WEED MANAGEMENT IN CARDAMOM PLANTATIONS

BY

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THESIS

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VELLANIKKARA, THRISSUR

KERALA, INDIA

1996

DECLARATION

I hereby declare that the thesis entitled **Weed Management in Cardamom Plantations** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree diploma fellowship associateship or other similar title of any other university or society

College of Horticulture
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CERTIFICATE

Certified that the thesis entitled **Weed Management in Cardamom Plantations** is a record of research work done independently by **Mr M V Sudheesh** under my guidance and supervision and that it has not previously formed the basis for the award of any degree diploma fellowship or associateship to him

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We the undersigned members of the Advisory Committee of **Mr M V Sudheesh** a candidate for the degree of **Master of Science in Agriculture** with major in **Agronomy** agree that the thesis entitled **'Weed Management in Cardamom Plantations** may be submitted by **Mr M V Sudheesh** in partial fulfilment of the requirement for the degree

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M V Sudheesh

To Amrithacharanangal

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Introduction

INTRODUCTION

Cardamom the queen of spices is one of the major spice crops of India occupying an area of 83 000 ha and having a production of 7500 metric tones annually More than 50 per cent of this area (43 000 ha) and more than 60 per cent (4700 t) of the production is from Kerala (FIB 1995) Being a plant loving cool climate it is cultivated in the forests at an altitude ranging from 600 to 1200 m

Even though cardamom accounts for more than 50 per cent of the area in Kerala lack of proper attention to this crop resulted in an unbalanced trend in area and production (Jacob *et al* 1995) This is primarily due to factors like occurrence of drought infestation of pests diseases etc The fluctuation in the price of the produce results in the lack of interest and attention of the farmers during the periods of low price levels By proper agronomic measures the productivity of the crop can be optimised so that the crop is remunerative even at average price levels One of the costly and labour intensive operations is the weed management Farmers usually go for 3 4 rounds of manual weeding requiring about 130 labourers per annum per hectare Developing a cheaper weed management programme can considerably reduce the bill on this item

Since cardamom is grown in forest environment the luxurient growth of weeds associated with this crop if not properly controlled may suppress the crop growth and yield The lack of attention in the early stages of the crop growth on weed management aspects will be reflected on the crop at later stages

No detailed study has been conducted on the weed management aspects of cardamom and there is no recommendation available which is economic and viable Korikanthimath and Venugopal (1986) conducted surveys in cardamom tracts in Karnataka and identified *Ageratum conyzoides Drymaria cordata* and *Bidens pilosa* as the major weeds in cardamom Nair (1990) has reported 132 weeds which were associated with cardamom He pointed out the need for the economic and viable methods for the control of major weeds of the garden He also reiterated the need for the biology studies of the weeds to evolve efficient and economic weed management

Although the Cardamom Research Station was established at Pampadumpara (now under KAU) four decades back and the Indian Cardamom Research Institute at Myladumpara (Ministry of Commerce Govt of India) subsequently no work has been conducted on weed management in this crop so far except for some preliminary studies under the AICRPWC (KAU 1991) It is very important to identify the major weeds of the cardamom areas and to study the biology of the major weeds to develop a sound weed management programme It is also essential to evaluate the scope of using chemical methods to reduce the cost for weed control Hence the present investigation was taken up with the following objec tives

1 to identify the weed flora associated with cardamom
2 to study the biology of major weeds of cardamom to evolve efficient weed management strategy
3 to assess the effect of weed competition on growth and yield of cardamom and
4 to compare the efficiency of herbicidal and manual methods of weed control in cardamom

Review of Literature

2 REVIEW OF LITERATURE

Cardamom is cultivated in about 83 000 ha of land Out of this a major part of the area is confined to forest In India more than 50 per cent of the total area and 60 per cent of production is from Kerala (FIB 1995) In Kerala it is grown in the forests of the Great mountain Sahya Since cardamom is cultivated in forest environment weeds common to forest areas which come in the group of climbers twiners creepers and grasses are common in the cardamom tracts These weeds deplete the soil fertility and reduce the general fitness of the crop growth especially during the early period of crop growth Except a few surveys on weed flora of cardamom not much works have been undertaken in the weed management aspects Hence studies on weeds and weed management in other crops of high altitude region are also included in the review

2 1 Weed spectrum

2 1 1 Weed flora of cardamom

Nair (1990) listed 132 weeds associated with cardamom of which weeds belonging to Compositae and Gramineae dominated The major dicotyledonous families include Compositae Leguminosae and Rubiaceae and the monocotyledons include Gramineae and Cyperaceae Among the dicotyledonous weeds *Ageratum conyzoides Tinospora cordifolia Neerium indicum Lantana camara Adathoda vasica Urena lobata Argemon mexicana Achyranthes aspera Eclipta alba Curcuma aromatica Phyllanthus niruri Cassia auriculata* and *Ixora coccinia* were the major ones Among grasses *Eleusine indica Avena fatua Paspalam scrobiculatum* were the important ones

Korikanthimath and Venugopal (1986) conducted a survey of weeds of cardamom in the estates of Coorg Karnataka Out of the 23 dicotyledonous weeds studied *Ageratum conyzoides* had the highest frequency Other important weeds were *Drymaria cordata* and *Pilea weightii*

Surveys conducted in cardamom gardens under the AICRP on Weed Control (ICAR) KAU Centre has identified the major weeds in Idukki districts which accounts for the major share of the area under this crop *Ageratum conyzoides Bidens pilosa Achyranthes aspera Crassocephalam crepioides Commelina benghalensis Eleusine indica Justicia prostrata Spilanthes calva Stachytarpheta indica* and *Synedrella nodiflora* were the weeds with high frequency and density (AICRPWC 1991)

2 1 2 Weeds of highranges

Lee (1988) reported that weeds like *Bidens tripartita* and *Sagittaria trifolia* dominated the paddy regions which were above 680 m in South Korea

Dominance of Gramineae and Asteraceae in high altitude coffee planta tions were reported by Caro and Muina (1990) Weed survey conducted by them in Eastern Cuba showed that coffee plantations above 450 m above mean sea level were dominated by the above two families Goldberg and Kigel (1986) also reported the dominance of *Asteraceae* and Gramineae in shaded coffee plantations in Israel Major weeds observed were *Commelina diffusa Bidens pilosa Erigeron canadensis* and *Paspalam conjugatum*

Sharma and Satyanarayanan (1978) reported the dominance of grasses in tea in Assam Sinha (1985) reported the dominance of *Paspalam conjugatum* and *Commelina benghalensis* in tea plantations

The review shows that in the surveys conducted in major cardamom growing tracts and highranges weeds belonging to Asteraceae and Gramineae were the major ones

2 2 Crop weed competition

2 2 1 Effect of major weeds of cardamom on different crops

Effect of shoot root and whole plant competition from *Ageratum conyzoides* on the growth of groundnuts were studied and reported by Banjikwa and Rulangaraga (1985) Whole plant and shoot competition with *Ageratum conyzoides* reduced the R G R N A R and seed dry weight Ishimine and Miyazato (1986) reported the nutrient depletion power and competitive nature of *Bidens pilosa* an aggressive perennial weed of sugarcane Leaf area number of flowers and number of shoots were increased with increase of nitrogen application Increase in moisture increased the shoot root ratio and dry matter production of weeds

Conyza canadensis has been reported to show allelopathic effect on amaranth (Varendi and Polos 1987) Water extracts of *Conyza canadensis* of root and leaves inhibited the growth of *Amaranthus retroflexus*

Weeds are also reported to act as alternate hosts for pest and disease organisms An aggregation of *Udonga montana* was noticed in high ranges of Wayanad on *Bidens pilosa* *Udonga montana* affects crops like banana ginger

cassava and coffee (Prakasan and Kumar 1992) Fleischer and Gaylor (1988) observed *Conyza canadensis* as an alternate host of *Lygus lineolaris* of cotton

2 3 Biology of important weeds of cardamom

Ageratum conyzoides Crassocephalam crepioides and *Erigeron canadensis* had lower limits of germination temperature than the other species which explains their comparatively greater incidence at high altitudes which represent a temperate climate Influence of light on seed germination was studied in *Ageratum conyzoides Bidens pilosa Eleusine indica* and *Euphorbia hirta* All species except *Ageratum conyzoides* germinated in the dark *Bidens pilosa* readily germinated in the dark (Sauerborn and Koch 1988)

2 4 Weed Management

2 4 1 Mechanical and cultural methods

In a field trial at Analardia weed control in plantations using disc harrow rotary cultivator an offset rotary shedder hand hoeing and herbicides were compared Significant differences between treatments were found only when yields were low due to frost followed by long drought (Silveira and Kurachi 1987) In a trial in 1981 Snoeck (1981) noticed that manuring was unsatisfactory in coffee plantations as it favoured development of grasses which competed with crop Good weed control was obtained with alternate application whenever weeds reached a height of 30 cm with Gramaxone and Radaxone each at 2 litres product/ha Duplessix (1990) reported that mechanical weeding alone was too unsatisfactory in rubber in terms of weed control and economics Plastic mulching was found to be very expensive

2 4 2 Chemical methods

Common weeds seen in cardamom can be controlled by post emergence and pre emergence herbicides and also by using herbicide mixtures A review on these aspects are given below

2 4 2 1 Post emergence herbicides

In a three year field trial Adeninkinju (1989) found that Gramaxone at 2 8 3 l/ha gave better weed control in coffee than the traditional method of cutlassing In the third year all the rates tested increased the yield of coffee over that of the cutlassed controls It was found that Gramaxone at 2 8 l/ha was most economic in controlling weeds in the coffee plantations Durigan and Costa (1982) reported that paraquat 0 4 kg/ha controlled all the major weeds of coffee In another study Borland (1974) also found that paraquat controlled major weeds like *Commelina benghalensis Ageratum conyzoides* and *Cyperus esculentus* very effec tively Kabir and Chaudhari (1991) also found that all treatments using Paraquat at different concentrations of 0 22 0 34 and 0 43 kg/ha succeeded in controlling the major weeds in tea All the treatments gave good results with less than 8 weeds per plot compared to 36 8 weeds in the conventional estate practice

Collins (1983) reported that all the major weeds like *Ageratum conyzoides* and *Eupatorium odaratum* of plantation crops were controlled by apply ing glyphosate Hurst and Sterns (1987) observed that *Erigeron canadensis* and *Solanum carolinses* were controlled effectively by glyphosate Ranaprawiro (1982) observed that manual weed control combined with Roundup (glyphosate) application suppressed weed regrowth and had a beneficial effect on growth of tea plants

Glyphosate holds great promise for the control of tough perennial grasses and deep rooted broad leaved weeds and can be used safely in tea upto 1 7 kg/ha against wide range of weeds (Sharma and Satyanarayanan 1978)

Quencez and Venou (1983) reported that *Eupatorium odoratum* and other broad leaved weeds of compositae family were controlled by the application of 2 4 D in rubber plantations

2 4 2 2 Pre-emergence herbicides

Rajamani *et al* (1992) reported that major weeds like *Bidens pilosa Ageratum conyzoides Cynodon dactylon* were controlled effectively in roses by herbicides like diuron 2 0-2 5 kg/ha Simazine 2 3 kg/ha and atrazine 2 3 kg/ha at Yercaud Herbicides evaluated in peaches showed that *Commelina benghalensis Ageratum conyzoides* and *Euphorbia hirta* were well controlled by Simazine 5 0 kg/ha and atrazine 3 5 kg/ha (Gautam and Chauhan 1985) Diuron 2 3 kg/ha and Atrazine 2 3 kg/ha gave effective control of weeds including *Parthenium hysterophorus Cynodon dactylon Eleusine indica* and *Paspalam conjugatum* in grapes (Prabhachalla 1987)

2 4 2 3 Use of herbicide mixtures

Cruz (1982) observed that paraquat 0 4 kg/ha + diuron 0 2 kg/ha was very effective in controlling major weeds in coffee *Paspalam conjugatum* and *Commelina benghalensis* were effectively controlled by a combination of Paraquat 2 l/ha + diuron 8 kg/ha in coffee (Caro *et al* 1985) In a field experiment con ducted in rubber plantation to compare the efficiency of paraquat + diuron and paraquat + 2 4-D paraquat diuron was more effective than paraquat + 2 4 D and

gave 65 per cent weed control (Subudin and Teng 1986) Paraquat + diuron gave great control of perennial grasses and broad leaved weeds in tea (Sharma 1978) Rai (1988) observed very good control of *Eupatorium odoratum* in rubber plantations in Indian West Coast with a combination of paraquat + 2 4 D Adding 2 4 D to paraquat improved overall weed control compared to paraquat alone *Conyza canadensis Ambrosia artemisifolia* were controlled very effectively in corn (Davis and Hagood 1986)

Glyphosate 1.8 kg picloram 22 5 l/ha gave effective control of *Ageratum conyzoides* and *Axonopus compressus* in oilpalm plantations (Endang and Lumhang 1984)

2 4 2 4 Herbicides and synergists

Efficiency of glyphosate was improved by the addition of ammonium sulphate (Harahap 1986) Variation of effectiveness of ammonium sulphate glyphosate combination due to climatic parameters was observed by Kent *et al* (1991) Ammonium sulphate increased the efficiency of the herbicides but its efficiency decreased with increase in relative humidity

Materials and Methods

3 MATERIALS AND METHODS

A study was conducted during 1995 96 to develop weed management practices for cardamom It consisted of a survey of the cardamom growing areas to identify the major weeds associated with the crop studies on the biology of important weeds identified in the survey and a field study to assess the efficiency of herbicidal and manual methods of weeding in the early stages of cardamom Effect of weed competition on growth and yield of cardamom were also studied

3 1 Weed survey

A survey was conducted in 42 randomly selected cardamom plantations in Idukki district The survey was conducted by travelling along the major roads of the region so as to get a representation of the entire area and making observations on the weeds at the selected gardens Fig 1 indicates locations of the survey and the number of sites surveyed in each location is given in parenthesis At every site species wise counts of all the weeds present in one m^2 area was noted from four random places and the average value was recorded Based on the data the following parameters were calculated (Sen 1981)

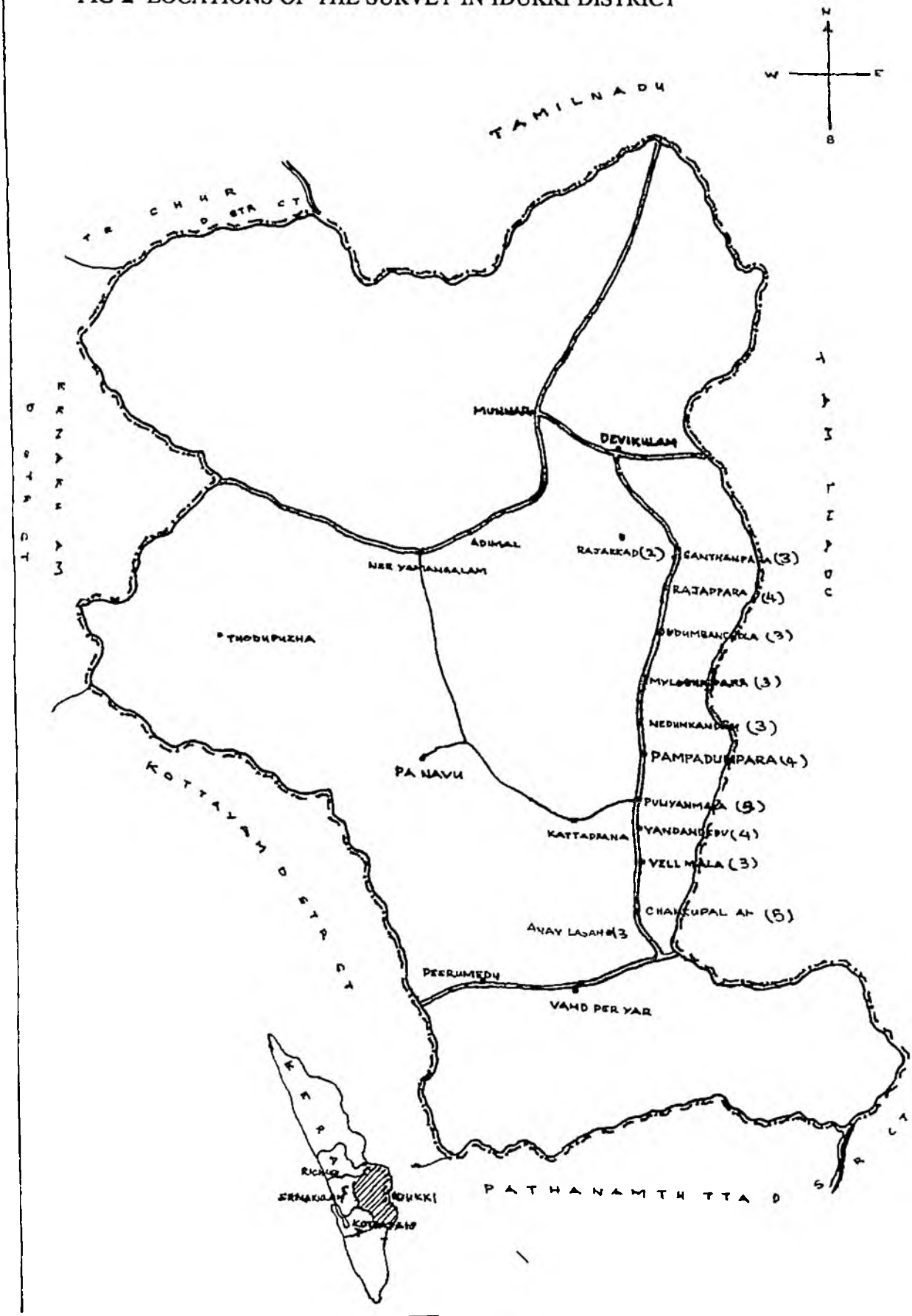
3 1 1 Density

$$\frac{\text{Total count of the species from all the plots}}{\text{Number of sites where the species is present}}$$

3 1 2 Frequency

$$\frac{\text{Number of sites where a particular species occurred}}{\text{Total number of plots surveyed}} \times 100$$

FIG 1 LOCATIONS OF THE SURVEY IN IDUKKI DISTRICT



3 1 3 Relative density

$$\frac{\text{Density of a species}}{\text{Total density of all species}}$$

3 1 4 Relative frequency

$$\frac{\text{Frequency of a species}}{\text{Total frequency of all species}}$$

3 1 5 $$\text{SDR} = \frac{\text{Relative density} + \text{Relative frequency}}{2}$$

3 2 Biology of weeds

Based on the survey ten dominant weeds of cardamom tracts were identified and the following related aspects were studied These studies were conducted at the Cardamom Research Station Pampadumpara

a) Normal time of germination under field conditions

Seeds of ten dominant weeds were collected and 50 seeds of each weed were sown in earthern pots filled with soil which was collected from a depth of one meter to avoid seeds of other weeds Earthern pots with five replications for each weed were kept in natural field conditions without irrigation Normal time of germination under field conditions was noticed by counting the number of seedling of each weed at monthly intervals After each observation the seedlings were removed and the soil in the top portion of the pot was tilled lightly

b) Time of flowering and seed setting

Time when flowering was noticed in a few plants was recorded as the time of first flowering Time when atleast 50 per cent plants bloomed were taken as 50 per cent flowering Time of seed setting was recorded as the time when majority of the seeds have become mature and dried

c) Number of seeds per plant

Number of seeds from 10 inflorescence were counted and the average was multiplied with average of number of inflorescence from 10 weeds to get the number of seeds per plant

d) 1000 seed weight

Weight of 1000 seeds was noted for three lots and the average was recorded

e) Height and dry matter production

Height of ten plants was measured and the average height was recorded Dry matter of ten plants was weighed and the average recorded

f) Dormancy of fresh weeds

Fresh weed seeds were sown in petridishes to study the dormancy Lots of 25 seeds of a particular weed were sown in three petridishes containing a filter paper to study the dormancy The filter paper was kept moist and germination of weed seeds was noted The study was done with fresh weeds immediately after harvest and one month later

g) Nutrient content of weeds at pre flowering stage and after seed setting

Nitrogen phosphorus and potassium accumulated by weeds were deter mined and expressed as percentage Ten dried weeds were powdered and analysed for nutrient removal at pre flowering stage and after the seed set The following methods were used for analyses

1 Nitrogen	Micro kjeldahl method (Soil survey staff 1967)
2 Phosphorus	Vanadomolybdophosphoric yellow colour method using Spectronic 20 (Jackson 1958)
3 Potassium	Triple acid extract method using Flame Photometer (Jackson 1958)

3 3 Weed control in cardamom plantations field trial

3 3 1 Site climate and soil

The investigations were conducted at the Cardamom Research Station Pampadumpara under the Kerala Agricultural University Vellanikkara Thrissur The station is located at 9° 45 N latitude 77° 10 E longitude and at an attitude of 1080 m above MSL Typical humid tropical climate is experienced in this area

The trial was started in 1994 95 under AICRP on Weed Control as a three year trial The observations during October 1995 to August 1996 forms the part of the thesis The details of meteorological observations recorded during the crop season are presented in Appendix I

The soil of the experimental field was loamy in texture The physical and chemical nature of the soil in the field are given in Table 1

Table 1 Physical and chemical composition of the soil of the experimental field

Particulars	Value	Method employed
A Mechanical composition		
Clay fraction (<0 01 mm)	43%	Robinsons s International Pipette
Sand fraction (>0 01 mm)	55%	method (Piper 1942)
B Chemical composition		
Organic carbon (%)	2 3	Walkley and Black method (Soil Survey Staff 1967)
Available N (kg/ha)	350	Semi micro kjeldahl method (Soil Survey Staff 1967)
Available P (mg/100 g soil)	1 3	Bray I extractant Molybdo phosphoric acid method (Jackson 1958)
Available K (mg/100 g soil)	11 0	Neutral normal ammonium acetate extract flame photometry (Jackson 1958)
pH	5 6	1 2 5 soil water suspension using pH meter

Trial was laid out in one year old cardamom plantation of variety PV 1

3 3 2 Treatments

Post emergence herbicides paraquat glyphosate alone and in combination with pre emergence herbicides diuron atrazine were tried Manual weeding and unweeded control were also included as treatments Altogether eleven treatments were tried as shown below

Treatments	Notation
1 Unweeded control	T_1
2 Manually weeded control (twice at start and 60 DAS)	T_2
3 Paraquat 0 4 kg/ha (twice at start and 60 DAS)	T_3
4 Paraquat 0 4 kg/ha + Diuron 1 0 kg/ha	T_4
5 Paraquat 0 4 kg/ha + Atrazine 1 0 kg/ha	T_5
6 Glyphosate 0 8 kg/ha	T_6
7 Glyphosate 0 8 kg/ha + Diuron 1 0 kg/ha	T_7
8 Glyphosate 0 8 kg/ha + Atrazine 1 0 kg/ha	T_8
9 Glyphosate 0 4 kg/ha + 0 5% Ammonium sulphate	T_9
10 Glyphosate 0 8 kg/ha + 0 5% Ammonium sulphate	T_{10}
11 Paraquat 0 4 kg/ha + 2 4 D 1 0 kg/ha	T_{11}

3 3 3 Design and Lay out

Trial was laid out in one year old cardamom plantation planted with variety PV 1 The experiment was laid out in randomised block design with three replications

1 Design RBD

2 Replications 3

3 Plot size 7 2 m x 9 6 m

The cardamom plants were planted at 2 4 m spacing Each plot had six observational plants and a common border row between two plots The layout plan is given in Fig 2. Because of the slopy location and forest trees present in the field gaps between some of the plots were unavoidable

3 3 4 Herbicide application

The herbicide was applied to the weeds in between the cardamom plants when the weeds were about one foot height Direct contact of the herbicide with the crop was avoided Herbicides were sprayed as per the rate specified in the treatments using a knapsack sprayer fitted with a flood jet nozzle Measured quantity of herbicide was mixed with the required quantity of water and sprayed uniformly The volume of the spray fluid was 600 l/ha Details of herbicides are given in Appendix II

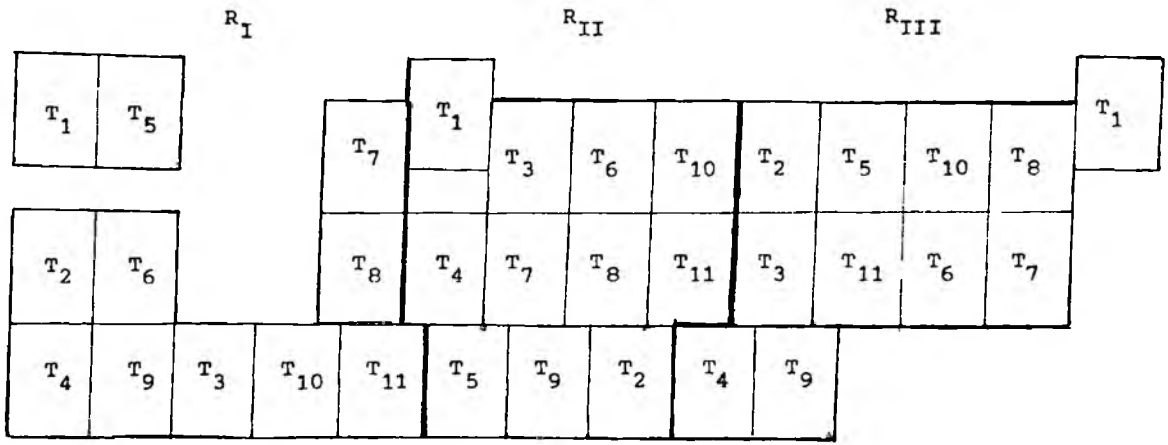
3 3 5 Variety

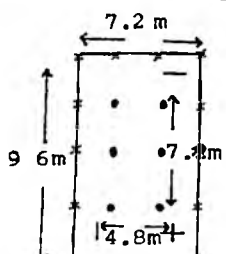
Cardamom variety PV 1 was used for the trial It is a Malabar variety evolved at C R S Pampadumpara by clonal selection

3 3 6 Field culture

The cultural practices recommended by the Kerala Agricultural University (KAU 1993) were followed during the course of the experiment except the weed control operations which varied as per the treatments

Fig 2. PLAN OF LAYOUT





SINGLE PLOT

Legend

* Border row plants

• Observational plants

Gross plot area
(7.2 m x 9.6 m) = 69 12 m^2

Net plot area
(4.8 m x 7.2 m) = 34.56 m^2

3 3 7 Observations

3 3 7 1 Weed population

The weed count were recorded species wise by throwing a quadrat 0 5 m x 0 5 m size at two spots per plot and reported in number per m^2

3 3 7 2 Dry matter production

All the weeds enclosed by the 0 25 m^2 size quadrat were uprooted oven dried weighed and drymatter was expressed in g m^2

3 3 7 3 Organic carbon content of soil

Organic carbon content of soil at the beginning of the trial (1994 95) as well as at the end of first year and second year of the trial were analysed Soil samples collected from each plot were analysed for percent organic carbon following Walkley and Black method (Soil Survey Staff)

3 3 7 4 Removal of NP and K by weeds

The nitrogen phosphorus and potassium removed by the weeds were calculated by multiplying the dry matter production of the weeds per hectare with the respective nutrient content Weeds collected for dry matter production were ground in a grinder mixed thoroughly and a subsample was used for analysis of N P and K content of the weeds The analysis was done as per methods already de scribed (section 3 8 9) and expressed in kg ha^{-1}

3 3 7 5 Growth characters of cardamom

a) Height

Height of individual plants were taken in cm Height from ground level to top of the tallest tiller was measured and recorded as height of the plant

b) Tiller number

Tillers of individual plants were counted and recorded

c) Per cent of flowered plants

Flowered plants per plot were counted and recorded as percentage of flowering plants per treatment

d) Yield

Cardamom pods produced by the plants per plot were dried weighed and recorded as yield in kg/ha

3 3 7 6 Residue studies of herbicides

Sixty days after spraying the chemicals soil samples were taken from different treatments for bioassay studies

A pot culture study was conducted in a completely randomised design with three replication using the sensitive crop cowpea Ten viable seeds of cowpea were sown in each pot and germination count was taken one week after sowing The plants were thinned to 5 and observations on plant height (2 weeks after emergence)

and dry weight of plants (4 weeks after emergence) were recorded and the data were analysed statistically

3 3 7 7 Effect of accidental spraying of herbicides on cardamom

In order to find out the effect of accidental contact of the herbicide by the non target cardamom plants while spraying with paraquat and glyphosate a separate trial was conducted the treatments were as follows

1 Control (no spray)
2 Spraying on 25 per cent of the tillers
3 Spraying on 50 per cent of the tillers
4 Spraying on 75 per cent of the tillers
5 Spraying on 100 per cent of the tillers

Paraquat at a concentration of 10 ml/litre and glyphosate at 8 ml/litre were sprayed so as to get complete coverage of the foliage 25 50 75 and 100 per cent of the tillers as per the treatments Trial was separately conducted for paraquat and glyphosate Each treatment was replicated four times Observations were taken on the effect of herbicides on the tillers sprayed with herbicides as well as non sprayed tillers in the same plant upto 20 days after spraying

3 3 7 8 Economics of weed control

Economics of herbicidal treatments and manurial methods in comparison to unweeded control was worked out Cost involved for weeding in different treat ments during the period of study for one hectare was worked out based on the cost of chemicals as well as the labour charges involved in each case

3 3 7 9 Statistical analysis

The data recorded for different characters were compiled and tabulated in proper form and were subjected to analysis of variance (Panse and Sukhatme 1978) Subsequently standard errors were worked out and wherever the F tests were significant appropriate critical difference (CD) were calculated to test the significance of the treatment differences

Analysis of variance for the data on weed population and weed dry matter production were carried out after transforming the data to $\sqrt{x}$ Abstract of analysis of variance is presented in Appendix III

Results and Discussion

4 RESULTS AND DISCUSSION

The results of the studies conducted to identify the weed flora associated with cardamom and to assess the effect of weed competition on growth and yield of cardamom as well as to compare the efficiency of chemical and manual methods of weed control in cardamom are presented and discussed in this chapter The data on different observations were subjected to statistical analysis and the results are dis cussed under the following heads

4 1 Studies on major weeds

4 1 1 Weed Survey

4 1 2 Biology of weeds

4 2 Weed control in cardamom

4 1 Studies on major weeds

4 1 1 Weed survey

A weed survey was conducted in 42 randomly selected cardamom estates in Idukki district Density frequency relative density relative frequency and S D R of the weeds were worked out and are presented in the Table 2 The weeds are arranged in the order of decreasing of S D R values

Data presented in Table 2 shows that maximum S D R (10 725) was recorded by *Ageratum conyzoides* and the least was recorded by *Commelina benghalensis* (1 15) These results are in accordance with that of the survey conducted by Lee (1988) who reported dominance of *Bidens tripartita* in higher regions in South Korea which were above 680 m Similar results were also reported

Table 2 Density frequency and SDR of weeds of cardamom

Sl No	Name of weed	Average density	Frequency (%)	Relative density	Relative frequency	SDR
1	*Ageratum conyzoides* L	5 0	82	9 5	11 95	10 725
2	*Bidens pilosa* L	5 25	76	10 1	11 07	10 58
3	*Crassocephalam crepioides* Hoore	4 92	68	9 4	9 91	9 65
4	*Synedrella nodiflora* Gaertn	4 58	70	8 7	10 2	9 45
5	*Paspalam conjugatum* Berg	2 64	82	5 0	11 95	8 47
6	*Scoparia dulcis* L	3 25	70	6 2	10 2	8 2
7	*Drymaria cordota* Willd	2 92	68	5 6	9 91	7 75
8	*Erigeron canadensis* L	3 18	53	6 1	7 7	6 9
9	*Spilanthes calva* DC	2 4	36	4 6	5 2	4 9
10	*Eleusine indica* Garten	1 92	34	3 68	4 95	4 31
11	*Achyranthes aspera* L	2 08	29	3 99	4 22	4 1
12	*Clerodendron viscosum* Vent	3 0	2	5 7	0 29	2 9
13	*Justicia prostrata* Gamble	3 0	2	5 7	0 29	2 9
14	*Stachytarphata indica* Vahl	2 5	5	4 79	0 72	2 75
15	*Phyllanthus niruri* L	2 0	5	3 83	0 72	2 27
16	*Oplismenus burmanni* P Beauv	2 0	2	3 83	0 29	2 06
17	*Commelina benghalensis* L	1 5	4	2 87	0 58	1 15

in the survey conducted by Korikanthimath and Venugopal (1986) in cardamom where *Ageratum conyzoides* and *Drymaria cordata* emerged as the major weeds The dominance of Asteraceae and Gramineae in the present survey was in confirmation with that of the survey conducted by Goldberg and Kigel (1986) The results also tally with the reports of the survey conducted by AICRP on Weed Control (ICAR) KAU centre which also identified *Ageratum conyzoides Bidens pilosa Crassocaphalam crepioides Spilanthes calva* as the major weeds (AICRPWC 1991)

Based on the S D R values ten major weeds were selected for studying their biology Important features of these weeds are as follows (Gamble 1935)

1 *Ageratum conyzoides* L Belongs to the family Asteraceae Common in damp hilly areas and in forests It is a troublesome weed in tea coffee and other plantations

2 *Biden pilosa* L Member of Asteraceae family Common in high altitude areas It is not truely indigenous

3 *Crassocephalam crepioides* Moore Belongs to the family Asteraceae fleshy weed seen in damp forest areas It is troublesome weed in tea and coffee

4 *Synedrella nodiflora* Gaertn Member of Asteraceae family Centre of Origin is Mexico This weed is common in plains and high altitudes

5 *Paspalam conjugatam* Berg Belongs to family Poaceae Common along the roadsides wastelands margins of streams and rivers and as a weed in cultivat ed field Very common in tea and rubber estates as an under growth and occa sional along the margins of the forests

6 *Scoparia dulcis* L Member of the family scrophulariaceae It is seen upto 3000 feet from mean sea level It is a Tropical American Plant very common in India

7 *Drymaria cordata* Wille Belongs to the family Caryophyllaceae Seen around western ghats upto 4000 ft in shady places

8 *Erigenon canadensis* L Member of the family Asteraceae very common in Nilgiri areas Centre of origin is North America

9 *Spilanthes calva* Dc Belongs ato the family Asteraceae Seen the plains hills and dampy forest areas The flower heads when chewed gives a burning taste

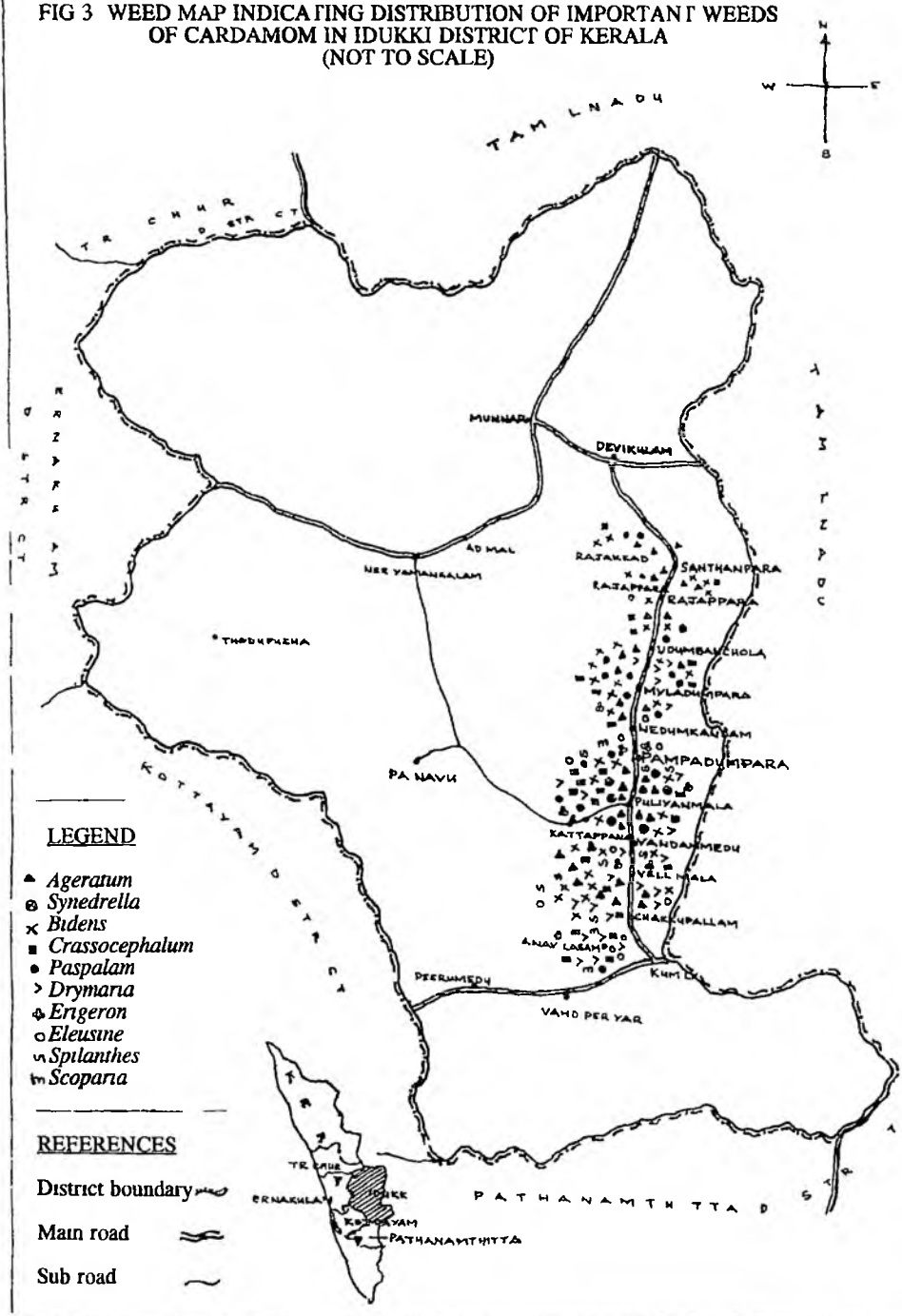
10 *Eleusine indica* Gaertn Member of Poaceae family Common along road sides waste lands margins of streams and rivers and as a weed in cultivated fields It is a cosmopolitan weed and also a good fodder

Most of the weeds described above are highly adapted to high attitudes where plantation crops linke tea coffee pepper and cardamom are grown So a detailed study of their biology is highly essential for the effective management of there weeds in cardamom plantations

The weed map indicating distribution of ten major weeds of cardamom in Idukki district of Kerala is shown in Fig 3

The map clearly indicates the dominance of *Ageratum conyzoides Bidens pilosa Crassocephalam crepioides* in the entire area surveyed Dominance of grasses were maximum at the Pampadumpara area and was decreasing towards

FIG 3 WEED MAP INDICATING DISTRIBUTION OF IMPORTANT WEEDS OF CARDAMOM IN IDUKKI DISTRICT OF KERALA (NOT TO SCALE)



north Dominance of *Scoparia dulcis* is maximum at Anavilasam and Pampadumpara areas *Erigeron canadensis Drymaria cordata Synedrella nodyflora* and *Spilanthes calva* were observed in the entire area with low density

4 1 2 Biology of weeds

4 1 2 1 Time of germination

Fifty seeds each of ten major weeds were sown in pots during November 1995 for studies on germination under natural conditions and observations were taken The per cent of seeds germinated at different periods are presented in Table 3

It is evident from the data that though the seeds were sown during November 1995 they did not germinate due to lack of rains Early summer showers were received from twelfth of April onwards and germination of weeds started immediately Among ten major weeds tried *Bidens pilosa* recorded maximum percentage of germination at all the stages

Drymaria cordata and *Erigeron canadensis* did not germinate till June In May 1996 none of the weed seeds germinated due to lack of rains With the onset of monsoons germination restarted in all the weeds and was continued as the rainfall was continuous It was due to the lowering of temperature after the month of June due to heavy rains It can also be seen from Table 3 that *Bidens pilosa* recorded maximum germination percentage at every time compared to all other weeds This must be the reason for dominance of *Bidens pilosa* in higher altitude regions

Table 3 Germination (%) of major weeds under field conditions

Sl No	Name of weed	Germination at different periods*				
		April 15th	May 15th	June 15th	July 15th	August 15th
1	*Ageratum conyzoides*	2 0	0 0	14 0	16 0	12
2	*Bidens pilosa*	20 0	0 0	7 6	9 6	8
3	*Crassocephalam crepioides*	4 4	0 0	8 4	11 6	14
4	*Synedrella nodiflora*	1 6	0 0	5 6	8 0	22
5	*Paspalam conjugatam*	2 0	0 0	4 4	6 0	6
6	*Scoparia dulcis*	1 6	0 0	3 6	6 0	8
7	*Drymaria cordata*	0 0	0 0	1 6	3 6	14
8	*Erigeron canadensis*	0 0	0 0	2 4	4 8	24
9	*Spilanthes calva*	2 4	0 0	5 6	7 6	0
10	*Eleusine indica*	2 0	0 0	3 6	5 6	6

Date of sowing November 22 1995
* No weed seeds germinated till rains in April

4 1 2 2 Flowering pattern of major weeds

Flowering pattern of major weeds were observed in the experimental plot Observation on time first flowering 50 per cent flowering and seed setting are presented in Table 4

It is seen that *Bidens pilosa Scoparia dulcis* and *Spilanthes calva* started flowering in May and flowering was continued Other major weeds started flowering by July Those weeds which started early flowering completed their 50 per cent flowering by middle to end of June and seed setting was observed from August to September in all the weeds

In *Scoparia dulcis* flowering was continuous and at the same time new flowers and mature seeds were seen in the same plant which shows the adaptation of this weed to the locality A similar continuous production of seeds as adaptation for survival is seen in small nettle (*Urtica urens*) which also produced seeds over a very large portion of its growing period (Hill 1977)

4 1 2 3 Seed production

Observations on the number of inflorescence seeds per inflorescence and seeds per plant are presented in Table 5

Scoparia dulcis recorded maximum number of inflorescence per plant (182) followed by *Erigeron canadensis* and *Ageratum conyzoides* while least (3) was seen in *Paspalam conjugatum*

The number of seeds per inflorescence was maximum in *Eleusine indica* (448) followed by *Paspalam conjugatum* (390) and minimum in *Drymaria cordata*

Table 4 Flowering pattern of major weeds of cardamom

Sl No	Name of weeds	First flowering	50 per cent flowering	Seed setting
1	*Ageratum conyzoides*	Middle of May	June end	August end
2	*Bidens pilosa*	Beginning of July	July end	Middle of September
3	*Crassocephalam crepioides*	Beginning of July	July end	Middle of September
4	*Synedrella nodiflora*	Beginning of July	July end	Middle of September
5	*Paspalam conjugatam*	July end	Beginning of August	Millde of September
6	*Scoparia dulcis*	Middle of May	Continued flowering	Middle of August
7	*Spilanthes calva*	Middle of May	Middle of June	Middle of September
8	*Erigeron canadensis*	Beginning of July	July end	Middle of September
9	*Drymaria cordata*	Beginning of July	July end	Middle of September
10	*Eheusine indica*	July end	Beginning of August	Middle of September

Table 5 Seed production in major weeds of cardamom

Sl No	Name of weed	Number of inflorescence	Seeds per inflorescence	Seeds per plant
1	*Ageratum conyzoides*	24	117	2808
2	*Bidens pilosa*	15	54	810
3	*Crassocephalam crepioides*	8	104	832
4	*Synedrella nodiflora*	9	37	333
5	*Paspalam conjugatum*	3	390	1170
6	*Scoparia dulcis*	182	144	26208
7	*Drymaria cordata*	8	25	200
8	*Erigeron canadensis*	24	200	4800
9	*Spilanthes calva*	18	72	1296
10	*Eleusine indica*	7	448	3136

(25) The seed production per plant was maximum in *Scoparia dulcis* (26208) where as it was the minimum in *Drymaria cordata* (200)

From the above results it is clear that not only the highest number of seeds per inflorescence (144) per plant but also the maximum average number of inflorescence (103) per plant resulted in the highest production of seeds per plant (26208) in *Scoparia dulcis*

4 1 2 4 1000 seed weight

Results presented in Table 6 shows that *Bidens pilosa* had maximum 1000 seed weight (1 64 g) followed by *Synedrella nodiflora* Minimum 1000 seed weight (0 04) was for *Scoparia dulcis* With increase in the number of seeds produced by a plant weight of seeds will decrease helping them in easy dispersal In *Scoparia dulcis* eventhough the seeds are not specially suited for wind dispersal as in the case of plants of Compositae family the very low weight of the seeds help the weed in the dispersal of its seed (Hill 1977)

4 1 2 5 Height and dry matter production of weeds

a) Height

Results presented in Table 6 showed that maximum height was recorded by *Crassocephalam crapioides* (77 cm) whereas minimum height was for *Paspalam conjugatum* (22 cm) and *Drymaria cordata* (22 cm) Height of the weeds were found to vary with species

Crassocephalam crepioides Bidens pilosa Ergeron canadensis and *Ageratum conyzoides* with their characteristic height will compete for light Hence

Table 6 Weight of 1000 seeds height and dry matter production of important weeds of cardamom

Sl No	Name of weed	1000 seed weight (g)	Height (cm)	Dry matter (g/plant)
1	*Ageratum conyzoides*	0 1	64	6 2
2	*Bidens pilosa*	1 64	65	4 6
3	*Crassocephalam crepioides*	0 26	77	6 8
4	*Synedrella nodiflora*	0 72	56	4 2
5	*Paspalam conjugatam*	0 32	22	1 92
6	*Scoparia dulcis*	0 04	38	3 8
7	*Drymaria cordata*	0 24	22	0 92
8	*Erigeron canadensis*	0 08	76	4 2
9	*Spilanthes calva*	0 08	70	5 2
10	*Eleusine indica*	0 48	23	2 2

during the early stages their competition can be quite dangerous for the establish ment of cardamom seedlings

b) Dry matter production

Dry matter production of *Crassocephalam crepioides* was maximum (6 8 g) compared to all other weeds *Drymaria cordata* (0 92 g) recorded minimum dry matter production

4 1 2 6 Dormancy of fresh weeds

It is clear from Table 7 that seeds os *Synednella nodiflora Paspalam conjugatum Drymaria cordata* and *Erigeron canadensis* did not germinate imme diately after maturity on the plants In other weeds germination immediately after maturity ranged from 4 to 24 per cent *Bidens pilosa* and *Eleusine indica* recorded maximum percentage of germination immediately after maturity (24%) Out of the four weeds which did not germinate immediately after maturity except *Synedrella nodiflora* all others are not common in the plains where temperature is higher

All the seeds germinated one month after the maturity (in December) when temperature had fallen down This indicates the adaptation of *Synedrella nodi flora Paspalam conjugatum Drymaria cordata* and *Erigeron canadensis* to higher altitude where temperature is lower than the plains Maximum percentage of germination one month after maturity was recorded by *Synedrella nodiflora* (64%) followed by *Bidens pilosa* (52%)

Table 7 Dormancy of weed seeds at maturity and one month later

Sl No	Name of weed	% germination		% Dormancy	
		At maturity	One month later	At maturity	One month later
1	*Ageratum conyzoides*	12	16	88	84
2	*Bidens pilosa*	24	52	76	48
3	*Crassocephalam crapioides*	12	8	88	92
4	*Synedrella nodiflora*	0	64	100	36
5	*Paspalam conjugatam*	0	24	100	76
6	*Scoparia dulcis*	12	24	88	76
7	*Drymaria cordata*	0	24	100	76
8	*Erigeron canadensis*	0	28	100	72
9	*Spilanthus calva*	4	32	96	68
10	*Eleisine indica*	24	8	76	92

4 1 2 7 Nutrient content of weeds

The data on nutrient content by weeds at pre flowering and post flowering stages are presented in Table 8

a) Nitrogen

The data presented in Table 8 shows that *Ageratum conyzoides* accumulated maximum percentage of nitrogen both at pre flowering (2 33%) and post flowering stages (2 01%) All other weeds had nitrogen content around two per cent at pre flowering stage At post flowering stage nitrogen content of all weeds declined to below two per cent except *Ageratum conyzoides* and *Paspalam conjugatum*

b) Phosphorus

Highest phosphorus content was recorded in *Eleusine indica* at pre flowering (0 192%) and post flowering (0 184%) stages A reduction in phosphorus content was also observed at post flowering stage

c) Potassium

Potassium content was the highest for *Synedrella nodiflora* at pre flowering and post flowering stages (3 0%) and 2 7%) respectively As in the case of N and P a reduction of K content at post flowering stage was observed

The reduction of N P and K per cent at the time of post flowering stage is due to the diversion of nutrients to flower heads for seed production This indicates that if at all hand weeding is to be practised it has to be done before the

Table 8 Nutrient content of major weeds of cardamom

Sl No	Name of weed	Pre flowering			Post flowering		
		N %	P %	K %	N %	P %	K %
1	*Ageratum conyzoides*	2 33	0 172	2 7	2 01	0 161	2 3
2	*Bidens pilosa*	1 94	0 146	2 9	1 710	0 132	2 2
3	*Crassocaphalam crapioides*	2 02	0 161	2 8	1 97	0 173	2 1
4	*Synedrella nodiflora*	2 06	0 133	3 0	1 86	0 152	2 7
5	*Paspalam conjugatam*	2 15	0 144	2 4	2 01	0 123	2 2
6	*Scoparia dulcis*	1 85	0 162	2 6	1 21	0 104	2 1
7	*Drymaria cordatapy*	2 01	0 151	2 9	1 89	0 132	2 6
8	*Erigeron canadensis*	1 92	0 141	2 8	1 90	0 121	2 1
9	*Spilanthes calvapy*	1 94	0 174	2 7	1 63	0 168	2 2
10	*Eleusine indica*	1 96	0 192	2 0	1 82	0 184	1 92

flowering of the weeds Delayed weeding after the seed production will lead to production of large number of seeds which will reinfest the field in subsequent seasons On the contrary if weeding is done before flowering seed production can be controlled to a greater extent This is especially important in the case of annual weeds which reproduce mostly through seeds In addition to controlling the seed production early weeding can utilise the weed as a source of organic matter of higher nutritive value

4 2 Weed control in cardamom

The results of the field trial conducted at Cardamom Research Station Pampadumpara to compare the efficiency of different chemical methods of weed control with that of the manual methods are presented and discussed in this chapter The trial was started in 1994 95 under the AICRP on Weed Control as a three year trial The observations of the 1995 96 (second year) forms the part of this thesis

4 2 1 Weed flora of the field

A total of 16 different species of weeds belonging to different families were present in the experimental field The proportion of ten weeds which had the maximum percentage of the total weed population is presented in Table 9 It can be seen that out of the important ten weeds in the experimental site 7 weeds (*Bidens pilosa Drymaaria cordata Ageratum conyzoides Paspalam conjugatum Crassocephalam crepioides Eleusine indica* and *Synedrella nodiflora*) figure in the list of the ten important weeds of cardamom area identified in the survey Hence the experimental field can be considered as a representative site for the trial As in the survey conducted by Goldberg and Kigel (1986) in coffee here also weeds

Table 9 Proportion of different weeds in unweeded control

Weeds	Proportion (%)
Drymaria cordata	19
Bidens pilosa	18
Commelina benghalensis	14
Crassocephalam crepioides	12
Oplismanus burmannii	10
Achyranthes aspera	10
Synedrella nodiflora	4
Paspalam conjugatum	4
Ageratum conyzoides	2
Eleusine indica	2

belonging to Compositae *Synedrealla nodiflora Bidens pilosa Crassocephalam crepioides* and *Ageratum conyzoides* together accounted for 36 per cent of weed population From Gramineae *Paspalam conjugatam Oplismenus burmannii* and *Eleusine indica* were the major weeds accounting for sixteen per cent of the popula tion *Drymaria cordata* (19%) *Commelina benghalensis* (15%) and *Achyranthes aspera* (10%) were the other major weeds

4 2 2 Weed count

Observations on the count of weeds at 45 and 90 days after start of the trial are presented in Table 10

At both stages unweeded control had the maximum weed count At 45 days stage among the herbicide treatments only those involving glyphosate 0 8 kg/ha (either alone or in combination with atrazine diuron or ammonium sulphate) reduced the weed population to a level on par with the hand weeding At 90 days stage evidently due to the germination of new seedlings these treatments also recorded significantly higher weed population compared to the hand weeding However the treatment where paraquat was repeated at 60 day controlled the weeds effectively to a level comparable to hand weeding which also received the second weeding at 60 days A comparison of the treatments with the unweeded control shows that all the herbicide treatments had significantly lower weed count than the unweeded control Here also treatments involving glyphosate 0 8 kg/ha alone or in combination with diuron or atrazine had lower weed counts than the combinations of paraquat with atrazine diuron and 2 4 D

Table 10 Effect of the treatments on count and dry matter production of weeds

Treatment	Weed count (no/m²)		Weed dry matter production (g/m²)	
	45 days	90 day	45 day	90 day
Unweeded control	16 60(1 196)*	34 33(5 851)*	34 90(5 904)*	110 77(10 513)*
Hand weeding	6 00(2 426)*	4 67(2 150)*	12 5(3 528)*	15 53(3 902)*
Paraquat 0 4 kg/ha (twice)	14 33(3 760)*	4 67(2 150)*	16 67(4 081)*	14 50(3 800)*
Paraquat 0 4 + Diuron 1 kg/ha	13 33(3 635)*	19 00(4 350)*	12 50(3 534)*	47 90(6 851)*
Paraquat 0 4 + Atrazine 1 kg/ha	12 00(3 376)*	16 33(4 044)*	14 00(3 739)*	51 80(7 043)*
Glyphosate 0 8 kg/ha	5 67(2 298)*	16 33(3 147)*	7 13(2 669)*	28 90(5 332)*
Glyphosate 0 8 + Diuron 1 kg/ha	7 33(2 702)*	12 67(3 478)*	8 43(2 890)*	42 30(6 328)*
Glyphosate 0 8 + Atrazine 1 kg/ha	7 00(2 609)*	14 67(3 816)*	10 83(3 285)*	30 37(5 24)*
Glyphosate 0 4 + 0 5% Ammonium sulphate	11 67(3 99)*	20 33(4 456)*	20 67(4 543)*	85 33(9 200)*
Glyphosate 0 8 + 0 5% Ammonium sulphate	7 67(2 759)*	10 67(3 260)*	10 50(3 215)*	37 33(6 120)*
Paraquat 0 4 + 2 4 D 1 kg/ha	12 00(3 458)*	22 00(4 638*)	11 67(3 257)*	60 87(7 754)*
SEm+	0 286	0 353	0 159	0 247
CD (0 05)	0 846	0 469	1 49	1 855

* The values in parenthesis are $\sqrt{x}$ transformed values

start of the trial are presented in Table 10 As in the case of weed count maximum weed dry matter production was recorded in unweeded control at both the stages The herbicide treatments in general reduced the dry matter production by weeds significantly At 45 days stage all the herbicide treatments were on par with the hand weeded control There was no significant difference between the various chemical treatments at this stage However at 90 days stage only the repeated application of paraquat 0 4 kg/ha glyphosate 0 8 kg/ha + diuron 1 0 kg/ha were comparable to hand weeded plot Among them the repeated application of paraquat recorded lower dry matter production than the hand weeding though not statistically significant

From the data it is seen that there was a considerable increase in the dry matter production of weeds from 45 days to 90 days The exceptions to this are hand weedmg and paraquat treatments which received the repetition of the treat ments at 60 days This is because of the continued growth of weeds which survived in initial treatment as well as the new ones which germinated In the case of paraquat a second application at 60 days has further reduced the growth of the weeds which were surviving the first application Data also shows that there was apreciable benefit by combining diuron or atrazine with glyphosate Comparative evaluation showing the performance of selected herbicide treatments at 45 and 90 days in reduc ing dry matter production is shown in Fig 4

Eventhough synergistic effect from mixing glypgosate with ammonium sulphate has been reported earlier same is not observed in this trial

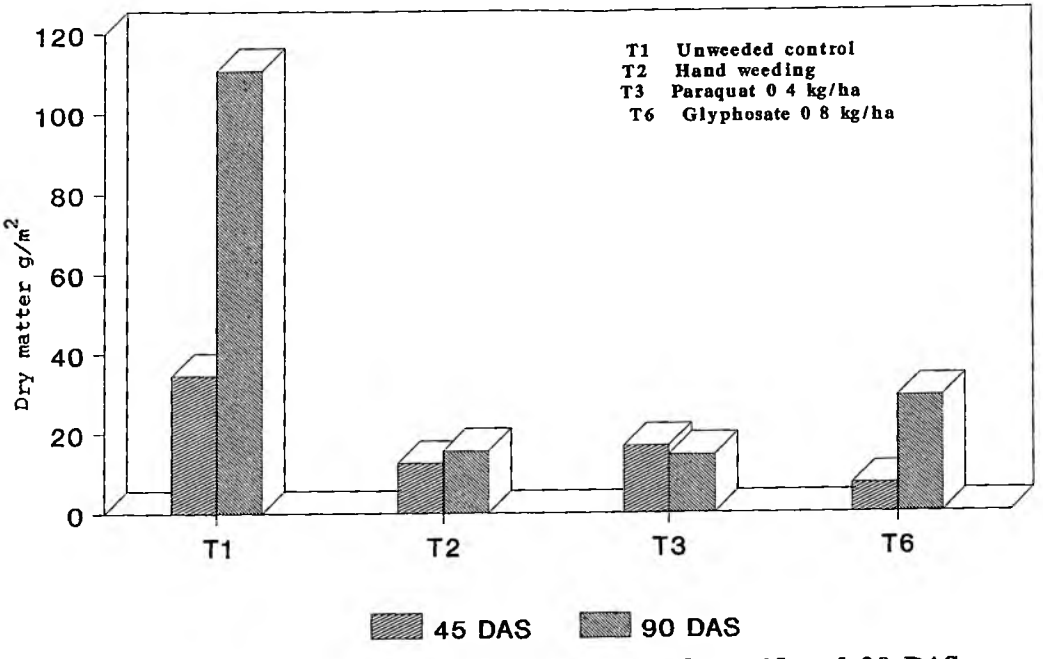


Fig 4. Dry matter production of weeds at 45 and 90 DAS in selected treatments

The trial indicates that for effective weed control upto 90 days application of paraquat 0 4 kg/ha at bimonthly interval or glyphosate 0 8 kg/ha once are as effective as two hand weedings Results of the present findings are in agreement with earlier reports of Borland (1974) Collins (1983) Adeninkinju (1989) who reported the control of similar of weeds in tea and coffee with paraquat and glyphosate

4 2 4 Removal of N, P and K by weeds

Nitrogen phosphorus and potassium removal by weeds were studied at 45 and 90 days after spraying during the year 1995 96 and the results are presented in Table 11

a) Nitrogen

Unweeded control recorded the highest nitrogen removal at 45 and 90 days This is due to the highest dry matter production by the unchecked growth of weeds in the unweeded control plots Among the different treatments tried glyphosate 0 8 kg/ha recorded the lowest nitrogen removal by weeds and all other treatments had significantly higher nitrogen removal This is due to better efficiency of glyphosate in controlling weed growth

At 90 days the N removal by weeds was the least in the plots treated with paraquat 0 4 kg/ha and it was significantly lower than all other treatments and was comparable to hand weeding In general nitrogen removal by weeds was more at 90 days than at 45 days due to the higher dry matter production of weeds at the later stages Because of the bimonthly application of paraquat the weed growth at 90 days stage was lower in the treatment and hence nitrogen removal was also reduced

Table 11 Effect of weed control treatment on the removal of N P and K at 45 and 90 DAS (kg/ha)

Sl No	Treatments	N		P		K	
		45 DAS	90 DAS	45 DAS	90 DAS	45 DAS	90 DAS
1	Unweeded control	32 140	117 667	2 109	6 835	41 263	128 230
2	Hand weeding	12 477	15 033	0 694	0 802	11 607	15 593
3	Paraquat 0 4 kg/ha (twice)	16 167	15 010	0 854	0 670	12 563	13 373
4	Paraquat 0 4 + Diuron 1 kg/ha	11 343	44 987	0 589	1 336	12 430	47 980
5	Paraquat 0 4 + Atrazine 1 kg/ha	11 800	49 467	0 815	2 798	14 913	52 657
6	Glyphosate 0 8 kg/ha	7 030	27 100	0 434	1 924	6 143	27 373
7	Glyphosate 0 8 + Diuron 1 kg/ha	8 510	43 060	0 503	2 381	8 093	43 197
8	Glyphosate 0 8 + Atrazine 1 kg/ha	10 423	28 230	0 521	1 765	11 097	31 207
9	Glyphosate 0 4 + 0 5 % Ammonium sulphate	18 513	83 900	1 260	6 750	20 860	89 243
10	Glyphosate 0 8 + 0 5% Ammonium sulphate	11 243	34 477	0 558	2 748	10 403	38 583
11	Paraquat 0 4 + 2 4 D 1 kg/ha	9 263	45 507	0 642	3 147	11 477	64 763
SE±		0 349	2 870	0 046	0 156	0 467	3 004
CD(0 05)		1 029	8 467	0 135	0 461	1 379	8 860

b) Phosphorus

The highest phosphorus removal by weeds at 45 and 90 days was recorded by unweeded control due to the highest dry matter production resulting from the uncontrolled growth of weeds Among the various treatments tried glyphosate 0 8 kg/ha was the best treatment in reducing phosphorus removal by weeds and was significantly superior to T_1 T_2 T_3 T_4 and T_9 whereas it was at par with rest of the treatments

At 90 days paraquat 0 4 kg/ha was the best in reducing phosphorus removal by weeds and was significantly superior to all other treatments except T_2

c) Potassium

Potassium removal by weeds also followed the same trend as in the case of nitrogen and phosphorus Among the various treatments tried the best treatment for reducing potassium removal by weeds were the same as for nitrogen and phosphorus at both the stages of observation

In general in unweeded plots removal of nutrients from soil will be the maximum When we go for hand weeding after the weeds have grown up to sufficient size even though we return the weeds back a temperory locking up of nutrients in the weeds plants will affect the crop growth adversely So timely appli cation of ideal herbicide is the best choice in weed management

4 2 5 Growth and yield of cardamom

The influence of different treatments on height of the plants number of

tillers per cent of flowered plants and yield of cardamom plants were recorded and are presented in Table 12

Data clearly showed that plant height (cm) per cent plants flowered (%) and yield (kg/ha) did not differ significantly due to the treatments

Though the height of cardamom plants did not show much difference among various treatments the maximum height (150 1 cm) was recorded by the treatment glyphosate 0 8 + diuron 1 0 kg/ha and the lowest height in unweeded control (142 8 cm)

Number of tillers per plant was significantly different under various treatments All the treatments where some weed control was adopted produced more tillers per palnt compared to the unweeded control Maximum number of tillers (9 6) was in paraquat 0 4 kg/ha (9 6) compared to the least (4 2) by unweeded control Treatment No 3 4 5 and 8 were significantly superior to all other treatments and were at par with each other

Though the per cent of flowered plants did not differ significantly maximum value was recorded by hand weeding (63%) In the unweeded plot none of the plants flowered This is clearly due to the adverse effect of weed competition on growth of the plants In banana delayed flowering due to uncontrolled weed competition has been reported by Savithri (1990)

Though the difference in yield between the treatments was non significant all the treatments except glyphosate 0 4 kg/ha + Ammonium sulphates recorded some yield when the unweeded control did not yield at all Among the different treatments glyphosate 0 8 kg/ha (43 97 kg/ha) and hand weed ing (31 15 kg/ha) had recorded the highest yields

Table 12 Effect of weed management treatments on the growth and yield of cardamom

Sl No	Treatments	Height (cm)	Tillers (no/plant)	Plants flowered (%)	Yield (kg/ha)
1	Unweeded control	142 8	4 2	0	0
2	Hand weeding	149 8	8 2	31 150	63
3	Paraquat 0 4 kg/ha (twice)	144 7	9 6	23.917	47
4	Paraquat 0 4 kg/ha + Diuron 1 kg/ha	142 4	9 2	6 78	33
5	Paraquat 0 4 kg/ha + Atrazine 1 kg/ha	148 8	9 4	5 84	11
6	Glyphosate 0 8	145 1	8 8	43 97	61
7	Glyphosate 0 8 + Diuron 1 kg/ha	150 1	8 1	16 68	27
8	Glyphosate 0 8 + Atrazine 1 kg/ha	149 7	7 4	1 35	6
9	Glyphosate 0 4 + 0 5% Ammonium Sulphate	147 9	8 8	0 0	0
10	Glyphosate 0 8 + 0 5% Ammonium Sulphate	143 3	9 3	23 84	25
11	Paraquat 0 4 + 2 4 D 1 kg/ha	149 76	8 3	18 13	46
SEm+		2 25	0 23	3 17	2 27
CD (0 05)		NS	0 69	NS	NS

Since the experiment was conducted during the early phase of the cardamom plants (2nd and year of growth) they were not in the steady bearing stage Still the results indicated that for better growth and yield of cardamom proper weed control is a must

4 2 6 Soil organic carbon content

Organic carbon content of soil was estimated at the beginning and after each year of trial and the results are presented in Table 13

The data clearly shows that there was no significant difference among the different treatments tried during both the years of study However there is a trend of increase in organic carbon content in the unweeded control compared to the other treatments This is probably due to the higher deposition of organic matter on the surface by the unchecked growth of weeds The results are in agreement with the findings of Savithri (1990) who reported higher organic carbon content due to unchecked growth of weeds in banana

4 2 7 Residual effect of herbicide treatments

Results of the residual effect of herbicides applied to cardamom is pre sented in Table 14

It was noticed that germination and height of cowpea plants were not affected by any of the herbicides applied to the soil But the dry matter production of cowpea plant was lower in the soil from the treatments of paraquat 0 4 kg/ha + diuron 1 kg/ha and paraquat 0 4 kg/ha + atrazine 1 kg/ha All the other treatments

Table 13 Effect of the treatments on the soil organic carbon content (%)

Sl No	Treatments	At the beginning of the trial	End of first year (1994-95)	End of second year (1995 96)
1	Unweeded control	1 17	1 27	1 57
2	Hand weeding	1 21	1 27	1 32
3	Paraquat 0 4 kg/ha (twice)	1 18	1 21	1 28
4	Paraquat 0 4 + Diuron 1 kg/ha	1 29	1 28	1 45
5	Paraquat 0 4 + Atrazine 1 kg/ha	1 24	1 20	1 25
6	Glyphosate 0 8 kg/ha	1 21	1 29	1 31
7	Glyphosate 0 8 + Diuron 1 kg/ha	1 22	1 20	1 31
8	Glyphosate 0 8 + Atrazine 1 kg/ha	1 21	1 19	1 19
9	Glyphosate 0 4 + 0 5% Ammonium sulphate	1 23	1 25	1 29
10	Glyphosate 0 8 + 0 5% Ammonium sulphate	1 24	1 17	1 24
11	Paraquat 0 4 + 2 4-D 1 kg/ha	1 18	1 18	1 210
SE+		0 013	0 016	0 032
CD (0 05)		NS	NS	NS

Table 14 Residual effect of herbicides applied to cardamom on the germination and growth of cowpea

Sl No	Treatments	Germination count	Height of plants (cm)	Dry weight of plants (g/plant)
1	Unweeded control	10 00(0 975)*	19 33	0 55
2	Paraquat 0 4 kg/ha (twice)	9 33(0 925)	17 87	0 55
3	Paraquat 0 4 + Diuron 1 0 kg/ha	9 67(0 950)	17 87	0 40
4	Paraquat 0 4 + Atrazine 1 0 kg/ha	9 67(0 950)	17 57	0 42
5	Glyphosate 0 8 kg/ha	9 00(0 883)	18 03	0 50
6	Glyphosate 0 8 + Diuron 1 0 kg/ha	9 67(0 950)	16 90	0 53
7	Glyphosate 0 8 + Atrazine 1 0 kg/ha	9 67(0 950)	17 4	0 50
8	Glyphosate 0 4 + 0 5% Ammonium sulphate	9 33(0 925)	18 07	0 50
9	Glyphosate 0 8 + 0 5% Ammonium sulphate	8 33(0 825)	16 4	0 52
10	Paraquat 0 4 + 2 4-D 1 0 kg/ha	9 67(0 950)	18 53	0 48
	CD(0 05)	NS	NS	0 093

* Sin $^{1}\sqrt{P}$ = transformed values are given in the parenthesis

were on par with control As there was no significant reduction in the growth in the soil from plots sprayed with paraquat alone this reduction can be attributed to the residual effect of diruon and atrazine

Hence the study revealed that atrazine and diuron residues persists in the soil even after sixty days of spraying when they are applied in combination with paraquat

4.2 8 Effect of accidental fall of herbicides on cardamom

Results of the trial to assess the effect of glyphosate and paraquat on cardamom at different levels of exposures are presented m Table 15

Glyphosate at all levels of exposure resulted in the yellowing and drying of the growing points Innermost leaves protected by leaves were also dried due to direct contact with the herbicide at 25 and 50 per cent exposure With increase m exposure of glyphosate (75% and 100%) newly emerged tillers in the unsprayed portion also dried Inflorescence in the plants also dried due to direct exposure at 25 and 50 per cent and at 75 and 100 per cent all the portions of inflorescence were dried

Paraquat application at all stages resulted in the drying of the plant por tions at contact Growing points protected by the leaves were recovered

The trial shows some recovery of cardamom plants even at 100 per cent exposure of paraquat Growing points of the plant were unaffected in all the treat ments In glyphosate even 25 per cent of exposure resulted in the drying of growing points of the plant Seventy five and 100 per cent exposure of glyphosate resulted in

Table 15 Effect of accidental falling of herbicide on cardamom plants

Treatments	Phytotoxic symptoms on the plant
Control	Healthy growth
A **Glyphosate**	
25% coverage	Yellowing of the leaves of the sprayed tillers Drying of inner most leaves in the sprayed tillers Inflorescence dried and decayed
50% coverage	Yellowing of the sprayed tillers drying of the innermost leaves of the sprayed and non sprayed tillers inflorescence dried and decayed
75% coverage	General yellowing of the whole plant Infloresence have been affected tip of the new tillers were dried
100% coverage	General yellowing and gradual drying of the entire plant Drying of the innermost leaves infloresence were dried
B **Paraquat**	
25% coverage	Those tillers on which herbicide has fallen had dried Growing points protected by leaves remain green Inflorescence dried due to exposure to herbicide
50% coverage	Tillers in contact with herbicide were dried Growing points were unaffected Inflorescence were dried
75% coverage	Inflorescences where herbicide has fallen were dried Growing points were unaffected
100% coverage	Some of the newly emerged tillers were green Whole inflorescence sprayed with the herbicide had dried

the drying of the growmg points and inflorescence even at the unsprayed portions So if some spray has fallen on cardamom plants accidently paraquat results only in temporary drying of the plant whereas glyphosate may cause its death

4 2 9 Economics of weed control

Results presented in Table 16 gives the expenditure for weed control in different treatments (Rs /ha) Hand weeding (twice) recorded the maximum (Rs 7800/) All the herbicide treatments were much cheaper than the hand weeded control Among them the most efficient treatments viz paraquat 0 4 kg/ha (twice) and glyphosate 0 8 kg/ha costed Rs 2077/ and Rs 1558/ respectively This indicates that more than Rs 6000/ per hectare can be saved if weed control by chemical methods are adopted The expenditure on weed control can be reduced to less than fourteen per cent by resorting to herbicidal weed control This is be cause of the large number of labourers required for hand weeding which has to be repeated more than once

Table 16 Economic of different weed control treatments

Sl No	Treatment	Cost of labour Men (Rs)	Cost of labour Women (Rs)	Cost of herbicides (Rs)	Total (Rs)
1	Unweeded control				
2	Hand weeding		7800		7800
3	Paraquat 0 4 kg/ha	960	360	756 81	2077
4	Paraquat 0 4 + Diuron 1 kg/ha	480	180	1200 42	1860
5	Paraquat 0 4 + Atrazine 1 kg/ha	480	180	1062 31	1722
6	Glyphosate 0 8 kg/ha	480	180	898 21	1558
7	Glyphosate 0 8 + Diuron 1 kg/ha	480	180	1128 24	1788
8	Glyphosate 0 8 + Atrazine 1 kg/ha	480	180	1582 63	2243
9	Glyphosate 0 4 + 0 5% Ammonium sulphate	480	180	449 75	1110
10	Glyphosate 0 4 + 0 5% Ammonium sulphate	480	180	898 25	1558
11	Paraquat 0 4 + 2 4 D	480	180	567 51	1228

Labour charges

Men	Rs 80/day
Women	Rs 60/day

Price of herbicide

Paraquat	Rs 224/lit
Glyphosate	Rs 450/lit
Diuron	Rs 332/lit
2 4-D	Rs 150/kg
Atrazine	Rs 344/kg
Ammonium sulphate	Rs 6/kg

Summary

SUMMARY

A study was conducted during 1995 96 to develop weed management practices for cardamom It consisted of a survey of the cardamom growing areas to identify the major weeds associated with the crop studies on the biology of important weeds identified in the survey and evaluation of common herbicides for controlling the weeds The survey was conducted in 42 randomly selected estates in the Idukki district the major cardamom growing area in the country Biology studies and evaluation of herbicides were conducted at the Cardamom Research Station Pampadumpara under the Kerala Agricultural University

In the survey ten major weeds were identified based on their S D R values They were *Ageratum conyzoides Bidens pilosa Crassocephalam crepioides Syndrella nodiflora Paspalam conjugatum Scoparia dulcis Drymaria cordata Erigeron canadensis Sprilanthes calva* and *Elusine indica* The results of the survey indicated the dominance of weeds belonging to Asteraceae and Gramineae families in cardamom tracts of Idukki district

A detailed biology study was conducted on different aspects like time of germination flowering pattern of weeds seed production and 1000 seed weight dormancy of weed seeds height and dry matter production of weeds and nutrient content of weeds

Germination study showed *Bidens pilosa* as the weed with maximum percentage of germination throughout the year All the weeds except *Drymaria*

cordata and *Erigeron canadensis* germinated immediately after the rains in April *Drymaria* and *Erigeron* germinated only after June

Except *Bidens pilosa Scoparia dulcis* and *Spilanthes calva* flowered in May and flowering was continued Rest of the weeds flowered by the beginning of July and set seeds by the end of September

Highest seed production was recorded by *Scoparia dulcis* (26808) and least was recorded by *Synedrella nodiflora* (333) Coupled with the very high seed production the low 1000 seed weight of *Scoparia dulcis* indicates its capacity to dessiminate and multiply fast

The analysis of nutrient content at pre flowering and post flowering stage revealed the reduction of nutrient percentage in weeds after flower production

Weed flora of the experimental field revealed the dominance of Compositae and Gramineae in the experimental field Out of the important ten weeds in the experimental field seven weeds (*Bidens pilosa Drymaria cordata Ageratum conyzoides Paspalam conjugatum Crassocephalam crepioides Eleusine indica* and *Synedrella nodiflora*) figured in the list of important weeds of cardamom identified in the survey

The results of the field trial to compare the efficiency of common herbicides indicated that for effective weed control upto 90 days application of paraquat 0 4 kg/ha at bimonthly interval or glyphosate 0 8 kg/ha is as effective as two hand weedings in cardamom gardens

Study on the N P and K removal by weeds indicated that in the treat ment glyphosate 0 8 kg/ha and paraquat 0 4 kg/ha (bimonthly) weeds removed less N P and K In general nutrient removal by weeds was more at 90 days than at 45 days due to higher dry matter production of weeds at the later stages

The characters like plant height (cm) per cent of flowered plants (%) and yield (kg/ha) did not differ significantly due to the treatments Though height did not show much difference among various treatments maximum height was recorded in glyphosate 0 8 kg/ha + diuron 1 0 kg/ha and the lowest height in unweeded control Maximum cardamom plants came to flowering in the second year in hand weedmg (63%) treatment In the unweeded plots none of the plants flowered indicating the adverse effect and growth of the plants due to weed competition

All the treatments where some weed control was adopted produced more tillers per plant compared to the unweeded control Maximum number of tillers (9 6) were recordded by paraquat 0 4 kg/ha and the least (4 2) by unweeded control

All the treatments except unweeded control and glyphosate 0 4 kg/ha + 0 5% Ammonium sulphate recorded some yield during the study period Highest yield was recorded by hand weedmg (31 5 kg/ha) followed by glyphosate 0 8 kg/ha (43 97 kg/ha) Since the experiment was conducted during the early phase of cardamom plants (2nd and 3rd year of growth) before they had reached the steady bearing stage the results give only an indication that for better growth and yield of cardamom proper weed control is essential

The organic carbon content of soil did not differ significantly due to the treatments However a trend of increase in organic carbon content of soil in the

unweeded control was noticed which must be due to the deposition of residue of the weeds on the surface Residue studies of herbicides in cardamom revealed that atrazine and diuron residues persists in the soil even after sixty days of spraying

Studies on phytotoxic symptoms produced by paraquat and glyphosate on cardamom plants revealed that paraquat produce lesser crop damage in case the spray falls on the crop plants accidentally

Economics of weed control operations revealed that more than Rs 6000/ per hectare can be saved if weed control by chemical methods are adopted Heading expenditure in hand weeding is due to the large number of labourers required for the operation which has to be repeated more than once

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APPENDIX I
Mean monthly weather parameters during the study

Month	Temperature C		No of rainy days	Rainy days of the month	Total rainfall (mm)
	Maximum	Minimum			
October	28 0	17 0	15	3rd to 8th 10th 12th 13th 17th 22nd 24th	162 0
November	26 0	16 5	15	4th 5th 6th 9th 13th 14th 15th 18th 24th	137 2
December	25 0	14 0	Nil	Nil	Nil
January	28 5	13 0	1	4th	0 99
February	32 0	13 5	1	22nd	0 61
March	31 0	14 5	1	14th	0 46
April	29 0	17 5	13	12th 19th 22nd 27th 29th 30th	233 4
May	29 0	17 0	Nil	Nil	Nil
June	29 0	16 0	18	1st 3rd 4th 9th 22nd 24th 26th	358 6
July	27 0	15 5	26	5th 7th 31st	470 2
August	25 0	17 0	30	Except 5th	648 2

APPENDIX II

Details of the herbicides used in the trial

Common Name	Trade Name	Formulation	Manufacturing company
1 2 4 D	Fernoxone	80% WSP	ICI
2 Paraquat	Gramaxone	24% WSC	ICI
3 Glyphosate	Round up	41% WSL	Monsanto
4 Diuron	Klass	80% WP	Bharat Pulversing Mills
5 Atrazine	Atrataf	50% WDP	Rallis India Ltd

APPENDIX III
Abstract of analysis of variance (١٩٩٧)

i Weed count and dry matter at 45 and 90 DAS

Character	Source	df	Mean sum of squares	
			45 DAS	90 DAS
Count	Treatment	10	1 141**	6 581
	Error	20	0 247	3 374
Dry weight	Treatment	10	2 427**	12 591**
	Error	20	0 076	1 184

** Indicates significance at 5% level

ii Abstract of ANOVA for N P and K removal by weeds

Characters	Source	df	Mean sum of square	
			45 DAS	90 DAS
N	Treatment	10	146 372**	2795 795**
	Error	20	4 025	271 937
P	Treatment	10	276 457**	2609 453**
	Error	20	7 211	297 752
K	Treatment	16	0 709**	13 403**
	Error	20	0 069	0 807

** Indicates significance at 5% level

iii Growth and yield of cardamom

Character	Source	df	Mean sum of square
Yield	Treatment	10	616 331
	Error	20	331 970
No of tillers	Treatment	10	6 791**
	Error	20	1 8059
Height	Treatment	10	25 37
	Error	20	166 915
% flower	Treatment	10	520 331
	Error	20	522 920

** Indicates significant at 5% level

iv Organic carbon (%) of soil at the beginning and at yearly intervals

Character	Source	df	Mean sum of square
OC_1	Treatment	10	0 00444
	Error	20	0 478
OC_2	Treatment	10	0 012
	Error	20	0 009
OC_3	Treatment	10	0 073
	Error	20	0 035

WEED MANAGEMENT IN CARDAMOM PLANTATIONS

BY

M V. SUDHEESH

ABSTRACT OF A THESIS

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ABSTRACT

A study was conducted during 1995 96 to develop weed management practices for cardamom at Cardamom Research Station Pampadumpara under Kerala Agricultural University A survey was conducted to identify the major weeds its biology was also studied A trial was also conducted to evaluate major herbicides in cardamom plantations Ten major weeds *Ageratum conyzoides Bidens pilosa Crassocephalam crapioides Synedrella nodiflora Paspalam conjugatum Scoporia dulcis Drymaria cordata Ergeron canadensis Spilanthes calva* and *Eleusine indica* were identified Survey indicated the dominance of Asteraceae and Gramineae in cardamom tracts of Idukki district

Maximum germination percentage was observed in *Bidens pilosa* All the weeds except *Bidens pilosa Scoparia dulcis* and *Spilanthes calva* flowered in May Rest of the weeds flowered by July and set seeds by the end of September Maximum seed production and lowest 1000 seed weight was recorded by *Scoparia dulcis* Nutrient study revealed the deversion of nutrients to flower heads after flower production

The results of the yield trial to compare efficiency of herbicides revealed the use of paraquat 0 4 kg/ha (bimonthly) or glyphosate 0 8 kg/ha is superior in terms of reducing the weed count weed dry matter and nutrient removal by weeds from the experimental plots Except tiller production all the characters plant height (cm) per cent flowering (%) and yield (kg/ha) did not differ significantly with treatments Phytotoxic study revealed paraquat as less toxic than glyphosate In combination with paraquat atrazine and diuron residues persisted upto 60 days in the experimental yield More than rupees 6000 can be saved by adopting chemical methods instead of hand weeding