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and probability of dry spells in cardamom tracts, influence of rainfall on the yield of cardamom, impact of rainfall distribution on cardamom production in Guatemala Vs India and effect of unprecedented drought during 1982-83 on cardamom plantations. Effective measures to combat drought viz. shade management, plot system of cultivation, provision of shelter belts, mulching, weeding, minimum tillage, contour farming and protective/supplemental irrigation are discussed. New schemes to rejuvenate drought hit cardamom plantations are listed.

Cardamom (*Elettaria cardamom* M) is popularly known as 'Queen' of spices. The total estimated area under cardamom in India is 94,000 hectares distributed in Western Ghats of Kerala (60%), Karnataka (30%) and Tamil Nadu (10%). Cardamom exports touched a new high level of Rs.63.53 crores during the year ended March, 1985 and the production is expected to be 4600 M. T. mark during 1985-86 (Anonymous, 1986). In the recent years, India has lost its near monopoly in world production as well as export and has been replaced from some of the traditional markets through intensive competition from Guatemala (Das, 1982). The National Average yield of Indian cardamom is only 62kg/ha as against 250 kg/ha in Guatemala, mainly because 75 to 80 percent of cardamom area in India faces long dry spells and grown under poor management.

The natural habitat of cardamom is the evergreen rain forests of Western Ghats. A cool humid microclimate the ideal conditions for cardamom prevailed in the forests of Western Ghats, in the past as more or less the whole of it was under forest. With the denudation of forests in the Western Ghats, the normal ecosystem was affected destabilising the microclimate and rainfall in the cardamom growing tracts. With the onset of dry season the cool humid microclimate in the cardamom plantations is rapidly changed as the hot waves of air from the hinterland pass across the cardamom tracts without much hindrance due to deforestation all around the cardamom packets, with the consequence cardamom has to grow in a hostile environment resulting in poor growth and yield.

## Impact of Drought on Cardamom

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### ABSTRACT

Cardamom (*Elettaria cardamomum* M) is an export-oriented plantation crop grown in evergreen forests of Western Ghats in South India. The production and export of Indian cardamom was badly hit by the unprecedented drought during the years 1972-73, 1976-77 and 1982-83. Climatic conditions such as rainfall exert great influence on cardamom production and productivity. An attempt is made in this paper to review the various aspects of impact of drought on cardamom viz. frequency

### 1. Frequency and probability of dry spells.

The study of dry spells is important as nearly 75 to 80 percent cardamom area in India is under rainfed condition. Frequency and probability of dry spells at Mercara, the district headquarters of Kodagu, which occupies 68 percent of cardamom area (17,136 ha) in Karnataka, was studied. The daily rainfall data for 20 years (1961-1980) were collected for the per-humid station, Mercara (Lat. 12°25' N, long 70°45', ht. 1130M). A period of atleast five consecutive rainless days were defined as dry spell.

Average rainfall (1961-80) from January to December was 6, 8, 19, 68, 136, 606, 1129, 683, 308, 120, 81, and 22 mm respectively. The three months, January, February and March were omitted as they formed the dry season with meagre rainfall. When a spell occurred continuously in two months, it was credited to the month in which the longer part occurred.

Table-1. Frequency distribution and mean length of dry spells at Mercara during the months April-December (1961-1980) Rathnam and Korikanthimath, 1985)

Length li (days)	Apr.	May.	June.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
(a) Frequency distribution									
5	3	5	—	—	—	2	2	—	1
6-10	14	10	1	1	1	7	9	11	6
11-15	4	9	1	—	—	1	3	3	4
16-20	2	3	—	—	—	—	2	3	2
21-25	1	—	—	—	—	—	—	1	5
26-30	—	—	—	—	—	—	—	—	3
31-35	1	—	—	—	—	—	—	3	2
36-40	1	—	—	—	—	—	—	1	4
41-45	1	—	—	—	—	—	—	—	—
46-50	—	—	—	—	—	—	—	—	—
51-55	—	—	—	—	—	—	—	—	1
<b>Total</b>	<b>27</b>	<b>27</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>10</b>	<b>16</b>	<b>22</b>	<b>28</b>
(b) Average length of dry spells									
	12.8	9.9	10.5	8.0	8.0	7.5	9.6	15.5	21.8

The frequency of dry spells at Mercara are presented in Table 1 for the nine months viz. April to December. The data show that among the nine months, December has the highest frequency of dry spells (28) followed by April and May. The winter month of December has also the longest average duration (21.8) followed by April and May in summer. June, July, August of the South-West monsoon are almost dry spell free. The frequency rises gradually from September onwards. The absolutely longest dry spells were April, 42 (1974), May, 19 (1976); June, 12 (1972); July, 6 (1965); August 9 (1968) September, 11 (1967); October, 19 (1967); November, 28 (1961); and December, 55 (1975).

The percentage probabilities of occurrence of dry spells of 5 or more days at Mercara is presented in Table-2. For a 5 day spell, December has the highest probability of 58 percent followed by April. Similarly, December has the highest probability of 48 percent, followed by April when a spell of 10 days is considered (Rathnam and Korikanthimath, 1985).

### 2. The influence of rainfall on the yield of Cardamom

Most of the cardamom growing area is rainfed and the information on the influence of distribution

Table-2. Percentage probabilities of occurrence of dry spells of 5 or more days at Mercara for the months April-December (Rathnam and Korikanthimath, 1965).

Month	Percentage probability of occurrence of dry spell of the selected length or more									
	5	6	7	8	9	10	11	12	13	14
April	48	43	34	25	23	21	18	14	13	11
May	41	33	29	23	20	18	18	15	11	8
June	8	8	8	4	4	4	4	4	0	0
July	5	5	0	0	0	0	0	0	0	0
August	5	5	5	5	5	0	0	0	0	0
September	29	24	9	6	3	3	3	0	0	0
October	34	30	21	14	15	14	11	9	6	6
November	42	42	34	34	26	21	21	21	21	21
December	58	56	56	50	48	48	44	42	42	38

and intensity of rainfall on the crop yield is lacking. To study this aspect, 13 cardamom estates were selected, where in data on yield and rainfall were available for more than a decade.

Annual rainfall, number of rainy days and yield/ha were collected from two estates in Mercara taluk; four estates in Somwarpet taluk and seven estates in Virajpet taluk for a period of ten years. Multiple regression analysis utilising: (1) Total rainfall during the year, (2) the number of rainy days and (3) the coefficient of variation in the monthly rainfall at each of the locations, as auxiliary variants, was attempted to study the relationship between rainfall attributes and cardamom yields.

The range and mean of annual rainfall, the number of rainy days and yields are presented in Table-3. The following regression equation was obtained, when the effects of total rainfall ( $X_1$ ) number of rainy days ( $X_2$ ) and coefficient of variation for the rainfall received in different months ( $X_3$ ) on the yield of cardamom was studied.

$$Y = 59.689 + 0.00095 X_1 - 0.173 X_2 + 0.764 X_3 \quad (R^2 = 0.03)$$

(0.017)    (0.524)  
(0.439)

Table-3. Rainfall fluctuation and cardamom yields in Coorg district for 10 years (Subbarao and Korikanthimath, 1982).

Rainfall in mm	No. of rainy days		Yield ha in Kgs.		
	Range	Mean	Range	Mean	
1620-3000	2536	98-150	123	59-237	140
1270-2358	1853	111-140	125	62-519	253
1085-3338	1828	114-158	137	39-104	58
1255-3626	1823	93-154	119	36-203	91
254-2173	1805	109-157	125	34-110	70
995-4410	1769	79-156	117	33-344	110
1283-1952	1685	108-144	127	93-371	183
784-3144	1684	100-159	125	52-162	88
1363-2074	1609	99-143	121	35-189	73
1029-1717	1499	115-147	127	36-61	45
920-2119	1442	92-146	122	36-361	104
1011-1815	1386	81-127	103	57-188	94
1043-1563	1361	106-131	113	67-292	118

The contribution of the variation in the monthly rainfall ( $X_3$ ) to the variation in the yield of cardamom is higher than that of total rainfall ( $X_1$ ) and the number of rainy days ( $X_2$ ). In other words, the analysis suggests that yield of cardamom is influenced more by the distribution of monthly rainfall than the total rainfall and the numbers of rainy days. In 10 out of 13 estates, maximum yield was recorded when the annual rainfall was less than 2000mm. Moreover in 42 out of 57 cases more than 100kg/ha was obtained when the annual rainfall was less than 2000 mm. This clearly explains that the total annual rainfall is not the criteria and further suggests that an annual rainfall of 2000 mm may be optimum for cardamom cultivation (Subbarao and Korikanthimath, 1983). Following of adequate and timely cultural operations would be of an immense help in efficient use of rain water.

### 3. Impact of distribution of rain fall on cardamom production in Gautemala Vs India

Gautemala's average productivity is quite high i.e. 250 kg/ha as compared to only 62 kg/ha in India. In some of the best managed estates as high as 800 kg/ha can be obtained both in India and Gautemala. The one reason for the increased national average of 250 kg/ha in Gautemala is the availability of well distributed rainfall (Mohan chandran, 1984). Gautemala's rainfall varies from 2000 to 5000 mm per annum in the cardamom growing belts.

Generally fairly good and assured rains are received during the period April-May to October-November. September - October period usually records the heaviest rain as against the peak periods of June-July in India. The period December to March is comparatively dry. Usually February receives a few light showers. Slightly better rainfall is received during March. Thus the soil is rarely devoid of moisture. The monthly rainfall distribution during 1976 in the Southern belt of Gautemala is furnished in Table-4. Thus the rainfall is evenly distributed and the dry period is very short in Southern part. Under this favourable condition, the

#### 4. Distribution of rainfall in Gautemala(1976).

	Rain fall in mm
January	5.25
February	52.25
March	113.00
April	332.25
May	281.00
June	743.75
July	216.50
August	266.00
September	322.50
October	548.00
November	159.75
December	2.00
<b>Total</b>	<b>3043.25</b>

number of rainy days 134

Source: Report of the Cardamom delegation to Gautemala (1977). Cardamom Board, Cochin. pp 7-8.

Cardamom plants are reported to grow luxuriantly 3.60 to 4.50 M high and with about 150 to 200 in each clump. There is better uniformity in growth and productivity. In view of the well distributed rainfall, wherein the dry breaks between rains rarely exceeds two weeks, cardamom is cultivated with little or no shade (Anonymous, 1984). As in the case of cardamom growing tracts in India, the well distributed rainfall is most important than the total rainfall even to Gautemala realising higher yields in cardamom.

#### Effect of unprecedented drought during 1982-83 on cardamom Plantations:

Cardamom industry faced a severe crisis as a result of unprecedented drought in Kerala, Karnataka and Tamil Nadu. During 1981-82 itself, the rainfall was comparatively poor and this had affected production of cardamom in 1982-83. But during 1983 there has been a continuous drought from December onwards. There was practically no rainfall from November 1982 to April/May 1983. The usual winter showers in March and April which are very important as far as cardamom plant is concerned was

totally absent and this has affected the yielding of the crop. Apart from the effect on the crop, severe drought has dried up plant population in most of the areas to a considerable extent. In areas having less shade, particularly in Western and Southern aspects and in rocky patches, the plants have completely dried up.

#### (1) Extent of Damage

The damage was estimated to be 30 to 70 percent. In Karnataka the extent of damage to the plant population is estimated to be about 50 percent. In Kerala it varies from village to village, while the damage in Vandanmettu area was estimated to be 30 percent, the damage in Pampadumpara and Rajakkad, Parathode etc., are estimated to be 60 to 70 percent. The damage in Wynad was estimated to be 50 percent.

#### (2) Loss of crop/income

In addition to the loss of plants there was a considerable crop loss during 1982-83 and since the affected areas were to be replanted, the loss of crop is expected to continue for three to four years as a result of drought. The loss of crop during 1982-83 was estimated as 1200 tonnes accounting Rs. 18 crores. In addition to this, there was a continuous loss of crop for next three years, nearly to the tune of 40 percent. The loss of economy as a result of the crop loss was estimated as Rs. 60 crores. Production and productivity of cardamom from 1971-72 to 1985-86 is given in Table-5 (Anonymous, 1984).

#### (3) Repercussions of drought on replanting of cardamom

Severe drought situation caused a great concern resulting in the requirement of funds to replant the affected areas. Assuming the loss of plantation to the extent of 50 percent, the area to be replanted was about 25,000 hectares. Estimating the cost of replanting per ha. to be Rs.10,000/, the total cost of replanting in the drought affected areas worked out to be Rs.25 crores. The loss to the economy as a result of the drought was estimated to the tune of Rs 85 to 90 crores (Mohanchandran, 1983).

Table-5. Production and productivity of Cardamom

Year	PRODUCTION (M. T.)		PRODUCTIVITY (Kg/ha)	
	India	Guatemala	Rate in Percentage	India Guatemala
1970-71	3170	503		46 83
1971-72	3785	460	+ 19.4	54 65
1972-73	2670	840	- 29.5	38 104
1973-74	2780	1030	+ 4.1	40 113
1974-75	2900	1190	+ 4.3	42 126
1975-76	3000	1313	+ 3.4	43 125
1976-77	2400	2563	- 20.0	35 136
1977-78	3900	1599	+ 62.5	56 67
1978-79	4000	2928	+ 2.6	58 123
1979-80	4500	4256	+ 12.5	64 182
1980-81	4400	3745	- 2.2	62 156
1981-82	4100	—	- 6.8	58
1982-83	2900	—	- 29.3	41
1983-84*	1600	—		18
1984-85*	3900	—		43
1985-86*	4600	—		

Source: Cardamom Statistics 1981-82, Cardamom Board, Banerji Road, Cochin, Kerala India pp 1-2)  
Furnished from subsequent years statistics

#### (4) Impact of drought on export and unit value of cardamom

The position of Indian cardamom became very bad consequent to the severe drought which played havoc on the cardamom plantations in India in 1982-83 and 1983-84 (Mohanchandran, 1985). There was a short fall in exports in the year 1982-83 as against 1981-82. The exports for 1981-82 was 221 tonnes valued at Rs.30.17 crores with a unit value of Rs.130/- per kg while it was only 1005 tonnes valued at Rs. 16.00 crores with a unit value of Rs. 150/- per kg in 1982-83. The main reason for the shortfall in exports during 1982-83 was the shortage of crop as a result of failure of monsoon in the previous season. The crop for the year was estimated only 2900 M. T. as against the previous crop of 4100 M. T. (1981-82). Consequent to the reduction of the crop, there was a considerable pressure for cardamom in the internal market as a result of this the price in the auctions was comparatively high. Because of the existence of

fairly high price in the internal market price of Indian Cardamom was quoted to be higher in the International markets. The reports from Baharain office revealed that Indian prices were higher by 3 to 6 dollars in the International market compared to the Gautemala prices for comparable grades.

#### (5) Measures to combat drought situations

Drought is one of the major problems confronting cardamom plantations. In certain areas about 5 to 6 months of drought is experienced. Therefore, it is necessary to take effective measures which would help the crop to withstand drought. Proper shade management, following of plot system, provision of shelter belts, mulching, weeding minimum tillage and supplemental/protective irrigations are some of the practices that can be followed to tide over drought in most of the cardamom plantations.

#### (i) Shade management

Cardamom is a psiohyte (shade loving plant) and is commonly cultivated under the protection of shade of trees. Filtered shade is ideal for cardamom which activates the plants metabolic processes resulting in vigorous growth and high yields. It is noticed that in the border areas where cardamom plants are exposed to the direct sun, severe scorching associated with an accentuation of pests (mites) and diseases (Chenthal) are often pronounced. Weeds grow luxuriantly in the open areas and pose a great problem in the management of cardamom estates (Korikanthimath, 1983.)

Malabar type of cardamom is less sensitive to sunlight and less susceptible to drought conditions than Mysore type.

Tall trees having well distributed branching habit and small leaves are ideal for cardamom. Some of the suitable common shade trees in cardamom estates are-Balangi (*Acrocarpus fraxinifolius* Wt.), Nili (*Bischofia javanica* Blums), Red cedar (*Cedrella toona* Boxb). To provide more light during rainy season when the intensity of light is less, it is necessary to carryout shade regulation before the onset of monsoon. It is equally important to see that shade trees put sufficient flush of leaves and provide adequate shade by the time summer sets in. The overhead canopy should therefore, be regulated once in a year during May-June.

st system

In the large plantations, it is usually seen that in some patches, cardamom does not come up. In some patches it may be difficult to establish cardamom in spite of repeated replanting. Such patches may be virtually taken as places unsuitable for cardamom. If in such patches a thick tree is established, it may afford protection to the surrounding areas and increase the over production of the estate.

The plot system of cardamom cultivation consists of dividing the large plantations into small plots of various sizes in accordance with the lie of the land and suitability for cardamom surrounded by vegetation belt. This system has been successfully tried in some of the estates in Coorg district of Karnataka. Here, cardamom plants receive full sunlight for a few hours in the morning and during rest of the day are covered by shadows cast by surrounding trees. Adoption of plot system would help in combating drought by preserving soil moisture, reducing the sweeping of desiccating wind through the plantations, avoiding scorching action of hot sun rays thus providing congenial microclimate for proper growth and higher yields in cardamom.

#### Shelter belts

Whenever feasible, it would be a good practice to grow trees as wind breaks along with contours particularly in Western aspects for better protection against desiccating wind in summer. Whenever the cardamom plantations are surrounded by open areas like roads, open grasslands and other crops, a forest belt to a minimum width of about 100' should be preserved. The principle of creating such shelter belts (with a minimum of 5 to 10 rows of trees for growth) can be extended further and all cardamom plantations of 15 ha should keep a belt area around the best growth with a neighbouring plantation of about 50 feet wide free from Cardamom (Antony and Srikanth, 1977). Such wind breaks will not only help to maintain the congenial forest environment required for moisture conservation but may also act as barriers against diseases/pest infestation from adjoining plantations.

#### (iv) Mulching

Naturally bestowed leaf fall of the shade trees can be conveniently used for mulching. It is estimated that on an average 5-8 tons of dry leaves fall from shade trees annually in a hectare of Cardamom Plantation. Mulching helps in conserving soil moisture which is quite necessary particularly during summer months to combat drought. It minimises temperature fluctuations, improving physical properties of soil and suppressing weed growth.

#### (v) Weeding

A rich herbaceous cover of weeds is seen in cardamom plantations till the dry months of February-March. Cardamom is a surface feeder and most of the weeds also have similar rooting pattern, thus causing a great set back to the growth and yield of cardamom.

In the first year of planting frequent weeding is quite essential to eliminate root competition between the young cardamom seedlings and the weeds. Subsequently, depending upon the intensity of weeds 2 to 3 rounds of weeding in a year would be necessary. The first round of weeding is to be carried out in May-June, the second in August-September and the third in December-January. The weeds removed during the first and second rounds may be heaped in the inter row space and allowed to decay. After decaying they may be used for mulching. In December-January the weeds removed may be directly used for mulching (Korikantimath, 1986). Timely weeding would help in avoiding the competition of weeds for soil moisture, which is of prime importance for cardamom, particularly under rainfed conditions.

#### (vi) Minimum tillage

Since the cardamom growing tracts receive heavy rainfall, excessive tillage operations should be avoided. The rich humus top soil around the plants to a distance of 75 cm may be scraped and applied as a thin layer to the base of clump just upto the collar region. It forms the soil mulch and covers the exposed roots and rhizomes due to the beating action of rain drops and conserves moisture.

#### (vii) Contour farming

The planting of cardamom should be taken all along the contour or across the slope. The clearings of shade trees before taking up planting and in subsequent shade regulation and the weeds should be kept between the rows across the slope so as to act as a barrier to check soil erosion and to prevent run off losses of rain water to a considerable extent for effective soil and moisture conservation.

#### (viii) Irrigation

The importance of irrigation in cardamom estates is increasingly felt in the recent years especially during the drought. It is found that production improves by 150 to 200 percent in irrigated areas. From January to May, there is not much of rainfall and even if it rains it is scanty. It is noticed that whenever summer showers are received, the performance of crop is better. The crop yield can be enhanced atleast to an average of 250 to 500kg/ha which is about 4 to 5 times more by supplemental irrigation during January to May (Sivanappan, 1985).

Rain water should be harvested by constructing farm ponds, check dams in small rivers and rivulets going through the cardamom estates and tracts in Western Ghats to take up irrigation during January to May. Cardamom is often cultivated in an undulating topography of land, so sprinkler irrigation is most suitable and a convenient method. Trickle irrigation would be a new hope to cardamom plantations (Kurup, 1978). Depending upon the lay of the land and the soil type, normally irrigation is given at an interval of 10-15 days till the commencement of monsoon. In areas where there is an acute shortage of water, protective irrigation coupled with adequate mulching would help in minimising the damage due to unprecedented drought conditions.

#### New Schemes to rejuvenate drought hit cardamom plantations.

The drought had affected atleast 30 percent of the cardamom plantations. In view of this a special sub-committee was constituted by Cardamom Board, Cochin

to visit the drought affected areas and to submit report. On the basis of the report of the subcommittee, Cardamom Board proposed many schemes for the rehabilitation of the drought affected areas, most important of which was increasing the number of certified nurseries, starting mini poly bag nurseries to produce 10 month old seedlings and also replantation of drought affected areas of 15000 hectares in the next three years commencing from 1984-85.

The operational period of replanting is 3 years, from 1984-85 at the rate of 5000 ha per annum. Small growers who own upto 8 ha. of registered cardamom plantations will be paid a subsidy of Rs. 2,500/ha in 3 annual instalments of Rs. 1,000, Rs. 800, and Rs.700/. Besides, they will also be paid 3 percent subsidy on interest for first five years on the loan amount of Rs. 7,550/they may be availing from Nationalised and Co operative banks for replantation purpose. The total financial commitments for the Government on payment of subsidies under this scheme is Rs. 442.40 lakhs. Institutional finance coming from Nationalised Banks for the implementation of the scheme is Rs 1,237 lakhs. (Anonymous, 1984). The impact of the scheme in production front will be reflected from 1989-90 and when fully implemented, the scheme will result in the additional production of 1500 M. T. per annum.

Drought is causing a great concern in the recent years affecting the production and export of cardamom. Indiscriminate felling of natural forest has accentuated the problem of drought. Strict measures are to be taken up for prevention of felling of shade trees to maintain congenial ecological conditions for cardamom. Keeping in view of the above problem permanent measures are to be chalked out for combating the occurrence of unprecedented drought. Based on such experience, a programme for research could be drawn on the following lines.

1. Increasing water use efficiency.
1. Impact of winter irrigation on cardamom as water may be available only upto Dec-Jan in certain patches.
2. Working out the impact of irrigation with mulching.

3. Feasibility and economics of introducing Drip irrigation in cardamom estates.
- II. Adoption of soil and water conservation measures-feasibilities of introducing check pits, staggered trenching, terracing and half mounding in steep slopes, contour farming etc.
- III. Shade management.
  1. Introducing of fast growing shade trees in the vacant exposed areas of cardamom estates.
  2. Introduction of shelter belts particularly in Western and Southern aspects-spacing and selection of tree species etc.
  3. Introduction of wind breaks particularly in high mountain ranges and wind swept areas.
- IV. Developing drought resistant varieties.
  1. Surveying cardamom belts for natural selection of drought resistant types.
  2. Physiological screening of germplasm for drought resistance.
- V. Imparting training to cardamom planters on rainfed agronomy of cardamom.

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### REFERENCES

- ANONYMOUS, 1977. Report of the Cardamom delegation to Guatemala, Cardamom Board, Cochin, pp. 7-8.
- ANONYMOUS, 1984. New schemes for drought hit cardamom plantations  
*Cardamom* 17 (8):3-4

- ANONYMOUS, 1986. Statistical abstract.  
*Cardamom* 19 (3):21
- ANTONY CHERIAN, 1977. Environmental Ecology an important factor in cardamom cultivation  
*Cardamom* 9 (1):9-11.
- DAS, P. K. 1982. Cardamom situation in India with reference to world trade.  
*J. Plant. Crops.* 10 (2):114-123
- KORIKANTHIMATH, V. S. 1986. Cardamom: Shade management.  
*The planters Chronicle* Nov./Dec. pp. 405-406.
- KORIKANTHIMATH, V. S. 1986. Agronomic practices for cardamom.  
*Farmer and Parliament.* 21(2):15-16
- KURUP, K. R. 1978. Trickle irrigation, New hops to Cardamom plantations.  
*Cardamom* 10 (6):11-16.
- MOHANCHANDRAN, K. 1983. Cardamom Plantation Industry faces severe crisis due to drought.  
*Cardamom* 15 (6):3-7.
- MOHANCHANDRAN, K. 1984. Planning for Plantation-A study on cardamom.  
*Cardamom* (17 (11):5-8
- RATNAM, B. P. and KORIKANTHIMATH, V. S. 1985. Frequency and probability of drought spells at Mercara.  
*Geobios.* 12:224-227
- SIVANAPPAN, P. K. 1985. Soil conservation and water management for cardamom.  
*Cardamom* 18 (6):3-8.
- SUBBARAO, G. and KORIKANTHIMATH, V. S. 1983. The influence of rainfall on the yield of cardamom (*Elettaria cardamomum* Maton) in Coorg district.  
*J. Plant Crops.* 11 (1):68-69