WEED MANAGEMENT IN SOLE AND INTERCROPPED COCONUT GARDENS

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "WEED MANAGEMENT IN SOLE AND INTERCROPPED COCONUT GARDENS" is a bonafide record of research work done by me during the course of the research and that the thesis has not previously formed the basis for the award to me any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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CERTIFICATE

Certified that this thesis entitled "WEED MANAGEMENT IN SOLE AND INTERCROPPED COCONUT GARDENS" is a record of research work done independently by Smt.K.E. Savithri under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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Introduction

INTRODUCTION

India is one of the largest coconut producing countries of the world and ranks third on the world map of coconut. In India, coconut is cultivated in an area of about 1.2 million hectares with an annual production of 6,620 million nuts (KAU, 1988a). Among the coconut growing states in the country, Kerala ranks first with an area of 6.89 lakh hectares and an annual production of 3,395 million nuts (KAU, 1988b). However, the per hectare yield and per palm productivity of coconut is lowest in Kerala compared to other states. Lack of proper management practices is undoubtedly the most important limiting factor responsible for the low productivity.

It is well known that weeds interfere with the normal growth and development of crops. This is true in the case of coconut also. The large interspace between the coconut trees and the tall columnar stem without lateral branches provide ample space for weeds to grow. This growth of weeds, if unchecked, brings about considerable reduction in the growth and yield of coconut (Marar, 1953; Kurup, 1955 and Nair, 1960).

Intercropping is a rule rather than an exemption in Kerala especially where the per capita holding size is very small. Intercropping in the early growth stages of coconut is more feasible as it affords plenty of vacant space for other crops to be fitted in. It also results in better utilisation of land and reduce the area infested by weeds. Weed competition is found to be a menace even in intercropped coconut gardens if adequate and timely weed control measures are not taken. The frequent rainfall in both seasons and unhindered solar radiation received on the surface of land especially in the early growth stages of coconut are congenial for the luxurient growth of weeds.

Banana is one of the most popular intercrop in coconut gardens of Kerala. Weed growth is a menace in this cropping system especially in the early growth stages of banana. Since banana has a superficial root system, deep tillage operations tend to damage the root system and are to be avoided if possible. Moreover, sole dependence on tillage is disadvantageous due to the high cost of labour in this part of the country. Any weed control measure that will reduce the excessive dependence on labour will be economical for a Kerala farmer.

Chemical weed control is the only way of reducing the cost of labour. Various contact herbicides such as paraquat and systemic herbicides such as dalapon, glyphosate and 2,4-D are available for chemical weed control. The weed flora in a coconut garden in Kerala comprises of monocots like Pennisetum pedicellatum, Ischaemum indicum, Digitaria sp., Cynodon dactylon, Cyperus rotundus etc. and dicots like Chromolaena odorata, Hemidesmus indicus, Ichnocarpus frutescens, Lantana camara, Hyptis suaveolens, Urena lobata, Sida sp., etc. It is possible to use herbicides either individually or in combination, for controlling these weeds.

The excessive use of herbicides leading to complete control of weeds may sometimes prove disadvantageous from the soil fertility point of view as it may lead to the possible depletion of organic matter content of soil. This is particularly detrimental in situations where torrential rain can result in severe soil and fertility erosion. Hence a technology wherein sufficient land cover is maintained without causing serious competition with the crops will be ideal for a tropical rainy situation as existing in Kerala. A combination of chemical, mechanical as well as cultural methods may give answer for this particular situation. Hence this investigation was taken up with the following objectives:

1) To evaluate the possibility of herbicidial control of weeds in sole coconut, sole banana and in coconut+banana cropping system.

2) To assess the crop-weed competition in the above situations.

3) To study the effect of different weed management methods on soil fertility status and soil moisture content in sole and intercropped coconut gardens.

4) To find out the economics of different weed control methods in coconut, banana and coconut+banana cropping system.

Review of Literature

REVIEW OF LITERATURE

Weed problems are very severe in coconut gardens due to the large interspace available between the coconut trees and the tall columnar stem without lateral branches. Intercropping coconut with banana is a widely adopted practice in Kerala. However, not much work has been done in Kerala with regard to weed management studies in sole and intercropped coconut gardens. Hence it was proposed to develop weed management practices for sole coconut garden as well as for coconut+banana cropping system. The review pertaining to the different aspects of the investigations are given below.

1. Weed spectrum

1.1 Weed flora of coconut

Major weed flora of coconut plantations have been listed by several workers. Nair and Chami (1963) reported that in coconut fields of CPCRI, Kasaragod, the dicotyledonous families, Leguminosae, Compositae and Rubiaceae formed the bulk of weeds and the monocotyledons were represented by the families Cyperaceae, Gramineae, Commelinaceae and Liliaceae. They also reported that among the dicotyledonous weeds, <u>Mimosa pudica</u>, <u>Cassia tora</u>, Borreria hispida, Borreria ocymoides, Oldenlandia corymbosa, Cleome viscosa, Cleome monophylla, Ageratum conyzoides, Scoparia dulcis, Acrocephalus indicus, Hyptis suaveolens, Tridax procumbens etc. arrest our attention. They also found that though Cyperus rotundus and Cyperus compressus form the major troublesome weeds among the monocotyledons, other grass weeds like Eragrostis plumosa, Eragrostis poaevoides, Eleusine indica, Panicum maximum, Pennisetum polystachion Digitaria marginata, Cynodon dactylon, Ischaemum ciliare Apocopis Wrightii etc. could not be ignored.

Eupatorium odoratum is a troublesome weed species found in coconut plantations of Ceylon (Salgado, 1972) and India (Mogali and Hosmani, 1981). Alif (1982) reported that weeds such as Imperata cylindrica, Eupatorium odoratum and Mikania cordata grow well under the ecological conditions of small scale plantations in South East Asia. Simbolen and Suhardjono (1986) found that the major weed species of coconut plantations in West Java, Lantana camara, Mikania cordata, Eupatorium odoratum, Imperata cylindrica and Lygodium sp. exhibited a wide ranging tolerance to edaphic and seasonal factors.

1.2 Weed flora of banana

In Jamaica, the predominant weeds in bananas were Brachiaria mutica, Cynodon dactylon, Rottboellia exaltata, Bidens pilosa, Commelina spp., Canna sp., Euphorbia spp., Alternanthera ficoidea and Ipomoea sp. (Anon, 1963a). Romanowski et al. (1967) reported that in bananas in Hawaii, the main weeds were the grasses, Digitaria sanguinalis, Setaria verticillata, Eragrostis pectinacea, Echinochloa colona, Cyperus rotundus, Cenchrus echinatus and Eleusine indica and the broad-leaved species, Borreria laevis, Emilia sonchifolia, Apium tenuifolium, Stachytarpheta jamaicensis, Solanum nodiflorum, Portulaca oleracea, Bidens pilosa and Coronopus didymus. In flood irrigated bananas in Jordan valley, the dominant weed species were Echinochloa sp., Malva sp. and Portulaca sp. (Horowitz, 1968).

Seeyave (1970a) found that the major weeds infesting bananas in Windward Islands were Commelina elegans, Paspalum conjugatum, Cleome sp. and Brachiaria mutica. Moreau (1974) reported that Paspalum conjugatum and Echinochloa crusgalli were the predominating grass weeds in banana fields in east coast of Madagascar. In 'False Horn' plantain in Ivory Coast, grass weeds were the most important followed by Compositae and Cyperaceae (Ndubizu, 1985).

A survey of weed flora in banana fields in India showed the presence of Cyperus rotundus, Cynodon dactylon, Digitaria marginata, Dactyloctenium aegyptium, Chloris barbata, *Urochloa panicoides*, *Eragrostis zeylanica*, *Commelina benghalensis* and *Amaranthus caturus* (Dhuria and Leela, 1971).

The foregoing review reveals that the major troublesome weeds found associated with coconut are *Cyperus* sp., *Imperata cylindrica*, *Eupatorium odoratum* and *Mikania cordata* and the common weeds found associated with banana are *Cyperus rotundus*, *Cynodon dactylon*, *Digitaria* sp., *Brachiaria mutica*, *Portulaca oleracea* and *Bidens pilosa*.

2. Crop weed competition

2.1 Effect of weed competition on coconut

The unchecked growth of weeds brings about considerable deleterious effects on the growth and yield of coconut trees (Jagoe, 1938; Rajpakse, 1950; Marar, 1953; Kurup, 1955; Albuquerque and Ibrahim, 1956 and Nair, 1960). Smith (1968b) observed that natural pastures under widely spaced tall coconuts compete with the palms and limit coconut yield.

Endang and Hutauruk (1982) reported the importance of weed control in immature oil palm and Lubis and Hutauruk (1982) in mature oil palm in relation to the detrimental effects of competition. Utulu (1986) observed that when weeds were allowed to grow with oil palm seedlings in polybags for period of 2-36 weeks after sowing sprouted oil palm nuts, there was a positive correlation between duration of weed interference and percentage growth reduction in oil palm seedling dry weight, height, leaf area and leaf number.

2.2 Effect of weed competition on banana

Cann (1965) stressed the importance of adequate control of weeds especially grasses, in banana from planting upto harvest. Kasasian and Seeyave (1968) observed that the main effect of weed competition on bananas is the delay in maturity.

Seeyave and Phillips (1970) found that the banana plants in clean weeded plots were taller with more girth, showed early bearing, produced higher yield and softer fruit. Ndubizu (1985) reported that in 'False Horn' plantain, leaf production, leaf area and percentage establishment were highest in plants hand weeded at 2 and 4 week intervals and least with 8 and 10 week intervals. Intervals greater than 6 weeks significantly reduced establishment, vegetative growth, time from planting to harvest and yield.

2.3 Effect of intercropping on crop-weed competition

One of the major reasons suggested for the prevalence of inter and mixed cropping in the traditional agriculture is the possibility of better control of weeds, compared to sole cropping (Arny et al., 1929; Moody, 1977; Willey, 1979; Moody and Shetty, 1981). Several authors (Geertz, 1963; Webster and Wilson, 1966; Watters, 1971; Enyi, 1973) have stated that the more complete cover provided by intercropping reduced the weed growth by competition and lessen the weeding requirement.

In Ceylon, growing of catch and cover crops such as cowpea and green gram in young coconut plantations prevented the establishment of Imperata sp. (Anon, 1966a). Gunathilake (1985) recommended intercropping coconut with shade producing crops like coffee and cocoa for weed control. Romney (1987) reported that the growth of coconut was found to be better in plots where coconut was intercropped with pigeon pea and cowpea due to complete removal of weed competition.

Chacko and Reddy (1981) observed that planting of banana at a high density and intercropping with cowpea during the initial stages drastically reduced weed growth with correspondingly higher yields. However, Chambers (1970) reported that there was no general use of sowing cover plants such as legumes as a means of commercial weed control in banana plantations, since they would inevitably compete with the crop for water and for nutrients other than nitrogen.

The above review reveals that weed competition can adversely affect the growth and yield of coconut and banana. Intercropping could be a means for reducing weed competition in coconut and banana plantations.

3. Weed management

3.1 Weed management in coconut

3.1.1 Mechanical and cultural methods

In coconut plantations, satisfactory control of Imperata cylindrica was obtained by frequent harrowing, grazing with penned cattle, with or without previous burning, growing a cover crop such as Pueraria javanica or Tephrosia candida or growing Euphorbia geniculata as a smother crop and small infestations of Eupatorium odoratum could be easily controlled by systematic uprooting (Salgado, 1961; Salgado, 1963). Bourgoing and Boutin (1987) noted that rolling a light weight wooden roller between the coconut rows at the time of cover crop sowing controlled Imperata cylindrica. Salgado (1972) observed that the effective method for the control of Eupatorium odoratum was removing the weed with a tyne cultivator followed by hand digging and cover cropping. Mogali and Hosmani (1981) reported that the cultural methods for the control of Eupatorium odoratum in plantation crops such as coconut include repeated slashing, uprooting the crown, growing competitive crop or cover crop.

For round weeding in young coconuts, monthly hoeing through out the year or in the dry season was the best mechanical treatment (Kasasian *et al*., 1968).

3.1.2 Chemical methods

Herbicides can be used for controlling weeds in coconut plantations. Goberdhan (1963) reported that in coconut gardens, application of dalapon 4.5 kg appeared to be competitive with cutlassing. Smith (1968a) also found that application of Gramoxone (paraquat) at 2.8 lit ha^{-1} $\pm$ Karmex (diuron) at 2.5 kg was more effective for controlling weeds in coconut plantations than regular cleaning with a cutlass. Salgado (1972) observed that slashing and mowing were useless for controlling *Eupatorium odoratum* in coconut plantations and the plants reacted as they might to pruning. In Surinam, four applications of paraquat at 5 ml product per litre of water was more effective than hand weeding for controlling weeds in the coconut palm circle (Anon, 1973). Whereas in Jamaica, the weed control obtained by Gramoxone (Paraquat) at 1.4 lit ha^{-1} + either Karmex (diuron) or Gesapaxe (ametryne + 2,4-D) at 2.2 kg ha^{-1} was equivalent to that obtained by cutlassing (Anon, 1975). Mathew (1978) observed that in an established coconut garden in Karnataka, herbicides were more efficient in checking the growth of weeds than the manual methods.

a. Pre-emergence herbicides

Diuron and atrazine were found effective in controlling weeds in coconut plantations. Romney (1968) reported that diuron and atrazine gave effective control of weeds in coconut fields. Balasubramanian et al. (1985) also obtained good control of weed growth in coconut plantations with Karmex (diuron) at 2.5 kg ha^{-1}. For round weeding in young coconuts, atrazine and diuron were the best herbicide treatments (Kasasian et al., 1968; Coomans and Delorme, 1978).

b. Post-emergence herbicides

Dalapon is a promising herbicide that can be used in coconut gardens especially for controlling grasses. In coconut plantations in Jamaica, dalapon at 2.3 and 3.6 kg in 100 gal water was the most effective treatment where grasses predominated (Anon, 1963 b). Kasasian et al. (1968) found that for round weeding young coconuts, dalapon 4.5 kg was one of the best herbicide treatments. The effective control of weeds especially grasses by dalapon in coconut fields was also reported by Romney (1968) and Balasubramanian et al. (1985).

Paraquat is another herbicide that can be used for effective control of weeds in coconut gardens. Romney (1964) reported that paraquat at 0.2 to 0.5 kg was used for general weed control in coconut plantations in Jamaica. Romney (1968) again reported that Gramoxone (paraquat) gave effective control of weeds in coconut fields. Juan and Abad (1980) reported that in coconut, before sowing cover crop seeds, weeds could be controlled with paraquat. Seth (1984) also found that paraquat was effective for controlling weeds in coconut garden. Kasasian et al.(1968) found that for round weeding in young coconuts, monthly applications of paraquat 0.2 kg was one of the best herbicide treatments.

The other herbicides found effective for controlling weeds in coconut plantations are 2,4-D (Anon, 1963b), amitrole (Romney, 1964), MSMA (Barnes and Evans, 1971) ametryne and glyphosate (Coomans and Delorme, 1978; Juan and Abad, 1980).

c. Herbicide mixtures

Mixing of herbicides is a method to increase the effectiveness. Goberdhan (1963) found that mixing of dalapon with atrazine gave excellent and long lasting control of both broad leaf and grass weeds in coconut plantations.

Hoyle (1968) observed that dalapon + 2, 4-D gave good control of weeds in coconut gardens. According to Barnes and Evans (1971), coconut fields can be successfully kept weed free by applying mixtures of MSMA with other herbicides. Coomans (1974) reported that the best weed control treatments in coconut plantations were MSMA at 1.8 kg + sodium chlorate 4 kg $\pm$ 2,4-D amine 1.4 kg ha^{-1} and MSMA 1.8 kg + 2,4-D ester 1.4 kg ha^{-1}. Outside the coconut tree circle, MSMA + ametryne at 4 litres product ha^{-1} and MSMA + picloram at 2.8 litres + 0.46 litres product ha^{-1} gave best results (Coomans and Delorme, 1978). Alif (1982) recommended MSMA + 2,4-D amine + sodium chlorate for the control of a mixed weed flora in coconut plantations.

Mixing paraquat with other herbicides can give longer control of weeds. Hoyle (1968) observed that in coconut plantations, triazine + paraquat mixture were effective with the higher rates giving the longer control. Romney (1968) recommended the use of paraquat at 0.9 lit product + diuron or atrazine 0.7 kg product for general weed control in coconut fields. Smith (1970) observed that in young coconut, mixtures of paraquat with diuron or atrazine helped in reducing the frequency of application. In new coconut plantations, weed control could be effected by establishing cover crops in furrows and spraying between the furrows with Paracol (paraquat + diuron) at 1.2 kg or diuron 2.4 kg and paraquat 0.55 kg ha^{-1} (Abad, 1980). Juan and Abad (1980) also reported that in coconut, before sowing cover crop seeds, weeds could be controlled with Paracol (paraquat + diuron) or Totacol (paraquat + diuron). Balasubramanian et al. (1985) found that Gramoxone (paraquat) at 2.5 litre + Fernoxone at 1.2 kg per ha^{-1} controlled weed growth in coconut gardens.

d. Sequential application of herbicides

Mathew (1978) observed that bromacil at 4 and 5 kg ha^{-1} followed two months later with dalapon at 10 kg ha^{-1} could control weeds in an established coconut garden for a period of 8 months.

The weed management studies reviewed above indicate the possibility of herbicidal control of weeds in coconut plantations. It also shows that pre-emergence herbicides such as diuron and atrazine, post-emergence herbicides like dalapon, paraquat, 2,4-D, glyphosate, amitrole etc., herbicide mixtures like dalapon + 2,4-D, paraquat + diuron or atrazine etc. can be used for controlling weeds in coconut.

3.2 Weed management in banana

3.2.1 Mechanical and cultural methods

In banana plantations, weed management is essential especially in early stages of growth. Seeyave and Phillips (1970) demonstrated that monthly clean weeding carried out by cutlass and hoe especially in the early life of banana produced the most rapid growth and highest yield of fruit. It is also demonstrated that since banana has a superficial root system, competitive effect of weeds will be more, at the same time manual weed control methods such as hoeing techniques which disturb the soil are undesirable because they cause root damage and also lead to soil erosion. Tai and Lai (1960) also noted the difficulties of ensuring adequate suppression of weeds by manual cutting round the bases of banana plants without causing damage to suckers.

Use of fast growing leguminous crop is a method to smother weeds in widely spaced crops. Chacko and Reddy (1981) reported that growing cowpea as an intercrop in banana resulted in the development of a dense canopy, covering the entire ground area and suppressing weed growth completely for a period of 70 days.

3.2.2 Chemical methods

Herbicides can be used for the effective control of weeds in banana plantations. In banana plantations, weeds were more effectively controlled by kerosene or gas oil at 600 l ha^{-1} + PCP 15 l ha^{-1} than by hoeing (Anon, 1962a). According to Robinson and Singh (1973), one dalapon spray at 6.24 g per litre and eleven paraquat sprays at 3 g per litre to a mixed weed growth in banana was much more effective than hand slashing. Gomes et al. (1984) found that in banana, four applications of 1.23 l glyphosate ha^{-1} or 0.3 l paraquat + 1.6 g diuron ha^{-1} in the first 18 months gave weed control comparable to that obtained from cutting.

a. Pre-emergence herbicides

Effective weed control in banana plantations by pre-emergence applications of diuron and atrazine was reported by several workers (Tai and Lai, 1960; Anon, 1962b; Cull, 1965; Romanowski et al., 1967; Anon, 1968 ; Horowitz, 1968; Kasasian and Seeyave, 1968; Sessing, 1968; Walker, 1968; Crozier and Romanowski, 1969; Seeyave and Phillips 1970; Dhuria and Leela, 1971; Perez and Rodriguez, 1976; Rodriguez et al., 1978; Nayar et al., 1979; Ramadass et al., 1980). Pre-emergence application of simazine (Tai and Lai, 1960; Anon, 1963c; Anon, 1965; Steele, 1966; Horowitz, 1968; Kasasian and Seeyave, 1968; Sessing, 1968; Walker, 1968; Seeyave and Phillips 1970; Moreau, 1971; Perez and Rodriguez, 1976; Das and Misra, 1977; Rodriguez et al., 1978; Mishra and Das, 1984) and linuron (Anon, 1963 c; Anon, 1965; Kasasian and Seeyave, 1968; Seeyave and Phillips, 1970) also gave good control of weeds in banana plantations. Horowitz (1968) reported that in flood irrigated bananas in Jordan Valley, the best control of weeds was given by dichlobenil or chlorthiamid less than 5 kg a.i. ha^{-1} applied to clean soil one month after spring planting. Pre-emergence application of chlorbromuron was found promising in banana (Anon, 1969a; Seeyave and Phillips, 1970).

Oxyfluorfen is another pre-emergence herbicide promising for use in tropical plantation and fruit crops (WSSA, 1983).

b. Pre-emergence herbicide mixtures

Pre-emergence application of herbicide mixtures can give better control of weeds in banana plantations. Application of simazine + TCA and linuron + TCA before the emergence of weeds resulted in good control of weeds in banana (Kasasian, 1962; Anon, 1963c; Anon, 1965; Anon, 1968). In a pre-emergence screening trial in Dominica, Monex (diuron 5.1 per cent +

MSMA 33.9 per cent) 2 gal ac^{-1} gave weed control lasting for about 4 months (Anon, 1969a). Perez and Rodriguez (1976) and Rodriguez et al. (1978) observed that two pre-emergence application of simazine + ametryne each at 2.5 kg ha^{-1} at an interval of 6 months gave good weed control in banana whereas Israeli and Hameiri (1976) reported that in sprinkler irrigated banana plantation in Jordan Valley, simazine + linuron (0.35 + 1 kg ha^{-1}) and simazine + diuron (0.5 + 0.8 kg ha^{-1}) were most effective against summer weeds and grasses when applied in spring.

c. Post-emergence herbicides

Paraquat is a good post-emergence herbicide for controlling weeds in banana plantations (Kasasian, 1962; Anon, 1963a; Anon, 1963c; Cull, 1965; Steele, 1966; Walker, 1968; Dhuria and Leela, 1973). Liu et al. (1981) observed that in plantains at Corozal and Gurabo substations, post-emergence weed control was excellent with glyphosate compared to paraquat. Liu and Garcia (1988) reported that three applications of glyphosate at 1 per cent every 6 weeks was optimum for weed control in plantain. Post-emergence application of dalapon gave good control of perennial grasses in banana fields (Kasasian, 1962; Anon, 1963c; Cull, 1965; Walker, 1968; Anon, 1969b). In banana in Jamaica, application of 2,4-D at 3.5 litre ha^{-1} gave good control of broad leaved weeds except Euphorbia spp. but was relatively ineffective against grasses (Anon, 1963a). In West Indies, 2,4-D was found to be one of the promising post emergence herbicide for weed control in banana (Anon, 1963c). Seeyave (1970b) found that in a 3 month plant crop and second ratoons of banana, chlorbromuron at 4-10.9 kg post emergence gave excellent control of weeds at the lowest rate.

d. Post-emergence herbicide mixtures

Post emergence application of herbicide mixtures was found very promising in banana. In bananas in West Indies, post-emergence application of simazine and linuron in mixtures with either paraquat or 2,4-D and 2,4-D + dalapon gave promising results (Anon, 1963c). A broad spectrum of weeds in banana plantations can be effectively controlled by post-emergence application of diuron + paraquat (Anon, 1968; Kasasian and Seeyave, 1968; Nayar et al., 1979, Ramadass et al., 1980). Orozco (1970) observed that diuron at 2 kg + atrazine at 2 kg ha^{-1} + 10 l banana spray oil + a wetter (5 per cent) gave the best control of weeds 5 cm high in bananas. Dhuria and Leela (1973) noted that in banana, lasso in combination with diuron (4.5 l ha^{-1} + 2 kg ha^{-1}) controlled weeds for 3 months. Almeida and Texeira (1974) reported that diuron at 3 kg + dalapon 8 kg and ametryne 2.5 kg + MSMA 1.5 kg ha^{-1} gave the best control of the weed flora in banana. Chehata *et al*. (1980) observed that in 8 month old bananas, application of post-emergence herbicides, diuron + MSMA at 2.99 kg + 10 l ha^{-1} ± paraquat at 2 l ha^{-1} and ametryne + diuron at 3.5 kg + glyphosate at 2.5 l ha^{-1} reduced weed infestation at 90 days after treatment.

According to Cull (1965) 2,2-DPA (dalapon) + amitrole can be used to control a wide variety of weeds in banana. In banana in Jamaica, MSMA 0.9 kg + 2,4-D 0.9 kg and pyriclor 0.5 kg + 2,4-D 0.9 kg gave 90 per cent control of all weeds (Anon, 1968). Seeyave (1970b) found that, in plant and ratoon crops of banana, chlorbromuron at 0.2 kg + paraquat 0.1 kg controlled weeds for at least twice as long as paraquat at 0.2 kg.

e. Sequential application of herbicides

Sessing (1968) reported that combination of pre-emergence application of diuron and atrazine 1.1 kg with post emergence application of paraquat at 2.1 lit ha^{-1} gave satisfactory control of weeds in ratoon bananas. Leigh (1969) also found that in the first three years after planting banana, the best results were obtained with diuron applied pre-emergence at 3.4 or 6.7 kg, followed by paraquat at 1.4 lit ha^{-1} as knock down sprays. Pena (1978) observed that in banana plantations, application of Karmex (diuron) and Gesatop (Simazine) both at 3-4 kg ha^{-1} after hoeing and fertilizing in January/February and supplemented with Gramoxone (paraquat) and Reglone (diquat) at 2-3 litres ha^{-1} as needed, controlled most weeds. Moreira (1972) noted that in banana planted in January application of diuron (as Karmex 80) at 2.4 kg a.i. in 1000 litres of water ha^{-1} at 2-3 pair leaf stage and a second treatment in late May with Karmex 2 kg ha^{-1} + Gramoxone (paraquat) 1 litre ha^{-1} kept the plantation weed free until the first fruit clusters appeared. Whereas Moreau (1971) reported that in bananas in the humid Tamatau region of Madagascar, one spraying with simazine (as Gesatop 80) at 3 kg ha^{-1} immediately after planting can give 3 months adequate weed control and then simazine at 1.1 kg + ametryne (as Gesapax) at 2 kg ha^{-1} can be used as a follow up treatment.

The weed management studies reviewed above indicate the possibility of herbicidal control of weeds in banana plantations. Pre-emergence herbicides like diuron, atrazine, simazine, linuron etc. either singly or in mixtures, post-emergence herbicides like paraquat, glyphosate, dalapon, 2,4-D etc. either singly or in mixtures, sequential application of diuron, atrazine or simazine followed by paraquat have been found useful for controlling weeds in banana.

3.3 Weed management in intercropping systems

Eventhough intercropping may cause reduction in weed growth, there is still need in most cases to do some weeding so that the weeds which emerge before the intercrop canopy closes in do not cause yield reduction (Moody, 1978). But weed control may be a greater problem in intercropping than when the component crops are grown alone. Mechanical weeding is difficult or even impossible in certain spatial arrangements such as the random planting or when the rows are too close to each other.

Herbicides are often crop specific. Thus, it has been difficult to find compounds that will control a broad spectrum of weeds without causing damage to the component crops in the intercropping system. However, research work on the methods of weed control in the intercropped situations, especially in plantation crops are meagre. Tosh et al.(1982) reported that diuron and simazine can be recommended as selective herbicides for effective weed control in interplanted pineapple banana plantation.

4. Effect of weed management

4.1 Effect on growth and yield of coconut

4.1.1 Effect on growth

Weed management can bring about a positive influence on the growth of coconut palms. Romney (1964) observed that in Jamaica, weed control alone has given a 46 per cent increase in the growth of young coconut palms. Atrazine and diuron in mixture with paraquat, applied when necessary to control weeds, significantly increased the growth of coconut fronds (Anon, 1964a). In Jamaica the use of herbicides in 2 year old Malayan Dwarf coconuts promoted the growth (Anon, 1966b). Hoyle (1968) found that in coconut, application of paraquat, diuron, dalapon, 2,4-D amine, atrazine, simazine, dalapon + 2,4-D and paraquat + simazine or atrazine to an area of 100 ft^2 around each palm produced slightly more palm growth than cutlassing. Smith (1968a) also found that young coconut palms grow more quickly and come into bearing earlier when the weeds were chemically controlled in circles around them. Smith (1970) reported that in young coconut, application of terbacil at 4.5 kg a.i. ha^{-1} on an area measuring 49 ft^2 has resulted in greatest frond production. Dumas and Schut (1976) observed that the Malayan Dwarf coconut palms receiving minimum weeding in the ring developed less well and began bearing 75 days later than the weeded palms.

In Jamaica in 8 month old Malayan Dwarf coconut palms, successive applications of paraquat at 0.2 kg + Agral 90 (a wetter) 0.1 per cent had little effect on the growth of the palms (Anon, 1964a). Smith (1970) reported that in young coconut, paraquat treatment at 6 and 8 week intervals did not result in significantly reduced growth. Chandapillai and Barnes (1973) observed that the pre-emergence application of diuron or the post-emergence application of MSMA + diuron + sodium chlorate, Sodium arsenite did not adversely affect the growth of coconut palms. Dumas and Schut (1976) found that in Malayan Dwarf palms, there was little difference in the effect on the palms between hand weeded and herbicide treated rings. Mathew (1978) observed no adverse effects on the growth of coconut cv. Arasikere Tall visually by the application of the herbicides, bromacil, dalapon, 2,4-D and paraquat. Juan et al. (1981) reported that in coconut seedlings cv. Catigan Dwarf sprayed with glyphosate at 1.64 and 3.28 kg ha^{-1}, no significant differences in girth, height or leaf production were observed between the sprayed seedlings and untreated control at 2,4,6 and 8 months after.

4.1.2 Effect on yield

Romney (1964) obtained 17 per cent increase in yield of coconut by weed control in Jamaica. In coconut in

Jamaica, application of paraquat increased the average number of nut set from 38 to 45 per palm (Anon, 1964a) and the yield of bearing coconut palms increased following regular weed control (Anon, 1966b). Smith (1968b) found that in tall coconuts, removal of the natural pastures using herbicides increased palm yield. Smith (1969) observed that in young coconut palms in Darlingford, the effect of using herbicides in the first three years upon the number of palms in bearing and the number of nuts per palm was very marked and in East Potosi, application of paraquat alone outyielded the cutlassed control and the yield was still greater where a residual herbicide was included. Barnes and Evans (1971) reported that keeping coconut fields free of weeds by applying mixtures of MSMA with other herbicides resulted in an improvement of the appearance of the trees and of their yields. However, Balasubramanian et al. (1985) found that in East Coast Tall palms, ploughing the entire area produced the highest nut yield than untreated control and herbicide treatments, presumably as a result of reduced weed growth and increased moisture infiltration.

The above review shows that use of herbicides does not have any adverse effects on the growth and yield of coconut.

4.2 Effect on growth and yield of banana

4.2.1 Effect on growth

Leigh (1969) observed no adverse effects on the growth of banana by the use of diuron, monuron, diquat, paraquat, simazine, amitrole, atrazine, dalapon and arsenic pentoxide from the time of planting. However, Rodriges (1980) reported that banana growth during three months after planting was inhibited by the application of diuron at 4 kg and simazine + ametryne at 2.4 + 2.4 kg ha^{-1}, but the inhibition effects disappeared at harvest. Tosh et al. (1982) noted that the growth of banana was much better in the diuron (3 kg ha^{-1}) and simazine (3 kg ha^{-1}) treated plots than in the dalapon, bromacil, metribuzin and metobromuron treated plots.

4.2.2 Effect on yield

Clean weeding every month induced early bearing in banana even when compared with monthly cutlass to a height of 2-3 inches (Anon, 1969a). Venereo (1980) observed that the yield of banana cv. Robusta was higher in either mechanically or chemically weeded plots compared to untreated control.

Yield of banana cv. Robusta was unaffected by pre-emergence application of simazine 1.4 kg, atrazine 0.7 kg and TCA 4.5 kg or simazine or linuron at 1.4 kg alone or mixed with TCA 2.3 kg (Anon, 1963c; Anon, 1965). Romanowski et al. (1967) observed that application of diuron 1.4 - 3.6 kg did not reduce the yield of bananas. Leigh (1969) noted no adverse effects on the yield of banana by using the herbicides diuron, monuron, diquat, paraquat, simazine, amitrole, atrazine, dalapon and arsenic pentoxide from the time of planting. Seeyave (1970a) reported that the bunch weight of Robusta bananas was not affected by pre-emergence application of paraquat, pyriclor, ametryne, simazine, diuron and chlorbromuron. Rodriges (1980) also found that the yield of banana was not affected by application of diuron at 4 kg and simazine + ametryne at 2.4 + 2.4 kg ha^{-1}.

Pre-emergence application of simazine 0.7 kg, atrazine 1.4 kg and TCA 9.1 kg resulted in marked but non-significant increase in yield of banana cv. Robusta (Anon, 1963c). Das and Misra (1977) found that in banana cv. Dwarf Cavendish, application of simazine at 6 kg ha^{-1} significantly increased the bunch weight, number of hands per bunch, length of fruit, pulp weight and pulp peel ratio. Rodriguez et al. (1978) reported that in banana cv. Robusta, pre-emergence application of simazine at 4.8 kg ha^{-1} and simazine + ametryne at 1.6 + 1.6 kg ha^{-1}

at intervals of 6 months gave increased yield. Tosh et al. (1982) obtained a much better yield of banana from the diuron (3 kg ha^{-1}) and simazine (3 kg ha^{-1}) treated plots. Mishra and Das (1984) noted that simazine at 6 kg ha^{-1} increased the number, length and weight of fruits of 'Jahaji' banana.

Yield of banana was not affected by post-emergence application of herbicides also. The yield of banana cv. Robusta was unaffected by post emergence application of diuron at 0.7 and 1.4 kg, simazine 0.7 or 1.4 kg + paraquat 0.2 kg, fenac 0.7 or 1.4 kg + paraquat 0.2 kg, TCA 18.1 kg and paraquat 0.5 kg (Anon, 1963c). In Dominica and Grenada, post-emergence application of simazine or linuron 1.4 kg + either paraquat 0.2 kg or 2,4-D amine 0.9 kg, paraquat 0.2 kg, 2,4-D 0.9 kg, dalapon 2.3 kg or dalapon 2.3 kg + 2,4-D 0.9 kg did not effect the yield of banana (Anon, 1965). Romanowski et al. (1967) observed that application of ametryne at 1.8 - 2.7 kg, aromatic oil 80 gal ac^{-1}, dalapon 4.5 kg and paraquat 0.5 - 0.9 kg + X-77 (wetter) did not reduce yields or delay maturity of bananas. Gomes et al. (1984) noted that the yield of prata banana was not affected by four applications of 1.23 l glyphosate ha^{-1} in the first 18 months, provided no herbicide came in contact with the banana plants.

Post-emergence application of TCA 4.5 kg and 9.1 kg, dalapon , 2.3 and 4.5 kg and paraquat 0.2 kg resulted in marked but non-significant increase in yield of banana cv. Robusta (Anon, 1963c). Almodovar (1977) reported that in plantain, six applications of paraquat at 2.34 l ha^{-1} gave high yield. Liu et al. (1981) found that fruit production of plantains as indicated by the number and weight of fruits increased with the increments of glyphosate concentrations at Corozal substation.

Robinson and Singh (1973) found that weed control did not increase the plant and first ratoon crop yields over unweeded treatment but advanced the time of cropping, hence the yields were greater over a 30 month period with economic advantages. Liu and Garcia (1988) obtained maximum yields of plantain in terms of number and weight of fruits from the non-weeded control.

Application of some herbicides lead to reduction in yield of banana. Pre-emergence application of diuron at 0.7 and 1.4 kg, fenac 0.7 kg and TCA 2.3 kg and post-emergence application of atrazine 0.7 kg and dalapon 9.1 kg resulted in marked but non-significant reduction in yield of banana cv. Robusta (Anon, 1963c). Romanowski et al.(1967) observed that application of atrazine at 0.9 - 1.8 kg caused biggest reduction in yield and delayed maturity of banana by 44-49 days. Reduction in yield of banana by application of atrazine was also reported by Dhuria and Leela (1973) and Leela (1982). Rodriguez et al.(1978) observed a reduction in yield of banana cv. Robusta in diuron treated plots.

Planting of banana cv. Robusta at a high density and inter cropping with cowpea in the initial stages gave higher yields of banana (Chacko and Reddy,1981).

Most of the findings reviewed above indicate that use of herbicides does not have any adverse effects on the growth and yield of banana.

4.3 Effect on soil moisture

In areas with a marked dry season, competition for water by weeds during the period of drought may considerably affect the coconut yields (Ohler, 1984). In Ivory Coast,it was observed that once the nitrogen supply was ensured through fertilizing, moisture stress was the principal limiting factor. Regular slashing and clean weeding treatments in particular were superior to a water demanding leguminous cover (Ohler, 1984).

Marar (1953) observed that a thorough system of cultivation and weed control resulted in a considerably higher soil moisture content during the dry season. In Sri Lanka, a sharper decline in soil moisture content was measured in soils under three different vegetative covers (weeds and two grass species) as compared to soils having no cover which were kept free from weeds.

Trials in a newly planted plantation of Malaysian Dwarfs in Jamaica showed that if weeding was not practised, seedlings died in the dry season. Even monthly ring weeding in a circle with a diameter of 75 cm plus cutting the other weeds every three months was not enough and resulted in serious growth reduction and death of some seedlings (Kasasian et al., 1968). Under the dry conditions prevailing in Jamaica, monthly hoeing was found necessary in order to protect the coconut seedlings.

4.4 Effect on soil fertility

With the use of herbicides, in the beginning, soil fertility may be upset due to several reasons including a set back to the microbial population and their activities but after some time, the fertility status is again maintained or even improved (Gupta and Moolani, 1971).

In coconut plantations, removal of weeds using

expose the soil over a wide area for extended periods which results in deterioration of soil structure and organic matter, which in due course may result in lower coconut yield (Anon, 1966b; Smith, 1968b). However research work on the effect of different weed control methods on the soil fertility under plantation crops are meagre.

5. Economics of weed control methods

5.1 Coconut

In coconut gardens, using herbicides for controlling weeds is found economic. In coconut plantations in Jamaica, the cheapest and most effective treatments applied as directed sprays were dalapon at 2.3 and 3.6 kg in 100 gal water where grasses predominated, and 2,4-D at 3.3 kg in 35 gal water for the control of broad leaf weeds (Anon, 1963 b). Hoyle (1968) found that in coconuts in Trinidad, application of low rates of paraquat and dalapon + 2,4-D were the cheapest treatments. Kasasian et al. (1968) noted that the best herbicide treatments for round weeding young coconuts from a cost/efficiency stand point were dalapon at 4.5 kg, atrazine and diuron 1.8 kg and paraquat 0.2 kg (applied monthly). Smith (1968a) found that in young coconut plantations, controlling the weeds with Gramoxone (paraquat) at 1.1 lit ac^{-1} ± Karmex (diuron) at 1.0 kg was cheaper and more effective than regular cleaning with a cutlass. Coomans (1974) found that in coconut plantations, the best treatments from the point of view of both efficacy and economy were MSMA at 1.8 kg + sodium chlorate 4 kg ± 2,4-D amine 1.4 kg ha^{-1} which with three applications per year costed only 75 per cent as much as six manual weedings. Abad and Juan (1980) reported that application of glyphosate at 1.64 kg ha^{-1} in one to three applications at two months intervals, followed by monthly spraying of paraquat at 1.32 kg ha^{-1} was found to be more practical and economical than manual weeding alone, especially in large scale polybag coconut nurseries.

Dumas and Schut (1976) observed that in Malayan Dwarf coconut palms, herbicide treatments were more costly than hand weeding, largely because of the poor stand of the operators. Mathew (1978) reported that in coconut garden comparative economics of various treatments indicated manual weeding to be the cheapest and the bromacil + dalapon combination was very expensive. Balasubramanian _et al_. (1985) found that in East Coast Tall palms, ploughing the entire area gave the lowest cost/profit ratio and herbicide application was considered uneconomic. Bourgoing and Boutin (1987) observed that rolling a light weight wooden roller between the coconut rows at the time of cover crop sowing controlled Imperata more economically than chemical weed control using glyphosate. Salgado (1972) reported that in coconut estates in Ceylon, removing _Eupatorium_ _odoratum_ with a tyne cultivator and establishment of the cover crop *Tephrosia purpurea* has been found to be the cheapest and most effective method for the control of the weed.

5.2 Banana

Using herbicides is an economic method of weed control in banana. Substitution of mechanical cultivation or spraying dalapon to control grass weeds in a banana plantation represented savings of Cr $3000 and Cr $ 3000-4000 ha^{-1} respectively on the cost of manual weeding (Monteiro, 1962). Leigh (1969) found that treatments containing diuron, either singly or in combination with other materials were more efficient and economical than all other treatments, including arsenic pentoxide for control of weeds in young banana plantations. Chambers (1970) found that in bananas, initial control of perennial grasses by dalapon at 1.1 - 2.3 kg followed by three to eight applications of paraquat totalling 0.3 - 0.65 kg per year can give economic and safe weed control. Nayar *et al.* (1979) reported that post-emergence application of Gramoxone 1.5 l + 2,4-D 3 kg ha^{-1} was the economical method of weed control in banana in Thrissur, Kerala compared to pre-emergence application of diuron 3 kg ha^{-1}

at bimonthly intervals and post-emergence application of Gramoxone 1.3 l + diuron 3 kg ha^{-1}. Tosh et al. (1982) noted that application of diuron and simazine at 3 kg ha^{-1} has proved to be an economic weed management practice in interplanted pineapple banana plantations.

Pre-emergence application of diuron at 1.4 and 1.8 kg and atrazine at 2.0 and 2.7 kg in 40 gal water to bananas proved less economical than cutlassing (Anon, 1964b). Chacko and Reddy (1981) reported that planting of banana at a high density and intercropping with cowpea during the initial stages was shown to be commercially viable.

Most of the findings reviewed above indicate that in coconut and banana plantations, economic weed control can be effected by using herbicides.

Materials and Methods

MATERIALS AND METHODS

Field experiments to develop weed management practices for sole and intercropped coconut gardens were conducted in Kerala, India during the period from 1986 to 1989. The project consisted of three separate field trials, viz.

I. Weed management in underplanted coconut garden.

II. Weed management in coconut + banana cropping system.

III. Weed management in sole banana.

The materials used and methods adopted in the course of these investigations are described below.

1. Location of the trial

The trials were conducted at the Agricultural Research Station, Mannuthy, of the Kerala Agricultural University. The research station is situated at 12° 32'N latitude and 74° 20' E longitude and at an altitude of 22.25 meters above mean sea level.

1.1. Soil

Trial-I and Trial-II were conducted in the existing coconut gardens of the farm. Trial-III was conducted in single crop upland rice field. The mechanical and chemical composition of the soil of the experimental fields are given in Table 1.

2. Cropping history of the experimental field

Trial-I was conducted in a pure coconut garden of about 65 years old, in which coconut seedlings were underplanted during 1971-72.

Trial-II was conducted in a coconut garden newly planted during 1981-82. No intercrops were raised till the conduct of the experiment.

Trial-III was conducted in a single crop upland rice field where a bulk crop of rice was raised during the previous season.

3. Climate

Trial-I and Trial-II were conducted under rainfed condition and Trial-III was irrigated as and when necessary. The monthly averages of maximum and minimum temperature, relative humidity, sunshine hours, evaporation and total

Table 1. Mechanical and chemical composition of soil of the experimental field

Particulars	Value			Method followed
	Trial-I	Trial-II	Trial-III	
A. <u>Mechanical composition</u>				
1. Sand (%)	76.01	74.01	46.01	Hydrometer method (Piper, 1942)
2. Silt (%)	7.99	3.99	24.00	
3. Clay (%)	16.00	22.00	29.99	
B. <u>Chemical composition</u>				
1. Organic carbon (%)	0.62	1.00	0.62	Walkley and Black method (Piper, 1942)
2. Total nitrogen (%)	0.12	0.12	0.13	Micro Kjeldahl method (Jackson, 1958)
3. Available P (kg/ha)	15.01	15.01	36.20	Bray I extractant, molybdo Phosphoric acid method (Jackson, 1958)
4. Available K (kg/ha)	784.00	294.00	140.00	Neutral normal ammonium acetate method (Jackson, 1958)
5. pH	5.3	5.2	5.5	1:2.5 soil water suspension using a pH meter (Jackson, 1958)
6. Electrical conductivity (mmhos/cm^2)	0.10	0.10	0.12	1:2.5 soil water suspension using a conductivity bridge (Jackson, 1958)

rainfall during the cropping period are presented in Appendix-I.

4. Materials

4.1. Variety

In Trial-I, the existing coconut garden consisted of 65 years old coconut palms cv. West Coast Tall. Coconut seedlings of the same variety were underplanted between the old palms and were in the pre-bearing stage.

In Trial-II, banana cv. Palayankodan (Musa AAB Group) having a duration of 12-16 months was used for intercropping in the young Laccadive Ordinary coconut garden planted during 1981-82. Cowpea variety New Era was used in the treatments involving cowpea.

In Trial-III also banana cv. Palayankodan and cowpea variety New Era were used.

4.2. Planting materials

The banana suckers were supplied by the Banana Research Station, Kannara. Care was taken to collect sword suckers of uniform age to the extent possible. Cowpea seeds were obtained from the Agricultural Research Station, Mannuthy.

4.3 Manures and fertilizers

Green leaves @ 10 kg per plant was applied to banana at the time of planting.

Urea, mussorie-phos and muriate of potash analysing 46 per cent N, 20 per cent P_2O_5 and 60 per cent K_2O respectively were used for the trials.

4.4 Herbicides

The details of herbicides used for the investigation are presented in Table 2.

5. Methods

5.1. Trial-I. Weed management in underplanted coconut garden.

The trial consisted of 13 treatments involving single and combined application of herbicides, manual weeding and unweeded control, as detailed below:

Treatments	Notation
1. Weedy check	C
2. Weed free	WF
3. Digging once (October-November)	D(1)
4. Digging twice (May-June and October-November)	D(2)
5. Sickle weeding twice (June-July and September-October)	S(2)
6. Paraquat 0.4 kg ha^{-1}, three sprays starting from active vegetative growth stage at monthly interval	P(3)
7. Glyphosate 0.4 kg ha^{-1}	G(L)

Table 2. Pre and post emergence herbicides used in the experiments

Herbicide	Trade name	Active ingredient (%)	Formulation and concentration	Manufacturer
A. Pre-emergence				
1. Diuron	Hexuron	80	80 WP	Bharat Pulverising Mills Private Ltd.
2. Oxyfluorfen	Goal	24	24 EC	Indofil Chemicals Ltd.
3. Atrazine	Atrataf	50	50 W	Rallis India Ltd.
B. Post-emergence				
1. Paraquat	Gramoxone	20	24 EC	Alkali and Chemical Corporation of India Ltd.
2. Glyphosate	Weedoff	41	41 EC	National Organic Chemical Industries Ltd.
3. Dalapon	Dalapon	74	85 WSP	Dow Chemical Company
4. 2,4-DEE	Agrodone Concentrate-48	34	48 EC	Agromore Ltd.

8.	Glyphosate 0.8 kg ha^{-1}	G(H)
9.	Dalapon 3.0 kg ha^{-1} followed by paraquat 0.4 kg ha^{-1} 2 weeks after	Da(1) $\rightarrow$ P(1)
10.	Paraquat 0.4 kg ha^{-1} + diuron 1.0 kg ha^{-1}	P + Di (1)
11.	Paraquat 0.4 kg ha^{-1} followed by glyphosate 0.4 kg ha^{-1} one month after	P(1) $\rightarrow$ G(L)
12.	2,4-D 1.0 kg (as ethyl ester) ha^{-1} + diuron 1.0 kg ha^{-1} immediately after sickle weeding	Si(1)$\rightarrow$2,4-D+Di(1
13.	Glyphosate 0.4 kg ha^{-1} followed by digging once after North East monsoon	G(L) $\rightarrow$D(1)

Treatments - 13

Replications - 3

Design - Randomised Block Design

Plot size - 10 x 9 m^2

Number of old palms per plot - 1

Number of young palms per plot - 1

Trial-II. Weed management in coconut + banana cropping system.

The treatments consisted of application of pre-emergence herbicides alone, pre-emergence herbicides followed by a post-emergence herbicide, growing cowpea as intercrop, cowpea followed by post-emergence herbicides, manual weeding and unweeded control as given below:

Treatments	Notation
1. Coconut alone - weedy check	Cc
2. Coconut alone - weeding only in the pits	C-WP
3. Coconut + banana - weeding only in the coconut pits	C+B-WP
4. Coconut + banana - weed free	C+B-WF
5. Coconut + banana - spade weeding twice and earthing up (June-July and September-October)	C+B-Sp
6. Coconut + banana - sickle weeding twice (June-July and September-October)	C+B-Si
7. Coconut + banana + cowpea	C+B+CP
8. Coconut + banana + cowpea followed by paraquat 0.4 kg ha^{-1} depending on weed growth after the harvest of cowpea	C+B+CP → P
9. Coconut + banana + cowpea followed by glyphosate 0.4 kg ha^{-1} depending on weed growth after the harvest of cowpea	C+B+CP → G
10. Coconut + banana - diuron 1.5 kg ha^{-1}	C+B-D
11. Coconut + banana - oxyfluorfen 0.2 kg ha^{-1}	C+B-O
12. Coconut + banana - atrazine 2.0 kg ha^{-1}	C+B-A
13. Coconut + banana - diuron 1.5 kg ha^{-1} followed by paraquat 0.4 kg ha^{-1} depending on weed growth	C+B-D → P
14. Coconut + banana - oxyfluorfen 0.2 kg ha^{-1} followed by paraquat 0.4 kg ha^{-1} depending on weed growth	C+B-O → P
15. Coconut + banana - atrazine 2.0 kg ha^{-1} followed by paraquat 0.4 kg ha^{-1} depending on weed growth	C+B-A → P

Treatments - 15

Replications - 3

Design - Randomised Block Design

Gross plot size - 15 x 8 m^2

Net plot size - 10 x 2.5 m^2

Number of coconut palms per net plot - 2

Number of banana plants per net plot - 2

Trial III. Weed management in sole banana.

The trial consisted of the same weed control treatments used under coconut+banana cropping system.

Treatments		Notation
1.	Weedy check	C
2.	Weed free	WF
3.	Spade weeding twice and earthing up (June-July and September-October)	Sp
4.	Sickle weeding twice (June-July and September-October)	Si
5.	Banana + Cowpea	Cp
6.	Banana + Cowpea followed by paraquat 0.4 kg ha^{-1} depending on weed growth after the harvest of cowpea	Cp → P
7.	Banana + cowpea followed by glyphosate 0.4 kg ha^{-1} depending on weed growth after the harvest of cowpea	CP → G
8.	Diuron 1.5 kg ha^{-1}	D
9.	Oxyfluorfen 0.2 kg ha^{-1}	O

10. Atrazine 2.0 kg ha^{-1} — A

11. Diuron 1.5 kg ha^{-1} followed by paraquat 0.4 kg ha^{-1} depending on weed growth — D → P

12. Oxyfluorfen 0.2 kg ha^{-1} followed by paraquat 0.4 kg ha^{-1} depending on weed growth — O → P

13. Atrazine 2.0 kg ha^{-1} followed by paraquat 0.4 kg ha^{-1} depending on weed growth — A → P

Treatments - 13

Replications - 3

Design - Randomised Block Design

Plot size - 4.26 x 4.26 m^2

Number of banana plants per plot - 4

Layout

The layout plan of the experiments are illustrated in Fig.1a, 1b and 1c.

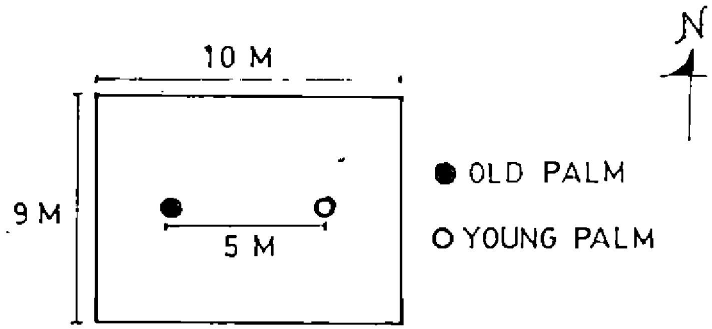
5.2 Planting

In Trial-I, the old palms were planted at a spacing of 10 m x 9 m. The seedling palms were interplanted in between two old palms on the 10 m spaced line. Thus the spacing between an old and young palm was 5 m.

In Trial-II, banana suckers were planted in pits of 50 cm^3 in two rows in between two rows of coconut on either

P+Di(1)	Si(1)→ 2,4-D+Di(1)	WF	C	G(L)→D(1)
R I	Si(2)	P(3)	G(L)	P(1)→G(L)
	D(1)	Da(1)→P(1)	G(H)	D(2)
D(1)	Da(1)→P(1)	Si(2)	P(1)→G(L)	C
R II	G(L)→D(1)	G(H)	D(2)	G(L)
	WF	P+Di(1)	Si(1)→ 2,4-D+Di(1)	P(3)
Si(1)→ 2,4-D+Di(1)	C	D(1)	D(2)	Da(1)→P(1)
R III	G(H)	G(L)	P(3)	WF
	Si(2)	P(1)→G(L)	G(L)→D(1)	P+Di(1)

PLANTING PATTERN OF COCONUT



● OLD PALM
O YOUNG PALM

DESIGN _ R B D
REPLICATIONS _ 3
TREATMENTS _ 13
PLOT SIZE _ 10 M × 9 M
No. OF OLD PALM PER PLOT _ 1
No. OF YOUNG PALM " _ 1

C _ WEEDY CHECK
WF _ WEED FREE
D(1) _ DIGGING ONCE
D(2) _ DIGGING TWICE
Si(2) _ SICKLE WEEDING TWICE
P(3) _ PARAQUAT THREE SPRAYS
G(L) _ GLYPHOSATE LOWER DOSE
G(H) _ GLYPHOSATE HIGHER DOSE
Da(1)→P(1) _ DALAPON F.B. PARAQUAT
P+Di(1) _ PARAQUAT + DIURON
P(1)→G(L) _ PARAQUAT F.B. GLYPHOSATE-LOWER DOSE

Si(1)→2,4-D+Di(1) _ SICKLE WEEDING F.B. 2,4-D+DIURON. G(L)→D(1) _ GLYPHOSATE LOWER DOSE F B DIGGING

FIG.1a. LAY OUT PLAN OF TRIAL _ I (WEED MANAGEMENT IN UNDERPLANTED COCONUT GARDEN)

R I

C+B+CP	C+B-D	C+B-WP	C+B-O→P	C+B-A
C+B-A→P	C+B-WF	CC	C+B+CP→P	C-WP
C+B-D→P	C+B+CP→G	C+B-Sp	C+B-O	C+B-Si

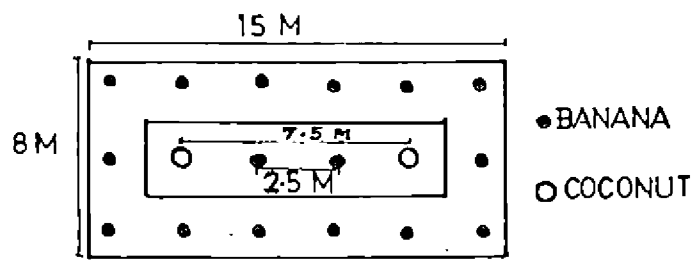
R II

C+B-D	C+B-WP	C+B-A→P	C+B-D→P	C+B-WF
C+B-O→P	CC	C+B+CP→G	C+B-O	C+B+CP→P
C+B-A	C+B-Si	C-WP	C+B+CP	C+B-Sp

R III

CC	C-WP	C+B-D	C+B-WF	C+B-WP
C+B-Sp	C+B-A→P	C+B-Si	C+B+CP→G	C+B-O
C+B+CP→P	C+B+CP	C+B-O→P	C+B-A	C+B-D→P

PLANTING PATTERN OF COCONUT AND BANANA



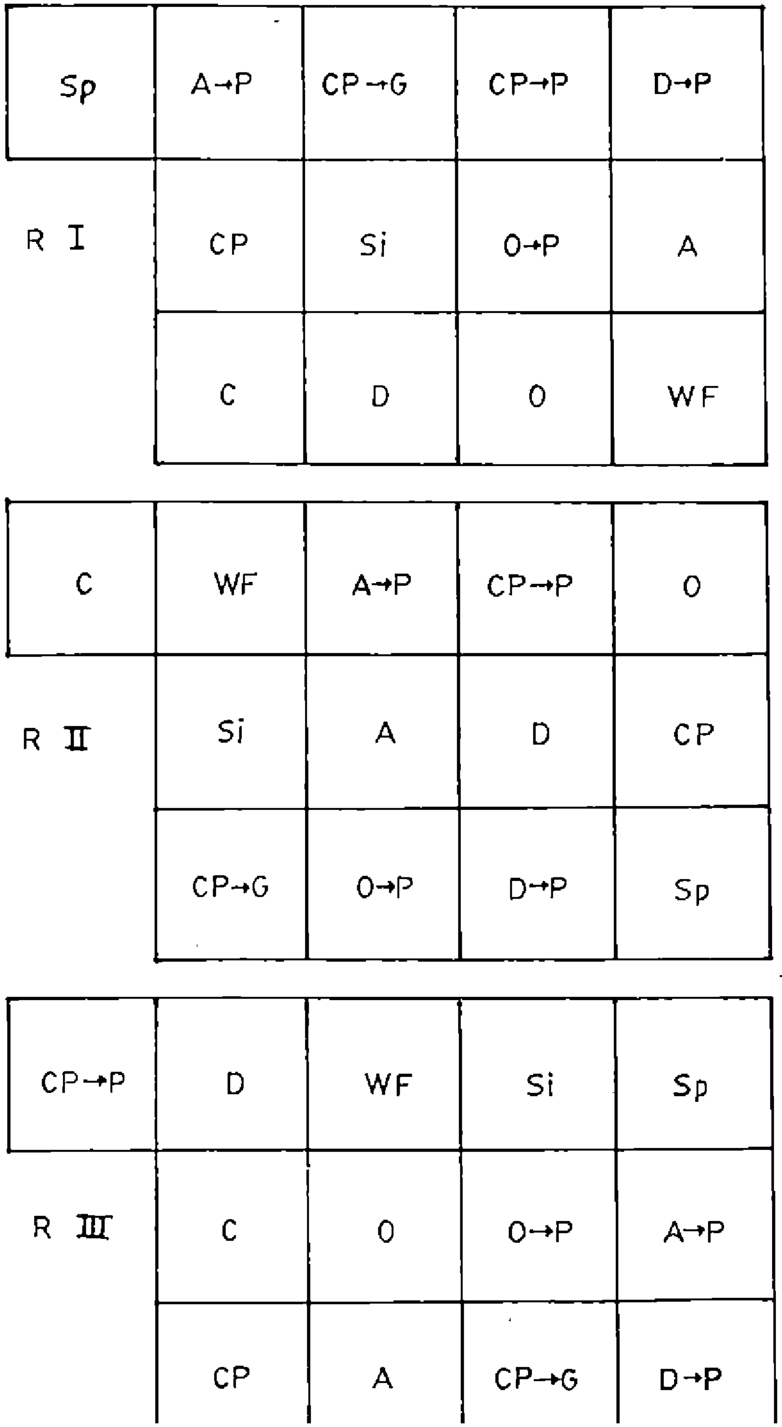
N

DESIGN _ RBD
REPLICATIONS _ 3
TREATMENTS _ 15
GROSS PLOT SIZE _ 15 M × 8 M
NET PLOT SIZE _ 10 M × 2.5 M
No. OF COCONUT PALMS PER NET PLOT _ 2
No. OF BANANA PLANTS " _ 2

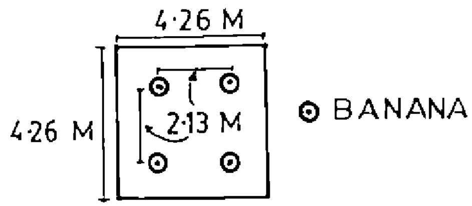
CC _ SOLE COCONUT-WEEDY CHECK
C-WP _ SOLE COCONUT-WEEDING PITS
C+B-WP _ COCONUT+BANANA-WEEDING PITS OF COCONUT
C+B-WF _ COCONUT+BANANA WEED FREE
C+B-Sp _ " " SPADE WEEDING
C+B-Si _ " " SICKLE WEEDING
C+B+CP _ " " +COWPEA
C+B+CP→P _ " " " F.B. _ PARAQUAT

C+B+CP→G _ COCONUT+BANANA+COWPEA F.B. GLYPHOSATE.
C+B-D _ " " _ DIURON
C+B-O _ " " _ OXYFLUORFEN
C+B-A _ " " _ ATRAZINE
C+B-D→P _ COCONUT+BANANA _ DIURON F.B. PARAQUAT
C+B-O→P _ " " _ OXYFLUORFEN F.B. PARAQUAT
C+B-A→P _ " " _ ATRAZINE " "

FIG.1b. LAY OUT PLAN OF TRIAL _ II (WEED MANAGEMENT IN COCONUT+ BANANA CROPPING SYSTEM)



PLANTING PATTERN OF BANANA



DESIGN	_ RBD
REPLICATIONS	_ 3
TREATMENTS	_ 13
PLOT SIZE	_ 4·26×4·26 M
No. OF PLANTS PER PLOT	_ 4

C	_ WEEDY CHECK
WF	_ WEED FREE
Sp	_ SPADE WEEDING
Si	_ SICKLE WEEDING
CP	_ COWPEA
CP→P	_ COWPEA F.B. PARAQUAT
CP→G	_ COWPEA F.B. GLYPHOSATE
D	_ DIURON
O	_ OXYFLUORFEN
A	_ ATRAZINE
D→P	_ DIURON F.B. PARAQUAT
O→P	_ OXYFLUORFEN F.B. PARAQUAT
A→P	_ ATRAZINE F.B. PARAQUAT

FIG. 1c. LAY OUT PLAN OF TRIAL-III (WEED MANAGEMENT IN SOLE BANANA)

ways at a spacing of 2.5 m between the banana plants within a plot.

In Trial-III, planting of banana suckers was done in pits of 50 cm^3 at a spacing of 2.13 m x 2.13 m.

In Trial-II and Trial-III, cowpea seeds were broadcasted at the rate of 40 kg per hectare.

5.3. Fertilizer application

For coconut, banana and cowpea, fertilizer application was done as per the package of practices recommendations of the Kerala Agricultural University (KAU, 1986).

5.4 After care

Unhealthy banana suckers were replaced with healthier ones to get uniform stand. Plant protection was done as per the package of practices recommendations of the Kerala Agricultural University (KAU, 1986).

5.5 Herbicide application

The ground was chipped clean of all weeds with a spade before the application of pre-emergence herbicides. Post-emergence herbicides were applied when sufficient weed growth developed to warrant spraying. Pre-emergence herbicides were applied with a flat fan nozzle and post emergence herbicides with a floodjet nozzle fitted to a calibrated knap sack sprayer. The spray fluid used was 500 l ha^{-1}.

5.6 Harvest

Cowpea was cut at the flowering stage, weighed and applied to coconut @ 20 kg per palm and the rest to banana plants. Banana was harvested on maturity of bunches and coconut was harvested at 45 days interval.

5.7 Observations

5.7.1 Observations on crop

In Trial-I, only the yield of old coconut palms was recorded. In Trial-II, the two coconut palms and the two banana plants between the coconut palms were used for collecting the biometric observations. In Trial-III, the observations were collected from all the four treatment plants.

A. Coconut

(i) Number of fronds per palm

Number of opened green fronds present were counted and recorded at yearly interval.

(ii) Girth of palm

The girth at collar was measured at yearly interval and expressed in cm.

(iii) Yield of coconut

Number of nuts harvested per palm in each harvest was recorded and expressed as yield of nuts per hectare per year.

B. Banana

(i) Growth characters

Observations on growth characters were taken at the time of shooting.

(a) Height of pseudostem

Height of pseudostem was measured from the ground level to the axil of the flag leaf at shooting and expressed in cm.

(b) Girth of pseudostem

The girth of pseudostem was measured at 20 cm above the ground level and expressed in cm.

(c) Number of functional leaves

Fully opened, functional (more than 50 per cent areagreen) leaves, present at the time of shooting were counted and recorded.

(d) Length of lamina

Length of lamina of the index leaf (third fully opened youngest leaf) at the time of shooting was measured from the point of attachment to the tip and expressed in m.

(e) Width of lamina

Width of lamina of the index leaf (third fully opened youngest leaf) at the time of shooting was measured at the middle of the lamina and expressed in m.

(f) Leaf area

Leaf area was computed using the formula given by Murray (1960) in which the product of length and width of lamina was multiplied by a factor 0.8 to give the area. The leaf area was expressed in m^2.

(g) Number of days for shooting and maturity

The number of days taken from planting to shooting and from planting to maturity of bunches of plant crop were recorded.

(h) Drymatter production

At the time of harvest, the plants were cut close to the ground and representative samples of leaves, pseudostem, peduncle and fruits were first air dried and then oven dried at 70°C till the attainment of constant weight and expressed as kg per hectare.

(ii) Bunch characters

The bunches were harvested as and when they matured. The following observations were made on the bunches harvested from the plants used for collecting biometric observations.

(a) Weight of bunch

Weight of bunch, including the portion of the peduncle (exposed outside the plant) was recorded in kg.

(b) Number of hands per bunch

The number of hands in the bunch was counted and recorded.

(c) Number of fingers per bunch

The total number of fingers per bunch was counted and recorded.

(d) Length of bunch

Length of bunch was measured from the point of origin of the first hand to that of the last hand and expressed in cm.

(e) Weight of hands

The hands were removed carefully from the peduncle and their total weight recorded.

(iii) Weed index

The weed index of different treatments were calculated using the formula

$$\text{Weed index (\%)} = \frac{(X - Y)}{X} \times 100$$ where

X = Yield from weed free plot

Y = Yield from treatment plot

5.7.2 Studies on weeds

The studies on weeds were made at an interval of 45 days from the start of the trial.

(i) Population

An area of 0.25 m^2 was selected at two places in each plot at random and the weed count was recorded species wise.

(ii) Drymatter production

A 0.25 m^2 quadrat was placed at two places at random in each plot and the above ground portions of the enclosed weeds were removed. These weeds were oven dried and the drymatter production was expressed as g per m^2.

(iii) Weed control efficiency

The weed control efficiency of different treatments were calculated using the formula.

$$\text{Weed control efficiency (\%)} = \frac{(X - Y)}{X} \times 100$$ where

X = Drymatter production of weeds in the unweeded control plot

Y = Drymatter production of weeds in the treatment plot

5.7.3. Nutrient uptake by the crop and weeds

The oven dried banana samples at harvest stage and weed samples at all stages were ground in a wiley mill and analysed for content of nitrogen, phosphorus and potassium.

Nitrogen in plant samples was estimated colorimetrically in sulphuric acid - hydrogen peroxide digest (Wolf, 1982).

1:1 nitric - perchloric acid mixture was used for digestion of plant samples for the estimation of phosphorus and potassium (Johnson and Ulrich, 1959).

Phosphorus in plant digests was estimated by the vanado - molybdo - phorphoric yellow colour method and potassium by flame photometry (Jackson, 1958).

The nutrient uptake was calculated by multiplying the drymatter of the crop or weed with the respective nutrient content and was expressed in kg ha^{-1}.

5.7.4 Soil moisture

In Trial-I and Trial-II soil samples at three depths, viz. 0-15 cm, 15-30 cm and 30-45 cm were collected from two places in each plot during the summer months (December-April) of 1986-87 and 1988-89 at monthly interval and the moisture content was determined gravimetrically and average values are presented. During 1987-88 there was rain during summer months and hence this observation was not taken.

5.7.5 Soil analysis

The pre-experiment soil samples, collected from each experimental site and the post experiment soil samples collected plot wise were analysed for organic carbon, total nitrogen, available phosphorus and available potassium.

The organic carbon was estimated by Walkley - Black method, total nitrôgen by modified micro-kjeldhal method, available phosphorus was extracted by Bray - I and estimated colorimetrically by the chlorostannous reduced blue colour method and available potassium was extracted by neutral normal ammonium acetate and estimated by flame photometry (Jackson, 1958).

5.7.6 Economics

The profit per rupee invested on weeding under different treatments were computed on the basis of the prevailing market rates of the commodities at the time of harvest.

5.7.7 Statistical analysis

The data recorded were subjected to the analysis of variance technique as suggested by Panse and Sukhatme (1978) for randomised block design. The data on coconut were subjected to the analysis of co-variance technique.

Analysis of the data on weeds was carried out after transforming the data to $\sqrt{x + 1}$ for those with zero values and to $\sqrt{x}$ for those without zero. However, original means are also presented for comparison.

Results and Discussion

RESULTS AND DISCUSSION

The results of experiments conducted to develop weed management practices for sole and intercropped coconut gardens are presented and discussed in this chapter.

Trial-I. Weed management in underplanted coconut garden

1. Weeds

1.1. Weed spectrum

The weed flora found in the experimental field are presented in Appendix-II. Out of these, the dicot weed *Chromolaena odorata* was the major weed of the area (Plate-1).

1.2 Weed population

Effect of treatments on the population of weeds was studied from the start of the trial in November 1986. In the first year the treatments were applied in November 1986 and observations were taken upto June 1987. Altogether four observations were taken at 45 days interval for a period of 180 days. In the second and third year the treatments were started in July and seven observations were taken upto the following June at 45 days interval for a period of 315 days.

1.2.1 Population of monocot weeds

The monocot weed population was significantly influenced by different weed control treatments (Tables 3a, b and c). Among the herbicide treatments, paraquat 0.4 kg ha^{-1} sprayed thrice at monthly interval (t_6) had the least number of monocot weeds throughout the experiment (Plate 3). Glyphosate 0.8 kg ha^{-1} (t_8) and dalapon 3.0 kg ha^{-1} followed by paraquat 0.4 kg ha^{-1} (t_9) were on par with the treatment t_6 (Plates 6 and 7) at all stages during 1986-87 and 1988-89 and upto 135 days during 1987-88. Glyphosate 0.4 kg ha^{-1} alone (t_7) was effective upto 90 days whereas when it was given after paraquat (t_{11}) the effect lasted upto 180 days. However, paraquat + diuron (t_{10}) and 2,4-D + diuron sprayed immediately after sickle weeding (t_{12}) were not effective in reducing the monocot weed population (Plate 8) and recorded even more number of monocot weeds than in the unweeded control in most of the stages.

The best control of monocot weeds obtained by repeated application of paraquat at monthly interval might be due to its contact effect on newly emerged weeds after each application. Efficiency of paraquat in controlling monocot weeds like Imperata cylindrica in coconut gardens was also reported by Seth (1984). Being a translocated

Table 3a. Effect of treatments on monocot weed population (plants/m^2) during 1986-87

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS	
		T	O	T	O	T	O	T	O
1	C	3.4	10.7	3.4	10.7	3.2	9.3	3.0	8.0
2	WF	1.8	2.7	1.0	0.0	1.0	0.0	1.0	0.0
3	D(1)	2.9	8.0	3.2	9.3	2.9	8.0	2.7	6.7
4	D(2)	2.9	8.0	3.2	9.3	2.9	8.0	1.0	0.0
5	Si(2)	6.3	38.7	6.5	41.3	6.5	41.3	6.9	46.7
6	P(3)	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0
7	G(L)	2.5	5.3	2.5	5.3	2.5	5.3	2.2	4.0
8	G(H)	1.0	0.0	1.4	1.3	1.4	1.3	1.4	1.3
9	Da(1) → P(1)	1.0	0.0	1.4	1.3	1.4	1.3	1.8	2.7
10	P + Di(1)	2.5	5.3	2.9	8.0	2.9	8.0	3.0	8.0
11	P(1) → G(L)	1.0	0.0	1.8	2.7	1.8	2.7	2.2	4.0
12	Si(1) → 2,4-D + Di(1)	4.0	14.7	4.3	17.3	4.4	18.7	4.3	17.3
13	G(L) → D(1)	2.9	8.0	3.2	9.3	2.9	8.0	2.5	5.3
	SE	0.25		0.27		0.33		0.67	
	CD (0.05)	0.74		0.79		0.97		1.96	

DAS = Days after spraying
T = $\sqrt{x + 1}$ transformed values
O = Original values

Table 3b. Effect of treatments on monocot weed population (plants/m^2) during 1987-88

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T	O	T	O	T	O	T	O	T*	O	T	O	T	O
1	C	4.9	22.7	4.8	22.7	4.3	17.3	2.8	6.7	3.2	9.3	3.2	9.3	3.7	13.3
2	WF	2.7	6.7	1.0	0.0	2.5	5.3	1.0	0.0	2.2	4.0	1.0	0.0	2.2	4.0
3	D(1)	5.9	34.7	5.9	34.7	2.5	5.3	2.5	5.3	5.0	24.0	5.4	28.0	5.5	29.3
4	D(2)	3.4	10.7	5.9	34.7	2.5	5.3	2.5	5.3	5.0	24.0	5.2	26.7	1.0	0.0
5	Si(2)	6.8	45.3	1.0	0.0	4.9	22.7	4.8	22.7	5.7	32.0	5.9	33.3	6.1	36.0
6	P(3)	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.8	2.7	2.2	4.0	2.5	5.3
7	G(L)	1.8	2.7	2.2	4.0	2.7	6.7	3.0	8.0	3.2	9.3	3.6	12.0	4.0	14.7
8	G(H)	1.0	0.0	1.0	0.0	1.0	0.0	2.5	5.3	2.7	6.7	2.9	8.0	3.2	9.3
9	Da(1) → P(1)	1.0	0.0	1.0	0.0	1.4	1.3	3.6	12.0	3.4	10.7	3.4	10.7	3.2	9.3
10	P + Di (1)	2.7	6.7	4.5	19.3	4.7	21.3	3.8	13.3	4.3	17.3	4.7	21.3	5.1	25.3
11	P(1) → G(L)	1.0	0.0	1.8	2.7	2.5	5.3	2.2	4.0	3.2	9.3	3.2	9.3	3.8	13.3
12	Si(1) → 2,4-D + Di(1)	2.7	6.7	4.3	17.3	4.7	21.3	4.7	21.3	6.0	34.7	5.5	29.3	5.6	30.7
13	G(L) → D(1)	1.8	2.7	2.5	5.3	1.0	0.0	2.5	5.3	3.0	8.0	3.4	10.7	3.8	13.3
	SE	0.27		0.31		0.20		0.20		0.23		0.22		0.23	
	CD (0.05)	0.80		0.89		0.58		0.59		0.68		0.64		0.66	

DAS = Days after spraying
T* = $\sqrt{x}$ transformed values
T = $\sqrt{x + 1}$ transformed values
O = Original values

Table 3c. Effect of treatments on monocot weed population (plants/m^2) during 1988-89

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T	O	T	O	T	O	T	O	T	O	T	O	T	O
1	C	4.1	16.0	5.8	33.3	4.0	14.7	3.0	8.0	3.0	8.0	2.7	6.7	3.7	13.3
2	WF	2.2	4.0	1.0	0.0	2.5	5.3	1.0	0.0	1.0	0.0	1.0	0.0	2.2	4.0
3	D(1)	6.1	36.0	6.8	45.3	2.5	5.3	2.5	5.3	3.4	10.7	3.4	10.7	4.7	21.3
4	D(2)	5.7	32.0	6.3	38.7	2.5	5.3	2.5	5.3	3.4	10.7	3.4	10.7	1.0	0.0
5	Si(2)	5.6	30.7	1.0	0.0	5.0	24.0	4.4	18.7	4.7	21.3	4.9	22.7	5.6	30.7
6	P (3)	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.4	1.3	1.4	1.3	2.5	5.3
7	G (L)	2.2	4.0	3.0	8.0	3.4	10.7	2.5	5.3	3.0	8.0	3.0	8.0	4.3	17.3
8	G (H)	1.0	0.0	1.4	1.3	1.4	1.3	1.4	1.3	1.4	1.3	1.8	2.7	2.7	6.7
9	Da(1) → P(1)	1.0	0.0	1.4	1.3	1.4	1.3	1.4	1.3	1.4	1.3	1.8	2.7	2.7	6.7
10	P + Di (1)	3.9	14.7	4.6	20.0	4.7	21.3	3.7	13.3	4.1	16.0	4.3	17.3	5.0	24.0
11	P(1) → G(L)	1.0	0.0	1.8	2.7	1.8	2.7	1.8	2.7	2.5	5.3	2.7	6.7	3.4	10.7
12	Si(1) → 2,4-D + Di(1)	4.7	21.3	5.1	25.3	5.4	28.0	4.1	16.0	4.4	18.7	4.4	18.7	4.7	21.3
13	G(L) → D(1)	2.2	4.0	3.2	9.3	1.0	0.0	2.2	4.0	2.2	4.0	2.5	5.3	3.8	13.3
	SE	0.18		0.28		0.30		0.33		0.29		0.29		0.23	
	CD (0.05)	0.52		0.83		0.87		0.96		0.85		0.86		0.68	

herbicide, one application of glyphosate 0.8 kg ha^{-1} was found as effective as three applications of paraquat 0.4 kg ha^{-1} in controlling monocot weeds. Abad (1980) and Schepens (1983) also reported the effectiveness of glyphosate in controlling monocot weeds like Imperata cylindrica and Cyperus rotundus in coconut plantations. Dalapon 3.0 kg ha^{-1} followed by paraquat 0.4 kg ha^{-1} was also found equally effective as three sprays of paraquat 0.4 kg ha^{-1} in reducing monocot weed population. Goberdhan (1963), Romney (1968), Nair and Chami (1964), Guillon (1968), Coomans (1976), Soedhono et al. (1978), Alif (1982) and Sasidharan et al.(1988) also reported the efficiency of dalapon in killing monocot weeds in coconut plantations.

Among the manual methods of weed control, digging (t_3 and t_4) was found to be better than sickle weeding (t_5) in reducing monocot weed population.

Unweeded control (t_1) recorded lesser number of monocot weeds compared to digging, sickle weeding and some of the herbicide treatments due to the luxurient and competitive growth of Chromolaena odorata and other dicot weeds (Plate 1). The digging treatments were given during June (t_4) and November (t_3 and t_4). Hence the monocot weed population was very low in t_3 and t_4 at 135 days (December) and in t_4 at 315 days (June) during 1987-88 and 1988-89. At 90 days the number of monocot weeds were very low in sickle weeded plots (t_5) as the observation was taken a few days after sickle weeding given in October.

1.2.2 Population of dicot weeds

The different weed control treatments could exert significant influence on the dicot weed population (Tables 4a, b and c). In most of the stages during first two years, 2,4-D + diuron applied immediately after sickle weeding (t_{12}) was most effective against dicot weeds (Plate 8), whereas in the third year paraquat 0.4 kg ha^{-1} sprayed thrice at monthly interval (t_6) was found to be the best in reducing dicot weed population. However, it was on par with 2,4-D + diuron applied immediately after sickle weeding in most of the stages during the year. During 1986-87 most of the herbicide treatments were effective in reducing dicot weed population significantly over unweeded control. However, this effect was not so pronounced in the subsequent years. This might be due to the lower number of weeds in the unweeded plot as a result of the severe competition from the already established weeds, preventing the growth of new weed seedlings. Eventhough glyphosate 0.4 kg ha^{-1} (t_7) was not effective against dicot weeds, its higher dose of 0.8 kg ha^{-1} (t_8) could reduce the dicot weed population significantly. Dalapon 3.0 kg ha^{-1} followed by paraquat 0.4 kg ha^{-1} (t_9) was found

Table 4a. Effect of treatments on dicot weed population (plants/m^2) during 1986-87

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS	
		T*	O	T	O	T*	O	T	O
1	C	12.0	143.4	9.1	82.7	9.0	81.3	9.5	90.7
2	WF	3.3	10.6	1.0	0.0	2.3	5.2	1.0	0.0
3	D (1)	7.2	51.3	10.2	102.7	8.9	80.0	8.1	65.3
4	D (2)	6.8	46.7	8.9	78.7	8.9	78.6	7.6	57.3
5	Si (2)	8.3	68.7	9.7	93.3	8.8	76.8	8.1	65.3
6	P (3)	7.4	54.0	7.7	58.7	7.2	51.3	7.1	52.0
7	G (L)	9.4	89.2	8.1	64.0	7.8	61.1	7.4	53.3
8	G (H)	7.1	50.6	6.7	44.0	6.6	43.9	6.8	45.3
9	Da(i) → P (1)	6.9	47.8	6.4	40.0	6.2	38.4	5.6	30.7
10	P + DI (1)	8.6	73.9	7.7	58.7	7.3	53.3	6.8	45.3
11	P (1) → G(L)	10.3	106.2	9.7	93.3	8.6	74.2	7.5	57.3
12	Si (1) → 2,4-D + Di(1)	6.9	47.3	5.1	25.3	4.7	22.4	4.7	21.3
13	G(L) → D(1)	7.2	51.3	10.0	100.0	8.9	79.9	8.1	65.3
	SE	0.53		0.27		0.37		0.57	
	CD (0.05)	1.56		0.79		1.07		1.66	

DAS = Days after spraying
T* = $\sqrt{x}$ transformed values
T = $\sqrt{x + 1}$ transformed values
O = Original values

Table 4b. Effect of treatments on dicot weed population (plants/m^2) during 1987-88

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T*	O	T	O	T*	O	T	O	T*	O	T	O	T	O
1	C	7.7	59.7	8.0	62.7	6.6	43.9	5.4	28.0	6.1	37.3	6.3	38.7	6.3	38.7
2	WF	2.8	7.6	1.0	0. 0	3.3	10.6	1.0	0.0	3.3	10.6	1.0	0.0	4.6	20.0
3	D(1)	7.8	61.1	8.2	66.7	5.2	26.5	6.9	46.7	7.2	51.9	7.5	54.7	8.1	64.0
4	D(2)	5.8	33.3	8.0	64.0	4.9	23.9	6.7	44.0	6.9	47.8	7.1	49.3	1.0	0.0
5	Si(2)	6.7	45.2	1.0	0.0	7.4	54.5	7.5	56.0	7.4	54.7	7.8	60.0	7.9	61.3
6	P (3)	4.8	22.6	8.7	74.7	5.8	33.4	6.3	38.7	6.1	37.0	6.5	41.3	6.9	46.7
7	G (L)	7.7	60.0	9.4	86.7	7.9	62.7	6.8	45.3	7.1	50.6	7.2	50.7	7.4	53.3
8	G (H)	5.5	30.6	6.4	40.0	6.0	35.7	5.7	32.0	6.0	35.9	6.2	37.3	6.5	41.3
9	Da(1) → P(1)	5.1	26.4	7.8	60.0	6.4	40.7	5.9	33.0	6.4	41.2	6.8	45.3	7.0	48.0
10	P + Di (1)	6.5	42.6	7.8	60.0	7.5	55.9	7.4	54.7	6.9	47.9	7.1	49.3	7.3	52.0
11	P (1) → G(L)	4.2	17.3	9.1	81.3	7.8	61.1	7.7	58.7	6.7	45.2	6.9	46.7	7.1	49.3
12	Si(1) → 2,4-D + Di(1)	4.5	19.9	7.1	49.3	5.9	35.3	5.4	28.0	4.3	18.6	4.5	20.0	4.7	21.3
13	G(L) → D(1)	7.7	59.8	9.2	84.0	2.0	4.0	4.1	16.0	4.2	17.3	5.1	25.3	6.6	42.7
	SE	0.26		0.26		0.39		0.24		0.24		0.25		0.24	
	CD (0.05)	0.77		0.76		1.15		0.69		0.69		0.72		0.71	

DAS = Days after spraying

T* = $\sqrt{x}$ transformed values

T = $\sqrt{x+1}$ transformed values

O = Original values

Table 4c. Effect of treatments on dicot weed population (plants/m^2) during 1988-89

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T*	O	T	O	T	O	T	O	T*	O	T	O	T	O
1	C	6.9	47.9	7.9	61.3	8.0	64.0	6.4	40.0	6.1	37.0	6.0	34.7	6.3	38.7
2	WF	4.6	21.3	1.0	0.0	3.2	9.3	1.0	0.0	3.4	11.8	1.0	0.0	4.3	17.3
3	D(1)	9.5	89.3	10.2	104.0	5.3	26.7	5.6	30.7	5.6	31.9	5.9	33.3	7.0	48.0
4	D(2)	7.4	54.7	8.6	73.3	4.9	22.7	5.3	26.7	5.2	26.6	5.4	28.0	1.0	0.0
5	Si (2)	7.9	62.9	1.0	0.0	5.7	32.0	6.1	36.0	6.2	38.6	6.4	40.0	8.0	62.7
6	P (3)	3.2	10.4	6.0	34.7	6.3	38.7	4.9	22.7	4.9	23.9	5.2	26.7	5.9	33.3
7	G (L)	7.3	53.2	8.2	66.7	8.6	73.3	6.8	45.3	6.8	46.6	7.0	48.0	8.1	64.0
8	G (H)	5.6	31.9	6.3	38.7	6.5	41.3	5.6	30.7	5.6	31.8	5.8	33.3	6.5	41.3
9	Da(1) → P(1)	6.3	39.7	7.1	49.3	7.3	52.0	5.7	32.0	5.7	33.0	6.0	34.7	6.6	42.7
10	P + Di(1)	7.0	49.1	7.9	61.3	8.0	64.0	5.9	34.7	6.0	35.7	6.3	38.7	6.8	45.3
11	P(1) → G(L)	5.5	30.6	8.7	74.7	8.9	78.7	6.7	44.0	6.7	45.2	6.9	46.7	7.4	53.3
12	Si(1) → 2,4-D + Di(1)	5.8	33.3	7.2	50.7	7.4	53.3	5.1	25.3	5.3	27.9	5.5	29.3	6.0	34.7
13	G(L) → D(1)	6.7	45.0	8.0	65.3	1.0	0.0	4.1	16.0	4.1	17.1	4.6	20.0	6.0	34.7
	SE	0.30		0.43		0.27		0.36		0.30		0.23		0.23	
	CD (0.05)	0.89		1.26		0.78		1.05		0.88		0.68		0.68	

DAS = Days after spraying
T* = $\sqrt{x}$ transformed values
T = $\sqrt{x + 1}$ transformed values
O = Original values

as effective as glyphosate 0.8 kg ha^{-1} in reducing dicot weed population. Digging given in November after glyphosate 0.4 kg ha^{-1} in July (t_{13}) brought about significant reduction in dicot weed population compared to unweeded control from 135 to 270 days. This again showed that glyphosate at 0.4 kg ha^{-1} was not enough as it failed to control the weeds till digging was given. There was germination of weed seeds after the digging and by 315 days weed count in these plots were also higher.

The best control of dicot weeds obtained by the application of 2,4-D + diuron immediately after sickle weeding might be due to the effective translocation of 2,4-D. The efficiency of 2,4-D in controlling broad leaved weeds in coconut plantations was also reported by Anon, (1963b). The reduction in dicot weed population by repeated application of paraquat 0.4 kg ha^{-1} might be due to its effect on newly emerged annual dicot weeds as well as on the regrowth of perennial dicot weeds. Romney (1964) reported that paraquat is a herbicide that can be used for general weed control in coconut plantations. Mogali and Hosmani (1981) and Schepens (1983) also recommended glyphosate for the control of dicot weeds like Eupatorium odoratum in coconut gardens.

Manual methods (digging or sickle weeding alone) did not record low dicot weed population compared to unweeded control. However, the lower number of dicot weeds in digging once (t_3) and in digging twice (t_4) at 135 days (December) and in digging twice (t_4) at 315 days (June) was due to the fact that digging was given just a few days before the observation. In t_5, sickle weeding given in October also resulted in negligible weed count at 90 days.

1.2.3 Population of *Chromolaena odorata*

Data on the change in the population of *Chromolaena odorata* as influenced by different weed control treatments are presented in Tables 5a, b and c. Weed free plot (t_2) recorded the least number of Chromolaena (Plate 2) and unweeded (t_1) the highest (Plate 1) throughout the experiment. All the weed control methods could reduce the population of the weed significantly over unweeded control. Among the herbicide treatments, paraquat 0.4 kg ha^{-1} sprayed thrice at monthly interval (t_6) recorded the least number of Chromolaena (Plate 3) in the second and third year whereas 2,4-D + diuron applied immediately after sickle weeding (t_{12}) recorded the least number of Chromolaena in the first year. All the herbicide treatments except glyphosate 0.4 kg ha^{-1} (t_7) were found as effective as the above treatments in reducing the population of Chromolaena in the first and third year, whereas in the second year apart from glyphosate 0.4 kg ha^{-1}, its higher dose of 0.8 kg ha^{-1} (t_8) and paraquat 0.4 kg ha^{-1} followed by glyphosate 0.4 kg ha^{-1} (t_{11}) also

Table 5a. Effect of treatments on the population of *Chromolaena odorata* (plants/m^2) during 1986-87

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS	
		T	O	T	O	T	O	T	O	T	O
1	C	4.4	18.7	4.0	14.7	4.1	16.0	4.0	14.7	4.1	16.0
2	WF	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0
3	D(1)	1.0	0.0	1.0	0.0	1.4	1.3	2.5	5.3	2.5	5.3
4	D(2)	1.0	0.0	1.0	0.0	1.4	1.3	2.2	4.0	1.0	0.0
5	Si (2)	2.5	5.3	2.5	5.3	2.5	5.3	2.7	6.7	3.1	9.3
6	P (3)	1.0	0.0	1.0	0.0	1.2	0.7	1.5	1.3	2.1	3.3
7	G (L)	1.8	2.7	2.2	4.0	2.5	5.3	2.7	6.7	3.0	8.0
8	G (H)	1.0	0.0	1.0	0.0	1.2	0.7	1.5	1.3	2.1	3.3
9	Da (1) → P(1)	1.0	0.0	1.0	0.0	1.2	0.7	1.5	1.3	2.1	3.3
10	P + Di (1)	1.0	0.0	1.0	0.0	1.2	0.7	1.5	1.3	1.9	2.7
11	P(1) → G(L)	1.0	0.0	1.0	0.0	1.5	1.3	1.7	2.0	2.1	3.3
12	Si(1) → 2,4-D+Di(1)	1.0	0.0	1.0	0.0	1.2	0.7	1.2	0.7	1.7	2.0
13	G(L) → D(1)	1.0	0.0	1.0	0.0	1.4	1.3	2.2	4.0	2.5	5.3
	SE	0.13		0.08		0.29		0.19		0.23	
	CD (0.05)	0.39		0.24		0.86		0.55		0.67	

DAS = Days after spraying
T = $\sqrt{x + 1}$ transformed values
O = Original values

Table 5b. Effect of treatments on the population of <u>Chromolaena</u> <u>odorata</u> (plants/m^2) during 1987-88

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T	O	T	O	T	O	T	O	T	O	T	O	T	O
1	C	4.0	14.7	3.6	12.0	3.8	13.3	3.8	13.3	3.8	13.3	4.1	16.0	4.1	16.0
2	WF	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0
3	D(1)	2.2	4.0	2.2	4.0	1.0	0.0	1.0	0.0	1.8	2.7	2.1	3.3	2.2	4.0
4	D(2)	1.0	0.0	1.4	1.3	1.0	0.0	1.0	0.0	1.2	0.7	1.5	1.3	1.0	0.0
5	Si(2)	2.5	5.3	1.0	0.0	2.2	4.0	2.2	4.0	2.5	5.3	2.5	5.3	2.7	6.7
6	P (3)	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.2	0.7
7	G(L)	2.1	3.3	2.2	4.0	2.5	5.3	2.2	4.0	2.5	5.3	2.5	5.3	2.6	6.0
8	G (H)	1.0	0.0	1.0	0.0	1.2	0.7	1.7	2.0	1.7	2.0	1.9	2.7	1.9	2.7
9	Da(1) → P(1)	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.2	0.7	1.5	1.3
10	P + Di (1)	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.2	0.7	1.5	1.3
11	P(1) → G(L)	1.0	0.0	1.0	0.0	1.2	0.7	2.2	4.0	2.2	4.0	2.2	4.0	2.4	4.7
12	Si(1) → 2,4-D + Di(1)	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.2	0.7	1.5	1.3
13	G(L) → D(1)	1.4	1.3	1.0	0.0	1.0	0.0	1.0	0.0	1.2	0.7	1.5	1.3	2.0	3.3
	SE	0.15		0.11		0.13		0.05		0.19		0.18		0.22	
	CD (0.05)	0.43		0.33		0.37		0.14		0.56		0.54		0.65	

DAS - Days after spraying

T - $\sqrt{x + 1}$ transformed values

O - Original values

Table 5c. Effect of treatments on the population of <u>Chromolaena odorata</u> (plants/m^2) during 1988-89

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T	O	T	O	T	O	T	O	T	O	T	O	T	O
1	C	4.0	14.7	3.6	12.0	4.0	14.7	3.8	13.3	4.0	14.7	4.0	14.7	4.3	17.3
2	WF	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0
3	D(1)	2.2	4.0	2.2	4.0	1.0	0.0	1.4	1.3	1.8	2.7	2.1	3.3	2.5	5.3
4	D(2)	1.2	0.7	1.4	1.3	1.0	0.0	1.4	1.3	1.7	2.0	1.9	2.7	1.0	0.0
5	Si(2)	2.5	5.3	1.0	0.0	2.2	4.0	2.8	6.7	2.7	6.7	2.7	6.7	2.9	7.3
6	P(3)	1.0	0.0	1.0	0.0	1.0	0.0	1.4	1.3	1.4	1.3	1.5	1.3	1.7	2.0
7	G(L)	2.1	3.3	2.2	4.0	2.2	4.3	2.8	6.7	2.7	6.7	2.7	6.7	2.7	6.7
8	G (H)	1.0	0.0	1.0	0.0	1.2	0.7	1.4	1.3	1.4	1.3	1.7	2.0	1.7	2.0
9	Da(1) → P(1)	1.0	0.0	1.0	0.0	1.2	0.7	1.4	1.3	1.5	1.3	1.5	1.3	1.5	1.3
10	P + Di (1)	1.0	0.0	1.0	0.0	1.2	0.7	1.8	2.7	1.8	2.7	1.8	2.7	1.8	2.7
11	P(1) → G(L)	1.0	0.0	1.0	0.0	1.2	0.7	1.4	1.3	2.1	3.3	2.1	3.3	2.2	4.0
12	Si(1) → 2,4-D + Di(1)	1.0	0.0	1.0	0.0	1.2	0.7	1.8	2.7	1.8	2.7	1.8	2.7	1.8	2.7
13	G(L) → D(1)	1.7	2.0	1.8	2.7	1.0	0.0	1.4	1.3	1.5	1.3	1.7	2.0	1.8	2.7
	SE	0.14		0.16		0.21		0.37		0.28		0.25		0.24	
	CD (0.05)	0.41		0.47		0.61		1.09		0.82		0.74		0.71	

DAS = Days after spraying
T = $\sqrt{x + 1}$ transformed values
G = Original values

recorded significantly higher number of Chromolaena compared to the most effective treatment, paraquat 0.4 kg ha^{-1} sprayed thrice at monthly interval, from 180 days onwards. Glyphosate 0.4 kg ha^{-1} followed by digging (t_{13}) was also on par with paraquat 0.4 kg ha^{-1} sprayed thrice at monthly interval, in most of the stages.

The best control of Chromolaena odorata obtained by spraying paraquat 0.4 kg ha^{-1} thrice at monthly interval might be due to its repeated contact effect which lead to the suppression of the regrowth of the established plants and the complete kill of the newly germinated seedlings after each application. Experiments conducted at the Kerala Agricultural University also showed the effective control of Chromolaena by the application of paraquat (Anon, 1987). However, application of glyphosate 0.4 kg ha^{-1} alone was found less effective in controlling Chromolaena compared to other herbicide treatments. This shows that the lower dose of 0.4 kg ha^{-1} of glyphosate is not enough for the control of the perennial, noxious weed Chromolaena odorata in coconut plantations, whereas its higher dose of 0.8 kg ha^{-1} is quite sufficient for its control. Similar results in controlling Chromolaena odorata were also reported by Dufour and Quencez (1978), Mogali and Hosmani (1981) and Schepens (1983).

1.2.4 Total weed population

The different weed control treatments influenced the total weed population significantly (Tables 6a, b and c). Most of the herbicide treatments were found effective in reducing total weed population significantly over unweeded control (t_1) in the first year. However, this effect was not so pronounced in the subsequent years due to the lower number of weeds in the unweeded control. The reason for this might be the severe competition from the already established weeds, preventing the establishment of new weed seedlings.

All the herbicide treatments were found to be more effective than sickle weeding (t_5) in reducing total weed population in most of the stages during the first two years, whereas glyphosate 0.4 kg ha^{-1} (t_7), paraquat + diuron (t_{10}) and paraquat followed by glyphosate (t_{11}) were on par with sickle weeding at 180, 225 and 270 days during the third year. In many of the previous studies also the efficiency of chemical methods of weed control has been reported to be equal to (Anon, 1975) or better than (Goberdhan, 1963; Smith, 1968a and Mathew, 1978) manual methods like cutlassing etc.

Among the herbicide treatments, paraquat 0.4 kg ha^{-1} sprayed thrice at monthly interval (t_6), glyphosate 0.8 kg ha^{-1} (t_8) and dalapon 3.0 kg ha^{-1} followed by paraquat 0.4 kg ha^{-1} (t_9) were equally effective in reducing the weed population

Table 6a. Effect of treatments on total weed population (plants/m^2) during 1986-87

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS	
		T*	O	T	O	T*	O	T	O
1	C	12.4	154.0	9.7	93.3	9.5	90.6	9.9	98.7
2	WF	3.6	13.3	1.0	0.0	2.3	5.2	1.0	0.0
3	D(1)	7.7	59.7	10.6	112.0	9.4	88.0	8.5	72.0
4	D(2)	7.4	55.2	9.4	88.0	9.3	86.6	7.6	57.3
5	Si (2)	10.4	107.7	11.6	134.7	10.9	118.5	10.6	112.0
6	P (3)	7.4	54.0	7.7	58.7	7.2	51.3	7.1	52.0
7	G (L)	9.7	94.5	8.4	69.3	8.2	66.6	7.6	57.3
8	G (H)	7.1	50.6	6.8	45.3	6.7	45.3	6.9	46.7
9	Da(1) → P(1)	6.9	47.8	6.5	41.3	6.3	39.6	5.9	33.3
10	P + Di (1)	8.9	79.2	8.2	66.7	7.8	61.2	7.4	53.3
11	P (1) → G(L)	10.3	106.2	9.8	96.0	8.8	76.9	7.8	61.3
12	Si(1) → 2,4-D+Di(1)	7.9	62.1	6.6	42.7	6.4	41.2	6.3	38.7
13	G(L) → D(1)	7.7	59.1	10.5	109.3	9.4	87.8	8.5	70.7
	SE	0.49		0.25		0.36		0.54	
	CD (0.05)	1.43		0.75		1.04		1.56	

DAS = Days after spraying
T* = $\sqrt{x}$ transformed values
T = $\sqrt{x + 1}$ transformed values
O = Original values

Table 6b. Effect of treatments on total weed population (plants/m^2) during 1987-88

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T*	O	T	O	T*	O	T	O	T*	O	T	O	T	O
1	C	9.1	82.5	9.3	85.3	7.8	61.3	6.0	34.7	6.8	46.6	7.0	48.0	7.3	52.0
2	WF	3.8	14.6	1.0	0.0	4.0	15.8	1.0	0.0	3.8	14.6	1.0	0.0	5.0	24.0
3	D(1)	9.8	95.4	10.1	101.3	5.6	31.9	7.3	52.0	8.7	76.0	9.1	82.7	9.7	93.3
4	D(2)	6.6	44.0	10.0	98.7	5.4	29.3	7.1	49.3	8.5	72.0	8.8	76.0	1.0	0.0
5	Si(2)	9.5	90.6	1.0	0.0	8.8	77.3	8.9	78.7	9.3	86.6	9.7	93.3	9.9	97.3
6	P(3)	4.8	22.6	8.7	74.7	5.8	33.4	6.3	38.7	6.3	39.8	6.8	45.3	7.3	52.0
7	G(L)	7.9	62.6	9.6	90.7	8.3	69.3	7.4	53.3	7.7	59.9	8.0	62.7	8.3	68.0
8	G(H)	5.5	30.6	6.4	40.0	6.0	35.7	6.2	37.3	6.5	42.6	6.8	45.3	7.2	50.7
9	Da(1) → P(1)	5.1	26.4	7.8	60.0	6.5	41.8	6.8	45.3	7.2	51.8	7.5	56.0	7.6	57.3
10	P + Di (1)	7.0	49.3	9.0	79.3	8.8	77.2	8.3	68.0	8.1	65.3	8.5	70.7	8.9	77.3
11	P(1) → G(L)	4.2	17.3	9.2	84.0	8.2	66.5	8.0	62.7	7.4	54.6	7.5	56.0	8.0	62.7
12	Si(1) → 2,4-D + Di(1)	5.2	26.6	8.2	66.7	7.5	56.9	7.1	49.3	7.3	53.1	7.1	49.3	7.3	52.0
13	G(L) → D(1)	7.9	62.5	9.5	89.3	2.0	4.0	4.7	21.3	5.0	25.3	6.1	36.0	7.5	56.0
	SE	0.25		0.25		0.39		0.20		0.21		0.22		0.22	
	CD (0.05)	0.74		0.73		1.13		0.58		0.62		0.65		0.63	

DAS = Days after spraying

T* = $\sqrt{x}$ transformed values

T = $\sqrt{x+1}$ transformed values

O = Original values

Table 6c. Effect of treatments on total weed population (plants/m^2) during 1988-89

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T*	O	T	O	T	O	T	O	T*	O	T	O	T	O
1	C	8.0	64.0	9.8	94.7	8.9	78.7	7.0	48.0	6.7	45.0	6.5	41.3	7.3	52.0
2	WF	5.0	25.3	1.0	0.0	4.0	14.7	1.0	0.0	3.4	11.8	1.0	0.0	4.7	21.3
3	D(1)	11.2	125.3	12.2	149.3	5.7	32.0	6.1	36.0	6.5	42.5	6.7	44.0	8.4	69.3
4	D(2)	9.3	86.6	10.6	112.0	5.4	28.0	5.7	32.0	6.1	37.2	6.3	38.7	1.0	0.0
5	Si(2)	9.7	93.9	1.0	0.0	7.5	56.0	7.4	54.7	7.7	59.8	8.0	62.7	9.7	93.3
6	P(3)	3.2	10.4	6.0	34.7	6.3	38.7	4.9	22.7	5.0	25.3	5.4	28.0	6.3	38.7
7	G(L)	7.6	57.2	8.7	74.7	9.2	84.0	7.2	50.7	7.4	54.6	7.5	56.0	9.1	81.3
8	G(H)	5.6	31.9	6.4	40.0	6.6	42.7	5.7	32.0	5.8	33.2	6.1	36.0	7.0	48.0
9	Da(1) → P(1)	6.3	39.7	7.2	50.7	7.4	53.3	5.8	33.3	5.9	34.5	6.2	37.3	7.1	49.3
10	P + Di (1)	8.0	63.9	9.1	81.3	9.3	85.3	7.0	48.0	7.2	51.9	7.5	56.0	8.4	69.3
11	P(1) → G(L)	5.5	30.6	8.8	77.3	9.1	81.3	6.9	46.7	7.1	50.4	7.4	53.3	8.1	64.0
12	Si(1) → 2,4-D + Di(1)	7.4	54.5	8.7	76.0	9.0	81.3	6.5	41.3	6.8	46.6	7.0	48.0	7.5	56.0
13	G(L) → D(1)	7.0	49.1	8.6	74.7	1.0	0.0	4.6	20.0	4.6	21.2	5.1	25.3	7.0	48.0
	SE	0.28		0.42		0.27		0.32		0.28		0.25		0.24	
	CD (0.05)	0.81		1.23		0.79		0.93		0.81		0.72		0.69	

DAS = Days after spraying

T* = $\sqrt{x}$ transformed values

T = $\sqrt{x+1}$ transformed values

O = Original values

(Plates 3, 4, 5, 6 and 7) in most of the stages. Application of 2,4-D + diuron immediately after sickle weeding (t_{12}) was also found to be as effective as the above treatments (Plate 8) in the first year and at some stages in the second and third year. Application of glyphosate 0.4 kg ha^{-1} was not as effective as its application at 0.8 kg ha^{-1}.

Paraquat, eventhough a contact herbicide, showed better results when it was applied repeatedly at intervals as each subsequent flush of weeds could be controlled. On the contrary, being a non-selective translocated herbicide, glyphosate could effect complete kill of almost all the weeds without any regrowth. In the treatment, dalapon followed by paraquat, the dalapon could control the grasses, whereas the other dicots (mostly annuals) could be controlled by the subsequent application of paraquat, resulting in better results. The efficiency of paraquat, glyphosate and dalapon for the control of weeds in coconut plantations was already reported by Romney (1964), Romney (1968), Coomans and Delorme (1978), Juan and Abad (1980) and Seth (1984).

The reduced weed population in glyphosate 0.4 kg ha^{-1} followed by digging (t_{13}) from 135 days to 270 days in the second and third year was due to the effect of digging given in November as already discussed.

Digging (t_3 and t_4) was found to be better than sickle weeding in reducing the weed population in most of the stages after November. The reduced number of weeds in digging once (t_3) and digging twice (t_4) at 135 days (December) and in digging twice at 315 days (June) in the second and third year is the effect of digging given just before the observation. Similar is the case in sickle weeding at 90 days.

1.3 Drymatter production

The data on the drymatter production of weeds as influenced by different weed control treatments are given in Tables 7a, b and c and illustrated in Fig.2.

The uncontrolled growth of weeds in unweeded plot (Plate 1) resulted in very high drymatter production. The herbicide treatments and manual methods of weed control were significantly better than unweeded control (t_1) but were inferior to weed free (t_2). The drymatter production of weeds was least in weed free plot (Plate 2) due to periodical weeding. Among the herbicide treatments, paraquat 0.4 kg ha^{-1} sprayed thrice at monthly interval (t_6), glyphosate 0.8 kg ha^{-1} (t_8) and dalapon 3.0 kg ha^{-1} followed by paraquat 0.4 kg ha^{-1} (t_9) were equally effective in reducing the drymatter production of weeds (Plates 3, 4, 5, 6 and 7) 2,4-D + diuron applied immediately after sickle weeding (t_{12}) was found as

Table 7a. Effect of treatments on drymatter production of weeds (g/m^2) during 1986-87

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS	
		T*	O	T	O	T*	O	T	O
1	C	20.1	403.3	22.2	493.5	21.4	456.0	20.8	430.1
2	WF	3.4	11.8	1.0	0.0	2.6	6.9	1.0	0.0
3	D(1)	4.5	20.4	8.0	64.0	8.0	63.7	11.7	136.4
4	D(2)	4.3	18.9	7.9	60.8	7.8	61.6	11.5	131.6
5	Si(2)	8.8	76.7	10.1	100.4	9.8	96.6	11.7	136.1
6	P(3)	6.4	41.1	8.6	73.5	8.2	66.7	9.8	96.0
7	G(L)	10.9	119.5	9.6	91.1	9.5	89.8	8.4	70.0
8	G(H)	9.8	95.1	7.8	60.0	7.6	58.1	7.4	54.4
9	Da(1) → P(1)	6.0	35.5	5.9	34.0	5.9	34.5	6.7	44.0
10	P + Di (1)	8.9	78.3	7.2	50.7	6.9	48.0	8.5	70.7
11	P(1) → G(L)	9.8	95.4	9.6	90.7	9.3	85.8	9.9	96.9
12	Si(1) → 2,4-D+Di(1)	6.8	46.4	6.2	37.3	6.0	36.5	6.8	45.3
13	G(L) → D(1)	4.5	20.1	8.0	62.7	7.8	61.3	11.6	136.1
	SE	0.50		0.20		0.18		0.43	
	CD (0.05)	1.47		0.58		0.52		1.26	

DAS = Days after spraying
T* = $\sqrt{x}$ transformed values
T = $\sqrt{x+1}$ transformed values
O = Original values

Table 7b. Effect of treatments on drymatter production of weeds (g/m^2) during 1987-88

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T*	O	T	O	T*	O	T	O	T*	O	T	O	T	O
1	C	21.0	441.0	23.1	534.7	22.0	484.6	20.4	413.6	22.9	525.5	23.8	563.6	25.4	643.3
2	WF	2.9	8.5	1.0	0.0	2.9	8.4	1.0	0.0	3.1	9.6	1.0	0.0	4.5	19.1
3	D(1)	19.1	365.0	20.4	416.7	4.3	18.4	5.3	27.1	10.0	99.1	10.6	114.0	13.2	180.5
4	D(2)	15.1	228.9	17.0	289.3	4.3	18.4	5.0	24.1	9.7	94.2	10.5	110.4	1.0	0.0
5	Si(2)	13.7	188.7	1.0	0.0	7.9	62.1	11.4	129.6	12.8	164.4	13.2	174.0	14.3	203.1
6	P(3)	4.3	18.5	10.2	103.3	8.2	66.7	8.2	66.1	9.6	92.7	10.1	101.9	10.8	118.0
7	G(L)	9.3	86.9	11.2	126.0	11.0	120.9	9.8	96.0	13.0	168.3	14.0	194.4	14.1	197.6
8	G (H)	5.9	34.9	6.6	42.4	7.6	57.6	8.1	64.5	9.3	86.3	9.9	97.6	10.6	112.7
9	Da(1) → P(1)	6.9	47.2	7.8	60.8	8.1	65.2	8.5	70.9	10.0	101.0	10.5	110.0	11.6	135.7
10	P + Di (1)	9.2	84.4	12.0	142.7	11.4	129.3	10.4	107.3	13.6	186.2	14.0	197.3	14.6	213.5
11	P(1) → G(L)	5.0	24.6	10.0	100.0	9.5	90.6	10.8	99.7	13.4	180.3	13.8	189.5	14.4	207.3
12	Si(1)→2,4-D + Di(1)	7.5	55.6	8.7	76.0	8.8	76.9	8.7	75.6	11.9	142.3	12.8	163.9	14.1	200.1
13	G(L) → D(1)	9.2	85.5	10.7	113.3	2.1	4.4	5.0	24.4	5.5	30.3	7.8	60.9	9.5	90.3
	SE	0.17		0.49		0.17		0.28		0.51		0.56		0.65	
	CD (0.05)	0.48		1.42		0.49		0.82		1.50		1.63		1.91	

DAS = Days after spraying

T* = $\sqrt{x}$ transformed values

T = $\sqrt{x + 1}$ transformed values

O = Original values

Table 7c. Effect of treatments on drymatter production of weeds (g/m^2) during 1988-89

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T*	O	T	O	T	O	T	O	T*	O	T	O	T	O
1	C	24.3	589.9	24.0	576.5	23.8	564.9	17.7	313.7	18.7	350.9	18.9	355.3	21.0	438.0
2	WF	3.2	10.1	1.0	0.0	3.1	8.9	1.0	0.0	2.8	7.8	1.0	0.0	3.5	11.2
3	D(1)	14.2	202.5	19.5	380.7	5.5	28.8	11.3	127.7	11.4	129.0	11.6	133.5	13.7	185.9
4	D(2)	12.1	147.0	15.8	249.1	5.1	24.7	11.0	121.5	11.1	122.2	11.3	126.3	1.0	0.0
5	Si(2)	11.9	141.7	1.0	0.0	9.5	90.1	12.5	154.5	12.7	160.2	12.9	165.5	14.2	200.3
6	P(3)	4.3	18.6	9.3	85.3	7.0	47.7	7.3	53.1	7.7	59.7	8.0	64.1	9.2	82.9
7	G(L)	12.1	146.2	13.9	198.9	9.6	93.7	10.2	106.7	10.7	113.8	10.9	121.5	12.0	144.4
8	G(H)	8.7	76.1	9.4	87.2	7.3	53.1	7.7	59.1	8.2	66.6	8.5	71.1	9.3	85.2
9	Da(1) → P(1)	9.0	80.6	9.8	95.1	8.1	63.2	8.2	68.1	8.7	75.0	9.0	81.3	9.9	97.5
10	P + Di (1)	11.2	124.9	12.1	146.1	10.2	103.1	10.6	111.7	10.8	117.1	11.1	123.3	11.9	139.9
11	P(1) → G(L)	9.7	94.6	10.8	114.7	9.6	92.1	10.1	102.0	10.3	106.9	10.6	111.5	10.9	118.8
12	Si(1) → 2,4-D + Di(1)	7.4	54.9	10.2	102.9	8.3	67.6	8.5	73.1	9.0	80.5	9.2	85.3	10.0	100.3
13	G(L) → D(1)	9.8	95.5	12.4	156.0	1.0	0.0	6.6	43.1	7.2	51.6	7.7	58.8	9.2	83.5
	SE	0.26		0.77		0.34		0.48		0.43		0.43		0.27	
	CD (0.05)	0.76		2.24		0.99		1.39		1.27		1.25		0.80	

DAS = Days after spraying

T* = $\sqrt{x}$ transformed values

T = $\sqrt{x+1}$ transformed values

O = Original values

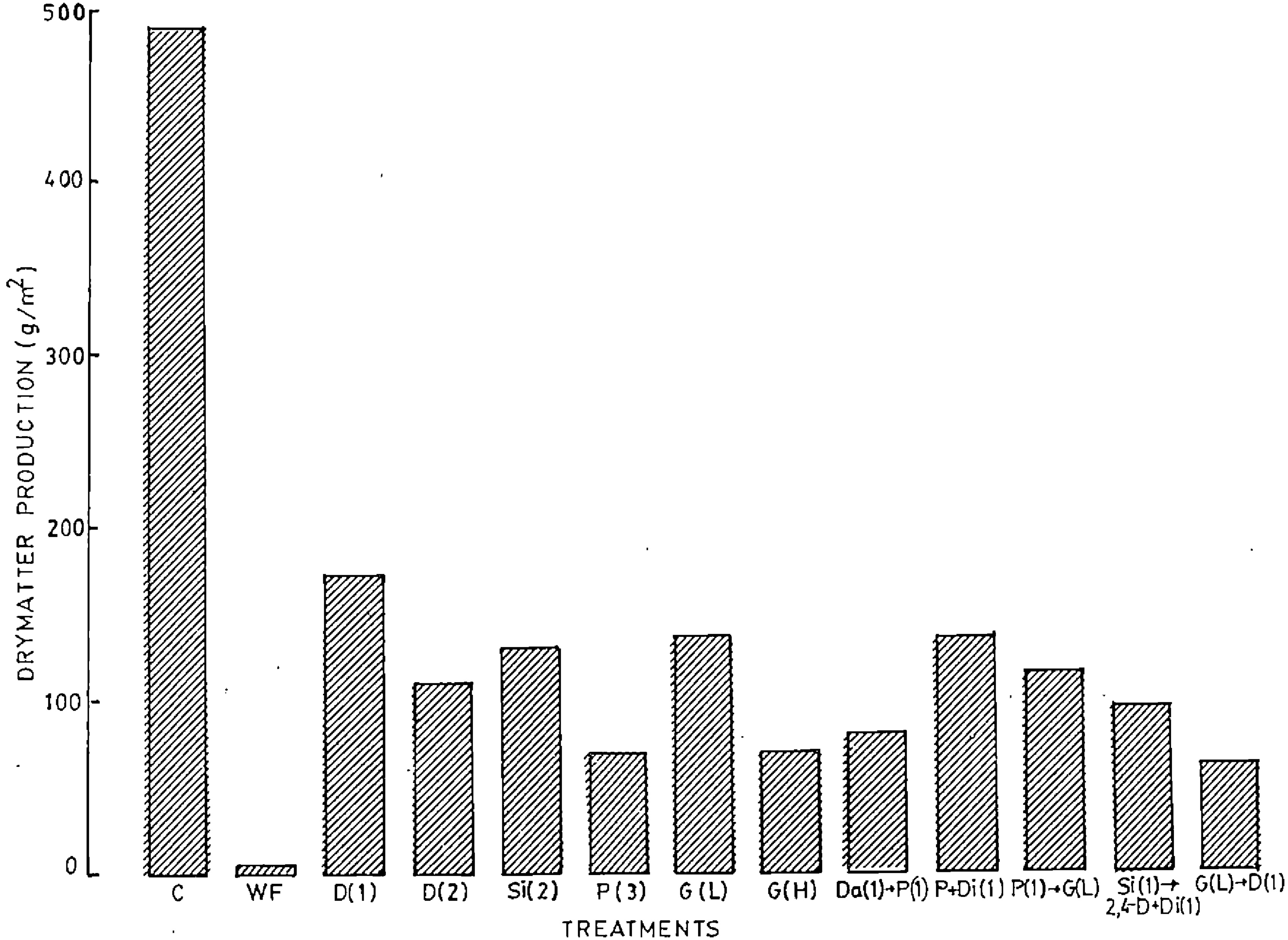


FIG. 2. DRYMATTER PRODUCTION OF WEEDS AS INFLUENCED BY TREATMENTS (AVERAGE OF 1987-'88 & 1988-'89)

effective as dalapon 3.0 kg ha^{-1} followed by paraquat 0.4 kg ha^{-1} in most of the stages (Plate 8). The attributed reason for the lower drymatter production of weeds is the lesser number of weeds due to the effect of the treatments as already discussed.

The effective control of weeds by repeated applications of paraquat was reported by Seth (1969) and Coomans (1970) in rubber and oil palm plantations. Schepens (1983) also recommended glyphosate for the control of major weeds in coconut. Seth (1969) also found the equal effectiveness of dalapon followed by paraquat and repeated applications of paraquat for controlling weeds in rubber and oil palm plantations.

Glyphosate 0.8 kg ha^{-1} recorded significantly lesser drymatter production of weeds compared to glyphosate 0.4 kg ha^{-1} (t_7) which again showed the superiority of the higher dose of glyphosate in controlling weeds in coconut garden. Application of glyphosate 0.4 kg ha^{-1} after paraquat 0.4 kg ha^{-1} (t_{11}) was also found inferior to glyphosate 0.8 kg ha^{-1} in bringing down the drymatter production of weeds, whereas application of glyphosate 0.4 kg ha^{-1} in July followed by digging in November (t_{13}) resulted in significant reduction in weed drymatter production from 135 days. It was due to the effect of digging given in November.

In manual methods of weed control such as digging twice (t_4) and sickle weeding twice (t_5) after the first digging (June) or sickle weeding (July) there was further luxurient growth of weeds (Plates 9 and 10) and needed for a second digging or sickle weeding for reasonable weed control. Digging (t_3 and t_4) was found to be significantly better than sickle weeding (t_5) in suppressing weed growth from 135 days. It was due to the effect of digging given in November. Similarly, the least weed drymatter production recorded by digging twice (t_4) at 315 days was due to the effect of digging given in June. During the second and third year, the effect of sickle weeding given a few days before the observation was reflected in the weed drymatter production in t_5 at 90 day stage.

Eventhough the number of weeds was lesser in the unweeded plot (Tables 6a, b and c), The drymatter production by the established weeds was very high due to the luxurient growth of weeds.

1.4 Weed control efficiency

Weed control efficiency of different treatments were worked out for each year from the average values of the weed drymatter production in the respective treatments during that year.

Data on the weed control efficiency of different treatments during each year of experiment and the pooled data are presented in Table 8. The pooled data showed that among the weed control treatments, weed free (t_2) recorded the maximum weed control efficiency (98.8 per cent). Among other treatments, dalapon 3.0 kg ha^{-1} followed by paraquat 0.4 kg ha^{-1} (t_9) and glyphosate 0.8 kg ha^{-1} followed by digging after North East monsoon (t_{13}) recorded 85.9 per cent weed control efficiency. Paraquat 0.4 kg ha^{-1} sprayed thrice at monthly interval (t_6), glyphosate 0.8 kg ha^{-1} (t_8) and 2,4-D + diuron immediately after sickle weeding (t_{12}) were on par with t_9 and t_{13}.

Among the manual methods, digging twice (t_4) recorded the highest weed control efficiency (79.5 per cent) which was significantly superior to sickle weeding (t_5) and digging once(t_3).

As already discussed, the treatments t_{13}, t_9, t_6, t_8 and t_{12} were effective in reducing the population of weeds and their drymatter production, which in turn had resulted in higher weed control efficiency values.

1.5 Nutrient removal

The nitrogen, phosphorus and potassium removal by weeds were studied at 45 days interval from the start of the trial.

Table 8. Weed control efficiency (per cent) of different treatments

Tr. No.	Treatments	1986-87	1987-88	1988-89	Pooled
1	C	-	-	-	-
2	WF	98.9	98.7	98.8	98.8
3	D(1)	84.0	66.0	62.7	70.9
4	D(2)	84.7	78.8	75.2	79.5
5	Si(2)	77.0	74.4	71.3	74.2
6	P(3)	84.4	84.2	87.1	85.3
7	G(L)	79.7	72.5	71.1	74.4
8	G(H)	85.0	86.2	84.4	85.2
9	Da(1) → P(1)	91.7	83.6	82.4	85.9
10	P+Di (1)	86.1	70.6	72.8	76.5
11	P(1) → G(L)	79.3	75.3	76.8	77.1
12	Si(1) → 2,4-D + Di(1)	90.7	78.1	82.3	83.7
13	G(L) → D(1)	84.3	88.7	84.6	85.9
	SE	0.73	1.05	1.69	1.38
	CD (0.05)	2.15	3.09	4.98	4.04

(a) Nitrogen

All weed control treatments brought down the nitrogen removal by weeds considerably compared to no weeding (Tables 9a, b and c). This is mainly due to the reduction in drymatter production of weeds brought about by the weed control treatments. However, among the herbicide treatments, paraquat three sprays (t_6), glyphosate 0.8 kg ha^{-1} (t_8), dalapon followed by paraquat (t_9) and 2,4-D + diuron immediately after sickle weeding (t_{12}) were proved to be equally effective in reducing nitrogen removal by weeds. This is due to the lesser weed drymatter production in plots receiving the above herbicide treatments as a result of their better efficiency compared to other treatments. The effectiveness of glyphosate 0.4 kg ha^{-1} followed by digging (t_{13}) was found to be equal to or more than the above herbicide treatments after the digging given in November (from 135 days onwards during second and third year).

Among the manual methods of weed control, digging twice (t_4) was found to be better than sickle weeding (t_5) in bringing down the nitrogen removal by weeds in most of the stages after the second digging given in November. However, the difference between digging once (t_3) and digging twice (t_4) was not conspicuous after the digging given in November.

Table 9a. Effect of treatments on N removal by weeds (kg ha^{-1}) during 1986-87

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS	
		T*	O	T	O	T*	O	T	O
1	C	8.4	71.0	9.1	80.9	7.7	59.3	8.8	75.7
2	WF	1.5	2.2	1.0	0.0	1.0	1.0	1.0	0.0
3	D(1)	2.0	3.9	3.2	9.0	3.1	9.7	4.9	23.3
4	D(2)	1.8	3.3	3.3	10.0	3.2	10.1	4.3	17.8
5	Si(2)	3.5	12.2	4.0	15.3	3.5	12.6	5.1	24.9
6	P(3)	2.7	7.0	3.6	11.7	3.4	11.4	4.2	16.9
7	G(L)	4.4	19.6	3.9	13.8	3.6	13.2	3.4	10.4
8	G(H)	3.4	11.8	3.2	9.1	2.8	7.8	3.2	9.3
9	Da(1) → P(1)	2.2	4.8	2.5	5.4	2.3	5.2	3.0	8.1
10	P + Di (1)	3.2	10.2	2.8	6.8	2.8	7.6	3.2	9.5
11	P(1) → G(L)	3.5	12.4	3.4	10.3	3.3	10.6	4.1	15.4
12	Si(1) → 2,4-D+Di(1)	2.6	6.8	2.5	5.3	2.3	5.4	2.9	7.4
13	G(L) → D(1)	1.8	3.1	3.1	8.8	3.1	9.8	5.1	24.9
	SE	0.20		0.07		0.07		0.18	
	CD (0.05)	0.58		0.21		0.20		0.51	

DAS = Days after spraying
T* = $\sqrt{x}$ transformed values
T = $\sqrt{x + 1}$ transformed values
O = Original values

Table 9b. Effect of treatments of N removal by weeds (kg ha^{-1}) during 1987-88

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T*	O	T	O	T*	O	T	O	T*	O	T	O	T	O
1	C	10.4	107.2	9.4	87.7	10.1	101.3	8.5	70.7	10.1	102.5	9.9	96.4	9.4	86.9
2	WF	1.3	1.7	1.0	0.0	1.3	1.8	1.0	0.0	1.3	1.8	1.0	0.0	1.8	2.4
3	D(1)	7.3	53.7	9.1	81.3	1.9	3.6	2.5	5.3	4.4	19.3	4.4	18.7	4.6	20.6
4	D(2)	5.7	32.3	7.0	47.5	2.0	3.8	2.3	4.7	4.2	17.2	4.0	14.9	1.0	0.0
5	Si(2)	5.5	30.0	1.0	0.0	3.7	13.8	4.6	20.6	4.9	24.2	4.9	23.5	4.9	23.2
6	P (2)	2.1	4.4	4.5	18.9	3.5	12.2	3.3	9.7	3.5	12.5	3.7	12.6	3.8	14.0
7	G (L)	4.3	18.2	4.9	23.1	4.7	22.1	4.0	15.3	4.9	23.7	6.1	36.7	5.2	25.7
8	G (H)	2.7	7.5	3.0	8.3	3.6	13.2	3.4	10.3	3.7	13.7	3.9	14.3	4.2	17.1
9	Da(1) → P(1)	3.4	11.5	3.3	9.7	3.2	10.4	3.2	9.6	3.6	13.1	3.9	14.3	3.8	14.0
10	P + Di(1)	4.1	17.0	5.4	27.8	5.1	26.1	4.0	15.1	5.0	25.1	5.4	27.8	4.9	23.3
11	P(1) → G(L)	1.9	3.5	4.1	15.9	3.9	15.5	4.2	17.0	5.2	27.4	5.5	28.8	5.4	28.0
12	Si(1) → 2,4-D + Di(1)	3.1	9.5	3.7	13.0	3.6	12.6	3.7	12.4	4.8	23.3	5.6	31.0	4.9	22.8
13	G (L) → D(1)	3.5	12.6	4.4	18.6	1.0	0.9	2.2	4.0	2.1	4.3	3.3	10.0	4.0	14.8
	SE	0.07		0.20		0.08		0.11		0.21		0.22		0.22	
	CD (0.05)	0.19		0.57		0.22		0.32		0.62		0.63		0.65	

DAS = Days after spraying

T* = $\sqrt{x}$ transformed values

T = $\sqrt{x + 1}$ transformed values

O = Original values

Table 9c. Effect of treatments on N removal by weeds (kg ha^{-1}) during 1988-89

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T*	O	T	O	T	O	T	O	T*	O	T	O	T	O
1	C	10.9	119.2	10.1	101.5	10.5	110.2	7.6	57.4	8.1	66.3	8.0	62.5	7.9	61.8
2	WF	1.4	2.0	1.0	0.0	1.6	1.6	1.0	0.0	1.2	1.4	1.0	0.0	1.6	1.5
3	D(1)	5.7	32.2	8.5	71.9	2.5	5.4	5.1	24.9	5.0	25.2	4.7	21.2	5.2	26.2
4	D(2)	4.8	23.4	6.4	39.6	2.4	4.7	5.0	23.7	4.8	23.1	4.3	17.8	1.0	0.0
5	Si(2)	4.9	24.2	1.0	0.0	4.3	17.6	5.1	25.3	4.9	24.4	5.2	26.3	5.4	28.2
6	P(3)	1.9	3.5	3.9	14.6	3.0	8.2	2.9	7.5	2.9	8.4	3.1	8.7	3.4	10.3
7	G (L)	5.1	25.7	5.9	35.0	4.3	17.7	4.2	17.5	4.2	17.3	4.7	21.4	4.6	20.4
8	G (H)	3.7	13.4	4.0	14.9	3.3	9.7	3.1	8.3	3.3	10.6	3.3	10.0	3.5	11.1
9	Da (1) → P(1)	3.6	13.2	3.9	14.0	3.4	10.4	3.2	9.6	3.3	10.6	3.4	11.0	3.5	11.1
10	P + Di (1)	4.3	18.4	5.2	25.7	4.5	19.5	4.3	17.8	4.2	17.2	4.4	18.7	4.0	15.4
11	P (1) → G(L)	3.7	13.9	4.4	18.8	4.1	16.2	4.4	18.7	4.1	17.0	4.3	17.7	4.2	16.8
12	Si (1) → 2,4-D + Di(1)	3.0	8.7	4.2	16.9	3.6	11.9	3.7	12.9	3.6	13.2	4.0	15.0	3.7	13.0
13	G (L) → D(1)	3.8	14.5	5.0	24.8	1.0	0.0	3.0	7.9	2.8	7.8	3.4	10.4	3.4	10.9
	SE	0.11		0.32		0.14		0.19		0.17		0.17		0.10	
	CD (0.05)	0.31		0.92		0.42		0.56		0.50		0.50		0.29	

DAS = Days after spraying

T* = $\sqrt{x}$ transformed values

T = $\sqrt{x + 1}$ transformed values

O = Original values

(b) Phosphorus

Unweeded control resulted in the maximum phosphorus removal by weeds (Tables 10a, b and c). All weed control treatments could bring down the phosphorus removal by weeds significantly over unweeded control (t_1). This is due to the efficiency of the weed control treatments in bringing down the drymatter production of weeds. Among the herbicide treatments, paraquat three sprays (t_6), glyphosate 0.8 kg ha^{-1} (t_8), dalapon followed by paraquat (t_9) and 2,4-D + diuron immediately after sickle weeding (t_{12}) were equally effective in reducing phosphorus removal by weeds. Glyphosate 0.4 kg ha^{-1} followed by digging (t_{13}) was found to be equal to or better than the above herbicide treatments in reducing phosphorus removal by weeds from 135 days onwards during the second and third year. This is due to the effect of digging given in November.

Digging (t_3 and t_4) was found to be better than sickle weeding (t_5) in reducing phosphorus removal by weeds in most of the stages during first year and from 135 days (after the digging given in November) onwards during the second and third year. This is also due to the better efficiency of digging in reducing weed drymatter production compared to sickle weeding.

Table 10a. Effect of treatments on P removal by weeds (kg ha^{-1}) during 1986-87

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS	
		T*	O	T	O	T*	O	T	O
1	C	1.4	2.0	2.2	4.0	1.9	3.6	2.6	5.6
2	WF	0.3	0.1	1.0	0.0	0.2	0.1	1.0	0.0
3	D(1)	0.5	0.3	1.2	0.5	0.9	0.8	1.4	1.1
4	D(2)	0.4	0.2	1.3	0.6	0.8	0.6	1.3	0.7
5	Si(2)	0.8	0.6	1.5	1.3	0.7	0.5	1.5	1.4
6	P(3)	0.6	0.4	1.3	0.6	0.8	0.7	1.6	1.5
7	G(L)	1.0	1.0	1.5	1.2	1.2	1.4	1.4	0.9
8	G(H)	0.9	0.8	1.3	0.6	0.9	0.8	1.3	0.7
9	Da(1) → P(1)	0.6	0.4	1.2	0.3	0.7	0.5	1.2	0.4
10	P + Di (1)	0.6	0.4	1.2	0.4	0.8	0.6	1.3	0.6
11	P(1) → G(L)	1.0	1.0	1.4	0.9	0.9	0.9	1.4	1.0
12	Si(1) → 2,4-D+Di(1)	0.6	0.4	1.3	0.6	0.7	0.5	1.2	0.4
13	G(L) → D(1)	0.4	0.2	1.3	0.8	1.0	1.0	1.7	1.8
	SE	0.04		0.01		0.02		0.03	
	CD (0.05)	0.14		0.04		0.05		0.10	

DAS = Days after spraying
T* = $\sqrt{x}$ transformed values
T = $\sqrt{x+1}$ transformed values
O = Original values

Table 10b. Effect of treatments on P removal by weeds (kg ha^{-1}) during 1987-88

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T*	O	T	O	T*	O	T	O	T*	O	T	O	T	O
1	C	4.0	15.9	3.1	8.6	3.0	9.2	3.0	7.9	3.2	10.0	3.4	10.7	4.5	19.3
2	WF	0.5	0.2	1.0	0.0	0.4	0.2	1.0	0.0	0.4	0.2	1.0	0.0	1.1	0.3
3	D(1)	3.0	8.8	3.1	8.8	0.7	0.5	1.3	0.6	1.4	2.1	1.7	1.8	1.8	2.3
4	D(2)	2.2	4.8	2.4	4.6	0.5	0.3	1.2	0.4	1.1	1.2	1.8	2.1	1.0	0.0
5	Si (2)	2.4	5.7	1.0	0.0	1.3	1.7	1.9	2.7	1.9	3.5	2.1	3.3	2.4	4.9
6	P (3)	0.6	0.3	1.8	2.2	1.3	1.8	1.5	1.4	1.3	1.8	1.8	2.1	1.8	2.2
7	G (L)	1.7	2.9	2.0	3.0	1.7	2.9	1.8	2.3	1.5	2.2	2.4	4.7	2.3	4.2
8	G (H)	1.1	1.2	1.5	1.1	1.2	1.6	1.4	1.0	1.1	1.1	1.5	1.3	1.9	2.7
9	Ds(1) → P(1)	1.1	1.3	1.6	1.6	1.4	2.0	1.5	1.3	1.4	1.9	1.7	1.8	2.0	2.9
10	P + Di (1)	1.4	2.0	1.9	2.7	1.6	2.5	1.6	1.7	1.7	3.0	1.9	2.6	2.1	3.4
11	P (1) → G(L)	0.7	0.5	1.8	2.1	1.5	2.2	1.7	1.9	1.9	3.4	2.1	3.6	2.2	3.9
12	Si(1) → 2,4-D + Di(1)	1.2	1.3	1.6	1.4	1.2	1.5	1.6	1.4	1.4	1.9	2.0	3.1	2.0	3.2
13	G(L) → D(1)	1.6	2.6	2.0	3.1	0.3	0.1	1.2	0.5	0.6	0.3	1.5	1.2	1.9	2.4
	SE	0.03		0.06		0.03		0.03		0.07		0.06		0.08	
	CD (0.05)	0.08		0.18		0.08		0.09		0.19		0.18		0.24	

DAS = Days after spraying

T* = $\sqrt{x}$ transformed values

T = $\sqrt{x + 1}$ transformed values

O = Original values

Table 10c. Effect of treatments on P removal by weeds (kg ha^{-1}) during 1988-89

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T*	O	T	O	T	O	T	O	T*	O	T	O	T	O
1	C	4.4	19.5	3.4	11.0	3.4	10.7	2.8	6.6	2.7	7.4	2.8	6.8	3.6	11.8
2	WF	0.5	0.2	1.0	0.0	1.1	0.2	1.0	0.0	0.4	0.2	1.0	0.0	1.1	0.2
3	D(1)	2.5	6.1	3.2	9.1	1.3	0.7	1.9	2.7	1.6	2.7	1.9	2.5	2.1	3.5
4	D(2)	2.1	4.4	2.4	4.7	1.2	0.5	1.8	2.3	1.4	2.0	1.8	2.4	1.0	0.0
5	Si(2)	1.8	3.4	1.0	0.0	1.9	2.7	2.1	3.2	2.0	3.8	2.1	3.5	2.4	4.8
6	P(3)	0.7	0.5	1.7	1.8	1.5	1.1	1.4	1.0	1.0	1.0	1.5	1.2	1.5	1.3
7	G (L)	2.2	4.8	2.4	4.8	1.8	2.3	1.9	2.6	1.3	1.8	2.0	2.9	2.1	3.5
8	G (H)	1.4	1.8	1.8	2.1	1.5	1.3	1.4	0.9	1.0	1.1	1.5	1.1	1.6	1.6
9	Da(1) → P(1)	1.6	2.4	1.7	2.0	1.6	1.7	1.4	1.1	1.2	1.4	1.5	1.3	1.6	1.6
10	P + Di (1)	1.7	3.0	2.0	3.1	1.8	2.2	1.5	1.4	1.5	2.2	1.8	2.3	1.8	2.2
11	P(1) → G(L)	1.4	2.0	1.8	2.4	1.7	1.9	1.7	1.9	1.5	2.2	1.8	2.3	1.8	2.3
12	Si(1) → 2,4-D + Di(1)	1.1	1.2	1.8	2.2	1.6	1.6	1.6	1.5	1.1	1.3	1.6	1.6	1.7	1.9
13	G(L) → D(1)	1.4	2.0	2.2	3.7	1.0	0.0	1.4	0.9	0.8	0.7	1.5	1.2	1.7	2.0
	SE	0.04		0.11		0.04		0.09		0.06		0.05		0.03	
	CD (0.05)	0.13		0.31		0.13		0.27		0.17		0.15		0.10	

DAS = Days after spraying

T* = $\sqrt{x}$ transformed values

T = $\sqrt{x + 1}$ transformed values

O = Original values

(c) Potassium

Potassium removal by weeds also showed the same trend as in the case of nitrogen and phosphorus (Tables 11a, b and c). Highest potassium removal by weeds was recorded by unweeded control (t_1). All weed control treatments recorded significantly lesser potassium removal by weeds compared to no weeding. This is due to the efficiency of weed control treatments in reducing drymatter production by weeds as already discussed. Among the herbicide treatments best results were obtained with paraquat three sprays (t_6), glyphosate 0.8 kg ha^{-1} (t_8), dalapon followed by paraquat (t_9) and 2,4-D + diuron immediately after sickle weeding (t_{12}). Glyphosate 0.4 kg ha^{-1} followed by digging (t_{13}) was found to be equal to or better than the above herbicide treatments in reducing potassium removal by weeds after the digging given in November (from 135 days onwards during the second and third year).

Digging (t_3 and t_4) was found to be better than sickle weeding (t_5) in reducing potassium removal by weeds after the digging given in November (from 135 days onwards during the second and third year). This is also due to the higher efficiency of digging in bringing down the drymatter production of weeds compared to sickle weeding.

Table 11a.-Effect of treatments on K removal by weeds (kg ha^{-1}) during 1986-87

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS	
		T*	O	T	O	T*	O	T	O
1	C	7.2	52.4	7.7	58.2	7.2	52.4	8.9	78.7
2	WF	1.4	2.1	1.0	0.0	1.0	1.0	1.0	0.0
3	D(1)	1.8	3.2	3.0	8.3	2.7	7.2	4.0	15.0
4	D(2)	1.6	2.5	2.9	7.3	2.9	8.2	3.9	14.5
5	Si(2)	3.3	10.6	3.7	12.4	3.4	11.9	4.4	18.8
6	P (3)	2.4	5.9	3.4	10.3	3.2	10.0	3.4	10.8
7	G (L)	3.6	12.9	3.3	10.0	3.7	13.9	3.2	9.5
8	G (H)	3.8	14.1	3.0	7.8	2.8	7.7	3.1	8.4
9	Da(1) → P(1)	2.1	4.6	2.5	5.0	2.1	4.3	2.5	5.3
10	P + Di (1)	3.1	9.6	2.7	6.2	2.5	6.5	3.4	10.5
11	P(1) → G(L)	4.0	16.2	3.5	11.3	3.1	9.7	3.7	12.6
12	Si(1) → 2,4-D+Di(1)	2.8	7.9	2.5	5.2	2.2	4.7	2.4	5.0
13	G(L) → D(1)	1.6	2.6	3.0	8.1	3.1	9.4	4.4	18.8
	SE	0.19		0.07		0.06		0.15	
	CD (0.05)	0.55		0.20		0.18		0.45	

DAS = Days after spraying
T* = $\sqrt{x}$ transformed values
T = $\sqrt{x+1}$ transformed values
O = Original values

Table 11b. Effect of treatments on K removal by weeds (kg ha^{-1}) during 1987-88

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T*	O	T	O	T*	O	T	O	T*	O	T	O	T	O
1	C	6.8	46.3	7.4	53.5	6.7	45.1	7.1	48.8	7.9	62.0	8.1	64.8	9.0	80.4
2	WF	1.3	1.8	1.0	0.0	0.9	0.8	1.0	0.0	0.9	0.9	1.0	0.0	1.8	2.3
3	D(1)	6.3	40.2	7.1	49.2	1.2	1.4	1.8	2.2	2.6	6.9	3.4	10.6	4.3	18.1
4	D(2)	6.1	36.6	5.9	34.1	1.2	1.5	1.8	2.3	2.7	7.3	3.5	11.0	1.0	0.0
5	Si(2)	4.8	22.6	1.0	0.0	2.7	7.3	4.1	15.9	3.4	21.5	4.2	16.5	4.7	20.9
6	P (3)	1.3	1.8	3.6	11.9	2.4	5.9	2.7	6.3	2.9	8.2	3.1	8.5	3.7	12.7
7	G (L)	3.1	9.6	3.8	13.6	3.6	12.7	3.5	11.3	4.7	21.9	4.8	22.4	4.8	22.3
8	G (H)	1.9	3.6	2.4	4.8	2.5	6.0	2.7	6.4	2.8	7.8	3.5	11.5	3.6	12.4
9	Da (1) → P(1)	2.5	6.3	3.0	7.9	2.6	6.5	2.9	7.4	3.0	8.9	3.4	10.4	3.9	14.3
10	P + Di (1)	3.2	10.1	4.2	16.8	3.6	12.9	3.6	12.1	4.0	16.4	4.3	17.8	5.3	27.8
11	P(1) → G(L)	1.6	2.4	3.3	10.3	3.2	10.0	3.5	11.0	3.9	15.3	4.3	17.6	4.7	21.4
12	Si(1) → 2,4-D + Di(1)	2.3	5.3	3.1	8.4	2.7	7.3	3.0	7.8	3.7	14.0	4.1	15.6	4.4	18.6
13	G(L) → D(1)	3.1	9.4	3.8	13.4	0.7	0.5	2.0	2.9	1.6	2.7	2.5	5.4	2.9	7.5
	SE	0.06		0.16		0.05		0.09		0.15		0.17		0.21	
	CD (0.05)	0.17		0.46		0.16		0.26		0.43		0.49		0.62	

DAS = Days after spraying

T* = $\sqrt{x}$ transformed values

T = $\sqrt{x + 1}$ transformed values

O = Original values

Table 11c. Effect of treatments on K removal by weeds (kg ha^{-1}) during 1988-89

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T*	O	T	O	T	O	T	O	T*	O	T	O	T	O
1	C	8.7	75.5	7.8	60.5	8.1	65.0	6.1	36.1	6.5	42.1	6.6	41.9	7.3	52.6
2	WF	0.9	0.8	1.0	0.0	1.4	0.9	1.0	0.0	0.9	0.8	1.0	0.0	1.5	1.3
3	D(1)	4.7	22.3	6.7	43.8	2.0	2.9	3.7	12.8	3.5	12.2	3.8	13.3	4.5	19.1
4	D(2)	4.3	18.1	5.4	28.6	1.9	2.5	3.5	11.5	3.3	10.8	3.7	12.6	1.0	0.0
5	Si(2)	3.5	12.5	1.0	0.0	3.4	10.8	4.4	18.5	4.3	18.9	4.4	18.7	4.8	21.6
6	P (3)	1.5	2.1	3.3	10.1	2.4	4.8	2.5	5.5	2.4	6.0	2.7	6.4	3.3	9.8
7	G (L)	5.1	26.0	4.8	22.5	3.2	9.7	3.6	12.3	3.4	11.7	3.6	12.5	4.1	15.9
8	G (H)	2.6	6.9	3.3	10.0	2.6	5.6	2.7	6.1	2.6	7.0	2.9	7.5	3.2	8.9
9	Da(1) → P(1)	3.4	11.3	3.6	11.9	2.8	6.6	2.8	6.8	2.7	7.5	3.0	8.1	3.3	9.7
10	P + Di (1)	3.2	10.0	4.3	17.5	3.5	11.1	3.6	11.7	3.5	12.1	3.6	12.3	4.3	17.2
11	P(1) → G(L)	3.0	8.8	3.7	12.6	3.4	10.6	3.5	11.5	3.5	12.1	3.5	11.5	3.6	11.9
12	Si (1) → 2,4-D + Di(1)	2.3	5.4	3.6	11.6	2.8	7.0	3.0	8.0	3.0	9.1	3.1	8.8	3.3	10.0
13	G (L) → D(1)	3.2	10.3	4.4	18.4	1.0	0.0	2.4	5.0	2.5	6.1	2.6	5.9	3.1	8.3
	SE	0.09		0.25		0.10		0.15		0.14		0.13		0.09	
	CD (0.05)	0.27		0.74		0.30		0.44		0.42		0.39		0.25	

DAS = Days after spraying

T* = $\sqrt{x}$ transformed values

T = $\sqrt{x + 1}$ transformed values

O = Original values

2. Coconut

2.1 Yield

The data on the effect of treatments on the yield of coconut are presented in Table 12 and illustrated in Fig.3. The discussion is mainly centered around the results during 1988 and 1989 since the experiment was started only in November 1986 and some of the treatments which are to be imposed during the South West monsoon period were to be skipped and the full effect of the treatments could not be experienced by the crop during the year 1987. The data showed that none of the treatments could bring about significant influence on the yield of coconut. However, the results revealed that all weed control treatments had a positive influence on the yield of coconut compared to unweeded control (t_1) and the maximum yield was obtained from the weed free treatment (t_2). Moreover, a progressive increase in yield was also noticed in all weed control treatments from first year to third year whereas unweeded control recorded a corresponding reduction in yield.

Eventhough it takes three years to get the effect of treatments expressed on productive characters especially yield in perennial crops like coconut, the effect was seen manifested to a certain extent after the first year itself and it was evidenced to a great extent during the third year of

Table 12. Effect of treatments on yield of coconut

Tr. No.	Treatments	Yield of nuts ha^{-1}			Weed index (%)
		1987	1988	1989	1989
1	C	4188.2	3937.2	3579.9	40.4
2	WF	5291.2	5641.9	6026.7	-
3	D(1)	4855.3	5004.1	5269.7	12.1
4	D(2)	4913.6	5277.5	5630.6	10.0
5	Si(2)	4688.9	4959.8	5291.0	12.4
6	P(3)	4774.3	5117.8	5570.6	7.0
7	G(L)	4484.2	4529.2	4689.9	23.5
8	G(H)	5077.3	5263.1	5491.7	9.7
9	Da(1) → P(1)	5025.2	5385.5	5846.6	6.0
10	P + Di(1)	4813.4	5105.6	5361.3	13.8
11	P(1) → G(L)	4967.4	4998.0	5072.6	19.8
12	Si(1) → 2,4-D+Di(1)	4966.3	5263.1	5602.7	10.4
13	G(L) → D(1)	4817.7	5044.2	5312.8	15.7
	SE	454.12	460.64	543.23	8.29
	CD (0.05)	NS	NS	NS	NS

NS = Not significant

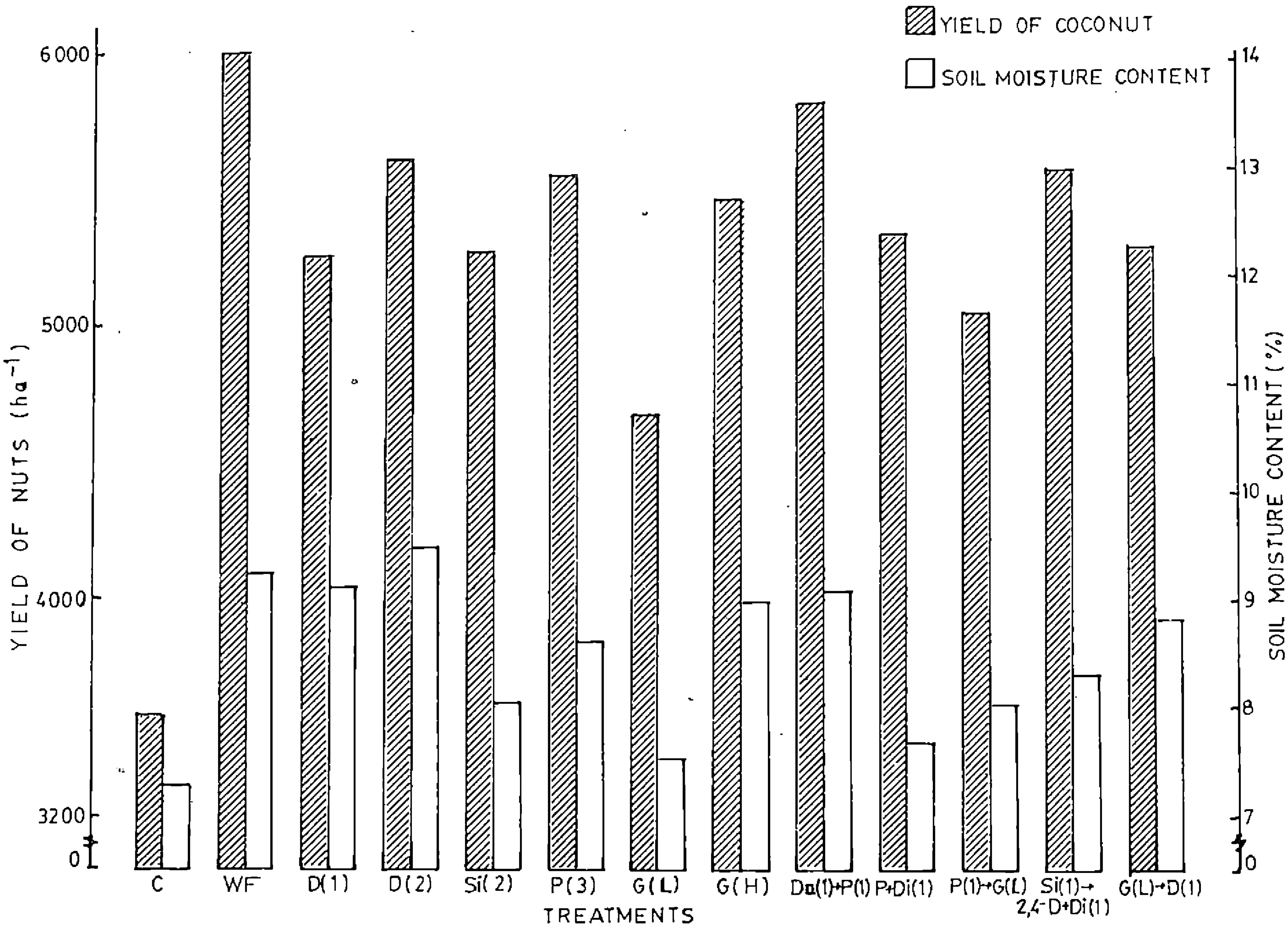


FIG. 3. YIELD OF COCONUT AND SOIL MOISTURE CONTENT AS INFLUENCED BY TREATMENTS (1989)

the experiment. This is possibly attributed to the immediate beneficial effect of treatments in reducing the button shedding as well as nut fall.

The unchecked weed competition for soil moisture and nutrients might have lead to a reduction in yield from first year to third year in unweeded control. Whereas in weed free treatment the absence of above competition effects might be the reason for recording highest yield.

Among the manual methods of weed control, digging twice (t_4) resulted in more nut yield compared to digging once (t_3) and sickle weeding (t_5). In t_3, digging was given during the fag end of North East monsoon. In t_4, one digging was given in June and another in November. In t_5, sickle weeding was given in July and October.

In t_4, the first digging was given after all weeds sprouted on receipt of the summer showers. This digging in June completely incorporated all the weeds present then in the coconut field. Another digging given in November helped to destroy the weeds sprouted after the first digging. Moreover, the second digging was given at a time when the North East monsoon almost ceased and there was sufficient moisture in the field. Hence, apart from the weed control effect this digging must have helped to conserve moisture in the sub soil during the ensuing summer season. Probably these reasons make this treatment superior to t_3 and t_5. In t_3, the weed growth is almost uninterrupted upto November and there would have been naturally competition effect to that extent. In sickle weeding, eventhough the top growth is removed initially during July, further sprouting of weeds was seen taking place rapidly and vigorously due to incescent rains received during South West monsoon. The second sickle weeding was given in October by which time the nutrient removal by the residual weeds had its deleterious effect on coconut making this treatment also inferior to t_4.

Among the chemical treatments dalapon followed by paraquat (t_9) has given the highest yield and the increase from the first to third year was to the extent of 821 nuts ha^{-1}. This was followed by t_{12} and t_6. Treatments such as t_7, t_{10}, t_{11} and t_{13} were having less effect on yield. However t_7 has recorded the lowest yield among the group.

The maximum yield was obtained from t_9. In this treatment, dalapon was applied during July followed by paraquat fifteen days after. Dalapon at 3.0 kg ha^{-1} would have controlled all the graminaceous weeds which were seen grown vigorously during the monsoon. The remaining dicot weeds were controlled by the contact herbicide paraquat thus resulted in almost weed free condition for sometime. This was reflected in weed drymatter production as given in Table 7 a, b and c, which recorded low weed growth during the rest of the period. The coconut was thus benefited by way of increased availability of nutrients as well as by conservation of soil moisture (Table 13 and Fig.3). T_{12} has exerted its beneficial effect due to a combination of manual sickle weeding and chemicals 2,4-D and diuron. Sickle weeding was given in July and was immediately followed by 2,4-D + diuron application. This one time operation has also enabled the treatment to give a better performance. The 2,4-D + diuron combination has resulted in complete anhilation of the weeds. The further growth was noticed only in a subdued manner.

In t_6, paraquat was applied thrice during July, August and September. In the region where the trial is conducted, South West monsoon is very active and North East monsoon is less. So the application of this herbicide happened to control whatever weed growth that has emerged from time to time during the peak monsoon period leaving the field with lesser weeds during the North East monsoon and summer seasons.

T_8 was more effective than t_7 probably because of a higher dose of 0.8 kg glyphosate has better weed control efficiency than 0.4 kg given in t_7. T_{11} was definitely inferior to the rest of the chemical treatments. In the latter, paraquat 0.4 kg was applied only once as against thrice in t_6. The glyphosate was also applied at reduced concentration of 0.4 kg in this treatment which was not very effective in controlling weeds as already explained. Paraquat and diuron were mixed and applied only once in t_{10}. Glyphosate was applied at lower concentration of 0.4 kg in t_{13} and naturally did not produce much effect as in t_7. Whatever little effect t_{13} had on yield was due to digging once. It is almost giving the same effect of t_3.

Increase in yield of coconut by weed control was also reported by Romney (1964), Anon (1966b), Smith (1968b), Barnes and Evans (1972) and Balasubramanian et al. (1985).

2.2 Weed index

The data on the weed index (Table 12) showed that the treatment differences were not statistically significant, eventhough the values ranged from 6 to 40.4 per cent. Coconut is a perennial crop and varies greatly in plant to plant performance. This might be the reason for the non-significance of the values in the analysis of co-variance.

The data showed that the loss in yield due to uncontrolled weed growth was about 40 per cent. However, it could be brought down to 10 per cent or less by better weed management in treatments like t_6, t_8, t_9 and t_{12} (Fig.4). Unlike in an annual crop such as rice, the crop loss due to weed competition is not very high in coconut. In annual crops, crop has to compete with the weeds even for the establishment and subsequent growth, whereas in the case of established coconut, the competition is only for nutrients and moisture. Hence the relative loss due to weed competition is lesser.

3. Soil moisture

The effects of treatments on soil moisture content during the summer months are presented in Table 13. The data showed that the treatments which received weed control either manual or chemical recorded more soil moisture content than the unweeded control. Manual digging (t_3 and t_4) resulted in higher soil moisture content than chemical weed control. Among the chemical methods, the treatments which gave maximum weed control recorded a higher soil moisture content (t_6, t_8, t_9 and t_{12}).

The attributed reason for the lowest soil moisture content in the unweeded control (t_1) is the high removal of soil moisture by the luxurient growth of weeds. This competition for soil moisture by weeds might be one of the reasons for lower yield of coconut in unweeded control (Table 12).

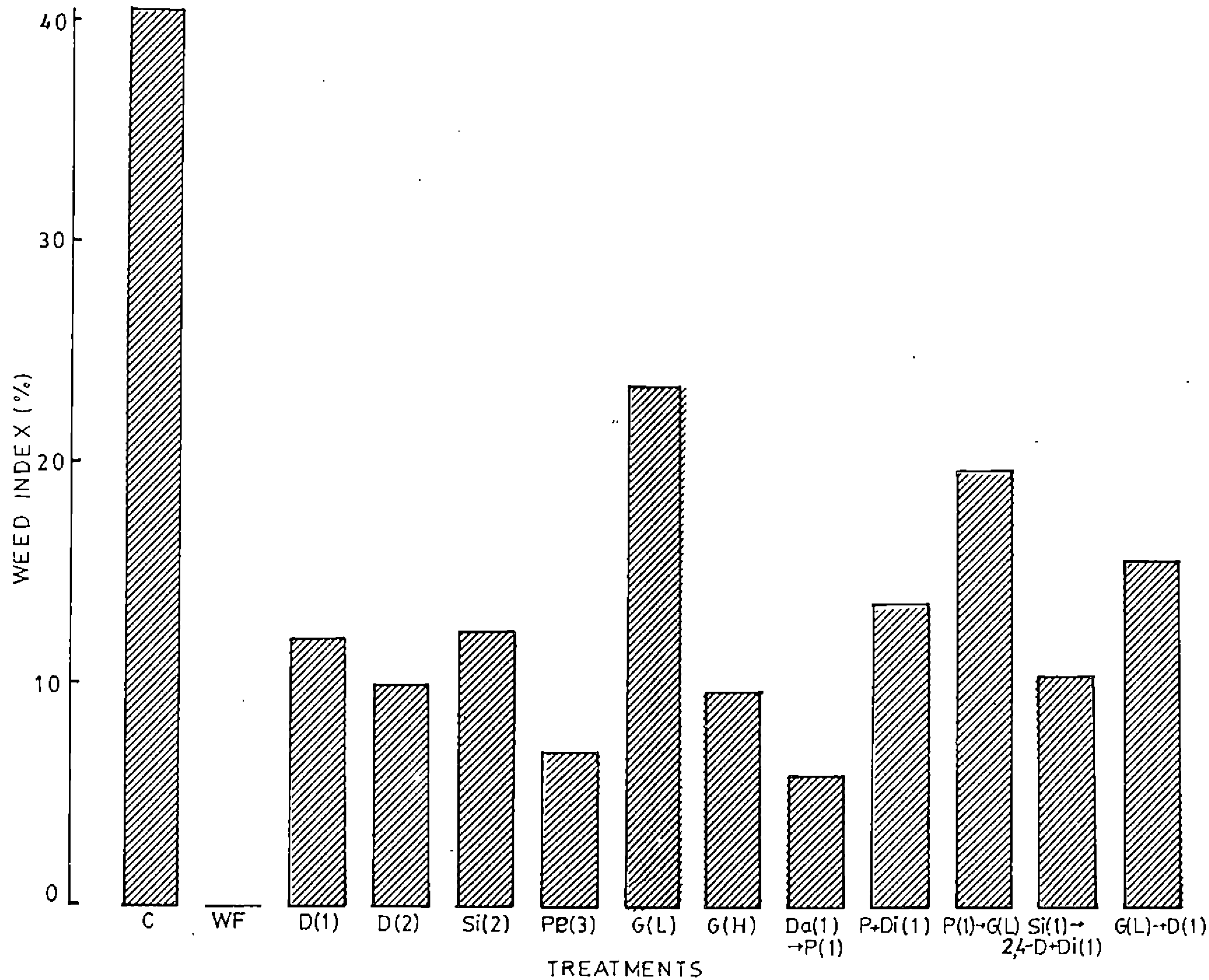


FIG. 4. WEED INDEX OF DIFFERENT TREATMENTS (1989)

Table 13. Effect of treatments on soil moisture content (per cent) during summer months

Tr. No.	Treatments	1987	1989	Mean
1	C	6.27	7.29	6.78
2	WF	8.52	9.26	8.89
3	D(1)	8.35	9.14	8.75
4	D(2)	8.49	9.50	9.00
5	Si(2)	7.07	8.08	7.58
6	P(3)	8.21	8.64	8.43
7	G(L)	7.01	7.56	7.29
8	G(H)	8.31	8.99	8.65
9	Da (1) → P(1)	8.35	9.09	8.72
10	P + Di (1)	6.98	7.70	7.34
11	P(1) → G(L)	7.29	8.05	7.67
12	Si(1) → 2,4-D+Di(1)	7.72	8.33	8.03
13	G(L) → D(1)	8.34	8.84	8.59

Ohler (1984) also reported that the competition for water by weeds during the dry period may considerably affect the coconut yields.

Higher soil moisture was recorded by the treatments which received digging (t_4, t_3 and t_{13}). This might be due to the favourable effect of digging on soil moisture conservation in underplanted coconut gardens. Deeper layer moisture saving is more beneficial under such situations.

Chemical weed control was found equally effective as digging in soil moisture conservation. It is observed that chemical as well as manual methods of weed control which recorded more soil moisture resulted in higher yield. Fig.3 also showed that the treatments which conserved more soil moisture also recorded higher yield. Higher soil moisture content as a result of weed control in coconut gardens was also observed by Marar (1953).

4. Soil fertility

Organic carbon, total nitrogen, available phosphorus and available potassium content of soil were estimated after each year of experiment. The results on these aspects are discussed below.

(a) Organic carbon

Unweeded control (t_1) recorded the highest organic carbon content of soil during all the three years and it was significantly superior to weed control treatments during 1988 and 1989 (Table 14). This is probably due to the more deposition of organic matter by the unchecked growth of weeds. On the contrary, in weed free treatment (t_2) the organic carbon content was very low and the treatments which received digging (t_3, t_4 and t_{13}) or sickle weeding (t_5) were significantly superior to it. The attributed reason is the probable incorporation of weeds by digging in t_3, t_4 and t_{13} and retention of stubbles in t_5.

The treatments which employ the use of chemicals which gave effective weed control as well as higher yield such as t_6, t_8, t_9 and t_{12} have resulted in lesser organic carbon content compared to others. Lesser addition of organic matter to soil due to higher weed control efficiency of these treatments compared to others is the probable reason.

(b) Nitrogen, phosphorus and potassium

Data presented in Table 14 showed that none of the treatments could bring about any significant influence on the total N, available P and available K content of soil. However,

Table 14. Effect of treatments on soil fertility

Tr. No.	Treatments	Organic carbon (%)			Total nitrogen (%)			Available phosphorus (kg ha^{-1})			Available potassium (kg ha^{-1})		
		1987	1988	1989	1987	1988	1989	1987	1988	1989	1987	1988	1989
1	C	0.643	0.658	0.752	0.118	0.119	0.120	15.446	15.696	15.759	770.000	784.000	798.000
2	WF	0.619	0.560	0.560	0.115	0.116	0.118	15.133	15.133	15.383	765.333	765.333	770.000
3	D(1)	0.629	0.569	0.619	0.116	0.118	0.118	15.383	15.446	15.446	765.333	774.667	788.667
4	D(2)	0.629	0.555	0.614	0.116	0.118	0.118	15.383	15.446	15.446	765.333	770.000	784.000
5	S(2)	0.628	0.574	0.683	0.116	0.118	0.119	15.383	15.446	15.446	765.333	774.667	788.667
6	P(3)	0.624	0.540	0.545	0.115	0.116	0.118	15.133	15.133	15.383	756.000	770.000	774.667
7	G(L)	0.628	0.569	0.599	0.116	0.117	0.119	15.383	15.383	15.446	765.333	774.667	779.333
8	G(H)	0.624	0.545	0.550	0.115	0.116	0.118	15.133	15.133	15.383	756.000	770.000	774.667
9	Da(1) → P(1)	0.624	0.545	0.560	0.115	0.116	0.118	15.133	15.133	15.383	756.000	770.000	774.667
10	P + Di (1)	0.619	0.569	0.589	0.116	0.117	0.119	15.383	15.383	15.446	765.333	774.667	779.333
11	P(1) → G(L)	0.628	0.569	0.574	0.116	0.117	0.119	15.133	15.133	15.383	756.000	770.000	774.667
12	Si(1)→2,4-D+Di(1)	0.624	0.550	0.560	0.115	0.116	0.118	15.133	15.133	15.383	756.000	770.000	774.667
13	GL(L) → D(1)	0.629	0.555	0.614	0.116	0.118	0.118	15.383	15.446	15.446	765.333	751.333	784.000
	SE	0.027	0.006	0.016	0.001	0.001	0.001	0.775	0.842	0.583	17.617	19.280	26.938
	CD (0.05)	NS	0.018	0.046	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS = Not significant

maximum N, P and K content was recorded by unweeded control (t_1) probably because unchecked weed growth resulted in more deposition of organic matter, presence of nutrients and lesser absorption of nutrients by the crop due to severe weed competition. Weed free treatment (t_2) recorded the lowest N, P and K content which might be due to periodical removal of weeds with no chance for decomposition and incorporation of organic matter into soil as well as more uptake of N, P and K by coconut with consequent impoverisation of inherent soil fertility.

The treatments t_3, t_4, t_5 and t_{13} have recorded a higher N, P and K content than t_2 probably because of the effect of digging or sickle weeding given in these treatments. The chemical treatments which gave effective control of weeds (t_6, t_8, t_9 and t_{12}) have recorded lesser quantities of N, P and K probably due to lesser addition of organic matter by weeds and more uptake of nutrients by coconut.

The results given above indicated that in coconut plantations, complete removal of weeds either by manual or chemical methods has lead to a reduction in soil fertility. This is a matter of concern for maintaining the productivity of soil particularly in rainy tropics as Kerala. Some sort of balancing will have to be attained by allowing certain amount of undergrowth in coconut plantations in such a way that this will not adversely affect the productivity of crops grown there in at the same time conserve organic matter in soil. The manual methods like digging once, digging twice and sickle weeding recorded significantly higher organic carbon content compared to weed free treatment. Among these, sickle weeding recorded the highest organic carbon content. Hence from the point of view of soil fertility, sickle weeding is the best weed management method in coconut plantations eventhough it is slightly costly.

5. Economics

The data presented in Table 15 showed that in underplanted coconut garden chemical weed control was cheaper than either manual or manual + chemical methods. This might be due to the fact that labour intensive operations wherever employed are costly and unsuitable for Kerala conditions from the economic point of view.

Moderate technology seems to be more economic (t_{10} and t_7). Among the chemical methods, application of paraquat + diuron (t_{10}) eventhough less efficient in controlling weeds was less cost intensive and gave comparatively higher yield and turned out to be the most economic treatment. This was followed by t_9 (dalapon followed by paraquat) which resulted in maximum yield with moderate cost. T_8 (glyphosate 0.8 kg) was found to be the next economic treatment.

Table 15. Economics of different treatments

Tr. No.	Treatments	Additional cost for the treatments Rs.	Yield of nuts ha^{-1}	Receipt	Profit per rupee invested on weeding Rs.
1	C	-	3580	8950.00	-
2	WF	3400	6027	15067.50	1.80
3	D(1)	1700	5270	13175.00	2.49
4	D(2)	3400	5631	14077.50	1.51
5	Si(2)	2640	5291	13227.50	1.62
6	P(3)	1230	5571	13927.50	4.05
7	G(L)	530	4690	11725.00	5.24
8	G(H)	890	5492	13730.00	5.37
9	Da(1) → P(1)	900	5847	14617.50	6.30
10	P + Di (1)	660	5361	13402.50	6.75
11	P(1) → G(L)	940	5073	12682.50	3.97
12	Si(1) → 2,4-D+Di(1)	1995	5603	14007.50	2.54
13	G(L) → D(1)	2230	5313	13282.50	1.94

Cost of nuts = Rs. 2.50/nut

Cost of paraquat (Gramoxone 24 EC) - Rs. 120/lit
" glyphosate (Weed off 41 EC) - Rs. 360/lit
" dalapon (Dalapon 85 WSP) - Rs. 80/kg
" diuron (Hexuron 80 WP) - Rs. 200/kg
" 2,4-DEE (Agrodone Concentrate 48) - Rs.86.60/lit

Coomans (1974) also reported that in coconut plantations, chemical weed control was cheaper than manual methods.

Plate 1 Unweeded control (t_1) - luxurient growth of weeds especially *Chromolaena odorata*

Plate 2 Weed free plot (t_2)

Plate 3 Paraquat three sprays (t_6) - good control of weeds

Plate 4 Glyphosate 0.8 kg ha^{-1} (t_8) - weed growth before application

Plate 5 Glyphosate 0.8 kg ha^{-1} (t_8) - 30 days after application - good control of weeds


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Plate 6 Glyphosate 0.8 kg ha^{-1} (t_8) - six months after application - subsequent growth of annual weeds

Plate 7 Dalapon followed by paraquat (t_9) - effective control of weeds

Plate 8 2,4-D + diuron immediately after sickle weeding (t_{12}) - effective on dicot weeds

Plate 9 Digging twice (t_4) - just before second digging - luxurient growth of weeds

Plate 10 Sickle weeding twice (t_5) - just before second sickle weeding - luxurient growth of weeds

Trial-II. Weed management in coconut + banana cropping system

1. Weeds

1.1 Weed spectrum

The weed flora found in the experimental field are presented in Appendix-VI. Out of these, the monocot weed Pennisetum pedicellatum was the major weed of the area (Plate 11).

1.2 Weed population

Change in the population of weeds was recorded from the beginning of the trial in August 1986. In the first year the treatments were applied in August 1986 and the observations were taken upto May 1987. Altogether six observations were taken at 45 days interval for a period of 270 days, whereas in the second and third year the treatments were given in June and seven observations were taken upto the following April at 45 days interval for a period of 315 days.

1.2.1 Population of monocot weeds

Effects of different treatments on the population of monocot weeds are presented in Tables 16a, b and c. Maximum

Table 16a. Effect of treatments on monocot weed population (plants/m^2) during 1986-87

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS	
		T	O	T	O	T	O
1	Cc	4.6	20.0	3.0	8.0	3.8	13.3
2	C - WP	4.5	20.0	3.4	10.7	4.0	18.7
3	C + B - WP	4.5	20.0	3.0	8.0	3.4	10.7
4	C + B - WF	4.4	18.7	1.0	0.0	1.0	0.0
5	C + B - Sp	4.4	18.7	1.0	0.0	1.0	0.0
6	C + B - Si	4.4	18.7	1.0	0.0	2.2	4.0
7	C + B + CP	1.4	1.3	1.4	1.3	2.2	4.0
8	C + B + CP → P	1.4	1.3	2.2	4.0	2.5	5.3
9	C + B + CP → G	1.4	1.3	2.2	4.0	2.8	6.7
10	C + B - D	1.0	0.0	2.1	4.0	1.0	0.0
11	C + B - O	1.8	2.7	2.5	6.7	2.2	4.0
12	C + B - A	2.9	8.0	2.8	6.7	2.7	6.7
13	C + B - D → P	1.0	0.0	1.0	0.0	1.0	0.0
14	C + B - O → P	1.8	2.7	2.5	5.3	2.7	6.7
15	C + B - A → P	3.2	9.3	2.5	5.3	3.0	9.3
	SE	0.36		0.34		0.45	
	CD (0.05)	1.05		1.00		1.30	

DAS = Days after spraying
T = $\sqrt{x + 1}$ transformed values
O = Original values

Table 16b. Effect of treatments on monocot weed population (plants/m^2) during 1987-88

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T	O	T	O	T	O	T	O	T	O	T	O	T	O
1	Cc	5.8	33.3	7.5	56.0	7.6	57.3	4.3	18.7	4.1	16.0	3.7	13.3	2.9	8.0
2	C - WP	5.9	34.7	6.6	42.7	6.8	45.3	4.7	21.3	4.1	16.0	3.6	12.0	2.9	8.0
3	C + B - WP	5.7	32.0	6.6	42.7	6.5	41.3	4.2	17.3	3.9	14.7	3.6	12.0	2.9	8.0
4	C + B - WF	3.3	10.7	1.0	0.0	2.2	4.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0
5	C + B - Sp	1.0	0.0	4.4	18.7	1.0	0.0	2.8	6.7	1.8	2.7	1.4	1.3	1.4	1.3
6	C + B - Si	1.0	0.0	6.0	35.3	1.0	0.0	4.8	22.7	4.2	17.3	3.7	13.3	3.4	10.7
7	C + B + CP	2.1	4.0	3.8	13.3	4.4	18.7	3.4	10.7	2.5	5.3	1.8	2.7	1.8	2.7
8	C + B + CP → P	2.2	4.0	3.6	12.0	3.9	14.7	1.8	2.7	1.4	1.3	1.4	1.3	1.4	1.3
9	C + B + CP → G	2.1	4.0	3.6	12.0	3.9	14.7	1.4	1.3	1.4	1.3	1.4	1.3	1.4	1.3
10	C + B - D	1.0	0.0	1.4	1.3	2.5	5.3	2.2	4.0	1.8	2.7	1.4	1.3	1.4	1.3
11	C + B - O	1.4	1.3	2.5	5.3	2.7	6.7	2.5	5.3	1.8	2.7	1.4	1.3	1.4	1.3
12	C + B - A	3.8	13.3	4.6	20.0	5.1	25.3	3.7	13.3	2.9	8.0	2.5	5.3	2.5	5.3
13	C + B - D → P	1.0	0.0	1.4	1.3	2.5	5.3	2.1	4.0	1.4	1.3	1.4	1.3	1.4	1.3
14	C + B - O → P	1.8	2.7	2.5	5.3	2.7	6.7	2.1	4.0	1.4	1.3	1.4	1.3	1.4	1.3
15	C + B - A → P	3.9	14.7	4.4	18.7	5.0	24.0	2.1	4.0	1.4	1.3	1.4	1.3	1.4	1.3
	SE	0.42		0.38		0.29		0.47		0.43		0.38		0.39	
	CD (0.05)	1.22		1.11		0.85		1.36		1.24		1.10		1.12	

DAS = Days after spraying
T = $\sqrt{x + 1}$ transformed values
O = Original values

Table 16c. Effect of treatments on monocot weed population (plants/m^2) during 1988-89

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T	O	T	O	T	O	T	O	T	O	T	O	T	O
1	Cc	5.3	28.8	6.6	42.7	6.7	44.0	4.5	20.0	3.9	14.7	2.3	5.3	2.3	5.3
2	C - WP	5.0	24.0	6.3	40.0	6.4	41.3	4.8	22.7	3.9	14.7	2.5	5.3	2.5	5.3
3	C + B - WP	4.4	18.7	6.1	37.3	6.2	38.7	4.6	21.3	3.4	12.0	2.3	5.3	2.1	4.0
4	C + B - WF	3.4	10.7	1.0	0.0	2.2	4.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0
5	C + B - Sp	1.0	0.0	4.5	20.0	1.0	0.0	2.5	5.3	1.4	1.3	1.0	0.0	1.0	0.0
6	C + B - Si	1.0	0.0	5.8	33.3	1.0	0.0	4.8	22.7	2.9	8.0	1.8	2.7	1.8	2.7
7	C + B + CP	1.8	2.7	4.4	18.7	4.6	20.0	4.0	16.0	2.5	5.3	1.4	1.3	1.4	1.3
8	C + B + CP → P	1.4	1.3	4.3	17.3	4.4	18.7	1.8	2.7	1.0	0.0	1.0	0.0	1.0	0.0
9	C + B + CP → G	1.4	1.3	4.2	17.3	4.4	18.7	1.8	2.7	1.0	0.0	1.0	0.0	1.0	0.0
10	C + B - D	1.4	1.3	2.2	4.0	2.5	5.3	2.2	4.0	1.4	1.3	1.0	0.0	1.0	0.0
11	C + B - O	1.4	1.3	2.8	6.7	3.0	8.0	2.5	5.3	1.4	1.3	1.0	0.0	1.0	0.0
12	C + B - A	3.6	12.0	4.6	20.0	4.7	21.3	4.3	17.3	3.2	9.3	2.2	4.0	2.2	4.0
13	C + B - D → P	1.4	1.3	1.8	2.7	2.2	4.0	1.8	2.7	1.0	0.0	1.0	0.0	1.0	0.0
14	C + B - O → P	1.4	1.3	2.8	6.7	2.7	6.7	1.8	2.7	1.0	0.0	1.0	0.0	1.0	0.0
15	C + B - A → P	3.8	13.3	4.5	20.0	4.7	21.3	1.8	2.7	1.0	0.0	1.0	0.0	1.0	0.0
	SE	0.37		0.41		0.32		0.42		0.36		0.30		0.28	
	CD (0.05)	1.07		1.18		0.91		1.22		1.05		0.87		0.80	

DAS = Days after spraying
T = $\sqrt{x + 1}$ transformed values
O = Original values

number of monocot weeds was recorded by unweeded controls (t_1, t_2 and t_3). Pre emergence application of herbicides was found to be effective in reducing monocot weed population. Among these herbicides least number of monocot weeds was observed in the plots sprayed with diuron (Plate 12). Oxyfluorfen (t_{11}) was found equally effective as diuron (Plate 13), whereas atrazine (t_{12}) was significantly inferior to diuron (Plate 14) in most of the stages. After 135 days there was a general decline in the weed count due to the drying of monocot weeds as the summer had set in. However, a comparison of t_{10} & t_{13}, t_{11} & t_{14} and t_{12} & t_{15} from 180 days onwards showed that there was a reduction in monocot weed population due to the subsequent application of paraquat, eventhough this was significant for atrazine only, probably due to the lesser number of monocot weeds in the diuron and oxyfluorfen treated plots. The lesser number of monocot weeds in diuron treated plots (t_{10}) is due to its higher efficiency in controlling monocot weeds as reported by Das and Misra (1977), Ramadass et al. (1980) and Mishra and Das (1984).

Intercropping of cowpea (t_7) could lower the monocot weed population which was clear from the weed count at 45 days. This can be attributed to the fast growth of cowpea thus covering the ground relatively at an early stage (Plates 16 and 17). After the harvest of cowpea (60 days) there was further germination of monocot weeds (Plate 18) which was clear from the weed counts at 90 and 135 days. However, these weeds could be effectively controlled by the post-emergence application of paraquat (t_8) or glyphosate (t_9) at 140 days and thus there was significant reduction in weed counts. The effects of paraquat and glyphosate in controlling monocot weeds were found to be equal. But the effects of these post emergence herbicides over cowpea alone could not be observed during summer months due to the general drying up of monocot weeds (counts from 225 days onwards). In 1987-88 and 1988-89, at 90 and 135 days raising cowpea resulted in reduction of monocot weeds to a level on par with that of atrazine, but it was not as efficient as diuron and oxyfluorfen.

Spade weeding (t_5) was found to be more effective than sickle weeding (t_6) in reducing monocot weed population in most of the stages. After the second spade weeding given in October, it was found to be as effective as diuron followed by paraquat in controlling monocot weeds. Sickle weeding could not bring down the number of monocot weeds compared to unweeded controls. The least number of monocot weeds recorded by sickle weeding and spade weeding at 90 days in the first year and at 45 and 135 days in the subsequent years was the effect of the respective treatments given a few days before the observation.

In general, monocot weeds were very less during summer months. In 1986, since the trial was started only in August, after giving an initial ploughing, there was no monocot weeds during summer months.

1.2.2 Population of dicot weeds

Different weed control treatments could exert significant influence on the population of dicot weeds (Tables 17a, b and c). Among the pre emergence herbicides, diuron (t_{10}) was found to be most effective in reducing dicot weed population (Plate 12). Oxyfluorfen (t_{11}) was found to be as effective as diuron in controlling dicot weeds (Plate 13). Eventhough atrazine (t_{12}) was inferior to diuron in effectiveness, it was on par with oxyfluorfen in reducing dicot weed population. The lesser effectiveness of atrazine in controlling dicot weeds might be due to the perennial nature of weeds which puts forth fresh shoots from the underground portions located very deep in the soil.

There was a general decline in the number of dicot weeds after 135 days as in the case of monocot weeds due to

Table 17a. Effect of treatments on dicot weed population (plants/m^2) during 1986-87

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS	
		T*	O	T	O	T*	O	T	O	T*	O	T	O
1	Cc	5.4	28.0	7.1	49.3	8.8	78.2	8.1	64.0	7.3	53.3	7.2	50.7
2	C - WP	5.3	28.0	7.6	57.3	7.5	56.7	7.7	58.7	7.2	51.8	7.0	48.0
3	C + B - WP	5.2	26.7	7.4	56.0	7.1	50.6	7.8	60.0	7.1	50.6	7.1	49.3
4	C + B - WF	5.2	26.7	1.0	0.0	2.6	6.5	1.0	0.0	2.0	4.0	1.0	0.0
5	C + B - Sp	5.3	28.0	1.0	0.0	4.2	17.6	4.3	17.3	4.0	16.8	4.3	17.3
6	C + B - Si°	5.3	28.0	1.0	0.0	7.5	55.6	7.6	56.0	7.0	49.3	5.0	24.0
7	C + B + CP	2.9	8.0	8.4	73.3	9.0	80.9	6.1	36.0	5.5	30.5	4.7	21.3
8	C + B + CP→P	2.7	6.7	7.8	60.0	12.0	143.3	5.4	28.0	4.7	22.5	4.0	14.7
9	C + B + CP→G	2.7	6.7	8.2	69.3	12.8	163.7	5.9	33.3	4.9	23.9	4.8	22.7
10	C + B - D	1.8	2.7	4.7	22.7	4.9	24.0	5.3	26.7	4.9	24.0	2.8	6.7
11	C + B - O	2.1	4.0	5.8	33.3	7.0	48.8	6.3	38.7	6.0	35.9	3.2	9.3
12	C + B - A	2.5	5.3	6.4	42.7	7.1	50.8	6.5	41.3	6.2	38.6	4.9	22.7
13	C + B - D →P	1.8	2.7	5.1	25.3	4.7	22.5	3.0	8.0	2.8	7.6	2.5	5.3
14	C + B - O →P	2.2	4.0	5.7	32.0	6.8	46.7	4.9	22.7	4.3	18.6	3.0	8.0
15	C + B - A →P	2.5	5.3	7.0	48.0	8.9	78.5	5.2	26.7	4.9	23.7	4.0	14.7
	SE	0.46		0.70		0.86		0.27		0.25		0.27	
	CD (0.05)	1.33		2.04		2.50		0.77		0.73		0.77	

DAS = Days after spraying
T* = $\sqrt{x}$ transformed values
T = $\sqrt{x+1}$ transformed values
O = Original values

Table 17b. Effect of treatments on dicot weed population (plants/m^2) during 1987-88

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T	O	T	O	T	O	T	O	T*	O	T	O	T*	O
1	Cc	7.6	57.3	9.1	82.7	9.3	85.3	7.5	56.0	7.4	54.0	7.3	53.3	7.1	50.0
2	C - WP	7.6	57.3	10.0	100.0	10.2	102.7	7.3	53.3	7.1	50.3	7.1	49.3	6.8	46.5
3	C + B - WP	7.4	53.3	9.6	92.0	9.7	93.3	6.7	44.7	6.5	42.4	6.5	41.3	6.3	39.9
4	C + B - WF	5.5	29.3	1.0	0.0	2.5	5.3	1.0	0.0	2.3	5.2	1.0	0.0	2.0	4.0
5	C + B - Sp	1.0	0.0	9.3	85.3	1.0	0.0	6.7	44.0	6.5	42.6	6.4	40.0	6.1	37.2
6	C + B - Si	1.0	0.0	12.0	143.3	1.0	0.0	9.1	81.3	8.8	77.2	8.7	74.7	8.2	66.6
7	C + B + CP	3.6	12.0	9.8	96.0	9.9	97.3	6.9	46.7	6.6	43.9	6.6	42.7	6.4	41.3
8	C + B + CP → P	3.6	12.0	9.8	96.0	9.9	97.3	4.6	20.0	4.3	18.6	4.4	18.7	4.2	17.3
9	C + B + CP → G	3.6	12.0	9.9	97.3	9.9	98.7	4.3	17.3	4.2	17.3	4.3	17.3	4.0	15.8
10	C + B - D	4.2	17.3	5.2	26.7	6.0	36.0	6.0	34.7	5.8	33.3	5.9	33.3	5.5	30.6
11	C + B - O	4.3	18.7	6.7	44.0	6.9	46.7	6.4	40.0	6.2	38.6	6.2	37.3	5.9	34.6
12	C + B - A	4.7	21.3	6.8	45.3	7.4	54.7	6.9	46.7	6.7	45.3	6.7	44.0	6.3	39.9
13	C + B - D → P	3.5	12.0	5.1	25.3	6.0	36.0	3.8	13.3	3.4	11.8	3.6	12.0	2.8	8.0
14	C + B - O → P	3.7	13.3	6.0	34.7	6.8	45.0	4.3	17.3	3.8	14.6	3.8	13.3	3.3	10.6
15	C + B - A → P	4.4	18.7	7.5	55.3	7.7	58.7	4.7	21.3	5.7	32.6	4.4	18.7	3.8	14.6
	SE	0.40		0.45		0.39		0.29		0.38		0.22		0.23	
	CD (0.05)	1.15		1.30		1.14		1.84		1.09		0.63		0.65	

DAS = Days after spraying

T* = $\sqrt{x}$ transformed values

T = $\sqrt{x+1}$ transformed values

O = Original values

Table 17c. Effect of treatments on dicot weed population (plants/m^2) during 1988-89

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T	O	T	O	T	O	T	O	T*	O	T	O	T*	O
1	Cc	7.4	53.3	8.2	66.7	8.3	68.0	6.8	45.3	6.7	45.1	6.8	45.3	6.5	42.5
2	C – WP	6.7	44.0	8.0	64.0	8.1	65.3	6.9	46.7	6.6	43.8	6.5	41.3	6.3	39.8
3	C + B – WP	6.5	41.3	7.4	54.7	7.5	56.0	6.3	38.7	6.1	37.2	6.2	37.3	5.9	34.6
4	C + B – WF	6.1	37.3	1.0	0.0	2.5	5.3	1.0	0.0	2.0	4.0	1.0	0.0	2.0	4.0
5	C + B – Sp	1.0	0.0	6.9	46.7	1.0	0.0	4.5	19.3	4.2	17.3	3.2	9.3	2.8	7.6
6	C + B – Si	1.0	0.0	8.3	68.0	1.0	0.0	6.5	41.3	6.3	39.7	4.7	21.3	4.5	19.9
7	C + B + CP	4.4	18.7	6.8	45.3	6.9	46.7	5.7	32.0	5.5	30.6	4.1	16.0	3.8	14.4
8	C + B + CP → P	4.1	17.3	6.4	41.3	6.9	46.7	3.0	8.0	2.8	7.6	3.6	12.0	3.3	10.6
9	C + B + CP → G	4.2	17.3	6.3	40.0	6.8	46.0	2.8	6.7	2.6	6.5	3.2	9.3	3.0	8.9
10	C + B – D	3.2	9.3	4.7	21.3	5.0	24.0	4.6	20.0	4.5	19.9	4.7	21.3	4.5	19.9
11	C + B – O	3.8	13.3	5.2	26.7	5.5	29.3	4.8	22.7	4.7	22.4	5.0	24.0	4.8	22.6
12	C + B – A	5.0	24.0	5.7	32.0	5.9	34.7	5.6	30.7	5.4	29.3	5.5	29.3	5.3	27.9
13	C + B – D → P	3.2	9.3	4.1	16.0	4.7	21.3	3.6	12.0	3.4	11.8	3.1	9.3	2.6	6.5
14	C + B – O → P	3.6	12.0	4.6	21.3	5.2	26.7	3.6	12.0	3.4	11.8	3.6	12.0	3.3	10.6
15	C + B – A → P	4.8	22.7	5.8	33.3	6.0	34.7	4.7	21.3	4.5	19.9	4.0	14.7	3.6	13.3
	SE	0.38		0.56		0.37		0.31		0.28		0.27		0.27	
	CD (0.05)	1.09		1.62		1.07		0.90		0.82		0.79		0.78	

DAS = Days after spraying
T* = $\sqrt{x}$ transformed values
T = $\sqrt{x+1}$ transformed values
O = Original values

the drying of annual dicot weeds in summer. However, comparisons of t_{10} & t_{13}, t_{11} & t_{14} and t_{12} & t_{15} from 180 days showed that there was a significant reduction in dicot weed count in pre-emergence herbicide treated plots due to the subsequent application of paraquat. Among these, diuron followed by paraquat (t_{13}) was most effective (Plate 15) which might be due to the lesser number of dicot weeds in diuron treated plots. The effectiveness of diuron in controlling dicot weeds might be associated with its inhibitory effect on one or more of the seedling growth phases, blocking the proper functioning of photosystem I, II or electron transport between 'Q' and 'PQ', preventing formation of ATP and NADPH required for CO_2 fixation and formation of phytotoxic substances (Ashton and Crafts, 1981). The efficiency of diuron in controlling dicot weeds in banana was also reported by Dhuria and Leela (1971), Ramadass et al. (1980) and Mishra and Das (1984). Oxyfluorfen followed by paraquat (t_{14}) was on par with diuron followed by paraquat. Eventhough atrazine followed by paraquat (t_{15}) was inferior to diuron followed by paraquat in reducing dicot weed population, it was found to be as effective as oxyfluorfen followed by paraquat. A general observation was that in such of the plots where diuron, oxyfluorfen as well as atrazine were used they were not found effective in controlling perennial deep rooted dicot weeds. The presence of more number of such weeds in atrazine treated plots was a coincidence. Hence the relative efficiency of the three chemicals in controlling the perennial dicot weeds was not much different from one another.

As in the case of monocot weeds, growing cowpea as an intercrop (t_7) could bring down the population of dicot weeds which is expressed in the weed count at 45 day stage. This might be due to the fast growth of cowpea which resulted in early ground coverage and smothering the weeds (Plates 16 and 17). The weed counts at 90 and 135 days indicated that there was further germination of dicot weeds after the harvest of cowpea. However, these weeds could very well be controlled by the post emergence application of either paraquat (t_8) or glyphosate (t_9) which were found to be equal in effectiveness. For example, plots which did not receive the post emergence herbicides recorded 46.7 dicot weeds/m^2 whereas plots which received paraquat or glyphosate recorded 20 and 17.3 dicot weeds/m^2 at 180 days during 1987-88. But the effects of these post emergence herbicides over cowpea alone were not so pronounced during summer months due to the drying up of annual dicot weeds.

Spade weeding (t_5) was found to be more effective than sickle weeding (t_6) in reducing dicot weed population as the former involved scraping of the ground with a spade which left no over growth. Sickle weeding could not bring down the number of dicot weeds compared to unweeded controls (t_1, t_2 and t_3) in most of the stages. The presence of lesser number of dicot weeds in unweeded controls than in sickle weeded plots at some stages was due to the large size of the weeds in unweeded controls.

Intercropping coconut with banana (t_3) recorded a lesser number of dicot weeds compared to sole crop of coconut (t_1 and t_2) in most of the stages eventhough the effect was not statistically significant.

1.2.3 Population of *Pennisetum pedicellatum*

Highest number of *P. pedicellatum*, the major weed in the area was observed in unweeded controls (Tables 18 a, b and c and Plate 11). Pre-emergente herbicides were found to be very effective in reducing the population of this noxious weed. Among these, diuron (t_{10}) was the most efficient in preventing the germination and establishment of the weed (Plate 12). Oxyfluorfen (t_{11}) was as effective as diuron (Plate 13) whereas atrazine (t_{12}) was not effective in reducing the population of *P. pedicellatum* compared to unweeded controls in most of the stages.

Table 18a. Effect of treatments on the population of <u>Pennisetum</u> <u>pedicellatum</u> (plants/m^2) during 1986-87

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS	
		T	O	T	O	T	O
1	Cc	3.7	13.3	2.7	6.7	2.7	6.7
2	C - WP	3.7	13.3	3.0	8.0	2.7	6.7
3	C + B - WP	3.4	10.7	2.7	6.7	2.7	6.7
4	C + B - WF	3.4	10.7	1.0	0.0	1.0	0.0
5	C + B - Sp	3.5	12.0	1.0	0.0	1.0	0.0
6	C + B - Si	3.5	12.0	1.0	0.0	1.0	0.0
7	C + B + CP	1.0	0.0	1.4	1.3	1.8	2.7
8	C + B + CP → P	1.0	0.0	1.4	1.3	1.8	2.7
9	C + B + CP → G	1.0	0.0	1.4	1.3	1.8	2.7
10	C + B - D	1.0	0.0	1.4	1.3	1.0	0.0
11	C + B - O	1.8	2.7	1.8	2.7	1.8	2.7
12	C + B - A	2.7	6.7	2.5	5.3	2.5	5.3
13	C + B - D → P	1.0	0.0	1.0	0.0	1.0	0.0
14	C + B - O → P	1.8	2.7	1.8	2.7	1.8	2.7
15	C + B - A → P	3.0	8.0	2.5	5.3	2.5	5.3
	SE	0.31		0.31		0.29	
	CD (0.05)	0.91		0.91		0.84	

DAS = Days after spraying
T = $\sqrt{x + 1}$ transformed values
O = Original values

Table 18b. Effect of treatments on the population of <u>Pennisetum pedicellatum</u> (plants/m^2) during 1987-88

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS	
		T	O	T	O	T	O	T	O
1	Cc	4.0	14.7	3.4	10.7	3.4	10.7	3.4	10.7
2	C-WP	4.0	14.7	3.4	10.7	3.4	10.7	3.4	10.7
3	C+B-WP	4.1	16.0	3.2	9.3	3.4	10.7	3.2	9.3
4	C+B-WF	2.5	5.3	1.0	0.0	1.4	1.3	1.0	0.0
5	C+B-Sp	1.0	0.0	3.4	10.7	1.0	0.0	1.0	0.0
6	C+B-Si	1.0	0.0	3.4	10.7	1.0	0.0	3.0	8.0
7	C+B+CP	1.0	0.0	2.5	5.3	2.7	6.7	2.5	5.3
8	C+B+CP → P	1.0	0.0	2.5	5.3	2.7	6.7	1.0	0.0
9	C+B+CP → G	1.0	0.0	2.5	5.3	2.5	5.3	1.0	0.0
10	C+B-D	1.0	0.0	1.0	0.0	1.4	1.3	1.0	0.0
11	C+B-O	1.4	1.3	1.4	1.3	1.8	2.7	1.4	1.3
12	C+B-A	2.5	5.3	2.8	6.7	2.9	8.0	2.8	6.7
13	C+B-D → P	1.0	0.0	1.0	0.0	1.4	1.3	1.0	0.0
14	C+B-O → P	1.4	1.3	1.4	1.3	1.8	2.7	1.0	0.0
15	C+B-A → P	2.5	5.3	2.8	6.7	2.9	8.0	1.0	0.0
	SE	0.20		0.25		0.36		0.19	
	CD(0.05)	0.59		0.72		1.05		0.55	

DAS = Days after spraying
T = $\sqrt{x + 1}$ transformed values
O = Original values

Table 18c. Effect of treatments on the population of <u>Pennisetum pedicellatum</u> (plants/m^2) during 1988-89

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS	
		T	O	T	O	T	O	T	O
1	Cc	3.9	14.7	3.4	10.7	3.6	12.0	3.4	10.7
2	C-WP	4.0	14.7	3.4	10.7	3.6	12.0	3.4	10.7
3	C+B-WP	3.6	12.0	3.2	9.3	3.2	9.3	3.2	9.3
4	C+B-WF	2.2	4.0	1.0	0.0	1.4	1.3	1.0	0.0
5	C+B-Sp	1.0	0.0	2.8	6.7	1.0	0.0	1.0	0.0
6	C+B-Si	1.0	0.0	2.8	6.7	1.0	0.0	1.0	0.0
7	C+B+CP	1.0	0.0	3.0	8.0	2.9	8.0	3.0	8.0
8	C+B+CP → P	1.0	0.0	2.5	5.3	2.7	6.7	1.0	0.0
9	C+B+CP → G	1.0	0.0	2.5	5.3	2.7	6.7	1.0	0.0
10	C+B-D	1.0	0.0	1.8	2.7	1.4	1.3	1.8	2.7
11	C+B+O	1.0	0.0	2.2	4.0	1.8	2.7	2.2	4.0
12	C+B-A	2.9	8.0	3.2	9.3	3.4	10.7	3.2	9.3
13	C+B-D → P	1.0	0.0	1.8	2.7	1.0	0.0	1.0	0.0
14	C+B-O → P	1.0	0.0	2.1	4.0	1.8	2.7	1.0	0.0
15	C+B-A → P	3.2	9.3	3.2	9.3	3.4	10.7	1.0	0.0
	SE	0.20		0.30		0.30		0.19	
	CD (0.05)	0.57		0.87		0.86		0.56	

DAS = Days after spraying
T = $\sqrt{x + 1}$ transformed values
O = Original values

A comparison of t_{10} & t_{13}, t_{11} & t_{14} and t_{12} & t_{15} at 180 days showed that the population of the weed could be further reduced by the subsequent application of paraquat at 140 days. However, P. pedicellatum is an annual monocot weed having a life period of six months which ends in December. Therefore the count was not taken after 180 days.

Intercropping of cowpea (t_7) in coconut-banana cropping system was found to be very effective for the control of P. pedicellatum which was clear from the weed count at 45 days. This might be due to the fast growth and weed smothering ability of cowpea as already discussed. However, the weed counts at 90 and 135 days showed that after the harvest of cowpea (60 days) there was further germination of P. pedicellatum. These weeds could very well be controlled by the subsequent application of paraquat (t_8) or glyphosate (t_9) which were found equal in effectiveness. This is clear in the weed count at 180 days.

Spade weeding (t_5) and sickle weeding (t_6) were found equally effective in controlling P. pedicellatum after giving these treatments in October except at 180 days in the second year. Whereas the weed counts at 45 days in the first year and at 90 days in the second and third years clearly showed that one spade weeding or one sickle weeding given in July was not sufficient for the control of the weed (Plates 19, 20, 21 and 22). This might be due to the exposure of the weed seeds present below ground level and their consequent germination in spade weeded plots and regrowth of the weeds in sickle weeded plots.

Weed counts in the third year indicated that growing banana as an intercrop in coconut garden (t_3) could reduce the population of P. pedicellatum by about 13 to 23 per cent compared to sole crop of coconut (t_1 and t_2). This might be due to the lesser germination and establishment of the weed under shade provided by banana.

1.2.4 Total weed population

Pre-emergence application of herbicides could bring about significant reduction in the total weed population (Tables 19a,b and c). Among these, diuron (t_{10}) was found to be the most effective herbicide (Plate 12). Oxyfluorfen (t_{11}) was found as effective as diuron (Plate 13) but atrazine (t_{12}) was significantly inferior to diuron in most of the stages. Eventhough oxyfluorfen was on par with atrazine in 1986-87, it was significantly superior to atrazine in most of the stages during the subsequent years.

After 180 days there was a general decline in the total weed population which was clear in the weed counts

Table 19a. Effect of treatments on total weed population (plants/m^2) during 1986-87

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS	
		T	O	T	O	T	O	T	O	T*	O	T	O
1	Cc	7.0	48.0	7.6	57.3	9.6	91.7	8.1	64.0	7.3	53.3	7.2	50.7
2	C-WP	6.9	48.0	8.3	68.0	8.5	72.9	7.7	58.7	7.2	51.8	7.0	48.0
3	C+B-WP	6.8	46.7	7.9	64.0	7.8	61.3	7.8	60.0	7.1	50.6	7.1	49.3
4	C+B-WF	6.8	45.3	1.0	0.0	2.6	6.5	1.0	0.0	2.0	4.0	1.0	0.0
5	C+B-Sp	6.9	46.7	1.0	0.0	4.2	17.6	4.3	17.3	4.0	15.8	4.3	17.3
6	C+B-Si	6.8	46.7	1.0	0.0	7.7	59.8	7.6	56.0	7.0	49.3	5.0	24.0
7	C+B+CP	3.1	9.3	8.5	74.7	9.2	85.1	6.1	36.0	5.5	30.5	4.7	21.3
8	C+B+CP → P	2.9	8.0	8.0	64.0	12.2	148.9	5.4	28.0	4.7	22.5	4.0	14.7
9	C+B+CP → G	2.9	8.0	8.5	73.3	13.1	170.3	5.9	33.3	4.9	23.9	4.8	22.7
10	C+B-D	1.8	2.7	5.1	26.7	4.9	24.0	5.3	26.7	4.9	24.0	2.8	6.7
11	C+B-O	2.7	6.7	6.4	40.0	7.3	52.8	6.3	38.7	6.0	35.9	3.2	9.3
12	C+B-A	3.7	13.3	6.9	49.3	7.6	57.3	6.5	41.3	6.2	38.6	4.9	22.7
13	C+B-D → P	1.8	2.7	5.1	25.3	4.7	22.5	3.0	8.0	2.8	7.6	2.5	5.3
14	C+B-O → P	2.7	6.7	6.1	37.3	7.3	53.1	4.9	22.7	4.3	18.6	3.0	8.0
15	C+B-A → P	4.0	14.7	7.4	53.3	9.5	89.9	5.2	26.7	4.9	23.7	4.0	14.7
	SE	0.46		0.66		0.87		0.27		0.25		0.26	
	CD (0.05)	1.34		1.91		2.51		0.77		0.73		0.77	

DAS = Days after spraying
T* = $\sqrt{x}$ transformed values
T = $\sqrt{x+1}$ transformed values
O = Original values

Table 19b. Effect of treatments on total weed population (plants/m^2) during 1987-88

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T	O	T	O	T	O	T	O	T*	O	T	O	T*	O
1	Cc	9.6	90.7	11.8	138.7	12.0	142.7	8.7	74.7	8.4	70.5	8.2	66.7	7.6	58.2
2	C - WP	9.6	92.0	12.0	142.7	12.2	148.0	8.7	74.7	8.2	66.4	7.9	61.3	7.4	54.5
3	C + B - WP	9.3	85.3	11.6	134.7	11.8	140.0	7.9	62.0	6.3	39.9	7.4	53.3	6.9	74.9
4	C + B - WF	6.4	40.0	1.0	0.0	3.2	9.3	1.0	0.0	2.3	5.2	1.0	0.0	2.0	4.0
5	C + B - Sp	1.0	0.0	10.2	104.0	1.0	0.0	7.2	50.7	6.7	45.3	6.5	41.3	6.2	38.6
6	C + B - Si	1.0	0.0	13.4	178.7	1.0	0.0	10.2	70.7	9.7	94.1	9.4	88.0	8.8	77.1
7	C + B + CP	4.1	16.0	10.5	109.3	10.8	116.0	7.6	57.3	7.0	49.2	6.8	45.3	6.6	43.9
8	C + B + CP → P	4.1	16.0	10.4	108.0	10.6	112.0	4.9	22.7	4.5	19.9	4.6	20.0	4.3	18.6
9	C + B + CP → G	4.1	16.0	10.5	109.3	10.7	113.3	4.4	18.7	4.3	18.6	4.4	18.7	4.2	17.3
10	C + B - D	4.2	17.3	5.3	28.0	6.4	41.3	6.3	38.7	6.0	35.9	6.0	34.7	5.6	31.9
11	C + B - O	4.4	20.0	7.0	49.3	7.3	53.3	6.8	45.3	6.4	41.2	6.3	38.7	6.0	36.9
12	C + B - A	6.0	34.7	8.1	65.3	9.0	80.0	7.8	60.0	7.3	53.3	7.1	49.3	6.7	45.3
13	C + B - D → P	3.5	12.0	5.2	26.7	6.5	41.3	4.2	17.3	3.6	13.0	3.7	13.3	3.0	9.2
14	C + B - O → P	4.0	16.0	6.4	40.0	7.2	52.0	4.7	21.3	4.0	15.8	3.9	14.7	3.4	11.8
15	C + B - A → P	5.9	33.3	8.3	67.3	9.1	82.7	5.4	28.0	4.6	21.2	4.6	20.0	4.0	15.8
	SE	0.39		0.40		0.39		0.28		0.43		0.23		0.25	
	CD (0.05)	1.13		1.15		1.12		0.82		1.23		0.68		0.73	

DAS = Days after spraying

T* = $\sqrt{x}$ transformed values

T = $\sqrt{x+1}$ transformed values

O = Original values

Table 19c. Effect of treatments on total weed population (plants/m^2) during 1988-89

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T	O	T	O	T	O	T	O	T*	O	T	O	T*	O
1	Cc	9.1	81.3	10.5	109.3	10.6	112.0	8.1	65.3	7.7	59.7	7.2	50.7	6.9	47.9
2	C - WP	8.3	68.0	10.2	104.0	10.4	106.7	8.3	69.3	7.6	58.3	6.9	46.7	6.7	45.3
3	C + B - WP	7.8	60.0	9.6	92.0	9.7	94.7	7.8	60.0	7.0	48.8	6.6	42.7	6.2	38.5
4	C + B - WF	7.0	48.0	1.0	0.0	3.2	9.3	1.0	0.0	2.0	4.0	1.0	0.0	2.0	4.0
5	C + B - Sp	1.0	0.0	8.2	66.7	1.0	0.0	5.1	24.7	4.3	18.5	3.2	9.3	2.8	7.6
6	C + B - Si	1.0	0.0	10.1	101.3	1.0	0.0	8.0	64.0	5.6	31.8	5.0	24.0	4.8	22.6
7	C + B + CP	4.7	21.3	8.0	64.0	8.2	66.7	7.0	48.0	6.0	35.9	4.3	17.3	4.0	15.8
8	C + B + CP → P	4.2	18.7	7.7	58.7	8.1	65.3	3.4	10.7	2.8	7.6	3.6	12.0	3.3	10.6
9	C + B + CP → G	4.4	18.7	7.5	57.3	8.1	64.7	3.2	9.3	2.6	6.5	3.2	9.3	1.0	8.9
10	C + B - D	3.4	10.7	5.1	25.3	5.5	29.3	5.0	24.0	4.6	21.3	4.7	21.3	4.5	19.9
11	C + B - O	4.0	14.7	5.9	33.3	6.2	37.3	5.4	28.0	4.9	23.9	5.0	24.0	4.8	22.6
12	C + B - A	6.1	36.0	7.2	52.0	7.5	56.0	7.0	48.0	6.2	38.6	5.9	33.3	5.6	31.9
13	C + B - D → P	3.4	10.7	4.3	18.7	5.1	25.3	3.9	14.7	3.4	11.8	3.1	9.3	2.6	6.5
14	C + B - O → P	3.7	13.3	5.3	28.0	5.8	33.3	3.9	14.7	3.4	11.8	3.6	12.0	3.3	10.6
15	C + B - A → P	6.1	36.0	7.4	53.3	7.5	56.0	5.0	24.0	4.5	19.9	4.0	14.7	3.6	13.3
	SE	0.41		0.55		0.37		0.41		0.36		0.24		0.26	
	CD (0.05)	1.20		1.60		1.08		1.20		1.04		0.71		0.75	

DAS = Days after spraying

T* = $\sqrt{x}$ transformed values

T = $\sqrt{x + 1}$ transformed values

O = Original values

from 225 days onwards. This might be due to the drying up of annual monocot and dicot weeds as the summer had set in. However, from 180 days, a comparison of weed counts between t_{10} & t_{13}, t_{11} & t_{14} and t_{12} & t_{15} showed that subsequent application of paraquat could bring down the population of weeds significantly in pre-emergence herbicide treated plots. Among these, diuron followed by paraquat (t_{13}) was the most effective treatment (Plate 15). This might be due to the lesser number of weeds present in the diuron treated plots as the treatment prevented the germination and establishment of weeds. Oxyfluorfen followed by paraquat (t_{14}) was found to be on par with diuron followed by paraquat, whereas atrazine followed by paraquat (t_{15}) was inferior to it. This might be due to the presence of more number of monocot and perennial dicot weeds in atrazine treated plots. Moreover, application of diuron alone was found to be on par with atrazine followed by paraquat in certain stages and was superior to atrazine followed by paraquat in certain other stages from 180 days onwards in the first and third year. This again showed the superiority of diuron for controlling weeds in coconut-banana cropping system. Balasubramanian et al. (1985) also obtained good control of weed growth in coconut plantations with diuron. Similar effect of diuron in banana was reported by Dhuria and Leela (1971) and Ramadass et al. (1980).

Weed count at 45 days clearly showed the positive effect of growing cowpea as an intercrop (t_7) in banana in reducing the total weed population. This might be due to the fast growth of cowpea and development of a dense canopy which covered the entire ground area and suppressed the growth of weeds (Plates 16 and 17). Similar effect of growing cowpea in banana was also reported by Chacko and Reddy (1981). After the harvest of cowpea (60 days) there was further germination of weeds which was clear from the weed counts at 90 and 135 days. A comparison of t_7, t_8 and t_9 at 180 days showed that the subsequent application of paraquat or glyphosate could reduce the population of weeds in cowpea raised plots.

Spade weeding (t_5) was found to be more effective than sickle weeding (t_6) in reducing the total weed population. After the second spade weeding given in October it was found equally effective as herbicides in controlling weeds in most of the stages. The least number of weeds recorded by spade weeding and sickle weeding at 90 days in the first year and at 45 and 135 days in the subsequent years was due to the effect of the respective treatments given a few days before the observation.

Growing banana as an intercrop in coconut garden without weeding (t_3) recorded a lower weed population compared to unweeded sole crop of coconut (t_1 and t_2) in most of the stages eventhough not statistically significant. Weed count in the third year showed that by mere intercropping banana with coconut (t_3) could bring down the population of weeds by about 8 to 26 per cent compared to unweeded sole crop of coconut (t_1). This might be due to the shading effect of banana.

1.3 Drymatter production

The drymatter production of weeds was significantly affected by different weed control treatments (Tables 20a, b and c). At all stages unweeded control recorded the highest weed biomass (Plate 11). All the weed control treatments could bring down the drymatter production of weeds significantly over unweeded control (Fig.5). Among the pre-emergence herbicides, diuron (t_{10}) was the most effective in reducing weed drymatter production (Plate 12). Eventhough oxyfluorfen (t_{11}) was inferior to diuron in the first year, it was found to be on par with diuron (Plate 13) in the subsequent years. However, atrazine (t_{12}) was inferior to diuron in most of the stages. The lower weed drymatter accumulation in diuron treated plots might be due to its better efficiency as a pre-emergence herbicide in preventing the establishment of weeds and its longer

Table 20a. Effect of treatments on drymatter production of weeds (g/m^2) during 1986-87

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS	
		T*	O	T	O	T*	O	T	O	T*	O	T	O
1	Cc	13.6	189.3	22.4	542.0	23.5	554.0	15.5	238.4	15.1	228.6	13.9	191.5
2	C-WP	13.4	183.2	23.0	540.7	24.4	594.6	15.5	238.7	15.1	227.3	14.0	196.4
3	C+B-WP	13.5	182.9	22.4	523.3	22.9	524.2	10.5	108.4	10.2	104.5	9.3	84.8
4	C+B-WF	13.3	178.3	1.0	0.0	2.9	8.6	1.0	0.0	1.5	2.1	1.0	0.0
5	C+B-Sp	13.3	179.7	1.0	0.0	3.3	11.0	3.4	10.4	3.5	12.4	5.3	27.7
6	C+B-Si	14.4	211.7	1.0	0.0	7.1	50.9	7.6	56.0	7.3	53.0	6.9	47.1
7	C+B+CP	1.7	1.9	9.6	92.0	10.1	101.5	7.9	61.3	7.0	49.1	6.5	41.1
8	C+B+CP → P	1.6	1.6	9.8	95.3	9.5	90.5	5.6	30.7	5.2	27.3	5.2	26.3
9	C+B+CP → G	1.7	1.9	9.1	82.7	10.8	116.3	6.7	44.0	5.9	34.6	5.7	32.0
10	C+B-D	1.5	1.3	5.9	34.7	6.0	35.8	5.7	31.7	5.2	27.3	4.2	16.8
11	C+B-O	1.9	2.7	13.0	168.7	13.1	170.4	8.3	68.7	7.6	57.2	4.8	22.5
12	C+B-A	2.6	5.7	12.1	146.7	11.3	127.5	8.7	75.3	8.1	65.9	5.4	27.7
13	C+B-D → P	1.5	1.3	5.6	30.7	5.3	28.3	5.0	24.0	4.6	21.3	3.7	12.8
14	C+B-O → P	2.1	3.6	12.8	166.0	13.1	172.1	5.1	25.3	4.8	22.6	3.9	14.1
15	C+B-A → P	2.6	5.7	11.4	128.0	11.4	130.5	5.5	29.1	5.2	26.6	4.7	20.9
	SE	0.85		1.60		1.64		0.19		0.19		0.39	
	CD (0.05)	2.46		4.63		4.76		0.56		0.55		1.12	

DAS = Days after spraying
T* = $\sqrt{x}$ transformed values
T = $\sqrt{x+1}$ transformed values
O = Original values

Table 20b. Effect of treatments on drymatter production of weeds (g/m^2) during 1987-88

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T	O	T	O	T	O	T	O	T*	O	T	O	T*	O
1	Cc	18.9	357.2	27.2	740.7	27.3	742.8	28.7	824.1	26.0	676.4	22.1	487.1	21.4	458.7
2	C - WP	18.9	358.0	27.2	740.3	27.4	748.9	28.7	823.3	25.1	632.2	21.8	475.9	21.1	446.9
3	C + B - WP	17.9	321.5	26.5	704.0	26.7	710.7	26.7	713.6	22.8	517.6	20.7	427.2	19.4	377.3
4	C + B - WF	10.4	108.0	1.0	0.0	5.2	26.0	1.0	0.0	4.5	20.6	1.0	0.0	4.3	18.4
5	C + B - Sp	1.0	0.0	13.3	176.7	1.0	0.0	8.0	63.5	7.8	61.4	7.8	60.8	6.7	45.1
6	C + B - Si	1.0	0.0	17.8	318.0	1.0	0.0	13.3	176.5	12.3	152.3	11.8	139.7	11.3	127.2
7	C + B + CP	1.6	1.5	8.9	78.7	15.8	248.4	15.9	252.0	12.0	144.4	11.7	135.1	11.2	126.2
8	C + B + CP → P	1.6	1.7	8.4	71.1	15.7	245.6	6.9	46.8	6.5	42.1	6.5	41.1	6.2	39.0
9	C + B + CP → G	1.6	1.7	8.7	74.7	15.7	244.7	6.9	46.7	6.5	41.9	6.5	40.9	6.2	38.8
10	C + B - D	2.8	6.7	4.8	22.0	9.1	82.7	9.2	83.3	8.6	73.9	8.4	69.6	8.1	65.9
11	C + B - O	2.9	8.0	6.0	35.3	10.0	99.7	11.0	120.0	10.1	101.7	10.1	100.7	9.8	95.4
12	C + B - A	3.5	12.1	6.8	46.0	11.3	127.6	12.6	158.8	11.8	139.7	11.6	134.5	11.2	126.1
13	C + B - D → P	2.5	5.3	4.4	18.0	9.1	82.5	4.8	21.6	4.5	20.6	4.4	18.9	4.2	17.3
14	C + B - O → P	2.5	5.3	6.1	37.3	9.9	98.5	7.1	50.7	6.7	45.1	6.6	42.9	6.2	38.0
15	C + B - A → P	3.3	10.1	7.0	48.7	11.3	127.3	8.4	70.7	7.9	62.8	7.8	60.1	7.3	52.7
	SE	0.41		0.76		0.43		0.60		0.53		0.37		0.31	
	CD (0.05)	1.19		2.21		1.26		1.74		1.52		1.08		0.89	

DAS = Days after spraying

T* = $\sqrt{x}$ transformed values

T = $\sqrt{x + 1}$ transformed values

O = Original values

Table 20c. Effect of treatments on drymatter production of weeds (g/m^2) during 1988-89

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T	O	T	O	T	O	T	O	T*	O	T	O	T*	O
1	Cc	18.2	330.8	24.8	615.3	26.2	685.7	19.8	394.7	19.0	360.5	17.4	302.3	17.3	298.8
2	C - WP	18.0	323.6	24.9	618.8	26.2	683.7	19.9	396.1	18.9	355.6	17.6	308.4	17.3	299.2
3	C + B - WP	16.6	278.0	23.5	553.5	24.5	599.3	16.5	274.1	15.4	237.9	10.7	112.9	10.5	110.8
4	C + B - WF	10.9	118.0	1.0	0.0	5.0	24.4	1.0	0.0	2.8	7.7	1.0	0.0	2.9	8.6
5	C + B - Sp	1.0	0.0	11.2	126.3	1.0	0.0	5.2	25.7	5.2	26.6	5.1	25.6	4.9	24.0
6	C + B - Si	1.0	0.0	14.3	203.3	1.0	0.0	10.0	98.3	9.7	93.8	6.7	44.5	6.6	43.4
7	C + B + CP	1.7	1.9	8.8	76.4	12.9	164.7	11.0	119.7	9.6	92.1	6.5	41.5	6.4	40.9
8	C + B + CP → P	1.6	1.7	8.3	69.3	12.4	153.7	5.3	27.5	5.3	27.9	5.7	31.7	5.6	31.2
9	C + B + CP → G	1.6	1.7	8.2	66.9	12.4	152.8	5.2	26.4	5.2	26.6	5.7	31.1	5.6	31.0
10	C + B - D	1.9	2.8	4.7	20.7	6.8	45.7	6.3	38.8	6.2	38.5	4.9	23.2	4.6	21.4
11	C + B - O	2.3	4.4	6.0	35.3	7.1	49.6	6.4	41.3	6.2	39.0	5.8	32.9	5.5	30.2
12	C + B - A	3.3	10.0	7.7	58.4	9.0	80.8	8.5	70.5	8.1	65.1	6.8	45.7	6.6	43.7
13	C + B - D → P	1.9	2.7	4.5	18.9	6.8	45.6	3.5	11.3	3.4	11.7	4.5	19.6	4.3	18.7
14	C + B - O → P	2.1	3.3	5.7	32.1	7.0	49.2	4.0	15.1	4.0	15.8	4.7	21.5	4.5	20.0
15	C + B - A → P	3.1	8.7	6.9	47.3	9.0	80.9	5.1	24.8	4.9	24.5	5.7	31.2	5.4	29.4
	SE	0.54		0.50		0.35		0.64		0.32		0.29		0.29	
	CD (0.05)	1.57		1.45		1.02		1.87		0.94		0.83		0.83	

DAS = Days after spraying
T* = $\sqrt{x}$ transformed values
T = $\sqrt{x + 1}$ transformed values
O = Original values

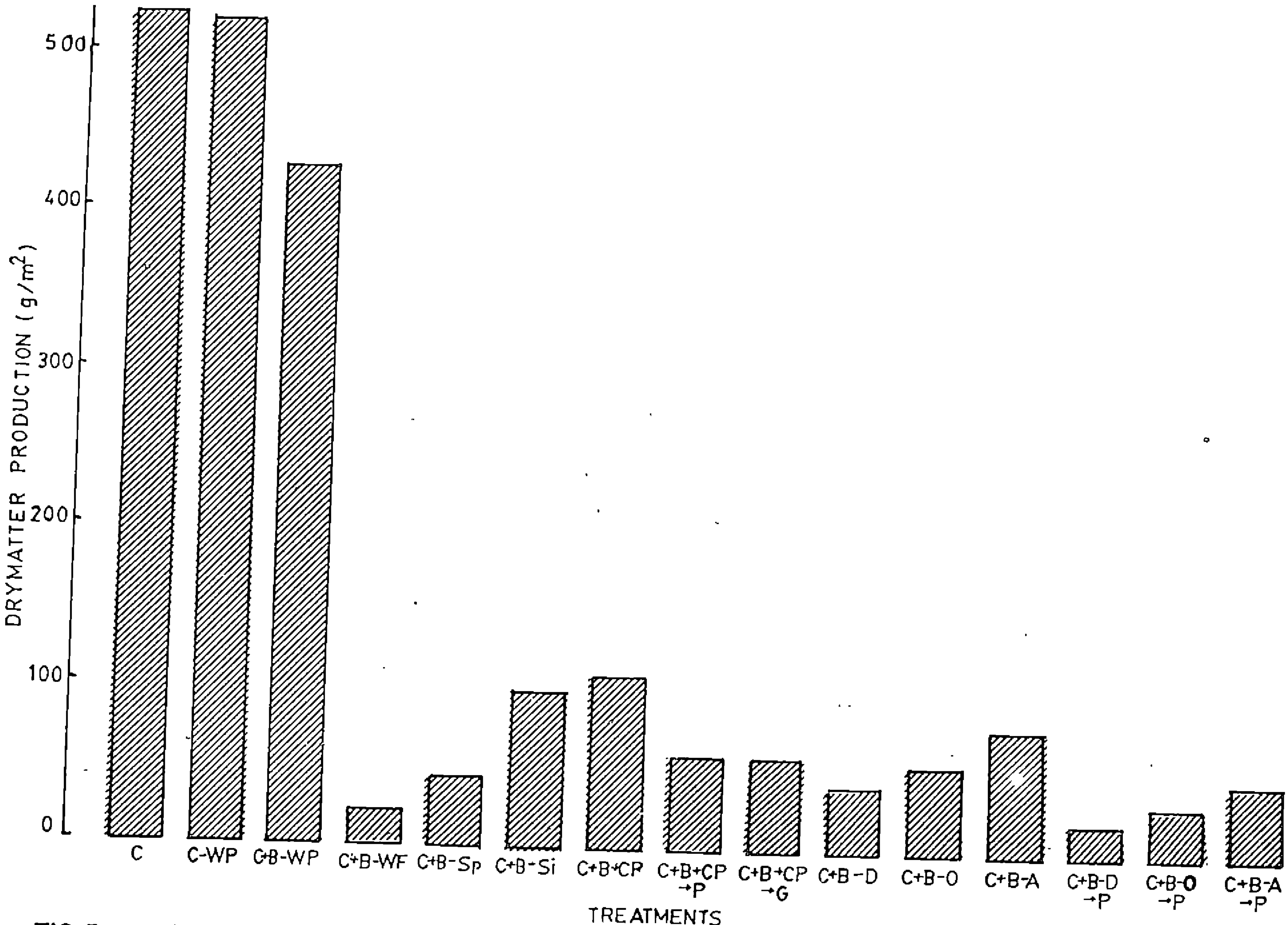

FIG. 5. DRYMATTER PRODUCTION OF WEEDS AS INFLUENCED BY TREATMENTS (AVERAGE OF 1987-'88 & 1988-'89)

persistence in soil which was also clear from the weed counts (Tables 19a, b and c).

The maximum drymatter accumulation was reached at 135 day stage and decreased thereafter. The decrease is because of the drying up of annual weeds including P. pedicellatum in summer. However, a comparison of t_{10} & t_{13}, t_{11} & t_{14} and t_{12} & t_{15} at 180 days indicated that subsequent application of paraquat could further reduce the drymatter production of weeds in plots already treated with pre-emergence herbicides. Among these, diuron followed by paraquat (t_{13}) was the most effective treatment (Plate 15). This might be due to the lesser weed population and drymatter accumulation consequent to diuron treatment. The treatment oxyfluorfen followed by paraquat (t_{14}) was on par with the above treatment during both first and third year eventhough it was inferior to the above treatment in 1987-88. However, atrazine followed by paraquat (t_{15}) was found to be significantly inferior to diuron followed by paraquat during the second and third year even if they were on par in the first year. This might be due to the lesser efficiency of atrazine in controlling monocots and perennial dicot weeds. Moreover, pre-emergence application of diuron alone was found to be as effective as atrazine followed by paraquat in reducing the weed drymatter production which again showed the superiority of diuron in controlling weeds in coconut-banana cropping system. Romney (1968) and Balasubramanian et al. (1985) also obtained good weed control in coconut plantation with diuron. Dhuria and Leela (1971) also recommended diuron for controlling weeds in banana. The comparable effect of oxyfluorfen with diuron in weed control was already reported by Rao and Kotoky (1981) in tea. The higher efficiency of diuron over atrazine in controlling weeds was also reported by Perez et al. (1986) in sugarcane. Leigh (1969) also obtained best results with diuron followed by paraquat in banana.

Intercropping of cowpea (t_7) was found to be very effective in bringing down the drymatter accumulation of weeds which was clear from the observation at 45 days. This might be due to the lesser weed growth as a result of fast growth and early ground coverage of cowpea (Plates 16 and 17). The observed drymatter accumulation at 90 and 135 days is attributed to the subsequent germination and growth of weeds after the harvest of cowpea. However, drymatter accumulation by these weeds could be reduced by the subsequent application of paraquat or glyphosate which was evident by a comparison of t_7, t_8 and t_9 at 180 days.

Spade weeding (t_5) could bring about significant reduction in the drymatter accumulation by weeds when compared to sickle weeding (t_6). This is also due to the lesser number of weeds in spade weeded plots compared to sickle weeded plots as is clear from the weed counts (Tables 19a, b and c). Moreover, spade weeding was found to be on par with oxyfluorfen followed by paraquat after giving the second spade weeding in October. Sickle weeding in turn also reduced the weed drymatter production significantly when compared to unweeded control even if it could not bring down the number of weeds. This is due to the large size of the weeds present in the unweeded control.

Among the unweeded controls, coconut + banana (t_3) recorded lower drymatter production of weeds compared to sole crop of coconut (t_1 and t_2) eventhough not significant at some stages. Growing banana as an intercrop in coconut garden could bring down the drymatter accumulation of weeds considerably. This reduction in weed drymatter production might be due to the reduced infiltration of light as the canopy of banana closes in.

1.4 Weed control efficiency

Weed control efficiency of different treatments were worked out for each year from the average values of the weed drymatter production in the respective treatments during that year.

The data on the weed control efficiency of different treatments in coconut+banana cropping system during each year of experiment are presented in Table 21. During all the three years the treatments diuron followed by paraquat (t_{13}), spade weeding (t_5), diuron (t_{10}) and atrazine followed by paraquat (t_{15}) were on par with weed free treatment (t_4). Oxyfluorfen followed by paraquat (t_{14}) was also on par with weed free treatment during the second and third year.

Data for the three years showed that among the pre-emergence herbicides, diuron recorded the highest weed control efficiency. It was followed by oxyfluorfen (t_{11}) during the second and third year. Subsequent application of paraquat in pre-emergence herbicide treated plots (t_{13}, t_{14} and t_{15}) resulted in a higher weed control efficiency. compared to application of pre-emergence herbicides alone (t_{10}, t_{11} and t_{12}).

Spade weeding recorded higher weed control efficiency compared to sickle weeding (t_6) and growing cowpea as an intercrop (t_7). Application of paraquat (t_8) or glyphosate (t_9) after the harvest of cowpea resulted in higher weed control efficiency compared to growing cowpea alone.

Table 21. Weed control efficiency (per cent) of different treatments

Tr. No.	Treatments	1986-87	1987-88	1988-89
1	Cc	-	-	-
2	C-WP	-6.1	0.8	-0.7
3	C+B-WP	22.5	11.5	27.2
4	C+B-WF	89.5	95.9	94.2
5	C+B-Sp	86.6	90.5	91.5
6	C+B-Si	77.2	78.7	81.9
7	C+B+CP	81.1	76.9	79.8
8	C+B+CP → P	85.1	88.5	87.3
9	C+B+CP → G	83.1	88.6	87.8
10	C+B-D	92.0	90.5	92.9
11	C+B-O	73.8	86.8	91.3
12	C+B-A	74.5	82.5	86.1
13	C+B-D → P	93.7	95.7	95.1
14	C+B-D → P	78.5	92.5	94.3
15	C+B-A → P	81.9	89.8	90.9
	SE	4.68	2.24	2.24
	CD (0.05)	13.62	6.52	6.53

Intercropping of banana in coconut garden (t_3) resulted in significantly higher weed control efficiency in all the three years than sole crop of coconut (t_1).

The higher weed control efficiency is the result of the effect of treatments in reducing the population and drymatter production of weeds, reasons for which have already been discussed.

1.4 Nutrient removal

The nitrogen, phosphorus and potassium removal by weeds were studied at 45 days interval from the start of the trial.

(a) Nitrogen

Unweeded controls (t_1, t_2 and t_3) recorded significantly higher nitrogen removal by weeds (Tables 22a, b and c). Among them, coconut intercropped with banana (t_3) recorded significantly lesser removal of nitrogen by weeds compared to sole crop of coconut (t_1 and t_2). All the weed control treatments could bring down the nitrogen removal by weeds significantly compared to no weeding.

Among the pre-emergence herbicides, diuron (t_{10}) was found to be the best in reducing the nitrogen removal by weeds.

Table 22a. Effect of treatments on N removal by weeds (kg ha^{-1}) during 1986-87

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS	
		T*	O	T	O	T*	O	T	O	T*	O	T	O
1	Cc	5.1	25.6	8.3	73.2	8.5	72.0	5.5	29.6	5.5	29.7	5.4	28.1
2	C-WP	5.0	24.7	8.5	73.0	8.8	77.3	5.7	31.0	5.8	33.4	5.1	25.5
3	C+B-WP	5.2	25.8	8.5	73.8	8.4	70.8	3.9	14.1	3.8	14.1	3.5	11.0
4	C+B-WF	5.0	24.1	1.0	0.0	1.1	1.2	1.0	0.0	0.6	0.3	1.0	0.0
5	C+B-Sp	5.1	25.3	1.0	0.0	1.3	1.7	1.7	2.0	1.4	2.0	2.1	3.6
6	C+B-Si	5.4	28.6	1.0	0.0	2.7	7.5	3.1	8.9	3.1	9.7	2.6	5.8
7	C+B+CP	1.1	0.3	3.5	11.4	3.9	14.9	3.3	9.8	2.8	8.0	2.6	5.8
8	C+B+CP → P	1.1	0.2	3.9	14.0	3.8	14.4	2.5	5.0	1.9	3.7	2.1	3.3
9	C+B+CP → G	1.1	0.3	3.7	12.6	3.6	13.3	2.7	6.2	2.3	5.1	2.3	4.3
10	C+B-D	1.1	0.2	2.4	4.7	2.2	4.7	2.3	4.5	1.8	3.1	1.7	2.0
11	C+B-O	1.2	0.4	4.9	22.8	4.7	22.2	3.3	9.7	2.8	7.7	1.9	2.7
12	C+B-A	1.4	0.9	4.8	22.3	4.7	21.8	3.5	11.1	3.3	10.8	2.2	3.7
13	C+B-D → P	1.1	0.2	2.2	4.0	2.0	3.8	2.1	3.4	1.7	3.0	1.6	1.5
14	C+B-O → P	1.2	0.5	4.7	21.6	4.7	22.4	2.3	4.2	1.8	3.2	1.6	1.7
15	C+B-A → P	1.4	0.9	4.8	21.9	4.3	18.4	2.4	4.8	2.0	3.9	1.9	2.5
	SE	0.30		0.58		0.61		0.07		0.07		0.13	
	CD (0.05)	0.88		1.69		1.78		0.20		0.22		0.38	

DAS = Days after spraying
T* = $\sqrt{x}$ transformed values
T = $\sqrt{x+1}$ transformed values
O = Original values

Table 22b. Effect of treatments on N removal by weeds (kg ha^{-1}) during 1987-88

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T	O	T	O	T	O	T	O	T*	O	T	O	T*	O
1	Cc	7.2	50.4	10.0	100.0	10.1	100.3	10.4	107.1	10.0	99.4	8.5	71.6	8.2	67.4
2	C - WP	7.0	48.3	9.6	91.8	10.1	101.1	10.8	116.1	9.2	85.4	8.1	64.2	7.8	60.3
3	C + B - WP	6.6	43.4	9.6	91.5	9.4	88.1	9.5	88.5	8.5	73.0	7.8	60.2	7.1	50.9
4	C + B - WF	4.6	19.8	1.0	0.0	2.2	3.8	1.0	0.0	1.8	3.3	1.0	0.0	1.7	2.9
5	C + B - Sp	1.0	0.0	5.0	23.9	1.0	0.0	3.6	12.0	3.1	9.3	3.4	10.7	2.6	6.8
6	C + B - Si	1.0	0.0	6.6	42.9	1.0	0.0	5.3	26.8	5.4	29.7	5.1	24.6	4.9	24.0
7	C + B + CP	1.1	0.2	3.5	11.1	5.9	33.5	6.2	37.0	4.4	19.5	4.2	16.7	4.0	15.6
8	C + B + CP → P	1.1	0.2	3.4	10.8	5.7	31.9	2.8	7.1	2.4	5.9	2.5	5.3	2.4	5.7
9	C + B + CP → G	1.1	0.2	3.3	9.7	6.1	36.0	2.8	6.9	2.4	5.9	2.6	5.8	2.2	5.0
10	C + B - D	1.4	0.9	2.0	3.0	3.2	9.4	3.7	12.7	3.2	10.0	3.2	9.4	3.3	10.8
11	C + B - O	1.5	1.1	2.5	5.4	3.6	12.4	4.4	18.2	3.8	14.3	3.8	13.6	3.9	15.2
12	C + B - A	1.7	1.9	2.7	6.2	4.2	16.6	5.2	26.0	4.7	22.2	4.3	17.5	4.5	20.7
13	C + B - D → P	1.3	0.8	1.8	2.3	3.5	11.1	2.0	2.9	1.7	2.9	1.9	2.6	1.6	2.6
14	C + B - O → P	1.4	0.9	2.4	4.9	3.7	12.8	2.7	6.6	2.6	6.9	2.6	5.8	2.5	6.0
15	C + B - A → P	1.7	1.9	2.7	6.3	4.4	18.7	3.4	10.4	3.3	11.1	3.1	8.8	2.9	8.4
	SE	0.14		0.27		0.16		0.22		0.21		0.[illegible]4		0.12	
	CD (0.05)	0.42		0.79		0.45		0.64		0.60		0.40		0.35	

DAS = Days after spraying
T* = $\sqrt{x}$ transformed values
T = $\sqrt{x + 1}$ transformed values
O = Original values

Table 22c. Effect of treatments on N removal by weeds (kg ha^{-1}) during 1988-89

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T	O	T	O	T	O	T	O	T*	O	T	O	T*	O
1	Cc	6.9	46.6	9.0	80.0	9.5	89.1	7.0	48.9	7.1	50.8	6.6	42.6	6.6	43.9
2	C - WP	6.8	45.6	9.4	87.3	9.9	96.4	7.4	53.5	7.1	50.1	6.8	45.3	6.6	44.0
3	C + B - WP	6.2	37.5	8.5	72.0	8.9	77.9	6.0	35.6	5.7	32.1	4.0	14.7	3.8	14.4
4	C + B - WF	4.2	16.6	1.0	0.0	2.1	3.3	1.0	0.0	1.1	1.2	1.0	0.0	1.2	1.4
5	C + B - Sp	1.0	0.0	4.3	17.8	1.0	0.0	2.3	4.2	2.0	3.9	2.2	3.8	2.0	3.8
6	C + B - Si	1.0	0.0	5.4	28.7	1.0	0.0	4.1	15.6	3.9	14.9	2.8	7.1	2.8	7.6
7	C + B + CP	1.1	0.3	3.4	10.3	5.0	24.2	4.4	18.2	3.7	13.5	2.7	6.1	2.3	5.5
8	C + B + CP → P	1.1	0.2	3.1	9.0	4.7	20.8	2.2	4.0	2.0	4.1	2.3	4.5	2.0	4.1
9	C + B + CP → G	1.1	0.2	3.2	9.4	4.7	21.5	2.2	3.9	1.9	3.7	2.3	4.4	2.0	4.2
10	C + B - D	1.2	0.4	1.9	2.7	2.6	5.9	2.5	5.5	2.3	5.4	2.0	3.0	1.8	3.3
11	C+ B - O	1.3	0.6	2.4	4.8	2.8	7.0	2.6	5.8	2.4	5.7	2.3	4.4	2.2	4.8
12	C + B - A	1.6	1.5	3.0	7.9	3.5	11.4	3.4	10.4	3.1	9.6	2.7	6.2	2.6	6.6
13	C + B - D → P	1.2	0.4	1.9	2.5	2.6	5.9	1.6	1.5	1.3	1.6	1.9	2.5	1.7	2.8
14	C + B - O → P	1.2	0.5	2.3	4.5	2.7	6.4	1.7	2.0	1.5	2.2	2.0	2.9	1.7	3.0
15	C + B - A → P	1.5	1.3	2.8	6.7	3.5	11.4	2.1	3.2	1.9	3.7	2.3	4.4	2.1	4.5
	SE	0.20		0.18		0.13		0.23		0.12		0.10		0.11	
	CD (0.05)	0.57		0.52		0.37		0.66		0.36		0.30		0.32	

DAS = Days after spraying

T* = $\sqrt{x}$ transformed values

T = $\sqrt{x + 1}$ transformed values

O = Original values

This is due to the higher efficiency of diuron in reducing the drymatter production of weeds. Oxyfluorfen (t_{11}) was found to be on par with diuron in most of the stages during second and third year eventhough it was inferior to diuron in most of the stages during the first year. This might be due to the comparable efficiency of diuron with oxyfluorfen in reducing weed drymatter production. However, atrazine (t_{12}) was significantly inferior to diuron throughout the experiment and to oxyfluorfen (t_{11}) in most of the stages during the second and third year. The attributed reason for this is the lesser efficiency of atrazine in reducing drymatter production of weeds compared to diuron and oxyfluorfen.

A comparison of t_{10} & t_{13}, t_{11} & t_{14} and t_{12} & t_{15} from 180 days indicated that nitrogen removal by weeds in pre-emergence herbicide treated plots could be reduced further by the subsequent application of paraquat. Among these, diuron followed by paraquat (t_{13}) was the best. Oxyfluorfen followed by paraquat (t_{14}) was on par with diuron followed by paraquat during the first and third year eventhough it was significantly inferior to diuron followed by paraquat during the second year. Atrazine followed by paraquat (t_{15}) was found to be as effective as oxyfluorfen followed by paraquat in the first and third year eventhough it was significantly inferior to oxyfluorfen followed by paraquat in the second year.

Nitrogen removal by weeds could be reduced by growing cowpea as an intercrop in the initial stages. After the harvest of cowpea there was an increase in nitrogen removal by weeds (90 and 135 days) which could be reduced by the subsequent application of paraquat or glyphosate (from 180 days).

Spade weeding (t_5) was found to be better than sickle weeding (t_6) in reducing the nitrogen removal by weeds. This is due to the higher efficiency of spade weeding in reducing drymatter production of weeds compared to sickle weeding.

(b) Phosphorus

Highest phosphorus removal by weeds was recorded by unweeded controls (t_1, t_2 and t_3). Among them, intercropping coconut with banana (t_3) recorded lesser phosphorus removal by weeds compared to sole crop of coconut (t_1 and t_2) in most of the stages eventhough the difference was not perceptible at some stages (Tables 23a, b and c). All weed control treatments could bring down the phosphorus removal by weeds compared to unweeded. This is due to the reduction in drymatter production of weeds brought about by the weed control treatments.

Table 23a. Effect of treatments on P removal by weeds (kg ha^{-1}) during 1986-87

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS	
		T	O	T	O	T*	O	T	O	T*	O	T	O
1	Cc	2.2	4.0	3.4	11.4	2.7	7.2	2.0	3.1	1.7	3.0	2.0	3.1
2	C-WP	2.3	4.4	3.7	13.0	2.4	5.9	2.0	3.1	1.3	1.8	2.0	3.1
3	C+B-WP	2.2	3.8	3.6	12.6	2.3	5.2	1.4	1.1	0.9	0.8	1.4	1.1
4	C+B-WF	2.3	4.3	1.0	0.0	0.4	0.2	1.0	0.0	0.2	0.0	1.0	0.0
5	C+B-Sp	2.2	3.8	1.0	0.0	0.5	0.2	1.0	0.1	0.4	0.2	1.1	0.3
6	C+B-Si	2.2	4.0	1.0	0.0	0.8	0.7	1.2	0.6	1.0	1.0	1.2	0.5
7	C+B+CP	1.0	0.0	1.7	1.8	1.3	1.6	1.4	1.0	0.6	0.4	1.2	0.4
8	C+B+CP → P	1.0	0.0	1.7	2.0	1.2	1.4	1.1	0.2	0.5	0.2	1.1	0.3
9	C+B+CP → G	1.0	0.0	1.7	1.7	1.4	1.9	1.3	0.6	0.5	0.3	1.2	0.4
10	C+B-D	1.0	0.0	1.3	0.8	0.7	0.5	1.1	0.3	0.5	0.2	1.1	0.2
11	C+B-O	1.0	0.1	2.1	3.5	1.5	2.2	1.4	0.9	0.8	0.6	1.1	0.2
12	C+B-A	1.1	0.1	2.0	3.1	1.3	1.7	1.4	1.0	0.8	0.7	1.1	0.2
13	C+B-D → P	1.0	0.0	1.2	0.5	0.7	0.5	1.1	0.2	0.4	0.2	1.0	0.1
14	C+B-O → P	1.0	0.1	1.9	2.7	1.7	2.8	1.1	0.2	0.4	0.2	1.1	0.1
15	C+B-A → P	1.1	0.1	1.9	2.4	1.6	2.5	1.1	0.3	0.5	0.2	1.1	0.2
	SE	0.11		0.22		0.19		0.01		0.02		0.03	
	CD (0.05)	0.32		0.65		0.54		0.04		0.05		0.10	

DAS = Days after spraying
T* = $\sqrt{x}$ transformed values
T = $\sqrt{x + 1}$ transformed values
O = Original values

Table 23b. Effect of treatments on P removal by weeds (kg ha^{-1}) during 1987-88

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T	O	T	O	T	O	T	O	T*	O	T	O	T*	O
1	Cc	3.1	8.6	3.6	11.9	2.9	7.4	3.8	13.2	3.3	10.8	2.7	6.3	2.7	7.3
2	C - WP	2.9	7.5	3.6	11.8	3.3	9.7	3.8	13.2	3.2	10.1	2.9	7.6	2.4	5.8
3	C + B - WP	2.5	5.1	3.5	11.3	2.8	7.1	3.2	9.3	2.6	6.7	2.6	5.6	2.2	4.9
4	C + B - WF	2.0	2.9	1.0	0.0	1.2	0.5	1.0	0.0	0.5	0.3	1.0	0.0	0.5	0.2
5	C + B - Sp	1.0	0.0	1.8	2.3	1.0	0.0	1.5	1.3	1.0	1.0	1.3	0.6	0.8	0.6
6	C + B - Si	1.0	0.0	2.3	4.1	1.0	0.0	2.3	4.2	1.6	2.4	1.7	1.8	1.1	1.3
7	C + B + CP	1.0	0.0	1.7	1.9	2.2	4.0	2.2	4.0	1.4	1.9	1.5	1.4	1.3	1.6
8	C + B + CP → P	1.0	0.0	1.6	1.5	2.2	3.9	1.3	0.8	0.7	0.5	1.2	0.5	0.6	0.4
9	C + B + CP → G	1.0	0.0	1.6	1.4	2.0	3.2	1.4	0.9	0.7	0.5	1.2	0.5	0.7	0.5
10	C + B - D	1.1	0.1	1.2	0.4	1.6	1.6	1.5	1.3	0.9	0.7	1.3	0.7	0.8	0.7
11	C + B - O	1.1	0.2	1.3	0.6	1.6	1.6	1.7	1.9	1.0	1.0	1.5	1.3	1.0	1.0
12	C + B - A	1.1	0.3	1.4	1.1	1.6	1.7	1.9	2.5	1.3	1.8	1.7	1.8	1.3	1.6
13	C + B - D → P	1.0	0.1	1.2	0.3	1.5	1.3	1.2	0.4	0.5	0.2	1.1	0.2	0.5	0.3
14	C + B - O → P	1.1	0.1	1.3	0.8	1.6	1.6	1.4	1.0	0.6	0.4	1.2	0.3	0.9	0.7
15	C + B - A → P	1.1	0.2	1.4	1.0	1.8	2.4	1.6	1.5	0.8	0.6	1.2	0.5	1.0	1.0
	SE	0.05		0.09		0.05		0.07		0.06		0.03		0.04	
	CD (0.05)	0.14		0.25		0.13		0.20		0.18		0.08		0.10	

DAS = Days after spraying

T* = $\sqrt{x}$ transformed values

T = $\sqrt{x+1}$ transformed values

O = Original values

Table 23c. Effect of treatments on P removal by weeds (kg ha^{-1}) during 1988-89

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T	O	T	O	T	O	T	O	T*	O	T	O	T*	O
1	Cc	2.8	6.9	3.7	12.9	3.1	8.9	2.5	5.1	2.4	5.8	2.2	3.9	2.0	3.9
2	C - WP	3.0	7.8	3.7	13.0	2.8	6.8	2.5	5.2	2.4	5.7	2.4	4.9	2.2	4.8
3	C + B - WP	2.3	4.5	3.6	11.6	3.0	7.8	2.1	3.6	2.0	3.8	1.6	1.5	1.2	1.4
4	C + B - WF	1.9	2.5	1.0	0.0	1.2	0.4	1.0	0.0	0.4	0.1	1.0	0.0	0.3	0.1
5	C + B - Sp	1.0	0.0	1.7	2.0	1.0	0.0	1.2	0.5	0.6	0.3	1.2	0.3	0.5	0.2
6	C + B - Si	1.0	0.0	2.3	4.3	1.0	0.0	1.6	1.6	1.2	1.5	1.3	0.6	0.7	0.4
7	C + B + CP	1.0	0.0	1.7	1.8	2.0	3.1	1.8	2.3	1.2	1.5	1.2	0.4	0.6	0.4
8	C + B + CP → P	1.0	0.0	1.6	1.7	1.9	2.5	1.2	0.4	0.6	0.4	1.1	0.3	0.6	0.4
9	C + B + CP → G	1.0	0.0	1.5	1.4	1.9	2.4	1.2	0.4	0.6	0.3	1.1	0.3	0.6	0.4
10	C + B - D	1.0	0.1	1.2	0.4	1.3	0.7	1.3	0.6	0.7	0.5	1.1	0.3	0.5	0.3
11	C + B - O	1.0	0.1	1.3	0.7	1.3	0.8	1.3	0.8	0.6	0.4	1.2	0.3	0.6	0.3
12	C + B - A	1.1	0.2	1.5	1.1	1.5	1.3	1.5	1.3	0.8	0.7	1.2	0.5	0.7	0.4
13	C + B - D → P	1.0	0.1	1.2	0.4	1.3	0.6	1.1	0.2	0.3	0.1	1.1	0.2	0.5	0.2
14	C + B - O → P	1.0	0.1	1.3	0.7	1.3	0.8	1.1	0.3	0.4	0.2	1.1	0.3	0.5	0.3
15	C + B - A → P	1.1	0.2	1.5	1.3	1.5	1.3	1.2	0.5	0.6	0.3	1.2	0.4	0.6	0.4
	SE	0.07		0.06		0.04		0.06		0.04		0.03		0.03	
	CD (0.05)	0.19		0.18		0.10		0.19		0.11		0.08		0.10	

DAS = Days after spraying
T* = $\sqrt{x}$ transformed values
T = $\sqrt{x + 1}$ transformed values
O = Original values

Among the pre-emergence herbicides, diuron (t_{10}) was the best in reducing phosphorus removal by weeds. This is due to the greater efficiency of diuron in bringing down the drymatter production of weeds. Oxyfluorfen (t_{11}) was found to be as effective as diuron in reducing phosphorus removal by weeds in most of the stages during the second and third year, eventhough it was significantly inferior to diuron in most of the stages during the first year. This is due to the comparable efficiency of oxyfluorfen with diuron in reducing the drymatter production of weeds. Atrazine (t_{12}) was found to be on par with oxyfluorfen but significantly inferior to diuron in most of the stages. This indicates the lesser efficiency of atrazine in bringing down the phosphorus removal by weeds which might be due to its lesser efficiency in controlling weeds.

Phosphorus removal by weeds in pre-emergence herbicide treated plots could be reduced further by the subsequent application of paraquat. Among these, diuron followed by paraquat (t_{13}) recorded the least phosphorus removal by weeds. This also is the result of lesser weed growth in the plots due to the better weed control efficiency of diuron.

Intercropping of cowpea (t_7) could reduce the phosphorus removal by weeds as is clear from the phosphorus uptake studies at 45 days. This is due to the fast growth of cowpea which thereby smoother the weeds. However, there was an increase in phosphorus removal by weeds after the harvest of cowpea due to the further germination of weeds which could be reduced by the subsequent application of paraquat (t_8) or glyphosate (t_9).

Spade weeding (t_5) was found to be better than sickle weeding (t_6) in reducing phosphorus removal by weeds. This might be due to the better efficiency of spade weeding in reducing drymatter production of weeds compared to sickle weeding.

(c) Potassium

Potassium removal by weeds also followed the same trend as in the case of nitrogen and phosphorus (Tables 24a, b and c). All the weed control treatments brought down the potassium removal by weeds significantly over unweeded controls (t_1, t_2 and t_3). Among the unweeded controls, intercropping coconut with banana (t_3) recorded lesser potassium removal by weeds compared to sole crop of coconut (t_1 and t_2) eventhough the difference was not conspicuous at some stages. This is due to the reduction in drymatter production of weeds as a result of intercropping.

Table 24a. Effect of treatments on K removal by weeds (kg ha^{-1}) during 1986-87

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS	
		T*	O	T	O	T*	O	T	O	T*	O	T	O
1	Cc	5.0	24.6	9.6	99.2	9.3	85.9	5.7	31.0	5.1	26.3	6.0	35.4
2	C-WP	4.9	23.8	9.7	94.6	9.2	85.0	5.6	30.6	5.1	26.1	6.0	35.4
3	C+B-WP	4.9	23.4	9.3	89.0	8.4	70.8	3.4	10.8	3.3	11.0	3.7	12.6
4	C+B-WF	4.9	22.8	1.0	0.0	1.1	1.2	1.0	0.0	0.4	0.2	1.0	0.0
5	C+B-Sp	4.9	23.4	1.0	0.0	1.4	2.0	1.5	1.4	1.0	1.0	1.8	2.3
6	C+B-Si	5.3	27.5	1.0	0.0	3.0	9.1	2.9	7.3	2.2	4.9	2.5	5.4
7	C+B+CP	1.1	0.2	3.4	10.9	3.8	14.2	2.9	7.5	2.3	5.2	2.5	5.1
8	C+B+CP → P	1.1	0.1	3.4	11.0	3.5	12.5	2.0	3.2	1.7	2.7	2.0	2.8
9	C+B+CP → G	1.1	0.2	3.3	9.8	4.0	16.3	2.3	4.5	1.8	3.3	2.1	3.5
10	C+B-D	1.1	0.2	2.4	4.9	1.8	3.2	1.7	1.7	1.4	2.0	1.6	1.5
11	C+B-O	1.2	0.3	5.2	26.1	4.1	17.0	2.8	7.1	2.2	4.9	1.9	2.5
12	C+B-A	1.4	1.0	6.6	43.3	4.6	21.4	3.0	7.9	2.4	5.6	2.0	3.1
13	C+B-D → P	1.1	0.2	2.4	4.8	1.6	2.7	1.8	2.2	1.3	1.7	1.4	1.0
14	C+B-O → P	1.2	0.5	5.7	32.0	4.9	23.8	1.9	2.7	1.5	2.3	1.6	1.5
15	C+B-A → P	1.4	1.0	5.2	26.2	4.4	19.6	2.0	3.1	1.8	3.1	2.0	3.0
	SE	0.30		0.67		0.64		0.06		0.06		0.14	
	CD (0.05)	0.86		1.94		1.85		0.17		0.17		0.40	

DAS = Days after spraying
T* = $\sqrt{x}$ transformed values
T = $\sqrt{x+1}$ transformed values
O = Original values

Table 24b. - Effect of treatments on K removal by weeds (kg ha^{-1}) during 1987-88

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T	O	T	O	T	O	T	O	T*	O	T	O	T*	O
1	Cc	7.2	51.1	11.7	135.5	15.3	234.0	10.8	115.4	8.9	79.8	7.2	50.2	7.9	61.9
2	C - WP	7.0	48.3	11.5	131.8	15.4	235.9	10.6	111.2	8.5	71.4	7.0	47.6	7.7	59.4
3	C + B - WP	6.6	42.8	11.0	119.7	14.8	216.8	9.0	80.6	7.1	50.7	6.6	42.7	6.6	43.4
4	C + B - WF	3.9	14.4	1.0	0.0	3.0	7.8	1.0	0.0	1.4	2.0	1.0	0.0	1.3	1.8
5	C + B - Sp	1.0	0.0	6.3	38.9	1.0	0.0	3.0	7.9	2.4	5.5	2.3	4.6	2.0	4.0
6	C + B - Si	1.0	0.0	7.7	58.7	1.0	0.0	4.8	22.1	3.4	11.9	3.2	9.5	3.5	12.5
7	C + B + CP	1.1	0.2	3.3	10.1	7.4	53.4	5.9	33.5	3.9	14.9	3.6	12.2	3.6	13.2
8	C + B + CP → P	1.1	0.2	3.1	9.1	7.2	50.3	2.4	4.8	2.0	4.0	2.1	3.5	2.0	3.9
9	C + B + CP → G	1.1	0.2	3.2	9.3	7.3	52.6	2.4	4.7	2.0	4.2	2.1	3.5	1.9	3.7
10	C + B - D	1.4	1.0	2.2	3.8	4.3	17.8	3.2	9.2	2.2	5.0	2.3	4.4	2.4	5.6
11	C + B - O	1.5	1.3	2.9	7.4	5.1	24.9	3.9	14.2	2.7	7.1	2.8	7.0	3.1	9.5
12	C + B - A	2.0	3.0	3.4	10.4	6.4	40.2	4.5	19.1	3.5	12.3	3.5	11.2	4.1	16.8
13	C + B - D → P	1.3	0.8	2.0	3.2	4.2	16.9	1.7	1.8	1.3	1.6	1.4	1.0	1.2	1.4
14	C + B - O → P	1.4	1.0	2.7	6.7	5.5	29.6	2.4	5.0	2.0	4.0	2.0	3.0	2.0	3.9
15	C + B - A → P	1.8	2.2	3.4	10.5	6.4	40.1	2.9	7.3	2.4	5.7	2.4	4.7	2.6	7.0
	SE	0.15		0.31		0.22		0.21		0.16		0.10		0.10	
	CD (0.05)	0.43		0.90		0.63		0.61		0.47		0.28		0.30	

DAS = Days after spraying

T* = $\sqrt{x}$ transformed values

T = $\sqrt{x + 1}$ transformed values

O = Original values

Table 24c. Effect of treatments on K removal by weeds (kg ha^{-1}) during 1988-89

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T	O	T	O	T	O	T	O	T*	O	T	O	T*	O
1	Cc	7.0	48.0	9.0	80.0	13.1	171.4	6.7	44.6	5.9	35.3	5.5	28.7	6.2	38.2
2	C - WP	6.9	46.3	9.0	80.4	12.5	155.9	6.7	43.6	5.9	34.8	5.4	27.8	6.3	39.2
3	C + B - WP	5.7	32.0	8.3	68.1	11.4	128.9	5.6	30.2	4.5	20.2	3.3	10.2	3.5	12.5
4	C + B - WF	4.0	15.3	1.0	0.0	2.4	4.7	1.0	0.0	0.8	0.6	1.0	0.0	0.9	0.8
5	C + B - Sp	1.0	0.0	4.2	16.4	1.0	0.0	2.0	3.0	1.6	2.7	1.8	2.3	1.5	2.2
6	C + B - Si	1.0	0.0	5.3	27.0	1.0	0.0	3.5	11.3	3.0	9.2	2.2	3.8	2.1	4.3
7	C + B + CP	1.1	0.2	3.3	9.9	5.7	31.8	4.2	16.8	3.0	9.2	2.1	3.5	2.2	4.7
8	C + B + CP → P	1.1	0.2	3.2	9.4	5.4	27.7	1.9	2.7	1.5	2.2	1.8	2.4	1.7	3.0
9	C + B + CP → G	1.1	0.2	3.1	8.7	5.3	27.5	1.9	2.5	1.5	2.1	1.8	2.3	1.7	3.0
10	C + B - D	1.1	0.3	1.8	2.2	2.7	6.4	2.3	4.3	1.5	2.3	1.5	1.4	1.4	1.9
11	C + B - O	1.2	0.4	2.3	4.3	3.2	9.2	2.4	4.7	1.6	2.7	1.7	2.0	1.8	3.4
12	C + B - A	1.5	1.3	3.0	8.2	4.6	20.2	3.2	9.4	2.4	5.7	2.1	3.6	2.4	5.6
13	C + B - D → P	1.1	0.3	1.8	2.1	2.8	7.1	1.4	1.0	0.9	0.9	1.5	1.2	1.2	1.5
14	C + B - O → P	1.2	0.4	2.3	4.3	3.2	9.5	1.6	1.5	1.1	1.3	1.6	1.6	1.5	2.2
15	C + B - A → P	1.4	1.1	3.1	8.7	4.6	20.2	1.9	2.5	1.5	2.2	1.9	2.5	1.9	3.6
	SE	0.19		0.18		0.16		0.21		0.09		0.08		0.11	
	CD (0.05)	0.54		0.51		0.47		0.60		0.27		0.23		0.31	

DAS = Days after spraying

T* = $\sqrt{x}$ transformed values

T = $\sqrt{x + 1}$ transformed values

O = Original values

Among the pre-emergence herbicides, diuron (t_{10}) was the best in reducing potassium removal by weeds followed by oxyfluorfen (t_{11}). Eventhough atrazine (t_{12}) was on par with oxyfluorfen during the first year, it was found to be significantly inferior to oxyfluorfen in most of the stages during the second and third year. This shows the better efficiency of diuron and lesser efficiency of atrazine in reducing potassium removal by weeds.
The increased potassium removal by weeds in atrazine treated plots also might be due to the presence of more grassy weeds.

The potassium removal by weeds in pre-emergence herbicides treated plots could be further reduced by the subsequent application of paraquat. Among them, diuron followed by paraquat (t_{13}) was the best. Oxyfluorfen followed by paraquat (t_{14}) was on par with diuron followed by paraquat during the first and the third year eventhough it was significantly inferior to diuron followed by paraquat during the second year. However, atrazine followed by paraquat (t_{15}) recorded more potassium removal by weeds compared to the above two treatments. This might also be due to the presence of more grassy weeds in atrazine treated plots.

Growing cowpea as an intercrop (t_7) resulted in significant reduction in potassium removal by weeds which was clear from the potassium uptake studies at 45 days. This might also be due to the lesser germination of weeds as a result of early ground coverage by the cowpea. However, after the harvest of cowpea there was an increase in potassium removal by weeds (90 and 135 days) which could be reduced significantly by the following application of paraquat or glyphosate (from 180 days onwards).

Among the manual methods of weed control, spade weeding (t_5) resulted in significantly lesser potassium removal by weeds compared to sickle weeding (t_6). This might also be due to the better efficiency of spade weeding in reducing drymatter production of weeds compared to sickle weeding.

2. Crops

2.1 Coconut

2.1.1 Growth characters

The growth of four year old coconut palms was measured in terms of girth and number of fronds at yearly interval. In the third year of the experiment the data could not be recorded from unweeded control (t_1) due to the destruction of young palms by the overgrown weeds.

(a) Girth

Data presented in Table 25 showed that the weed control treatments could not bring about significant

Table 25. Effect of treatments on growth characters of coconut

Tr. No.	Treatments	Girth (cm)			No. of fronds		
		1987	1988	1989	1987	1988	1989
1	Cc	63.1	68.9	-	8.9	10.6	-
2	C-WP	67.8	78.5	88.7	9.1	11.3	12.0
3	C+B-WP	69.1	81.8	93.2	9.1	11.4	11.9
4	C+B-WF	69.7	85.3	99.3	9.3	13.8	14.3
5	C+B-Sp	69.4	81.3	93.0	9.1	13.4	14.0
6	C+B-Si	68.4	80.2	91.8	9.1	11.8	12.2
7	C+B+Cp	68.3	79.3	91.2	9.1	11.9	12.5
8	C+B+CP → P	69.2	81.1	92.8	9.1	12.6	13.2
9	C+B+CP → G	68.7	81.1	93.2	9.1	13.0	13.5
10	C+B - D	70.2	82.0	93.6	9.1	12.9	13.6
11	C+B-O	69.3	81.6	92.3	9.1	12.9	13.6
12	C+B-A	68.7	80.8	90.6	9.1	12.2	13.1
13	C+B-D → P	70.3	82.6	94.4	9.3	13.3	13.9
14	C+B-O → P	70.6	82.7	92.7	9.3	13.1	13.8
15	C+B-A → P	69.2	81.0	92.3	9.1	12.6	13.3
	SE	1.24	1.90	2.29	0.15	0.45	0.46
	CD (0.05)	NS	5.53	NS	NS	1.33	1.38

NS = Not significant

influence on the girth of coconut after three years of experiment. However, unweeded control (t_1) recorded the lowest girth of coconut during 1987 and 1988. Highest girth of coconut was recorded by weed free treatment (t_4) during 1988 and 1989. The girth of coconut recorded by spade weeding (t_5) was found to be more than that recorded by sickle weeding (t_6). Growing cowpea as an intercrop followed by the application of paraquat (t_8) or glyphosate (t_9) resulted in a slightly higher girth of coconut compared to growing cowpea alone (t_7). Among the pre-emergence herbicides, application of diuron (t_{10}) resulted in a higher girth of coconut followed by oxyfluorfen (t_{11}). Similarly, application of diuron followed by paraquat (t_{13}) and oxyfluorfen followed by paraquat (t_{14}) recorded more girth of coconut compared to atrazine followed by paraquat (t_{15}).

The lowest girth of coconut recorded by unweeded control during 1987 and 1988 and the subsequent death of young palms in the above treatment during 1989 might be due to the continuous competition by weeds for soil moisture and nutrients. The absence of weed competition, periodical addition of green matter of weeds to coconut and more uptake of nutrients by coconut might be the reasons for the highest girth of coconut in weed free plot. Spade weeding was found more efficient than sickle weeding. The attributed reason for this is the more addition of green matter of weeds to coconut at the time of spade weeding and the lesser competition by weeds for soil moisture and nutrients.

The weeds germinated after the harvest of cowpea were controlled by the application of paraquat or glyphosate in treatments t_8 and t_9 respectively, thereby reduced their competition for soil moisture and nutrients. This is the attributed reason for the slightly higher coconut girth in the above treatments (t_8 and t_9) compared to growing cowpea alone (t_7).

Among the pre-emergence herbicide treatments, the higher weed control efficiency of diuron and oxyfluorfen lead to a lesser weed competition and resulted in a slightly higher girth of coconut compared to atrazine (t_{12}). Subsequent application of paraquat in diuron (t_{13}) and oxyfluorfen (t_{14}) treated plots resulted in still lesser competition by weeds for moisture and nutrients. This might be the reason for the incfease in girth of coconut in t_{13} and t_{14} compared to that in t_{10} and t_{11}. Fig.6 showed that the treatments which conserved higher soil moisture also resulted in higher girth of coconut.

This emphasise the importance of weed control in young coconut plantations. Deleterious effects of unchecked

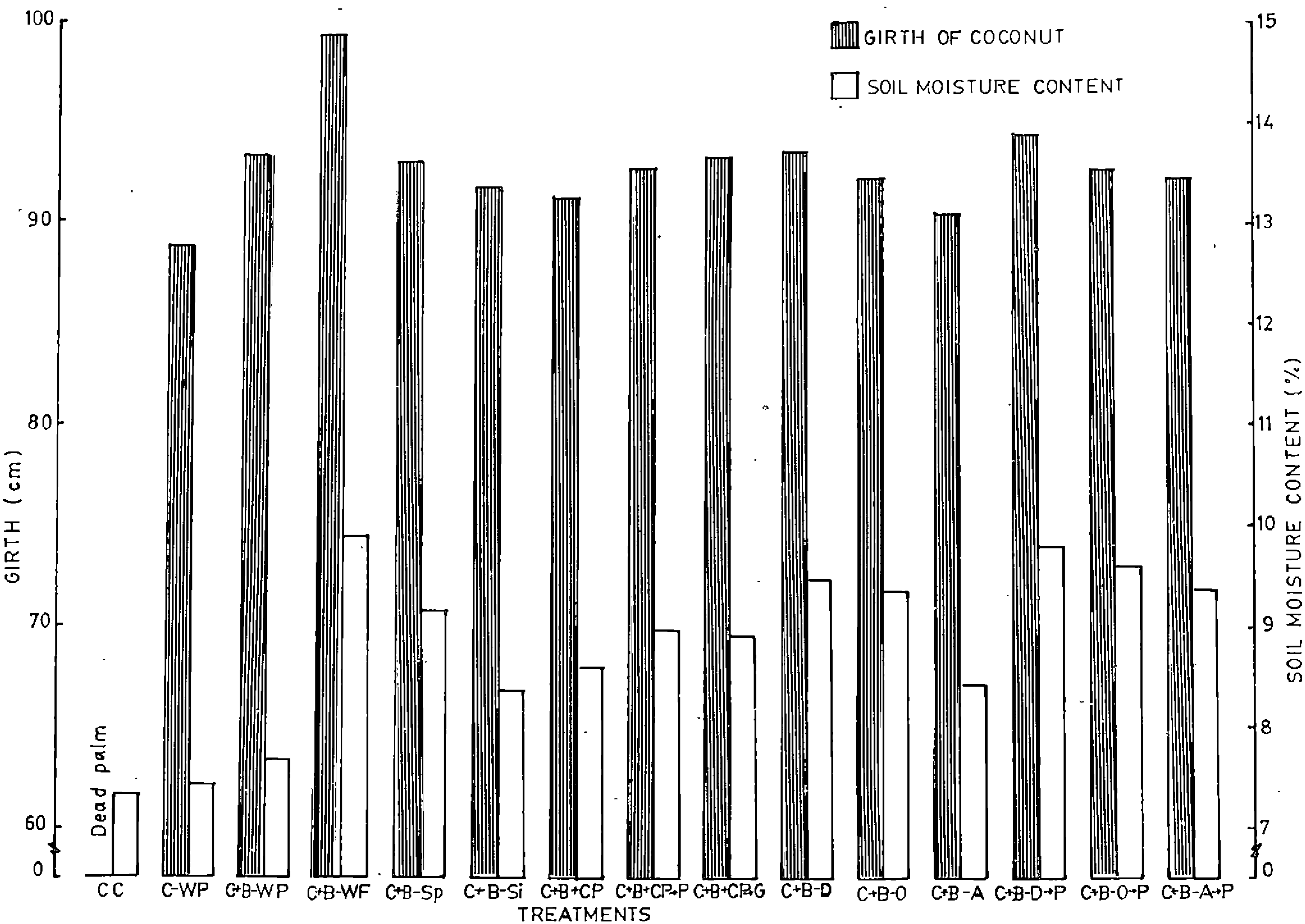

FIG. 6. GIRTH OF COCONUT (1989) AND SOIL MOISTURE CONTENT (1987) AS INFLUENED BY TREATMENTS

weed competition on the growth of coconut have been reported by Jagoe (1938), Rajpakse (1950), Marar (1953), Kurup (1955), Albuquerque and Ibrahim (1956) and Nair (1960).

The data clearly showed that the applied chemicals did not have any adverse effects on the girth of coconut. Similar results were reported by Chandapillai and Barnes (1973) and Juan et al. (1981).

(b) Number of fronds

The data presented in Table 25 showed that unweeded control (t_1) recorded the least number of fronds during 1987 and 1988. Highest number of fronds was recorded by weed (free (t_4) and it was found to be significantly superior to weeding in pits of coconut (t_2 and t_3), sickle weeding (t_6) and growing cowpea as an intercrop (t_7) during 1989. Spade weeding twice (t_5) recorded number of fronds of coconut on par with that of weed free. The number of fronds recorded by sickle weeding (t_6) was found to be more than that in weeding in pits (t_2 and t_3) but significantly lesser than that in weed free and spade weeding twice.

Raising cowpea as an intercrop (t_7) resulted in a higher number of fronds compared to weeding in pits (t_3). Subsequent application of paraquat (t_8) or glyphosate (t_9)

in cowpea grown plots resulted in an increase in the number of fronds compared to growing cowpea alone.

Among the pre-emergence herbicides, application of diuron (t_{10}) and oxyfluorfen (t_{11}) resulted in a slightly higher number of fronds compared to atrazine (t_{12}). Subsequent application of paraquat in diuron (t_{13}) and oxyfluorfen (t_{14}) treated plots resulted in a slight increase in the number of fronds compared to application of diuron and oxyfluorfen alone.

The least number of fronds in the unweeded control might be the result of deleterious effect of continuous weed competition on the growth of coconut. Weed free recorded the highest number of fronds and was found significantly superior to weeding in pits (t_3). The attributed reasons for this is the favourable growth conditions provided by the absence of weed competition and the periodical addition of green matter of weeds.

The probable reason for the equal effectiveness of spade weeding to that of weed free is the more addition of weed green matter to coconut at the time of spade weeding. The lesser effectiveness of sickle weeding over spade weeding might be due to the lesser addition of weed green matter compared to spade weeding. Moreover, in spade weeding the complete weed growth was removed whereas in sickle weeding small weeds and stubbles were left as such which again absorb moisture and nutrients.

The slightly better performance of raising cowpea as an intercrop over weeding in pits might be the result of addition of 20 kg of cowpea green matter to coconut. After the harvest of cowpea there was germination of weeds and the control of which by a subsequent application of either paraquat or glyphosate lead to a reduction in competition by weeds for moisture and nutrients. This is probably the reason for the better performance of the treatments t_8 and t_9 over t_7.

As in the case of girth of coconut, the better weed control efficiency of diuron and oxyfluorfen compared to atrazine had reflected in the number of fronds also. Subsequent application of paraquat in diuron and oxyflyorfen treated plots reduced the weed competition still further and added some amount of organic matter to the soil and resulted in a slightly higher number of fronds compared to application of diuron (t_{10}) and oxyfluorfen (t_{11}) alone.

The data showed that any of the applied herbicides did not affect the number of fronds adversely. Similar results were also reported by Anon (1966b) and Juan et al.(1981)

2.2 Banana

2.2.1 Growth characters

The growth of banana was measured in terms of height of pseudostem, girth of pseudostem, number of functional leaves and leaf area at the time of shooting. These results are presented and discussed characterwise in the following pages.

(a) Height of pseudostem

In general, ratoon crop was taller than the plant crop (Tables 26 and 27). Banana plants in weed free treatment (t_4) recorded the maximum plant height and those in the unweeded control (t_3) had the lowest height both in the case of plant crop and ratoon crop. In plant crop, all weed control treatments recorded significantly more plant height compared to unweeded control, whereas in ratoon crop weed free was the only treatment significantly superior to unweeded control. However, the same trend could be observed in both the crops.

Spade weeding (t_5) as well as growing cowpea as an intercrop (t_7) recorded more plant height compared to sickle weeding (t_6) eventhough the difference was not statistically significant. Cowpea followed by application of paraquat (t_8)

Table 26. Effect of treatments on growth characters of banana at shooting - Plant crop

Tr. No.	Treatments	Height (cm)	Girth (cm)	Functional leaves	Leaf area (m^2)	Days for shooting	Days for maturity
1	Cc	-	-	-	-	-	-
2	C-WP	-	-	-	-	-	-
3	C+B-WP	166.5	37.5	8.5	0.50	400.0	488.7
4	C+B - WF	238.0	55.5	11.3	0.93	365.3	450.3
5	C+B-Sp	204.8	48.0	10.8	0.79	357.3	442.3
6	C+B-Si	199.7	45.5	9.7	0.75	372.3	458.3
7	C+B+Cp	200.0	46.5	10.3	0.75	366.0	452.0
8	C+B+CP → P	211.2	48.8	10.5	0.77	366.0	451.0
9	C+B+CP → G	214.3	48.7	10.5	0.81	366.0	451.0
10	C+B - D	211.7	49.0	10.7	0.79	359.3	444.3
11	C+B - O	211.5	48.0	10.7	0.78	361.7	446.7
12	C+ B-A	200.2	45.8	10.0	0.75	354.0	439.0
13	C+B-D → P	216.6	50.8	10.8	0.80	354.0	439.0
14	C+B-O → P	215.5	49.8	10.8	0.80	357.3	442.3
15	C+B-A → P	210.0	48.8	10.5	0.77	359.3	444.3
	SE	8.46	1.86	0.41	0.05	3.74	3.75
	CD (0.05)	24.70	5.44	1.20	0.16	10.92	10.93

Table 27. Effect of treatments on growth characters of banana at shooting - Ratoon crop

Tr. No.	Treatments	Height (cm)	Girth (cm)	Functional leaves	Leaf area (m^2)
1	Cc	-	-	-	-
2	C-WP	-	-	-	-
3	C+B-WP	270.2	60.5	9.8	1.0
4	C+B-WF	336.7	74.5	13.5	1.5
5	C+B-Sp	313.0	71.3	13.5	1.4
6	C+B-Si	298.7	66.7	12.3	1.3
7	C+B+Cp	302.0	68.7	12.5	1.4
8	C+B+CP → P	305.3	69.8	13.0	1.4
9	C+B+CP → G	307.7	69.8	13.0	1.4
10	C+B-D	309.2	70.8	13.2	1.4
11	C+B-G	308.2	70.5	13.2	1.4
12	C+B-A	301.3	67.7	12.3	1.3
13	C+B-D → P	313.2	70.8	13.3	1.5
14	C+B-O → P	312.2	70.8	13.3	1.5
15	C+B-A → P	307.8	69.2	12.8	1.4
	SE	16.39	3.45	0.46	0.13
	CD (0.05)	NS	NS	1.35	NS

NS - Not significant

or glyphosate (t_9) resulted in a still better height of pseudostem compared to growing cowpea alone.

Among the pre-emergence herbicides, application of diuron (t_{10}) recorded the maximum plant height which was closely followed by oxyfluorfen (t_{11}). Application of paraquat in pre-emergence herbicide treated plots (t_{13}, t_{14} and t_{15}) resulted in a slight increase in height of pseudostem compared to application of pre-emergence herbicides alone (t_{10}, t_{11} and t_{12}). Among them, more plant height was recorded by diuron followed by paraquat (t_{13}) and oxyfluorfen followed by paraquat (t_{14}).

The continuous unchecked weed competition for soil moisture and nutrients might be the reason for the lowest height of banana plants in the unweeded control plot (Plate 23). The tallest plants in the weed free plot might be the result of the conducive growth condition provided by the absence of weed competition due to periodical weeding and more uptake of nutrients by banana (Plate 24).

In plant crop, all weed control treatments recorded significantly more plant height compared to unweeded control whereas in ratoon crop weed free was the only treatment significantly superior to unweeded control. This might be due to the fact that the crop weed competition was more in the plant crop especially in the early stages and the same was less in ratoon crop as a result of shading by banana.

In spade weeding, the weeds were completely removed by scraping the ground whereas in sickle weeding only the top growth of weeds was cut and removed leaving the stubbles and small weeds which again compete with the crop for moisture and nutrients. This might be the probable reason for the better performance of spade weeding over sickle weeding.

In cowpea grown plots, the addition of six kg green matter of cowpea to banana might have resulted in a slight better performance compared to sickle weeding. The subsequent application of paraquat or glyphosate in cowpea grown plots lead to a further reduction in weed competition, addition of some amount of organic matter to the soil and more uptake of nutrients by banana. This is the attributed reasons for the slight increase in height of pseudostem in the above treatments compared to growing cowpea alone.

The better weed control efficiency of diuron and oxyfluorfen compared to atrazine might have reflected in the height of pseudostem in the former two treatments. Subsequent application of paraquat in diuron and oxyfluorfen treated plots has lead to a slight increase in height of pseudostem compared to application of diuron and oxyfluorfen alone probably because, these two treatments have resulted in still further reduction of weed competition, addition of some organic matter to soil and more uptake of nutrients by banana.

(b) Girth of pseudostem

In general, ratoon crop had more girth of pseudostem than the plant crop (Tables 26 and 27). Lowest girth of pseudostem was observed in unweeded control (t_3) and the highest in weed free treatment (t_4) both in the plant and ratoon crops. In plant crop, all weed control treatments could bring about significant increase in the girth of banana compared to unweeded control whereas in ratoon crop, only weed free treatment and spade weeding (t_5) were found significantly superior to unweeded control. However, the same beneficial effect could be observed in both the crops.

Spade weeding and intercropping of cowpea (t_7) resulted in a higher girth of banana compared to sickle weeding (t_6) eventhough not significant. The application of paraquat (t_8) of glyphosate (t_9) in cowpea grown plots resulted in a still better girth of banana compared to growing cowpea alone.

Among the pre-emergence herbicides, application of diuron (t_{10}) recorded the highest girth of banana followed by oxyfluorfen (t_{11}). Subsequent application of paraquat in diuron (t_{13}) and oxyfluorfen (t_{14}) treated plots lead to a slight increase in the girth of pseudostem over that of diuron and oxyfluorfen alone.

Severe weed competition for soil moisture and nutrients might be the reason for the lowest girth of banana in the unweeded control plot (Plate 23). On the contrary, the periodical weeding in weed free plot might have provided the most favourable growth conditions for banana and resulted in highest girth of pseudostem (Plate 24). The better performance of spade weeding over sickle weeding might be due to the same reasons that have discussed earlier.

The beneficial effect of the addition of six kg of cowpea green matter to banana in cowpea intercropped plots might have lead to an increase in the girth of banana over sickle weeding. Over and above the addition of cowpea green matter to banana, the control of weeds germinated after the harvest of cowpea by the application of paraquat or glyphosate resulted in a further reduction of weed competition, addition of some organic matter to soil and more uptake of nutrients by banana. This might be the probable reasons for the better performance of the above treatments compared to growing cowpea alone.

The attributed reason for the more girth of banana in diuron and oxyfluorfen treated plots compared to atrazine is their better weed control efficiency (Table 21) which resulted in lesser weed competition for soil moisture and nutrients. Further reduction in weed competition and addition of some amount of organic matter to soil by the subsequent application of paraquat in diuron and oxyfluorfen treated plots might be the reasons for a still better performance of these treatments over application of diuron and oxyfluorfen alone.

(c) Number of functional leaves

The data presented in Tables 26 and 27 showed that at shooting, the ratoon crop recorded more number of functional leaves compared to plant crop. However, both in plant crop and ratoon crop, at shooting, highest number of functional leaves was recorded by weed free (t_4) and the lowest by unweeded control (t_3). In plant crop, all weed control treatments except sickle weeding (t_6) and atrazine (t_{12}) recorded higher number of functional leaves and was on par with weed free treatment whereas in ratoon crop the number of functional leaves recorded by all weed control treatments were on par with weed free. However, the same trend could be observed in both the crops.

Spade weeding (t_5) recorded a higher number of functional leaves compared to sickle weeding eventhough not significant. Growing cowpea as an intercrop (t_7) also showed a better performance over sickle weeding. Subsequent application of paraquat (t_8) or glyphosate (t_9) in cowpea grown plots resulted in a trend in increasing the number of functional leaves over growing cowpea alone.

Among the pre-emergence herbicides, application of diuron (t_{10}) and oxyfluorfen (t_{11}) resulted in a more number of functional leaves over application of atrazine (t_{12}). Subsequent application of paraquat in diuron (t_{13}) and oxyfluorfen (t_{14}) treated plots showed a trend in increasing the number of functional leaves over the application of diuron and oxyfluorfen alone.

(d) Leaf area

As in the case of other growth characters, area of the index leaf (3rd leaf from the top) was more in ratoon crop compared to plant crop (Table 26 and 27). In both plant crop and ratoon, maximum leaf area was recorded by weed free treatment (t_4) and the minimum by unweeded control (t_3). The effect of treatments on leaf area followed almost the same trend in plant crop as well as in ratoon crop.

Spade weeding (t_5) recorded a slightly higher leaf area compared to sickle weeding (t_6). The favourable influence of growing cowpea as an intercrop (t_7) on leaf area over sickle weeding was observed in ratoon crop. In plant crop, application of paraquat or glyphosate in cowpea grown plots (t_8 and t_9) resulted in an increase in leaf area compared to growing cowpea alone.

Application of diuron (t_{10}) and oxyfluorfen (t_{11}) resulted in a higher leaf area compared to atrazine (t_{12}) in both plant and ratoon crop. Subsequent application of paraquat in diuron (t_{13}) and oxyfluorfen (t_{14}) treated plots resulted in an increase in leaf area over the application of diuron and oxyfluorfen alone.

The results presented above revealed that the applied herbicides did not have any adverse effects on the growth of banana. Similar results were also reported by Leigh (1969). Seeyave and Phillips (1970) also noted taller banana plants with more girth in clean weeded plots. Ndubizu (1985) also observed favourable effect of weed control on leaf production and leaf area of plantain.

(e) Number of days taken for shooting and maturity

Effects of different weed control treatments on the number of days taken for shooting and maturity of plant crop are presented in Table 26. From the data it can be observed that banana plants in all weed control treatments took significantly lesser number of days for shooting and maturity compared to those in unweeded control plots. The attributed reason for this delayed shooting and maturity of banana in unweeded control plot is the severe weed competition. Delayed maturity of banana due to weed competition was also reported by Kasasian and Seeyave (1968) and early bearing of banana in clean weeded plots was also observed by Seeyave and Phillips (1970).

2.2.2 Yield and yield attributes

The bunch yield and yield attributes of banana such as number of hands per bunch, number of fingers per bunch, length of bunch and weight of hands per bunch were recorded at the time of harvest and the results are presented and discussed characterwise in the following pages.

(a) Number of hands per bunch

The data presented in Tables 28 and 29 showed that ratoon crop produced more number of hands per bunch compared to plant crop. However, in both the crops highest number of hands per bunch was recorded by weed free treatment (t_4) and the lowest by unweeded control (t_3). Moreover, in plant crop as well as in ratoon crop, the number of hands per bunch recorded by all weed control treatments were significantly superior to that recorded by unweeded control. Over and above this, the effect of treatments showed almost the same trend in both the crops.

Table 28. Effect of treatments on yield and yield attributes of banana - Plant crop

Tr. No.	Treatments	Hands per bunch	Fingers per bunch	Length of bunch (cm)	Wt.of hands per bunch (kg)	Bunch yield (kg ha^{-1})	Weed index (%)
1	Cc	-	-	-	-	-	-
2	C-WP	-	-	-	-	-	-
3	C+B-WP	5.0	59.3	20.7	3.1	5554.2	41.9
4	C+B-WF	8.5	102.0	33.2	5.3	9553.2	-
5	C+B-Sp	8.2	95.8	32.8	5.3	9020.0	5.7
6	C+B-Si	7.3	85.8	29.0	4.7	8042.4	15.6
7	C+B+CP	7.7	90.0	30.0	4.8	8442.3	11.4
8	C+B+CP → P	8.0	92.2	31.3	5.1	8753.4	8.6
9	C+B+CP → G	8.2	93.7	31.5	5.1	8797.8	7.9
10	C+B-D	8.2	93.2	32.5	5.1	8797.8	7.9
11	C+B-O	8.0	93.2	31.5	5.1	8708.9	8.7
12	C+B-A	7.3	85.8	29.5	4.8	8042.4	15.4
13	C+B-D → P	8.2	94.3	32.7	5.3	8842.2	7.4
14	C+B-O → P	8.2	94.3	32.2	5.2	8753.4	8.5
15	C+B-A → P	7.8	92.8	31.3	5.0	8531.2	10.6
	SE	0.45	5.45	1.50	0.26	516.75	5.63
	CD (0.05)	1.31	15.89	4.36	0.74	1508.37	16.53

Table 29. Effect of treatments on yield and yield attributes of banana - Ratoon crop

Tr. No.	Treatments	Hands per bunch	Fingers per bunch	Length of bunch (cm)	Wt.of hands per bunch (kg)	Bunch yield (kg ha^{-1})	Weed index (%)
1	Cc	-	-	-	-	-	-
2	C-WP	-	-	-	-	-	-
3	C+B-WP	7.8	111.7	31.3	4.7	7553.7	40.7
4	C+B-WF	12.2	205.8	49.0	8.1	13152.3	-
5	C+B-Sp	11.2	181.7	44.2	7.6	12441.3	3.6
6	C+B-Si	9.8	154.2	39.3	6.8	11019.5	14.4
7	C+B+Cp	10.0	159.8	39.5	6.9	11286.1	10.9
8	C+B+CP → P	10.3	166.2	41.2	7.1	11552.7	10.3
9	C+B+CP → G	10.5	168.0	41.7	7.1	11686.0	8.2
10	C+B-D	11.0	176.5	43.7	7.3	12041.4	4.8
11	C+B-O	11.0	175.0	43.5	7.3	12041.4	7.4
12	C+B-A	10.0	158.3	39.8	6.8	10975.0	13.1
13	C+B-D → P	11.2	187.0	43.7	7.6	12441.3	2.0
14	C+B-O → P	11.2	186.0	43.7	7.6	12441.3	2.9
15	C+B-A → P	10.5	172.0	42.3	7.2	11774.8	7.8
	SE	0.54	10.25	2.51	0.47	761.54	5.15
	CD (0.05)	1.57	29.91	7.33	1.38	2222.88	15.11

Both spade weeding (t_5) and growing cowpea as an intercrop (t_7) resulted in more number of hands per bunch compared to sickle weeding (t_6) eventhough the difference was not statistically significant. Subsequent application of paraquat or glyphosate in cowpea grown plots (t_8 and t_9) resulted in a slight increase in the number of hands per bunch compared to growing cowpea alone (t_7).

Among the pre-emergence herbicides, application of diuron (t_{10}) resulted in highest number of hands per bunch which was closely followed by oxyfluorfen (t_{11}). Post emergence application of paraquat in pre-emergence herbicide treated plots (t_{13}, t_{14} and t_{15}) showed a trend in increasing the number of hands per bunch compared to application of pre-emergence herbicides alone (t_{10}, t_{11} and t_{12}). Among them, more number of hands per bunch was recorded by diuron followed by paraquat (t_{13}) and oxyfluorfen followed by paraquat (t_{14}).

The lowest number of hands per bunch in unweeded control might be the result of continuous weed competition for soil moisture and nutrients. On the contrary, the absence of weed competition due to periodical weeding provided favourable growth conditions for banana which might have thereby resulted in highest number of hands per bunch.

The better performance of spade weeding over sickle weeding might be due to the fact that in spade weeding, the weeds were completely removed by scraping the ground whereas in sickle weeding only the top growth was removed by cutting with sickle leaving the stubbles and small weeds which again compete with the crop for soil moisture and nutrients.

The slight increase in the number of hands per bunch by growing cowpea as an intercrop compared to sickle weeding might be the favourable effect of addition of six kg of cowpea green matter to banana. The probable reason for the still better performance of subsequent application of paraquat or glyphosate in cowpea grown plots over growing cowpea alone is the further reduction in weed competition and at the same time addition of some amount of organic matter to soil as a result of paraquat or glyphosate application.

Pre-emergence application of diuron and oxyfluorfen resulted in more number of hands per bunch compared to atrazine which is probably due to the better weed control efficiency of the former two treatments. Application of paraquat in pre-emergence herbicide treated plots lead to a still further reduction in weed competition and more uptake of nutrients by banana. This might be the reason for the trend in increasing the number of hands per bunch by the application of paraquat in pre-emergence herbicide treated plots compared to application of pre-emergence herbicides alone.

(b) Number of fingers per bunch

As in the case of number of hands per bunch, ratoon crop produced more number of fingers per bunch compared to plant crop (Tables 28 and 29). In plant crop as well as in ratoon crop, highest number of fingers per bunch was recorded by weed free treatment (t_4) and the lowest by unweeded control (t_3). Moreover, in both the crops, all weed control treatments could bring about significant increase in the number of fingers per bunch compared to unweeded control. In plant crop, all weed control treatments except sickle weeding (t_6) and atrazine (t_{12}) were on par with weed free treatment whereas in ratoon crop, only spade weeding (t_5), diuron (t_{10}), diuron followed by paraquat (t_{13}) and oxyfluorfen followed by paraquat (t_{14}) were on par with weed free. However, the effect of treatments showed more or less identical trend in both the crops.

Spade weeding as well as growing cowpea as an intercrop (t_7) produced more number of fingers per bunch compared to sickle weeding eventhough the difference was not statistically significant. Application of paraquat or glyphosate for controlling the weeds germinated after the harvest of cowpea (t_8 and t_9) resulted in a slight increase in the production of number of fingers per bunch compared to growing cowpea alone (t_7).

Among the pre-emergence herbicides, application of diuron (t_{10}) and oxyfluorfen (t_{11}) recorded more number of fingers per bunch compared to atrazine (t_{12}). Application of paraquat in pre-emergence herbicide treated plots (t_{13}, t_{14} and t_{15}) resulted in a slight increase in the number of fingers per bunch compared to application of pre-emergence herbicides alone (t_{10}, t_{11} and t_{12}).

Continuous severe weed competition for soil moisture and nutrients might have resulted in lowest number of fingers per bunch in unweeded control. On the contrary, the periodical weeding in weed free plot provided the most favourable growth conditions for banana and might have resulted in highest number of fingers per bunch. The better performance of spade weeding over sickle weeding might be due to the same reasons that have discussed elsewhere.

The favourable influence of addition of six kg cowpea green matter to banana in cowpea intercropped plots might be the reason for its slight better performance over sickle weeding. Apart from the addition of cowpea green matter to banana, application of paraquat or glyphosate after the harvest of cowpea lead to a further reduction in weed competition and more uptake of nutrients by banana. This might be the probable reason for the slight increase in the production of fingers per bunch in the above treatments compared to growing cowpea alone.

The better weed control efficiency of diuron and oxyfluorfen compared to atrazine might have reflected in the production of fingers per bunch. Application of paraquat in pre-emergence herbicide treated plots lead to a further reduction in weed competition and increase in nutrient uptake by banana. This might be the reason for the slight increase in the production of fingers per bunch in the above treatments compared to application of pre-emergence herbicides alone.

(c) Length of bunch

Ratoon crop recorded more length of bunch compared to plant crop (Tables 28 and 29). In both the crops, maximum length of bunch was recorded by weed free treatment (t_4) and the minimum by unweeded control (t_3). Moreover, all weed control treatments resulted in significant increase in the length of bunch compared to unweeded control.

Both spade weeding (t_5) and growing cowpea as an intercrop (t_7) resulted in slight increase in the length of bunch compared to sickle weeding (t_6). Application of paraquat or glyphosate for controlling weeds germinated after the harvest of cowpea (t_8 and t_9) showed a better performance over growing cowpea alone (t_7).

Pre-emergence application of diuron (t_{10}) and oxyfluorfen (t_{11}) resulted in more length of bunch compared to atrazine (t_{12}) eventhough the difference was not statistically significant. Application of paraquat in pre-emergence herbicide treated plots (t_{13}, t_{14} and t_{15}) resulted in a trend in increasing the length of bunch compared to application of pre-emergence herbicides alone (t_{10}, t_{11} and t_{12}).

(d) Weight of hands per bunch

Data presented in Tables 28 and 29 showed that ratoon crop recorded more weight of hands per bunch than plant crop. In both plant crop and ratoon crop all weed control treatments could bring about significant increase in the weight of hands per bunch compared to unweeded control (t_3) and the weight of hands per bunch recorded by all weed control treatments were on par with that of weed free treatment (t_4). Highest weight of hands per bunch was recorded by weed free treatment and the lowest by unweeded control in both the crops.

Effect of treatments on the weight of hands per bunch showed the same trend as in the case of other yield attributes of banana. Spade weeding (t_5) as well as growing cowpea as an intercrop (t_7) resulted in a slight increase in the weight of hands per bunch compared to sickle weeding (t_6). Application of paraquat or glyphosate after the harvest of cowpea (t_8 and t_9) slightly increased the weight of hands per bunch compared to growing cowpea alone (t_7).

Among the pre-emergence herbicides, application of diuron (t_{10}) and oxyfluorfen (t_{11}) resulted in a slightly higher weight of hands per bunch compared to atrazine (t_{12}). Application of paraquat in pre-emergence herbicide treated plots (t_{13}, t_{14} and t_{15}) resulted in a further increase in the weight of hands per bunch compared to application of pre-emergence herbicides alone (t_{10}, t_{11} and t_{12}).

(e) Bunch yield

In general, ratoon crop recorded more bunch yield than plant crop (Tables 28 and 29 and Fig.7). In both the crops, weed free treatment (t_4) recorded the highest yield

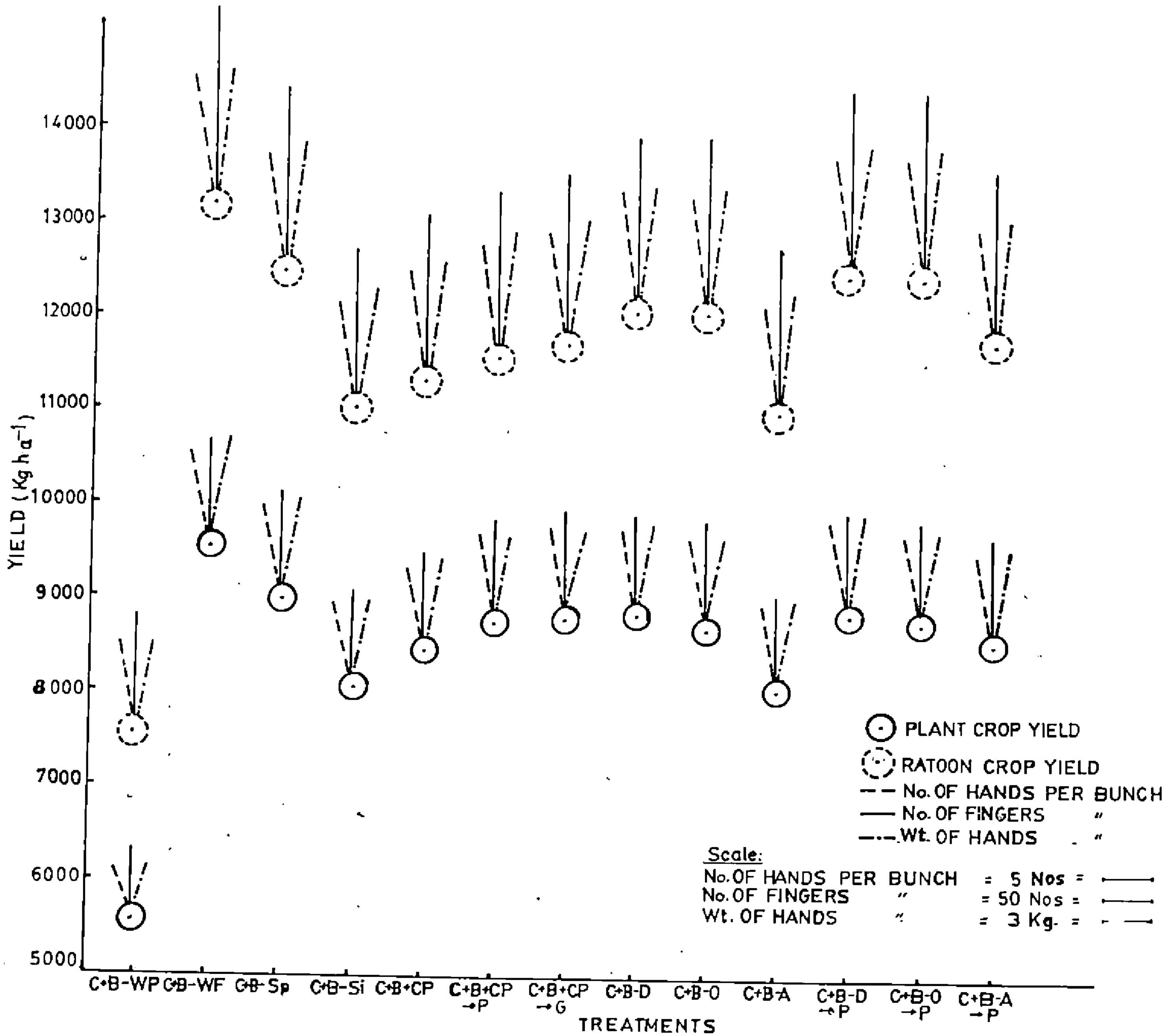

FIG. 7. YIELD AND YIELD ATTRIBUTES OF BANANA AS INFLUENCED BY TREATMENTS

(9553.2 kg and 13152.3 kg/ha respectively) and unweeded control the lowest (5554.2 kg and 7553.7 kg/ha respectively). Moreover, all weed control treatments could bring about significant increase in bunch yield over unweeded control. In plant crop, all weed control treatments except sickle weeding (t_6) and atrazine (t_{12}) were on par with weed free. Whereas in ratoon crop all weed control treatments were on par with weed free. However, almost the same trend could be observed in both the crops.

Effect of treatments on bunch yield of banana followed the same trend as that on all yield attributes of banana since bunch yieldwas the sum total of all yield attributes.

Spade weeding (t_5) as well as growing cowpea as an intercrop (t_7) resulted in higher bunch yield compared to sickle weeding (t_6). Application of paraquat or glyphosate after the harvest of cowpea (t_8 and t_9) increased the bunch yield compared to growing cowpea alone (t_7).

Pre-emergence application of diuron (t_{10}) and oxyfluorfen (t_{11}) resulted in more bunch yield compared to atrazine (t_{12}). Application of paraquat in pre-emergence herbicide treated plots (t_{13}, t_{14} and t_{15}) resulted in an increase in bunch yield compared to application of pre-emergence herbicides alone (t_{10}, t_{11} and t_{12}).

The production of highest number of hands, number of fingers and weight of hands per bunch in the absence of weed competition due to periodical weeding might have contributed to the highest bunch yield in weed free treatment (Fig.7). On the contrary, severe weed competition for soil moisture and nutrients in unweeded control lead to the production of lowest number of hands, number of fingers and weight of hands per bunch which thereby resulted in lowest bunch yield.

Spade weeding involved the complete removal of weeds by scraping the ground as against sickle weeding where the stubbles and small weeds left after cutting with sickle compete with the crop for soil moisture and nutrients. This might have lead to the production of more yield attributes of banana in spade weeded plots and thereby contributed to more bunch yield compared to sickle weeded plots.

The beneficial effect of addition of six kg of cowpea green matter to banana might have resulted in the production of more yield attributing characters and thereby more bunch yield compared to sickle weeding. Further reduction in weed competition, addition of some amount of organic matter to soil and more uptake of nutrientsby banana as a result of the application of paraquat or glyphosate after the harvest of cowpea might have favourably influenced the production of yield attributes which thereby contributed to more bunch yield compared to growing cowpea alone.

The higher weed control efficiency of diuron and oxyfluorfen compared to atrazine (Table 21) might have provided favourable conditions for the growth of banana and production of more yield attributes. Application of paraquat in pre-emergence herbicide treated plots lead to a further reduction in weed competition and more uptake of nutrients by banana which might have contributed to production of more yield attributes thereby more bunch yield compared to application of pre-emergence herbicide alone. Fig. 8 showed that the treatments which resulted in higher weed control efficiency and higher soil moisture content also resulted in higher yield of banana.

The results given above showed the importance of weed control in coconut banana cropping system and the non-adverse effects of the applied herbicides on the yield of banana. Venereo (1980) also obtained higher yield of banana from either mechanically or chemically weeded plots compared to untreated control. Similar non-adverse effects of pre-emergence herbicides on the yield of banana was already reported by Romanowski et al. (1967) and Gomes et al. (1984)

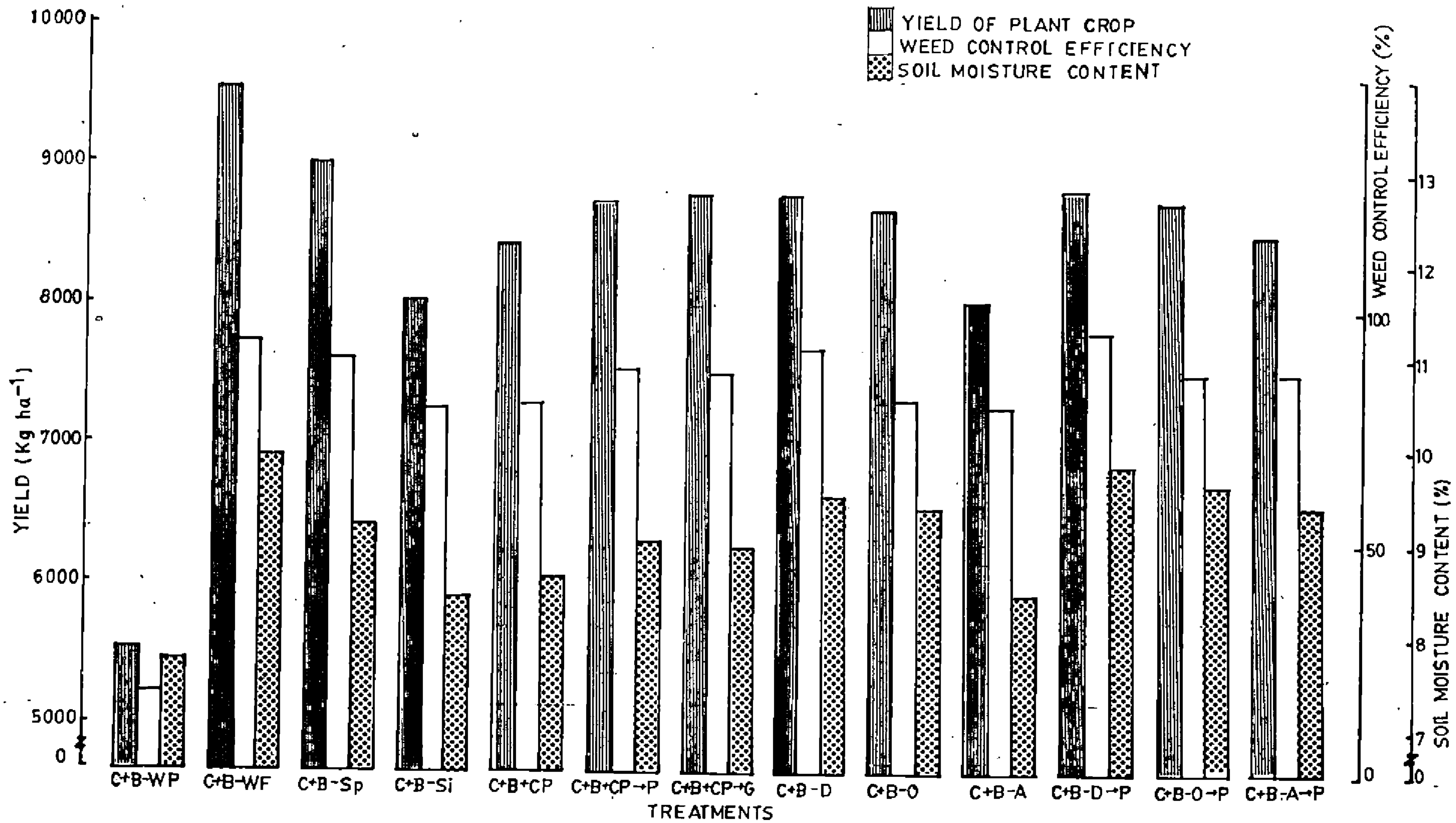

FIG. 8. YIELD OF PLANT CROP OF BANANA, WEED CONTROL EFFICIENCY (AVERAGE OF 1986-'87 & 1987-'88) AND SOIL MOISTURE CONTENT (1987) AS INFLUENCED BY TREATMENTS

respectively. Higher yields of banana by intercropping of cowpea in the initial stages was also obtained by Chacko and Reddy (1981).

(f) Weed index

The data presented in Tables 28 and 29 showed that the weed index of different weed control treatments were on par with each other. In plant crop, the lowest weed index of 5.7 per cent was recorded by spade weeding (t_5) whereas in ratoon crop, diuron followed by paraquat (t_{13}) had the lowest weed index (2.0 per cent). In both the crops, highest weed index was recorded by unweeded control.

The data showed that the loss in yield due to uncontrolled weed growth was about 42 per cent in plant crop and 41 per cent in ratoon crop. However, it could be brought down to 10 per cent or less by better weed management in treatments like spade weeding twice (t_5), cowpea followed by paraquat (t_8) or glyphosate (t_9), application of pre-emergence herbicides diuron (t_{10}) and oxyfluorfen (t_{11}) alone or followed by paraquat (t_{13} and t_{14}). Fig.9 also showed the effect of the above weed control treatments in reducing the weed index.

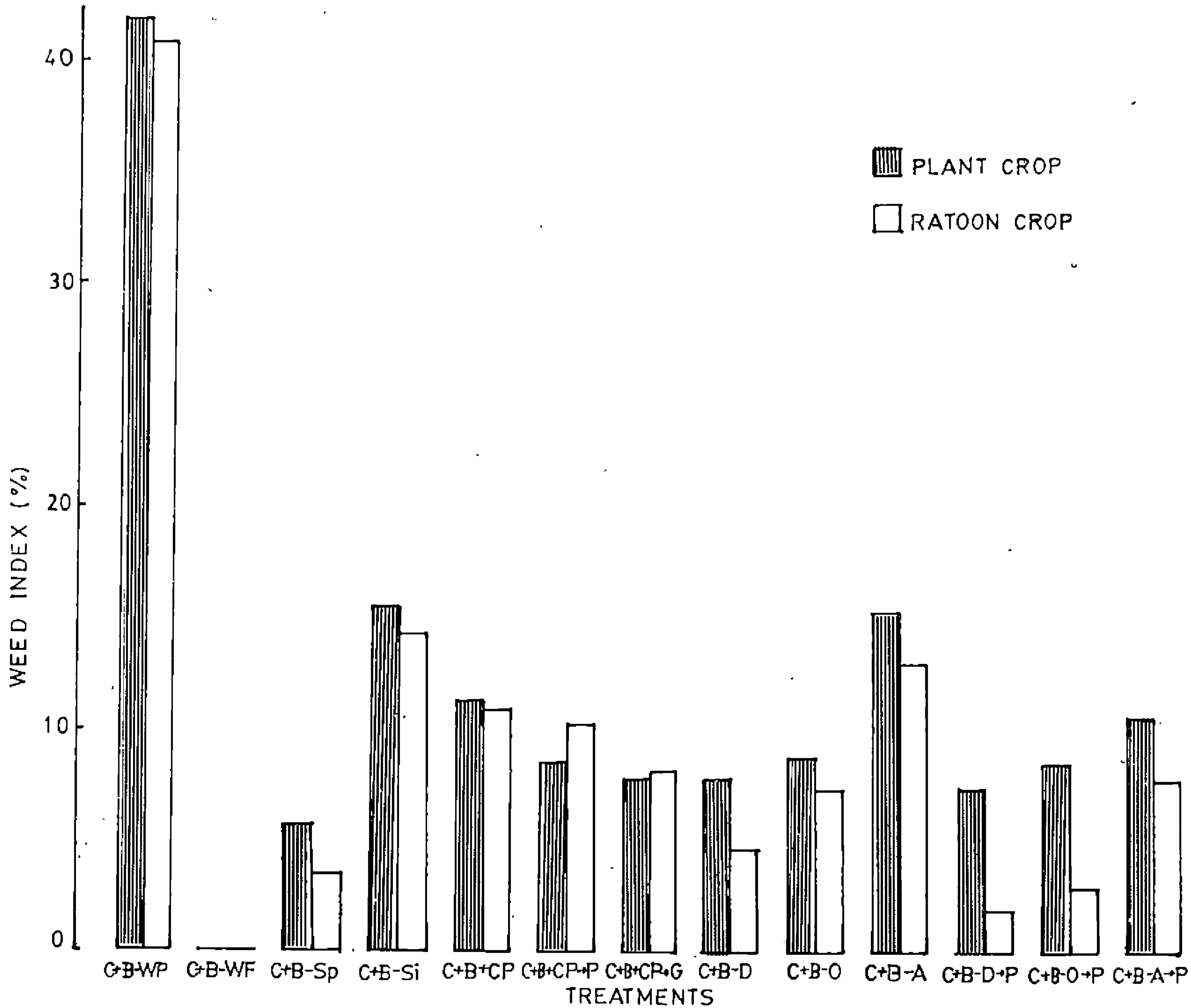

FIG. 9. WEED INDEX OF DIFFERENT TREATMENTS

(g) Drymatter production

Data presented in Table 30 showed that ratoon crop recorded more drymatter production compared to plant crop. In both plant crop and ratoon crop weed free treatment (t_4) recorded the highest drymatter production of banana (4638.9 kg and 6860.5 kg ha^{-1} respectively) and unweeded control (t_3) had the lowest (3101.5 kg and 5234.2 kg ha^{-1} respectively). In plant crop, only spade weeding (t_5) and diuron followed by paraquat (t_{13}) were on par with weed free treatment whereas in ratoon crop, there was no conspicuous difference between weed free and other weed control treatments. However, the effect of treatments on drymatter production of banana in both the crops showed identical trend and it was also similar to that of all growth and yield characters of banana.

Spade weeding as well as intercropping of cowpea (t_7) resulted in more drymatter production of banana compared to sickle weeding (t_6) eventhough the difference was not perceptible. Post-emergence application of paraquat or glyphosate after the harvest of cowpea (t_8 and t_9) lead to a little increase in banana drymatter production compared to growing cowpea alone (t_7).

Table 30. Effect of treatments on drymatter production of banana (kg ha^{-1})

Tr. No.	Treatments	Plant crop		Ratoon crop
		Drymatter production	Per day drymatter production	Drymatter production
1	Cc	-	-	-
2	C-WP	-	-	-
3	C+B-WP	3101.5	6.3	5234.2
4	C+B-WF	4638.9	10.3	6860.5
5	C+B-Sp	4234.5	9.6	6416.2
6	C+B-Si	3839.1	8.4	6060.7
7	C+B+CP	3963.5	8.8	6140.7
8	C+E+CP → P	4110.1	9.1	6234.0
9	C+B+CP → G	4119.0	9.1	6287.3
10	C+B-D	4079.0	9.2	6322.9
11	C+B-O	4043.4	9.1	6322.9
12	C+B-A	3919.0	8.9	6109.6
13	C+B-D → P	4216.8	9.6	6447.3
14	C+B-O → P	4190.1	9.5	6416.2
15	C+B-A → P	4101.2	9.2	6242.9
	SE	132.28	0.31	355.74
	CD (0.05)	386.11	0.91	NS

NS = Not significant

Pre-emergence application of diuron (t_{10}) and oxyfluorfen (t_{11}) resulted in higher drymatter production of banana compared to atrazine (t_{12}) eventhough the difference was not appreciable. Further, the application of paraquat in pre-emergence herbicide treated plots (t_{13}, t_{14} and t_{15}) lead to a slight increase in drymatter production of banana compared to application of pre-emergence herbicides alone (t_{10}, t_{11} and t_{12}).

The favourable growth conditions provided by periodical weeding in weed free treatment resulted in more growth and yield of banana which might have contributed to maximum drymatter production whereas continuous severe weed competition for soil moisture and nutrients in unweeded control might have adversely affected the growth and yield of banana and resulted in lowest drymatter production.

The lesser weed competition in spade weeded plots compared to sickle weeded plots due to the same reasons discussed elsewhere might have resulted in more growth and yield of banana and thereby higher drymatter production in the former compared to the latter.

The beneficial influence of cowpea green matter addition to banana (6 kg) might have reflected in the growth and yield of banana and thereby resulted in more drymatter production compared to sickle weeding. Further reduction in weed competition, addition of some amount of organic matter to soil and more uptake of nutrients by banana as a result of the application of paraquat or glyphosate after the harvest of cowpea are the probable reasons for more drymatter production in t_8 and t_9 compared to t_7.

The better weed control efficiency of diuron and oxyfluorfen provided more favourable conditions for the growth and yield of banana compared to atrazine which thereby resulted in higher drymatter production. Subsequent application of paraquat in pre-emergence herbicide treated plots might have reduced the weed competition further and resulted in more growth and yield thereby more drymatter production compared to application of pre-emergence herbicides alone.

Data on the per day drymatter production of plant crop of banana are presented in Table 30. Highest per day drymatter production was recorded by weed free treatment (t_4) and the lowest by unweeded control (t_3). Moreover, all weed control treatments could bring about significant increase in per day drymatter production of banana compared to unweeded control. Among the weed control treatments, spade weeding (t_5), diuron followed by paraquat (t_{13}) and oxyfluorfen followed by paraquat (t_{14}) were on par with weed free treatment.

However, the effect of treatments on per day drymatter production followed almost the same trend as that on drymatter production.

2.2.3 Correlation studies

Bunch yield of both plant and ratoon crop was correlated with different growth and yield attributing characters of banana and the correlation coefficient (r values) are presented in Table 31. The data showed that in both plant and ratoon crops, all the growth and yield attributing characters are positively correlated with yield of banana. The correlations were more pronounced in ratoon compared to plant crop. It was also noted that yield attributing characters are more correlated with yield compared to growth characters.

Among the yield attributing characters, the number of hands per bunch contributed maximum to the bunch yield in plant crop. Whereas in ratoon crop weight of hands per bunchwas more related to the bunch yield. This might be due to the fact that in plant crop, durationwas more and hence per day drymatter accumulationwas less. On the contrary, in ratoon crop, durationwas less and per day drymatter accumulationwas more. Among the growth characters, leaf area exhibited highest correlation with yield in both crops.

Table 31. Correlation of yield with growth and yield attributing characters of banana

Characters	r values	
	Plant crop	Ratoon crop
Growth characters		
1. Height of pseudostem	0.95901**	0.98239**
2. Girth of pseudostem	0.95980**	0.98361**
3. Number of functional leaves	0.95711**	0.99398**
4. Leaf area	0.96795**	0.99547**
Yield attributing characters		
1. Number of hands per bunch	0.96493**	0.99712**
2 Number of fingers per bunch	0.96278**	0.99713**
3. Length of bunch	0.96354**	0.99629**
4. Weight of hands per bunch	0.96358**	0.99987**

** Significant at 1 per cent level

2.2.4 Nutrient uptake

(a) Nitrogen

In general, ratoon crop recorded more N uptake compared to plant crop (Table 32). In both crops, all weed control treatments could bring about significantly higher N uptake by banana compared to unweeded control (t_3). Among treatments, weed free (t_4) recorded the highest N uptake by banana and unweeded control the lowest. In plant crop, weed free treatment was significantly superior to all other treatments whereas in ratoon crop, all weed control treatments were on par with weed free treatment. The effect of treatments on N uptake by banana showed almost the same trend in both crops.

Spade weeding (t_5) as well as intercropping of cowpea (t_7) resulted in higher N uptake by banana compared to sickle weeding. Subsequent application of paraquat or glyphosate in cowpea grown plots (t_8 and t_9) lead to an increase in N uptake by banana compared to growing cowpea alone (t_7). Among the pre-emergence herbicides, application of diuron (t_{10}) and oxyfluorfen (t_{11}) resulted in higher N uptake by banana compared to atrazine (t_{12}). Further application of paraquat in pre-emergence herbicide treated plots (t_{13}, t_{14} and t_{15}) lead to an increase in N uptake

Table 32. Effect of treatments on nutrient uptake (kg ha^{-1}) by banana

Tr. No.	Treatments	Plant crop			Ratoon crop		
		Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
1	Cc	-	-	-	-	-	-
2	C-WP	-	-	-	-	-	-
3	C+B-WP	23.3	3.1	124.1	40.8	5.2	212.0
4	C+B-WF	37.6	5.6	223.1	56.9	8.9	332.7
5	C+B-Sp	34.3	5.1	198.2	52.6	7.7	302.2
6	C+B-Si	30.7	3.8	162.4	49.7	7.3	258.2
7	C+B+CP	31.7	4.0	170.4	50.4	7.4	265.3
8	C+B+CP → P	33.3	4.1	185.8	51.1	7.5	285.5
9	C+B+CP → G	33.4	4.1	186.2	51.6	7.5	288.6
10	C+B-D	33.0	4.9	191.7	52.5	8.2	297.8
11	C+B-O	32.8	4.9	188.0	52.5	8.2	295.9
12	C+B-A	31.4	3.9	170.1	49.5	7.3	269.4
13	C+B-D → P	34.2	5.1	198.6	53.5	8.4	304.3
14	C+B+O → P	33.9	5.0	193.6	53.3	8.3	300.3
15	C+B-A → P	33.2	4.1	185.8	51.2	8.1	284.7
	SE	1.07	0.15	6.04	2.76	0.42	15.41
	CD (0.05)	3.12	0.43	17.63	8.06	1.22	44.97

by banana compared to application of pré-emergence herbicides alone (t_{10}, t_{11} and t_{12}).

Absence of weed competition due to periodical weeding might have resulted in highest N uptake by banana in weed free treatment. Whereas severe weed competition in unweeded control might have resulted in lowest N uptake by banana.

Lesser weed competition due to complete removal of weeds resulted in more N uptake by banana in spade weeded plots compared to sickle weeded plots where only the top growth of weeds was cut leaving the stubbles and small weeds in the field which compete with the crop for moisture and nutrients.

Addition of cowpea green matter to banana might have resulted in more N uptake by banana in cowpea grown plots compared to sickle weeded plots. Application of paraquat or glyphosate after the harvest of cowpea further reduced the weed competition and might have lead to an increase in N uptake by banana compared to growing cowpea alone.

The higher weed control efficiency of diuron and oxyfluorfen lead to lesser weed competition and more N uptake by banana compared to atrazine. Application of paraquat in pre-emergence herbicide treated plots reduced the weed competition further with an increase in N uptake by the crop compared to application of pre-emergence herbicides alone.

(b) Phosphorus

Data presented in Table 32 showed that as in the case of N, ratoon crop recorded more P uptake than plant crop. In both the crops, all weed control treatments significantly increased the P uptake by banana compared to unweeded control (t_3). Among the treatments, weed free (t_4) recorded the highest P uptake by banana and unweeded control had the lowest. In plant crop, weed free treatment was significantly superior to all other weed control treatments whereas in ratoon crop the treatments spade weeding (t_5), diuron (t_{10}), oxyfluorfen (t_{11}), diuron followed by paraquat (t_{13}), oxyfluorfen followed by paraquat (t_{14}) and atrazine followed by paraquat (t_{15}) were on par with weed free. However, the effect of treatments on P uptake by banana showed almost the same trend in both the crops.

Spade weeding (t_5) as well as growing cowpea as an intercrop (t_7) resulted in an increase in P uptake by banana compared to sickle weeding (t_6). Application of paraquat or glyphosate after the harvest of cowpea (t_8 and t_9) showed a trend in increasing the P uptake by banana compared to growing cowpea alone (t_7). Among the pre-emergence herbicides, application of diuron (t_{10}) and oxyfluorfen (t_{11}) resulted in higher P uptake by banana compared to atrazine (t_{12}). Application of paraquat in pre-emergence herbicide treated plots (t_{13}, t_{14} and t_{15}) lead to an increase in P uptake by banana compared to application of pre-emergence herbicides alone (t_{10}, t_{11} and t_{12}).

(c) Potassium

As in the case of N and P, ratoon crop resulted in more K uptake compared to plant crop (Table 32). In both crops, all weed control treatments could exert a significant positive influence on K uptake by banana compared to unweeded control (t_3). Among the treatments, weed free (t_4) recorded the highest K uptake by banana and unweeded control had the lowest. In plant crop, weed free treatment was significantly superior to all other weed control treatments whereas in ratoon crop, spade weeding (t_5), cowpea followed by glyphosate (t_9), diuron (t_{10}), oxyfluorfen (t_{11}), diuron followed by paraquat (t_{13}) and oxyfluorfen followed by paraquat (t_{14}) were on par with weed free treatment. However, the effect of treatments on K uptake by banana followed almost similar trend in both the crops.

Both spade weeding and growing cowpea as an intercrop (t_7) resulted in higher K uptake by banana compared to sickle weeding (t_6). Subsequent application of paraquat or glyphosate in cowpea grown plots (t_8 and t_9) lead to an increase in K uptake by banana compared to growing cowpea alone (t_7). Among the pre-emergence herbicides, application of diuron (t_{10}) and oxyfluorfen (t_{11}) resulted in higher K uptake by banana compared to atrazine (t_{12}) and the effect was significant in plant crop. Further application of paraquat in pre-emergence herbicide treated plots (t_{13}, t_{14} and t_{15}) lead to an increase in K uptake by banana compared to application of pre-emergence herbicides alone (t_{10}, t_{11} and t_{12}).

The results given above indicated that weed control either manual or chemical increased the nutrient uptake by banana in coconut banana cropping system. Fig.10 also showed the effect of weed control treatments on drymatter production and nutrient uptake by banana.

3. Soil moisture

Data presented in Table 33 showed that moisture content in the soil was inversely related to weed growth in the treatments. Among the treatments, highest soil moisture content was recorded by weed free plot (t_4). The minimum soil moisture content was recorded in the unweeded controls (t_1, t_2, t_3).

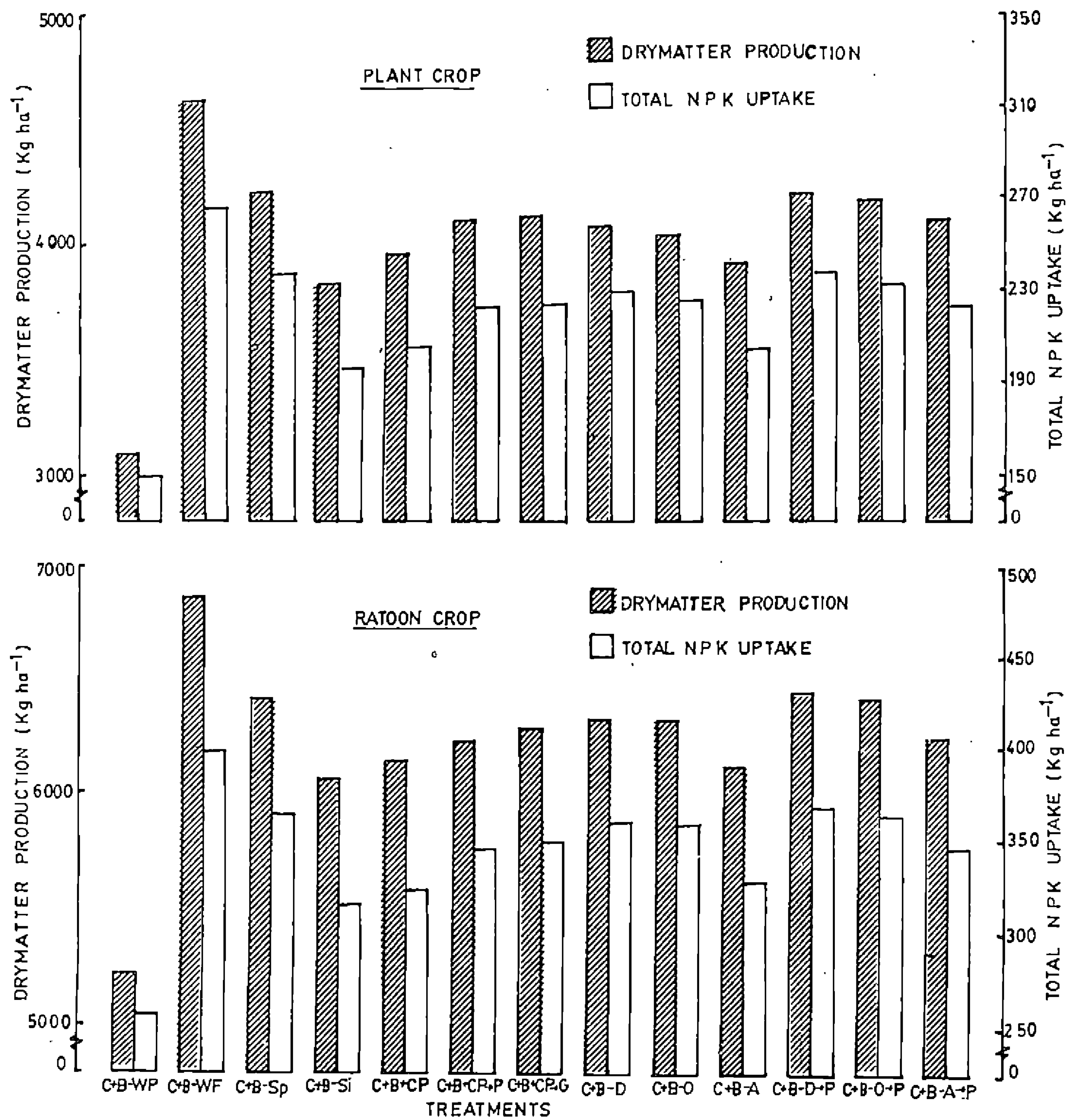

FIG. 10. DRYMATTER PRODUCTION AND TOTAL NPK UPTAKE OF PLANT AND RATOON CROP OF BANANA AS INFLUENCED BY TREATMENTS

Table 33. Effect of treatments on soil moisture content during summer months

Tr. No.	Treatments	1987	1989	Mean
1	Cc	7.33	7.76	7.55
2	C-WP	7.42	7.75	7.59
3	C+B-WP	7.67	8.13	7.90
4	C+B-WF	9.87	10.27	10.07
5	C+B-Sp	9.15	9.39	9.27
6	C+B-Si	8.38	8.86	8.62
7	C+B+Cp	8.60	9.06	8.83
8	C+B+Cp → P	8.97	9.69	9.33
9	C+B+CP → G	8.92	9.67	9.30
10	C+B-D	9.49	9.94	9.72
11	C+B-O	9.35	9.67	9.51
12	C+B-A	8.42	9.15	8.79
13	C+B-D → P	9.81	10.25	10.03
14	C+B-O → P	9.61	10.06	9.84
15	C+B-A → P	9.37	9.77	9.57

This might be due to the high removal of soil moisture by the luxurient growth of weeds. Among the unweeded plots, intercropping of banana with coconut (t_3) resulted in a slightly higher soil moisture compared to sole crop of coconut (t_1 and t_2). The competition for soil moisture during summer months by the uncontrolled weed growth even in the coconut pits (t_1) is one of the attributed reasons for the death of coconut seedlings in t_1. Similar competition effects might have resulted in lesser growth of coconut in t_2 and t_3 and lesser growth of banana in t_3. The higher soil moisture content in t_3 compared to t_1 and t_2 is probably because of lesser weed growth and shade due to the presence of banana. Weed free treatment recorded the maximum soil moisture content probably due to the least weed growth which resulted in minimum soil moisture loss.

Among the manual methods of weed control, spade weeding (t_5) resulted in a higher soil moisture content compared to sickle weeding (t_6). The attributed reason is the lesser weed growth in spade weeded plot compared to sickle weeded plot which resulted in lesser soil moisture loss.

Growing cowpea as an intercrop (t_7) resulted in higher soil moisture content compared to sickle weeding. Cowpea followed by paraquat (t_8) or glyphosate (t_9) recorded a still higher soil moisture content compared to growing cowpea alone which might be due to the better control of weeds in t_8 and t_9.

Among the pre-emergence herbicides, application of diuron (t_{10}) recorded the highest soil moisture content followed by oxyfluorfen (t_{11}). Whereas atrazine (t_{12}) recorded the least. This might be due to the better weed control efficiency of diuron and oxyfluorfen compared to atrazine which resulted in less soil moisture loss. Subsequent application of paraquat in pre-emergence herbicide treated plots (t_{13}, t_{14} and t_{15}) resulted in a higher soil moisture content compared to application of pre-emergence herbicides alone (t_{10}, t_{11} and t_{12}). This might also be due to the better weed control efficiency of the former treatments compared to the latter. Moreover, the chemical treatments such as diuron followed by paraquat (t_{13}), oxyfluorfen followed by paraquat (t_{14}), atrazine followed by paraquat (t_{15}), diuron alone (t_{10}) and oxyfluorfen alone (t_{11}) recorded more soil moisture content than manual methods like spade weeding and sickle weeding. This is attributed to the better weed control efficiency of chemical methods compared to manual methods.

The results given above indicated that weeding is essential for soil moisture conservation during summer months in young coconut gardens (Fig.9). Higher soil moisture content during the dry season as a result of weed control was also reported by Marar (1953). Controlling weeds using herbicides is found to be more effective on soil moisture conservation during summer months compared to manual methods like spade weeding and sickle weeding.

4. Soil fertility

Organic carbon, total nitrogen, available phosphorus and available potassium content of soil were estimated after each year of experiment. Data presented in Table 34 showed that there was a progressive change in the soil fertility as the year of experiment is advanced. Hence the data of 1989 only are discussed below.

(a) Organic carbon

Highest organic carbon content of soil was recorded by unweeded controls (t_1, t_2 and t_3) and were significantly superior to all other treatments except sickle weeding (t_6). This is probably because of the more deposition of organic matter by the unchecked growth of weeds. Among them, intercropping of banana with coconut (t_3) recorded lesser organic carbon content compared to sole crop of coconut (t_1 and t_2) eventhough the difference was not perceptible. This might be due to the slight reduction in weed growth in t_3 compared to t_1 and t_2.

Table 34. Effect of treatments on soil fertility

Tr. No.	Treatments	Organic carbon (%)			Total nitrogen (%)			Available phosphorus (kg ha^{-1})			Available potassium (kg ha^{-1})		
		1987	1988	1989	1987	1988	1989	1987	1988	1989	1987	1988	1989
1	Cc	0.979	1.142	1.210	0.125	0.127	0.130	15.759	15.696	15.759	452.667	616.000	700.000
2	C-WP	0.998	1.122	1.191	0.124	0.126	0.127	15.759	15.696	15.759	448.000	588.000	704.667
3	C+B-WP	0.964	1.107	1.141	0.123	0.124	0.125	15.696	15.446	15.696	406.000	546.000	686.000
4	C+B-WF	0.791	0.767	0.787	0.120	0.120	0.121	15.071	15.071	15.133	298.667	401.333	513.333
5	C+B-Sp	0.939	0.998	1.053	0.121	0.122	0.123	15.383	15.383	15.383	331.333	485.333	522.667
6	C+B-Si	0.959	1.082	1.132	0.123	0.123	0.124	15.383	15.383	15.446	382.667	522.667	616.000
7	C+B+CP	0.924	0.925	1.033	0.122	0.122	0.123	15.133	15.133	15.383	364.000	490.000	588.000
8	C+B+CP → P	0.816	0.870	0.939	0.120	0.121	0.121	15.071	15.071	15.133	350.000	471.333	546.000
9	C+B+CP → G	0.816	0.885	0.925	0.120	0.121	0.121	15.071	15.071	15.133	340.667	466.667	532.000
10	C+B-D	0.698	0.831	0.846	0.123	0.122	0.122	15.133	15.133	15.133	317.333	480.667	546.000
11	C+B-O	0.718	0.846	0.870	0.115	0.122	0.123	15.133	15.133	15.133	364.000	485.333	578.667
12	C+B-A	0.885	0.895	0.924	0.123	0.123	0.123	15.446	15.133	15.446	396.667	604.000	672.000
13	C+B-D → P	0.668	0.698	0.712	0.120	0.120	0.121	15.071	15.071	15.071	308.000	466.667	536.667
14	C+B-O → P	0.703	0.712	0.713	0.121	0.121	0.121	15.071	15.071	15.133	340.667	471.333	546.000
15	C+B-A → P	0.742	0.816	0.900	0.121	0.122	0.122	15.071	15.071	15.133	382.667	490.000	616.000
	SE	0.017	0.057	0.027	0.003	0.002	0.002	0.752	0.733	0.866	9.591	14.271	17.656
	CD (0.05)	0.049	0.164	0.077	NS	NS	NS	NS	NS	NS	27.778	41.334	51.137

NS = Not significant

In weed free treatment (t_4), the organic carbon content was very low and all other weed control treatments except t_{10}, t_{13} and t_{14} were significantly superior to t_4. In weed free treatment there was no chance for the incorporation or deposition of organic matter to soil and might have resulted in very low organic carbon content. The lesser organic carbon content in t_{10}, t_{13} and t_{14} might be due to lesser addition of organic matter to soil as a result of their higher weed control efficiency.

(b) Nitrogen, phosphorus and potassium

Data presented in Table 34 indicated that none of the treatments could bring about any significant influence on total N and available P content of soil. However, maximum N and P content was recorded by unweeded controls (t_1, t_2 and t_3) probably because unchecked weed growth resulted in more deposition of organic matter, presence of nutrients and lesser absorption of nutrients by coconut in t_1 and t_2 and by coconut and banana in t_3. Among them, t_3 recorded slightly lesser N and P content compared to t_1 and t_2. This might be due to the slight reduction in weed growth and absorption of N and P by banana in addition to coconut as against t_1 and t_2.

Weed free treatment (t_4) recorded very low N and P content which might be due to periodical removal of weeds with no chance for decomposition and incorporation of organic matter into soil as well as more uptake of N and P by coconut and banana with consequent impoverisation on inherent soil fertility. The lesser N and P content recorded by t_{13} and t_{14} might be due to lesser addition of organic matter and more uptake of N and P by coconut and banana as a result of their better weed control efficiency.

Available K content of soil also followed the same trend as in the case of N and P. Highest K content was recorded by unweeded controls (t_1, t_2 and t_3) and lowest by weed free treatment (t_4). The reasons might be the same that discussed under N and P. Among the manual methods of weed control, spade weeding recorded significantly lesser available K content of soil compared to sickle weeding. The higher weed control efficiency and more uptake of K by crops in spade weeded plots compared to sickle weeded plots are the probable reasons. Lesser K content of soil in t_8, t_9, t_{10}, t_{13} and t_{14} compared to other treatments might be attributed to better weed control efficiency and more absorption of nutrients by the crops.

The results presented above indicated that in coconut banana cropping system, continuous weed free condition provided either by manual or chemical methods will lead to a reduction in soil fertility. Hence from the soil fertility point of view, spade weeding twice or sickle weeding twice is the best weed management method in coconut+banana cropping system.

5. Economics

The data presented in Table 35 indicated that chemical weed control was more economical than manual, cultural and cultural +.chemical methods. The highest profit per rupee invested on weeding was obtained from diuron treated plots (Rs.9.46). Pre-emergence herbicide treated plots (t_{10}, t_{11} and t_{12}) recorded more profit compared to application of pre-emergence herbicides followed by paraquat (t_{13}, t_{14} and t_{15}).

Growing cowpea as an intercrop (t_7), cowpea followed by application of paraquat (t_8) or glyphosate (t_9) resulted in more or less equal profit and it was found to be lesser than manual methods like spade weeding (t_3) and sickle weeding (t_4).

Spade weeding and sickle weeding recorded more or less equal profit and it was found to be more than that from weed free treatment (t_4).

Table 35. Economics of different treatments

Tr. No.	Treatments	Additional cost for the treatments Rs.	Bunch yield plant crop + ratoon (kg ha^{-1})	Receipt Rs.	Profit per rupee invested on weeding Rs.
1	CC	-	-	-	-
2	C-WP	-	-	-	-
3	C+B-WP	510.00	13108	26216	-
4	C+B-WF	10710.00	22706	45412	1.88
5	C+B-Sp	8670.00	21461	42922	2.05
6	C+B-Si	6450.00	19062	38124	2.00
7	C+B+CP	8220.00	19728	39456	1.71
8	C+B+CP → P	9450.00	20306	40612	1.61
9	C+B+CP → G	9810.00	20484	40968	1.59
10	C+B - D	2145.00	20839	41678	9.46
11	C+B - O	2769.00	20750	41500	6.77
12	C+B - A	2220.00	19017	38034	6.91
13	C+B - D → P	3375.00	21284	42568	5.71
14	C+B - O → P	3999.00	21195	42390	4.64
15	C+B - A → P	3450.00	20306	40612	4.90

Cost of bunch - Rs. 2/kg

Cost of diuron (Hexuron 80 WP) - Rs. 200/kg
" oxyfluorfen (Goal 23.5 EC) - Rs. 700/lit
" atrazine (Atrataf 50 W) - Rs. 100/kg
Cost of paraquat (Gramoxone 24 EC) Rs. 120/lit
" glyphosate (Weed off 41 EC) - Rs. 360/lit

The high cost of labour required for manual and cultural methods might be the reason for the lesser profit from these treatments compared to chemical weed control alone. Among the pre-emergence herbicides, application of diuron recorded the highest bunch yield and maximum profit per rupee invested on weeding. The application of paraquat in pre-emergence herbicide treated plots (t_{13}, t_{14} and t_{15}) lead to an increase in bunch yield of banana compared to application of pre-emergence herbicides alone (t_{10}, t_{11} and t_{12}). But the profit per rupee invested on weeding was higher in the latter treatments. This might be due to the fact that the increase in yield was not high enough to compensate the cost of paraquat and its application charge.

The lesser profit obtained from cowpea grown plots and cowpea followed by paraquat or glyphosate compared to manual methods like spade weeding and sickle weeding might be due to the higher cost involved in the former treatments.

Smith (1968a) also reported that in young coconut plantations, chemical weed control was cheaper than manual weeding like cutlassing.

Plate 11 Unweeded control (t_1) - luxurient growth of weeds especially *Pennisetum pedicellatum*

Plate 12 Diuron 1.5 kg ha^{-1} (t_{10}) - good control of weeds

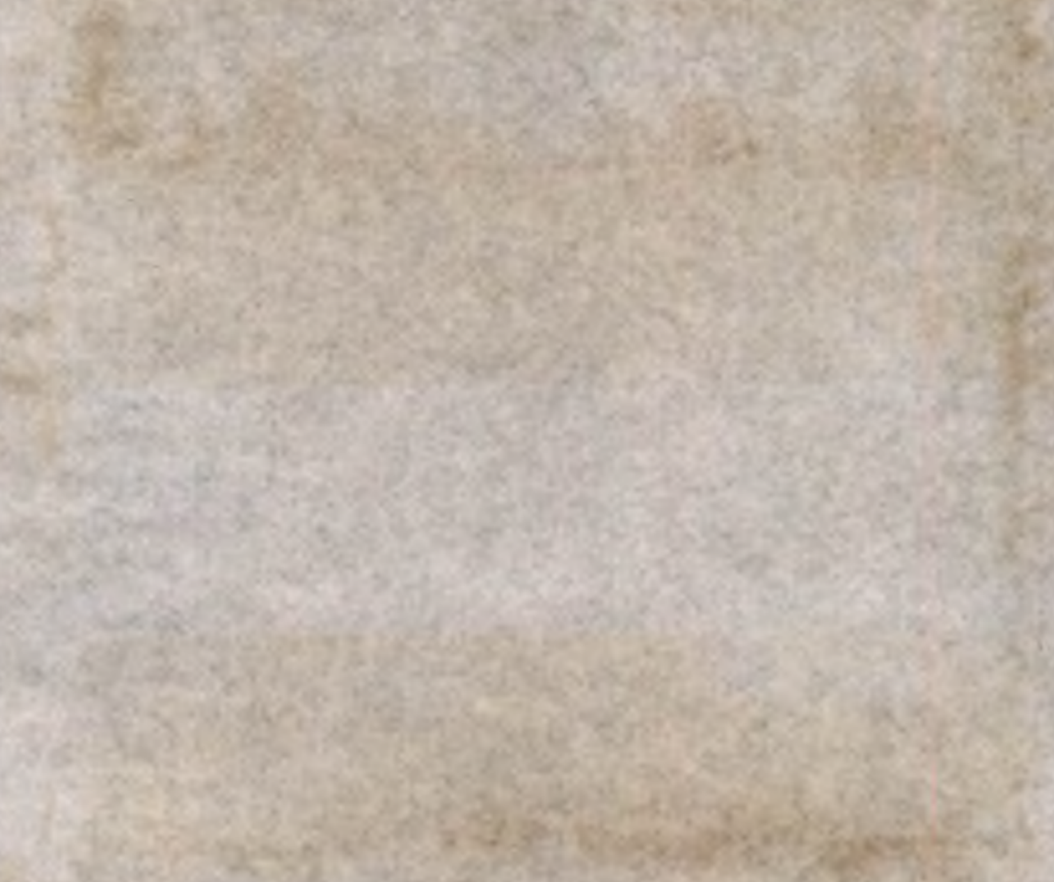

Plate 13 Oxyfluorfen 0.2 kg ha^{-1} (t_{11}) - good control of weeds

Plate 14 Atrazine 2.0 kg ha^{-1} (t_{12}) - relatively poor control of weeds

Plate 15 Diuron followed by paraquat (t_{13}) - as good as the weed free treatment


C+B


C+B

Plate 16 Coconut + banana + cowpea (t_7) - complete coverage of interspaces

Plate 17 Coconut + banana + cowpea (t_7) - the interspaces immediately after the harvest of cowpea - no weeds seen


R.T.
C+B+CP


R.T.
C+B+CP

Plate 18 Coconut + banana + cowpea (t_7) - subsequent growth of weeds - 60 days after the harvest of cowpea


C + B + CP

Plate 19 Spade weeding twice (t_5) - subsequent germination of weeds a few days after first spade weeding

Plate 20 Spade weeding twice (t_5) - just before second spade weeding - luxurient growth of weeds


C+B


C+B
Spade weeding

Plate 21 Sickle weeding twice (t_6) - vigorous regrowth of weeds a few days after first sickle weeding

Plate 22 Sickle weeding twice (t_6) - just before second sickle weeding - luxurient growth of weeds

Plate 23. Coconut + banana - weeding in coconut pits (t_3) - the severe competition from weeds

Plate 24 Weed free plot (t_4)

Trial-III. Weed management in sole banana

1. Weeds

1.1 Weed spectrum

The weed flora found in the experimental field are presented in Appendix-X. Out of these, the monocot weed *Digitaria ciliaris* was the major weed of the area (Plate 25).

1.2 Weed population

Effect of treatments on the population of weeds was studied at 45 days interval for a period of 315 days from the start of the trial in November 1988.

1.2.1 Population of monocot weeds

Highest number of monocot weeds was recorded by unweeded control in most of the stages (Table 36 and Plate 25). Among the pre-emergence herbicides, diuron (t_8) recorded the lowest monocot weed population throughout the experiment (Plates 26 and 27) and it was significantly superior to oxyfluorfen (Plates 28 and 29) and atrazine (Plates 30 and 31) in most of the stages. This shows the better efficiency of diuron in preventing the germination and establishment of monocot weeds compared to oxyfluorfen and atrazine. Ramadass *et al.* (1980), Tosh *et al.* (1982) and Seeyave (1970a) also reported the efficiency of diuron in controlling monocot

Table 36. Effect of treatments on monocot weed population (plants/m^2)

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T	O	T	O	T*	O	T	O	T*	O	T	O	T*	O
1	C	2.9	8.0	4.7	22.7	7.5	55.7	13.5	184.0	12.2	149.3	10.9	117.3	11.0	121.2
2	WF	2.9	8.0	1.0	0.0	3.8	14.6	1.0	0.0	3.0	9.2	1.0	0.0	2.6	6.5
3	Sp	2.9	8.0	4.6	20.0	7.5	55.8	12.9	166.7	9.6	91.5	5.2	26.7	5.3	27.9
4	Si	2.9	8.0	5.0	24.0	8.0	64.0	13.3	180.0	9.6	91.7	5.5	29.3	5.5	30.6
5	Cp	1.0	0.0	3.4	10.7	5.3	27.9	8.5	72.0	7.8	61.5	5.0	24.0	4.8	22.6
6	CP → P	1.0	0.0	3.3	10.7	5.3	27.9	8.5	73.3	2.8	7.6	3.1	9.3	2.9	8.7
7	CP → G	1.0	0.0	3.4	10.7	5.3	27.9	8.6	74.7	2.0	4.0	2.7	6.7	2.5	6.2
8	D	1.0	0.0	2.5	5.3	2.9	8.7	4.1	16.0	4.2	17.3	5.0	24.0	4.8	22.6
9	O	2.5	5.3	3.4	10.7	4.9	23.9	8.3	68.0	7.4	54.2	6.3	40.0	6.1	37.7
10	A	1.0	0.0	3.9	14.7	6.1	37.3	12.0	142.7	11.1	122.4	8.6	76.0	8.2	67.7
11	D → P	1.0	0.0	2.9	8.0	3.2	10.4	4.2	17.3	2.3	5.2	2.9	8.0	2.7	7.1
12	O → P	1.4	1.3	3.6	12.0	4.9	23.9	8.1	65.3	3.6	13.3	4.8	22.7	4.5	19.9
13	A → P	1.0	0.0	4.3	18.7	6.3	39.9	12.0	142.7	4.0	15.8	5.3	28.0	5.0	24.8
	SE	0.33		0.41		0.30		0.76		0.60		0.46		0.39	
	CD (0.05)	0.98		1.19		0.88		2.22		1.74		1.36		1.13	

DAS = Days after spraying
T* = $\sqrt{x}$ transformed values
T = $\sqrt{x+1}$ transformed values
O = Original values

weeds in banana. Oxyfluorfen (t_9) was significantly superior to atrazine (t_{10}) from 135 days onwards eventhough it was inferior and equal to atrazine at 45 and 90 days respectively. At 180 and 225 days, the population of monocot weeds in atrazine treated plot and in unweeded control (t_1) were on par.

The data showed that the increase in monocot weed population reached a maximum at 180 days after which it declined. This decrease is due to the intensive shading by banana. However, a comparison of t_8 & t_{11}, t_9 & t_{12} and t_{10} & t_{13} at 225 days stage showed that subsequent application of paraquat could reduce the population of monocot weeds significantly compared to application of pre-emergence herbicides alone (Plates 32, 33 and 34). Among these, diuron followed by paraquat (t_{11}) was the most effective treatment which was significantly superior to oxyfluorfen followed by paraquat (t_{12}) and atrazine followed by paraquat (t_{13}) at 270 and 315 days. This might be due to the lesser number of monocot weeds in diuron treated plots. Moreover, application of diuron alone was found to be as effective as oxyfluorfen followed by paraquat in reducing monocot weed population.

Intercropping of cowpea could reduce the monocot weed population which was clear from the weed counts at

45 days (Plates 35 and 36). The attributed reason for this is the fast growth of cowpea and early ground coverage thus smothering the weeds. However, weed counts at 90, 135 and 180 days clearly showed that after the harvest of cowpea (60 days) there was further germination of monocot weeds (Plate 37) and a comparison of t_5, t_6 and t_7 at 225 days indicated the efficiency of subsequent application of paraquat (Plate 38) or glyphosate (Plate 39) in controlling these weeds.

Weed counts from 45 days to 180 days showed that one spade weeding (t_3) or one sickle weeding (t_4) was not sufficient for reducing monocot weed population in banana. However, after the second spade weeding or second sickle weeding there was significant reduction in the number of monocot weeds in these treatments and they were found equal in effectiveness (Plate 40 and 41).

1.2.2 Population of dicot weeds

Effects of different treatments on the population of dicot weeds are presented in Table 37. Pre-emergence herbicides could reduce the dicot weed population significantly over unweeded control in most of the stages. Among these, atrazine treated plots (t_{10}) recorded the least number of dicot weeds throughout the experiment. Diuron (t_8) was found

Table 37. Effect of treatments on dicot weed population (plants/m^2)

Sr. No.	Treatments	45 DAS T	45 DAS O	90 DAS T	90 DAS O	135 DAS T	135 DAS O	180 DAS T	180 DAS O	225 DAS T	225 DAS O	270 DAS T	270 DAS O	315 DAS T*	315 DAS O
1	C	12.7	161.3	8.5	72.0	7.1	49.3	5.3	26.7	3.4	10.7	4.3	17.3	4.6	21.3
2	WF	12.7	161.3	1.0	0.0	3.8	13.3	1.0	0.0	3.0	8.0	1.0	0.0	3.3	10.6
3	Sp	12.8	164.0	9.2	85.3	7.2	50.7	5.4	28.0	3.4	10.7	4.7	21.3	4.6	21.2
4	Si	12.7	162.7	8.0	65.3	6.9	46.7	5.2	26.7	3.4	10.7	4.1	16.0	4.3	18.6
5	CP	1.0	0.0	6.7	46.7	5.5	29.3	4.7	21.3	3.2	9.3	4.1	16.0	3.8	14.4
6	CP → P	1.0	0.0	6.6	45.3	5.6	30.7	4.7	21.3	3.0	8.0	3.6	12.0	3.3	10.6
7	CP → G	1.0	0.0	6.6	44.0	5.6	30.7	4.7	21.3	2.9	8.0	3.7	13.3	3.4	11.8
8	D	1.0	0.0	2.2	4.0	2.5	5.3	3.3	10.7	3.2	9.3	2.9	8.0	2.6	6.5
9	O	2.7	6.7	4.2	17.3	3.2	9.3	4.3	17.3	3.4	10.7	3.1	9.3	2.8	7.6
10	A	1.0	0.0	1.0	0.0	1.8	2.7	2.7	6.7	2.7	6.7	2.2	4.0	2.0	4.0
11	D → P	1.0	0.0	2.2	4.0	2.5	5.3	3.4	10.7	2.2	4.0	3.6	12.0	3.3	10.6
12	O → P	2.2	4.0	3.7	13.3	3.4	10.7	4.4	18.7	2.5	5.3	3.7	13.3	3.4	11.8
13	A → P	1.0	0.0	1.0	0.0	1.8	2.7	2.2	4.0	1.4	1.3	3.4	10.7	3.0	9.2
	SE	0.41		0.64		0.25		0.37		0.25		0.32		0.27	
	CD (0.05)	1.19		1.88		0.74		1.09		0.72		0.93		0.78	

DAS = Days after spraying
T* = $\sqrt{x}$ transformed values
T = $\sqrt{x+1}$ transformed values
O = Original values

to be on par with atrazine in reducing dicot weed population whereas oxyfluorfen (t_9) was significantly inferior to atrazine upto 180 days after which the difference was not perceptible. This indicates the better efficiency of atrazine in controlling dicot weeds (Plate 41) and the comparable efficiency of diuron with atrazine (Plate 27 and 41).

A comparison of t_8 & t_{11}, t_9 & t_{12} and t_{10} & t_{13} at 225 days clearly showed the need for a subsequent application of paraquat for reducing dicot weed population in the pre-emergence herbicide treated plots, as the effect of the pre-emergence herbicides did not last for the full season. Among these, atrazine followed by paraquat (t_{13}) recorded the least number of dicot weeds (Plate 34) and was significantly superior to diuron followed by paraquat (Plate 32) and oxyfluorfen followed by paraquat (Plate 33). This might be due to the presence of lesser number of dicot weeds in atrazine treated plots which again showed the superiority of atrazine in controlling dicot weeds. However, at 270 and 315 days there were more number of dicot weeds in these plots (Plates 32 and 33) than in plots treated with pre-emergence herbicides alone (Plate 27 and 29). This is probably due to the further germination of dicot weeds as the monocot weeds were controlled effectively.

Growing cowpea as an intercrop in banana (t_5, t_6 and t_7) was effective in bringing down the population of dicot weeds which was clear from the weed count at 45 days. This might be due to the fast growth and weed smothering ability of cowpea. Weed count at 90 days showed that there was further germination of dicot weeds in cowpea raised plots after the harvest of cowpea. Eventhough the subsequent application of paraquat or glyphosate could reduce the population of these dicot weeds (weed count at 225 days), the effect was not perceptible due to the general decline in the number of dicot weeds in other plots also. This is probably due to the development of dense canopy by banana.

Spade weeding (t_3) and sickle weeding (t_4) were not found effective in reducing dicot weed population.

1.2.3 Population of Digitaria ciliaris

Population of Digitaria was significantly influenced by different weed control treatments (Table 38). Among the pre-emergence herbicides, diuron (t_8) was found to be the most effective in reducing the population of Digitaria throughout the experiment (Plate 27) and was significantly superior to oxyfluorfen (t_9) and atrazine (t_{10}) in most of the stages (Plates 29 and 31). This is due to the better efficiency of diuron in preventing the establishment of the

Table 38. Effect of treatments on the population of _Digitaria ciliaris_ (plants/m^2)

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T	O	T	O	T	O	T	O	T	O	T	O	T	O
1	C	2.5	5.3	4.1	16.0	7.1	49.3	13.1	173.3	9.7	94.7	8.2	66.7	8.0	62.7
2	WF	2.5	5.3	1.0	0.0	2.7	6.7	1.0	0.0	2.5	5.3	1.0	0.0	2.2	4.0
3	Sp	2.5	5.3	3.4	10.7	7.2	50.7	12.6	160.0	9.1	82.7	4.7	21.3	4.6	20.0
4	Si	2.5	5.3	3.6	12.0	7.7	58.7	13.1	173.3	8.8	80.0	4.9	22.7	4.7	21.3
5	CP	1.0	0.0	2.5	5.3	5.0	24.0	8.2	68.0	6.2	38.7	4.4	18.7	4.3	17.3
6	CP → P	1.0	0.0	2.5	5.3	4.9	22.7	8.3	69.3	2.5	5.3	1.8	2.7	2.1	4.0
7	CP → G	1.0	0.0	2.7	6.7	5.0	24.0	8.3	69.3	1.0	0.0	1.4	1.3	1.4	1.3
8	D	1.0	0.0	1.4	1.3	2.1	4.0	3.4	10.7	3.4	10.7	3.6	12.0	3.4	10.7
9	O	1.8	2.7	2.2	4.0	4.7	21.3	8.1	64.0	5.4	28.0	5.3	28.0	4.9	24.0
10	A	1.0	0.0	2.5	5.3	5.9	33.3	11.7	137.3	9.6	90.7	6.7	49.3	6.1	37.3
11	D → P	1.0	0.0	1.8	2.7	2.5	5.3	3.4	10.7	2.2	4.0	1.7	2.7	2.1	4.0
12	O → P	1.4	1.3	2.2	4.0	4.7	21.3	7.7	58.7	2.7	6.7	3.3	10.7	3.7	13.3
13	A → P	1.0	0.0	2.5	5.3	6.1	36.0	11.7	136.0	3.6	12.0	4.4	18.7	4.5	20.0
	SE	0.22		0.28		0.29		0.77		0.55		0.51		0.38	
	CD (0.05)	0.64		0.81		0.86		2.23		1.60		1.49		1.10	

DAS = Days after spraying
T = $\sqrt{x+1}$ transformed values
O = Original values

weed compared to oxyfluorfen and atrazine. Atrazine was found to be significantly inferior to oxyfluorfen in most of the stages even if it was on par with oxyfluorfen at 90 and 270 days and superior to oxyfluorfen at 45 days. This indicates the lesser efficiency of atrazine in controlling the weed compared to diuron and oxyfluorfen.

In general, population of Digitaria reached the maximum at 180 days and thereafter showed a decline. However, the weed count from 225 days indicated the effective control of Digitaria by the subsequent application of paraquat in pre-emergence herbicide treated plots. Among these, diuron followed by paraquat (t_{11}) was found to be the most effective treatment eventhough the difference was not appreciable at 225 days. This is probably due to the lesser number of Digitaria in diuron treated plots. Moreover, application of diuron alone was found to be as effective as oxyfluorfen followed by paraquat (t_{12}) in reducing the population of Digitaria. These results again show the superiority of diuron in controlling the weed.

Weed count at 45 days indicated that raising cowpea as an intercrop in banana could reduce the population of Digitaria (t_5, t_6 and t_7). However, after the harvest of cowpea (60 days), there was further germination of the weed (Plate 37) as evidenced by weed counts at 90, 135 and 180 days which could effectively be controlled by the subsequent application of paraquat or glyphosate (Plates 38 and 39).

The data showed that one spade weeding (t_3) or one sickle weeding (t_4) given in November was not enough for the control of Digitaria which was seen in the counts taken from 45 to 180 days. However, after giving these treatments in May there was considerable reduction in the population of the weed in these plots eventhough the difference was not conspicuous at 225 days.

1.2.4 Total weed population

Pre-emergence herbicides could bring about significant reduction in total weed population (Table 39). Among these, diuron (t_8) was the most effective herbicide (Plates 26 and 27) which was significantly superior to oxyfluorfen (t_9) at all stages and to atrazine (t_{10}) from 135 days onwards. This is probably due to the better efficiency of diuron in preventing the germination and establishment of both monocot and dicot weeds as already discussed. Similar results were also reported by Nayar et al. (1979) and Ramadass et al. (1980). Atrazine was found to be significantly inferior to oxyfluorfen from 180 days onwards eventhough it was on par with oxyfluorfen

Table 39. Effect of treatments on total weed population (plants/m^2)

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T	O	T	O	T*	O	T	O	T*	O	T	O	T*	O
1	C	13.0	169.3	9.7	94.7	10.3	105.2	14.5	210.7	12.6	160.0	11.6	134.7	11.9	142.6
2	WF	13.0	169.3	1.0	0.0	5.3	27.9	1.0	0.0	4.2	17.3	1.0	0.0	4.2	17.3
3	Sp	13.1	172.0	10.3	105.3	10.3	106.6	13.9	194.7	10.1	102.1	7.0	48.0	7.0	49.2
4	Si	13.1	170.7	9.5	89.3	10.5	110.7	14.3	206.7	10.1	102.9	6.8	45.3	7.0	49.3
5	CP_o	1.0	0.0	7.5	57.3	7.6	57.2	9.7	93.3	8.4	71.1	6.4	40.0	6.1	37.2
6	CP → P	1.0	0.0	7.4	56.0	7.6	58.4	9.7	94.7	4.0	15.8	4.7	21.3	4.4	19.6
7	CP → G	1.0	0.0	7.4	54.7	7.7	58.6	9.8	96.0	3.4	11.8	4.5	20.0	4.3	18.3
8	D	1.0	0.0	3.2	9.3	3.7	13.9	5.2	26.7	5.2	26.5	5.7	32.0	5.4	29.3
9	O	3.6	12.0	5.3	28.0	5.8	33.3	9.3	85.3	8.1	65.1	7.1	49.3	6.8	46.2
10	A	1.0	0.0	3.9	14.7	6.3	39.9	12.2	149.3	11.4	128.9	8.8	80.0	8.5	71.8
11	D → P	1.0	0.0	3.6	12.0	4.0	15.8	5.4	28.0	3.0	9.2	4.5	20.0	4.3	18.1
12	O → P	2.5	5.3	5.1	25.3	5.9	34.5	9.2	84.0	4.3	18.6	6.1	36.0	5.7	32.0
13	A → P	1.0	0.0	4.3	18.7	6.5	42.6	12.1	146.7	4.1	17.0	6.2	38.7	5.8	34.2
	SE	0.35		0.59		0.27		0.65		0.57		0.39		0.32	
	CD (0.05)	1.02		1.73		0.79		1.91		1.67		1.13		0.95	

DAS = Days after spraying
T* = $\sqrt{x}$ transformed values
T = $\sqrt{x+1}$ transformed values
O = Original values

at 90 and 135 days and significantly superior to oxyfluorfen at 45 days. This is due to the lesser efficiency of atrazine in controlling monocot weeds especially the major weed Digitaria as is clear from the data given in Tables 36 and 38.

A comparison of t_8 & t_{11}, t_9 & t_{12} and t_{10} & t_{13} from 225 days showed that subsequent application of paraquat could bring about significant reduction in total weed population in pre-emergence herbicide treated plots (Plates 32, 33 and 34). Among these, diuron followed by paraquat (t_{11}) was the most effective treatment which was probably due to the presence of lesser number of weeds in diuron applied plots. Over and above this, treatment of diuron alone was found to be as effective as oxyfluorfen followed by paraquat (t_{12}) in reducing total weed population. All these indicate the superiority of diuron for controlling weeds in banana. Oxyfluorfen followed by paraquat and atrazine followed by paraquat (t_{13}) were found equal in effectiveness.

Intercropping of cowpea could bring about significant reduction in total weed population which was clear from the weed count at 45 days (Plates 35 and 36). Weed count at 90 days showed that there was further germination of weeds after the harvest of cowpea (Plate 37). However, subsequent application of paraquat (t_6) or glyphosate (t_7) could reduce the population of these weeds significantly (Plates 38 and 39). Paraquat and glyphosate were found equal in effectiveness for controlling these weeds.

Spade weeding (t_3) and sickle weeding (t_4) were not effective in bringing down the total weed population upto 180 days. This shows that one spade weeding or one sickle weeding given in November is not enough for reducing weed population. However, after the second spade weeding or sickle weeding given in May, there was significant reduction in weed count (Plates 40 and 41) compared to unweeded control (count from 225 days).

1.3 Drymatter production

The data given in Table 40 and illustrated in Fig.11 showed that pre-emergence herbicides could bring about significant reduction in the drymatter production of weeds. Among these, diuron (t_8) was found to be the most effective herbicide (Plates 26 and 27) which was significantly superior to oxyfluorfen (t_9) upto 180 days (Plates 28 and 29) and to atrazine (t_{10}) at all stages (Plates 30 and 31) except at 45 days. This is due to the lesser germination of weeds in diuron treated plots as already discussed. Atrazine was

Table 40. Effect of treatments on drymatter production of weeds (g/m²)

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T	O	T	O	T*	O	T	O	T*	O	T	O	T*	O
1	C	11.5	132.4	16.0	256.3	16.9	284.5	19.0	363.3	13.2	174.5	12.1	144.8	12.0	145.2
2	WF	11.5	132.0	1.0	0.0	4.0	15.9	1.0	0.0	3.3	10.6	1.0	0.0	3.2	10.0
3	Sp	11.6	133.9	14.8	221.3	16.7	280.5	19.0	360.5	10.2	103.2	7.7	59.2	7.8	60.8
4	Si	11.9	140.7	14.5	214.7	16.7	280.1	18.8	358.4	10.2	104.0	7.9	61.5	7.9	62.5
5	CP	1.0	0.0	9.8	97.1	10.6	111.5	13.5	183.2	10.2	103.5	7.4	54.8	7.3	52.7
6	CP → P	1.0	0.0	9.7	97.1	10.6	111.9	13.5	185.9	6.8	46.4	5.5	29.7	5.2	26.6
7	CP → G	1.0	0.0	9.8	95.5	10.6	111.5	13.4	181.9	6.9	47.3	5.2	26.5	5.0	25.0
8	D	1.0	0.0	2.7	6.3	4.6	21.0	7.0	48.5	9.3	86.8	6.8	44.7	6.6	43.1
9	O	4.9	25.7	8.1	65.2	9.4	88.6	12.6	158.8	9.8	95.9	7.3	52.4	7.1	50.8
10	A	1.0	0.0	6.5	44.4	11.2	125.3	17.1	289.7	10.9	117.8	8.2	66.5	8.0	63.7
11	D → P	1.0	0.0	2.7	6.5	4.6	21.2	7.3	53.1	6.7	44.5	5.1	25.5	5.0	24.9
12	O → P	4.0	16.3	7.9	63.3	9.3	86.8	12.5	154.9	6.8	46.0	5.6	30.7	5.4	28.9
13	A → P	1.0	0 .0	7.5	55.7	11.2	126.0	17.1	291.2	7.3	53.6	5.9	34.4	5.7	31.9
	SE	0.58		0.85		0.22		0.73		0.43		0.39		0.33	
	CD (0.05)	1.69		2.48		0.64		2.14		1.25		1.14		0.97	

DAS = Days after spraying
T* = $\sqrt{x}$ transformed values
T = $\sqrt{x + 1}$ transformed values
O = Original values

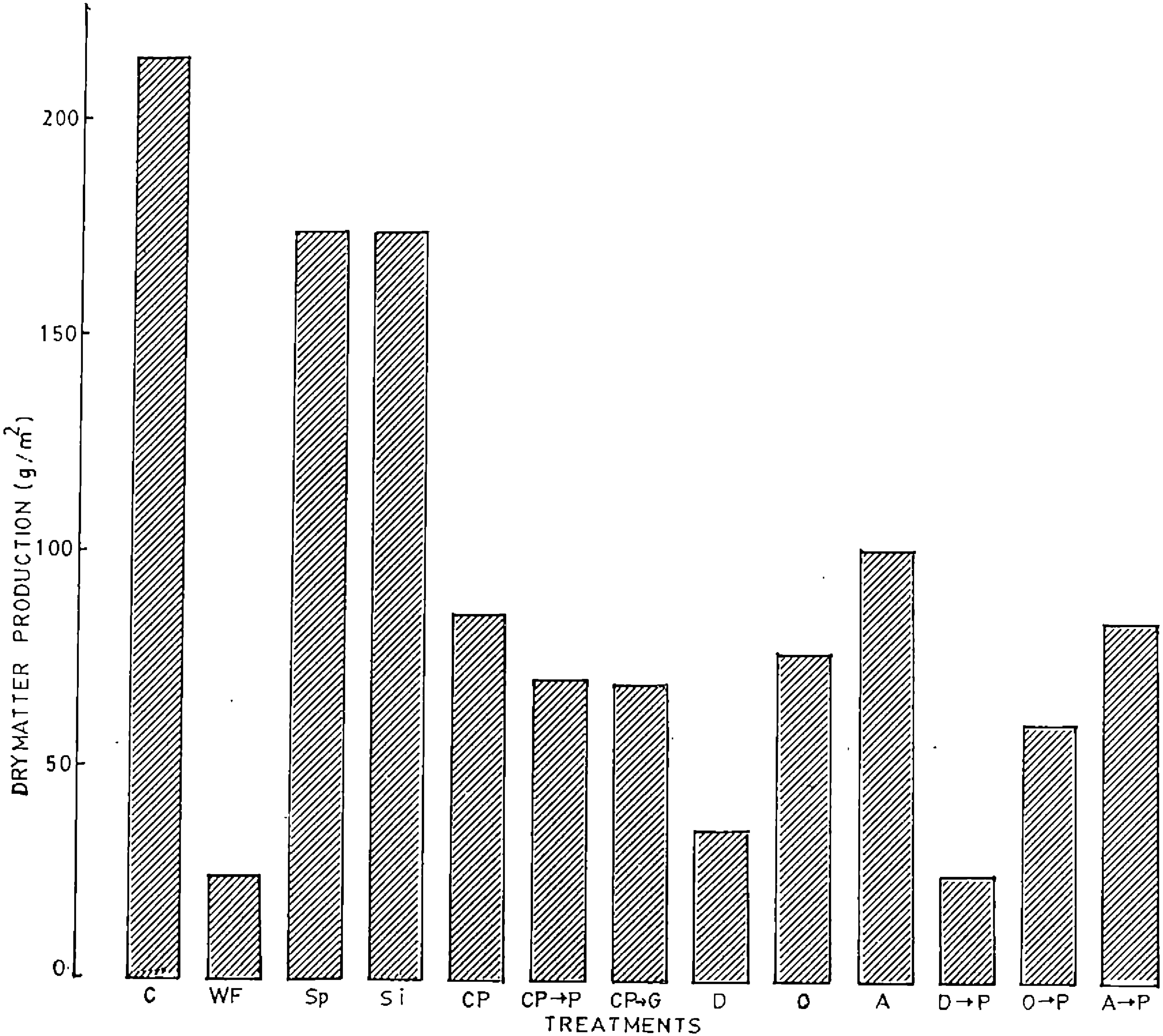

FIG.11. DRYMATTER PRODUCTION OF WEEDS AS INFLUENCED BY TREATMENTS

significantly inferior to oxyfluorfen at 135 and 180 days during which the drymatter production of weeds was maximum. This is probably due to the more number of weeds in atrazine treated plots. After 180 days the difference between atrazine and oxyfluorfen was not perceptible due to the decrease in number of weeds as the crop canopy closes in.

Observation from 225 days showed that subsequent application of paraquat in pre-emergence herbicide treated plots could reduce the weed drymatter production significantly (Plates 32, 33 and 34). Among them, diuron followed by paraquat (t_{11}) recorded the least weed drymatter eventhough it was on par with oxyfluorfen followed by paraquat (t_{12}) and atrazine followed by paraquat (t_{13}). Apart from this, application of diuron alone was found as effective as atrazine followed by paraquat in reducing the drymatter production of weeds. This indicates that diuron can very well be recommended for weed control in banana. Similar results were also reported by Dhuria and Leela (1971).

Raising cowpea as an intercrop in banana in the early stages could bring down the weed drymatter production significantly (Plates 35 and 36) as is revealed in the observation at 45 days. This might be due to the weed smothering ability of cowpea. Similar results were also reported by Chacko and Reddy (1981). However, there was an increase in weed drymatter production from 90 days onwards indicating further germination and establishment of weeds after the harvest of cowpea (Plate 37). Observation at 225 days showed that subsequent application of paraquat or glyphosate could reduce the drymatter production by these weeds significantly (Plates 38 and 39).

Both spade weeding (t_3) and sickle weeding (t_4) could not bring down the weed drymatter production upto 180 days. This shows that one spade weeding or one sickle weeding given in November is not sufficient for weed control in banana. However, observation from 225 days indicated that after the second spade weeding or sickle weeding given in May, there was significant reduction in drymatter production of weeds in these plots and both the treatments were found equal in effectiveness (Plates 40 and 41).

1.4 Weed control efficiency

Weed control efficiency of different treatments were worked out from the average values of the weed drymatter production in the respective treatments.

Data on the weed control efficiency of different treatments in sole banana are presented in Table 41. Among the different weed control treatments, weed free (t_2) recorded the highest weed control efficiency (88.7 per cent)

Table 41. Weed control efficiency (per cent) of different treatments

Tr. No.	Treatments	Weed control efficiency (%)
1	C	-
2	WF	88.7
3	Sp	18.7
4	Si	18.7
5	CP	59.7
6	CP → P	66.7
7	CP → G	67.4
8	D	83.3
9	O	64.0
10	A	52.5
11	L → P	88.3
12	O → P	71.4
13	A → P	60.3
	SE	1.79
	CD (0.05)	5.24

and the herbicide treatment, diuron followed by paraquat (t_{11}) was on par with it.

Among the pre-emergence herbicides, diuron (t_8) recorded significantly higher weed control efficiency and was followed by oxyfluorfen (t_9). Subsequent application of paraquat in pre-emergence herbicide treated plots (t_{11}, t_{12} and t_{13}) resulted in an increase in weed control efficiency. However, the effect was not significant in the case of diuron.

Growing cowpea as an intercrop (t_5) resulted in significantly higher weed control efficiency compared to spade weeding (t_3) and sickle weeding (t_4). Application of paraquat (t_6) or glyphosate (t_7) after the harvest of cowpea increased the weed control efficiency significantly over growing cowpea alone (t_5).

The higher weed control efficiency is the result of the effect of treatments in reducing the population and drymatter production of weeds as discussed earlier.

1.5 Nutrient removal

The nitrogen, phosphorus and potassium removal by weeds was studied at 45 days interval from the start of the trial.

(a) Nitrogen

Unweeded control recorded the highest nitrogen removal by weeds (Table 42). This is due to the highest drymatter production by the unchecked growth of weeds in the unweeded control plots. Among the pre-emergence herbicides, diuron (t_8) was the best in reducing nitrogen removal by weeds and it was found to be significantly superior to oxyfluorfen (t_9) and atrazine (t_{10}) in most of the stages. This might be due to the higher efficiency of diuron in reducing drymatter production of weeds. Nitrogen removal by weeds in oxyfluorfen treated plots was significantly lesser than that in atrazine treated plots at 135 and 180 days stage at which the weed drymatter production was maximum. This indicates the better efficiency of oxyfluorfen compared to atrazine in reducing nitrogen removal by weeds.

In general, nitrogen removal by weeds increased, reached the maximum at 180 days and then declined. The decline in nitrogen removal by weeds after 180 days is due to the reduction in drymatter production of weeds consequent to the disappearance of annual weeds and shading effect of banana. However, a comparison of t_8 & t_{11}, t_9 & t_{12} and t_{10} & t_{13} from 225 days showed that the nitrogen removal by weeds in pre-emergence herbicide treated plots could be further reduced

Table 42. Effect of treatments on N removal by weeds (kg ha^{-1})

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T	O	T	O	T*	O	T	O	T*	O	T	O	T*	O
1	C	3.5	11.7	5.9	33.3	6.1	37.0	6.9	47.2	5.3	27.7	5.0	23.7	4.8	23.1
2	WF	3.2	9.6	1.0	0.0	1.3	1.7	1.0	0.0	1.0	1.0	1.0	0.0	0.8	0.6
3	Sp	3.3	9.8	5.2	26.3	5.9	34.8	6.8	44.7	3.5	12.3	2.9	7.7	2.7	7.5
4	Si	3.5	11.1	5.2	26.6	5.9	34.7	6.7	44.4	3.6	12.9	3.0	8.3	2.8	7.7
5	CP	1.0	0.0	3.4	11.1	4.0	16.4	5.3	26.9	3.5	12.3	2.7	6.5	2.4	5.7
6	CP → P	1.0	0.0	3.3	10.6	3.6	13.3	4.9	23.1	2.2	5.1	2.0	3.1	1.7	2.7
7	CP → G	1.0	0.0	3.6	11.8	3.6	13.3	4.8	22.6	2.3	5.2	1.9	2.7	1.6	2.6
8	D	1.0	0.0	1.5	1.2	1.8	3.1	2.6	6.0	2.8	7.6	2.4	4.6	2.1	4.4
9	O	2.0	3.2	3.3	10.4	3.6	13.0	4.8	22.1	3.4	11.9	2.7	6.2	2.4	5.5
10	A	1.0	0.0	2.5	5.8	4.3	18.4	6.2	37.7	3.8	14.6	3.0	7.9	2.6	6.9
11	D → P	1.0	0.0	1.4	1.0	1.8	3.1	2.7	6.3	2.0	3.9	1.9	2.6	1.6	2.6
12	O → P	1.8	2.2	3.0	8.2	3.6	13.2	5.0	23.6	2.0	4.0	2.1	3.3	1.7	3.0
13	A → P	1.0	0.0	2.9	7.2	4.4	19.1	6.6	42.7	2.2	4.7	2.2	3.8	1.8	3.3
	SE	0.17		0.28		0.08		0.25		0.15		0.12		0.11	
	CD (0.05)	0.48		0.83		0.23		0.74		0.43		0.36		0.32	

DAS = Days after spraying

T* = $\sqrt{x}$ transformed values

T = $\sqrt{x + 1}$ transformed values

O = Original values

significantly by the subsequent application of paraquat. The difference between the different pre-emergence herbicides followed by paraquat (t_{11}, t_{12} and t_{13}) was not conspicuous.

Growing cowpea as an intercrop in banana (t_5) reduced the nitrogen removal by weeds upto 60 days. This is due to the weed smothering ability of the fast growing crop, cowpea which resulted in lesser nitrogen removal by weeds. However, the nitrogen removal by the weeds germinated after the harvest of cowpea (from 90 days to 180 days) could be significantly reduced by the subsequent application of paraquat (t_6) or glyphosate (t_7) (data from 225 days onwards).

Nitrogen removal studies upto 180 days indicate that one spade weeding or one sickle weeding is not sufficient to bring down the nitrogen removal by weeds compared to unweeded control due to their lesser efficiency in reducing weed drymatter production. However, after the second spade weeding or sickle weeding, there was significant reduction in nitrogen removal by weeds compared to unweeded control (from 225 days). This is due to the efficiency of these treatments in reducing weed drymatter production.

(b) Phosphorus

Highest phosphorus removal by weeds was recorded by unweeded control (Table 43) which might be due to the highest

Table 43. Effect of treatments on P removal by weeds (kg ha^{-1})

Tr. No.	Treat-ments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T	O	T	O	T*	O	T	O	T*	O	T	O	T*	O
1	C	1.8	2.4	2.2	3.8	2.3	5.1	2.7	6.5	2.0	4.2	2.3	4.3	2.1	4.4
2	WF	1.7	2.0	1.0	0.0	0.5	0.3	1.0	0.0	0.4	0.2	1.0	0.0	0.4	0.2
3	Sp	1.7	2.0	1.8	2.2	2.1	4.2	2.5	5.4	1.2	1.5	1.6	1.4	1.1	1.3
4	Si	1.8	2.1	1.9	2.8	2.0	4.2	2.7	6.5	1.2	1.6	1.6	1.7	1.2	1.5
5	CP	1.0	0.0	1.6	1.7	1.3	1.7	2.1	3.3	1.2	1.6	1.4	1.0	1.0	0.9
6	CP → P	1.0	0.0	1.6	1.7	1.3	1.7	1.9	2.8	0.9	0.8	1.3	0.6	0.7	0.5
7	CP → G	1.0	0.0	1.5	1.4	1.3	1.7	1.9	2.7	0.9	0.9	1.2	0.6	0.7	0.5
8	D	1.0	0.0	1.0	0.1	0.5	0.2	1.2	0.5	1.1	1.3	1.3	0.7	0.8	0.6
9	O	1.2	0.3	1.5	1.2	1.2	1.3	1.8	2.1	1.3	1.7	1.4	0.9	0.9	0.8
10	A	1.0	0.0	1.3	0.7	1.4	1.9	2.3	4.3	1.5	2.1	1.5	1.2	1.1	1.1
11	D → P	1.0	0.0	1.0	0.1	0.5	0.3	1.2	0.5	0.9	0.8	1.2	0.5	0.7	0.4
12	O → P	1.1	0.2	1.5	1.1	1.1	1.3	1.8	2.3	0.9	0.8	1.3	0.7	0.8	0.6
13	A → P	1.0	0.0	1.4	0.8	1.4	1.9	2.3	4.4	1.0	1.1	1.4	0.8	0.8	0.7
	SE	0.05		0.08		0.03		0.08		0.06		0.04		0.05	
	CD (0.05)	0.15		0.23		0.08		0.25		0.17		0.12		0.13	

DAS = Days after spraying
T* = $\sqrt{x}$ transformed values
T = $\sqrt{x + 1}$ transformed values
O = Original values

drymatter production of uncontrolled growth of weeds. Among the pre-emergence herbicides, diuron (t_8) was the best in reducing phosphorus removal by weeds and it was significantly superior to oxyfluorfen (t_9) and atrazine (t_{10}) in most of the stages. This is due to the higher efficiency of diuron in reducing drymatter production of weeds as already discussed. Oxyfluorfen in turn was significantly superior to atrazine in reducing phosphorus removal by weeds at 135 and 180 days at which the weed growth was maximum. This shows the better efficiency of oxyfluorfen compared to atrazine in reducing phosphorus removal by weeds.

A comparison of t_8 & t_{11}, t_9 & t_{12} and t_{10} & t_{13} at 225 days showed that phosphorus removal by weeds in pre-emergence herbicide treated plots could be reduced by subsequent application of paraquat. This also is due to the reduction drymatter production of weeds.

Intercropping of cowpea in banana (t_5) resulted in a reduction in phosphorus removal by weeds. The attributed reason for this is the reduction in drymatter production of weeds brought about by the weed smothering ability of cowpea. However, subsequent application of paraquat (t_6) or glyphosate (t_7) resulted in further reduction of phosphorus removal by weeds (from 225 days). This is due to the further reduction in drymatter production of weeds.

The data showed that spade weeding (t_3) or sickle weeding (t_4) could bring about reduction in phosphorus removal by weeds only after their second application in May (after 180 days). This also is due to the reduction in weed drymatter production brought about by the treatments. However, the difference in effect of spade weeding and sickle weeding was not perceptible due to the general disappearance of annual weeds.

(c) Potassium

Potassium removal by weeds also followed the same trend as in the case of nitrogen and phosphorus (Table 44). Among the pre-emergence herbicides, diuron (t_8) was the best in reducing potassium removal by weeds and it was found to be significantly superior to oxyfluorfen (t_9) and atrazine (t_{10}) in most of the stages. This is due to the higher efficiency of diuron in reducing the weed drymatter production as already discussed. Oxyfluorfen was found to be significantly superior to atrazine in reducing potassium removal by weeds at 135 and 180 days at which the weed competition was maximum. This shows the better efficiency of oxyfluorfen in reducing potassium removal by weeds compared to atrazine. The higher potassium removal by weeds in atrazine treated plots might be due to the lesser efficiency of atrazine in reducing drymatter production of

Table 44. Effect of treatments on K removal by weeds (kg ha^{-1})

Tr. No.	Treatments	45 DAS		90 DAS		135 DAS		180 DAS		225 DAS		270 DAS		315 DAS	
		T	O	T	O	T*	O	T	O	T*	O	T	O	T*	O
1	C	4.7	21.2	6.7	43.6	7.1	49.8	8.1	65.4	6.3	40.1	6.7	43.4	6.6	43.6
2	WF	4.5	19.8	1.0	0.0	1.8	3.2	1.0	0.0	1.6	2.5	1.0	0.0	1.5	2.3
3	Sp	4.6	20.8	6.0	35.4	6.9	47.7	8.0	63.1	5.2	26.8	3.9	14.2	3.8	14.6
4	Si	4.8	22.5	5.9	34.3	6.9	47.6	8.0	64.5	5.6	31.2	4.0	15.4	3.9	15.3
5	CP	1.0	0.0	4.2	17.0	4.4	19.5	5.7	32.1	4.6	20.7	3.5	11.5	3.4	11.3
6	CP → P	1.0	0.0	4.2	17.0	4.4	19.6	5.7	32.5	3.3	10.7	3.1	8.9	2.6	6.6
7	CP → G	1.0	0.0	4.2	16.7	4.4	19.5	5.8	32.7	3.3	10.6	2.7	6.1	2.4	5.8
8	D	1.0	0.0	1.4	1.0	1.9	3.6	3.1	8.7	4.2	17.4	3.3	9.8	3.1	9.5
9	O	2.1	3.7	3.5	11.7	4.0	16.4	5.7	31.8	4.8	23.5	3.7	12.8	3.5	12.2
10	A	1.0	0.0	2.9	8.0	4.8	23.2	7.9	60.8	5.4	28.9	4.2	16.6	3.9	15.3
11	D → P	1.0	0.0	1.5	1.2	1.8	3.4	3.3	9.8	3.2	10.5	2.6	6.0	2.4	5.8
12	O → P	1.8	2.4	3.4	10.8	3.8	14.8	5.3	27.1	3.3	10.8	2.9	7.2	2.6	6.9
13	A → P	1.0	0.0	3.3	9.8	4.9	23.9	8.0	62.6	3.6	13.1	3.1	8.6	2.8	7.7
	SE	0.21		0.34		0.09		0.31		0.21		0.19		0.16	
	CD (0.05)	0.62		0.99		0.27		0.90		0.60		0.55		0.47	

DAS = Days after spraying
T* = $\sqrt{x}$ transformed values
T = $\sqrt{x+1}$ transformed values
O = Original values

weeds and also due to the presence of more grassy weeds which had a higher potassium content.

A comparison of t_8 & t_{11}, t_9 & t_{12} and t_{10} & t_{13} at 225 days clearly showed the significant effect of subsequent application of paraquat in pre-emergence herbicide treated plots in reducing the potassium removal by weeds. This again is due to the reduction in drymatter production of weeds as discussed in the case of nitrogen and phosphorus. However, among them the difference was not perceptible.

Raising cowpea as an intercrop in banana (t_5) could reduce the potassium removal by weeds which was due to the weed smothering ability of cowpea as discussed earlier. Further, potassium removal studies at 225 days clearly showed that subsequent application of paraquat (t_6) or glyphosate (t_7) could bring about significant reduction in potassium removal by weeds germinated after the harvest of cowpea. This again is due to the consequent reduction in weed drymatter production.

Spade weeding (t_3) or sickle weeding (t_4) could bring about significant reduction in potassium removal by weeds after giving these treatments for the second time (May) i.e. after 180 days. However, no conspicuous difference could be observed between these two treatments due to the general disappearance of annual weeds and prevention in establishment of weeds consequent to the shading by banana.

2. Banana

2.1 Growth characters

The growth of banana was measured in terms of height of pseudostem, girth of pseudostem, number of functional leaves and leaf area at the time of shooting. The results of these growth characters and number of days taken for shooting and maturity are given and discussed characterwise in the following pages.

(a) Height of pseudostem

Height of pseudostem of banana plants was favourably influenced by all weed control treatments (Table 45). Tallest banana plants were observed in weed free treatment (t_2) and the shortest in unweeded control (t_1). All weed control treatments except sickle weeding (t_4) and atrazine (t_{10}) were recorded plant height significantly superior to unweeded control. Moreover, the treatments cowpea followed by paraquat (t_6) cowpea followed by glyphosate (t_7), diuron (t_8), oxyfluorfen (t_9), diuron followed by paraquat (t_{11}), oxyfluorfen followed by paraquat (t_{12}) and atrazine followed by paraquat (t_{13}) recorded a plant height on par with weed

Table 45. Effect of treatments

Tr. No.	Treatments	Height (cm)	Girth (cm)
1	C	198.5	42.2
2	WF	265.2	57.7
3	Sp	232.0	51.3
4	Si	217.5	46.3
5	CP	234.2	50.5
6	CP → P	238.5	51.7
7	CP → G	239.8	52.0
8	D	240.5	52.5
9	O	239.5	51.8
10	A	222.0	48.3
11	D → P	242.8	56.0
12	O → P	241.8	55.3
13	A → P	238.8	54.7
	SE	9.85	1.45
	CD (0.05)	28.74	4.24

on growth characters of banana at shooting

Functional leaves	Leaf area (m^2)	Days for shooting	Days for maturity
9.3	0.73	332.0	417.0
14.2	1.33	244.0	327.0
12.7	1.19	257.3	340.3
11.3	1.00	289.0	373.0
12.0	1.12	271.3	355.3
12.7	1.18	268.0	351.0
13.0	1.19	254.0	337.0
12.7	1.22	244.7	327.7
12.7	1.21	246.0	329.0
12.2	1.03	245.0	328.0
13.5	1.26	244.7	327.7
13.5	1.23	244.7	327.7
13.5	1.21	245.0	328.0
0.70	0.09	6.31	6.30
2.05	0.26	18.42	18.40

free treatment. However, the effect of treatments showed almost the same trend as in trial-II.

Spade weeding (t_3) as well as growing cowpea as an intercrop (t_5) resulted in more plant height compared to sickle weeding eventhough the difference was not perceptible. Application of paraquat or glyphosate after the harvest of cowpea increased the plant height slightly compared to growing cowpea alone (t_5).

Among the pre-emergence herbicides, application of diuron recorded the maximum plant height and it was closely followed by oxyfluorfen. Application of paraquat in pre-emergence herbicide treated plots (t_{11}, t_{12} and t_{13}) resulted in an increase in plant height compared to application of pre-emergence herbicides alone (t_8, t_9 and t_{10}) eventhough the difference was not conspicuous.

The absence of weed competition and addition of weed green matter to banana by periodical weeding might have resulted in more uptake of nutrients and thereby produced tallest banana plants in weed free treatment (Plate 42). On the other hand, severe weed competition for nutrients might have affected the growth of banana and resulted in shortest plants in unweeded control.

The complete removal of weeds by scraping the ground, addition of more weed green matter to banana and earthing up favourably influenced the growth of banana and resulted in taller banana plants in spade weeding treatment compared to sickle weeding where only the top growth of weeds was cut and added to banana and the stubbles and small weeds left in the field still compete with the crop for nutrients.

Growing cowpea as an intercrop and cutting and applying cowpea greenmatter to banana influenced the crop beneficially. These are the probable reasons for the increase in height of banana plants in cowpea grown plots compared to sickle weeded plots. Application of paraquat or glyphosate after the harvest of cowpea lead to a further reduction in weed competition and added some amount of organic matter to soil over and above the beneficial effect of cowpea. This might be the reasons for the slight increase in height of banana plants in the above two treatments compared to growing cowpea alone.

The higher weed control efficiency of diuron and oxyfluorfen lead to a lesser weed competition and more uptake of nutrients by banana compared to atrazine. These are the attributed reasons for the occurrence of taller plants in the former two treatments. Application of paraquat in pre-emergence herbicide treated plots resulted in a further reduction in weed competition, addition of some amount of organic matter to soil and more uptake of nutrients by banana. This might be the reasons for the slight increase in height of plants in the above treatments compared to application of pre-emergence herbicides alone.

(b) Girth of **pseudostem**

Banana plants in the weed free treatment (t_2) recorded the maximum girth of pseudostem and unweeded control (t_1) recorded the least plant girth (Table 45). All weed control treatments except sickle weeding (t_4) were found to be significantly superior to unweeded control. Moreover, the treatments, diuron followed by paraquat (t_{11}), oxyfluorfen followed by paraquat (t_{12}) and atrazine followed by paraquat (t_{13}) were on par with weed free treatment. However, the effect of treatments showed identical trend as that in coconut banana cropping system.

Both spade weeding (t_3) and growing cowpea as an intercrop (t_5) recorded more girth of pseudostem compared to sickle weeding eventhough the difference was not significant. Application of paraquat or glyphosate after the harvest of cowpea (t_6 and t_7) recorded a trend in increasing the girth of pseudostem compared to growing cowpea alone (t_5).

Among the pre-emergence herbicides, application of diuron (t_8) resulted in maximum plant girth and it was closely followed by oxyfluorfen (t_9). Application of paraquat in pre-emergence herbicide treated plots (t_{11}, t_{12} and t_{13}) resulted in an increase in plant girth compared to application of pre-emergence herbicides alone (t_8, t_9 and t_{10}) and the effect of application of paraquat in atrazine treated plots (t_{13}) was significant compared to application of atrazine alone (t_{10}).

Weed free treatment recorded the maximum girth of pseudostem. This might be due to the more favourable growth conditions provided by peridocial weeding and more uptake of nutrients by banana due to lesser weed competition (Plate 4.2). On the contrary, severe weed competition lead to lesser uptake of nutrients by banana and might have resulted in lowest plant girth in unweeded control.

Lesser weed competition due to complete removal of weeds, more addition of weed green matter to banana and earthing up might have resulted in more uptake of nutrients by banana and thereby increased plant girth in spade weeded plots compared to sickle weeded plots where only the top growth of weeds was cut and added to banana leaving the stubbles and small weeds in the field which still compete with the crop for nutrients.

The beneficial influence of addition of cowpea green matter to banana is the probable reason for the increased girth of banana in cowpea grown plots compared to sickle weeding. Subsequent application of paraquat in cowpea grown plots might have reduced the weed competition further and increased the nutrient uptake by banana and thereby resulted in a slight increase in plant girth compared to growing cowpea alone.

The better weed control efficiency of diuron and oxyfluorfen might have resulted in lesser weed competition and more uptake of nutrients by the crop compared to atrazine and resulted in more girth of pseudostem. Subsequent application of paraquat in pre-emergence herbicide treated plots might have reduced the weed competition further and increased the nutrient uptake by banana and thereby resulted in more plant girth compared to application of pre-emergence herbicides alone.

(c) Number of functional leaves

The data presented in Table 45 showed that highest number of functional leaves was recorded by weed free treatment (t_2) and the lowest by unweeded control (t_1). All weed control treatments except sickle weeding (t_4) were found to be significantly superior to unweeded control.

Moreover, all weed control treatments except sickle weeding and growing cowpea as an intercrop (t_5) were on par with weed free treatment. However the effect of treatments showed almost similar trend as in trial II.

The treatments spade weeding (t_3) and growing cowpea as an intercrop produced more number of functional leaves compared to sickle weeding eventhough the difference was not perceptible. Controlling the weeds germinated after the harvest of cowpea by the subsequent application of paraquat or glyphosate (t_6 and t_7) resulted in a slight increase in the production of functional leaves compared to growing cowpea alone.

Pre-emergence application of diuron (t_8) and oxyfluorfen (t_9) resulted in a slightly higher number of functional leaves compared to atrazine (t_{10}). Further application of paraquat in pre-emergence herbicide treated plots (t_{11}, t_{12} and t_{13}) lead to an increase in the production of functional leaves compared to application of pre-emergence herbicides alone (t_8, t_9 and t_{10}) eventhough the difference was not conspicuous.

(d) Leaf area

The data presented in Table 45 showed that at the time of shooting the area of the index leaf (3rd leaf from the top) was maximum in weed free treatment (t_2) and minimum in unweeded control (t_1). All weed control treatments recorded a leaf area significantly superior to that in unweeded control. Moreover, all weed control treatments except sickle weeding (t_4) and atrazine (t_{10}) were on par with weed free treatment. However, the effect of treatments followed almost the same trend as in the case of other growth characters as well as that in trial-II.

As in the case of other growth characters of banana, spade weeding (t_3) as well as growing cowpea as an intercrop (t_5) resulted in an increase in leaf area compared to sickle weeding eventhough not significant. Application of paraquat or glyphosate after the harvest of cowpea (t_6 and t_7) showed a trend in increasing the leaf area compared to growing cowpea alone (t_5).

Pre-emergence application of diuron (t_8) and oxyfluorfen (t_9) recorded slightly more leaf area than atrazine. Application of paraquat in pre-emergence herbicide treated plots (t_{11}, t_{12} and t_{13}) showed a trend in increasing the leaf area compared to application of pre-emergence herbicides alone (t_8, t_9 and t_{10}).

The results on growth characters of banana presented above revealed the importance of weed control in banana and the non-adverse effects of applied herbicides on the growth of banana.

The suppression of growth of banana in plots where there was no weed control was also reported by Tosh et al. (1982). Cann (1965) also stressed the importance of adequate control of weeds in banana. Seeyave and Phillips (1970) also observed taller banana plants with more girth in clean weeded plots. Increased leaf production and leaf area with better weed control was also reported by Ndubizu (1985) in plantain. Leigh (1969) also observed no adverse effects on the growth of banana by using chemicals for weed control.

(e) Number of days taken for shooting and maturity

Banana plants in all weed control treatments exhibited earliness in flowering and maturity compared to those in unweeded control (Table 45). The data showed that banana plants in weed free plot came to flowering first. Early bearing of banana in clean weeded plots was also reported by Seeyave and Phillips (1970). The delayed shooting and maturity of banana in unweeded control plot might be the result of severe weed competition. Delayed maturity of banana due to weed competition was also reported by Kasasian and Seeyave (1968).

2.2 Yield and yield attributes

Number of hands per bunch, number of fingers per bunch, length of bunch, weight of hands per bunch and bunch yield were recorded at the time of harvest and the results are presented and discussed characterwise in the following pages.

(a) **Number of hands per bunch**

All weed control treatments favourably influenced the number of hands per bunch eventhough the difference between sickle weeding (t_4) and unweeded control (t_1) was not perceptible (Table 46). Among them, weed free treatment (t_2) recorded the highest number of hands per bunch and unweeded control had the lowest. Moreover, the weed control treatments, spade weeding (t_3), diuron (t_8), oxyfluorfen (t_9), diuron followed by paraquat (t_{11}), oxyfluorfen followed by paraquat (t_{12}) and atrazine followed by paraquat (t_{13}) were on par with weed free treatment. However, the effect of treatments on number of hands per bunch followed almost the same trend as that in trial-II.

Spade weeding resulted in significant increase in the number of hands per bunch compared to sickle weeding. Growing cowpea as an intercrop (t_5) resulted in a slight increase in the number of hands per bunch compared to sickle

Table 46. Effect of treatments on yield and yield attributes of banana

Tr. No.	Treatments	Hands per bunch	Fingers per bunch	Length of bunch (cm)	Wt. of hands per bunch (kg)	Bunch yield (kg ha^{-1})	Weed Index (%)
1	C	6.3	86.8	33.7	6.2	15501.5	40.7
2	WF	9.8	150.5	51.7	10.8	27403.1	-
3	Sp	8.8	122.5	45.7	8.4	22407.3	15.3
4	Si	7.3	100.8	39.0	7.0	18440.1	29.9
5	CP	7.7	109.2	41.0	7.4	19689.1	26.2
6	CP → P	7.8	117.5	41.7	7.6	20497.2	22.9
7	CP → G	8.0	118.0	42.0	7.7	20570.7	22.3
8	D	9.2	124.2	48.7	8.8	23288.9	11.2
9	O	8.7	118.7	44.8	8.3	21893.1	17.7
10	A	7.8	108.3	42.2	7.5	20056.4	24.4
11	D → P	9.8	132.3	50.0	9.3	24831.7	5.7
12	O → P	9.2	130.3	48.3	9.3	24684.7	9.2
13	A → P	9.7	130.0	48.0	9.1	24684.8	7.8
	SE	0.37	7.09	2.03	0.50	1488.02	3.96
	CD (0.05)	1.07	20.70	5.93	1.47	4343.43	11.60

weeding. Application of paraquat or glyphosate after the harvest of cowpea (t_6 and t_7) showed a trend in increasing the number of hands per bunch compared to growing cowpea alone.

Among the pre-emergence herbicides, application of diuron recorded the highest number of hands per bunch and it was followed by oxyfluorfen. Moreover, diuron was found to be significantly superior to atrazine (t_{10}). Application of paraquat in pre-emergence herbicide treated plots (t_{11}, t_{12} and t_{13}) increased the number of hands per bunch compared to application of pre-emergence herbicides alone (t_8, t_9 and t_{10}) and the effect was significant in atrazine treated plots.

The most favourable conditions provided by the absence of weed competition due to periodical weeding might have lead to more uptake of nutrients (Table 49) and better growth of banana and thereby resulted in the production of highest number of hands per bunch in weed free treatment. On the other hand, in unweeded control, unchecked weed competition might have lead to a lesser uptake of nutrients by banana and suppressed the growth of banana which resulted in the lowest number of hands per bunch.

The lesser weed competition due to complete removal of weeds, addition of more weed green matter to banana and earthing up are the attributed reasons for the significant increase in the number of hands per bunch in spade weeded plots compared to sickle weeded plots where only the top growth of weeds was cut and added to banana leaving the stubbles and small weeds in the field which again compete with the crop for nutrients.

The increase in the number of hands per bunch in cowpea grown plots compared to sickle weeding might be the result of the beneficial influence of addition of cowpea green matter to banana. Over and above the beneficial effect of cowpea, application of paraquat or glyphosate after the harvest of cowpea reduced the weed competition and might have lead to a better uptake of nutrients by banana and thereby resulted in a trend in increasing the number of hands per bunch compared to growing cowpea alone.

The higher weed control efficiency of diuron and oxyfluorfen have lead to lesser weed competition and more uptake of nutrients which might have resulted in the production of more number of hands per bunch compared to atrazine. Subsequent application of paraquat in pre-emergence herbicide treated plots might have reduced the weed competition further, added some amount of organic matter to soil, increased the uptake of nutrients by banana and thereby resulted in more number of hands per bunch compared to application of pre-emergence herbicides alone.

(b) Number of fingers per bunch

Data presented in Table 46 showed that all weed control treatments had a positive influence on the number of fingers per bunch of banana compared to unweeded control (t_1) eventhough the effect of sickle weeding (t_4) was not perceptible. Among the treatments, weed free treatment (t_2) recorded the highest number of fingers per bunch and unweeded control had the lowest. Moreover, the treatments, diuron followed by paraquat (t_{11}), oxyfluorfen followed by paraquat (t_{12}) and atrazine followed by paraquat (t_{13}) were on par with weed free treatment. However, the effect of treatments on number of fingers per bunch followed almost the same trend as in trial-II.

Spade weeding (t_3) as well as growing cowpea as an intercrop (t_5) recorded more number of fingers per bunch compared to sickle weeding eventhough the difference was not significant. Application of paraquat or glyphosate after the harvest of cowpea (t_6 and t_7) resulted in a slight increase in the number of fingers per bunch compared to growing cowpea alone.

Among the pre-emergence herbicides, application of diuron (t_8) recorded the highest number of fingers per bunch and it was followed by oxyfluorfen (t_9). Application of paraquat in pre-emergence herbicide treated plots (t_{11}, t_{12} and t_{13}) resulted in an increase in the number of fingers per bunch compared to application of pre-emergence herbicides alone (t_8, t_9 and t_{10}) and the effect was significant in atriazine treated plots.

As discussed earlier the absence of weed competition due to periodical weeding, addition of weed green matter to banana and more uptake of nutrients by banana are the probable reasons for the production of highest number of fingers per bunch in weed free treatment. Whereas, severe weed competition and lesser uptake of nutrients by banana might be the reasons for the lowest number of fingers per bunch in unweeded control.

In spade weeding, the weeds were completely removed by scraping the ground and earthing up was given to banana after adding the weed green matter. This might have lead to lesser weed competition and more uptake of nutrients by banana compared to sickle weeding where only the top growth of weeds was cut and added to banana leaving the stubbles and small weeds as such which again complete with the crop for nutrients. These are the attributed reasons for the better performance of spade weeding over sickle weeding.

The beneficial effect of added cowpea green matter is the probable reason for the slight increase in the number of fingers per bunch in cowpea grown plots compared to sickle weeded plots. Apart from the favourable influence of cowpea, application of paraquat or glyphosate after the harvest of cowpea might have reduced the weed competition further, added some amount of organic matter to soil, increased the uptake of nutrients by banana and thereby resulted in a slight increase in the production of number of fingers per bunch compared to growing cowpea alone.

The better weed control efficiency of diuron and oxyfluorfen compared to atrazine might have reduced the weed competition and increased the nutrient uptake by banana and thereby resulted in more number of fingers per bunch in the former two treatments. Subsequent application of paraquat in pre-emergence herbicide treated plots might have reduced the weed competition further, increased the nutrient uptake by banana and thereby resulted in more number of fingers per bunch compared to application of pre-emergence herbicides alone.

(c) Length of bunch

All weed control treatments except sickle weeding (t_4) exhibited a favourable influence on the length of bunch compared to unweeded control (Table 46). Among the treatments, weed free treatment (t_2) resulted in maximum length of bunch and unweeded control (t_1) the least. Moreover, the treatments, diuron (t_8), diuron followed by paraquat (t_{11}), oxyfluorfen followed by paraquat (t_{12}) and atrazine followed by paraquat (t_{13}) were on par with weed free treatment. However, the effect of treatments on the length of bunch showed almost the same trend as in trial-II.

Spade weeding (t_3) recorded significantly more length of bunch compared to sickle weeding. Growing cowpea as an intercrop (t_5) resulted in a slight increase in the length of bunch compared to sickle weeding. Application of paraquat of glyphosate after the harvest of cowpea (t_6 and t_7) lead to a trend in increasing the length of bunch compared to growing cowpea alone (t_5).

Among the pre-emergence herbicides, application of diuron (t_8) resulted in maximum length of bunch followed by oxyfluorfen (t_9). Subsequent application of paraquat in pre-emergence herbicide treated plots (t_{11}, t_{12} and t_{13}) resulted in an increase in length of bunch compared to application of pre-emergence herbicides alone (t_8, t_9 and t_{10}) eventhough the difference was not conspicuous.

(d) Weight of hands per bunch

As in the case of other yield attributes of banana weed free treatment (t_2) recorded the maximum weight of hands per bunch and unweeded control (t_1) had the lowest (Table 46). Among the weed control treatments, diuron followed by paraquat (t_{11}) and oxyfluorfen followed by paraquat (t_{12}) were on par with weed free treatment. However, the effect of treatments on weight of hands per bunch followed almost identical trend as that in trial-II.

Spade weeding (t_3) recorded more weight of hands per bunch compared to sickle weeding (t_4) eventhough the difference was not significant. Growing cowpea as an intercrop (t_5) resulted in a slight increase in the weight of hands per bunch compared to sickle weeding. Application of paraquat or glyphosate after the harvest of cowpea (t_6 and t_7) showed a trend in increasing the weight of hands per bunch compared to growing cowpea alone (t_5).

Among the pre-emergence herbicides, application of diuron (t_8) recorded the highest weight of hands per bunch and it was closely followed by oxyfluorfen (t_9). Application of paraquat in pre-emergence herbicide treated plots (t_{11}, t_{12} and t_{13}) showed an increase in weight of hands per bunch compared to application of pre-emergence herbicides alone (t_8, t_9 and t_{10}) eventhough the difference was not perceptible.

(e) Bunch yield

Data presented in Table 46 and illustrated in Fig.12 showed that all weed control treatments could bring about favourable influence on the bunch yield of banana compared to unweeded control (t_1) eventhough the effects of sickle weeding (t_4) and growing cowpea as an intercrop (t_5) were not significant. Among the treatments, weed free (t_2) recorded the highest bunch yield of 27403.1 kg ha^{-1} and unweeded control had the lowest yield of 15501.5 kg ha^{-1}. Moreover, the bunch yield obtained from the treatments diuron (t_8), diuron followed by paraquat (t_{11}) oxyfluorfen followed by paraquat (t_{12}) and atrazine followed by paraquat (t_{13}) were on par with that obtained from weed free treatment. However, the effect of treatments on bunch yield of banana showed almost similar trend as that in trial-II.

Spade weeding (t_3) brought about an increase in bunch yield compared to sickle weeding (t_4). Growing cowpea as an intercrop (t_5) also resulted in a higher bunch yield compared to sickle weeding. Application of paraquat or glyphosate after the harvest of cowpea (t_6 and t_7) lead to a further increase in bunch yield compared to growing cowpea alone (t_5).

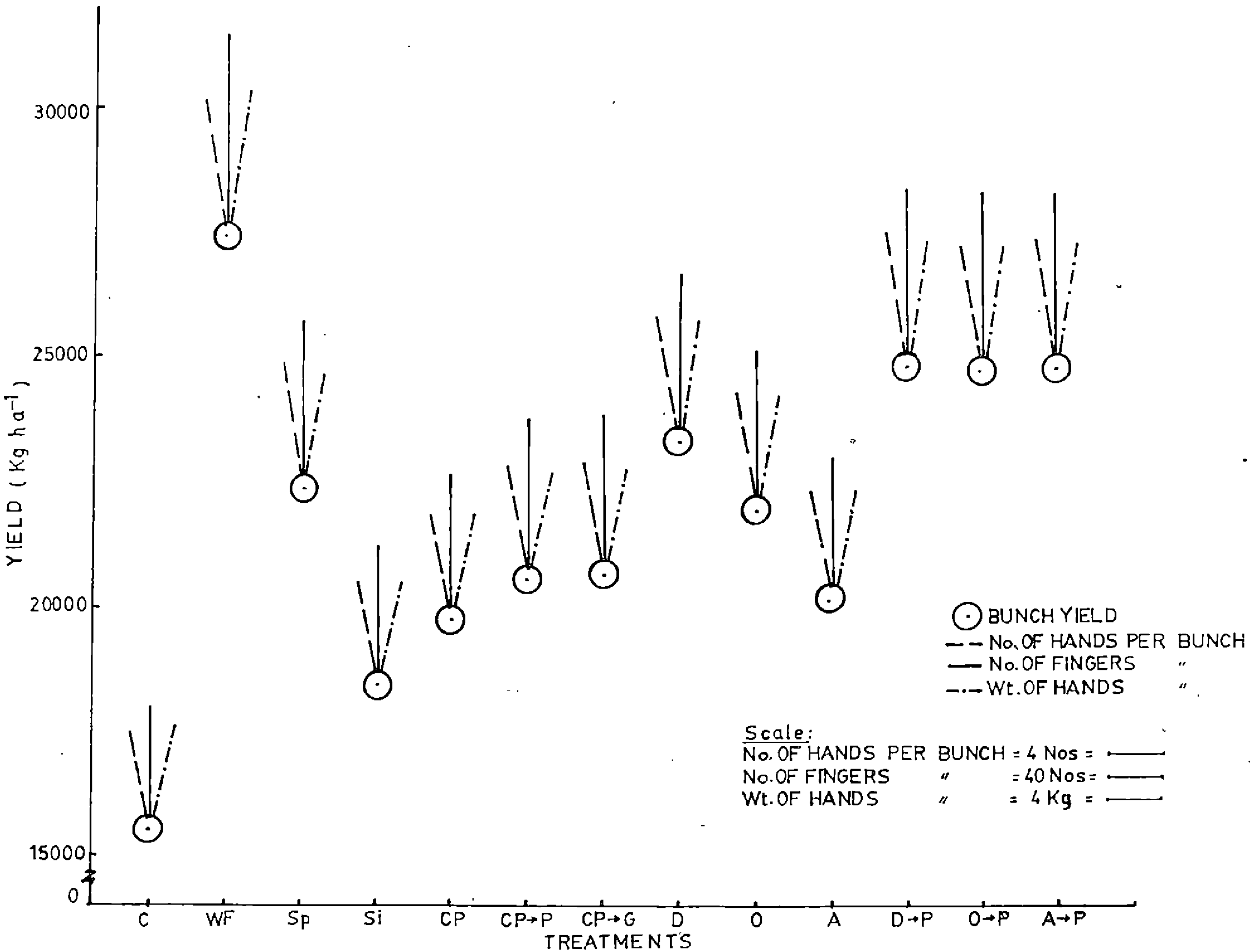

FIG. 12. YIELD AND YIELD ATTRIBUTES OF BANANA AS INFLUENCED BY TREATMENTS

Among the pre-emergence herbicides, application of diuron (t_8) resulted in highest bunch yield of 23288.9 kg ha^{-1} and it was followed by oxyfluorfen (t_9). Subsequent application of paraquat in pre-emergence herbicide treated plots (t_{11}, t_{12} and t_{13}) lead to a further increase in bunch yield compared to application of pre-emergence herbicides alone (t_8, t_9 and t_{10}) eventhough the difference was significant in the case of atrazine (t_{10} and t_{13}) only.

The production of highest number of hands per bunch, fingers per bunch and weight of hands per bunch as a fesult of more uptake of nutrients in the absence of weed competition provided by periodical weeding might have contributed to highest bunch yield in weed free treatment. On the contrary, lesser uptake of nutrients due to severe weed competition lead to lesser production of yield attributes and might have resulted in lowest bunch yield in unweeded control.

In spade weeding, complete removal of weeds by scraping the ground, addition of weed green matter to banana and earthing up might have favourably influenced the uptake of nutrients by banana which resulted in production of more yield attributes and might have contributed to more bunch yield compared to sickle weeding where only the top growth of weeds was cut and added to banana leaving the stubbles and small weeds in the field which again compete with the crop for nutrients.

The beneficial influence of cowpea green matter added to banana might have reflected in the production of number of hands, number of fingers and weight of hands per bunch and contributed to more bunch yield compared to sickle weeding. Over and above the beneficial effect of cowpea, further reduction in weed competition as a result of application of paraquat or glyphosate after the harvest of cowpea lead to more uptake of nutrients by banana and production of more yield attributes and might have resulted in more bunch yield compared to growing cowpea alone.

The lesser weed competition due to higher weed control efficiency of diuron and oxyfluorfen compared to atrazine lead to more uptake of nutrients by banana and production of more number of hands, number of fingers and weight of hands per bunch and might have resulted in more bunch yield (Fig.13). Further reduction in weed competition in pre-emergence herbicide treated plots as a result of paraquat application lead to further increase in uptake of nutrients by banana and production of more yield attributes and might have resulted in more bunch yield compared to application of pre-emergence herbicides alone.

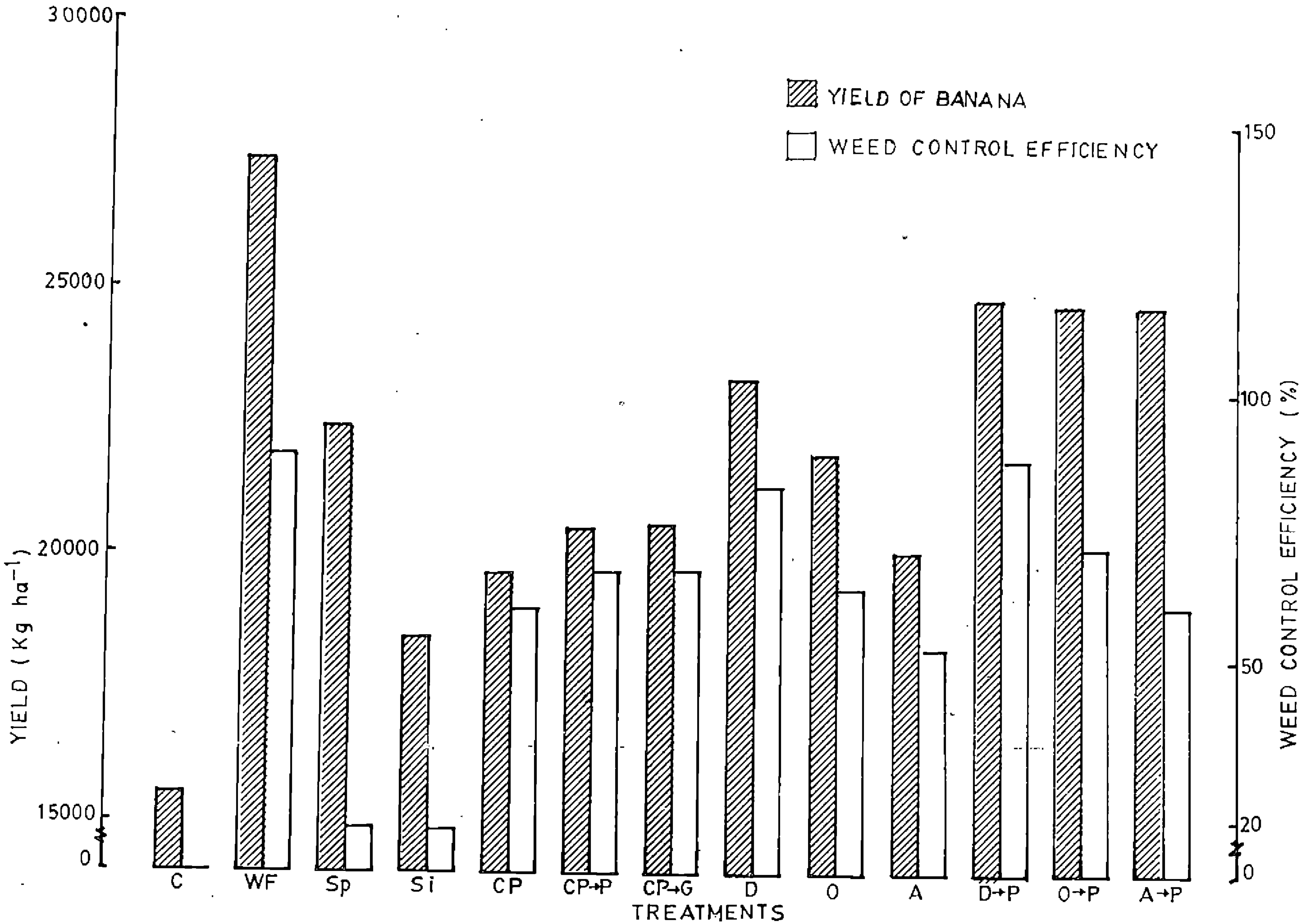

FIG. 13. YIELD OF BANANA AND WEED CONTROL EFFICIENCY AS INFLUENCED BY TREATMENTS

The results given above indicated the necessity of weed control in sole banana and also the non-adverse effects of the applied herbicides on the yield of banana. Venereo (1980) also obtained higher yield of banana from either mechanically or chemically weeded plots compared to untreated control. Similar non-adverse effects of pre-emergence herbicides on the yield of banana was already reported by Romanowski et al. (1967), Leigh (1969), Seeyave (1970a) and Rodriges (1980) and that of post-emergence application of paraquat and glyphosate was reported by Romanowski et al. (1967) and Gomes et al. (1984) respectively. Chacko and Reddy (1981) also obtained higher yields of banana by intercropping of cowpea with banana in the initial stages.

(f) Weed index

The data presented in Table 46 showed that all weed control treatments recorded significantly lower weed index compared to unweeded control (t_1). Among the weed control treatments, the lowest weed index of 5.7 per cent was recorded by diuron followed by paraquat (t_{11}). The treatments oxyfluorfen followed by paraquat (t_{12}), atrazine followed by paraquat (t_{13}), diuron (t_8) and spade weeding (t_3) were on par with t_{11}.

The data showed that the loss in yield due to uncontrolled weed growth was about 41 per cent. However, it could be brought down the less than 10 per cent by better weed management in treatments like t_{11}, t_{12} and t_{13}. Fig.14 also showed the positive effects of weed control treatments in reducing the weed index.

(g) Drymatter production

All weed control treatments had a positive influence on the drymatter production of banana compared to unweeded control (t_1) eventhough the effect was not significant in the case of sickle weeding (t_4), growing cowpea as an intercrop (t_5) and atrazine (t_{10}) (Table 47 and Fig.15). Among the treatments, weed free treatment (t_2) recorded the highest drymatter production of banana (8279.7 kg ha^{-1}) and unweeded control had the lowest (4481.5 kg ha^{-1}). Moreover, weed free treatment was found to be significantly superior to all other weed control treatments. However, the effect of treatments on drymatter production of banana showed almost identical trend as that in trial-II.

The data showed that spade weeding (t_3) aswell as growing cowpea as an intercrop resulted in more drymatter production compared to sickle weeding. Subsequent application of paraquat or glyphosate in cowpea grown plots (t_6 and t_7) lead to a further increase in drymatter production compared to growing cowpea alone (t_5).

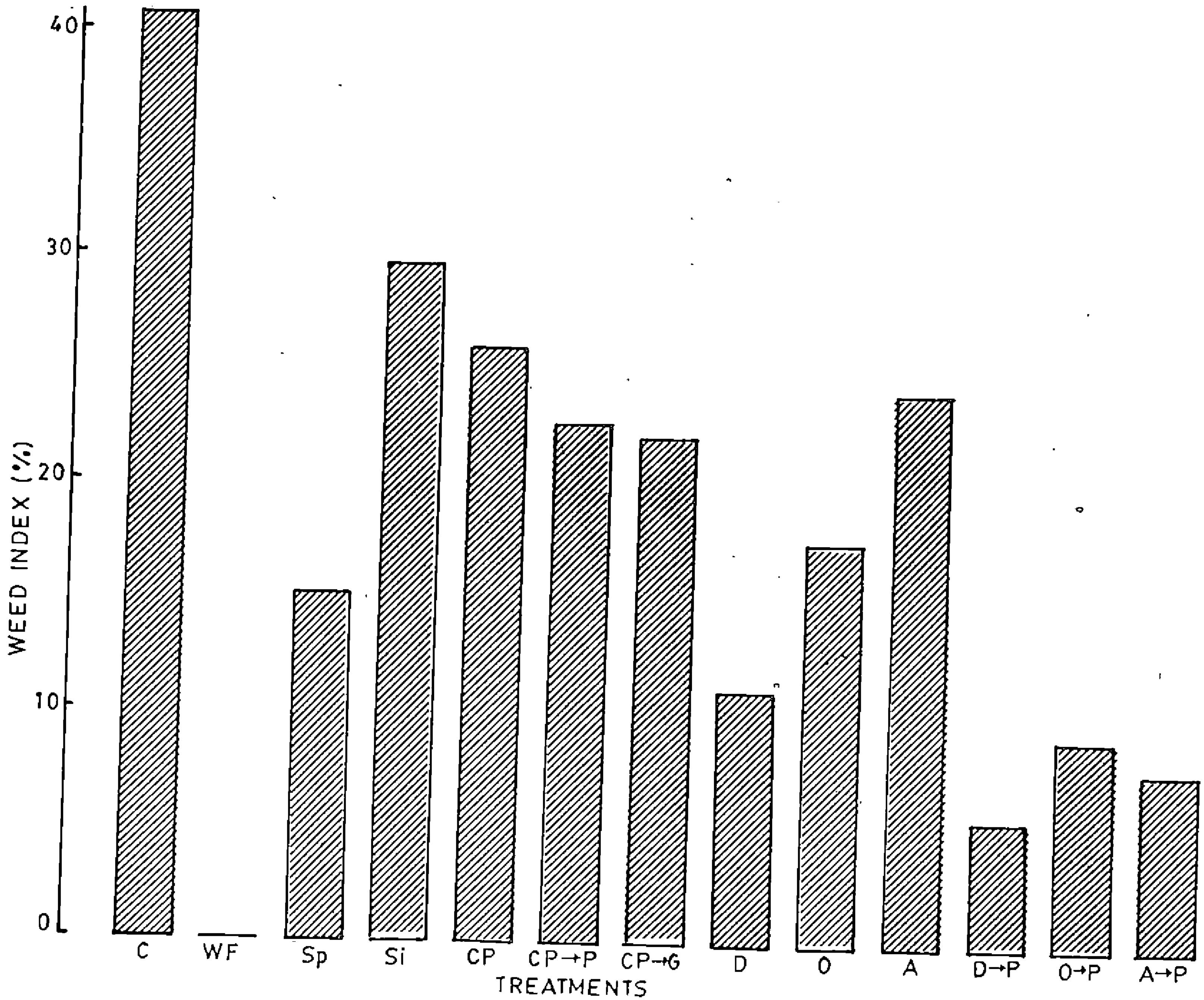

FIG. 14. WEED INDEX OF DIFFERENT TREATMENTS

Table 47. Effect of treatments on drymatter production of banana

Tr. No.	Treatments	Drymatter production (kg ha^{-1})	Per day drymatter production (kg ha^{-1})
1	C	4481.5	10.7
2	WF	8279.7	25.3
3	Sp	6310.8	18.5
4	Si	5326.3	14.2
5	CP	5656.9	15.9
6	CP $\longrightarrow$ P	6259.4	17.8
7	CP $\longrightarrow$ G	6200.6	18.4
8	D	6736.9	20.5
9	O	6604.7	20.1
10	A	5399.8	16.4
11	D $\longrightarrow$ P	6854.4	21.0
12	O $\longrightarrow$ P	6670.8	20.5
13	A $\longrightarrow$ P	6509.1	19.9
	SE	439.18	1.33
	CD (0.05)	1281.94	3.88

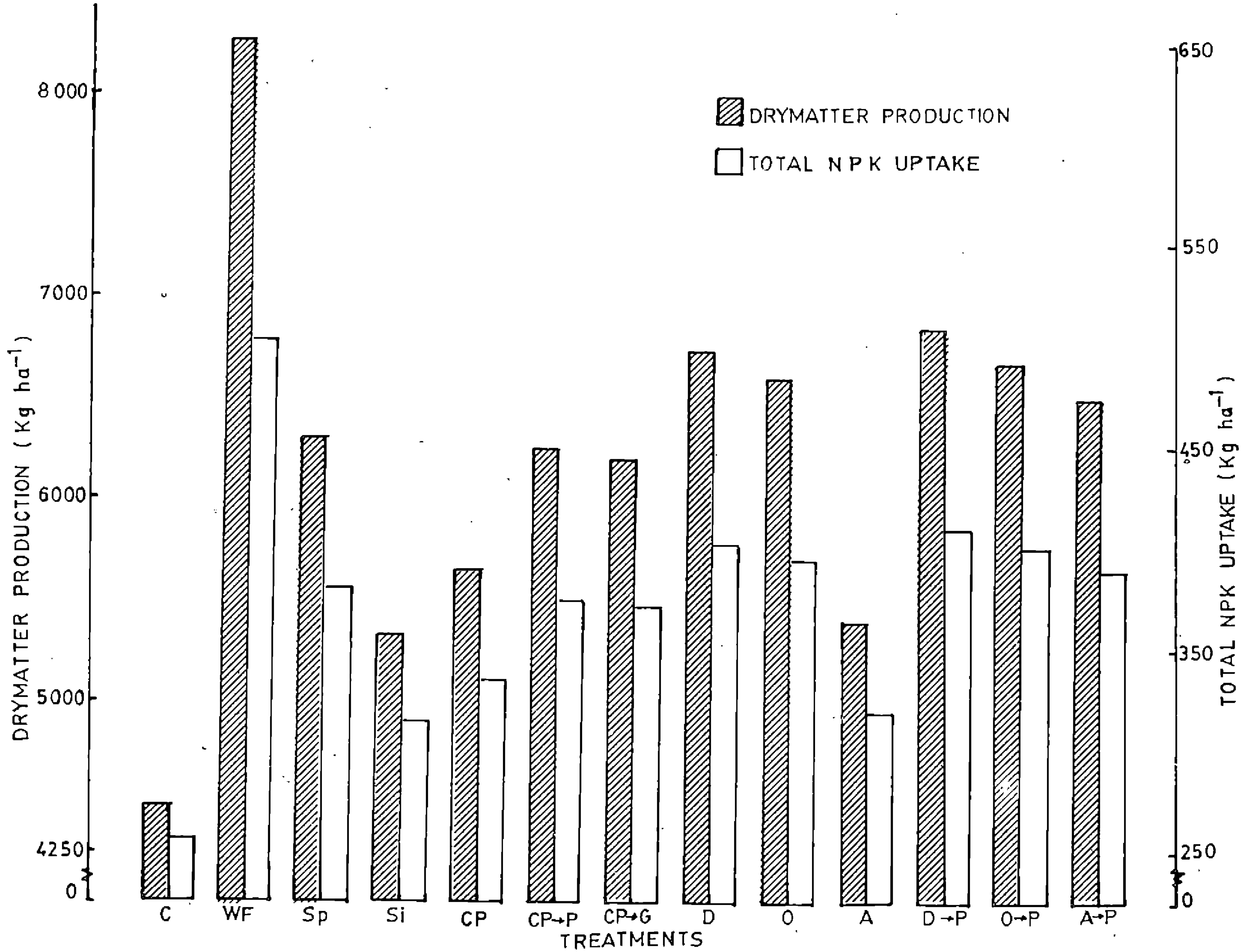

FIG.15. DRYMATTER PRODUCTION AND TOTAL NPK UPTAKE OF BANANA AS INFLUENCED BY TREATMENTS

Among the pre-emergence herbicides, application of diuron (t_8) recorded the highest drymatter production ($6736.9 \ kg \ ha^{-1}$) and it was followed by oxyfluorfen (t_9). Further application of paraquat in pre-emergence herbicide treated plots (t_{11}, t_{12} and t_{13}) lead to an increase in drymatter production of banana compared to application of pre-emergence herbicides alone (t_8, t_9 and t_{10}).

In weed free treatment, the absence of weed competition due to periodical weeding lead to more uptake of nutrients and better growth and yield of banana and might have contributed to higher drymatter production (Fig.15). On the contrary, the retarded growth and lowest yield of banana due to continuous severe weed competition and lesser uptake of nutrients might have resulted in lowest drymatter production in unweeded control.

More uptake of nutrients by banana due to lesser weed competition as a result of complete removal of weeds and the favourable influence of added weed. Green matter and earthing up lead to more growth and yield of banana and might have resulted in more drymatter production compared to sickle weeding where only the top growth of weeds was cut and added to banana.

In cowpea grown plots, the beneficial effect of added cowpea green matter lead to a better growth and yield of banana and might have contributed to more drymatter production compared to sickle weeding. Application of paraquat or glyphosate after the harvest of cowpea reduced the weed competition further, increased the uptake of nutrients by banana and resulted in more growth and yield of banana. This might be the probable reason for the increase in drymatter production of banana in the above treatments compared to growing cowpea alone.

Among the pre-emergence herbicides, the higher weed control efficiency of diuron and oxyfluorfen (Table 41 and Fig.13) compared to atrazine lead to lesser weed competition, more uptake of nutrients and higher growth and yield of banana in the former two treatments. These are the attributed reasons for the higher drymatter production of banana in diuron and oxyfluorfen treated plots compared to atrazine. Application of paraquat in pre-emergence herbicide treated plots reduced the weed competition further, increased the uptake of nutrients and resulted in more growth and yield of banana compared to application of pre-emergence herbicides alone. This might be the reasons for the increase in drymatter production of banana as a result of paraquat application in pre-emergence herbicide treated plots compared to application of pre-emergence herbicides alone.

Data presented in Table 47 showed that all weed control treatments could exert a favourable influence on per day drymatter production of banana compared to unweeded control (t_1) eventhough the effect was not significant in the case of sickle weeding (t_4). Among the treatments, weed free (t_2) recorded the highest per day drymatter production of banana and unweeded control had the lowest. Moreover, weed free treatment was significantly superior to other weed control treatments. However, the effect of treatments on per day drymatter production of banana followed almost the same trend as that in trial-II.

2.3 Correlation studies

Bunch yield was correlated with different growth and yield attributing characters of banana and the correlation coefficient (r values) are presented in Table 48. The data showed that as in trial-II, all the growth and yield attributing characters are positively correlated with yield of banana. It was also noted that the yield attributing characters are more correlated with yield compared to growth characters. Among the yield attributing characters, the weight of hands per bunch contributed highest to the bunch yield of banana.

Table 48. Correlation of yield with growth and yield attributing characters of banana

Characters	r values
Growth characters	
1. Height of pseudostem	0.89259**
2. Girth of pseudostem	0.95825**
3. Number of functional leaves	0.92642**
4. Leaf area	0.89685**
Yield attributing characters	
1. Number of hands per bunch	0.97633**
2. Number of fingers per bunch	0.98333**
3. Length of bunch	0.98422**
4. Weight of hands per bunch	0.98793**

** Significant at 1 per cent level

2.4 Nutrient uptake

(a) Nitrogen

Data presented in Table 49 showed that all weed control treatments had a favourable influence on the N uptake by banana compared to unweeded control (t_1) eventhough sickle weeding (t_4), growing cowpea as an intercrop (t_5) and atrazine (t_{10}) failed to bring about perceptible difference. Among the treatments maximum N uptake was recorded by weed free (t_2) and minimum by unweeded control. Moreover, weed free treatment was significantly superior to all other weed control treatments.

Spade weeding (t_3) as well as growing cowpea as an intercrop (t_5) resulted in more N uptake by banana compared to sickle weeding. Application of paraquat or glyphosate after the harvest of cowpea (t_6 and t_7) lead to an increase in N uptake by banana compared to growing cowpea alone (t_5). Among the pre-emergence herbicides, application of diuron (t_8) and oxyfluorfen (t_9) resulted in a higher N uptake by banana compared to atrazine (t_{10}) and the difference between diuron and atrazine was conspicuous. Further application of paraquat in pre-emergence herbicide treated plots (t_{11}, t_{12} and t_{13}) lead to an increase in N uptake by banana compared to application of pre-emergence herbicides alone (t_8, t_9 and t_{10}).

Table 49. Effect of treatments on nutrient uptake (kg ha^{-1}) by banana

Tr. No.	Treatments	Nitrogen	Phosphorus	Potassium
1	C	35.9	5.4	215.1
2	WF	68.7	11.6	423.1
3	Sp	52.4	8.8	318.7
4	Si	43.7	6.9	264.2
5	Cp	46.4	7.4	281.7
6	CP → P	52.0	8.8	314.2
7	CP → G	51.5	8.7	311.9
8	D	55.9	9.6	338.2
9	O	54.8	9.2	331.6
10	A	44.3	7.0	268.9
11	D → P	56.9	9.6	344.8
12	O → P	55.4	9.3	335.5
13	A → P	54.0	9.1	326.8
	SE	3.63	0.60	21.99
	CD (0.05)	10.59	1.74	64.20

The absence of weed competition due to periodical weeding might have resulted in highest N uptake by banana in weed free treatment whereas severe weed competition in unweeded control might have resulted in lowest N uptake by banana.

Lesser weed competition in spade weeded plots due to complete removal of weeds, addition of weed green matter to banana and earthing up might have lead to more N uptake by banana compared to sickle weeded plots where only the top growth of weeds was cut and added to banana leaving the stubbles and small weeds in the field which still compete with the crop for nutrients.

In cowpea grown plots, the addition of cowpea green matter to banana might have favourably influenced the N uptake by banana compared to sickle weeding. Over and above the beneficial effect of cowpea, application of paraquat or glyphosate after the harvest of cowpea lead to a reduction in weed competition and might have resulted in more N uptake by banana compared to growing cowpea alone (t_5).

The better weed control efficiency of diuron and oxyfluorfen compared to atrazine lead to lesser weed competition and might have resulted in more N uptake by banana in the former two treatments. Subsequent application of paraquat in pre-emergence herbicide treated plots reduced the weed competition further and might have lead to an increase in N uptake by banana compared to application of pre-emergence herbicides alone.

(b) Phosphorus

As in the case of N, all weed control treatments had a positive influence on P uptake by banana compared to unweeded control (Table 49) eventhough the effects of sickle weeding (t_4) and atrazine (t_{10}) were not significant. Among the treatments, highest P uptake was recorded by weed free treatment (t_2) and lowest by unweeded control. Moreover, weed free treatment was significantly superior to all other weed control treatments. However, the effect of treatments on P uptake by banana showed almost identical trend as that in the case of N.

Spade weeding (t_3) as well as intercropping of cowpea (t_5) resulted in higher P uptake by banana compared to sickle weeding and the effect of spade weeding was significant. Application of paraquat or glyphosate in cowpea grown plots (t_6 and t_7) lead to a further increase in P uptake by banana compared to growing cowpea alone (t_5). Among the pre-emergence herbicides, application of diuron (t_8) and oxyfluorfen (t_9) resulted in significantly higher P uptake by banana compared to atrazine (t_{10}). Subsequent application of paraquat in preemergence herbicide treated plots especially in oxyfluorfen and atrazine treated plots (t_{12} and t_{13}) lead to an increase in P uptake by banana compared to application of pre-emergence herbicides only (t_9 and t_{10}).

(c) Potassium

As in the case of N and P, all weed control treatments resulted in an increase in K uptake by banana compared to unweeded control (Table 49) eventhough the effect was not significant in the case of sickle weeding (t_4) and atrazine (t_{10}). Among the treatments, weed free (t_2) recorded the highest K uptake by banana and unweeded control (t_1) had the lowest. Moreover, weed free treatment was significantly superior to all other weed control treatments. However, the effect of treatments on K uptake by banana followed a similar trend as in the case of N and P.

Both spade weeding (t_3) and intercropping of cowpea (t_5) resulted in an increase in K uptake by banana compared to sickle weeding (t_4). Application of paraquat or glyphosate after the harvest of cowpea (t_6 and t_7) lead to an increase in K uptake by banana compared to growing cowpea alone (t_5). Among the pre-emergence herbicides, application of diuron (t_8) and oxyfluorfen (t_9) resulted in higher K uptake by banana compared to atrazine (t_{10}) and the difference in K uptake between diuron and atrazine was found significant. Further application of paraquat in the pre-emergence herbicide treated plots (t_{11}, t_{12} and t_{13}) lead to an increase in K uptake by banana compared to application of pre-emergence herbicides alone (t_8, t_9 and t_{10}).

The results given above revealed that weed control either manual or chemical had a positive influence on the nutrient uptake by banana. Fig.15 also showed the effect of weed control onthe uptake of nutrients by banana.

3. Soil fertility

Organic carbon, total nitrogen, available phosphorus and available potassium content of soil were estimated after the experiment. The results on these aspects are discussed below.

The data presented in Table 50 showed that none of the treatments had any significant influence on organic carbon, total N, available P and available K content of soil. However, the effect of treatments on soil fertility followed almost similar trend as in trial-II.

Highest soil fertility was recorded by unweeded control (t_1). This might be due to more deposition of organic matter, presence of nutrients as well as lesser absorption of nutrients by banana due to unchecked weed growth in unweeded

Table 50. Effect of treatments on soil fertility

Tr. No.	Treatments	Organic carbon (%)	Total nitrogen (%)	Available phosphorus (kg ha^{-1})	Available potassium (kg ha^{-1})
1	C	0.667	0.138	35.833	168.000
2	WF	0.625	0.130	34.207	140.000
3	Sp	0.634	0.131	35.020	144.667
4	Si	0.644	0.131	35.020	149.333
5	Cp	0.634	0.131	35.020	149.333
6	CP → P	0.625	0.130	34.583	144.667
7	CP → G	0.625	0.130	34.583	144.667
8	D	0.625	0.130	34.643	144.667
9	O	0.634	0.131	35.020	144.667
10	A	0.644	0.131	35.457	163.333
11	D → P	0.625	0.130	34.583	144.667
12	O → P	0.629	0.130	35.020	144.667
13	A → P	0.634	0.131	35.020	158.667
	SE	0.015	0.003	0.663	5.978
	CD (0.05)	NS	NS	NS	NS

NS = Not significant

control plot. In general, weed free treatment as well as the treatments which resulted in better weed control efficiency recorded lesser soil fertility status compared to others. This is probably because of the lesser addition of organic matter and more absorption of nutrients by banana.

The results given above indicated that in banana continuous weed free condition either by manual or chemical methods will result in a slight reduction soil fertility status.

4. Economics

The data presented in Table 51 showed that in banana, chemical weed control was cheaper than manual, cultural and cultural + chemical methods. Highest profit per rupee invested on weeding was obtained from diuron treated plots (Rs.28.58). Application of diuron (t_8) and oxyfluorfen (t_9) alone resulted in more profit compared to application of paraquat subsequent to the above treatments (t_{11} and t_{12} respectively).

Weed free treatment (t_2) recorded more profit than spade weeding (t_3) and sickle weeding (t_4). Growing cowpea as an intercrop (t_5), cowpea followed by paraquat (t_6) or glyphosate (t_7) resulted in more or less equal profit and it was higher than that obtained from sickle weeded plots. Spade weeding recorded more profit than sickle weeding.

Table 51. Economics of different treatments

Tr. No.	Treatments	Additional cost for the treatments Rs.	Bunch yield (kg ha^{-1})	Receipt Rs.	Profit per rupee invested on weeding Rs.
1	C	-	15501.5	31003.00	-
2	WF	3400.00	27403.1	54806.20	7.00
3	Sp	2720.00	22407.3	44814.60	5.08
4	Si	1980.00	18440.1	36880.20	2.97
5	Cp	2570.00	19689.1	39378.20	3.26
6	CP → P	2980.00	20497.2	40994.40	3.35
7	CP → G	3100.00	20570.7	41141.40	3.27
8	D	545.00	23288.9	46577.80	28.58
9	O	753.00	21893.1	43786.20	16.98
10	A	570.00	20056.4	40112.80	15.98
11	D → P	955.00	24831.7	49663.40	19.54
12	O → P	1163.00	24684.7	49369.40	15.79
13	A → P	980.00	24684.8	49369.60	18.74

Cost of bunch = Rs.2/kg

Cost of diuron (Hexuron 80 WP) - Rs.200/kg
" oxyfluorfen (Goal 23.5 EC) - Rs.700/lit
" atrazine (Atrataf 50 W) - Rs.100/kg
" paraquat (Gramoxone 24 EC) - Rs.120/lit
" glyphosate (weed off 41 EC) - Rs.360/lit

The higher cost of labour required for manual and cultural methods might be the reason for the lesser profit from these treatments compared to chemical weed control. Among the pre-emergence herbicides, application of diuron resulted in highest bunch yield and highest profit per rupee invested on weeding. Application of paraquat in diuron and oxyfluorfen treated plots lead to an increase in bunch yield compared to application of diuron and oxyfluorfen alone. But the profit was higher from the latter treatments compared to the former treatments. This might be due to the fact that the additional yield obtained was not high enough to eompensate the cost of paraquat and its application charge.

The higher profit obtained from cowpea grown plots, cowpea followed by paraquat or glyphosate compared to sickle weeding might be due to the higher yield obtained from the former treatments compared to the latter.

The higher profit recorded by spade weeding compared to sickle weeding, intercropping of cowpea, cowpea followed by paraquat or glyphosate might also be due to the higher yield obtained from the former treatment compared to the latter treatments. The highest yield obtained from weed free treatment might have resulted in more profit from this treatment compared to spade weeding, sickle weeding and cowpea grown plots.

Plate 25 Unweeded control (t_1) - luxurient growth of weeds especially *Digitaria ciliaris*

Plate 26 Diuron 1.5 kg ha^{-1} (t_8) - weed growth three months after application

Plate 27 Diuron 1.5 kg ha^{-1} (t_8) - weed growth six months after application

Plate 28 Oxyfluorfen 0.2 kg ha^{-1} (t_9) - weed growth three months after application

Plate 29 Oxyfluorfen 0.2 kg ha^{-1} (t_9) - weed growth six months after application

Plate 30 Atrazine 2.0 kg he^{-1} (t_{10}) - weed growth three months after application

Plate 31 Atrazine 2.0 kg ha^{-1} (t_{10}) - weed growth six months after application - good control of dicot weeds but relatively poor control of monocot weeds

Plate 32 Diuron followed by paraquat (t_{11}) - good control of weeds

Plate 33 Oxyfluorfen followed by paraquat (t_{12}) - good control of weeds

Plate 34 Atrazine followed by paraquat (t_{13}) - good control of weeds

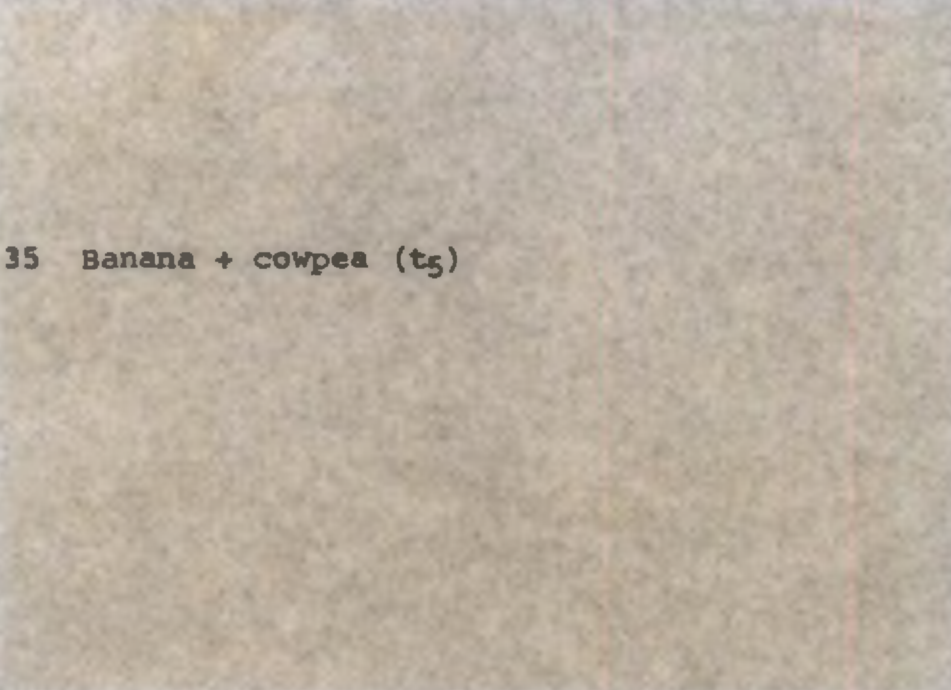

Plate 35 Banana + cowpea (t_5)

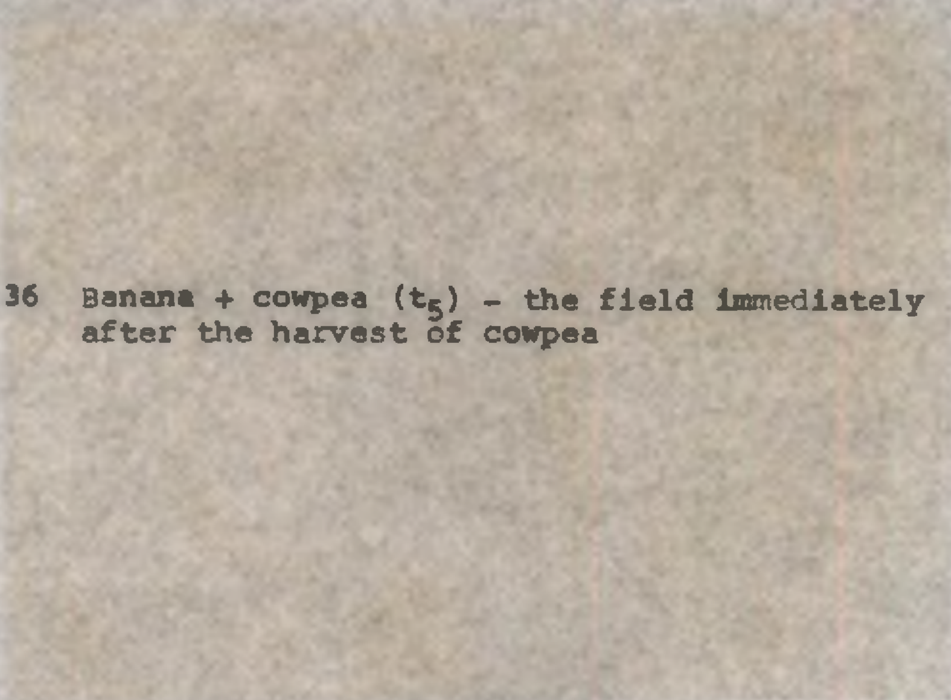

Plate 36 Banana + cowpea (t_5) - the field immediately after the harvest of cowpea

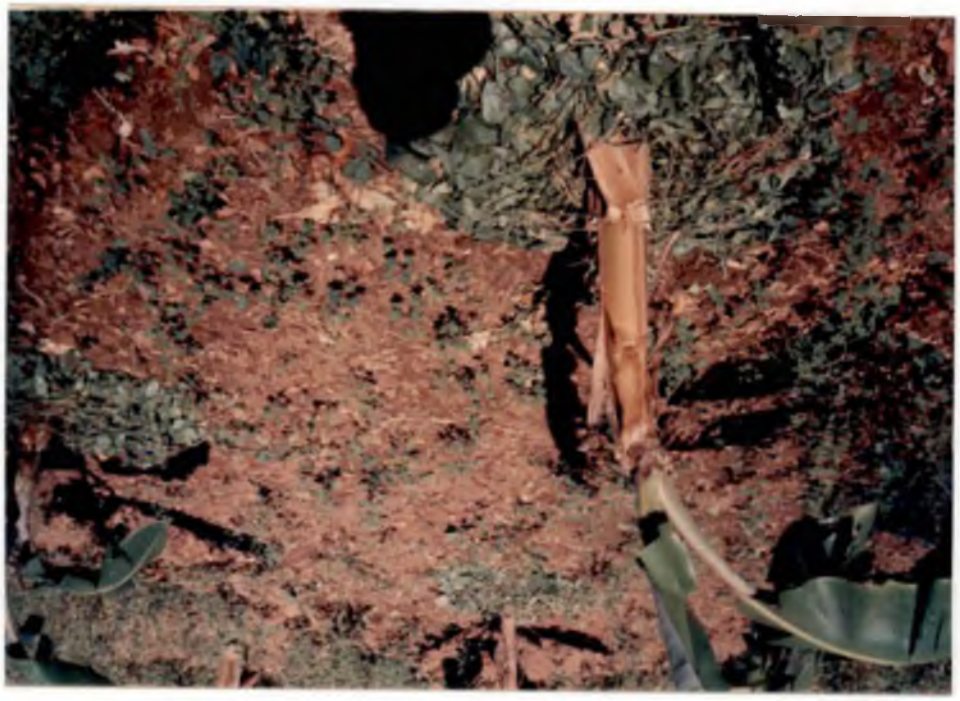

Plate 37 Banana + cowpea (t_5) - weed growth four months after the harvest of cowpea

Plate 38 Banana + cowpea followed by paraquat (t_6) - good weed control

Plate 39 Banana + cowpea followed by glyphosate (t_7) - good weed control


B + Cowpea
Paraquat 0·4 kg


B + Cowpea

Plate 40 Spade weeding twice (t_3) - subsequent germination of weeds after second spade weeding

Plate 41 Sickle weeding twice (t_4) - subsequent regrowth of weeds after second sickle weeding

Summary

SUMMARY

Investigations were conducted at the Agricultural Research Station, Mannuthy, Thrissur, Kerala, India to develop weed management practices for sole and intercropped coconut gardens during the period from 1986 to 1989. There were three field trials. In trial-I the treatments comprised of three manual methods (digging once, digging twice and sickle weeding), six chemical methods (paraquat three sprays, glyphosate 0.4 kg ha^{-1} , glyphosate 0.8 kg ha^{-1} dalapon followed by paraquat, paraquat + diuron and paraquat followed by glyphosate), two combinations of manual and chemical methods (2,4-D + diuron immediately after sickle weeding and glyphosate followed by digging) were compared with weed free and unweeded control in underplanted coconut garden. In trial-II, the treatments comprised of two manual methods (spade weeding and sickle weeding), one cultural method (growing cowpea as an intercrop), two cultural + chemical methods (cowpea followed by paraquat or glyphosate), three pre-emergence herbicides (diuron, oxyfluorfen and atrazine), three pre-emergence herbicides + post-emergence herbicide (diuron followed by paraquat, oxyfluorfen followed by paraquat and atrazine followed by paraquat) were compared

with weed free and unweeded control in coconut banana cropping system. Unweeded control in coconut banana cropping system was compared with that in sole crop of coconut. In trial-III, the treatments tried in coconut banana cropping system were evaluated in sole crop of banana and there were thirteen treatments. All these three trials were laid out in Randomised Block Design and replicated thrice.

The results obtained from these trials are summarised below.

Trial-I

The dicot weed <u>Chromolaena odorata</u> was the major weed found in the experimental field.

Application of paraquat 0.4 kg ha^{-1} thrice at monthly interval, glyphosate 0.8 kg ha^{-1} and dalapon 3.0 kg ha^{-1} followed by paraquat 0.4 kg ha^{-1} were effective in reducing monocot, dicot and total weed population, weed drymatter production as well as nutrient removal by weeds. Application of 2,4-D 1.0 kg ha^{-1} + diuron 1.0 kg ha^{-1} immediately after sickle weeding was most effective against dicot weeds. It was also effective in reducing total weed population, weed drymatter production and nutrient removal by weeds. All the above treatments were effective in reducing the population of the major weed <u>Chromolaena odorata</u>.

Maximum weed control efficiency was recorded by weed free treatment. It was followed by dalapon 3.0 kg ha^{-1} followed by paraquat 0.4 kg ha^{-1}, glyphosate 0.4 kg ha^{-1} followed by digging after North-East monsoon, paraquat 0.4 kg ha^{-1} sprayed thrice at monthly interval, glyphosate 0.8 kg ha^{-1} and application of 2,4-D 1.0 kg ha^{-1} + diuron 1.0 kg ha^{-1} immediately after sickle weeding in the descending order of weed control efficiency. Digging twice resulted in higher weed control efficiency compared to digging once and sickle weeding.

Maximum yield of 6027 nuts ha^{-1} was obtained from weed free treatment and the lowest yield of 3580 nuts ha^{-1} was recorded by unweeded control. Among other treatments application of dalapon 3.0 kg ha^{-1} followed by paraquat 0.4 kg ha^{-1} resulted in highest yield (5847 nuts ha^{-1}).

Lowest weed index of 6.0 per cent was recorded by application of dalapon 3.0 kg ha^{-1} followed by paraquat 0.4 kg ha^{-1} and highest weed index of 40.4 per cent was recorded by unweeded control.

Unweeded control had the lowest soil moisture content during summer months. Digging resulted in higher soil moisture content compared to chemical methods of weed control. Among the latter, paraquat 0.4 kg ha^{-1} sprayed thrice at monthly interval, glyphosate 0.8 kg ha^{-1}, dalapon 3.0 kg ha^{-1} followed by paraquat 0.4 kg ha^{-1}, 2,4-D 1.0 kg ha^{-1} + diuron 1.0 kg ha^{-1} immediately after sickle weeding recorded higher soil moisture content during summer months.

Unweeded control recorded the highest organic carbon, total N, available P and available K content of soil. Digging and sickle weeding recorded higher soil fertility compared to weed free treatment and chemical treatments.

Chemical weed control was cheaper than manual or manual + chemical methods. Application of paraquat 0.4 kg ha^{-1} + diuron 1.0 kg ha^{-1} was the most economic treatment. Application of dalapon 3.0 kg ha^{-1} followed by paraquat 0.4 kg ha^{-1} was the next economic treatment.

Trial-II

The monocot weed, *Pennisetum pedicellatum* was the major weed found in the experimental field.

Among the pre-emergence herbicides, diuron 1.5 kg ha^{-1} was most effective in reducing weed population, drymatter production and nutrient removal by weeds. Oxyfluorfen 0.2 kg ha^{-1} was equally effective as diuron 1.5 kg ha^{-1}. Intercropping of cowpea could reduce the weed population, weed drymatter production and nutrient removal by weeds upto its harvest (60 days). Subsequent application of paraquat in pre-emergence herbicide treated plots, paraquat or glyphosate after the harvest of cowpea resulted in a further reduction in weed population, drymatter production and nutrient removal by weeds.

Maximum weed control efficiency was recorded by diuron 1.5 kg ha^{-1} followed by paraquat 0.4 kg ha^{-1} and weed free treatment.

Maximum growth of coconut was observed in weed free treatment and minimum in unweeded control. Among the pre-emergence herbicides, diuron 1.5 kg ha^{-1} recorded the highest girth and number of fronds of coconut and it was followed by oxyfluorfen 0.2 kg ha^{-1}.

In plant and ratoon crop of banana, weed free treatment recorded the maximum growth and unweeded control recorded the minimum growth. Among the pre-emergence herbicides, diuron 1.5 kg ha^{-1} resulted in maximum plant growth and it was followed by oxyfluorfen 0.2 kg ha^{-1}.

Delayed shooting and maturity of banana was observed in unweeded control.

Maximum yield of 9553.2 kg ha^{-1} in plant crop and 13152.3 kg ha^{-1} in ratoon crop was recorded by weed free treatment. Lowest yield of 5554.2 kg ha^{-1} in plant crop and 7553.7 kg ha^{-1} in ratoon crop was recorded by unweeded control. Among the pre-emergence herbicides, diuron 1.5 kg ha^{-1} recorded the highest yield and yield attributes of banana in both the crops and it was followed by oxyfluorfen 0.2 kg ha^{-1}.

In plant crop of banana lowest weed index of 5.7 per cent was recorded by spade weeding. Whereas in ratoon crop the lowest weed index of 2.0 per cent was recorded by diuron 1.5 kg ha^{-1} followed by paraquat 0.4 kg ha^{-1}. In both the crops highest weed index was recorded by unweeded control (41.9 and 40.7 per cent respectively).

Yield of both plant and ratoon crop of banana was positively correlated with growth and yield attributing characters.

In plant crop and ratoon crop of banana weed free treatment recorded the maximum drymatter production (4638.9 kg and 6860.5 kg ha^{-1} respectively) and unweeded control had the lowest (3101.5 kg and 5234.2 kg ha^{-1} respectively). Among the pre-emergence herbicides, diuron 1.5 kg ha^{-1} recorded the highest drymatter production and it was followed by oxyfluorfen 0.2 kg ha^{-1}.

In both the crops, maximum N, P and K uptake by banana was recorded by weed free treatment and minimum by unweeded control. Among pre-emergence herbicides, diuron 1.5 kg ha^{-1} as well as oxyfluorfen 0.2 kg ha^{-1} recorded higher nutrient uptake by banana.

Weed free treatment recorded the highest soil moisture content during summer months and unweeded control had the lowest. Among the pre-emergence herbicides, diuron 1.5 kg ha^{-1} recorded the highest soil moisture content and it was followed by oxyfluorfen 0.2 kg ha^{-1}. The soil moisture content recorded by these treatments was higher than that recorded by spade weeding, sickle weeding and growing cowpea as an intercrop.

Unweeded control recorded the highest organic carbon, total N, available P and available K content of soil. In weed free treatment the soil fertility was very low. Manual methods like spade weeding and sickle weeding recorded higher soil fertility compared to chemical treatments. Among the chemical treatments, the treatments having higher weed control efficiency resulted in lower soil fertility.

In coconut+banana cropping system chemical weed control was cheaper than manual, cultural as well as cultural + chemical methods. Diuron 1.5 kg ha^{-1} was the most economic treatment.

Trial-III

The monocot weed Digitaria ciliaris was the major weed found in the experimental field.

Among the pre-emergence herbicides, diuron 1.5 kg ha^{-1} was most effective in reducing monocot and total weed population, weed drymatter production and nutrient removal by weeds. Whereas atrazine was most effective in reducing the dicot weed population. Subsequent application of paraquat in pre-emergence herbicide treated plots brought about a significant reduction in weed population, weed drymatter production and nutrient removal by weeds. Growing cowpea as an intercrop could reduce the weed population, weed drymatter as well as nutrient removal by weeds upto its harvest (60 days).

Maximum weed control efficiency was recorded by weed free treatment. Among other treatments, diuron 1.5 kg ha^{-1} followed by paraquat 0.4 kg ha^{-1} resulted in highest weed control efficiency.

The effect of treatments on growth, yield, drymatter production and nutrient uptake of banana exhibited almost the same trend as in trial-II. The maximum yield of 27403.1 kg ha^{-1} and drymatter production of 8279.7 kg ha^{-1} were recorded by weed free treatment.

Delayed shooting and maturity of banana was observed in unweeded control.

The lowest weed index of 5.7 per cent was recorded by diuron 1.5 kg ha^{-1} followed by paraquat 0.4 kg ha^{-1} and highest weed index of 40.7 per cent was recorded by unweeded control.

Yield of banana was positively correlated with growth and yield attributing characters.

None of the treatments had any significant influence on organic carbon, total N, available P and available K content of soil. However the effect of treatments on soil fertility followed almost the same trend as in trial-II.

In sole banana also chemical weed control was cheaper than manual, cultural and cultural + chemical methods. Diuron 1.5 kg ha^{-1} was the most economic treatment.

Future line of work

1. Certain weeds found in coconut plantations such as *Ichnocarpus frutescens* and *Hemidesmus indicus* which have got a very deep root system were not seen adequately controlled by any of the chemicals used. Hence further investigations using wider spectrum of chemicals are necessary.

2. Growing cowpea as an intercrop in coconut+ banana cropping system as well as in pure banana field was found effective for smothering weeds only upto 60 days after sowing at which stage it was cut as green manure. Subsequent germination of weeds in these plots was noticed. Hence further work is necessary to test the usefulness of growing a second crop of cowpea for controlling weeds.

3. It was noted that in coconut plantations complete weed control using chemicals may not be conducive for maintaining soil fertility. Detailed investigations are necessary to find out a weed management method wherein organic matter is maintained and at the same time weed growth is curtailed without affecting crop growth and production.

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*Originals not seen

Appendices

Appendix-I. Weather data during the cropping period

	Mean temperature (°C)		Mean RH (%)	Total rainfall (mm)	Total evoporation (mm)	Mean sunshine hours
	Max.	Min.				
1986						
July	29.5	23.2	84	381.4	104.8	4.8
August	29.4	22.7	83	358.7	128.5	5.5
September	30.5	22.7	81	296.3	118.2	5.7
October	31.8	22.9	80	421.3	120.6	6.4
November	31.2	22.0	71	176.2	141.8	7.4
December	32.5	23.5	60	10.8	223.4	9.3
1987						
January	33.2	22.7	52	0.0	266.8	9.6
February	35.0	22.4	52	0.0	230.0	10.1
March	36.4	22.2	55	0.0	257.6	10.2
April	36.2	25.3	64	13.3	214.9	7.8
May	36.1	24.7	66	95.0	218.6	9.0
June	30.7	23.7	83	837.7	106.5	4.2
July	30.3	23.5	84	336.5	117.4	5.7
August	29.6	23.5	87	388.4	100.0	3.7
September	31.5	23.9	79	174.0	120.0	7.4
October	31.9	23.9	79	280.4	118.2	6.2
November	31.6	22.8	77	224.4	103.8	6.7
December	31.6	23.3	70	64.6	143.3	8.1
1988						
January	32.4	22.0	56	0.0	217.4	10.4
February	35.8	23.1	56	7.8	191.2	10.0
March	35.7	24.4	67	37.9	202.5	9.1
April	35.1	24.3	70	145.4	172.9	8.8

(Contd.)

Appendix-I (Contd.)

(1)		(2)	(3)	(4)	(5)	(6)	(7)
1988							
	May	33.7	25.4	76	242.6	144.9	6.2
	June	30.0	23.7	86	632.1	86.3	4.2
	July	29.0	23.2	88	545.0	78.7	3.0
	August	29.2	24.3	86	507.8	97.6	3.7
	September	29.9	23.2	85	700.0	87.5	5.1
	October	31.7	23.3	78	116.6	113.7	7.1
	November	32.6	22.9	68	11.0	116.7	7.9
	December	32.6	22.3	57	14.9	206.3	9.0
1989							
	January	33.9	22.2	54	0.0	253.8	8.1
	February	36.3	21.2	45	0.0	227.7	9.8
	March	36.5	23.3	58	31.3	218.6	9.5
	April	35.3	25.1	69	52.6	179.2	8.3
	May	33.7	24.5	74	115.8	152.0	7.0
	June	29.4	22.7	86	784.6	83.0	3.2
	July	29.1	23.3	86	562.0	98.1	4.2
	August	29.5	23.1	83	319.9	110.0	5.4
	September	29.9	23.1	82	180.1	97.8	5.5
	October	31.0	23.0	80	351.3	112.4	6.2
	November	32.5	22.7	63	8.1	141.3	8.5
	December	32.7	23.2	60	0.0	204.7	9.7

Appendix - II

Weed flora found in underplanted coconut garden

Botanical name	Common name
Monocot weeds	
1 *Brachiaria mutica* (Forssk.) Stapf	Para grass
2 *Cynodon dactylon* (L.) Pers.	Bermuda grass
3 *Cyperus rotundus* L.	Purple nutsedge
4 *Ischaemum indicum* (Houtt.) Merr.	Padappanpullu (M)
5 *Paspalum scrobiculatum* L.	Knot grass
6 *Pennisetum pedicellatum* Trin.	Deenanath grass
Dicot weeds	
1 *Ageratum conyzoides* L.	Appakkodi (M)
2 *Biophytum sensitivum* (L.) DC.	Mukkutti (M)
3 *Blumea oxydonta* DC.	Bhoothamkolli (M)
4 *Caesalpinia mimosoides* Lamk.	Timullu (M)
5 *Centrosema pubescens* Benth.	Centrosema
6 *Chromolaena odorata* (L.) King & Robins.	Siam weed
7 *Cyanotis cristata* (L.) D. Don.	NA
8 *Desmodium triflorum* (L.) DC.	Cherupulladi (M)
9 *Hemidesmus indicus* (L.) R. Br.	Indian Sarasaparilla
10 *Ichnocarpus frutescens* (L.) R. Br.	Paal vally (M)
11 *Justicia trinervia* Vahl	NA

(Contd.)

Appendix II (Contd.)

	Botanical name
12	*Knoxia mollis* W. & A.
13	*Lantana camara* L.
14	*Merrimia umbellata* (L.). Hall. f.
15	*Mimosa pudica* L.
16	*Naregamia alata* W. & A.
17	*Phyllanthus debilis* Klein ex Willd.
18	*Rungia pectinata* (L.) Nees
19	*Sebastiania chamaelea* (L.) Muell. - Arg.
20	*Sida acuta* Burm. f.
21	*Sida rhombifolia* L.
22	*Synedrella nodiflora* (L.) Gaertn.
23	*Urena lobata* L.

M = Malayalam name

Common name)
NA
Puchedi (M)
NA
Sensitive plant
Nilanaragom (M)
Kizhanelli (M)
NA
Odiyavanakku (M)
Aana kurunthotti (M)
Kurunthotti (M)
Mudiyendrapacha (M)
Uram (M)

NA = Not available

Appendix - III. N content of weed samples (%)

Tr. No.	Treatments	45 DAS			90 DAS			135 DAS			180 DAS			225 DAS			270 DAS		315 DAS	
		86-87	87-88	88-89	86-87	87-88	88-89	86-87	87-88	88-89	86-87	87-88	88-89	86-87	87-88	88-89	87-88	88-89	87-88	88-89
1	C	1.76	2.43	2.02	1.64	1.64	1.76	1.30	2.09	1.95	1.76	1.71	1.83	1.76	1.95	1.89	1.71	1.76	1.35	1.41
2	WF	1.89	2.02	1.95	-	-	-	1.47	2.15	1.76	-	-	-	1.30	1.83	1.76	-	-	1.24	1.30
3	D(1)	1.89	1.47	1.59	1.41	1.95	1.89	1.52	1.95	1.89	1.71	1.95	1.95	1.76	1.95	1.95	1.64	1.59	1.14	1.41
4	D(2)	1.76	1.41	1.59	1.64	1.64	1.59	1.64	2.09	1.89	1.35	1.95	1.95	1.52	1.83	1.89	1.35	1.41	-	-
5	Si(2)	1.59	1.59	1.71	1.52	1.59	1.64	1.30	2.23	1.95	1.83	1.59	1.64	1.24	1.47	1.52	1.35	1.59	1.14	1.41
6	P(3)	1.71	2.37	1.89	1.59	1.83	1.71	1.71	1.83	1.71	1.76	1.47	1.41	1.95	1.35	1.41	1.24	1.35	1.19	1.24
7	G(L)	1.64	2.09	1.76	1.52	1.83	1.76	1.47	1.83	1.89	1.52	1.59	1.64	1.64	1.41	1.52	1.89	1.76	1.30	1.41
8	G(H)	1.24	2.15	1.76	1.52	1.95	1.71	1.35	2.30	1.83	1.71	1.59	1.41	1.52	1.59	1.59	1.47	1.41	1.52	1.30
9	Da(1) → P(1)	1.35	2.44	1.64	1.59	1.59	1.47	1.52	1.59	1.64	1.83	1.35	1.41	1.35	1.30	1.41	1.30	1.35	1.03	1.14
10	P + Di(1)	1.30	2.02	1.47	1.35	1.95	1.76	1.59	2.02	1.89	1.35	1.41	1.59	1.30	1.35	1.47	1.41	1.52	1.09	1.10
11	P(1) → G(L)	1.30	1.42	1.47	1.14	1.59	1.64	1.24	1.71	1.76	1.59	1.71	1.83	1.30	1.52	1.59	1.52	1.59	1.35	1.41
12	Si(1)→2,4-D+Di(1)	1.47	1.71	1.59	1.41	1.71	1.64	1.47	1.64	1.76	1.64	1.64	1.76	1.83	1.64	1.64	1.89	1.76	1.14	1.30
13	G(L) → D(1)	1.52	1.47	1.52	1.41	1.64	1.59	1.59	2.15	-	1.83	1.64	1.83	1.35	1.41	1.52	1.64	1.76	1.64	1.30

DAS = Days after spraying

Appendix - IV. P content of weed samples (%)

Tr. No.	Treatments	45 DAS			90 DAS			135 DAS			180 DAS			225 DAS			270 DAS		315 DAS	
		86-87	87-88	88-89	86-87	87-88	88-89	86-87	87-88	88-89	86-87	87-88	88-89	86-87	87-88	88-89	87-88	88-89	87-88	88-89
1	C	0.05	0.36	0.33	0.08	0.16	0.19	0.08	0.19	0.19	0.13	0.19	0.21	0.16	0.19	0.21	0.19	0.19	0.30	0.27
2	WF	0.10	0.27	0.21	-	-	-	0.08	0.24	0.21	-	-	-	0.13	0.16	0.19	-	-	0.16	0.19
3	D(1)	0.13	0.24	0.30	0.08	0.21	0.24	0.13	0.27	0.24	0.08	0.21	0.21	0.24	0.21	0.21	0.16	0.19	0.13	0.19
4	D(2)	0.10	0.21	0.30	0.10	0.16	0.19	0.10	0.16	0.19	0.05	0.16	0.19	0.10	0.13	0.16	0.19	0.19	-	-
5	Si(2)	0.08	0.30	0.24	0.13	0.27	-	0.05	0.27	0.30	0.10	0.21	0.21	0.13	0.21	0.24	0.19	0.21	0.24	0.24
6	P(3)	0.10	0.19	0.27	0.08	0.21	0.21	0.10	0.27	0.24	0.16	0.21	0.19	0.24	0.19	0.16	0.21	0.19	0.19	0.16
7	G(L)	0.08	0.33	0.33	0.13	0.24	0.24	0.16	0.24	0.24	0.13	0.24	0.24	0.13	0.13	0.16	0.24	0.24	0.21	0.24
8	G(H)	0.08	0.33	0.24	0.10	0.27	0.24	0.13	0.27	0.24	0.13	0.16	0.16	0.21	0.13	0.16	0.13	0.16	0.24	0.19
9	Da(1) → P(1)	0.10	0.27	0.30	0.10	0.27	0.21	0.13	0.30	0.27	0.08	0.19	0.16	0.24	0.19	0.19	0.16	0.16	0.21	0.16
10	P + Di(1)	0.05	0.24	0.24	0.08	0.19	0.21	0.13	0.19	0.21	0.08	0.16	0.19	0.19	0.16	0.19	0.13	0.19	0.16	0.16
11	P(1) → G(L)	0.10	0.21	0.21	0.10	0.21	0.21	0.10	0.24	0.21	0.10	0.19	0.19	0.19	0.19	0.21	0.19	0.21	0.19	0.19
12	Si(1)→2,4-D+Di(1)	0.08	0.24	0.21	0.16	0.19	0.21	0.13	0.19	0.24	0.08	0.19	0.21	0.16	0.13	0.16	0.19	0.19	0.16	0.19
13	G(L) → D(1)	0.08	0.30	0.21	0.13	0.27	0.24	0.16	0.27	-	0.13	0.19	0.21	0.19	0.10	0.13	0.19	0.21	0.27	0.24

DAS = Days after spraying

Appendix - V. K content of weed samples (%)

Tr. No.	Treatments	45 DAS			90 DAS			135 DAS			180 DAS			225 DAS			270 DAS		315 DAS	
		86-87	87-88	88-89	86-87	87-88	88-89	86-87	87-88	88-89	86-87	87-88	88-89	86-87	87-88	88-89	87-88	88-89	87-88	88-89
1	C	1.30	1.05	1.28	1.18	1.00	1.05	1.15	0.93	1.15	1.83	1.18	1.15	1.58	1.18	1.20	1.15	1.18	1.25	1.20
2	WF	1.78	2.13	0.75	-	-	-	1.45	0.95	1.03	-	-	-	1.48	0.90	1.00	-	-	1.23	1.18
3	D(1)	1.56	1.10	1.10	1.30	1.18	1.15	1.13	0.75	1.00	1.10	0.83	1.00	1.83	0.70	0.95	0.93	1.00	1.00	1.03
4	D(2)	1.30	1.60	1.23	1.20	1.18	1.15	1.33	0.83	1.03	1.10	0.95	0.95	1.33	0.78	0.88	1.00	1.00	-	-
5	Si(2)	1.38	1.20	0.88	1.23	1.20	1.20	1.23	1.18	1.20	1.38	1.23	1.20	1.50	0.70	1.18	0.95	1.13	1.03	1.08
6	P(3)	1.43	0.95	1.15	1.40	1.15	1.18	1.50	0.88	1.00	1.13	0.95	1.03	1.83	0.88	1.00	0.83	1.00	1.08	1.18
7	G(L)	1.08	1.10	1.78	1.10	1.08	1.13	1.55	1.05	1.03	1.35	1.18	1.15	1.58	1.30	1.03	1.15	1.03	1.13	1.10
8	G(H)	1.48	1.03	0.90	1.30	1.13	1.15	1.33	1.05	1.05	1.55	1.00	1.03	1.55	0.90	1.05	1.18	1.05	1.10	1.05
9	Da(1) → P(1)	1.30	1.33	1.40	1.48	1.30	1.25	1.25	1.00	1.05	1.20	1.05	1.00	1.75	0.88	1.00	0.95	1.00	1.05	1.00
10	P + Di(1)	1.23	1.20	0.80	1.23	1.18	1.20	1.35	1.00	1.08	1.48	1.13	1.05	1.83	0.88	1.03	0.90	1.00	1.30	1.23
11	P(1) → G(L)	1.70	0.98	0.93	1.25	1.03	1.10	1.13	1.10	1.15	1.30	1.10	1.13	1.43	0.85	1.13	0.93	1.03	1.03	1.00
12	Si(1) → 2,4-D+Di(1)	1.70	0.95	0.98	1.40	1.10	1.13	1.28	0.95	1.03	1.10	1.03	1.10	1.68	0.98	1.13	0.95	1.03	0.93	1.00
13	G(L) → D(1)	1.30	1.10	1.08	1.30	1.18	1.18	1.53	1.20	-	1.38	1.18	1.15	1.50	0.88	1.18	0.88	1.00	0.83	1.00

DAS = Days after sprayin

Appendix - VI

Weed flora found in coconut - banana cropping system

	Botanical name	Common name
Monocot weeds		
1	Brachiaria mutica (Forssk.) Stapf	Para grass
2	Cynodon dactylon (L.) Pers.	Bermuda grass
3	Cyperus rotundus L.	Purple nutsedge
4	Digitaria ciliaris (Retz.) Koeler	Crab grass
5	Ischaemum indicum (Houtt.) Merr.	Padappan pullu (M)
6	Pennisetum pedicellatum Trin.	Deenanath grass
Dicot weeds		
1	Ageratum conyzoides L.	Appakkodi (M)
2	Atylosia scarabaeoides (L.) Benth.	NA
3	Biophytum sensitivum (L.) DC.	Mukkutti (M)
4	Borreria articularis (L.f.) F. Will.	Tharthaval (M)
5	Caesalpinia mimosoides Lamk.	Timullu (M)
6	Centrosema pubescens Benth.	Centrosema
7	Chromolaena odorata (L.) King & Robins.	Siam weed
8	Colocasia esculenta (L.) Schott	Kattushembu (M)
9	Costus speciosus (Koen.) J.E. Sm.	Channakkuva (M)
10	Cyclea peltata (Lamk.) Hook f.& Thoms.	Padakizhangu (M)
11	Desmodium triflorum (L.) DC.	Cherupulladi (M)
12	Emilia sonchifolia (L.) DC.	Muyalcheviyan (M)

(Contd.)

Appendix - VI (Contd.)

	Botanical name
13	Euphorbia hirta L.
14	Glycosmis pentaphylla (Retz.) DC.
15	Hemidesmus indicus (L.) R. Br.
16	Hyptis suaveolens (L.) Poit.
17	Ichnocarpus frutescens (L.) R.Br.
18	Indidofera hirsuta L.
19	Ipomoea - pes - tigridis L.
20	Knoxia mollis W. & A.
21	Lantana camara L.
22	Merrimia tridentata (L.) Hall. f.
23	Merrimia umbellata (L.) Hall.f.
24	Metracarpus villosus (Sw.) DC.
25	Mimosa pudica L.
26	Mucuna pruriens (L.) DC.
27	Phyllanthus debilis Klein ex Willd.
28	Scoparia dulcis L.

Common name
Garden spurge
Panal (M)
Indian Sarasaparilla
Naatta puchedi (M)
Paalvally (M)
Narunji (M)
Tigers foot
NA
Puchedi (M)
NA
NA
NA
Sensitive plant
The cowhage plant
Kizhanelli (M)
NA

(Contd.)

Appendix - VI (Contd.)

	Botanical name	Common name
29	*Sebastiania chamaelea* (L.) Muell. - Arg.	Odiyavanakku (M)
30	*Sida acuta* Burm.f.	Aana kurunthotti (M)
31	*Sida cordifolia* L.	Country - mallow
32	*Sida rhombifolia* L.	Kurunthotti (M)
33	*Stachytarpheta indica* (L.) Vahl	Aaron's rod
34	*Synedrella nodiflora* (L.) Gaertn.	Mudiyendra - pacha (M)
35	*Urena lobata* L.	Uram (M)
36	*Vernonia cinerea* (L.) Less.	Ash colored Fleabane
37	*Vicoa indica* (L.) DC.	Mookkuthi poov (M)

M = Malayalam name NA = Not available

Appendix - VII. N content of weed samples (%)

Tr. No.	Treatments	45 DAS 86-87	45 DAS 87-88	45 DAS 88-89	90 DAS 86-87	90 DAS 87-88	90 DAS 88-89	135 DAS 86-87	135 DAS 87-88	135 DAS 88-89	180 DAS 86-87	180 DAS 87-88	180 DAS 88-89	225 DAS 86-87	225 DAS 87-88	225 DAS 88-89	270 DAS 86-87	270 DAS 87-88	270 DAS 88-89	315 DAS 87-88	315 DAS 88-89
1	Cc	1.35	1.41	1.41	1.35	1.35	1.30	1.30	1.35	1.30	1.24	1.80	1.24	1.30	1.47	1.41	1.47	1.47	1.41	1.47	1.47
2	C-WP	1.35	1.35	1.41	1.35	1.24	1.41	1.30	1.35	1.41	1.30	1.41	1.35	1.47	1.35	1.41	1.30	1.35	1.47	1.35	1.47
3	C+B-WP	1.41	1.35	1.35	1.41	1.30	1.30	1.35	1.24	1.30	1.30	1.24	1.30	1.35	1.41	1.35	1.30	1.41	1.30	1.35	1.30
4	C+B-WF	1.35	1.83	1.41	-	-	-	1.41	1.47	1.35	-	-	-	1.52	1.59	1.52	-	-	-	1.59	1.59
5	C+B-Sp	1.41	-	-	-	1.35	1.41	1.59	-	-	1.95	1.89	1.64	1.59	1.52	1.47	1.30	1.76	1.47	1.52	1.59
6	C+B-Si	1.35	-	-	-	1.35	1.41	1.47	-	-	1.59	1.52	1.59	1.83	1.95	1.59	1.24	1.76	1.59	1.89	1.76
7	C+B+Cp	1.47	1.47	1.41	1.24	1.41	1.35	1.47	1.35	1.47	1.59	1.47	1.52	1.64	1.35	1.47	1.41	1.24	1.47	1.24	1.35
8	C+B+CP → P	1.41	1.35	1.35	1.47	1.52	1.30	1.59	1.30	1.35	1.64	1.52	1.47	1.35	1.41	1.47	1.24	1.30	1.41	1.47	1.30
9	C+B+CP → G	1.35	1.35	1.41	1.52	1.30	1.41	1.14	1.47	1.41	1.41	1.47	1.47	1.47	1.41	1.41	1.35	1.41	1.41	1.30	1.35
10	C+B-D	1.30	1.41	1.41	1.35	1.35	1.30	1.30	1.14	1.30	1.41	1.52	1.41	1.14	1.35	1.41	1.19	1.35	1.30	1.64	1.52
11	C+B-O	1.35	1.41	1.35	1.35	1.52	1.35	1.30	1.24	1.41	1.41	1.52	1.41	1.35	1.41	1.47	1.19	1.35	1.35	1.59	1.59
12	C+B-A	1.52	1.59	1.47	1.52	1.35	1.35	1.71	1.30	1.41	1.47	1.64	1.47	1.64	1.59	1.47	1.35	1.30	1.35	1.64	1.52
13	C+B-D → P	1.41	1.52	1.35	1.30	1.30	1.30	1.35	1.35	1.30	1.41	1.35	1.30	1.41	1.41	1.35	1.14	1.35	1.30	1.52	1.47
14	C+B-O → P	1.47	1.76	1.47	1.30	1.30	1.41	1.30	1.30	1.30	1.64	1.30	1.30	1.41	1.52	1.41	1.19	1.35	1.35	1.59	1.52
15	C+B-A → P	1.52	1.83	1.47	1.71	1.30	1.41	1.41	1.47	1.41	1.64	1.47	1.30	1.47	1.76	1.52	1.19	1.47	1.41	1.59	1.52

DAS = Days after spraying

Appendix - VIII. P content of weed samples (%)

Tr. No.	Treatments	45 DAS			90 DAS			135 DAS			180 DAS			225 DAS			270 DAS			315 DAS	
		86-87	87-88	88-89	86-87	87-88	88-89	86-87	87-88	88-89	86-87	87-88	88-89	86-87	87-88	88-89	86-87	87-88	88-89	87-88	88-89
1	Cc	0.21	0.24	0.21	0.21	0.16	0.21	0.13	0.10	0.13	0.13	0.16	0.13	0.13	0.16	0.16	0.16	0.13	0.13	0.16	0.13
2	C-WP	0.24	0.21	0.24	0.24	0.16	0.21	0.10	0.13	0.10	0.13	0.16	0.13	0.08	0.16	0.16	0.16	0.16	0.16	0.13	0.16
3	C+B-WP	0.21	0.16	0.16	0.24	0.16	0.21	0.10	0.10	0.13	0.10	0.13	0.13	0.08	0.13	0.16	0.13	0.13	0.13	0.13	0.13
4	C+B-WP	0.21	0.27	0.21	-	-	-	0.19	0.19	0.16	-	-	-	0.13	0.13	0.16	-	-	-	0.13	0.13
5	C+B-Sp	0.21	-	-	-	0.13	0.16	0.19	-	-	0.08	0.21	0.19	0.13	0.16	0.13	0.10	0.10	0.13	0.13	0.10
6	C+B-Si	0.19	-	-	-	0.13	0.21	0.13	-	-	0.10	0.24	0.16	0.19	0.16	0.16	0.10	0.13	0.13	0.10	0.10
7	C+B+Cp	0.16	0.19	0.16	0.19	0.24	0.24	0.16	0.16	0.19	0.16	0.16	0.19	0.08	0.13	0.16	0.10	0.10	0.10	0.13	0.10
8	C+B+CP → P	0.19	0.21	0.19	0.21	0.21	0.24	0.16	0.16	0.16	0.08	0.16	0.16	0.08	0.13	0.13	0.10	0.13	0.10	0.10	0.13
9	C+B+CP → G	0.24	0.24	0.19	0.21	0.19	0.21	0.16	0.13	0.16	0.13	0.19	0.16	0.08	0.13	0.13	0.13	0.13	0.10	0.13	0.13
10	C+B-D	0.21	0.21	0.24	0.24	0.16	0.21	0.13	0.19	0.16	0.08	0.16	0.16	0.08	0.10	0.13	0.10	0.10	0.13	0.10	0.13
11	C+B-O	0.19	0.21	0.21	0.21	0.16	0.19	0.13	0.16	0.16	0.13	0.16	0.19	0.10	0.10	0.10	0.08	0.13	0.10	0.10	0.10
12	C+B-A	0.21	0.21	0.21	0.21	0.24	0.19	0.13	0.13	0.16	0.13	0.16	0.19	0.10	0.13	0.10	0.08	0.13	0.10	0.13	0.10
13	C+B-D → P	0.19	0.19	0.24	0.16	0.19	0.21	0.16	0.16	0.13	0.08	0.19	0.16	0.08	0.10	0.10	0.08	0.08	0.10	0.16	0.13
14	C+B-O → P	0.19	0.24	0.24	0.16	0.21	0.21	0.16	0.16	0.16	0.08	0.19	0.19	0.08	0.08	0.10	0.10	0.08	0.13	0.19	0.13
15	C+B-A → P	0.21	0.21	0.24	0.19	0.21	0.27	0.19	0.19	0.16	0.10	0.21	0.19	0.08	0.10	0.13	0.10	0.08	0.13	0.19	0.13

DAS = Days after spraying

Appendix - IX. K content of weed samples (%)

Tr. No.	Treatments	45 DAS			90 DAS			135 DAS			180 DAS			225 DAS			270 DAS			315 DAS	
		86-87	87-88	88-89	86-87	87-88	88-89	86-87	87-88	88-89	86-87	87-88	88-89	86-87	87-88	88-89	86-87	87-88	88-89	87-88	88-89
1	Cc	1.30	1.43	1.45	1.83	1.83	1.30	1.55	3.15	2.50	1.30	1.40	1.13	1.15	1.18	0.98	1.85	1.03	0.95	1.35	1.28
2	C-WP	1.30	1.35	1.43	1.75	1.78	1.30	1.43	3.15	2.28	1.28	1.35	1.10	1.15	1.13	0.98	1.80	1.00	0.90	1.33	1.28
3	C+B-WP	1.28	1.33	1.15	1.70	1.70	1.23	1.35	3.05	2.15	1.00	1.13	1.10	1.05	0.98	0.85	1.48	1.00	0.90	1.15	1.13
4	C+B-WF	1.28	1.33	1.30	–	–	–	1.38	3.00	1.93	–	–	–	0.80	0.95	0.78	–	–	–	0.98	0.95
5	C+B-Sp	1.30	–	–	–	2.20	1.30	1.80	–	–	1.30	1.25	1.18	0.80	0.90	1.00	0.83	0.75	0.88	0.88	0.90
6	C+B-Si	1.30	–	–	–	1.85	1.33	1.78	–	–	1.30	1.25	1.15	0.93	0.78	0.98	1.15	0.68	0.85	0.98	0.98
7	C+B+Cp	0.95	1.00	1.13	1.18	1.28	1.30	1.40	2.15	1.93	1.23	1.33	1.40	1.05	1.03	1.00	1.25	0.90	0.85	1.05	1.15
8	C+B+CP → P	0.88	1.00	1.00	1.15	1.28	1.35	1.38	2.05	1.80	1.03	1.03	0.98	1.00	0.95	0.80	1.08	0.85	0.75	1.00	0.95
9	C+B+CP → G	0.88	1.08	1.15	1.18	1.25	1.30	1.40	2.15	1.80	1.03	1.00	0.95	0.95	1.00	0.80	1.10	0.85	0.73	0.95	0.98
10	C+B-D	1.23	1.55	0.95	1.40	1.73	1.05	0.90	2.15	1.40	0.55	1.10	1.10	0.73	0.68	0.60	0.88	0.63	0.60	0.85	0.88
11	C+B-O	1.23	1.65	1.00	1.55	2.08	1.23	1.00	2.50	1.85	1.03	1.18	1.13	0.85	0.70	0.68	1.13	0.70	0.60	1.00	1.13
12	C+B-A	1.75	2.50	1.28	2.95	2.25	1.40	1.68	3.15	2.50	1.05	1.20	1.33	0.85	0.88	0.88	1.13	0.83	0.78	1.33	1.28
13	C+B-D → P	1.23	1.55	1.15	1.55	1.75	1.10	0.95	2.05	1.55	0.93	0.85	0.88	0.80	0.80	0.75	0.78	0.55	0.63	0.78	0.80
14	C+B-O → P	1.28	1.93	1.23	1.93	1.80	1.33	1.38	3.00	1.93	1.05	0.98	0.98	1.03	0.88	0.80	1.03	0.70	0.73	1.03	1.10
15	C+B-A → P	1.80	2.15	1.25	2.05	2.15	1.83	1.50	3.15	2.50	1.08	1.03	1.00	1.18	0.90	0.90	1.45	0.78	0.80	1.33	1.23

DAS = Days after spraying

Appendix - X

Weed flora found in sole banana plantation

	Botanical name	Common name
Monocot weeds		
1	Brachiaria mutica (Forssk.) Stapf	Para grass
2	Cynodon dactylon (L.) Pers.	Bermuda grass
3	Cyperus iria L.	Sedge weed
4	Digitaria ciliaris (Retz.) Koeler	Crab grass
5	Echinochloa colona (L.) Link.	Jungle rice
6	Eleusine indica (L.) Gaertn.	Goose grass
Dicot weeds		
1	Ageratum conyzoides L.	Appakkedi (M)
2	Centrosema pubescens Benth.	Centrosema
3	Chromolaena odorata (L.) King & Robins.	Siam weed
4	Cleome viscosa L.	Wild mustard
5	Coldenia procumbens L.	NA
6	Emilia sonchifolia (L.) DC.	Muyalcheviyan (M)
7	Heliotropium indicum L.	Indian Turnsole
8	Hyptis suaveolens (L.) Poit.	Naatta puchedi (M)
9	Ludwigia parviflora Roxb.	Water prim rose

(Contd.)

Appendix - X (Contd.)

	Botanical name	Common name
10	Metracarpus villosus (Sw.) DC.	NA
11	Mimosa pudica L.	Sensitive plant
12	Mollugo pentaphylla L.	Parpadakapullu (M)
13	Phyllanthus debilis Klein ex Willd.	Kizhanelli (M)
14	Physalis minima L.	Njodi - njotta (M)
15	Portulaca oleracea L.	Indian purslane
16	Sida acuta Burm f.	Aana kurunthotti (M)
17	Synedrella nodiflora (L.) Gaertn.	Mudiyendra pacha (M)
18	Triumfetta rhomboidea Jacq.	NA

M = Malayalam name NA = Not available

Appendix - XI. N, P and K content of weed samples (%)

No.	Treatments	N							P							K						
		DAS							DAS							DAS						
		45	90	135	180	225	270	315	45	90	135	180	225	270	315	45	90	135	180	225	270	315
1	C	0.88	1.30	1.30	1.30	1.59	1.64	1.59	0.18	0.15	0.18	0.18	0.24	0.30	0.30	1.60	1.70	1.75	1.80	2.30	3.00	3.00
2	WF	0.73	-	1.09	-	0.68	-	0.64	0.15	-	0.18	-	0.18	-	0.15	1.50	-	2.00	-	2.40	-	2.35
3	Sp	0.73	1.19	1.24	1.24	1.19	1.30	1.24	0.15	0.10	0.15	0.15	0.15	0.24	0.21	1.55	1.60	1.70	1.75	2.60	2.40	2.40
4	Si	0.79	1.24	1.24	1.24	1.24	1.35	1.24	0.15	0.13	0.15	0.18	0.15	0.27	0.24	1.60	1.60	1.70	1.80	3.00	2.50	2.45
5	CP	-	1.14	1.47	1.47	1.19	1.19	1.09	-	0.18	0.15	0.18	0.15	0.18	0.18	-	1.75	1.75	1.75	2.00	2.10	2.15
6	CP → P	-	1.09	1.19	1.24	1.09	1.03	1.03	-	0.18	0.15	0.15	0.18	0.21	0.18	-	1.75	1.75	1.75	2.30	3.00	2.50
7	CP → G	-	1.24	1.19	1.24	1.09	1.03	1.03	-	0.15	0.15	0.15	0.18	0.21	0.18	-	1.75	1.75	1.80	2.25	2.30	2.30
8	D	-	1.89	1.47	1.24	0.88	1.03	1.03	-	0.10	0.10	0.10	0.15	0.15	0.15	-	1.60	1.70	1.80	2.00	2.20	2.20
9	O	1.24	1.59	1.47	1.47	1.24	1.19	1.09	0.13	0.18	0.15	0.13	0.18	0.18	0.15	1.45	1.80	1.85	2.00	2.45	2.45	2.40
0	A	-	1.30	1.47	1.30	1.24	1.19	1.09	-	0.15	0.15	0.15	0.18	0.18	0.18	-	1.80	1.85	2.10	2.45	2.50	2.40
1	D → P	-	1.47	1.47	1.19	0.88	1.03	1.03	-	0.13	0.13	0.10	0.18	0.21	0.18	-	1.85	1.60	1.85	2.35	2.35	2.35
2	O → P	1.35	1.30	1.52	1.52	0.88	1.09	1.03	0.15	0.18	0.15	0.15	0.18	0.24	0.21	1.45	1.70	1.70	1.75	2.35	2.35	2.40
3	A → P	-	1.30	1.52	1.47	0.88	1.09	1.03	-	0.15	0.15	0.15	0.18	0.24	0.21	-	1.75	1.90	2.15	2.45	2.50	2.40

DAS = Days after spraying

WEED MANAGEMENT IN SOLE AND INTERCROPPED COCONUT GARDENS

By

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ABSTRACT OF A THESIS

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ABSTRACT

Field experiments were conducted during the period from 1986 to 1989 at the Agricultural Research Station, Mannuthy, Thrissur to develop weed management practices for sole and intercropped coconut gardens. There were three field trials. In trial-I the treatments comprised of three manual methods (digging once, digging twice and sickle weeding), six chemical methods (paraquat three sprays, glyphosate 0.4 kg ha^{-1}, glyphosate 0.8 kg ha^{-1} dalapon followed by paraquat, paraquat + diuron and paraquat followed by glyphosate), two combinations of manual and chemical methods (2,4-D + diuron immediately after sickle weeding and glyphosate followed by digging) were compared with weed free and unweeded control in underplanted coconut garden. In trial-II, the treatments comprised of two manual methods (spade weeding and sickle weeding), one cultural method (growing cowpea as an intercrop) two cultural + chemical methods (cowpea followed by paraquat or glyphosate), three pre-emergence herbicides (diuron, oxyfluorfen and atrazine), three pre-emergence herbicides + post-emergence herbicide (diuron followed by paraquat, oxyfluorfen followed by paraquat and atrazine followed by paraquat) were compared with weed free and unweeded control in coconut+banana cropping system. Unweeded control in

coconut banana cropping system was compared with that in sole crop of coconut. In trial-III, the treatments tried in coconut+banana cropping system were evaluated in sole crop of banana and there were thirteen treatments. All these three trials were laid out in Randomised Block Design and replicated thrice.

Paraquat 0.4 kg ha^{-1} sprayed thrice at monthly interval, glyphosate 0.8 kg ha^{-1}, dalapon 3.0 kg ha^{-1} followed by paraquat 0.4 kg ha^{-1} and 2,4-D 1.0 kg ha^{-1} + diuron 1.0 kg ha^{-1} immediately after sickle weeding were equally effective for controlling weeds in underplanted coconut garden. These treatments resulted in higher soil moisture content but lower soil fertility compared to other chemical treatments. Among them, dalapon 3.0 kg ha^{-1} followed by paraquat 0.4 kg ha^{-1} resulted in maximum yield of 5847 nuts ha^{-1} and was the most economic treatment. From the soil fertility point of view sickle weeding twice was found to be the best.

In coconut+banana cropping system as well as in sole crop of banana, diuron 1.5 kg ha^{-1} was the most effective pre-emergence herbicide in controlling weeds. It was followed by oxyfluorfen 0.2 kg ha^{-1}. Intercropping of cowpea was found effective in smothering weeds upto its harvest (60 days). Subsequent application of paraquat 0.4 kg ha^{-1} in pre-emergence herbicide treated plots and paraquat 0.4 kg ha^{-1} or glyphosate 0.4 kg ha^{-1} in cowpea grown plots increased the weed control efficiency of the treatments. Application of diuron 1.5 kg ha^{-1} followed by paraquat 0.4 kg ha^{-1} resulted in highest weed control efficiency next to weed free treatment.

Maximum growth of coconut, growth and yield of banana, drymatter production and nutrient uptake by banana were observed in weed free treatment and minimum in unweeded control. Among the pre-emergence herbicides, diuron 1.5 kg ha^{-1} resulted in maximum growth of coconut, growth and yield of banana, drymatter production and nutrient uptake by banana. It was followed by oxyfluorfen 0.2 kg ha^{-1}. Lowest weed index was recorded by spade weeding in plant crop and diuron 1.5 kg ha^{-1} followed by paraquat 0.4 kg ha^{-1} in ratoon crop in coconut+banana cropping system and diuron 1.5 kg ha^{-1} followed by paraquat 0.4 kg ha^{-1} in sole crop of banana.

Diuron 1.5 kg ha^{-1} recorded the highest soil moisture content during summer months compared to other pre-emergence herbicides in coconut+banana cropping system and it was followed by oxyfluorfen 0.2 kg ha^{-1}. However, these treatments resulted in lower soil fertility compared to atrazine 2.0 kg ha^{-1} as well as manual methods of weed control in both coconut+banana cropping system and sole crop of banana. Diuron 1.5 kg ha^{-1} was the most economic treatment in the trials mentioned above.