WEED CONTROL METHOD FOR SEMI-DRY DIBBLED CROP OF RICE

BY

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DECLARATION

I hereby declare that this thesis entitled "Weed control method for semi-dry dibbled crop of rice" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that this thesis entitled "Weed control method for semi-dry dibbled crop of rice" is a record of research work done independently by Smt. S.Lakshmi, 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

Rice (*Oryza sativa* L.) assumes prime importance among food crops of Kerala. But the average yield of rice is low in our State. Among the many factors that contribute to this low yield the part played by weeds is quite substantial. The results of multilocation trials conducted in India revealed that reduction in yield of rice due to weeds alone is 15-20 per cent for transplanted rice, 30-35 per cent for direct seeded rice under puddled conditions and over 50 per cent for upland rice (Gopalakrishna Pillai and Rao, 1974). Based on 108 dry season trials and 176 wet season trials in farmers field in Phillipines 11-13 per cent yield gap is accounted for between farmers weed control practices and improved weed control techniques (De Datta, S.K., 1981).

Area under rice in Kerala is 7.9 lakh hectares out of which 3.5 lakh hectares are cultivated during *Virippu* (first crop) season. More than 80 per cent of this area is under semi dry condition. During *Virippu* season, especially under semi dry condition, weed problem is acute.

In this system of rice cultivation in the Onattukara region of Kerala State paddy seeds are dibbled after the receipt of pre-monsoon showers in April/May and the crop endures a drought during the early period of its growth upto 30 days of dibbling. After the onset of South West monsoon, the crop is grown under flooded condition. The high temperature which prevails during the early period of growth of the crop favours dense weed growth. The competition of crop with both monocot and dicot weeds is found to be higher in the early stages than that during the later stages of growth. The weeds mainly compete for water, nutrients, sunlight and space. So a suitable method of weed control is highly essential for this region.

The present investigation was undertaken to find out a suitable weed control method for semi-dry dibbled crop of rice in a medium duration variety Jaya, a dominant variety of rice in the Virippu season of Onattukara region, with the following objectives:

1. To find out a suitable weed control method for semi dry dibbled crop of rice during Virippu season in Onattukara.
2. To find out the effect of herbicides on the growth, yield and quality of rice during the Virippu season.
3. To work out the economics of crop production in Onattukara.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

A. Weed spectrum in rice fields

Petro et al. (1970) found that *Eragrostis major*, *Cyperus amabilis*, *Cyperus exaltatus*, *Fimbristylis diphilla*, *Marsilia quadrifolia* and *Oxalis corniculata* were the important weeds in the Agricultural University Farm, Bhuvaneswar. Gopalakrishna Pillai and Rao (1974) observed that in the wet land rice fields of Moncombu, Kerala, *Echinochloa colonum*, *Fimbristylis miliacea* and *Cyperus rotundus* were the predominating weeds.

Chouhan and Patil (1975) found out that *Cyperus pilosus*, *Cyperus iria*, *Cyperus bulbosus*, *Echinochloa crus-galli*, *Eleucine indica*, *Dichanthimum annulatum* and *Commelina benghalensis* were the important weeds of rice in the experimental farm Raipur. Mohammed Ali and Sankaran (1975) observed that *Echinochloa crus-galli*, *Echinochloa colonum*, *Cyperus difformis*, *Cyperus iria* and *Marsilea quadrifolia* were the predominant weeds found at Coimbatore, Tamil Nadu.

According to Nair et al. (1975) the most important weeds found at Rice Research Station, Pattambi, were *Echinochloa crus-galli*, *Branchiaria* spp., *Cleome* spp., and *Fimbristylis miliacea*. The most troublesome weeds of rice in Punjab were different species of *Echinochloa* and *Cyperus* (Shetty and Gill, 1975).

Ravindran (1976) reported that *Echinochloa* spp., *Cyperus* spp., *Fimbristylis miliacea*, *Ammania multiflora*, *Ludwigia parviflora* and *Monochoria viginalis* were the common weeds in rice fields of Vellayani, Kerala. *Cyperus difformis* accounted for 80 per cent of the total weed population in the established rice region of Egypt (Heckl 1977). Mosha et al. (1977) reported that the weed flora in Kibkowa region of Zanzibar included *Cyperus compressus*, *Crotalaria* spp. and *Echinochloa colonum*. Melachrinos et al. (1979) reported that trials made over several years showed that *Echinochloa* spp. is the most important weed of rice. Sreedevi (1979) reported 32 different species of weeds in the experimental area at Rice Research Station and Instructional Farm, Mannuthy in the first crop seasn of 1978 of which broad leafed weeds dominated followed by grasses and sedges.

Ahmed and Moody (1980) reported that 14 weed species were growing in association with dry seeded rice. *Echinochloa colonum* and *Leptochloa chinensis* were the major weeds. Only five species of weeds were identified in the transplanted crop following the dry seeded crop. *Monochoria viginalis* dominated in the transplanted crop.

According to Noda (1980) the principal weed species in rice was Echinochloa crus-galli and its sub species. Sukumari (1982) found that predominant weeds in the experimental site at Vellayani, Kerala were Echinochloa crus-galli, Echinochloa colonum, Brachiaria ramosa, Ischaemum rugosam, Fimbristylis miliacea, Cyperus iria and Monochoria viginalis.

From the review on weed spectrum in rice fields, it was found that among the grass weeds, Echinochloa spp. was the most predominant one, while among the sedges Cyperus spp. and Fimbristylis miliacea were the foremost. Ludwigia parviflora, Marsilia quadrifolia and Monochoria viginalis accounted for the broad leafed group.

B. Losses in rice production due to weeds

Weed infestation causes considerable reduction in yield in rice. Weeds reduce the market value of the produce and increase the cost of harvesting, drying, cleaning, etc.

According to Chang (1973) yield reduction caused by weeds varied from 11 to 16 per cent depending upon weed density in the rice fields of Taiwan. Gopalakrishna Pillai and Rao (1974) estimated that the extent of yield reduction in rice due to weeds alone was around 15-20 per cent for transplanted rice and over 50 per cent for upland rice. They also reported that the potential loss in production of rice in India was about 15 million tonnes per annum. Shetty and Gill (1974) reported that grain yield declined by about 10 q/ha, when the time of removal of weeds was extended from 6-8 weeks after transplanting. The extent of yield reduction, compared to grain yield in hand weeded plots in transplanted rice due to weeds alone amounted to 26 per cent. Ahmad et al. (1977) reported that yield losses due to weeds were 66 per cent and 36 per cent in IR-6-945 and Basmathi-370 respectively.

It may be concluded that losses in rice production due to weeds are at least equivalent or frequently higher than those caused by other pests. The losses are found to be higher in direct seeded crop than in transplanted crop.

C. Methods of weed control

Effective weed control systems combine preventive, mechanical, cultural and chemical methods. Non chemical method may combine some or all of the following practices-- planting weed free seed, crop rotation, levelling the land, thorough seed bed preparation, selecting the proper seeding method and managing water and fertilizers properly.

Chemical method involves the use of herbicides that selectively control weeds in rice when applied correctly (Smith and Seaman, 1973).

1. Non chemical methods

(a) Preventive:--

Practices that help to prevent weed infestation or their spread in clean fields include the use of high quality seed that is free of weed seeds, irrigation with water free of weed seeds and cultivation with clean equipment. According to Smith and Shaw (1966) red rice is usually spread by contaminated seed.

(b) Mechanical:-

According to Patel (1965) the use of rotary weeder has been found to increase rice yields by 3 per cent of those obtained with hand weeding. The use of rotary weeder is most widely practised in Phillipines and other Asian countries to control weeds in transplanted rice (Anonymous, 1974-a) and Vachhani et al.,(1963). Grist (1975) also reported that Japanese rotary weeder provided a favourable environment for rice. According to Curfs (1976) with upland rice in Nigeria mechanical weed control alone was not effective. Harrowing was effective in reducing weed growth. Fagade (1976) reported that in field trials with upland rice, weeds can be controlled by hand hoeing and highest grain yield was given by hoeing twice. A further hoeing after one hoeing gave further yield increase of 97 per cent.

(c) Water management:-

Smith (1967) recommended draining the field soon after seeding to control aquatic weeds and algae. Further he reported that land levelling and proper construction of levees permitted uniform depth of water and reduced the weed infestations. Maximum rice yields were recorded from submerged paddy fields even without weeding (Crafts et al. 1973).

(d) Manual weed control:-

In rice field, the general method is hand weeding. Weeding will have to be more thorough in direct sown crop than in transplanted crop as the weed growth is much heavier in the former.

Grist (1953) and Haynes (1955) recommended hand weeding as the best method of controlling weeds in rice. Vachhani et al. (1963) from Central Rice Research Institute, Cuttack, reported that hand weeding is as good as herbicidal spray.

Experiments conducted at International Rice Research Institute, Manila revealed that a single hand weeding at about 25 days after seeding gave maximum yield in upland paddy. Postponing the weeding by 20 days from 25-45 days of sowing, reduced the yield at the rate of 43 kg/ha/day and sharply increased labour requirements (Anon. 1965). Soerjani et al. (1969) recommended hand weeding as a practical method in small farms and chemicals for large farms. Chakraborty (1974) found out that yield in rice was greatest after 3 weedings by hand. Two hand weedings 20 and 40 days after sowing decreased weed population and nutrient uptake by them and gave higher paddy yields. Schmoleri and Young (1975) concluded that for small holdings, using traditional methods remain the most economical. Manual weeding eventhough effective is time consuming (Curfs 1975). Chang et al. (1976) reported that the cost of manual weed control is about 10 times more than chemical weed control. Ravindran (1976) reported hand weeding on 20th and 40th day after transplanting rice, though increased yield the net profit was lower due to increased labour charges. Kaushik and Mani (1978) reported that experiments conducted at Indian Agricultural Research Institute, New Delhi showed that hand weeding treatments (hand weeding alone and hand weeding + 3 per cent urea) gave most effective weed control and were effective in increasing plant productivity and grain production.

Schiller and Indaphun (1979) recommended two hand weedings at 30 and 60 days since yield was maximum compared with the unweeded control. Sukumari (1982) reported two hand weedings on 20th and 40th days to be as effective as continuous weeding during 21-40 days, and keeping field weed free from 1 to 60 days. It can be concluded that hand weeding eventhough effective is not economical.

2. Chemical weed control

A number of herbicides are reported to be very useful in controlling weeds in cereal crops. Among them Bentazon (Basagran), Pendimethalin (Stomp), Benthiocarb (Saturn), Nitrofen (Tok E-25), Propanil (Stam F-34), Butachlor (Machete) are the important ones. Literature on bentazon pendimethalin, benthiocarb and nitrofen are cited here.

(a) Bentazon:-

Trials in Pavia Province highlighted the excellent control of sedges obtained with Basagran in 'Roma' and 'Arborio' rice varieties and recommended to apply bentazon at 5 litres of product in 800 litres of water/ha, 30-40 days after sowing rice and a further input of water into the fields 48-72 hrs. after the treatment (Picco 1974). Kotsov and Krster(1975) reported that Basagran at 3-4 litres/ha applied at 4-5 leaf stage of rice gave 98.6 - 100 per cent control of weeds. Experiments at International Rice Research Institute, revealed that bentazon at 1.5 kg ai/ha gave the highest yield in low land rice.(Anon 1976). Results of trials conducted with bentazon in the rice growing areas of Europe and America by Luibet et al. (1976) showed that bentazon at 1.5-2.0 kg/ha and in special cases 3 kg/ha gave excellent control of Ammania, Cyperus, Commelina, Scirpus and many other weeds.

Bentazon is selective at all stages of growth of rice. Okafor et al. (1976) reported that in upland rice bentazon 2 kg ai/ha 7 days after crop emergence was highly selective and gave full control of nut sedge (Cyperus rotundus). Silva (1976) found that the bentozon at 4 and 8 litres product/ha applied in a clay soil rich in organic matter using rice variety Ribi, gave excellent weed control and selectivity was good. Bentazon at 0.25 - 4 lb/acre controlled a number of common rice weeds (Cole et al. 1977), Hackl (1977) reported that bentozon controlled 80 per cent of weed population. Orcino (1977) reported that Basagran provided selective control of Scirpus maritimus and other problem broad leafed weeds. Bentazon at 1.5 - 6 kg/ha applied at bud or flowering stage of Scirpus species kept plots almost weed free till harvest.

Bentazon activity increased with increase in ambient temperature at lower rates and this reduced the total number of tubers under water (Stonov. et al. 1977) Weerd and Del. (1977) found out that among the herbicides tried against Cyperus difformis Basagran at 4-5 lit/ha showed excellent selectivity in direct sown rice when it was applied after draining out in the early tillering phase when the weed has developed three leaves at the time of the treatment. Atwell et al. (1978) reported that in a total of 35 trials bentazon at 0.5-1 lb/acre gave good control of broad leafed weeds, sedges and rushes in rice grown under all cultural conditions. Moursi et al. (1978) recommended bentazon at 3 litres/feddan (feddan - 0.42 ha) for control of Cyperus difformis and the fresh weight of weed was reduced by 22.9 per cent and it was more effective when applied post-emergence one week after sowing.

Bentazon 7 lit/ha was good for weed control in seeded rice (Risk et al., 1979). Santos et al. (1979) found that treatments containing bentazon at 1 kg/ha or more applied post-emergence gave good control of Portulaca oleracea, Amaranthus viridis and Cyperus esculentus and bentazon at 0.75 kg/ha controlled the first two.

Abud (1980) reported that in a field trial bentazon 1.44 kg/ha recorded the lowest yield. Ramazanov (1981) found out that basagran at 2.5 kg/ha post-emergence gave 40-90 per cent control of Scirpus species. The best rate was 4 kg/ha which gave the highest weed control.

Bentazon can be regarded as a selective herbicide for rice in the control of important weeds of rice like Cyperus sp., Scirpus sp. and other broad leafed weeds.

(b) Pendimethalin (Penoxalin):-

In direct sown flooded rice at International Rice Research Institute, Penoxalin 2 kg/ha applied 6 days after sowing controlled the main weeds Echinochloa crus-galli, Monochoria vaginalis and Cyperus difformis (Anon. 1974). Tosh (1975) reported that penoxalin 2 kg/ha was highly selective in the control of weeds in direct sown rice on upland soil with no adverse effect on germination and no sustained injury to the crop. Ravindran (1976) found out that penoxalin at 1.5 kg ai/ha on 6th day after transplanting brought down the weed growth and increased the yield. In field trials with dry land and irrigated rice, grain yields tended to increase with application of 1-2 kg penoxalin/ha applied pre-emergence (Santos et al. 1976). Singh & Singh. (1976) reported that pendimethalin at 1.6-4 kg/ha applied on direct sown rice in kharif was good in the control of weeds, but yield was inferior to propanil.

Senegal (1977) obtained best result in weed control in upland rice with pendimethalin 2 kg/ha applied immediately after sowing. Singlachar et al. (1977) revealed that, of the 9 herbicides tried in direct sown upland rice variety IET-1444, penoxalin at 2 kg/ha pre-emergence gave the best weed control. Pendimethalin at 2.5 - 3.5 litres of the product/ha was recommended for control of weeds in rice by Abud (1978) based on experiments conducted. Moursi (1978) detected the greatest reduction in fresh and dry weight of Cyperus difformis with stomp at 2.5 lit/feddan which was the most effective herbicide against Echinochloa colonum and reduction in fresh weight of Echinochloa crus-galli was 80.9 per cent with stomp at 1 lit/feddan. Stomp was less effective applied post-emergence than pre-emergence.

Resende (1978) reported that the yield was more than doubled in upland rice by using Herbadox-500E (pendimethalin) at 2.5 -4.2 lit/ha, according to soil type. Rizk (1979) obtained highest grain yield in seeded rice by application of stomp 5 litres of product. Pendimethalin at 1 kg/ha pre-emergence showed promise for general grass control (Tollervey et al. 1979) contrary to the general findings. Abud (1980) reported lowest yield from the plots treated with pendimethalin at 1.25 kg/ha.

Pendimethalin controls weeds in upland rice and the dosage is mostly 2 kg ai/ha.

(c) <u>Benthiocarb</u>:-

Experiments at Central Rice Research Institute, Cuttack revealed that benthiocarb gave efficient control of weeds in rice (Anon 1971), Chang, W.L.(1973) reported that Saturn 3 kg ai/ha applied 4 days after transplanting showed little or no toxicity to rice and out yielded all other treatments. Chang and De Datta (1974) evaluated 7 granular herbicides in which benthiocarb applied after 6 days of sowing was most selective in controlling broad leafed weeds and sedges with no sustained injury to rice crop. Gunwardena et al. (1974) found out that Saturn granular 1.3 - 1.8 lb/acre applied in 1-2 inches of water 6-7 days after sowing rice in low lands was very promising. Sridhar et al.(1974) tried several herbicides in rice in which benthiocarb treated plots recorded better weed control and least phytotoxicity and maximum yields. Benthiocarb at 3 and 4 lb/acre applied pre-emergence, delayed pre-emergence and early post-emergence gave very good to excellent control of <u>Commelina communis</u>, <u>Cyperus iria</u>, <u>Exchinochloa colonum</u>, <u>Brachiaria</u> spp, <u>Sesbania exaltata</u> etc.

Weed control with benthiocarb was most effective at 3 lb/acre when application was done 5 days after sowing.

It was less effective at 14 days and least effective at 20 days (Baker, J.B. 1975). Bueno et al. (1975) reported that in experiments under upland and lowland rainfed direct seeded conditions benthiocarb E.C. at 2.5 kg/ha was effective against grasses when applied pre-emergence. Larrea and Lucena (1975) conducted a general survey of weed control in rice and found out that the most effective one was thiobencarb applied at 4 kg/ha. Saturn at 3-7 kg ai/ha applied before sowing rice decreased weed population by 81-98 per cent. Chang et al. (1976) reported that thiobencarb 4 kg/ha gave good weed control in transplanted rice in Saudi Arabia, but it was more toxic to the rice crop. Medera, et al. (1976) found out that thiobencarb at 3.5 kg/ha applied 2 days after sowing rice showed good control of Echinochloa crus-galli.

Trials conducted by Montoreano et al. (1976) showed good selective control of grasses including Echinochloa spp. with early pre-emergence application of thiobencarb at 5 kg/ha in rice and the control lasted throughout the growth cycle of the crop. In experiments at North Japan, Nishikawa et al (1976) found out that among soil applied herbicides benthiocarb applied at the rate when rice had 3 leaves was the most promising post-emergence treatment which controlled Eleocharis acicularis, Cyperus difformis, Scirpus hotarui and *Elatine triandra*. Among the herbicides evaluated by Sridhar et al. (1976) in granular form, in direct sown paddy, thiobencarb at 1.5 kg ai/ha applied 6 days after sowing reduced the species number and total dry weight of weed population.

Takematsu et al. (1976) treated fifty five species of weeds with thiobencarb in which annual graminaceous and cyperaceous weeds and *Eleocharis acicularis* were more sensitive to benthiocarb than other weeds. Trials conducted in Colombia by Tobar (1976) revealed excellent control of grass weeds especially *Echinochloa colonum* when rice was treated with Saturn 7 days after sowing through the prolonged activity of the herbicide. Le Clair (1976) obtained excellent control of barnyard grass by the application of thiobencarb in rice fields which showed little or no phytotoxicity.

Crop injury by benthiocarb to rice seedlings was investigated by Nako (1977) under different conditions in direct sown rice. He found that an increase in soil moisture content after thiobencarb application caused a decrease of establishment and inhibition of growth at seedling stage and crop injury was severe on seedlings in treatments at germination and 0.8 - 1 leaf stage and slight in treatments at spike and second leaf stages. A rate of

100 g/are did not cause any injury to seedlings even under high moisture content and at any growth stage. Senegal (1977) reported that in direct sown rice, thiobencarb at 1 kg/ha as granules, 4 days after sowing gave the best selective weed control. Smith (1977) conducted trials on silt loam and clay soils in dry sown rice in which thiobencarb 3 lb/acre applied in 2 leaf stage of rice or pre-emergence application of thiobencarb at 4 lb/acre was effective.

In a trial conducted by Souza et al. (1977) at a lowland site rich in organic matter, Saturn at 4 and 5 kg/ha pre-emergence gave the most effective control of infesting weeds which included Eclipta alba also. Ravindran et al. (1978) reported that in a trial during the third crop season in which 6 herbicides were applied to drained soil 6 days after transplanting rice, thiobencarb 2 kg/ha was the most effective one. Best result over several years with herbicides applied to the soil after sowing rice, was given by Saturn at 8 lit/ha (Melachrinos et al. 1979). A series of pot experiments carried out by Wirjahardja and Susila (1980) with six IR varieties showed thiobencarb to be the most selective one. Yang et al.(1980) reported that Saturn gave excellent weed control of Cyperus serotinus and was the only herbicide which reduced the total amount of perennial weeds and controlled annuals. Eastin (1981) showed that benthiocarb applied pre-emergence provided better weed control. Gill and Mehra (1981) reported that benthiocarb 1.5 - 3 kg/ha applied 3-4 days after transplanting rice was highly effective.

Benthiocarb has been established as a prominent herbicide for control of weeds in rice both upland and low-land conditions.

(d) Nitrofen:-

Experiments conducted at Central Rice Research Institute, Cuttack revealed that nitrofen gave efficient weed control in rice (Anon 1971). Guh and Kwon (1975) reported that nitrofen applied at 30 and 60 kg product/ha pre-emergence was not effective. Nair and Sadanandan (1975) found out in an experiment at Vellayani that Tok granular was not effective. Raghavalu and Murthy (1976) reported Tok E.25 at 3.5 kg/ha was less effective in rice.

In trials during *kharif* on heavy soils of medium fertility by Verma et al. (1978) pre-emergence application of nitrofen at 2.5 kg/ha provided selective control of grasses, sedges and broad leafed weeds. According to Moorthy and Dubey (1979) nitrofen was the least effective herbicide when applied 7 days after broadcasting pre-germinated seeds. Rathi and Tewari (1979) reported that pre-emergence application of

Tok E.25 was effective against weeds in upland direct seeded rice. According to Singh et al. (1979) nitrofen 2 kg/ha post-emergence was best in weed control in rice.

Tok E.25 control weeds in direct sown rice. But its efficiency under lowland conditions is not yet established.

D. Crop-weed competition

Under normal conditions of crop production, factors such as water, nutrients and light are considered to be of major importance in determining the nature and extent of crop weed competition.(Moolani & Sachan 1966). Nietro et al. (1968) favoured hand weeding as the method to determine the critical period of crop-weed competition in crops with uniform weed population in all the plots. Muzik (1970) found that weed competition was most serious when crops were young and that moderate infestation was sometimes as serious as a heavy infestation. Shetty & Gill. (1974) reported that the most critical period of crop-weed competition was between 4 and 6 weeks after transplanting.

According to Smith (1974) high yielding and lodging cultivars competed with barnyard grass for periods ranging from 10 days after emergence to the whole season and the competition increased with increase in the period required for crop maturity. Nair et al. (1975) reported that weed competition was more critical during the early vegetative growth phase and concluded that upland rice could tolerate 30 days of weed competition without adverse effect on yield. Sharma et al. (1977) reported that in direct sown upland rice, yield reductions due to weed competition ranged from 42-65 per cent and most critical period when crop losses due to weed competition were most severe, ranged from 10-20 days after emergence. Yield increased as the length of the weed free period also increased.

According to Mercado et al. (1978) the critical period of competition in lowland rice is 3rd to 8th week when direct seeded. Singlachar et al. (1978) reported that the dwarf plants with erect habit promoted more weed growth and suffered more yield loss than the tall variety. The minimum weed-free period after transplanting for optimum grain yield in dwarf and tall types was 45 and 30 days respectively. Choi (1979) reported that crop-weed competition was minimum when weeded only once 4 or 6 weeks after transplanting. According to Abraham Varughese (1978) the critical period of crop weed competition was between 21 and 40 days after transplanting in variety Triveni. Hawton (1981) suggested that the best indicator of weed competition was top dry matter since the relationship between crop and weed was often linear, provided the two are competing directly. Sukumari (1982) reported that critical period of competition with regard to grain and straw yield was 21-40 days of sowing.

(a) Competition for water

Kaul and Raheja (1952) reported that transpiration co-efficient were 556 for *Ischamum pilosum*, 813 for *Cynodon dactylon*, 1108 for *Tephrosia purpurea* and 1042 for *Tridax procumbens* while it was only 432 for sorghum.

(b) Competition for nutrients

Noda, et al. (1968) reported maximum competition for nitrogen during the first half of the growing season between rice and barnyard grass. According to Smith (1968), weeds competed with the crop thoroughly for nutrients when water is not limiting. Chang (1972) concluded that *Echinochloa crus-galli* and *Cyperus difformis* were most competitive with rice where fertility is high and *Monochoria viginalis* and *Marsilea quadrifolia* had similar effects at high and low fertility levels. Chakraborty (1973) suggested that weeds competed with rice throughout the growing season for nitrogen. In weed free treatments grain yield increased for the varieties used with no fertilizer application as well as with fertilizer application.

(c) Competition for space and light

King (1966) observed that the rate of growth of certain weed species enabled them to suppress the growth of crop plants and eventually to crowd them out altogether.

Arai (1967) stated that competition for light begin as early as 20 days after transplanting rice and is dependent on the early growth rate and size of weeds and that competition was serious at later stages of crop growth. Seventy per cent reduction in light intensity in rice by highest density of barnyard grass is reported by Noda et al. (1968). Smith (1968) reported that barnyard grass shaded rice clearly during the crop season, since it was usually as tall as rice and competition was purely for light when water was not limiting. According to Kawano et al. (1974) with normal supply of N, plants competed primarily for light. Usually effect of competition for light was much greater than that for N in rice populations. In trials conducted by Guh et al. (1980) it was seen that shading effects of weeds were greater in direct sown than in transplanted plots.

Hence it can be concluded that the crop competition with weeds for the inputs water, space, sunlight and nutrients can create a great loss in the yield of crop.

E. Crop tolerance to herbicides

Baker (1975) reported that rice tolerance was satisfactory when benthiocarb was used as delayed pre-emergence or early post-emergence but not when applied as pre-emergence. According to Guh et al. (1975) the high rates of herbicides like butachlor and nitrofen reduced the crop tolerance. Sugar and starch contents of rice correlated well with the tolerance of the cultivar and the herbicide and the herbicide rate applied. Takematsu et al. (1976) treated 34 varieties of rice with benthiocarb, of which those varieties cultivated in Japan, U.S.A. and Italy were more tolerant to benthiocarb than the indica varieties like IR-8, Leuang Tawng, C4-63 and Taichung Native. Cole et al. (1977) reported that bentazon at 0.25 to 4 lb/acre post-emergence applied by air in a minimum of 10 gallon spray was well tolerated by the rice.

Hackl (1977) observed that Basagran was well tolerated by direct sown rice upto bloom. Experiments at International Rice Research Institute, Phillipines showed that herbicide injury in rice was influenced by the location of the first node in relation to the treated soil layer. Cultivars whose first nodes were near the soil surface were susceptible to pre-emergent herbicide and those with short mesocotyls were tolerant. Some cultivars like TKM-6 were completely killed. The nearer the sprayed layer to the soil the greater were the injury and stand reduction of all cultivars. When seeded 5 cm deep, all cultivars were unaffected by the herbicide thiobencarb. (Anon 1979). Gill and Mehra (1981) reported that all the five cultivars tried, tolerated 1.5 -3 kg ai/ha of butachlor and benthiocarb applied 3-4 days after transplanting seedlings.

The herbicides at rates below the toxic concentration can reduce the growth of the weed and improve crop growth simultaneously.

F. <u>Effect of herbicides on weed control in direct sown rice</u>

Experiments at International Rice Research Institute revealed that the best weed control treatments for direct sown flooded rice were USB-3584 at 1 kg + 2,4-DIPE 0.5 kg and penoxalin 2 kg/ha applied 6 days after sowing. (Anon 1974), Chang (1974) suggested that herbicides applied early (6 days after sowing direct seeded flooded rice) gave better weed control. In low land wet sown rice linuron granular at 0.25 lb/acre, Machete EC., Saturn granular, 2,4-DIPE applied 1-2 inches in water 6-7 days after sowing were very promising (Gunwardena et al. 1974).

Pre-emergence application of Machete granules at 1.5 kg ai/ha or post-emergent application of 3 kg propanil ai/ha was recommended by Nair et al (1974) for control of weeds in direct seeded rice fields. Benthiocarb at 3 and 4 lb/acre as pre-emergent, delayed pre-emergence or early post-emergence gave very good to excellent control of weeds in drill seeded rice. (Baker, 1975). Experiments under upland and lowland rainfed direct seeded conditions showed butachlor EC at 2 kg/ha and thiobencarb 2.5 kg/ha was effective against grasses when applied pre-emergence (Bueno et al. 1975).

After a general review of weed control in direct sown rice Larrea & Lucena (1975) recommended thiobencarb at 4 kg/ha. Luib et al. (1976) recommended the use of bentazon as a post-emergence herbicide in direct sown rice. Chemical weed control studies in direct seeded rice by Nishikawa et al. (1976) showed molinate 300 g ai/ha to be good. The pre-emergence herbicides tested by Rao et al. (1976) on direct seeded rice in uplands showed a weed control efficiency of 69-78 per cent and 85-86 per cent respectively with thiobencarb and nitrofen. Stam-F.34 (propanil) and AC 292553 (pendimethalin) were evaluated by Singh et al.(1976) at 1.6 - 4 kg/ha in direct sown rice during kharif and Stam-F.34 gave the highest yield.

Among the herbicides evaluated in granular form in direct sown paddy by Sridhar et al. (1976) thiobencarb at 1.5 kg/ha applied 6 days after sowing reduced weed count. Experiments at International Rice Research Institute revealed that weed control is more critical and difficult in broadcast than in transplanted rice and weeding with chemicals applied 6 days after sowing recorded highest yield in a dry sown crop which equalled two hand weedings. Heckl (1977) reported that basagran was well tolerated by direct sown rice upto bloom. Of the three herbicides evaluated in direct sown rice by Mosha et al. (1977) propanil gave very good overall weed control.

Nako (1977) reported that increase in soil moisture content after thiobencarb application decreased the establishment of direct sown upland rice. In direct sown rice thiobencarb at 1 kg/ha as granular 4 days after sowing gave the best selective weed control (Senegal 1977). According to Sharma (1977) yield reductions due to weed competition ranged from 42-65 per cent in field experiments with direct sown upland rice.

Singlachar and Chandrasekhar (1977) found out that the best herbicide for direct sown upland rice IET 1444 was pendimethalin 2 kg/ha. Basagran at 4.5 lit/ha showed excellent selectivity in direct sown rice against

Cyperus difformis. According to Kaushik and Mani (1978) weed competition was very severe in direct sown rice. Mercado et al.(1978) reported that piperophos gave the highest weed control in rainfed lowland direct seeded rice. Weeds were a great problem in directly sown rice and the best treatment was butachlor 0.5 kg/ha (Zahidul Hoque 1978). Experiments at International Rice Research Institute, Philippines, revealed that benthiocarb 2.0 kg/ha gave the highest yield, and in general grain yields in dry sown crop were higher than in wet sown crop when granular herbicides were used for weed control. A pre-emergence herbicide followed by a hand weeding resulted in high yields in direct seeded rice (Anon 1979-a). Balachandran Nair et al. (1979) suggested propanil at 0.75 kg + 2,4-D Sodium 0.5 kg/ha (post-emergent) followed by propanil alone at 1.5 kg and butachlor alone at 1.5 kg/ha under semi dry condition. Trials with rice sown in dry soils by Melachrinos et al. (1979) showed Saturn at 8 lit/ha to be the best herbicide for rice. Ramakrishnan Nair et al. (1979) reported weeds to be a great problem in direct sown rice under semi dry conditions and recommended Stam F-34 at 2 kg ai/ha for their control. Nitrofen gave better weed management in upland direct seeded paddy under irrigated condition (Rethi and Tewari, 1979).

Pot experiments carried out by Risk (1979) showed stomp, cobex, destune and basagran to be effective in direct seeded rice. Schiller et al. (1979) reported that uncontrolled weed competition in direct sown upland rice in North Thailand reduced grain yield by 2-25 per cent compared to regular weeding. Best weed control in direct seeded paddy field was obtained with nitrofen at 2 lit + machete 2 lit/ha by Yeh et al. (1979). According to Andrede (1980) yields from direct drilled rice treated with glyphosate were higher than those from conventionally sown rice. Best results in direct seeded dry sown rice was obtained with C.288 at 2 kg/ha by Duboy et al. (1980). Propanil 2 kg/ha post-emergence provided good weed control in unpuddled fields of direct sown rice (Kaushik and Mani, 1980).

According to Moorthy (1980) Piperophos + dimethametryne at 0.4 kg/ha gave best weed control in direct sown rice on puddled soil. Schiller et al. (1980) obtained highest grain yield with 2 hand weedings at 30 and 60 days after sowing in direct seeded upland rice. Butachlor at 2 kg ai/ha gave efficient weed control in dry seeded rainfed rice (Ahmed 1981). Dixit et al. (1981) proved herbicidal weed control to be better than hand weeding in direct seeded upland rice. According to Kannaiyan, et al. (1981)

2,4-D and propanil were superior in controlling weeds in dry seeded wet land rice.

Weed control in direct sown rice is more laborious since the weed growth is more. Under this condition of dense growth of weeds, the use of herbicides proves to be economical.

G. Influence of herbicides on growth yield and quality of rice

Picco (1974) reported an yield increase of 5.4 per cent when weeds were controlled with Basagran and 37.7 per cent increase over the plots treated with molinate. According to Ramamoorthy, et al. (1974) 7 kg propanil/ha gave higher paddy yields and yield was negatively correlated with the weight of weeds. Dibbling 40-100 kg seeds/ha gave an yield of 3.72 t/ha. Sridhar et al. (1974) observed that benthiocarb treated plots recorded highest number of tillers and productive tillers, maximum yield and increased panicle number by reduced crop weed competition. Guh et al.(1975) reported reduction in plant height, culm length, number of leaves, and dry matter production by high rates of butachlor, nitrofen and PAM. Nitrofen and PAM at high rates but not butachlor significantly decreased the number of tillers and the spikelet/tiller ratio. Sugar and starch content of rice correlated reasonably well with herbicide and the herbicide rate applied. High rates of herbicides remarkably decreased panicle length.

Yield increases of 12 per cent and 39 per cent were obtained with the application of satrol and basagran respectively, by Kotsov et al. (1975). Mani (1975) reported that herbicide use enhanced the crop yield remarkably in rice. According to Nair and Sadanandan (1975) the herbicides Machete, Tok and Weedone had no effect on growth, panicle number, 1000 grain weight and paddy yield. Saturn at 3-7 kg ai/ha increased paddy yield by 30-580 kg/ha (Agarkov et al. 1976). Trials at International Rice Research Institute, revealed that application of bentazon 1.5 kg/ha gave the highest yield (Anon 1976).

The highest grain yield was given by the application of 3.9 kg benthiocarb followed by 1.5 kg butachlor/ha. Grain yield was closely related to the number of panicles/m^2 (Cheng et al. 1976). Nishikawa et al.(1976) reported an yield of 26 per cent higher with application of 300 g ai/ha of molinate. Sridhar et al. (1978) obtained highest grain yield by treatment with thiobencarb at 1.5 kg ai/ha. Experiments at International Rice Research Institute showed that highest yield in dry season were given by weeding with chemicals applied 6 days after sowing and just after seed emergence (Anon 1977). According to Cole et al. (1977)

bentazon 0.25 - 4 lb/acre increased grain yield and did not adversely affect seed germination or quality.

Neko (1977) reported that an increase in soil moisture content after benthiocarb application inhibited growth of crop at seedling stage and no yield reduction obtained by application of 50 g/acre. No effect on rice yield by the application of saturn was obtained by Souza, et al. (1977). Atwell et al. (1976) reported increase in rice quality or grade through the elimination of weed seeds by the use of Bentazon. Ravindran et al. (1978) obtained highest grain yield with benthiocarb EC at 2 kg/ha and pendimethalin 1.5 kg/ha showed the highest number of productive tillers/m^2 and greatest weight of panicle. In trials conducted by Verma et al. (1978) nitrofen 2.5 kg/ha promoted yield.

Experiments at IRRI showed that benthiocarb 2.0 kg/ha recorded highest yield and in general grain yield was higher in dry sown crop than in wet sown crop when granular herbicides were used (Anon 1979-b and c). Mahatim Singh et al. (1979) reported Stam F-34 to be the most effective in increasing yield components and yield followed by Tok, 2,4-D and MCPA at 2 kg each/ha. The highest grain yield was obtained with stomp 5 lit/ha in pot experiments by Rizk et al. (1979) and an increase in number of panicles/pot length of panicle, number of spikelets/panicle and straw yield. Thousand grain weight showed no significant response.

Kaushik and Mani (1980) reported that propanil at 2 kg/ha was the most efficient herbicide in increasing grain production of rice. According to Yang et al. (1980) the yield was higher for plots treated with Saturn and Ronstar. The fresh and dry weight of weeds at tillering and ripening stages were negatively correlated with the number of rice panicles and grain and with the yield of hulled rice.

Use of herbicides increased the grain yield and quality of rice under all conditions of growth of crop.

H. <u>Uptake of nutrients by weeds and crops</u>

Boerma (1963) reported reduction in weed competition due to application of propanil resulted in an increased absorption of N by rice almost 3 times. Swain (1967) found out that barnyard grass in rice fields removed 60-80 per cent of nitrogen from the soil and in the absence of the weed, N absorption by rice increased 3 times. Verma and Mani (1970) observed that unchecked weed growth depleted soil nutrient to the extent of 20.0, 11.8 and 20.0 kg/ha of N, P_2O_5 and K_2O in rice crop and found that weed control by Stam F-34 (2 kg/ha) brought down the nutrient depletion by weeds to 1.6, 1.0 and 2.4 kg/ha of N, P_2O_5 and K_2O respectively.

Chakraborty (1973) found that weeds removed 29.9 and 30.9 kg/ha of N in two years and 3 hand weedings brought down the N depletion to 2.66 and 9.88 kg/ha. He also noted that in T.N.1 rice, weeds removed 3.28 and 51.7 kg/ha of N in hand weeded and control plots respectively.

Mallappa (1973) found an inverse relation between the N uptake by weeds and rice. Ramamoorthi, et al. (1974) found out that two hand weedings or propanil at 7 kg/ha decreased nutrient uptake by weeds by reducing weed population and yield was negatively correlated to the weight of weeds and NPK uptake by them. Sankaran et al. (1974) observed that weeds in unweeded control removed 62.1, 20.0 and 65.3 kg N, P_2O_5 and K_2O/ha in rice. Shetty et al.(1974) reported that the total uptake of nutrients by the crop and weed together in a weeded plot was less than the uptake of nutrients by the crop alone in the weed free treatments.

According to Mani (1975) herbicide use affected, an appreciable decrease in nitrogen depletion by weed growth, as a consequence of which considerable improvement in N uptake by crop plants occurred. Okafor and Datta (1975) reported that total N uptake by weeds was negatively correlated with rice grain yield for all levels of N in all seasons ($r = 0.72$). Ravindran (1976) found out that N uptake by weeds was negatively correlated with N uptake by crop, Unchecked weed growth depleted soil N to the extent of 20.86 kg/ha while a single application of penoxalin, G at 1.5 kg/ha brought down the uptake of N by weeds to 0.96 kg/ha and considerably improved the uptake by the crop (99.55 kg N/ha) while unchecked weed growth resulted in an uptake of 65.54 kg N/ha by the crop.

Balu (1977) reported that uptake of N, P_2O_5 and K_2O was more for CV-CO 37 than for ADT-37. Abraham Varghese (1978) observed that the nutrient removal in weedy check was 23.99, 7.92 and 30.48 kg/ha of N, P_2O_5 and K_2O by weeds and 57.54, 28.44 and 70.04 kg/ha of N, P_2O_5 and K_2O by the crop. Piperophos and dimethametryne at 0.5 kg/ha and various esters of 2,4-D increased the N uptake by the rice crop due to reduction in the number of weeds (Moorthy 1979), Kaushik and Mani (1980) reported that weeds in the unweeded check removed 24.7, 5.8 and 63.4 kg/ha of N, P, K respectively. Sukumari (1982) reported maximum nutrient uptake in plots weeded 1-60 days.

Under all conditions of growth of rice, it has been proved that the increase in uptake of nutrients by weeds causes a corresponding decrease in nutrient uptake by the crop.

I. Herbicidal residue studies

Wicks et al. (1969) reported that atrazine applied to sorghum at recommended rates did not persist long enough to cause losses of winter wheat in a winter wheat--sorghum--rotation. In an experiment conducted by Vamadevan and Patil (1972) to study the residual effect of herbicides, Ronstar, EMD-60-70 and tavron (G) under 3 water management practices in rice found that tavron (G) appeared to have greatest residual effect under saturated condition. In general it was observed that the toxicity of all the chemicals tried was completely reduced within the third week after application. Trials conducted at Taiwan revealed that one application of herbicides such as butachlor, MO-401, nitrofen and benthiocarb in rice does not leave residues in amounts toxic to several upland crops that follow rice (Anon 1973).

Rangiah et al. (1974) found that Machete (G) at 2-5 kg/ha applied 4 days after transplanting and Stam F-34 at 3 kg ai/ha applied 3 weeks after transplanting followed by one hand weeding five weeks after planting provided effective weed control but the chemicals themselves lacked adequate residual activity against perennial weed growth. Prabhakara Setty, et al. (1977) made studies to find out the residual toxicity of Vernam, Diuron, Tillam and Nitrofen applied to kharif groundnut on germination and dry weight of bhindi, cotton, wheat, gram, safflower and linseed seedlings. There was no residual effect of nitrofen at 4 lit/ha on germination or dry weight of seedlings of any crop and it provided a growth regulatory effect resulting in more dry weight of seedling. This may be due to reduction in their concentration because of leaching and biological degradation of the chemical.

Trials at IRRI showed that the degree of weed control achieved with pre-emergent herbicides were so poor since their residual effects were so short and so all the plots had to be weeded 4 weeks after emergence to prevent total crop failure (Anon 1979-a). Gilmour et al. (1980) observed no sterility or yield reduction due to the residues of MSMA applied 4 years previously. Xavier et al. (1980) reported that molinate left no residues in the soil at harvest and was not leached below 10 cm depth of soil.

One of the most important rainfed cropping patterns in Bangla Desh is dry sown rice followed by transplanted rice. Butachlor applied at 2 kg ai/ha to the dry sown crop had no residual effect on transplanted crop (Ahmed et al. 1981). Trials conducted by Eastin (1981) showed that residual activity of thiobencarb, butachlor, oxidiazon and bifenox applied pre-emergent was sufficient to prevent weed growth throughout the c rop growth in rice. The experiment conducted by weed research organisation to assess the effect of repeated use of herbicides on soil fertility showed that MCPA, Trillate, Simazine and linuron in maize left no herbicide build up in soil and eliminated the fear of decreasing soil fertility due to continuous herbicide regimes (Fryer 1981).

Most of the herbicides used for rice do not leave any residue in the soil which favours the use of herbicide for rice crop without affecting the growth of the succeeding crop.

MATERIALS AND METHODS

MATERIALS AND METHODS

A field experiment was undertaken to find out a weed control method for semi dry dibbled crop of rice, during the first crop season in Onattukara region of Kerala State.

MATERIALS

Experimental site and cropping history

The experimental site was selected in blocks B-9 and B-10 of the Rice Research Station, Kayamkulam with facilities for drainage. The area was under a bulk crop of Sesamum during the previous season. The farm is situated at 9°8' N latitude and 76°31' E longitude at an altitude of 3.05 m above mean sea level. This area enjoys a typical humid tropical climate.

Season

The trial was conducted during the *Virippu* season (first crop) of 1981 (May to September).

Climate

The meteorological parameters recorded were rainfall, maximum and minimum temperatures, relative humidity at forenoon and afternoon and sunshine hours. The weekly averages of all these meteorological parameters for the crop period, the mean of the weekly averages for the past five years and the variation between them are presented in Appendix I and Fig.I.

Soil

The soil of the site is sandy in texture. The physical and chemical composition of the soil is given in Table I.

Variety

The rice variety selected for the experiment was Jaya - the progeny of the cross between TN-1 and T-141, evolved at All India Co-ordinated Rice Improvement Project, Hyderabad. Jaya is a medium duration variety which takes 130 to 135 days to mature in the kharif season. This is a high yielding variety with wide adaptability. It is cultivated in Kerala in all the three seasons.

Rice seeds with 95 per cent germination obtained from the Rice Research Station, Kayamkulam were used for the experiment.

Fertilizers

Urea analysing 46 per cent N, super phosphate analysing 16 per cent P_2O_5 and muriate of potash analysing 60 per cent K_2O were used for the experiment.

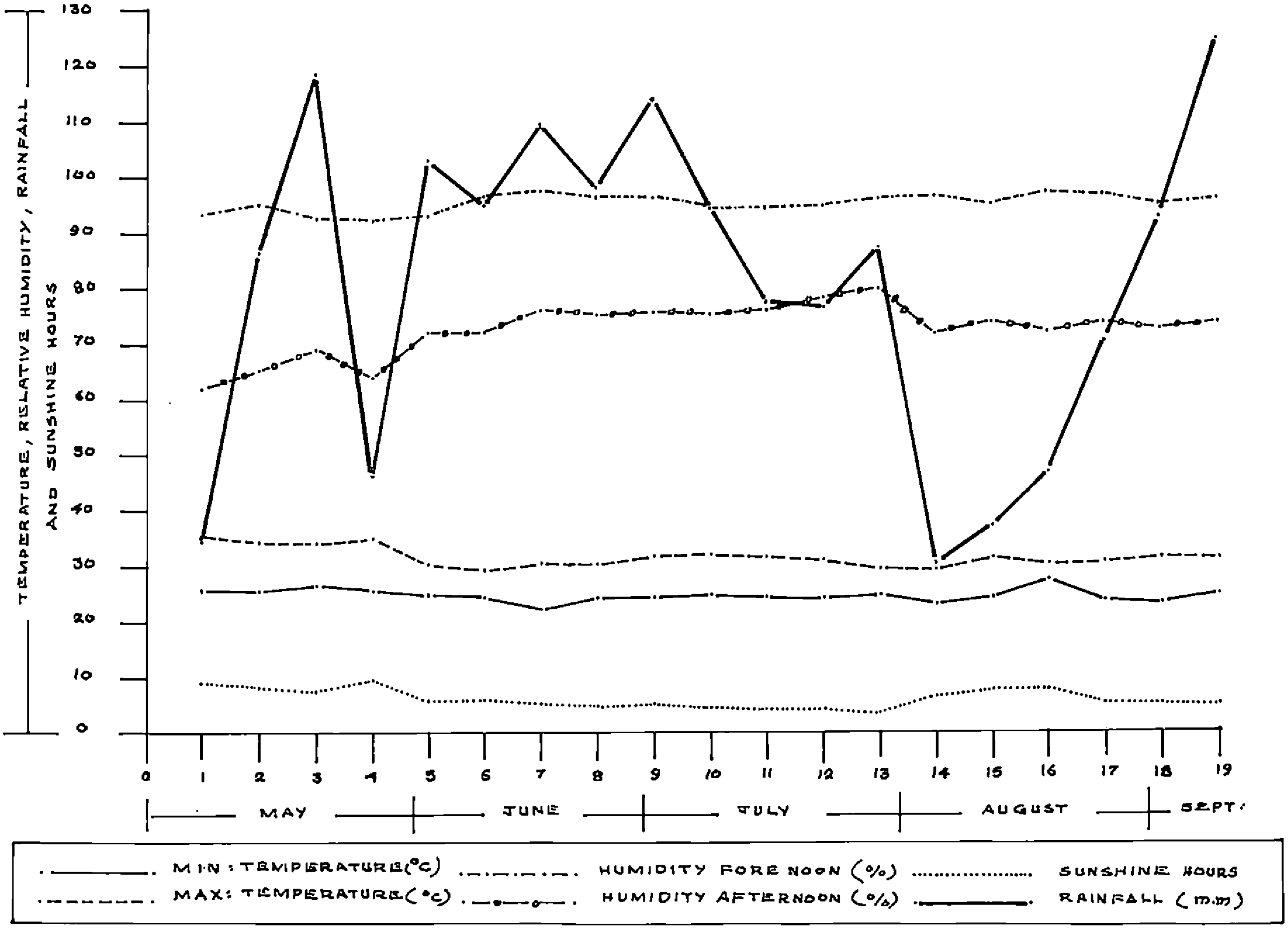

FIG: 1 WEATHER CONDITIONS DURING THE CROP SEASON 30th APRIL TO 9th SEPTEMBER

Table-1

SOIL CHARACTERISTICS OF THE EXPERIMENTAL FIELD

A. Physical properties (percentage)

1. Coarse sand	..	56.1	
2. Fine sand	..	30.8	
3. Silt	..	6.1	
4. Clay	..	5.9	

B. Chemical properties (kg/ha)

1. Total Nitrogen	..	224	Microkjeldahl method
2. Available P_2O_5	..	48.0	Bray's method
3. Available K_2O	..	60.0	Ammonium acetate method
4. pH	..	5.3	(1:2.5 soil solution using pH meter)

Herbicides

Bentazon (Basagran):- Basagran is a proprietory product of BASF India Limited. The product containing active ingredient bentazon (3-isopropyl-1H-2,1,3-benzothiadiazin-4 (3H)-one-2,2-dioxide) is available in the form of 50 per cent EC. It is a contact herbicide which has only a slight pre-emergence efficacy and it is usually applied post-emergence. It controls a wide range of weeds in rice very effectively.

Penoxalin (Stomp):- Stomp is a proprietory product of Cynamid India Limited. This is a new product containing active ingredient pendimethalin (N-(1-ethyl propyl)-2,6-dinitro-3,4-xylidine) which is the present name to penoxalin. It is available in the form of 33 per cent EC or 3 per cent G. This is a pre-emergence herbicide for selective weed control in rice, which controls broad leafed weeds by inhibiting seedling development.

Benthiocarb (Saturn):-

Saturn is a carbamate herbicide containing 50 per cent active ingredient - benthiocarb (S-4 (chloro benzyl)-N, N-diethyl thiol carbamate). It is a product of Kumiai Chemical Industry Company Limited, Tokyo, Japan which is marketed by Pesticides India, Udaipur. This is highly selective between rice and barnyard grass and applied as pre-emergence and post-emergence spray. It is available in EC and granular form.

Nitrofen (Tok E-25):- Tok E-25 is a selective herbicide containing 25 per cent of the active ingredient nitrofen (2,4-di chlorophenyl-p-nitrophenyl ether). It is available in EC and granular forms. This is marketed by Indofil Chemicals Limited.

METHODS

Experimental details

The experiment was laid out in simple Randomised Block Design with 3 replications. Total number of treatments were 12. The lay out plan is given in Fig.2.

Treatments		Abbreviations
1. Bentazon 1.5 kg ai/ha applied on the second day of dibbling		T1
2. Bentazon 2.0 kg ai/ha	,,	T2
3. Penoxalin 1.0 kg ai/ha	,,	T3
4. Penoxalin 1.5 kg ai/ha	,,	T4
5. Benthiocarb 1.5 kg ai/ha	,,	T5
6. Benthiocarb 2.0 kg ai/ha	,,	T6
7. Nitrofen 1.875 kg ai/ha	,,	T7
8. Hand weeding on 15th day after dibbling		T8
9. Hand weeding on 30th day	,,	T9
10. Hand weeding on 15th & 30th	,,	T10
11. Unweeded control		T11
12. Completely weed free		T12

Spacing	-	20 x 15 cm
Gross plot size	-	6 x 4 m
Net plot size	-	4.5 x 3.2 m

An area of 0.9 x 4.0 m at the bottom of each plot has been set apart for weed observation. The balance area of 5.1 x 4.0 m was used for taking biometric and final yield observations. In this plot 2 rows had been left all around the plot as border rows. So net plot area works out to 4.5 x 3.2 m.

Standardisation of sprayer and application of herbicides

A knapsack sprayer of 10 lit capacity having a pressure gauge was used for the spraying of herbicides. A flood jet nozzle WFN-62 (ASPEE) was used for the spraying operation. The discharge rate of the nozzle was worked out and found to be 240 lit/ha. All the herbicides at prescribed doseges were applied at the rate of 240 lit of spray solution per hectare. The spray solution was applied as a blanket spray in the respective plots, on the second day of sowing. The spraying was done in the early hours to prevent spray drift.

Weeding operations

In order to maintain a weed free condition throughout the crop period (T12) regular hand weedings were done once in 3 days. The local practice of hand weeding was done by

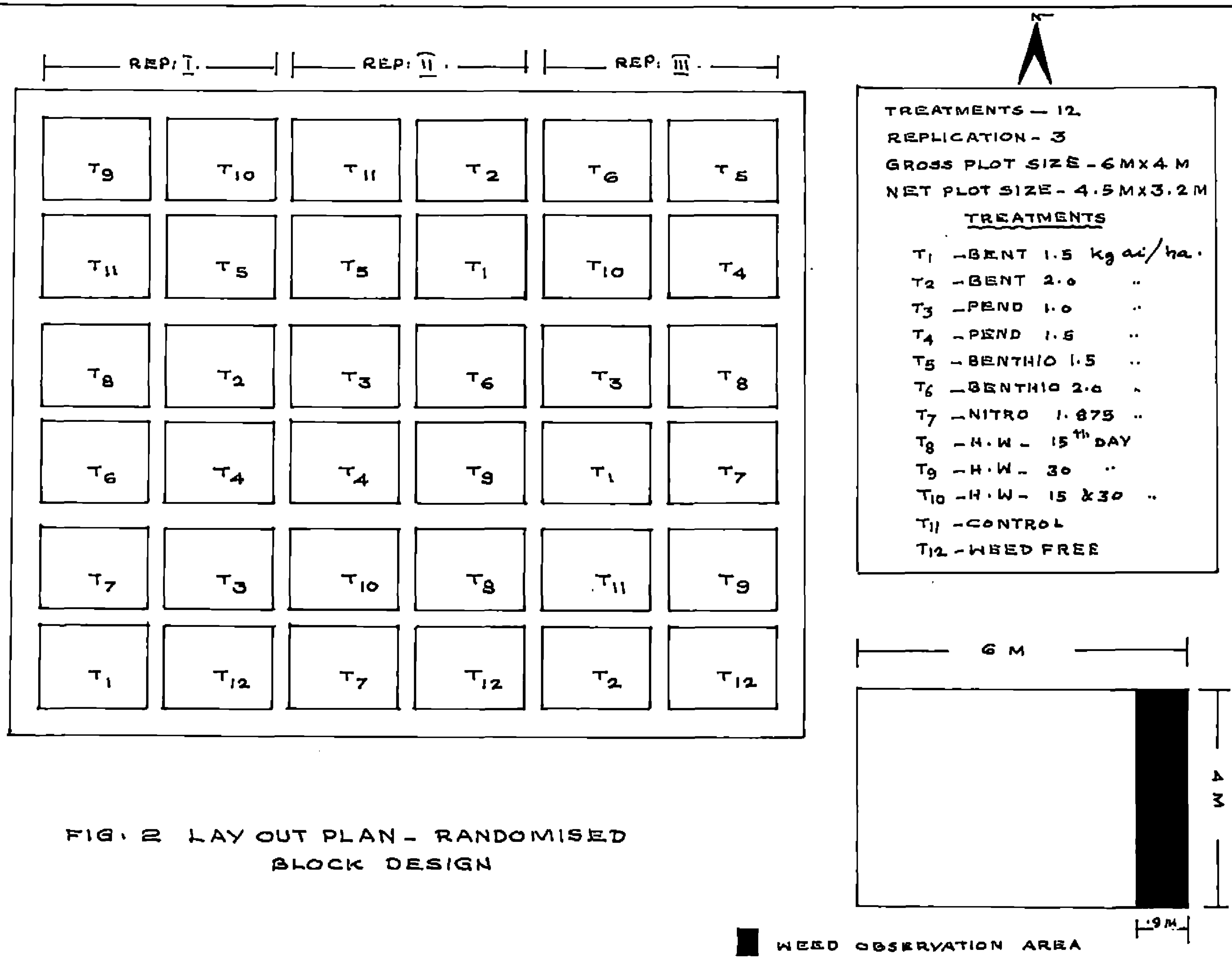

FIG. 2 LAY OUT PLAN – RANDOMISED BLOCK DESIGN

providing an inter-cultivation with a hand hoe locally known as Kochuthoomba on the 15th day of sowing and by pulling out the weeds by hand on the 30th day of sowing as per the requirements of treatments of treatment numbers T8, T9 and T10.

Details of cultivation

The experimental area was ploughed with power tiller. Plots of 6.0 x 4.0 m were laid out with 12 plots in each block. The plots and blocks were separated with bunds of 30 and 45 cm respectively. Irrigation and drainage channels were provided for all plots. Individual plots were prepared separately for dibbling. Dry seeds were dibbled at a spacing of 20 cm between rows and 15 cm between plants on 6th May 1981 with the onset of pre-monsoon showers. A seed rate of 90 kg/ha was used. A uniform crop stand was maintained by thinning and gap filling with least disturbance to weeds on 14th June, 1981 as per the local practice.

Urea, super phosphate and muriate of potash were applied to each plot separately so as to supply nutrients at the rate of 90 kg N, 45 kg P_2O_5 and 45 kg K_2O per ha respectively. Full P, 50 per cent N and 50 per cent K as basal, 25 per cent N at tillering stage and 25 per cent of

N and 50 per cent of K a week before panicle initiation stage were applied.

All these cultural practices were carried out as per the Package of Practices (1979) recommended by Kerala Agricultural University.

The crop was grown under dry condition during the initial period. Subsequently with the onset of rains, water level was maintained at 5 cm till 10 days before harvest. Occasional draining of water from the plots was also done.

One protective spray with Malathion 0.2 per cent was given on the 80th day of dibbling. The stand of the crop was good. There was no serious attack of pests and diseases. The crop was harvested on 7th September, 1981, 124 days after dibbling.

Observations

An area of 0.9 x 4.0 m was kept apart on the same side of all the plots for periodical observation on weeds upto harvest. All the other biometric observations were taken from the balance area.

I. Observation on weeds

A. Weed species

The weeds collected from the experimental site before the start of the experiment and during the experiment were identified and grouped into grasses, sedges and broad leafed weeds.

B. Weed count

Weed samples were collected from an area of 0.5 m^2 on 20th, 40th, 60th, 80th and 100th day of dibbling and at harvest. Weeds were pulled out washed and identified. They were grouped into monocots and dicots and their counts were taken. The weed population is expressed as monocot, dicot and total weeds per m^2.

C. Dry weight of weeds

The weeds taken as mentioned above were dried in the sun and later oven dried till it recorded constant weight. The dry weight of weeds were recorded at 20 days interval from 20th to 100th day of dibbling and at harvest and weight were expressed as g per m^2.

II. Observation on crop

A. Crop growth characters

For periodical observations, three sample units of two hills x two hills were randomly selected in each plot (Gomez 1972) and the following observations were recorded.

(a) Height of the plant

The plant height in cm was recorded at 20th, 40th, 60th.

80th, 100th day after dibbling and at harvest. Height was measured from the base of the plant to the tip of the longest leaf or to the tip of the longest earhead whichever was taller (Gomez 1972).

(b) Number of tillers per m^2

Total number of tillers from 3 sampling units were counted at 60th and 80th day of dibbling and the number of tillers per m^2 was worked out.

(c) Leaf Area Index

Leaf Area Index was calculated by the method suggested by Gomez (1972) Leaf Area Index was computed on 60th and 80th days. 'n' sample hills (6 nos.) were selected. The maximum width 'W' and length 'L' of all leaves of middle most tillers were noted and Leaf Area Index was calculated as shown below.

Leaf area per leaf:	K x L x W where K is the adjustment factor which is 0.67 at seedling stage and at harvest and 0.75 at other stages.
Leaf area per hill:	Total area of the middle tiller x total number of tillers
Leaf Area Index:	$\frac{\text{Sum of leaf area/hill of 6 sample hills in cm}^2}{\text{Area of land covered by 6 hills in cm}^2}$

B. Yield characters

(a) Number of productive tillers per hill

At harvest productive tillers from 12 hills selected were counted and number of productive tillers per hill worked out.

(b) Length of the panicle

Length of the middle panicles of all hills in a sampling unit were measured and mean worked out.

(c) Height of the panicle

All the panicles in the sampling unit were weighed and weight per panicle calculated.

(d) Number of filled grains per panicle

The main culm panicles from the 12 hills were threshed and number of filled grains (f) number of unfilled grains (u) and weight of filled grains (w) were determined.

The rest of the panicles from all the 12 hills were threshed and number of unfilled grains (u) and weight of filled grains (W) assessed.

From this data, the number of filled grains per panicle was calculated using the formula given below (Gomez 1972).

No.of filled grains/panicle = $\frac{f}{w} \times \frac{W+w}{P}$

where 'p' is the total no.of panicles from all the 12 hills.

(e) Thousand grain weight

From the values obtained for calculating the number of filled grains per panicle thousand grain weight was calculated and adjusted to 14 per cent moisture using the following formula given by Gomez (1972).

$$\text{Thousand grain weight} = \frac{100 - M}{86} \times \frac{w}{f} \times 1000$$

where M is the moisture content of filled grains.

(f) Grain yield

Dry weight of grain was recorded from the net harvested area after cleaning and drying and the weight adjusted to 14 per cent moisture and expressed as yield in kg per hectare.

(g) Straw yield

The straw harvested from the net plot was cleaned by separating weeds, uniformly dried in sunlight, weighed and expressed as yield in kg per hectare.

(h) Weed Index

Weed Index was computed by following the formula suggested by Gill and Vijayakumar (1969).

$$WI = \frac{(x-y)}{x} \times 100$$

WI - Weed Index

x - Yield from weed free plot or the treatment which recorded minimum weeds

y - Yield from the treatment for which weed index is to be worked out

(1) Weed Control Efficiency

Weed control efficiency was calculated by using the following formula:

$$WCE = \frac{x - y}{x} \times 100$$

x – Weed count from the unweeded control plot or treatment which recorded maximum number of weeds

y – Weed count from the treatment for which weed control efficiency is to be worked out.

III. Chemical Analysis

(a) Soil analysis

Composite soil samples collected prior to the commencement of the experiment were analysed to determine the physical and chemical composition. The pH of soil was determined using a pH meter in a 1:2.5 soil solution.

(b) Plant Analysis

The N, P_2O_5 and K_2O content of the weed samples collected periodically from the 60th day, 80th day and 100th day of dibbling and at harvest were estimated. N, P_2O_5 and K_2O content of the crop were estimated at 60th day, 80th day and 100th day of dibbling and at harvest. Nutrient uptake by the crop at 60th, 80th and 100th days of sowing and at harvest were estimated separately and expressed in kg per hectare.

The N, P_2O_5 and K_2O uptake by weeds on 20th, 40th, 60th, 80th and 100th day of dibbling and at harvest were estimated and expressed in kg per hectare.

1. Total Nitrogen

Total nitrogen content was estimated by Microkjeldahl digestion method (Jackson 1967).

2. Total Phosphorus

Total P_2O_5 content was estimated colorimetrically by Vanadomolybdophosphoric acid yellow colour method after triple acid extraction (9:2:1 HNO_3, H_2SO_4, HCl O_4). The colour was read in a Klett summerson photo-electric colorimeter at 660 nm (Jackson 1967).

3. Total Potassium

Total K_2O content of the samples were estimated by Flame Photometer method after triple acid, digestion. K_2O content was read in 'EEL Flame Photometer' (Jackson 1967).

4. Protein content of grains

Protein content of grain was computed by multiplying the N content of whole grain by factor 6.25 (Simpson et al. 1965).

IV. Statistical analysis

The data was analysed statistically following the methods of Snedecor and Cochran (1967) 'F' test was carried out by analysis of variance method and significant results were compared by working out critical differences. The data on weed characters were analysed after necessary transformation.

Important correlations were also worked out.

RESULTS

RESULT

The data on biometric observations were analysed statistically and the analysis of variance tables are presented in Appendices II to X. The mean values are given in Tables 2 to 13.

I. OBSERVATION ON WEEDS

A. Weed species

The different species of weeds collected from the experimental site before and during the experimentation were identified. They were grouped into grasses, sedges and broad-leafed weeds and presented in Table 2. The predominant weeds were *Echinochloa colonum*, *Echinochloa cruss-galli*, *Sacciolepis indica*, *Cyperus iria*, *Cyperus rotundus*, *Cleome viscosa* and *Monochoria viginalis*.

B. Weed count

Monocot, dicot and total weed population were recorded at 20 days interval upto 100 days after sowing and also at harvest. Weed counts taken from a sample area of 0.5 m^2 were analysed after converting to weed count/m^2. Mean values of weed population are presented in Tables 3 a, b and c.

Data on weed population were analysed after $\sqrt{x+1}$ transformation.

Table-2

List of weeds found in the experimental field

Scientific name	Family
I. GRASSES	
1. *Brachiaria ramose* (Griseb) Stapf	Graminae
2. *Echinochloa colonum* (Linn) Link	,,
3. *Echinochloa crus-galli* (Linn) P.Beavu	,,
4. *Oryza sativa* var.fatua Linn.	,,
5. *Panicum repens* Linn.	,,
6. *Sacciolepis indica* (L) A.Chase	,,
7. *Sacciolepis interrupta* (Willd.) Stapf	,,
II. SEDGES	
1. *Cyperus iria* Linn.	Cyperaceae
2. *Cyperus rotundus* Linn.	,,
3. *Fimbristylis miliacea* (Linn.)Vahl.	,,
III. BROAD LEAFED WEEDS	
1. *Ammania baccifera* Linn.	Lythraceae
2. *Cleome viscosa* Linn.	Capparidaceae
3. *Cyanotis axillaris* (L) D.Don	Commelinaceae
4. *Ludwigia parviflora* (Linn.)Roxb	Onagraceae
5. *Monochoria viginalis* (Burmf)Prest	Pontederiaceae

1. Monocot weed population/m^2

The analysis of variance tables are presented in Appendix II and the mean values in Table 3a.

(a) 20th day after sowing

Highest monocot weed population (23.38/m^2) was recorded in T11 followed by T9 and T3. All these three treatments recorded significantly higher number than the remaining treatments. T4 and T1 were on par, and recorded lower number than the treatments mentioned earlier.

Zero weed count was recorded by T12, T8 and T10 recorded weed population of 3.38 and 4.25/m^2 respectively. Among the herbicide treatments T6 was found to be on par with T7 and T2, while there was no significant difference between T7, T2 and T5 (Benthiocarb 1.5 kg/ha).

(b) 40th day of sowing

Highest weed count recorded in T8 was 18.94/m^2 which was on par with T11 (unweeded control) and were higher than all other treatments. T3 recorded the next higher weed population and was significantly higher than the rest.

As on the 20th day T12 recorded zero weed count. T10 recorded minimum weed count which was on par with T9, T6 and T7. T7 in turn was on par with T5, T2 and T4 while T1 was on par with T4, T2 and T5.

Table-3(a)

Monocot weed population/m^2 at different days after dibbling

(After $\sqrt{x + 1}$ transformation)

Treatments	20	40	60	80	100	Harvest
T1	11.82 (138.89)	11.19 (124.75)	9.08 (81.82)	10.19 (103.54)	10.65 (113.13)	11.49 (130.81)
T2	7.31 (52.53)	9.46 (88.89)	7.38 (53.37)	7.91 (61.62)	8.58 (72.73)	9.46 (88.89)
T3	17.14 (300.33)	14.30 (204.54)	10.14 (102.02)	11.10 (122.22)	11.71 (136.36)	12.71 (160.61)
T4	12.07 (144.95)	10.17 (102.53)	9.67 (92.93)	10.51 (109.60)	11.21 (124.75)	12.45 (154.54)
T5	8.99 (81.31)	8.62 (73.23)	7.44 (54.55)	8.39 (69.19)	9.03 (80.81)	9.84 (95.96)
T6	6.17 (37.37)	8.02 (64.65)	4.24 (17.17)	5.84 (35.35)	6.62 (44.44)	7.95 (63.13)
T7	6.65 (43.43)	8.02 (64.65)	5.29 (27.27)	6.26 (38.38)	7.08 (49.50)	8.16 (66.66)
T8	3.38 (14.14)	18.94 (205.55)	12.71 (160.61)	12.94 (166.70)	13.32 (176.77)	13.94 (193.43)
T9	19.71 (388.89)	6.83 (39.90)	10.23 (104.04)	11.51 (131.82)	12.21 (148.49)	13.06 (169.70)
T10	4.25 (17.17)	5.31 (27.78)	8.45 (70.20)	9.04 (80.81)	9.74 (93.94)	10.89 (117.68)
T11	23.38 (547.98)	17.62 (311.11)	15.33 (251.01)	15.98 (270.20)	16.54 (287.37)	17.38 (315.63)
T12	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)
CD(0.05)	2.063	2.701	2.543	2.493	2.460	2.392

Note: Figures in paranthesis are the original weed count/m^2

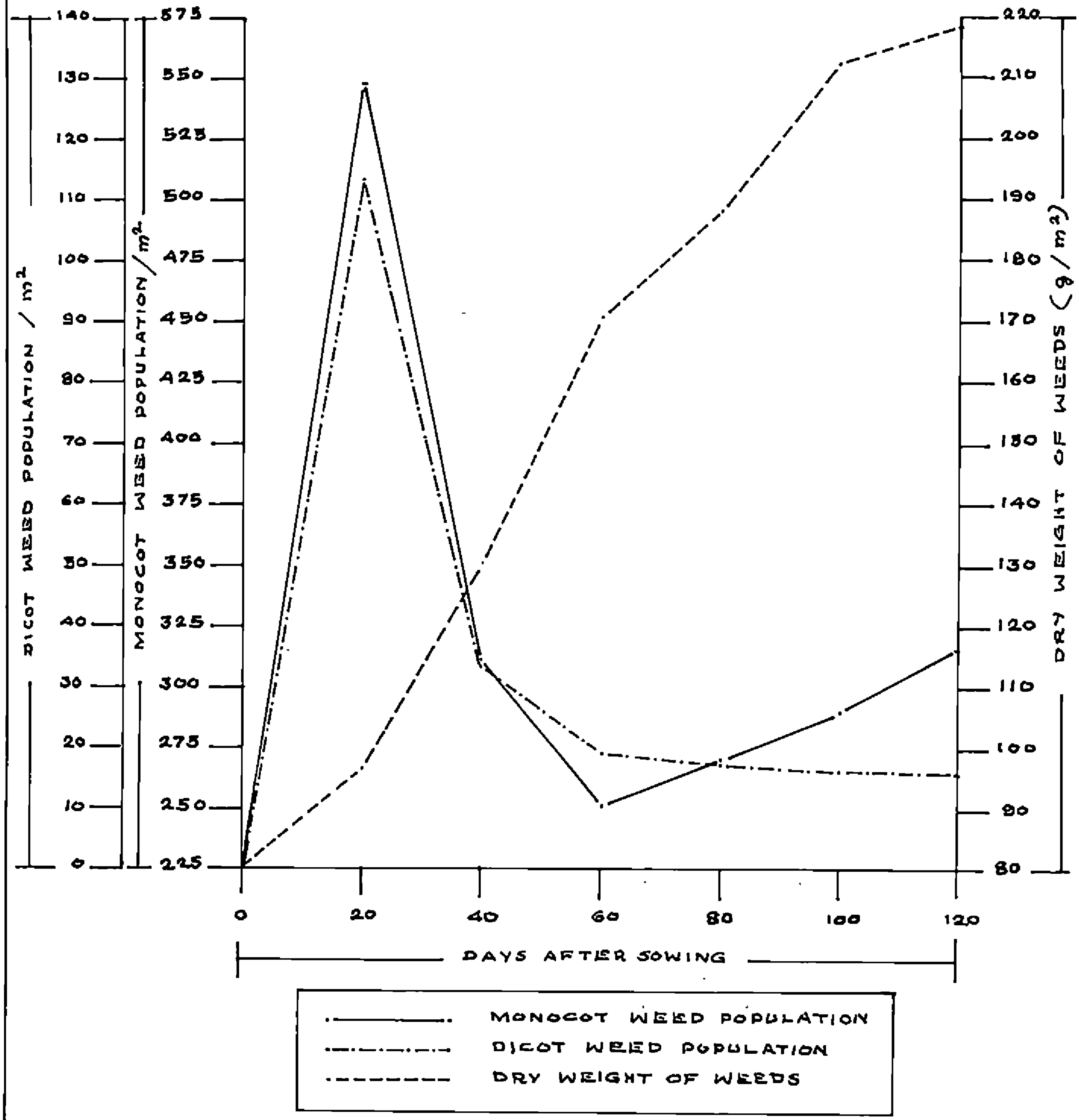

FIG: 3 MONOCOT AND DICOT WEED POPULATION AND DRY WEIGHT OF WEEDS IN THE UNWEEDED CONTROL PLOT

(c) <u>60th day of sowing</u>

Highest weed count (15.33/m^2) was recorded in the unweeded control and it was having significantly higher weed count than all other treatments. T8 was on par with T9, T3 and T4. T4 in turn was on par with T1, T10, T5 and T2. T 12 recorded zero weed count. Among the herbicide treatments, T6 recorded minimum weed count (4.25/m^2) which was on par with T7.

(d) <u>80th day of sowing</u>

T11 recorded highest weed count (15.98/m^2) followed by T8 which was on par with T9, T3 and T4. T4 in turn was on par with T1, T10 and T5. T6 which recorded minimum weed count (5.84/m^2) was on par with T7, T2 and T5.

(e) <u>100th day of sowing</u>

Highest weed count recorded in T11 (16.54/m^2) was significantly higher than all other treatments. T8, T9, T3 and T4 were on par. While T3 and T4 were on par with T1 and T10. T12 recorded zero weed count. T6 with minimum weed count (6.62/m^2) was on par with T7, T2 and T5.

(f) <u>Harvest</u>

T11 recorded highest weed count (17.38/m^2). T8 recorded next lower number and was on par with T9, T3 and T4. T6 with minimum weed count (7.95/m^2) was on par with other herbicide treatments, T7, T2 and T5. T2 and T5 were on par with T10 and T1.

2. Dicot weed population/m^2

The analysis of variance tables are presented in Appendix II and the mean values in Table 3b.

(a) 20th day of sowing

The dicot weed population was highest (10.41/m^2) in T11 which was on par with T1, T3 and T4. T4 in turn was on par with T2, T9, T6, T7 and T5. Lowest weed count was recorded in T8 (3.10/m^2) which was on par with T12 and was also on par with T10, T5, T7 and T8.

(b) 40th day of sowing

Highest dicot weed development during the 40th day of sowing (9.43/m^2) was recorded in T1 which was on par with T8 and T5. T8 and T5 in turn was on par with T4, T3, T7, T6, T9, T11 and T2. Lowest weed count was recorded in T10 which was on par with complete weed free condition.

(c) 60th day of sowing

Highest count of 5.31/m^2 was recorded in T9 which was on par with T3 and T11. T3 and T11 were also on par with T4, T5 and T7. T8 recorded lowest count of 2.70/m^2 which was on par with T2, T6, T10 and T7. T12 was weed free.

Table-3(b)

Dicot weed population/m^2 at different days after dibbling

(After $\sqrt{x + 1}$ transformation)

Treat-ments	20	40	60	80	100	Harvest
T1	9.80 (96.67)	5.71 (32.83)	2.92 (8.08)	3.29 (9.61)	3.78 (13.13)	4.72 (21.72)
T2	6.51 (48.49)	5.27 (28.29)	2.97 (8.08)	3.49 (11.12)	3.81 (13.64)	3.60 (11.62)
T3	8.92 (80.81)	6.37 (41.92)	4.67 (20.20)	3.95 (14.71)	4.31 (17.84)	3.90 (15.15)
T4	7.85 (60.61)	6.38 (39.90)	4.15 (16.67)	4.03 (15.17)	4.47 (19.19)	4.30 (18.18)
T5	5.05 (26.77)	3.30 (9.89)	3.91 (14.66)	3.55 (11.63)	3.53 (11.95)	3.87 (14.14)
T6	6.11 (40.40)	3.18 (9.11)	3.03 (8.08)	3.17 (9.10)	3.72 (12.96)	3.74 (13.13)
T7	6.10 (36.87)	3.18 (9.11)	3.49 (11.11)	3.44 (11.12)	3.80 (13.64)	3.62 (12.12)
T8	4.33 (17.75)	7.42 (59.09)	2.70 (6.06)	3.32 (10.11)	3.26 (9.60)	3.64 (11.62)
T9	8.23 (66.66)	5.89 (33.84)	5.31 (27.78)	4.20 (16.67)	4.20 (16.67)	3.34 (10.10)
T10	4.44 (19.19)	3.53 (12.63)	3.33 (10.61)	3.74 (13.14)	4.23 (16.69)	4.32 (17.68)
T11	10.41 (112.63)	9.43 (93.43)	4.45 (19.19)	4.22 (17.00)	4.20 (16.01)	4.11 (15.66)
T12	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)
CD (0.05)	3.070	2.704	1.101	0.932	0.694	1.202

Note: Figures in paranthesis are the original weed count/m2

(d) 80th day of sowing

Unweeded control plot (T11) recorded highest weed count of 4.22/m^2 which was on par with all the other treatments except T6 which recorded lowest weed count of 3.17/m^2. T6 was on par with all other treatments except T9 and T11.

(e) 100th day of sowing

T4 recorded highest dicot weed count which was on par with all others except T12, T8, T5 and T6. T8 recorded lowest number of weeds (3.26/m^2) and was on par with T5, T6, T1, T7 and T2. T12 was weed free.

(f) Harvest

At harvest, highest number of dicot weeds (4.72/m^2) was noted in T1 which was on par with all others except T9 which was on par with all the others except T1.

3. Total weed population/m^2

The analysis of variance tables are presented in Appendix II and the mean values in Table 3c.

(a) 20th day of sowing

Highest weed count (26.04/m^2) was recorded in T9 which was significantly higher than all others. T9 was followed by T11 which also recorded significantly higher weed count than the rest of the treatments. T4 and T1

Table-3(c)

Total weed population/m^2 at different days after dibbling

(After $\sqrt{x + 1}$ transformation)

Treat-ments	20	40	60	80	100	Harvest
T1	15.22 (231.82)	12.51 (157.58)	9.51 (89.90)	10.65 (113.13)	11.26 (132.93)	12.36(152.52)
T2	9.99 (101.51)	10.86 (117.17)	7.91 (61.62)	8.58 (72.73)	9.34 (86.36)	10.06(100.50)
T3	19.30 (381.31)	15.70 (246.46)	11.10 (122.22)	11.71 (136.36)	12.47 (154.66)	13.28(175.76)
T4	14.51 (209.60)	11.97 (143.42)	10.51 (109.60)	11.21 (124.75)	12.28 (150.00)	13.18(172.73)
T5	10.32 (108.08)	9.16 (83.12)	8.39 (69.19)	9.03 (80.81)	9.70 (93.43)	10.54(110.10)
T6	8.70 (77.78)	8.51 (73.76)	5.11 (25.25)	6.63 (44.44)	7.53 (57.07)	8.71(76.26)
T7	8.99 (80.30)	8.51 (73.76)	6.26 (38.38)	7.08 (49.50)	7.95 (63.13)	8.88 (78.79)
T8	5.64 (31.89)	15.79 (264.65)	12.94 (166.67)	13.34 (176.77)	13.71 (187.16)	14.35(205.05)
T9	16.45 (311.11)	8.64 (73.74)	11.51 (131.82)	12.21 (148.49)	12.88 (165.15)	13.46(180.30)
T10	6.96 (36.37)	6.41 (40.40)	9.04 (80.81)	9.74 (93.94)	10.54 (110.61)	11.57(135.35)
T11	25.64 (660.61)	20.95 (404.54)	15.98 (270.20)	16.54 (287.37)	17.24(310.61)	17.87(331.31)
T12	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)
CD (0.05)	5.072	2.831	2.341	2.392	2.460	2.363

Note: Figures in paranthesis are the original weed count/m^2

were on par with T3 on one hand and with T5 on the other. Minimum weed count recorded in T8 was 6.48/m^2 which was on par with T10, T6, T7, T2 and T5. T12 was weed free.

(b) <u>40th day of sowing</u>

The analysis showed that highest total weed count (18.55/m^2) during the 40th day of sowing occurred in T11 which was on par with T8. T8 in turn was on par with T3 and T1. T10 recorded lowest weed count of 6.41/m^2 which was on par with T9. T9 in turn was on par with T6, T7, T2 and T5.

(c) <u>60th day of sowing</u>

T11 recorded highest weed count of 15.98/m^2 which was higher than all other treatments. T8 recorded next higher weed count and it was on par with T9 and T3. While T3, T2, T1 and T10 were on par. Lowest weed count of 5.11/m^2 was recorded in T6 which was on par with T7, T2, T5, T10 and T1 were also on par.

(d) <u>80th day of sowing</u>

Total weed growth was highest in T11 which was significantly higher than all other treatments. This was followed by T8 which was on par with T9, T3 and T4. T6 which recorded least weed count of 6.63/m^2 was on par with T7 and T2. T7, T2, T5 and T10 were also on par. T10 in turn was on par with T1, T4, T3 and T9.

(e) <u>100th day of sowing</u>

Highest weed population on 100th day of sowing ($17.24/m^2$) was recorded in unweeded control which was higher than the rest of the treatments. T8, T9, T3, T4 and T1 were on par. Lowest weed population was recorded in T6 which was on par with T7, T2 and T5, T2, T5, T10 and T1 were also on par. T12 was weed free.

(f) <u>Harvest</u>

Weed infestation at harvest was highest ($17.87/m^2$) in T11 which was higher than rest of the treatments. T8, T9, T3, T4 and T1 were on par. T6 with the lowest weed count of $8.71/m^2$ was on par with T7, T2 and T5, T2, T5, T10. T1 were also on par.

C. <u>Dry matter production of weeds</u>

Dry matter accumulation of weeds on 20th, 40th, 60th, 80th and 100th day of sowing and at harvest were analysed separately and the analysis of variance tables and mean values are presented in Appendix III and Table 4a respectively.

(a) <u>20th day of sowing</u>

Highest dry matter accumulation (96 g/m^2) was noticed in T11 which was significantly higher than all others. T8 was on par with T9 which in turn was on par with T3. T3, T4 and T10 were on par. T7 recorded lowest

Table-4 (a)

Dry matter production by weeds g/m^2 at different days after dibbling

Treatments	Days after dibbling					
	20	40	60	80	100	Harvest
T1	8.67	14.67	21.33	26.00	35.33	60.33
T2	5.00	6.00	10.00	14.67	19.33	35.33
T3	28.00	33.67	38.00	41.33	46.33	68.00
T4	23.67	28.00	34.33	40.00	45.00	70.00
T5	10.33	14.33	16.33	19.00	25.00	31.00
T6	5.67	4.67	2.00	2.67	6.00	11.00
T7	4.67	3.00	3.33	3.33	5.00	11.33
T8	40.00	47.00	53.67	59.67	65.33	95.33
T9	36.33	40.33	49.33	56.00	59.00	114.33
T10	20.33	24.00	27.67	29.00	32.00	44.33
T11	96.00	130.00	170.00	188.33	212.33	217.67
T12	0	0	0	0	0	0
CD(0.05)	10.164	9.022	9.022	8.820	6.910	19.381

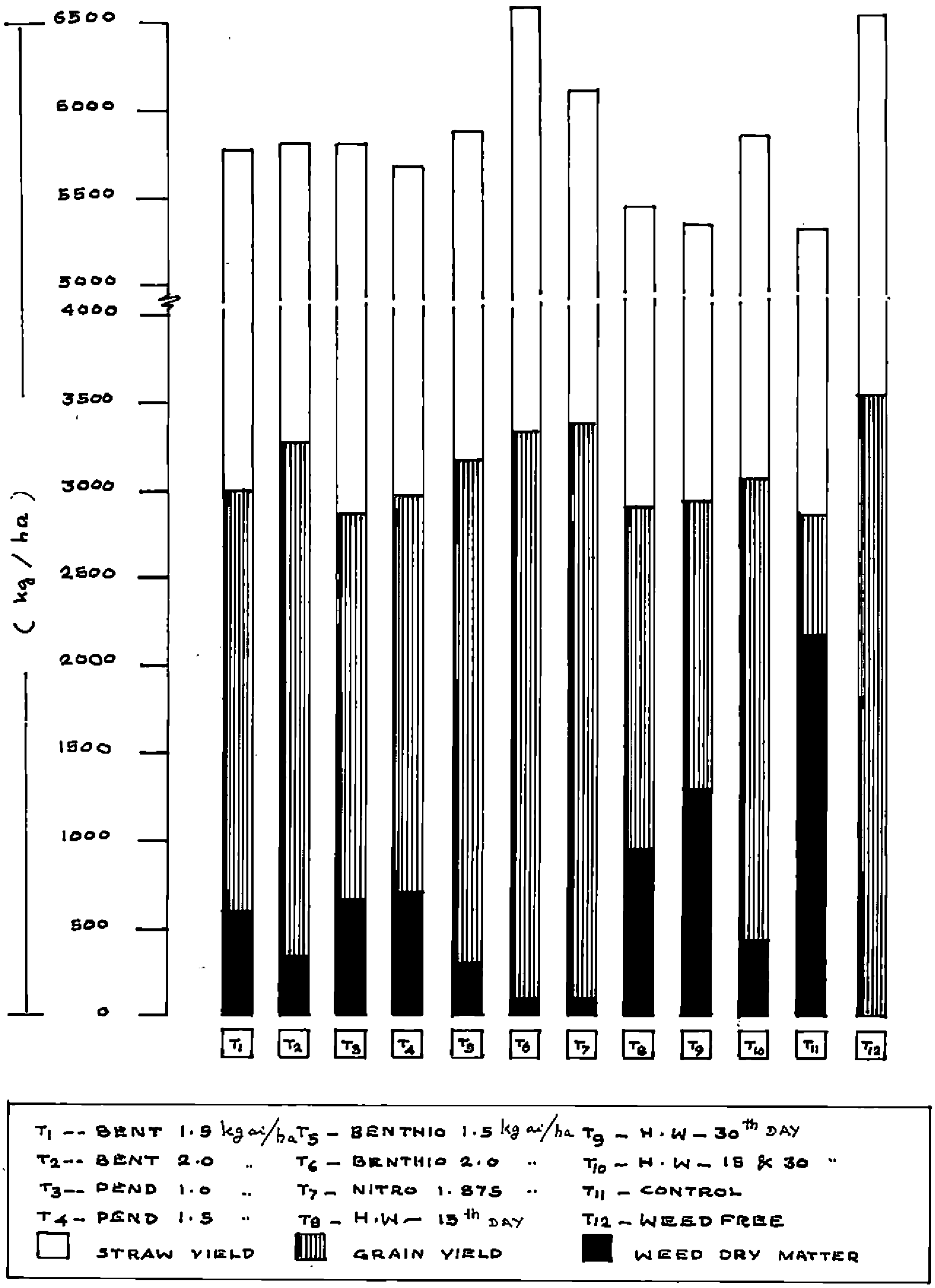

FIG: 4. EFFECT OF TREATMENTS ON WEED DRY MATTER ACCUMULATION GRAIN AND STRAW YIELD dry weight of 4.67 g/m^2 which was on par with T2, T6, T1 and T5. T5 and T10 were on par. T12 recorded zero dry weight.

(b) <u>40th day of sowing</u>

Highest dry matter accumulation of 130 g/m^2 was recorded in T11 which was significantly higher than other treatments. T8, T9 were on par, with T9 was also on par with T3. T3, T4 and T10 were on par. T7 recorded lowest dry matter (3.00 g/m^2) which was on par with T6 and T2. T2 in turn was on par with T5 and T1.

(c) <u>60th day of sowing</u>

T11 record 170 g/m^2 which continued to be the highest and significantly superior to all others. T9 and T8 were on par and recorded next higher weed dry weight and was superior to all the rest. T3 and T4, T4 and T10, T10 and T1, T1 and T5, T5 and T2 were on par. Lowest weed dry matter accumulation noticed in T6 was 2 g/m^2 which was on par with T7 and T2.

(d) <u>80th day of sowing</u>

Highest weed dry matter was noticed in T11 and significantly higher than the rest. T8 and T9 were on par and gave higher weed dry weight than the rest. T3 and T4 were also on par. T6 with least dry matter accumulation of

2.67 g/m^2 was on par with T7. T2 and T5 were on par. T5 in turn was on par with T1 which was also on par with T10.

(e) 100th day of sowing

T11 recorded highest dry weight of 212.33 g/m^2 and was significantly higher than others. T8 and T9, T3 and T4, T1 and T10, T5 and T6, T6 and T7 were all on par. T7 recorded least dry matter of 5 g/m^2.

(f) Harvest

The dry weight of weeds recorded by T11 was highest (217.67 g/m^2) and superior to the rest. T4 and T8, T4 and T3 and T1, T10, T2 and T5, T7 and T6 were on par. T6 recorded lowest weight of 11 g/m^2.

D. Weed control efficiency

Weed control efficiency was worked out on the basis of total weed population/m^2 at harvest and presented in Table 4b. T6 recorded the highest weed control efficiency (77.9 per cent) followed by T7 (76.2 per cent). The lowest efficiency was recorded in T8 (38.1 per cent). T2, T5, T10, T1, T4, T3 and T9 recorded weed control efficiencies of 69.7 per cent, 66.7 per cent, 59.2 per cent, 54.[illegible] per cent, 47.9 per cent, 47.9 per cent and 45.6 per cent respectively. In the case of T11 the efficiency was zero.

Table-4(b)

Weed control efficiency (per cent)

Treatments		Weed control efficiency (per cent)
T1	..	54.0
T2	..	69.7
T3	..	47.0
T4	..	47.9
T5	..	66.7
T6	..	77.0
T7	..	76.2
T8	..	38.1
T9	..	45.6
T10	..	59.2

II. OBSERVATION ON CROP

A. Crop growth characters

(1) Height of plant

Height of the plant were recorded on 20th, 40th, 60th, 80th and 100th day of sowing and at harvest. The data were analysed separately and the analysis of variance tables are presented in Appendix IV. The mean values are presented in Table 8.

(a) 20th day of sowing

Maximum height of 29.96 cm was recorded in T6 which was on par with T12. T12 and T7, T2 and T5, T5 and T10, T10 and T8, T8 and T1, T1 and T4, T4 and T3, T9 and T11 were all on par. Minimum height of 19.34 cm was recorded in unweeded control (T11.)

(b) 40th day of sowing

T6 recorded maximum height (55.77 cm) which was significantly superior to all other treatments. T6 was followed by T12 which was also higher than the rest. T7 and T2, T2 and T5, T5 and T10, T1, T4 and T3, T3 and T8 were on par. T9 recorded 37.33 cm and T11 30.04 cm, and both were having lower height than all other treatments.

(c) 60th day of sowing

Maximum height of 84.45 cm was noticed in T6 which was superior to all other treatments. T12 produced next

Table-5

Height of plants in cm at different days after dibbling

Treat-ments	Days after dibbling					Harvest
	20	40	60	80	100	
T1	22.46	44.37	63.70	65.71	74.71	79.50
T2	26.09	50.03	69.20	73.13	83.63	90.63
T3	21.25	43.08	60.83	62.54	70.25	74.30
T4	21.79	43.74	62.65	65.08	73.58	78.67
T5	25.00	48.50	68.03	70.21	80.34	86.38
T6	29.96	55.77	84.45	89.59	100.67	108.21
T7	27.46	51.33	71.21	75.21	86.13	93.08
T8	23.39	41.91	59.03	61.29	68.13	71.13
T9	20.21	37.33	59.74	61.38	69.29	73.29
T10	24.50	46.28	67.32	70.34	80.34	86.42
T11	19.34	30.04	55.37	57.79	65.04	68.04
T12	28.50	53.45	76.40	81.21	93.29	100.92
CD(0.05)	1.561	1.820	3.224	4.314	4.404	4.352

tall plants which was also superior to the rest of the treatments. T7, T2 and T5, T2, T5 and T10, T1, T4 and T3, T4, T3 and T9, T9 and T8 were on par. The lowest height of 55.37 cm was recorded in T11 and significantly lower than all other treatments.

(d) 80th day of sowing

Treatment T6 with a height of 89.59 cm was significantly superior than all others which was followed by T12, T7 and T2, T2, T10 and T5, T1, T4 and T3, T3, T9 and T8, T9, T8 and T11 which were on par. T11 recorded minimum height of 57.79 cm.

(e) 100th day of sowing

T6 continued to produce tall plants (100.67 cm) which was significantly higher than all other treatments and followed by T12, T7 and T2, T2, T5 and T10, T1 and T4, T4, T3 and T9, T9, T8 and T11 which. were on par. T11 recorded minimum height of 64.04 cm.

(f) Harvest

T6 with a maximum height of 108.21 cm was superior to all other treatments while T12 which followed T6 was significantly higher than the rest. T7 and T2, T2, T10 and T5, T1 and T4, T3, T9 and T8, T8 and T11 were on par. T1 recorded the minimum height of 68.04 cm.

(2) Number of tillers/m^2

Data on tiller number were collected on 60th and 80th day of sowing. The analysis of variance table is presented Appendix V and the mean values in Table 6.

(a) 60th day of sowing

Highest tiller number of 278/m^2 was noticed in T6 which was on par with T7 and T12. T2 and T5, T5 and T10, T1, T9 and T3, T3, T4, T8 and T11 were on par. T11 produced least number of tillers (125.1/m^2).

(b) 80th day of sowing

T6 which recorded 539.3/m^2 was significantly superior to all other treatments. T2 and T7, T7, T2 and T5, T2, T5 and T10, T10, T1 and T4, T4, T3, T8 and T9, T9 and T11 were on par. T11 produced least number of 287.7/m^2.

(3) Leaf Area Index

Leaf Area Index was calculated on 60th and 80th day of sowing. Mean values are given in Table 6 and analysis of variance in Appendix V.

(a) 60th day of sowing

T6 with a highest LAI of 3.89 was on par with T12 and T7. T2 was on par with T10, T5 and T1. T8 was on par with T4, T3 and T9. T11 recorded lowest LAI of 2.07 and was significantly lower than all other treatments.

Table-6

Number of tillers/m^2 and LAI at 60th and 80th days after dibbling

Treat-ments	No.of tillers		LAI	
	60	80	60	80
T1	159.85	361.34	3.11	3.81
T2	214.06	404.46	3.38	4.41
T3	145.95	326.65	2.67	3.58
T4	133.44	348.50	2.74	3.65
T5	195.99	403.10	3.27	4.28
T6	278.00	539.32	3.89	4.72
T7	268.27	425.34	3.69	4.16
T8	128.08	322.48	2.78	3.37
T9	148.78	315.53	2.60	3.55
T10	187.65	372.52	3.33	3.86
T11	125.10	287.73	2.07	3.21
T12	266.88	460.09	3.69	4.58
CD (0.05)	24.143	35.022	0.431	0.202

(b) <u>80th day of sowing</u>

Highest LAI of 4.72 was recorded by T6 which was on par with T12. T12 and T2, T2 and T5, T5 and T7, T10 and T1, T1, T4 and T3, T3, T9 and T8, T8 and T11 were also on par. T11 recorded lowest LAI of 3.21.

B. <u>Yield characters</u>

The analysis of variance table is presented in Appendix VI and mean values in Table 7.

(a) <u>Productive tillers/hill</u>

Highest number of productive tillers (6.09) were recorded in T6 which was on par with T12. T12 in turn was on par with T5. T5 was also on par with T7, T2, T4, T10, T1, T3 and T8. T11 recorded least productive tillers of 3.80 which was on par with T9, T8, T3, T1, T10 and T4.

(b) <u>Length of the panicle</u>

The length of panicle did not show significant difference. Highest length of 22.40 cm was recorded in T6 which was on par with T12, T7, T2, T5, T10, T1 and T4. Treatments T3, T9, T8 and T11 were also on par and recorded significantly lower length than the treatments mentioned earlier.

(c) <u>Weight of the panicle</u>

Maximum weight (2.11 g) was recorded in T6 which was significantly superior than all others. T12, T7 and

Table-7

Yield components

Treatments	No. of productive tillers/ hill	Length of panicle (cm)	Wt. of panicle (g)	No. of filled grains/ panicle	Thousand grain wt.(g)
T1	4.34	17.43	1.74	64.46	25.86
T2	4.54	19.64	1.94	71.71	24.80
T3	4.04	15.49	1.61	62.00	23.41
T4	4.50	16.50	1.64	63.29	22.90
T5	4.71	18.61	1.84	71.38	23.47
T6	6.09	22.40	2.11	75.38	22.82
T7	4.63	20.67	1.95	72.63	23.96
T8	4.00	14.34	1.51	57.17	22.87
T9	3.92	14.57	1.55	60.26	23.38
T10	4.50	18.11	1.76	68.29	23.75
T11	3.80	13.64	1.49	54.42	23.19
T12	5.42	21.86	1.99	73.96	23.23
CD(0.05)	0.714	0.550	0.101	1.934	1.213

T2 were on par and T2 in turn was on par with T5. T5, T10 and T1 did not show any significant difference. While T1 and T4 were on par. T3 and T9 were on par with T4. Lowest weight of 1.49 g was recorded in T11 which was on par with T8 and T9.

(d) Number of filled grains per panicle

Highest number of filled grains was noted in T6 (75.4 per cent) which was on par with T12, which in turn was on par with T7. T7, T2 and T5 were on par. T10 was superior to the remaining treatments. T4 was on par with T1 on one side and T3 on the other side. T3 was on par with T9. T11 recorded least number of 54.4 followed by T8 (57.2).

(e) Thousand grain weight

The treatments showed variation in this aspect. T1 recorded maximum weight of 25.86 g which was on par with T2. T2, T7 and T10 were on par. T7, T10, T5, T3 and T9 were also on par. Least weight of 22.82 g was recorded in T6 which was on par with T8, T4, T11, T12, T9, T3 and T5.

(f) Grain yield

The analysis of variance table is presented in Appendix VII and the mean values in Table 8.

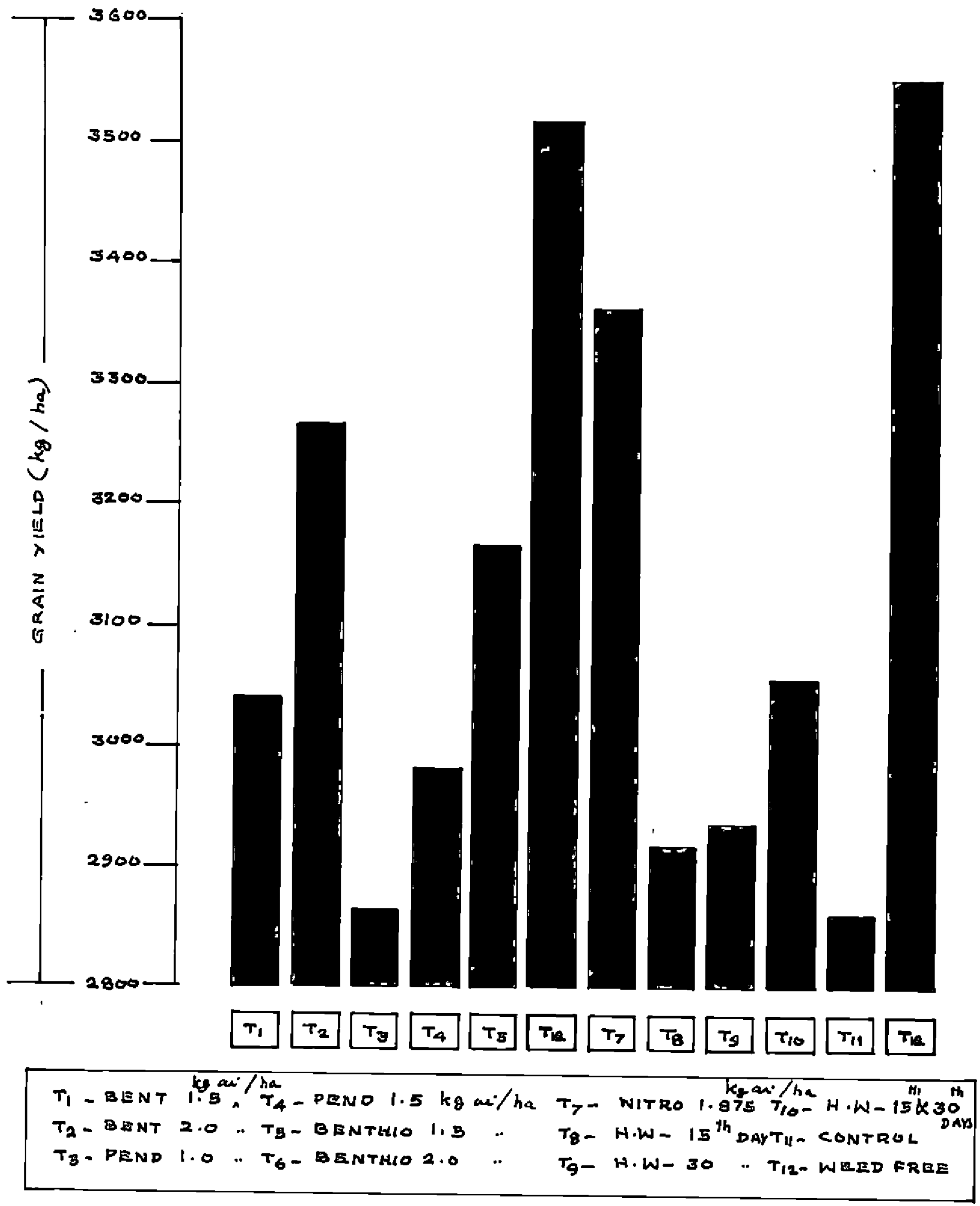

FIG: 5 EFFECT OF TREATMENTS ON GRAIN YIELD

Table-8

Grain and straw yield (kg/ha)

Treat-ments	Grain yield	Straw yield
T1	3014	5768
T2	3263	5790
T3	2865	5784
T4	2978	5658
T5	3163	5861
T6	3509	6557
T7	3358	6107
T8	2916	5422
T9	2934	5331
T10	3056	5833
T11	2861	5310
T12	3523	6486
CD (0.05)	54.504	277.880

Highest grain yield of 3523 kg/ha was produced in T12 which was on par with T6 and superior to all other treatments. T7, T12 and T5 were significantly superior to the remaining treatments. T10 and T1, T1 and T4, T4 and T9, T9 and T8, T8 and T3, T3 and T11 were all on par and yield was in the descending order. T11 recorded lowest yield of 2861 kg/ha.

(g) Straw yield

The analysis of variance table is presented in Appendix VIII and the mean values in Table 8.

Highest straw yield of 6557 kg/ha was produced in T6 which was on par with T12. T7, T5 and T10 were on par. T5 and T10 were also on par with T2. T2, T3, T1 and T4, T8, T9 and T11 were also on par and T11 recorded lowest straw yield of 5310 kg/ha.

(h) Weed Index

Weed indices were calculated for different treatments using the formula suggested by Gill and Vijayakumar (1969) and presented in Table 9.

T12 was taken as the base for calculation of weed index, as it recorded highest yield. Highest weed index (18.8) was worked out in the unweeded control which was followed by T3 (18.7). Among the hand weeded plots T8

Table-9

Weed Index

Treatments		Weed index
T1	..	14.44
T2	..	7.38
T3	..	18.67
T4	..	15.45
T5	..	10.23
T6	..	0.40
T7	..	4.65
T8	..	17.22
T9	..	16.71
T10	..	16.57
T11	..	18.79

recorded highest weed index of 17.2 followed by T9 with an index of 16.7 and T10 recorded 16.6.

Lowest weed index recorded in T6 were 0.40 which was followed by T7, T2, T5, T1 and T4 with weed indices of 4.7, 7.4, 10.2, 14.14 and 15.5 respectively.

III. CHEMICAL ANALYSIS

A. Nutrient uptake by weeds

Nutrient uptake by weeds were recorded at 20, 40, 60, 80 and 100th days of sowing and also at harvest and analysed separately. The analysis of variance tables are presented in Appendix VIII and the mean values in Tables 10 a, b and c.

1. Nitrogen uptake by weeds

The analysis of variance table are presented in Appendix VIII and mean values in Table 10a.

(a) 20th day of dibbling

N uptake by weeds was highest (1.12 kg/ha) in T11 and it was significantly higher than all other treatments. T4 and T9, and T1 and T8 were on par. T6 recorded the lowest uptake of 0.20 kg/ha which was on par with T2 and T7. T7 was also on par with T5 and T10.

(b) 40th day of dibbling

Highest N uptake of 13.86 kg/ha was recorded in

Table-10(a)

Nitrogen uptake by weeds (kg/ha) at different days after dibbling

Treatments	20	40	60	80	100	Harvest
T1	0.64	2.63	3.33	3.76	4.06	4.86
T2	0.27	0.82	1.30	1.72	1.72	2.10
T3	0.83	4.54	6.77	6.87	6.05	6.82
T4	0.96	3.92	5.76	6.01	6.60	6.92
T5	0.34	1.30	2.17	2.23	2.23	2.22
T6	0.20	0.18	0.21	0.25	0.45	0.53
T7	0.28	0.29	0.41	0.47	0.49	0.50
T8	0.59	8.66	10.39	9.84	11.89	12.56
T9	0.94	6.68	9.26	9.74	10.67	11.26
T10	0.34	3.87	4.00	4.83	5.37	6.19
T11	1.12	13.86	32.69	32.42	34.41	35.44
CD (0.05)	0.114	2.148	1.590	1.457	2.102	3.300

the unweeded control plot. T9 was on par with T8 on one side and T3 on the other. T3 was also par with T4, T10 and T1. Lowest uptake of 0.18 kg/ha was recorded in T6 which was on par with T7, T2 and T5, T5 and T1 were also on par.

(c) 60th day of dibbling

N uptake by weeds was highest (32.70 kg/ha) in T11 and it was significantly higher than all other treatments. T3 and T9 were on par. T4 was on par with T3 on one side and T10 on the other. T1 was on par with T5 and T10. Lowest N uptake was recorded in T6 which was on par with T7 and T2. T2 was on par with T5.

(d) 80th day of dibbling

Highest N uptake by weeds occurred in T11 (32.42 kg/ha) which was significantly higher than all other treatments. T8 was on par with T9 and recorded next higher uptake. T3 and T4, T10 and T1, T5 and T2 were also on par in the descending order of uptake. T6 recorded least uptake (0.25 kg/ha) and was on par with T7 which in turn was on par with T2.

(e) 100th day of dibbling

T11 recorded highest uptake of 34.42 kg/ha. T9 was on par with T8 and recorded the next higher uptake.

T3, T4 and T1 were on par. T1 was also on par with T10 and T5. T6 which recorded lowest uptake of 0.45 kg/ha was on par with T7, T2 and T5.

(f) Harvest

Highest uptake occurred in T11 (35.44 kg/ha), T8, T9 and T3 were on par. T3 was also on par with T4 and T1. T7 which recorded least uptake of 0.50 kg/ha was on par with T6, T5, T2 and T10.

2. Phosphorus uptake by weeds

The analysis of variance tables are presented in Appendix-VIII and mean values in Table 10 b.

(a) 20th day of sowing

Highest uptake of 8.19 kg/ha was recorded in T11, T4, T9, T8 and T2 were on par. T3 was also on par with T1, T10, T2, T7 and T6. T6 recorded lowest uptake of 0.09 kg/ha.

(b) 40th day of dibbling

Highest uptake of 11.61 kg/ha occurred in T11 followed by T4, T9 and T8 were on par. T3 recorded significantly lower uptake than T11, T4, T9 and T8, T1 and T10 were on par. T6 with least uptake of 0.10 kg/ha was on par with T7 and T2.

Table-10(b)

P_2O_5 uptake by weeds (kg/ha) at different days after dibbling

Treat-ments	20	40	60	80	100	Harvest
T1	1.24	1.26	1.38	1.44	1.50	2.63
T2	0.71	0.83	0.87	0.87	0.89	0.93
T3	2.12	2.12	2.28	2.84	3.47	5.03
T4	4.18	4.44	4.98	5.63	5.62	6.10
T5	0.53	0.69	0.73	0.86	1.72	2.42
T6	0.09	0.10	0.17	0.18	0.18	1.01
T7	0.18	0.21	0.31	0.40	0.56	0.65
T8	3.21	3.52	3.99	4.06	4.45	5.10
T9	3.25	3.67	3.89	4.47	6.30	7.00
T10	0.89	1.07	1.09	1.62	1.76	2.13
T11	8.19	11.61	12.49	14.20	19.70	22.51
CD(0.05)	2.144	0.743	0.612	0.801	1.982	1.578

(c) 60th day of dibbling

T11 recorded an uptake of 12.49 kg/ha which was significantly superior to all other treatments; T8 followed T4 in P_2O_5 uptake. T3, T4 and T9 were on par with T10 which was on par with T1 and T5 on one hand and with T9 on the other. T6 with lowest uptake of 0.17 kg/ha was on par with T7, T2 and T5.

(d) 80th day of sowing

Highest uptake of 14.20 P_2O_5 kg/ha was recorded in T11, T8 and T9, T3 and T4, T1 and T10, T5 and T2 were all on par T6 which recorded least uptake was on par with T7 and T2.

(e) 100th day of sowing

T11 (19.60) and T8 (4.45 kg/ha) were significantly superior to rest of the treatments though they were not on par with each other. T9 was on par with T3. T4, T1 and T10 were also on par. T10 in turn was also on par with T5 and T2. T6 which recorded least uptake was on par with T7, T2 and T5.

(f) Harvest

Highest uptake (22.51 kg/ha) at harvest was in T11. T4, T9, T8 and T3 were on par. T7 with lowest uptake of 1.01 was on par with T7, T5, T2, T10, T1 and T3.

3. <u>Potash uptake by weeds</u>

The analysis of variance tables are presented in Appendix ~~X~~ VIII and mean values in Table 10 c.

(a) <u>20th day of sowing</u>

As usual unweeded control plot recorded highest uptake of 16.95 kg/ha followed by T8, T9 and T10 were on par. T10 was also on par with T5 and T1. T6 recorded least uptake. T6, T7, T2, T3 and T1 were on par.

(b) <u>40th day of dibbling</u>

T11 recorded highest uptake of 23.73 kg/ha followed by T8, T9 and T10 were on par. T10 and T4 were also on par. T3, T5 and T1 recorded no significant difference between themselves. T6 and T7 recorded least uptake of 0.25 kg/ha. T2 recorded the next lower uptake of 0.75 kg/ha.

(c) <u>60th day of dibbling</u>

Highest uptake of 26.40 kg/ha was recorded in T11. Both T11 and T8 were significantly higher than other treatments. T3, T9, T4 and T10 were on par. T1 was on par with T10, T5 and T2. T6 with lowest uptake of 0.25 kg/ha was on par with T9 and T2.

(d) <u>80th day of dibbling</u>

T11 recorded highest uptake of 30.98 kg/ha and

Table-10(c)

K_2O uptake by weeds (kg/ha) at different days after dibbling

Treatments	20	40	60	80	100	Harvest
T1	1.24	2.08	3.02	3.96	6.08	9.06
T2	0.62	0.75	1.32	2.15	3.21	5.11
T3	0.75	2.62	5.76	6.46	8.03	10.30
T4	1.24	3.35	4.95	6.12	7.97	10.78
T5	1.55	2.23	2.26	2.79	4.15	4.50
T6	0.16	0.25	0.25	0.37	0.97	1.45
T7	0.17	0.25	0.47	0.48	0.82	1.55
T8	6.42	7.38	7.90	9.60	11.87	15.51
T9	2.55	3.78	5.58	9.10	9.40	18.62
T10	2.48	3.63	4.14	4.57	5.65	6.82
T11	16.95	23.73	26.39	30.97	38.20	38.40
T12	0	0	0	0	0	0
CD (0.05)	1.301	0.407	1.764	1.698	1.523	3.353

was significantly higher than all other treatments. T9 and T8, T4 and T3, T10 and T1, T5 and T2, T7 and T6 were on par. T6 recorded lowest uptake of 0.37 kg/ha.

(e) 100th day of dibbling

Highest uptake of K_2O was in T11 (38.20 kg/ha) which was followed by T8 which were significantly higher than others. T9, T3 and T4 were on par. T10 was on par with T1 and T5. T7 recorded least uptake of 0.83 kg/ha which was on par with T6. T2 recorded K_2O uptake significantly higher than T5.

(f) Harvest

T11 recorded highest uptake of 38.40 kg/ha T9 and T8 were on par. T4, T3 and T1 were also on par. T1 was also on par with T10. T10, T2 and T5 were on par. T6 recorded least K_2O uptake and was on par with T7 and T5.

4. Nutrient uptake by the crop

The analysis of variance tables corresponding to N, P_2O_5 and K_2O uptake by the crop at 60th, 80th and 100th day of sowing and at harvest are presented in Appendix IX and mean values in Table 11 a,b and c.

(a) Nitrogen uptake

(a) 60th day of dibbling

Completely weed free plot recorded highest uptake

Table-11(a)

Nitrogen uptake by the crop (kg/ha) at different days after dibbling

Treat-ments	60	80	100	Harvest
T1	78.33	82.85	85.53	86.95
T2	84.84	89.62	91.42	93.11
T3	69.28	71.19	74.75	76.14
T4	69.20	72.11	75.62	77.95
T5	84.82	87.53	91.40	92.12
T6	96.62	102.42	105.86	106.18
T7	88.02	92.11	95.86	97.51
T8	62.66	66.42	68.26	69.83
T9	54.24	56.80	60.86	61.70
T10	79.62	82.42	86.68	87.70
T11	43.91	45.10	48.44	49.51
T12	98.84	104.62	107.97	108.71
CD (0.05)	11.011	12.523	10.121	11.502

of 98.84 kg/ha which was on par with T6 and T7. T7, T2, T5 and T10 were on par. T10 was also on par with T1 and T4. T11 recorded least uptake of 43.91 kg/ha. T9 and T8 were on par. T8 was also on par with T3 and T4.

(b) <u>80th day of dibbling</u>

T12 recorded highest uptake (104.62 kg/ha) and was on par with T6. T6 in turn was on par with T7. T2, T5, T10 and T1 were on par. T1 was also on par with T4, T11 recorded least uptake. T8 and T9, T8, T3 and T4 were also on par.

(c) <u>100th day of dibbling</u>

T2 which recorded highest uptake of 107.97 kg/ha was on par with T6 and T7. T7 in turn was also on par with T2, T5, T10 and T1. T1, T4 and T3 were also on par. T11 which recorded least uptake was on par with T9. T9, T8 and T3 were also on par.

(d) <u>Harvest</u>

T12 which recorded an uptake of 108.71 kg/ha was on par with T6 and T7. T7 was also on par with T2, T5, T10 and T1. T1, T4 and T3 were on par. T11 recorded least uptake and was on par with T9 which in turn was on par with T8.

(2) <u>Phosphorus uptake</u>

(a) <u>60th day of dibbling</u>

T12 which recorded highest uptake (50.98 kg/ha)

Table-11(b)

Phosphorus uptake by the crop at different days after dibbling

Treatments	60	80	100	Harvest
T1	39.24	43.75	46.51	47.84
T2	48.48	53.42	56.04	57.71
T3	35.33	39.39	43.00	43.30
T4	36.64	40.09	43.45	44.15
T5	46.80	50.13	54.33	55.08
T6	49.72	54.16	57.44	59.25
T7	49.88	54.95	58.17	58.98
T8	31.64	34.97	37.33	38.15
T9	29.62	32.64	34.02	36.42
T10	44.24	48.66	51.42	53.11
T11	24.20	28.65	30.50	30.90
T12	50.98	55.16	59.80	61.10
CD (0.05)	2.103	3.201	3.502	4.022

was on par with T6, T7 and T2. T7 and T2 were on par with T5. T5 and T10, T1 and T4, T4 and T3. T8 and T9 were also on par. T11 recorded least uptake.

(b) <u>80th day of dibbling</u>

T12 recorded 55.16 kg/ha was on par with T6 and T7. T6, T7 and T2, T2 and T5, T5 and T10, T1 and T4, T4 and T3, T8 and T9 were all on par. T11 recorded least uptake.

(c) <u>100th day of dibbling</u>

T12 which recorded 59.80 kg/ha was the highest and was on par with T6, T7 and T2. T2 and T5, T5 and T10, T10 and T1, T4 and T3, T8 and T9 were on par. T11 recorded least uptake of 30.50 kg/ha.

(d) <u>Harvest</u>

T12 recorded maximum uptake of 61.10 kg/ha and was on par with T6 and T7. T6, T7 and T2, T2 and T5 were on par. T11 recorded least uptake of 30.90 kg/ha. T9 and T8, T4 and T3 were on par.

(3) <u>Potash uptake</u>

(a) <u>60th day of dibbling</u>

In the case of K_2O also T12 recorded highest uptake of 97.44 kg/ha and was on par with T6 and T7. T7 was also on par with T2, T5, T10 and T1. T10, T1, T4 and T3 were

Table-11(c)

Potash uptake by the crop at different days after dibbling (kg/ha)

Treatments	60	80	100	Harvest
T1	78.60	83.15	85.82	87.44
T2	85.04	89.84	91.66	92.42
T3	70.06	72.19	75.95	76.53
T4	70.11	72.20	75.84	78.24
T5	85.80	87.82	92.40	94.31
T6	96.84	102.62	106.42	108.75
T7	88.98	93.10	96.24	98.22
T8	63.86	66.62	68.84	70.15
T9	55.62	57.02	61.26	62.70
T10	79.84	82.62	87.08	87.74
T11	44.08	44.18	48.84	50.46
T12	97.44	104.84	108.26	109.51
CD (0.05)	9.522	10.403	12.052	12.102

also on par. T11 recorded least uptake followed by T9 and T8 which were on par.

(b) 80th day of dibbling

Highest uptake of 104.84 kg/ha occurred in T12 which was on par with T6 and T7. T7, T2, T5 and T10 were also on par. T3 and T4, were on par with T1 and T10 on one side and T8 on the other. T11 recorded lowest uptake. T9 and T8 were on par.

(c) 100th day of dibbling

Highest uptake occurred in T12 and was on par with T6. T2 and T5 were on par with T7 on one hand and T1 and T10 on the other. T10 and T4, T4, T3 and T8 and T8 and T9 were all on par. T11 recorded least uptake of 48.84 kg/ha.

(d) Harvest

T12 continued to record highest uptake of 109.51 kg/ha and was on par with T6 and T7. T7, T2, T5 and T10 were on par. T10 and T1, T4 and T3, T8 and T9 were also on par. T11 recorded the lowest uptake of 50.46 kg/ha.

(4) Protein content of grains

The analysis of variance table is presented in AppendixIX and mean values in Table-12.

Protein content of grains was highest (8.75 per cent) in T12 which was on par with T5. T5 and T6,

Table-12

Protein content of grains (per cent)

Treatments		Protein percentage
T1	..	8.19
T2	..	8.17
T3	..	8.07
T4	..	8.13
T5	..	8.59
T6	..	8.51
T7	..	8.38
T8	..	8.03
T9	..	8.05
T10	..	8.29
T11	..	8.02
T12	..	8.75
CD (0.05)	..	0.176

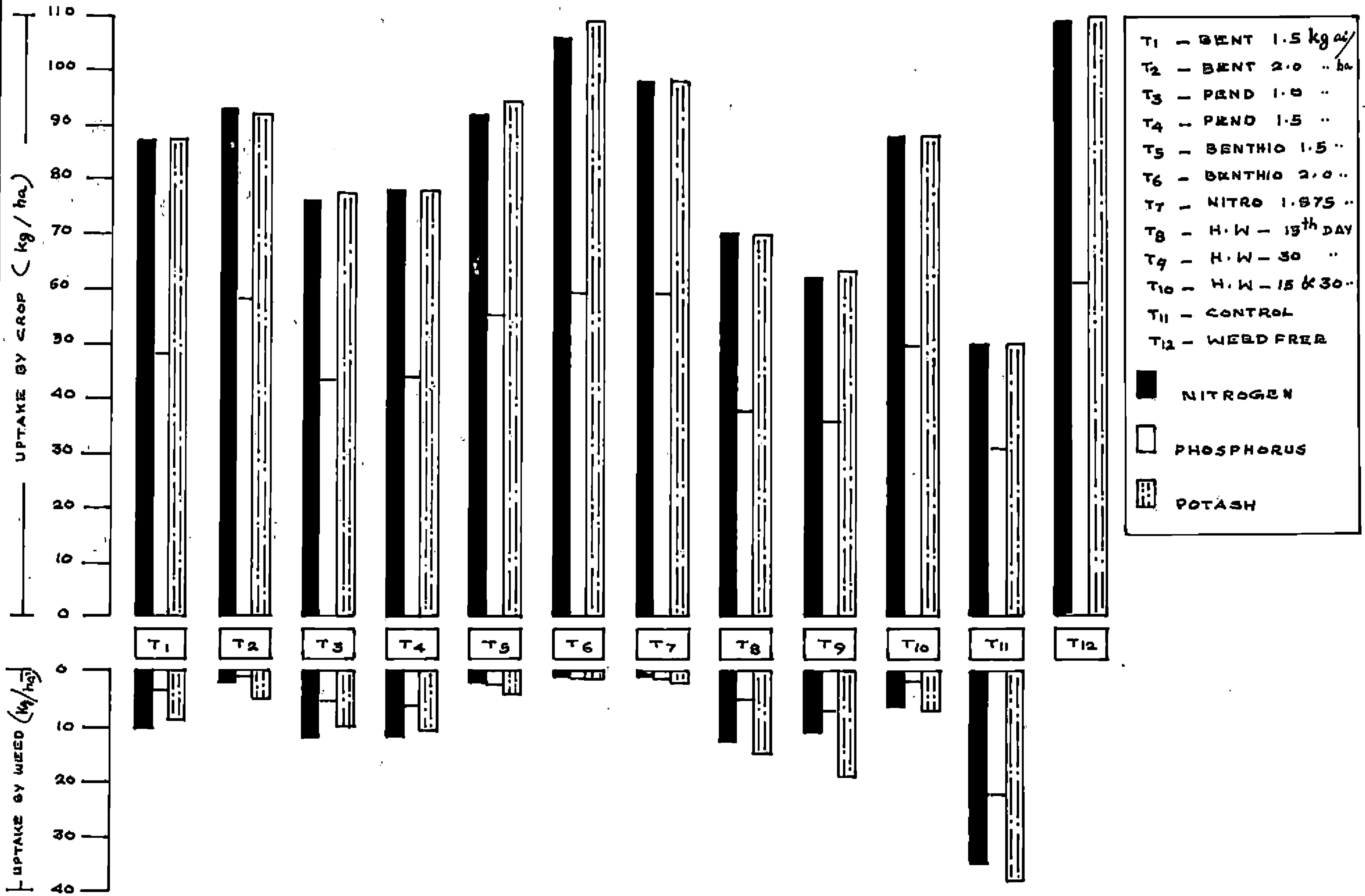

FIG. 6 EFFECT OF HERBICIDES ON NUTRIENT UPTAKE BY CROP AND WEED

T6 and T7, T7 and T10, T10, T1, T2 and T4 were all on par. T11 recorded lowest protein content of 8.02 per cent which was on par with T8, T9, T3, T4, T2 and T1.

IV. CORRELATION STUDIES

The values of simple correlation co-efficients were worked out and presented in Table-13. All the correlations were significant. The dry matter production of crop was negatively correlated with that of weeds and 'r' value was -0.6617.

N, P_2O_5 and K_2O uptake by the crop was negatively correlated with N, P_2O_5 and K_2O uptake by weeds as well as dry matter production of weeds. The 'r' value corresponding to the uptake of three major nutrients were -0.5808, -0.7402 and -0.5180 respectively. The 'r' values correlating the dry matter production of weeds and N, P_2O_5 and K_2O uptake by the crop were -0.4820, -0.4252 and -0.4134 respectively.

The grain yield was negatively correlated with the dry matter production of weeds and nutrient (N, P_2O_5 and K_2O) uptake by weeds. The 'r' values were -0.4950, -0.4720 and -0.4304 respectively for dry matter production and nutrient uptake. The grain yield was positively correlated with N, P_2O_5 and K_2O uptake by the crop with 'r' values of 0.4724, 0.4884 and 0.4724 respectively.

Table-13

Values of simple correlation co-efficient

Sl. no.	Characters correlated	Correlation co-efficients
1.	Dry matter production by crop x Dry matter production by weed	- 0.6617**
2.	Dry matter production by weeds x N uptake by the crop	- 0.4820**
3.	Dry matter production by weeds x P uptake by the crop	- 0.4252**
4.	Dry matter production by weeds x K uptake by the crop	- 0.4134**
5.	Grain yield x Dry matter production by weeds	- 0.7459**
6.	Grain yield x N uptake by crop	0.4724**
7.	Grain yield x P_2O_5 uptake by crop	0.4884**
8.	Grain yield x K_2O uptake by crop	0.4724**
9.	Grain yield x N uptake by weed	- 0.4950**
10	Grain yield x P_2O_5 uptake by weed	- 0.4720**
11	Grain yield x K_2O uptake by weed	- 0.4304**
12	N uptake by crop x N uptake by weed	- 0.5808**
13	P_2O_5 uptake by crop x P_2O_5 uptake by weed	- 0.7402**
14	K_2O uptake by crop x K_2O uptake by weed	- 0.4134**

** Significant at 0.01 level

ECONOMICS

The data revealed that herbicide treatments gave higher net profit than hand weeding treatments, except in the case of pendimethalin. Of all herbicide treatments benthocarb 2.0 kg ai/ha gave the highest net profit of Rs.2307.00/ha followed by nitrofen 1.875 kg ai/ha and bentazon 2.0 kg ai/ha with profits of Rs.1489.00/ha and Rs.1186.00/ha respectively. Benthiocarb 1.5 kg ai/ha recorded profit of Rs.961.00/ha. Local practice of hand weeding twice recorded a profit of Rs.346.00/ha.

Table 14

Economics of crop production

Treatments	Yield		Increase in yield over control		Cost of weed control in Rs/ha	Price of increased yield			Incremental net profit Rs./ha
	Grain	Straw	Grain	Straw		Grain Rs./ha	Straw Rs./ha	Total Rs./ha	
T_1	3014	5768	153	458	220	459	226	685	465
T_2	3263	5790	402	480	260	1206	240	1446	1186
T_3	2865	5784	4	474	230	12	237	249	19
T_4	2978	5658	117	348	245	351	174	525	280
T_5	3163	5861	302	551	220	906	275	1181	961
T_6	3509	6557	648	1247	260	1944	623	2567	2307
T_7	3358	6107	497	797	400	1491	398	1889	1489
T_8	2916	5422	55	112	200	165	56	221	21
T_9	2934	5331	73	21	600	365	10	375	225
T_{10}	3056	5833	195	522	500	585	261	846	346
T_{11}	2861	5310	0	0	0	0	0	0	0
T_{12}	3523	6486	662	1176	3000	1986	588	2574	-426

Grain - Rs.3/ kg

Straw - 50 ps/kg

DISCUSSION

DISCUSSION

A suitable weed control method for semi dry dibbled crop of rice was studied with rice variety Jaya at the Rice Research Station, Kayamkulam during *Viripu* (first crop) season of 1981. The results obtained from the experiment were statistically analysed and are discussed below.

I. WEED CHARACTERS

A. Weed species

The weedflora infesting rice crop comprised of grasses, sedges and broad leafed weeds. Competition was mostly by grasses followed by sedges and broad leafed weeds. Predominant grasses were *Brachiaria ramosa*, *Echinochloa colonum*, *Echinochloa crus-galli* and *Sacciolepis indica*. *Cyperus iria* and *Cyperus rotundus* were the important sedges whereas *Cleome viscosa* and *Monochoria viginalis* were common among the broad leafed weeds.

B. Weed population

Weed population was recorded from 20th day of dibbling onwards upto harvest at 20 days interval. Monocot and dicot weed population were estimated separately. In rice it was observed that monocot weeds predominated throughout the crop period. Monocots having similar growth habits could compete with rice crop especially dwarf indicas, more efficiently than the dicots. Moreover dicot weeds required more space compared to monocots and so due to lack of sufficient space they could not thrive well. Monocots like Echinochloa colonum, Echinochloa crus-galli, Sacciolepis indica etc. had growth habits very similar to rice and so rice could not suppress them. De Datta et al. (1968), Gopalakrishna Pillai et al. (1974), Ravindran (1976), Abraham Varughese (1978) and Sukumari (1982) got similar results.

(a) Monocot weed population

Monocot weed population recorded maximum in the unweeded control plot at all stages of observation. In this case the mean number of weeds was the highest on the 20th day of dibbling which decreased on 40th day and from then onwards the number was more or less constant. This was because of the flooding of the field after rains on 32nd day.

In the plots receiving hand weeding on 15th and 30th days it was found that the monocot weed population was comparatively lower than those present in the other two hand weeded plots in all the observations from 20th day of dibbling upto harvest. From 60th day of dibbling upto harvest, in general hand weeding either on 15th day or o on 30th day were on par, while hand weeding on 15th and 30th day was superior to the other two hand weedings. This shows that for rice crop grown under semi-dry conditions two hand weedings are required during the crop period to suppress the monocot weed population.

In the case of plots treated with herbicides (benthiocarb 2.0 kg ai/ha, nitrofen 1.875 kg ai/ha and bentazon 2.0 kg ai/ha) the weeds were comparatively lesser in number throughout the crop growth period. This shows that these chemicals were effective in suppressing monocot weed growth in rice fields than other herbicide treatments.

Comparing hand weeding and chemical weed control it may be noted that hand weeding on 15th and 30th days was as good as bentazon 2.0 kg ai/ha and benthiocarb 1.5 kg ai/ha, while benthiocarb 2.0 kg ai/ha and nitrofen 1.875 kg ai/ha were significantly superior to hand weeding. Penoxalin at both the rates was not effective in controlling monocot weeds in rice grown under semi-dry conditions.

Since the crop and the major portion of weeds were having similar growth habits weeds were able to adjust with the available space in the field for their growth. Moreover the crop being a semi-dwarf type the ability to smother weeds were comparatively less as compared to tall indicas. This is in agreement with the findings of several earlier workers as Chang (1971), Baskett et al. (1973), Ravindran (1976), Varughese (1978), Singlachar et al. (1978), Choi (1979), Yang et al. (1980), Eastin (1981) and Sukumari (1982).

(b) Dicot weed population

Dicot weed population was higher in the early stages of growth of rice ie. upto 40th day of dibbling. This consisted mainly of dryland weed Cleome viscosa which was the principal weed of the previous summer crop, sesamum. After the receipt of rains they were killed due to flooding while other dicot weeds like Monochoria viginalis continued to persist in the field.

In the unweeded control plot maximum number of dicot weeds were found upto 20th day of dibbling, after which they were reduced due to rains, and was more or less same as that in the other plots.

Comparing the hand weeding treatments, hand weeding on 15th and 30th day of sowing suppressed the weed growth efficiently upto 40th day of dibbling compared to either of the two types of hand weedings on 15th or 30th day of dibbling. After 40th day the dicot weed population was comparatively less in all the hand weeded plots.

Dicot weed population was considerably reduced by all the chemicals upto 40th day of dibbling. After 40th day of dibbling there was not much variation in the dicot weed population in the herbicide treated plots.

Comparing hand weeding and chemical weed control, it can be seen that herbicides control the dicot weeds much better than hand weeding upto 40th day of dibbling. After this period there is not much variation between the hand weeded and herbicide applied plots since the dicot weeds were destroyed due to the rains which have set in by 32nd day of dibbling. Sridhar et al. (1974), Baker (1975), Luib et al. (1976), Nishikawa (1976), Atwell et al. (1978) and Santos et al. (1979) have reported similar results.

(c) Total weed population

Total weed population was recorded on 20th, 40th, 60th, 80th and 100th day of dibbling and at harvest which showed significant difference due to treatment effect.

Total weed population was the highest on 20th day of dibbling in the unweeded control and rainfall on 32nd day reduced the weed population substantially but not as good as the chemical or manual weed control and the population continued to reduce upto 60th day of dibbling after which they were more or less the same. This shows that in Onattukara region the weed population automatically get reduced with the onset of monsoon, but the reduction was not sufficiently high enough for the crop to grow without competition.

Among the hand weedings, it was found that hand weeding on 15th and 30th days continued to suppress weed growth throughout the crop period when compared to single hand weedings given on 15th or 30th day of dibbling. Since the dicot weed population was proportionately smaller than the monocot weed population the reduction in total weed number after rains was not much.

Herbicide application was found to suppress the total weed population as compared to unweeded control. Among the herbicides nitrofen 1.875 kg ai/ha, benthiocarb 2.0 kg ai/ha, bentazon 2.0 kg ai/ha and benthiocarb 1.5 kg ai/ha were found to be very effective in suppressing the total weeds throughout the crop growth, compared to other chemicals. Baker (1975), Larrea (1975), Rao et al. (1976), Sridhar et al. (1976). Ravindran (1976), Ravindran et al. (1978), Gill and Mehra (1981) obtained similar results of weed control with benthiocarb.

Between mechanical methods and chemical methods it may be noted that hand weeding on 15th and 30th day was able to suppress the weed number more than any of the chemical methods on 20th and 40th day. Studies conducted by Abraham Varughese (1978) and Sukumari (1982) brought out the fact that a weed free period between 20th and 40th day of sowing is the most critical period of weed infestation. Therefore it may be concluded that hand weeding on 15th and 30th day of dibbling was as good as chemical methods in controlling weed population, during the critical period.

The weed population in plots treated with benthiocarb 2.0 kg ai/ha and nitrofen 1.875 kg ai/ha was found to be on par. Since benthiocarb 1.5 kg ai/ha is as good as benthiocarb 2.0 kg ai/ha it is enough that a lower dose is applied which is more economical in respect of weed control.

C. Dry matter production by weeds

Dry matter production was the highest in the control plot at all stages of growth and was significantly higher than all other treatments. Unchecked weed growth during the crop period was responsible for the increased dry weight of weeds in the control plot. The weeds exploited the nutrients and other benefits meant for the crop plants resulting in more dry matter production of weeds and less of crop.

Plots hand weeded once recorded higher weed dry matter than the plots hand weeded twice. This showed that hand weeding once was not much effective in suppressing weed growth which consumed considerable quantity of soil nutrients.

Among the herbicide treated plots benthiocarb 2.0 kg ai/ha and nitrofen 1.875 kg ai/ha recorded lowest dry weight. This proved that these herbicides had the ability to suppress weed growth for longer periods due to their prolonged toxic effect. Bentozon 2.0 kg ai/ha and benthiocarb 1.5 kg ai/ha recorded the next lower dry weight throughout the crop growth. Benthiocarb 1.5 kg ai/ha suppressed weed dry matter accumulation in the early period upto 40th day of dibbling, which is considered as critical period of weed infestation. Abraham Varughese (1978) and Sukumari (1982) also obtained similar results.

Comparing dry matter production in herbicide treated and hand weeded plots it can be seen that herbicides benthiocarb 2.0 kg ai/ha, nitrofen 1.875 kg ai/ha and benthiocarb 1.5 kg ai/ha were significantly superior to hand weeding twice in suppressing dry matter accumulation by weeds. This is due to the prolonged toxic effect of the chemical even after the rain have set in. Though the total weed population was high in nitrofen 1.875 kg ai/ha and benthiocarb 2.0 kg ai/ha treated plots than plots receiving hand weeding on 15th and 30th days in the early stages of crop growth, the dry matter accumulation was just the reverse. This shows that weeds germinated in the chemical treated plots were incapable of accumulating dry matter due to the toxic effect. Hence it is not the total weed number but the dry matter accumulation which is more important with regard to crop production.

Ravindran (1976), Sridhar et al. (1976) and Moursi (1978) reported reduction in weed dry matter by the use of chemicals, compared to hand weeding.

D. <u>Weed control efficiency</u>

Weed control efficiency of the various treatments in comparison with the complete weed free condition showed that nitrofen 1.875 kg ai/ha and benthiocarb 2.0 kg ai/ha had a very high efficiency of more than 76 per cent while benthiocarb 1.5 kg ai/ha and bentazon 2.0 kg ai/ha had an effect ranging between 66-70 per cent. Bentazon 1.5 kg/ha and hand weeding 15th and 30th days had an efficiency ranging between 54-60 per cent while all others had as efficiency below 50 per cent. This indicates that nitrofen 1.875 kg ai/ha, benthiocarb 2.0 kg ai/ha, bentazon 2.0 kg ai/ha and benthiocarb 1.5 kg ai/ha were more efficient than hand weeding on 15th and 30th days of sowing while it was more efficient than the other chemicals. This is in agreement with the works of Mohmmed Ali and Sankaran (1975), Ravindran (1976) and Sreedevi (1979).

II. OBSERVATION ON CROP

A. Crop growth characters

(a) Plant height

In general the height of plant was found to be minimum for unweeded control plot throughout the crop growth. The severe crop-weed competition reduced the availability of nutrients and other benefits for the crop.

The height was more in plots hand weeded twice than those plots which received a single hand weeding only.

Among the herbicide treatments, benthiocarb 2.0 kg ai/ha was superior to all others, which was followed by completely weed-free condition, nitrofen 1.875 kg ai/ha, bentazon 2.0 kg ai/ha and benthiocarb 1.5 kg ai/ha. It may be noted that weed population both monocot and dicot as well as total, and dry matter accumulation were lower in these treatments. The reduction in weed competition for space, nutrients and water has helped the crop plant to have a luxuriant growth and express itself to the maximum height possible.

Comparing hand weeding and chemical weed control it may be noted that chemical weed control by the application of benthiocarb 2.0 kg ai/ha and nitrofen 1.875 kg ai/ha was as good as the complete weed free plots. Hand weeding on 15th and 30th day of dibbling produced the same height as those plants in plots treated with benthiocarb 1.5 kg ai/ha and bentazon 2.0 kg ai/ha.

Similar results were reported by Mukhopadhyay et al. (1971), Ravindran (1976) and Sreedevi (1979).

(b) Tiller count

Tiller production in rice was significantly influenced by weed competition. The tiller count progressively increased in all plots upto 80th day of dibbling after which there was a reduction in number. This may be due to the fact that all tillers did not turn productive and growth of the early tillers suppressed the later ones which being a character of rice crop.

The minimum tiller count was noticed in the unweeded control plot which show that weed competition reduced tillering of the crop.

The best among the hand weeding treatment was complete weed free condition followed by hand weeding on 15th and 30th days and then plots receiving hand weeding only once.

Among the herbicides benthiocarb 2.0 kg ai/ha was found to produce maximum number of tillers closely followed by nitrofen 1.875 kg ai/ha. Among other chemicals bentazon 2.0 kg ai/ha and benthiocarb 1.5 kg ai/ha followed the above two treatments.

Comparing chemical weed control and hand weeding it can be seen that benthiocarb 2.0 kg ai/ha treated plots were superior and as good as plots completely free of weeds. Hand weeding 15th and 30th day was as good as bentazon 2.0 kg ai/ha and benthiocarb 1.5 kg ai/ha.

In the early stages of crop growth the most important factor that limits crop production in Onattukara is the limited availability of moisture, since the crop is sown under dry conditions. The growth and dry matter accumulation of weeds were suppressed by these chemicals which helped to enhance the production of tillers. Similar results of reduction in tillering due to weed competition was recorded by Swain (1967), Smith and Shaw (1968), Kleing and Noble (1968), Noda et al. (1968), Chang and De Datta (1972), Sridhar et al. (1974), Swain et al. (1975), Narayana Swami (1976), Ravindran et al. (1978) and Sukumari (1982).

(c) LAI

LAI was also influenced by the treatment effect. LAI increased in all plots upto 80th day of dibbling after which it decreased. This was due to drying up of older leaves after the panicles have come out and the production of boot leaf stops further increase in leaf area which is a character of rice crop.

The minimum LAI was noted in the unweeded control plot at all stages of growth which was due to the severe competition between the crop and weed.

Among the hand weeding treatments maximum LAI was noticed in the completely weed free plot which was due to the absence of competition with weeds. Hand weeding twice was found to be better than weeding only once with respect to leaf area development.

Benthiocarb 2.0 kg ai/ha treated plot was found to have the highest LAI among the herbicide treated plots closely followed by nitrofen 1.875 kg ai/ha. Bentazon 2.0 kg ai/ha and benthiocarb 1.5 kg ai/ha were the next best.

Comparing hand weeding and chemical weed control, application of benthiocarb 2.0 kg ai/ha, and nitrofen 1.875 kg ai/ha was on par with the completely weed free condition.

Similar results of decrease in LAI due to weed competition were reported by Guh et al. (1975), Sreedevi (1979) and Irthuyaraj et al. (1980).

B. Yield characters

(a) Productive tillers/hill

Productive tillers/hill was significantly influenced by the treatments. Unweeded control plot produced minimum number of productive tillers/hill which showed that severe crop weed competition reduced the productive tillers/hill.

Highest productive tillers of 5.42/hill was noted in the plots kept weed free which was superior to all other hand weedings.

Among the hand weeding treatments maximum productive tillers of 4.5 was found in hand weeding on 15th and 30th days which was on par with hand weeding either on 15th or on 30th day which shows that any of the hand weeding treatment could influence the productive tiller number. This may be due to the suppression of weed growth by one or two weedings. Stirring given to the soil might have helped in the reduction of weed growth as well as conservation of moisture in soil.

Among the herbicide treatments, benthiocarb 2.0 kg ai/ha recorded the maximum productive tillers/hill which was on par with the weed free treatment. This may be due to no competition from the weed and the crop could utilise maximum nutrients for their growth and grain formation. All other herbicide treatments were found to be on par between themselves.

Between hand weeding and chemical control, all treatments except benthiocarb 2.0 kg ai/ha was found to be on par with hand weeding on 15th and 30th days and hand weeding 15th day.

This is in agreement with the observation of Matsushima (1957) that productive tillers/hill are greatly influenced by the N supply and level of solar radiation at tillering. Arai (1967), Main and Rehman (1969), Chang and Datta (1972), Mohammed Ali and Sankaran (1975), Narayana Swami (1976), Ravindran (1976), Sharma et al. (1977), Abraham Varughese (1978) and Sukumari (1982) observed reduction in productive tillers due to weed competition.

(b) Panicle characters

The treatments had significant effect on length of the panicle, weight of the panicle and number of filled grains per panicle.

The minimum record of panicle characters was noticed in the unweeded control plot. This may be due to the competition between crop and weed for nutrients and other benefits of crop production.

Among the hand weeding treatments hand weeding on 15th and 30th days was able to produce more length, weight and number of filled grains/panicle, than plots hand weeded once.

Benthiocarb 2.0 kg ai/ha was able to give maximum in all the panicle characters, which was followed by completely weed free plot. Nitrofen 1.875 kg ai/ha, bentazon 2.0 kg ai/ha, benthiocarb 1.5 kg ai/ha, bentazon 1.5 kg ai/ha and pendimethalin 1.5 and 1.0 kg ai/ha had panicle characters in the descending order.

Comparing herbicide applied and hand weeded plots, it can be seen that chemical weed control favoured the panicle characters. This indicates that lesser weed competition helped the crop in getting maximum favourable conditions for yield attributing characters like number of productive tillers/hill, length and weight and number of filled grains/panicle.

Sukumari (1982) reported decrease in length of the panicle due to competition with weeds. Sreedevi (1979), John (1981) and Sukumari (1982) reported reduction in panicle weight due to weed competition. Main and Rehman (1969), Yogeswara Rao and Padmanabhan (1972), Narayana Swami (1976), Ravindran (1976), Sharma et al. (1977), Sreedevi (1979), John (1981) and Sukumari (1982) reported significant effect of weed growth on number of filled grains/panicle.

(c) Thousand grain weight

Though there was significant difference between treatments on thousand grain weight the common trend exhibited by the number of productive tillers, length and weight of the panicle and number of filled grains/panicle was not exhibited in this case. Bentazon 1.5 kg ai/ha produced a maximum grain weight which was on par with bentazon 2.0 kg ai/ha and superior to all other treatments. Nitrofen 1.875 kg ai/ha treated plots recorded the next higher grain weight which was on par with all other herbicides as well as with weed free plot and hand weedings. This indicates that in general thousand grain weight was influenced only by bentazon and none of the other treatments. No special reason can be attributed under the present situation for such a result. Nair and Sadanandan (1975) also obtained similar results.

In general most of the yield components were influenced favourably by benthiocarb 2.0 kg ai/ha followed by nitrofen 1.875 kg ai/ha bentazon 2.0 kg ai/ha benthiocarb 1.5 kg ai/ha as well as hand weeding on 15th and 30th days of dibbling.

(d) Grain yield

Data show that competition between crop and weed affected the grain yield significantly. Unweeded control plot recorded minimum yield which was due to the effect of weed competition on the yield attributes.

Among the hand weeding treatments complete weed free condition produced the maximum grain yield followed by hand weeding on 15th and 30th days. Hand weeding once did not produce good yield.

Highest yield among the herbicide treated plots was recorded in benthiocarb 2.0 kg ai/ha treated plots. This can be attributed to the greater number of productive tillers, heavier panicles and more number of filled grains per panicle. Ravindran (1976) also reported that benthiocarb 2.0 kg ai/ha produced highest grain yield in transplanted rice. Nitrofen 1.875 kg ai/ha, benthiocarb 1.5 kg ai/ha and bentazon 2.0 kg ai/ha treated plots also recorded better yield than pendimethalin treated plots.

Between hand weeding and chemical weed control, benthiocarb 2.0 kg ai/ha, nitrofen 1.875 kg ai/ha, bentazon 2.0 kg ai/ha and benthiocarb 1.5 kg ai/ha produced 14.8 per cent, 9.9 per cent, 6.8 per cent and 3.5 per cent higher yield respectively than the local practice of hand weeding twice. The above findings are in agreement with the works of Chang et al. (1971), Mohammed Ali and Sankaran (1975), Larrea and Lucena (1971), Rangiah et al. (1974), Ravindran (1976) and Sreedevi (1979).

(e) Straw yield

Minimum straw yield was recorded in the unweeded control plot where the plant height and tiller production were lesser due to severe weed competition.

Hand weeding twice recorded higher straw yield than hand weeding once.

Among the herbicides benthiocarb 2.0 kg ai/ha recorded maximum straw yield which was on par with the completely weed free condition. Nitrofen 1.875 kg ai/ha and benthiocarb 1.5 kg ai/ha also recorded higher yields.

Hand weeding twice was on par with plots treated with nitrofen 1.875 kg ai/ha and benthiocarb 1.5 kg ai/ha.

The higher straw yield is attributed to the plant height, larger leaf area, more number of tillers and more nutrient uptake by the crop. This is in agreement with the findings of Mani (1975), Ravindran (1976), Abraham Varughese (1978), Sreedevi (1979), John (1981) and Sukumari (1982).

(f) Weed Index

Weed index is the reduction in yield due to the presence of weeds in comparison with the yield of plots having minimum weeds. Benthiocarb 2.0 kg ai/ha recorded an index of 0.4 which shows that it was as good as the weed free situation. Among the herbicides nitrofen 1.875 kg ai/ha, bentazon 2.0 kg ai/ha and benthiocarb 1.5 kg ai/ha were the next best.

With regards to hand weeding there was not much variation with weeding once or twice. The control plot showed maximum weed index which was nearly the same as pendimethalin at 1.0 kg ai/ha. Reduction is weed index by proper control of weeds were reported by Ravindran (1976), Abraham Varughese (1978), Sreedevi (1979), John (1981) and Sukumari (1982).

III. CHEMICAL ANALYSIS

(a) Nutrient uptake by weeds

Table-10 a, b and c show that uptake of N, P_2O_5 and K_2O by weeds.

It is seen that the uptake of nutrients in the weedy check varies with regard to the type of nutrient though the maximum uptake of all the nutrients was noted in the weedy check compared to other treatments. In the case of N, the uptake was steep and linear upto 60 days after sowing, after which it levelled off. In the early stages, the uptake was very low. From 20th to 40th day the increase was 12.74 kg/ha while from 40 to 60 days it was 17.83 kg/ha.

The pattern of uptake of P_2O_5 was different. There was uniform uptake throughout the growth period though the quantity of uptake was less. In the case of potash uptake there was a constant increase upto 100 days after sowing.

From these it can be concluded that the weeds complete with rice crop for N upto 60th day of dibbling and in the case of P_2O_5 and K_2O upto harvest. So the weeds are to be removed before 60th day of sowing as well as before nitrogen fertilisation especially in nitrogen defficient soils (Table 1), so that competition can be reduced.

Among the hand weeding treatments hand weeding twice was able to reduce the uptake than hand weeding once.

Among the various herbicides N, P_2O_5 and K_2O uptake in general was low in benthiocarb 2.0 kg ai/ha and nitrofen 1.875 kg ai/ha treated plots followed by bentazon 2.0 kg ai/ha and benthiocarb 1.5 kg ai/ha.

This was attributed to the low dry matter accumulation by weeds in these treatments.

Comparing herbicides and hand weeding, herbicides were more effective in reducing the uptake than the hand weeding. Reduced uptake by weeds in herbicide applied plots were reported by Verma and Mani (1970), Ramamoorthy et al. (1974), Ravindran (1976), Sreedevi (1979) and John (1981).

(b) Nutrient uptake by the crop

In general N and K_2O uptake by the crop was higher than P_2O_5 at all stages of crop growth. N, P_2O_5 and K_2O uptake in the unweeded control plot showed a minimum uptake at all stages from maximum tillering (60th day) upto harvest. The rate of N uptake increased upto 100th day after dibbling and then it decreased. The rate of uptake of phosphorus decreased from 80th day of dibbling, while the increased uptake of potash continued throughout the crop growth. This shows that the crop has the ability to absorb nutrients throughout its growth period and competition by weeds reduced the uptake by the crop.

Among the hand weeding treatments, hand weeding twice was able to increase the uptake than hand weeding once. Among the various herbicides nutrient uptake in benthiocarb 2.0 kg/ha treated plots and nitrofen treated plots were on par with the complete weed free condition which recorded maximum uptake of nutrients. Bentazon 2.0 kg/ha and benthiocarb 1.5 kg/ha also recorded better uptake.

Comparing herbicides and hand weeding, it can be seen that herbicides are more effective in increasing the uptake by crop, which was due to reduced crop-weed competition and hence greater dry matter accumulation by the crop.

According to Takahashi and Murayama (1953) and Sukumari (1982) absorption of nutrients such as N, P_2O_5 and K_2O were usually rapid between tillering and panicle formation. Chemical weed control which provided little weed growth by persistent action of herbicides in the soil maximised nutrient uptake by the crop by avoiding competition during tillering and panicle initiation of the crop. If weed growth were more in this period, they could deprive the crop of substantial quantity of nutrients as shown in the unweeded control plot.

Boerma (1963), Swain (1967), Mani (1975), Ravindran (1976), Abraham Varughese (1979), Moorthy et al. (1979) and Sukumari (1982) obtained similar results.

(c) Protein content of grain

Least protein content was noticed in the unweeded control and protein content in plots hand weeded twice was more compared to plots hand weeded once.

Highest protein content was noticed in the completely weed free plot and was followed by benthiocarb treated plots, which was on par with nitrofen treated plots. Rest of the herbicide treatments were on par.

Among herbicides and hand weeding, those plots treated with herbicides recorded higher protein content than the hand weeded plots.

The higher protein content in plots where no weed existed was due to the higher nitrogen uptake by the crop between panicle initiation and harvest. Takahashi et al. (1953), Murayama et al. (1955) and Tsuno (1968) pointed out that the period of production of assimilates that are translocated to the ear extends from two weeks before heading to 4 weeks after it.

Ramamoorthy et al. (1974) and Ravindran (1976) found that percentage of protein increased in weeded plots compared to unweeded plots. Gomez and Datta (1975), Abraham Varughese (1978), Sreedevi (1979) and Sukumari(1982) also observed that control of weeds increased protein content of grain in rice.

IV. CORRELATION STUDIES

Weeds in the rice field were grouped into grasses, sedges and broad-leafed weeds. From Tables 3 and 4 it can be seen that grasses and sedges were the predominant ones. The growth pattern of grasses and sedges were more or less similar to that of the rice crop. Therefore the competition for water in the early stages of growth and for nutrients and light during the entire crop growth were severe. Weeds have better capacity to absorb nutrients than rice crop both under favourable and unfavourable conditions.

Correlation studies showed that dry matter production by crop was negatively correlated with dry matter production by weeds, which in turn was negatively correlated with the nutrient uptake by the crop. Nutrient uptake by weed and crop were negatively correlated. Grain yield of rice was negatively correlated with the nutrient uptake by weed and positively correlated with the nutrient uptake by the crop.

In a mixed population of crop and weeds a severe competition for nutrients existed between them. So whenever nutrient uptake by weeds increased, the nutrient uptake by the crop was correspondingly reduced which in turn reduced the dry matter production by the crop, which was reflected in grain yield also. Whenever the nutrient uptake by weeds increased the dry matter production of weeds also increased.

Okafor and Datta (1976) and Ravindran (1976) got negative correlation between N uptake by weeds and grain yield. Balu (1977) also found an inverse relationship between grain yield and nutrient uptake by weeds. Mallappa (1973) and Ravindran (1976) got inverse relationship between N uptake by crop and weeds. Abraham Varughese (1978) and Sukumari (1982) observed negative correlation between the nutrient uptake by rice crop and weeds.

V. <u>ECONOMICS</u>

From the table, it can be found that all the treatments are Superior to unweeded control except T_9 and T_{12}, which showed a loss of Rs.225.00 and Rs.426.00 respectively. Even though the yield is substantially increased in T_{12} the profit is offset by the high labour charge. Even the normal method of weed control that is being practised in Onattukara (hand weeding on 15th and 30th days) region gives only a nominal profit of Rs.346.00. This shows that hand weeding on 15th and 30th day is economical compared to single hand weeding on 15th or 30th day.

Among the herbicide treatments, benthiocarb 2.0 kg ai/ha followed by nitrofen 1.875 kg ai/ha, bentazon 2.0 kg ai/ha and benthiocarb 1.5 kg ai/ha gave substantially higher net returns over the local practice. This shows that for Onattukara region higher profits can be obtained by applying any of the above herbicides instead of hand weeding according to the availability of herbicides in the market. The order of priority of herbicides is as follows. Benthiocarb 2.0 kg ai/ha, nitrofen 1.875 kg ai/ha, bentazon 2.0 kg ai/ha and benthiocarb 1.5 kg ai/ha.

SUMMARY

SUMMARY

An experiment was conducted at the Rice Research Station of Kerala Agricultural University at Kayamkulam during the first crop season of 1981-82 to find out a suitable weed control method for semi-dry dibbled crop of rice using the variety Jaya. The results of the study are summarised below.

1. The competition was mostly by grasses followed by sedges and broad leafed weeds. Brachiaria ramosa, Echinochloa colonum, Echinochloa crus-galli, Sacciolepis indica, Cyperus iria, Cleome viscosa and Monochoria viginalis were the important weeds in the field.

2. Throughout the crop growth period, monocot weeds predominated and monocot weed population constituted more than 90 per cent of the total weed flora.

3. Benthiocarb 2.0 kg ai/ha, nitrofen 1.875 kg ai/ha and bentazon 2.0 kg ai/ha controlled monocot weed population throughout the crop growth.

4. Dicot weed population was maximum upto 40th day of dibbling, after which the number decreased substantially and continued to maintain more or less a constant level.

5. All the herbicide treatments were effective in controlling dicot weed population upto 40th day of dibbling.

6. Hand weeding 15th and 30th days was found to suppress total weed population as good as the chemical treatments.

7. Benthiocarb 2.0 kg ai/ha, nitrofen 1.875 kg ai/ha, bentazon 2.0 kg ai/ha and benthiocarb 1.5 kg ai/ha suppressed weed dry matter accumulation throughout the crop growth.

8. Benthiocarb 2.0 kg ai/ha and nitrofen 1.875 kg ai/ha recorded weed control efficiency of more than 76 per cent while bentazon 2.0 kg ai/ha and benthiocarb 1.5 kg ai/ha recorded an efficiency between 66 and 70 per cent.

9. Regarding the height of plants, benthiocarb 2.0 kg ai/ha and nitrofen 1.875 kg ai/ha was as good as the complete weed free condition. Hand weeding 15th and 30th day was as good as benthiocarb 1.5 kg ai/ha and bentazon 2.0 kg ai/ha.

10. Benthiocarb 2.0 kg ai/ha, and nitrofen 1.875 kg ai/ha were as good as the complete weed free condition which were followed by bentazon 2.0 kg ai/ha

and benthiocarb 1.5 kg ai/ha, with respect to the number of tillers/m^2 and LAI.

11. Benthiocarb 2.0 kg ai/ha was on par with complete weed free condition with respect to the number of productive tillers/hill. All other herbicide treatments were on par with hand weeding 15th and 30th days.

12. Chemical weed control in general favoured the production of highest panicle characters like length of the panicle, weight of the panicle and number of filled grains per panicle compared to hand weeding.

13. Bentazon 1.5 kg ai/ha and 2.0 kg ai/ha produced higher thousand grain weight.

14. Yield of grain was significantly influenced by the herbicides and benthiocarb 2.0 kg ai/ha, nitrofen 1.875 kg ai/ha, bentazon 2.0 kg ai/ha and benthiocarb 1.5 kg ai/ha produced 14.8 per cent, 9.9 per cent, 6.8 per cent and 3.5 per cent higher yield respectively than the local practice of hand weeding twice.

15. Straw yield production was maximum in benthiocarb 2.0 kg ai/ha treated plots which was on par with complete weed free condition. Hand weeding twice was as good as benthiocarb 1.5 kg ai/ha and nitrofen 1.875 kg ai/ha.

16. The lower value of weed index (0.4) was recorded in benthiocarb 2.0 kg ai/ha treated plot and highest value of 18.8 was recorded in the unweeded control.

17. Nitrogen uptake by weeds was steep and linear upto 60 days of dibbling, after which it levelled off.

18. P_2O_5 uptake by weeds was uniform throughout the crop growth, though the quantity of uptake was less.

19. K_2O uptake by weeds was significant upto 100 days of dibbling after which it levelled off.

20. Herbicides - benthiocarb 2.0 kg ai/ha, nitrofen 1.875 kg ai/ha, benthiocarb 1.5 kg ai/ha and bentazon 2.0 kg ai/ha recorded lower uptake by weeds than hand weeding twice.

21. N and K_2O uptake by the crop was higher than P_2O_5 uptake at all stages of crop growth.

22. N uptake by crop increased upto 100 days after dibbling and then it levelled off.

23. The rate of P_2O_5 uptake decreased from 80th day of dibbling, while the K_2O uptake continued throughout the crop growth.

24. Nutrient uptake in plots treated with benthiocarb 2.0 kg ai/ha and nitrofen 1.875 kg ai/ha was on par with complete weed free condition.

25. Highest protein content was recorded in the complete weed free condition which was on par with the benthiocarb treated plots and nitrofen treated plot.

26. Correlation studies showed that grain yield of crop was correlated negatively with nutrient uptake by weeds and positively with nutrient uptake by the crop. Dry matter production by crop was negatively correlated with dry matter production by weed which in turn was negatively correlated with nutrient uptake by weed. Nutrient uptake by crop and weed were negatively correlated.

27. Based on the economics of production, benthiocarb 2.0 kg ai/ha, nitrofen 1.875 kg ai/ha and bentazon 2.0 kg ai/ha recorded net profits of Rs. 1684.00, Rs. 1091.00 and Rs. 946.00/ha respectively.

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* Original not seen

APPENDICES

APPENDIX-I

Weather data during the crop period (30-4-1981 to 9-9-1981) and its variation from the past 5 years

Sl. no.	Standard week no.	Periods	Temperature°C				Humidity (percent)				Sunshine hours		Total rainfall	
			Maximum		Minimum		Fore noon		After noon					
			C.P	V	C.P	V	C.P	V	C.P	V	C.P	V	C.P	V
1	18	30/4 - 6/5	34.1	+0.26	24.6	-0.22	93	+3.0	62.4	+ 1.6	8.46	-0.36	35.12	- 16.72
2	19	7/5 -13/5	33.5	+0.74	24.7	-0.14	95	+2.8	65.2	+ 2.8	7.08	-0.58	86.24	- 35.24
3	20	14/5 -20/5	34.1	+1.52	25.6	+0.72	92	-2.4	68.8	- 9.8	6.88	+3.08	118.32	-118.32
4	21	21/5 -27/5	34.2	+1.36	25.0	-0.30	92	-1.0	62.8	- 5.8	8.50	-0.50	46.48	- 33.08
5	22	28/5 - 3/6	30.4	-1.28	24.4	-0.18	92	-2.4	72.4	+ 9.6	5.46	-3.56	102.22	+101.48
6	23	4/6 -10/6	29.1	-0.37	23.6	-0.64	96	+2.4	70.6	+13.4	5.30	-4.40	95.00	+239.60
7	24	11/6 -17/6	29.5	-1.38	22.3	-1.40	97	+3.0	74.6	+12.4	5.34	-2.14	109.12	+180.48
8	25	18/6 -24/6	29.9	-1.26	23.6	-0.22	96	+1.4	74.6	+13.4	3.92	+0.88	98.14	- 4.94
9	26	25/6 - 1/7	30.9	+0.48	23.6	-0.08	96	+2.0	75.0	+10.0	4.72	+0.78	112.70	- 98.70
10	27	2/7 - 8/7	31.7	+1.20	24.0	+0.36	94	-0.8	73.6	- 2.6	4.26	+3.34	94.48	- 29.78
11	28	9/7 -15/7	31.1	+0.82	24.0	+0.34	94	-0.6	75.0	- 4.0	3.94	+1.86	72.24	+ 38.76
12	29	16/7 -22/7	30.8	+0.70	23.6	+0.38	95	+0.4	77.6	- 4.6	3.96	+3.24	70.90	- 10.10
13	30	23/7 -29/7	29.0	+0.12	23.5	+0.22	96	+1.0	79.0	-23.0	2.96	-1.96	87.22	+ 50.18
14	31	30/7 - 5/8	29.0	-1.34	23.1	-0.76	96	+1.4	70.8	-10.2	5.82	-2.02	28.98	+ 11.02
15	32	6/8 -12/8	30.5	-0.14	24.4	+0.58	95	+0.6	72.6	+ 4.4	6.60	+0.80	37.22	+ 27.58
16	33	13/8 -19/8	29.7	-1.72	27.3	+3.42	97	+2.0	71.0	+11.0	6.50	-1.10	46.24	+ 72.56
17	34	20/8 -26/8	29.9	-0.20	22.9	-0.78	96	+0.6	73.2	- 3.2	5.44	-0.06	69.72	+ 63.68
18	35	27/8 - 2/9	30.6	-1.54	23.9	-0.82	94	-0.2	72.3	- 2.3	4.54	+1.46	92.76	- 79.24
19	36	3/9 - 9/9	30.5	-0.20	23.8	+0.60	96	+1.3	73.2	+ 0.8	4.40	-0.40	124.40	+ 18.00

CP = during the crop period
V = variation from the past five years

\+ more than 5 years mean
\- less than 5 years mean

APPENDIX-II

Summary of the analysis of variance tables for weed population/m^2 at different days after dibbling

Source	d.f.	Mean squares					
		20	40	60	80	100	Harvest
a) Monocot weed population/m^2							
Total	35						
Replication	2	4.55	0.80	4.79	5.79	3.67	4.18
Treatment	11	141.26**	59.19**	43.29**	43.97**	45.55**	48.77**
Error	22	1.47	2.54	2.24	2.17	2.10	1.98
b) Dicot weed population/m^2							
Total	35						
Replication	2	3.20	8.19	0.50	0.30	0.34	0.24
Treatment	11	19.83**	13.05**	3.76**	2.17**	2.53**	2.58**
Error	22	3.29	2.54	0.42	0.30	1.64	2.10
c) Total weed population/m^2							
Total	35						
Replication	2	1.68	3.28	4.69	4.88	4.56	3.48
Treatment	11	130.99**	66.36**	45.18**	45.57**	48.13**	50.91**
Error	22	8.96	2.74	1.91	1.99	2.10	1.94

** significant at 0.01 level

Note: Data analysed after $\sqrt{x + 1}$ transformation

APPENDIX-III

Summary of the analysis of variance tables for dry weight of weeds/m^2 at different days after dibbling

Source	d.f.	Mean squares					
		20	40	60	80	100	Harvest
Total	32						
Replication	2	57.48	113.30	54.91	127.64	109.94	146.58
Treatment	10	2128.47**	3856.27**	6582.39**	7991.96**	9831.65**	10440.83**
Error	20	35.58	28.04	28.04	26.84	16.47	129.48

** significant at 0.01 level

APPENDIX-IV

Summary of the analysis of variance tables for height of plants (cm) at different days after dibbling

Source	d.f.	Mean squares					
		20	40	60	80	100	Harvest
Total	35						
Replication	2	0.60	6.82	3.74	9.64	36.86	85.32
Treatment	11	33.91**	153.17**	199.83**	256.42**	349.20**	460.25**
Error	22	0.05	1.15	3.62	6.47	7.01	6.58

** significant at 0.01 level

APPENDIX-V

Summary of the analysis of variance tables for tiller number/m^2 and LAI at 60th and 80th days after dibbling

Source	d.f.	Mean Squares			
		No.of tillers		LAI	
		60	80	60	80
Total	35				
Replication	2	286.11	1880.13	0.04	0.02
Treatment	11	9854.58**	15055.02**	0.87**	0.72**
Error	22	203.38	427.64	0.07	0.01

** significant at 0.01 level

APPENDIX-VI

Summary of the analysis of variance tables for yield components

Source	d.f	Mean squares				
		No.of productive tillers per hill	Panicle length	Panicle weight	No.of filled grains/ panicle	Thousand grain weight
Total	35					
Replication	2	0.095	0.03	6.78	12.27	0.30
Treatment	11	1.29**	26.44**	1.29**	145.08**	2.39*
Error	22	0.18	1.04	3.38	1.30	5.15

** significant at 0.01 level
* significant at 0.05 level

APPENDIX-VIII

Summary of the analysis of variance tables for nutrient uptake by weeds at different days after dibbling

Source	d.f.	Mean squares					
		20	40	60	80	100	Harvest
a) Nitrogen uptake							
Total	32						
Replication	2	0.02	4.43	1.51	5.13	11.35	11.50
Treatment	10	0.42**	56.95**	253.78**	360.70**	475.68**	578.26
Error	20	0.005	1.71	0.87	0.73	1.52	3.76
b) Phosphorus uptake							
Total	32						
Replication	2	2.76	0.02	0.62	0.008	0.21	0.96
Treatment	10	17.43**	32.10**	37.77**	47.77**	96.81**	122.80**
Error	20	1.58	0.19	0.13	0.46	1.51	0.95
c) Potash uptake							
Total	32						
Replication	2	0.80	0.31	4.20	4.70	8.06	6.22
Treatment	10	75.15**	139.34**	159.40**	218.97**	221.12**	285.77**
Error	20	6.50	0.06	1.07	0.99	0.79	3.87

** significant at 0.01 level

APPENDIX-VII

Summary of the analysis of variance table for yield

Source	d.f.	Mean squares	
		Grain yield (kg/ha)	Straw yield (kg/ha)
Total	35		
Replication	2	396.58	10909.70
Treatment	11	173700.67*	479894.63**
Error	22	1035.92	26926.27

** significant at 0.01 level

* significant at 0.05 level

APPENDIX-VIII

Summary of the analysis of variance tables for nutrient uptake by weeds at different days after dibbling

Source	d.f.	Mean squares					
		20	40	60	80	100	Harvest
a) Nitrogen uptake							
Total	32						
Replication	2	0.02	4.43	1.51	5.13	11.35	11.50
Treatment	10	0.42**	56.95**	253.78**	360.70**	475.68**	578.26**
Error	20	0.005	1.71	0.87	0.73	1.52	3.76
b) Phosphorus uptake							
Total	32						
Replication	2	2.76	0.02	0.62	0.008	0.21	0.96
Treatment	10	17.43**	32.10**	37.77**	47.77**	96.81**	122.80**
Error	20	1.58	0.19	0.13	0.46	1.51	0.95
c) Potash uptake							
Total	32						
Replication	2	0.80	0.31	4.20	4.70	8.06	6.22
Treatment	10	75.15**	139.34**	159.40**	218.97**	221.12**	285.77**
Error	20	6.50	0.06	1.07	0.99	0.79	3.87

** significant at 0.01 level

APPENDIX-IX

Summary of the analysis of variance tables for nutrient uptake by the crop (kg/ha) at different days after dibbling and protein content of grain (per cent)

Source	d.f.	Mean square					
		60			80		
		N	P_2O_5	K_2O	N	P_2O_5	K_2O
Total	35						
Replication	2	2.93	2.36	5.79	5.86	0.18	2.28
Treatments	11	120.07**	21.36**	50.89**	386.30**	51.38**	160.82**
Error	22	2.87	1.38	6.99	3.54	4.84	4.64

........contd.........

Mean square						
100			Harvest			Protein content of grain
N	P_2O_5	K_2O	N	P_2O_5	K_2O	
37.57	42.78	31.12	417.03	15.36	78.38	0.0014
393.45**	82.59**	217.72**	721.10*	127.01*	418.58*	0.18**
4.86	33.07	12.81	238.97	13.84	72.67	0.01

* significant at 0.05 level

** significant at 0.01 level

WEED CONTROL METHOD FOR SEMI-DRY DIBBLED CROP OF RICE

BY
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ABSTRACT OF A THESIS
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DEPARTMENT OF AGRONOMY
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VELLAYANI, TRIVANDRUM

1983

ABSTRACT

An experiment was conducted at the Rice Research Station of Kerala Agricultural University at Kayamkulam during the *Virippu* (first crop) season of 1981-82 to find out a suitable weed control method for semi-dry dibbled crop of rice, in simple randomised block design with 7 herbicide treatments, 4 hand weeding treatments of which one was the local practice and another unweeded control.

Monocot weeds were found to be better competitors than dicot weeds. Weed population was maximum during the first 40 days of dibbling. The herbicides reduced weed population and dry matter accumulation compared to hand weeded plots and increased the weed control efficiency.

All the crop growth characters like plant height, tiller count and LAI were influenced favourably by the application of herbicides compared to hand weeding. Yield attributing factors like number of productive tillers/hill, length of the panicle, weight of the panicle and number of filled grains per panicle were adversely influenced by competition with weeds and control of weeds by the use of herbicides like benthiocarb 2.0 kg ai/ha and nitrofen 1.875 kg ai/ha increased the yield

attributing characters which was reflected on the grain and straw yield.

N, P_2O_5 and K_2O uptake by weeds were low in the plots treated with herbicides compared to hand weeding. This correspondingly increased the uptake of nutrients by the crop. Benthiocarb 2.0 kg ai/ha and 1.5 kg ai/ha, nitrofen 1.875 kg ai/ha and bentazon 2.0 kg ai/ha were found to be effective in suppressing weed growth compared to the local practice. Significant correlations between the important crop and weed characters were also obtained.

Based on the findings, benthiocarb 2.0 kg ai/ha, nitrofen 1.875 kg ai/ha and bentazon 2.0 kg ai/ha can be safely recommended for the semi-dry Virippu crop of Onattukara region for getting highest yield as well as highest net profit per unit area.