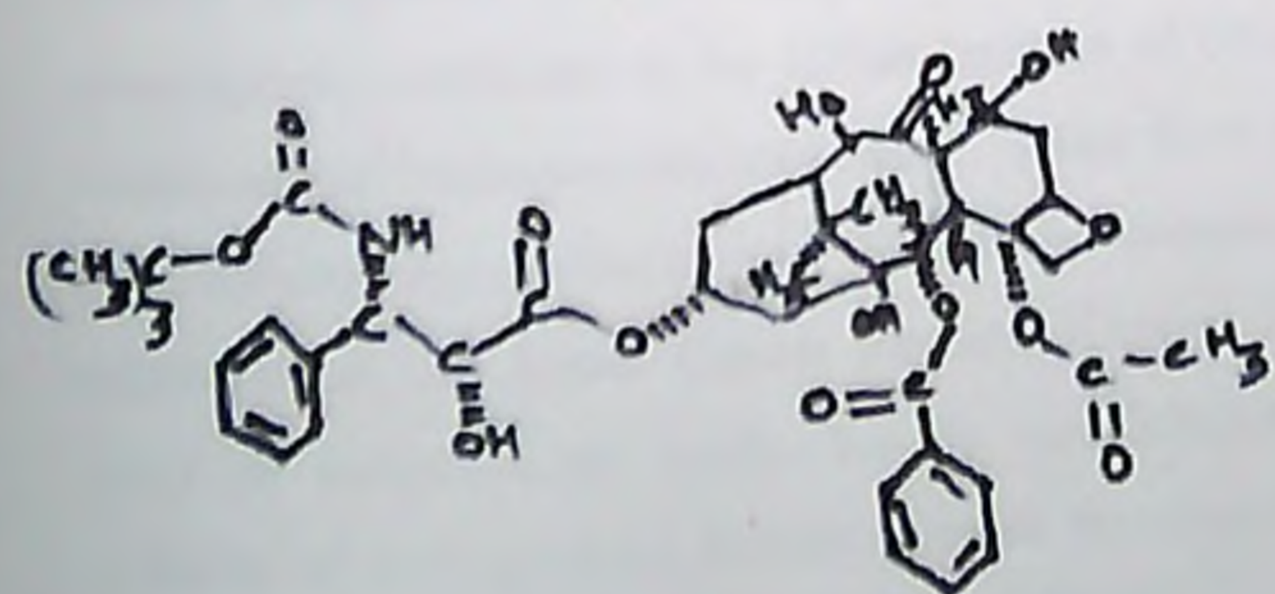
7 (c) CLINICAL USE

Paclitaxel is given intravenously and is most effective against ovarian carcinomas and advanced breast carcinomas Docetaxel is also given intravenously, is being tested on carcinomas of bladder, cevix, lungs ovaries, on malignant melanoma and on non-Hodgkin's lymphoma.

7 (d) STRUCTURE OF PACLITAXEL AND DOCETAXEL



PACLITAXEL



DOCETAXEL

8 (a) *Camptotheca accuminata*

Common name : Chineese Happy tree.

Constituent : Camptothecin

Camptotheca accuminata is a tree indigenous to the main land of China. The stem and bark are known to contain several alkaloids. The cytotoxic quinoline alkaloids Camptothecin, was first isolated by Wall and Co-workers in 1966. The tree is identified as promising antitumour and antiviral for 21st century. Leaves from younger tree had higher Camptothecin concentration than those from older trees.

8 (b) *Nothapodytes foetida*

Common name : Nothapodytes.

Family : Icacinaceae.

Malayalam name : Peenari

Northapodytes foetida is a tree widely distributed in South India, SriLanka and Cambodia. Aiyama *et al* (1988) isolated novel derivative of the anti tumour compound (20 S) camptothecin from the wood of *Nothapodytes foetida*. Investigation conducted in the Indian Institute of Chemical Technology on the alkaloid constituent of Nothapodytes was able to isolate three antitumour alkaloids camptothecin , 9-Methoxy camptothecin and 20-0-acetyl camptothecin (Das 1997). Experiments conducted at the Amala Cancer Research Centre, Thrissure, Kerala, on comparative study of camptothecin production by establishment of callus and cell suspension caullures of *Nothapodytes foetida* revealed that camptothecin content of invitro derived roots was higher than that of Suspension culture

8 (c) *Tabernae montana heyeana*

Common Name : Tabernae Montana.

Family : Apocynaceae.

Malayalam name : Nambiar Vattom.

Constituent : Camptothecin.

Tabernae montana heyeana is found commonly in South India is another fair source of camptothecin various plant part of ornamental *Tabernae montana divertica* are used in SriLanka to treat skin disease and cancer.

All the three plants are excellent source of quinole alkaloid, camptothecin.

Detailed investigation conducted at Amala Cancer Research Centre (Padikkala,2001) was able to isolate Camptothecin from indigenous plants of South India namely *Ophiorrhizha rugosa*. The result suggest that high amount of camptothecin in ophiorrhizha roots open up avenue for mass production of roots by culturing in bioreactors.

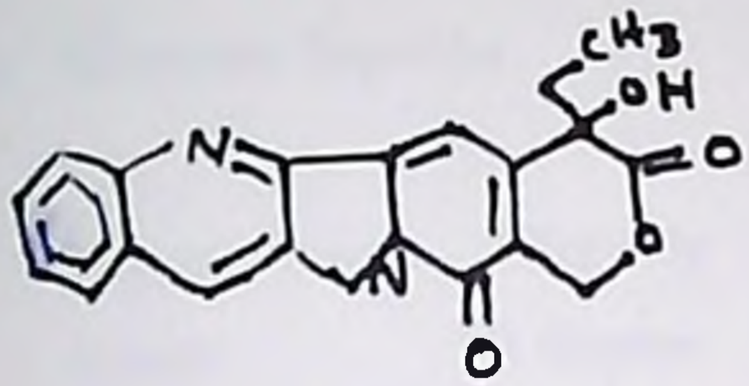
8 (d) ACTION OF CAMPTOTHECIN

Earlier clinical studies showed camptothecin to posses broad spectrum anticancer activity but toxicity and poor solubility were problems. These compounds act as DNA topoisomerase – I inhibitors. Topoisomerase are the enzymes that wind and unwind the DNA that makes up the chromosome. The chromosome must be unwound in order for the cell to use the genetic information to synthesis protein. Camptothecin keep the Chromosome wind tight and proteins are not Synthesised. As a result cells stop growing. Because cancer cells grow and reproduce at much fast rate than normal cells, they are more vulnerable to topoisomerase inhibition than are normal cells. In 1996 the FDA approve topotecan and Irinotecan for cancer treatment.

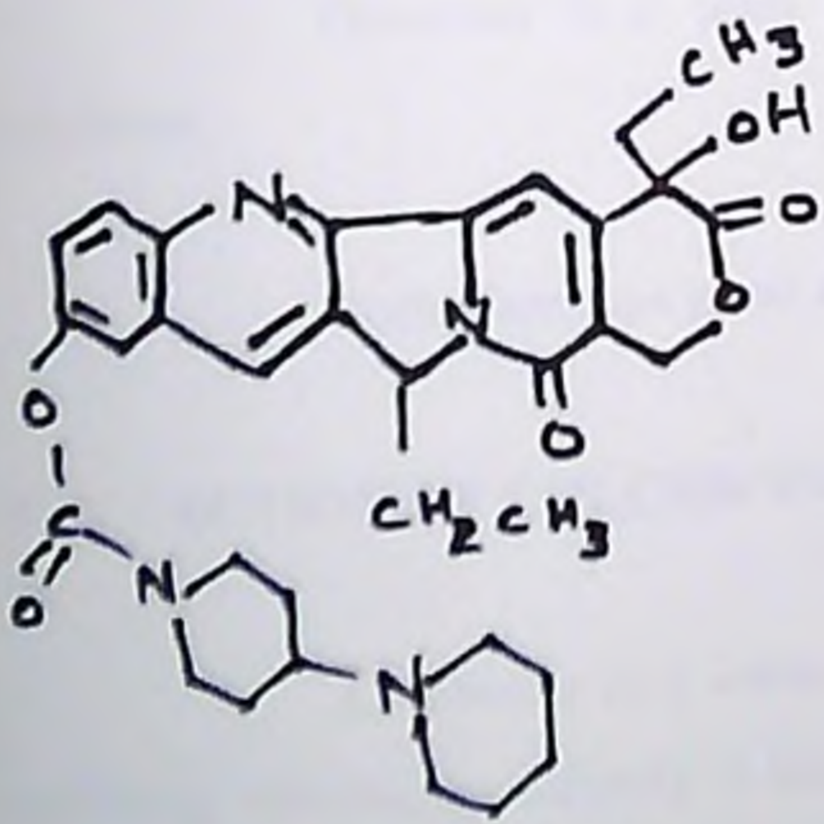
8 (e) CLINICAL USE

FDA approved topotecan as a treatment for advanced ovarian cancers Irinotecan HCL was approved as a treatment for metastatic cancer of the colon or rectum. The drug is normally prescribed in colorectal cancer cases that haven't responded to standard treatment with the Chemotherapy agent, fluorouracil.

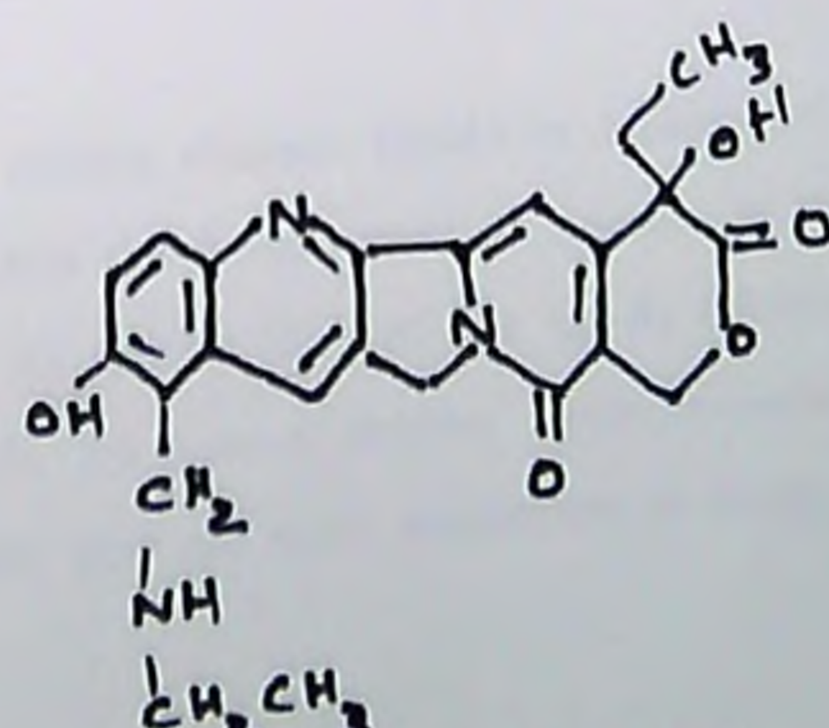
8 (f) STRUCTURE OF CAMPTOTHECIN AND ANALOGS



CAMPTOTHECIN



IRINOTECAN



TOPOTECAN

9 (a) *Colichicum autumnale*

Common name : Colichicum / Naked ladies

Family : Liliaceae

Constituent : Colchicine

Colichicum is a perennial herb mistaken for wild onion. The extreme toxicity of this plant has been known since the ancient time.

9 (b) *Gloriosa Superba*

Common name : Glory lily
Family : Liliaceae
Mlayalam name : Methonni
Constituent : Colchicine

Gloriossa is a plant grown for its seeds, which are rich source of colchicine.

Both plants are good source of Colchicine.

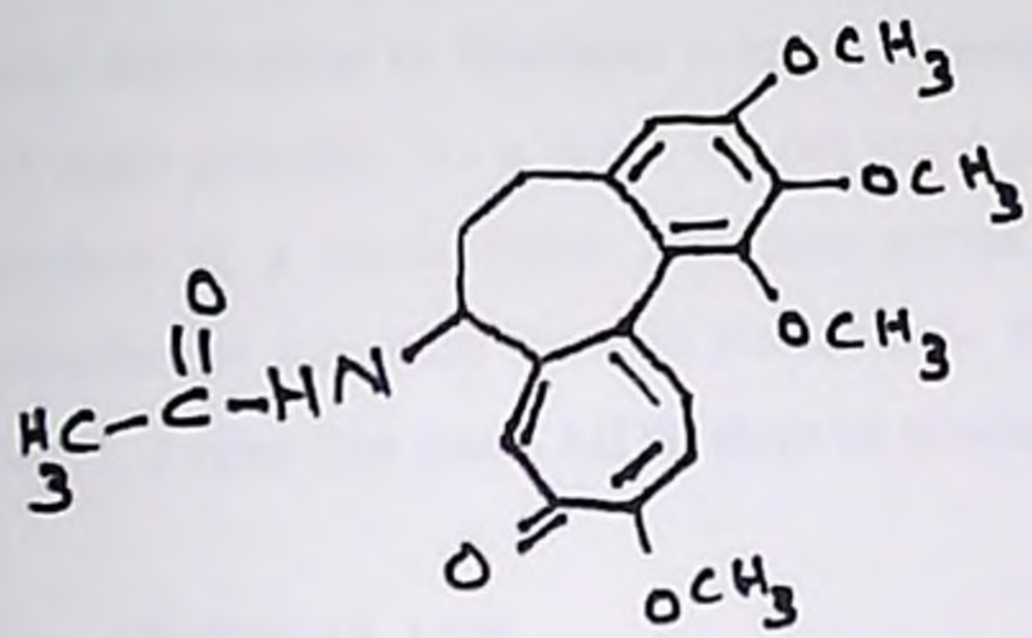
9 (c) ACTION OF COLCHICINE

Colchicine is a water soluble alkaloid, blocks or supress cell division by inhibiting Mitosis, specifically it inhibits the development of spindles as the nuclei are dividing. Normally, cell would use its spindle fibre to line up its Chromosome. But can't parcel them out in to new cells. So it never divides. Because cancer cell divide much more rapidly than normal cells, they are most susceptible to being poisoned by mitotic inhibitors. However Colchicine has prove to have narrow range of effectiveness compared to other Chemotheraptic drugs. Refer fig (I).

9 (d) CLINICAL USE

It is mostly used in Veterinary medicine to treat cancers in some animals. It is also used as an antimitotic agent in cancer research involving cell cultures. Side effects include temporary reduction in the number of leukocytes in the blood stream. It also causes teratogenic birth defects in lab animals.

9 (e) STRUCTURE OF COLCHICINE



COLCHICINE

10 (a) *Tabebuia impetignosa*

Common name	: Lapacho tree
Family	: Bignoniaceae
Constituent	: ß Lapachone and Lapachol

It is a tree native to rain forest through out Central and South America. Popular reports indicate that the bark of this tree and several other related members of Tabebuia are used in Central and South American folk medicine to make a tea that is used to treat a wide range of meladies, from arthritis to cancer. Medical researchers have indeed found that same compounds in the wood of this tree, mainly ß -lapachon e and lapachol have anticancer properties.

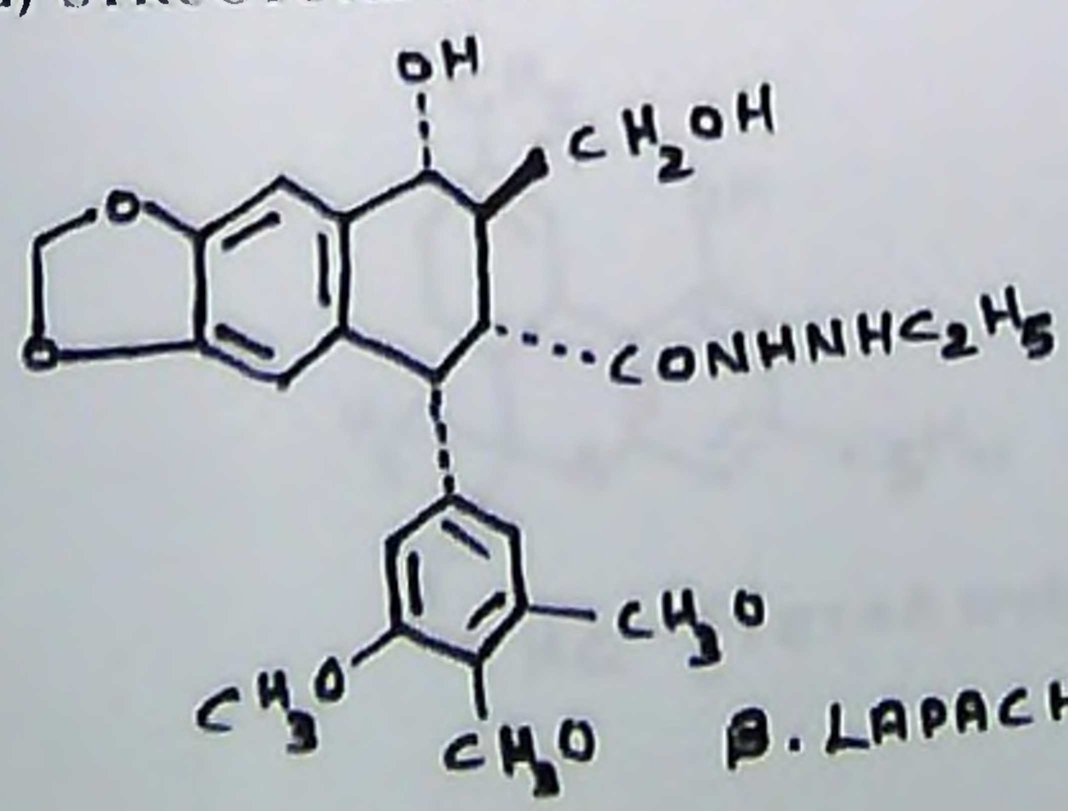
10 (b) ACTION OF ß -LAPACHONE AND LAPACHOL

It inhibits DNA topoisomerase I. It works by disrupting DNA replication. Topoisomerase I is an enzyme that unwinds the DNA that make up the Chromosome. The Chromosomes must be unwound in order for the cell to use the genetic information to Synthesis proteins. It keeps Chromosome tight, and so the cell can't make proteins. As a result the cell stops growing. Because cancer cell grow and reproduce at a much faster rate than normal cells, they are more vulnerable to topoisomerase inhibition than are normal cells. It also interferes with the replication of HIV – 1, a virus that cause AIDS, there by slowing the advancement of the disease.

10 (c) CLINICAL USE

It seem to be highly effective against several types of cancer, including lung, breast, colon and prostrate cancers and malignant melanoma. The use of ß - lapachone in humans has been limited due to its toxicity. It causes side effects such as severe nausea and anemia.

10 (d) STRUCTURE OF ß. LAPACHONE



ß. LAPACHONE

11 (a) *Canabis sativa*

Common name : Hemp

Family : Canabaceae

Malayalam name : Kanjavu

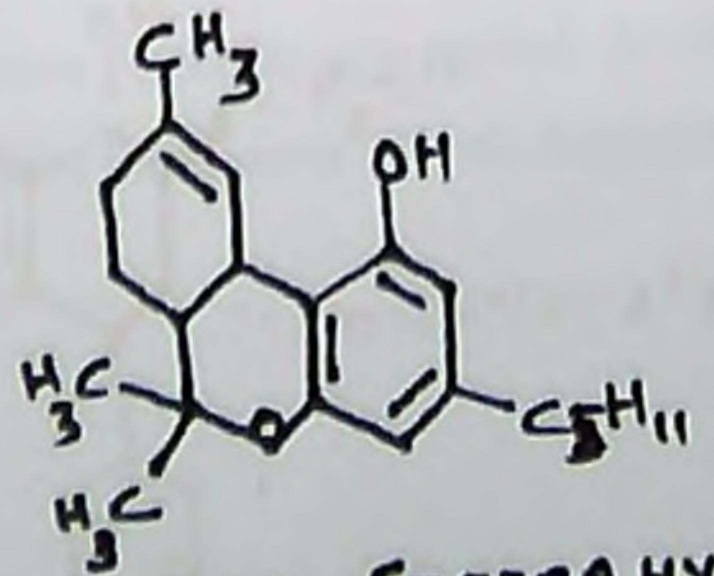
Constituent : Tetra hydro Cannabinol

It is an annual herb in the hemp family which grow 3-10 feet tall and has hairy leaves. The plants are distinctly male or female and they flower from June to October. The plant contain toxic compound Tetra hydro cannabinol (THC). It was first isolated from hemp in 1965. THC's intoxicating and medicinal properties have been touted for thousands of years, however, use of substance is highly controlled.

11 (b) CLINICAL USE OF THC

It is federally recognized as an appetite stimulant and anti-nausea agent. It is available only through special prescription to treat persons suffering from Chemotherapy – or radiation – related nausea, and to treat people suffering from AIDS related anorexia. The FDA approved it for use as an antiemetic for chemotherapy patients in 1985 and as an appetite stimulant for AIDS patient in 1992.

11 (c) STRUCTURE OF TETRA HYDRO CANNABINOL



THC [TETRA HYDRO CANNABINOL]

12 (a) *Betula alba*

Common name : White birch tree

Family : Betalaceae

Constituent : Betulinic acid

The tree is a rich source of betulinic acid. Betulinic acid is a penta cyclic triterpene chemically derived from betulin, a substance found in abundance in the outer bark of white birch. Betulinic acid has been found to selectively kill the human melanoma cells while leaving healthy cell alive. For the past four decades the incidence of melanoma has been increasing at higher rate than any other type of cancer.

12 (b) ACTION OF BETULINIC ACID

Betulinic acid seems to work by inducing apoptosis in cancer cells. Due its apparent specificity for melanoma cells, betulinic acid seems to be more promising anticancer substance than drugs like taxol.

12 (c) CLINICAL USE

Highly effective against melanoma cancer cells. It seemed to effectively inhibit growth of tumours in mice. Betulinic acid has also been found to retard the progression of HIV-1 infection, which eventually leads to AIDS, by preventing the formation of syncytia (Cellular aggregates). In addition betulinic acid has antibacterial properties and inhibits the growth of both *Staphylococcus aureus* and *Escherichia coli*.

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12 (d) STRUCTURE OF BETULINIC ACID

BETULINIC ACID

13 (a) *Arnebia sp*

Common name : Arnebia

Family : Boraginaceae

Constituent : Arnebin I and III

Arnebia is genus of hispid herbs mostly confined to Asia, with a few species occurring in the drier parts of North Africa. The plant is herbaceous and perennial with hight of 20-90 cm. The roots of the plants are sold in market under the trade name 'Ratanjot'. It comprises the root of various Boraginaceous plant species, and is regarded as one of the important herbal drugs of indigenous systems of medicine.

13 (b) CLINICAL USE

Arnebia nobilis roots have come in to prominence because of their anticancer activity. A 50% ethanolic extract of roots of *Arnebia nobilis* yield two naphtha quinone arnebin-I and arnebin-III. These are effective against rat walker Carcinoma. Arnebin-I was effective against P 388 lymphoid leukemia in mice.

Effective dose of arnebin-I has been found to be 4 mg/kg and 3 mg/kg against walker Carcinoma (WM) in rats and P 388 lymphoid leukemia (PS) in mice.

14 (a) *Tryptergium wilfordii*

Common name : Three wing nut

Family : Celasteraceae

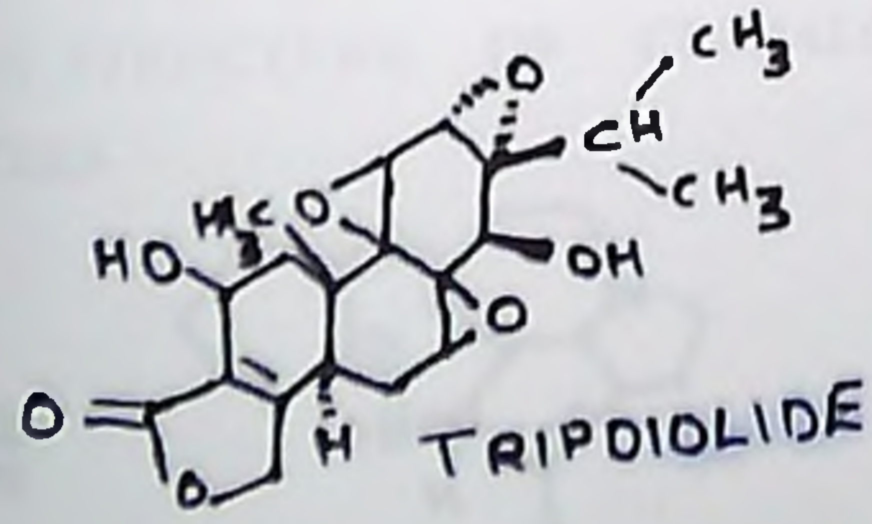
Constituent : Tripdiolide and triptolide

It is a shrub distributed through out Taiwan, China, Korea and Japan. kupchan et all have isolated two diterpenoids that tripdiolide and triptolide collectively known as tripdiolides.

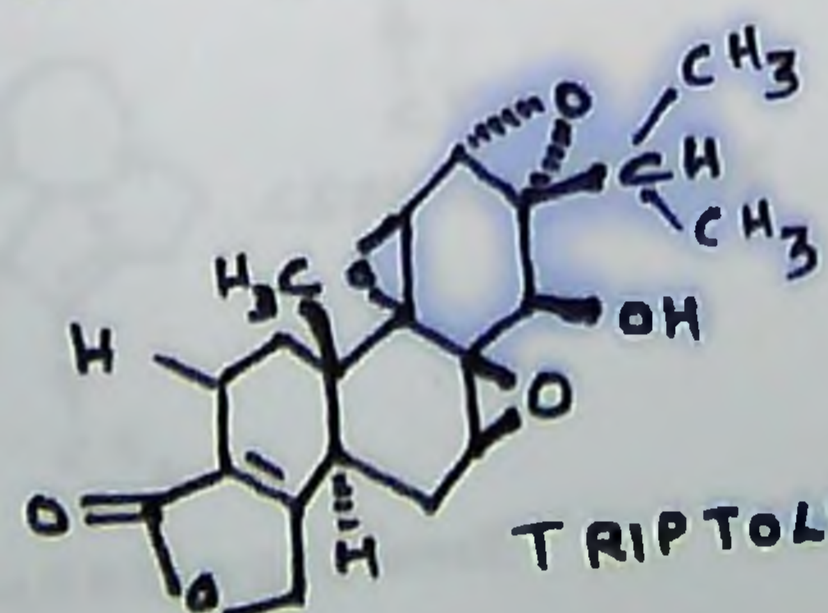
14 (b) CLINICAL USE

Tripdiolides have proven to be active against leukemia and Lewis lung Carcinoma.

14 (c) STRUCTURE OF TRIPDIOLIDES



TRIPDIOLIDE



TRIPTOLIDE

15 (a) *Cephalotaxus harringtonia*

Common name : Japaneese plum yew

Family : Cephalo taxaceae

Constituent : Harringtonine, Deoxyharringtonine, isoharringtonine and Homoharringtonine.

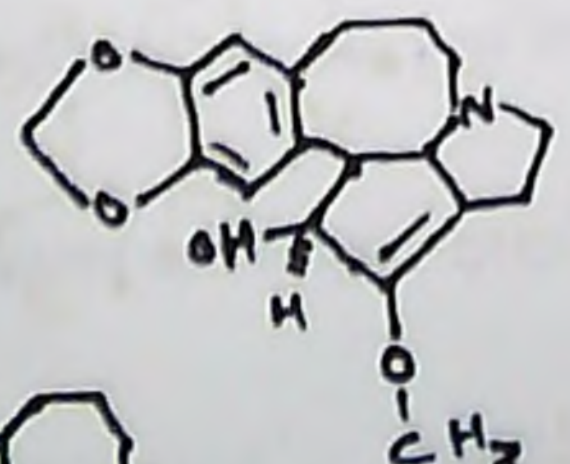
The tree contain antitumour alkaloids harring tonine, Deoxygtonine, isoharringtonine and homoharring tonine. These alkaloids are isolated from the plant by Powell et al, consists of complex esters of the inactive alcohol- Cephalotaxine.

The total alkaloid content of *Cephalotaxus* harringtonia is approximately 0.1 percent dry weight with the antitumour alkaloid representing 6% of the total alkaloid content. Production of the compound in natural habitat is low, because of the slow growth of the plant and limited plant population.

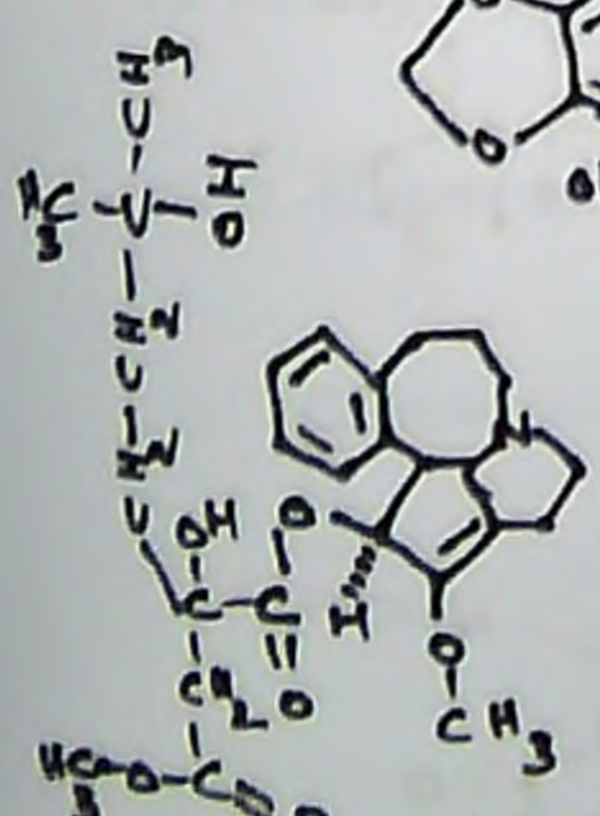
15 (b) CLINICAL USE

All the four alkaloids were proved effective against Colon tumour, melanoma and leukamia.

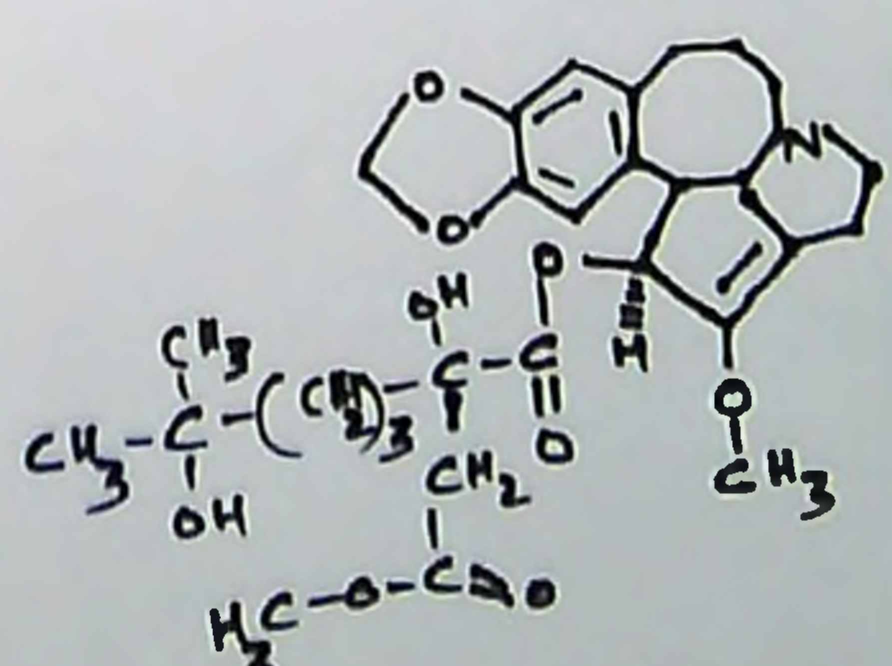
15 (c) STRUCTURE OF CEPHALOTAXINE AND CEPHALOTAXINE ESTERS



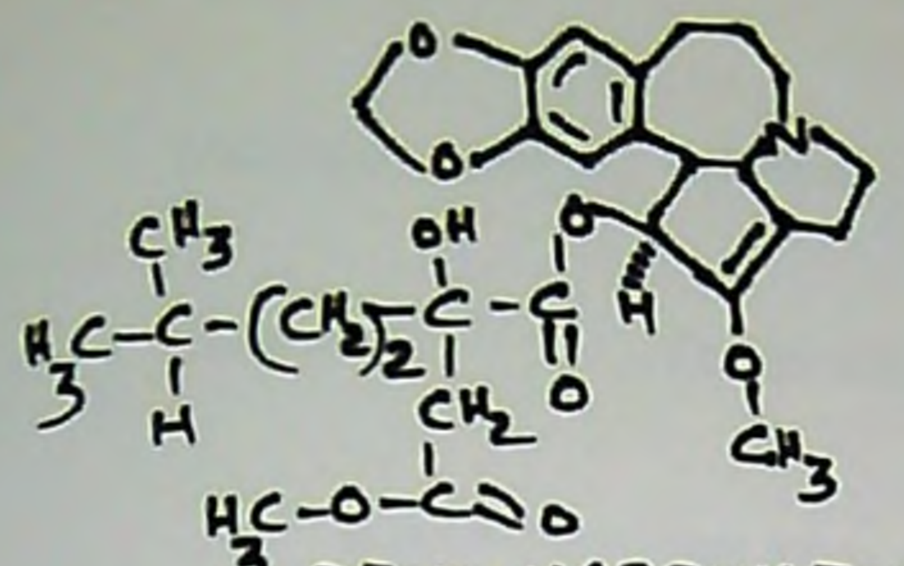
CEPHALOTAXINE



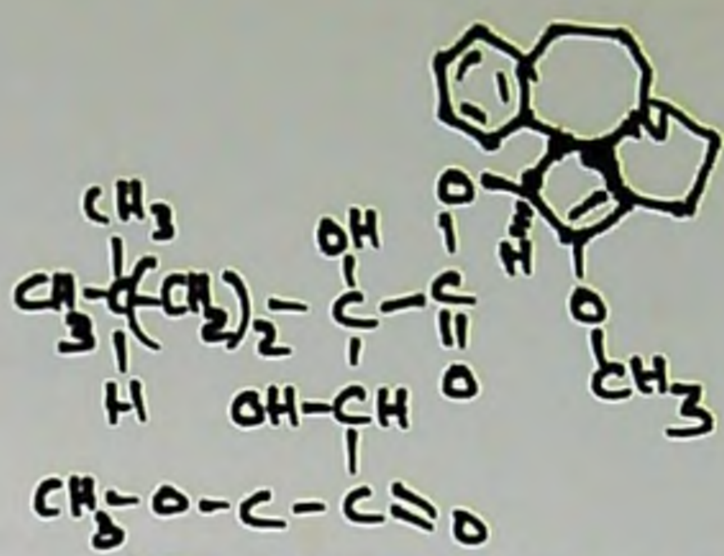
HARRINGTONINE



HOMOHARRINGTONINE



DEOXY HARRINGTONINE



ISO HARRINGTONINE

16 (a) *Papaver Somniferum*

Common name : Opium poppy

Family : Papaveraceae

Malayalam name : Karuppu

It is a herb. A milky juice is obtained from the unripe fruit. It operate chiefly on the Cerebro- Spinal system through nerves.

16 (b) CLINICAL USE

In a comparative study of anticarcinogenic propertis of some commonly consumed species and leafy vegetables, it was observed that poppy seeds inhibited Benzo (α) purene induced neoplasia in Swissmice, which is responsible for the induction of carcinomas in Squamous cells. The result showed that poppy seed has anti carcinogenic property. An injection of seed decotion is also said to help Uterine Cancer. The polysaccharide of poppy seed showed antitumour activity in mice.

17 (a) *Allium sativum*

Common name : Garlic

Family : Liliaceae

Malayalam name : Veluthully

Constituent : Diallyl trisulphide, Allicin

It is cosmopolitan spice. Garlic has been in use for more than 5000 years. It is cultivated in most Mediterranean Countries today.

17 (b) ACTION OF GARLIC

Through the precise mechanism may not be clear administration of well tolerated garlic products may confer important protection from cancer. Garlic strengthen the immune system which is vitally important for fighting cancer. Garlic and related foods play an important dietary role in the cancer process.

17 (c) CLINICAL USE

Garlic has shown significant effect on cancer that effect the stomach and intestine. Diallyl trisulphide is a compound in garlic that lowers spread of lung cancer. Two other compounds S-allycystein (SAC) and diallyl disulphide (DADS) present in garlic were also found to possess carcinogenic properties.

18 (a) *Anona muricata*

Common name : Graviola

Family : Anonaceae

A healing tree that grows deep with in the Amazon rain forest in South Amerca. Extract from this powerful tree, conquer cancer safely and effectively with an all natural therapy that does not cause extreme nausea, weight loss, and hair loss. Graviola has yet to be clinically tested on animal/human. Because Graviola is natural product it can't be patented with out the promise of exclusive sales and high profitability it will likely never again draw the attention of a major drug company or research lab. So we may never see a double blind clinical study on the tree that is reported to help defeat cancer.

18 (b) CLINICAL USE

The tree has been studied in more than 20 laboratory test since 1970's. Where it shown to be effectively target and kill malignant cells in 12 different types of cancer including Colon, breast, prostrate lung and pancreatic cancer. The most recent study conducted at Catholic University of South Korea earlier this year revealed that two chemicals extracted from Graviola Seeds showed 'Selective cytotoxicity' comparable with Adriamycin for breast and colon cancer.

19 (a) *Curcuma longa*

Common name : Turmeric

Family : Zingiberaceae

Malayalam name : Manjal

Constituent : Curcumin

Commonly cultivated spice. It has been used for many years in Ayurvedic preparations and other natural system of medicine. Rhizome contain curcumin which posses anti cancer property.

19 (b) ACTION OF CURCUMIN

It has powerful antioxidant properties. It enhance production of cancer fighting cells, protecting against environmental toxins, with an immune-enhancing effect and powerful anti bacterial properties. It is potent Cytotoxic agent against bladder tumour cells.

19 (c) CLINICAL USE

Sindhwani, P *et al* (2001) studied the effect of curcumin on bladder tumour cell lines as well as its efficient on the intravesical implantation of tumour cells. Carcumin effectively inhibit tumour implantation. In China it is used to treat the early stages of Cervical Cancer. An alcohol extract of turmeric applied externally in skin cancer has been shown to reduce itching, relieve pain and promote healing. In fact turmeric has been found to be highly effective at inhibiting recurring melanoma in people. Research has also demonstrated its protective effects against colon and breast cancer.

20 (a) *Ixora Coccinea*

Common name : Ixora

Family : Rubiaceae

Mlayalam name : Chethi

Constituent : Ursolic acid

Commonly cultivated ornamental shrub. The extract from the flower of Ixora found to contain Ursolic acid which has already been reported to show antitumour activity

20 (b) CLINICAL USE

Ursolic acid demonstrated invivo antiliukemic activity.

21 (a) *Nerium oleanda*

Common name : Oleander

Family : Apocynaceae

Malayalam name : Arali

Constituent : Anvizel and Oleandrin

Commonly seen flowering tree. It contain alkaloid anvizel and oleandrin both possessing anti carcinogenic properties.

21 (b) ACTION OF OLEANDRIN AND ANVIZEL

Both alkaloid causes abnormal metaphase and cell death there by preventing cancerous cell growth.

Apart from this there are so many plants which posses anti Carcinogenic properties which include *Boerhavia diffusa* (Thazhuthama), *Melia azadirachta*, *Strychnos nuxvomica* (Kanjiram), *Trichosanthus cucumerina* (Wild Snakegourd), *Emilia sonchifolia* (Muyal Cheviyan), *Occimum Sanctum* (Thulasi), *Plumbago zeylanica* *Bixa orellana* (Monkey turmeric), *Aloe vera* (Kattarvazha), *Ophiorhizza rugosa* (Velutha amalpuri) etc

The above list of anti cancer plants is only a fraction of the ever increasing list of plants claimed to have such properties. Even then FDA had approved only seven plant derived drugs for the treatment of cancer.

22. PLANT DERIVED ANTI CANCER DRUGS WITH FDA APPROVAL

- Taxol / Paclitaxel
- Vinblastine
- Vincristine
- Topotecan
- Irinotecan
- Etoposide
- Teniposide

Drugs trade name and Manufactures of important anti cancer drugs are given below

Chemical name	Trade name	Manufacturer
Vinblastine	Velban	Elililly
Vincristine	Oncovin	Elililly
Vinorelbine	Navelbine	Glaxo
Etoposide	Ve Pesid Aka Vp-16	Bristol - Myerssquibb
Paclitaxel	Taxol	-do-
Docetaxel	Taxotere	Rhone-poulene Roree
Topotecan	Hycantin	Smithkline Beecham Pharmaceuticals
Irinotecan	Camptosae	Pharmacia & Up john

23. CONCLUSION

Cancer in most cases are caused due to repeated exposure of a living tissue to certain toxic substance. So one single step by which men can guard himself against such unpredictable, hidden toxic agents in his surroundings and food is to revert back to nature. Nature has created plants in the world for every ailments and there is cure for every disease, Man has to find it out. So in coming drugs the research should be oriented towards the identification, selection and screening of plants which may or may not posses anti tumour principle.

24. DISCUSSION

1. How Vinca alkaloids are given to patients ?

Vinca alkaloids are given intravenously. It is the most commonly used plant derived anti cancer drugs. It is mainly available under the trade names Velban, Oncovin and Navelbine respectively for Vinblastine, Vincristine and Vinorelbine.

2. Whether these alkaloids are given in crude form ? If not what will happen if it is given as such ?

In natural system of medicine like Ayurveda, tribal medicine etc the alkaloids are used in the crude form itself but in modern medical systems semisynthetic analogs and derivatives of these alkaloids are used.

3. Most of these anti cancer drugs work by inhibiting the mitotic cell cycle, whether it will effect the normal cell ?

These anti cancer drugs does not effect the normal cell. The dose is fixed after many clinical trials and the dose given will be like that it will effect only cancer cells. Since cancer cells are fastly dividing they are more amenable to the action of these drugs.

4. What is the full form of FDA, Where is the head quarters ?

FDA is food and drug administration. Its head quarters is situated at USA.

5. What is the Scientific name of 'Talisapatra' ?

Taxus baccata

6. Any genetically engineered plant possessing anti cancer property ?

Genetically engineered tomato plant contain more lycopene content. Lycopene act as a anti oxidant and also posses anti cancerous properties.

7. Where the Taxus sp are commonly seen ?

In Himalayan region. It prefers a temperate climate.

8 In India which are the institute where the studies on anti cancerous plant are going on?

Amala Cancer Research Center, Tropical Botonical Garden, Kasturba Medical College, Manipal, Kottackal Ayurveda College etc are main Institute.

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