EFFECT OF OXYFLOURFEN FOR WEED CONTROL IN DRY-SOWN RICE

By

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THESIS

Submitted in partial fulfilment of the requirement for the degree

Master of Science in Agriculture

Faculty of Agriculture
Kerala Agricultural University

Department of Agronomy
COLLEGE OF HORTICULTURE
Vellanikkara Thrissur

1992

DECLARATION

I hereby declare that this thesis entitled **Effect of Oxyflourfen for Weed Control in Dry-sown 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 any other similar title of any other University or Society

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CERTIFICATE

Certified that the thesis entitled **Effect of Oxyflourfen for Weed Control in Dry-sown Rice** is a record of research work done by Mrs Priya I 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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ACKNOWLEDGEMENT

It is with deep sense of gratitude that I express my heartfelt thanks and indebtedness to **Dr. E. Tajudeen** Professor and Head Department of Agronomy College of Horticulture Vellanikkara who is the Chairman of my Advisory Committee for his invaluable help sincere guidance timely suggestions and constant encouragement throughout the preparation of this thesis

I am immensely thankful to Dr. **A.I. Jose** Professor and Head Department of Soil Science and Agricultural Chemistry College of Horticulture Vellanikkara **Dr. M Abdul Salam** Associate Professor Department of Agronomy College of Horticulture Vellanikkara and Dr **Jose Mathew** Associate Professor in Agronomy Regional Agricultural Research Station Pattambi who are the members of my advisory committee for their valuable help and timely advice which have paved the way for the successful completion of my research

My sincere thanks are due to **Sri N. Ravindranathan** Associate Professor in Agricultural Statistics College of Co-operation and Banking Mannuthy for rendering all possible facilities and guidance for statistical analysis

I am indeed grateful to Dr M. **Aravindakshan** Director of Research Kerala Agricultural University for permitting me to do my research work at Regional Agricultural Research Station Pattambi

I also want to place on record my heartfelt gratitude and indebtedness to **M/s Indofil Agencies** Bombay for providing me financial assistance for conducting the research project during the years 1990 91 and 1991 92

I am extremely thankful to Dr. K M. Rajan Associate Director Regional Agricultural Research Station Pattambi for providing me all facilities to conduct the research study at the station

The help rendered by **Sri. V P. Sukumara Dev** Professor in Plant Pathology **Sri P Ahmed** Assistant Professor in Agricultural Extension and other staff of the various departments of Regional Agricultural Research Station Pattambi is gratefully acknowledged

I also thank **M/s Blaise Computer Consultancy** Mannuthy for the neat and timely execution of the thesis

It is with gratitude I remember the warm blessing and constant encouragement of my loving parents which was the main source of inspiration for my success

I am indebted to my husband **Sri. V. Nandakumar** for providing me constant help and motivation for the timely submission of this thesis

Above all I thank **God Almighty** for showering his choicest blessing without which all the efforts will be in vain

Priya

PRIYA, I

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Introduction

INTRODUCTION

Rice is the staple food of the people of Kerala and is cultivated in an area of 6 5 lakh ha Out of 2 86 lakh ha under rice during the Virippu season, nearly 87 per cent is grown under semi-dry conditions (FIB, 1989) Excessive weed growth is a major constraint in this system of cultivation After the receipt of first showers, the crop and weed germinate almost simultaneously resulting in intense crop-weed competition The weeds compete with the crop for light, water and nutrients They also adversely affect the microclimate around the plant and harbour disease organisms and pests The grassy weeds which germinate along with rice seeds constitute the major portion of the weed population creating severe competition in upland rice

In dry-sown rice, a much wider range and intensity of weed problem can be expected than in transplanted or puddled wet seeded rice because of differences in land preparation, the lack of standing water at the early stage of crop growth and simultaneous growing of weeds and rice The extent of yield reduction due to weeds was estimated as 50 to 60 per cent in upland rice (Pillai et al , 1974)

The most common methods of weed control are the mechanical and cultural methods, of which hand weeding is the most common. But hand weeding is an expensive slow and labour intensive activity and may require repeated operations. When labour is scarce and costly, chemical weed control with herbicides offer great potential.

Nearly 200 herbicides, often chemically and functionally diverse, are available in the world for use in various crops including rice. Herbicides offer the most practical, effective and economical means of reducing weed competition, crop losses and production costs in dry-sown rice. At present, there are only few chemicals which can control all types of annual and perennial weeds. In dry sown rice, the range of herbicides that could be effectively used without causing injury to rice seedlings is limited.

Oxyflourfen is a recently introduced, pre-emergent herbicide and is found to be very effective in rice (Kerala Agricultural University (KAU), 1989b Raju and Reddy, 1986 Pillai *et al* , 1983). However, Moorthy and Manna (1988) reported that this herbicide @ 0.1 kg a.i./ha caused phytotoxicity to upland rice. The results indicate that the herbicide effectiveness and crop safety can be achieved by using the correct dosage. This necessitates the formulation of a suitable recommendation with regard to the optimum time of application and dose of oxyflourfen in dry-sown rice.

Weed free condition upto 60 days is essential for getting good yields in dry-sown rice (Sankaran and De Datta, 1985) One of the studies conducted in KAU (1983) indicated that during the first crop season, the granular formulation of oxyflourfen at 0 1 kg a i /ha when applied at six days after sowing were found to be quite effective in controlling weeds in dry-sown rice Dawood and Balasubrahmanian (1988) reported that oxyflourfen 0.1 - 0 15 kg a i /ha when applied five days after transplanting to rice gave best control of annual weeds

The present investigation was therefore undertaken with the following objectives

1 To study the efficacy of oxyflourfen in controlling weeds in dry-sown rice

2 To find out optimum dose and time of application of oxyflourfen for weed control

3 To work out the economics of herbicide use in relation to manual weed control

Review of Literature

REVIEW OF LITERATURE

The problem of weed as well as the resultant yield loss is very serious in dry seeded rice as compared to other cultural systems Herbicides have several advantages over other weed control methods in dry-sown rice A brief review of the various aspects of weed problems and its effect on dry-seeded rice is attempted in this chapter. Literature on the different aspects of chemical control of weeds in dry-sown rice using oxyflourfen, butachlor and thiobencarb is also reviewed The review covers the literature on the upland and semi-dry rice

2.1 Weed spectrum in dry-sown rice

Weeds are more serious problem in the production of dry-seeded rice than in other cultures A much wider range and intensity of weed problems can be expected in dry-seeded rice In India, grasses are the pre-dominant weed group in upland rice (Pande et al , 1966 Nair et al , 1975)

Pande et al (1967) Patro and Misra (1969), Chatterjee et al (1971), Misra and Roy (1971) and Mukhopadhyay et al (1972) reported that Echinochloa colona (L) Link, Echinochloa crusgalli (L) Beauv, Cynodon dactylon (L) pers, Eleusine indica (L) Gaertn Ipomoea sp , Fimbrystylis miliacea, Commelina benghalensis L, Phyllanthus niruri L and Amaranthus sp are the major weeds in upland rice irrespective of edaphic differences

Nair et al (1974) reported that the important weeds in the direct-seeded rice fields of Kerala were Echinochloa crusgalli, Cyperus sp , Fimbrystylis miliacea and Monochoria vaginalis Weed species during the early kharif season of rainfed uplands at Pattambi, Kerala were, Echinochloa crusgalli, Brachiaria sp , Cleome sp , Cyperus rotundus, Amaranthus viridis, Fimbrystylis miliacea, Eclipta alba and Commelina benghalensis (Nair et al , 1975) Major weeds in dry-seeded rainfed bunded rice fields of Bangladesh were Echinochloa colona (L) Link, Eleusine indica (L) Gaertn, Cyperus iria and Fimbrystylis littoralis Gaud (Nizam et al , 1981) In direct-seeded rice the perennial sedges Cyperus rotundus and Cyperus esculentus constitute a serious problem since they germinate and grow simultaneously with the rice plants (Okofor 1981) Weeds present in dry land rice at Faizabad were Panicum colonum, Cyperus rotundus Paspalam sp , Phyllanthus niruri, Eclipta erecta, Cynodon dactylon Ammania baccifera and Bonnaya sp (Singh et al , 1982)

The weed population in upland rice comprised of 14 per cent Echinochloa sp , 22 per cent other grasses, 23 per cent Cyperus sp and 41 per cent broad leaved weeds in Himachal Pradesh (Biswas and Thakur, 1983) The major grass species found in Nigeria in upland rice were Digiteria horizontalis and Eleusine indica, major broad leaved weeds were Ageratum conyzoides and Boerhavia diffusa (Kehinde and Fagade, 1986) Singh and Dash (1986) reported that in dry-seeded unpuddled rainfed fields Echinochloa colona and Cyperus rotundus were the major weeds

Jayasree (1987) and Palaikudy (1989) reported from their studies in dry-sown rice in Kerala that the major weeds consisted of Isachne miliacea Echinochloa colona Saccolepis interrupta among grasses and Cyperus iria among sedges Dicot weeds were very few in number and the main species present were Alternanthera sessilis, Ludwigia purie etc

Borreria hispida and Ageratum conyzoides, Digiteria sanguinalis, Setaria glauca and Cynodon dactylon were the major weed species in upland rainfed rice growing areas of Nagaland (Singh, 1990) Weed species in upland rice in Meghalaya were Echinochloa colonum (L) Link, Ischaemum rugosum satisb, Chenopodium ambrosodes L, *Rotala rotundifolia* (Ham) Koen, *Fimbrystylis dichotoma* vahl, *Ageratum conyzoides* Linn, *Spergula arvensis*, *Bidens pilosa*, *Oxalis corriculata* Linn, *Scirpus erectus* *Cyperus sp* , *Sagittaria sagittifolia* Linn, *Borreria hispida* K and *Imperata cylindrica* L (Varshney, 1991)

The review clearly indicated that the weed spectrum in dry-sown rice is diverse and varies considerably between locations Grasses constituted the major weed flora in dry seeded rice Among grasses *Echinochloa colona* was the most serious weed *Echinochloa crusgalli* was very common and problematic in semi-dry conditions Among sedges *Cyperus rotundus* is most serious in uplands while *Cyperus iria* is most common in semi-dry conditions

2.2 Crop-weed competition in rice

Weed competition is probably the most important single factor limiting the yield of crops Cereals are most sensitive to competition from weeds in their early stages of growth The weeds compete with crop plants for water, nutrients light etc They have the ability to absorb more water and nutrients than crop plants

2 2 1 Critical period of crop-weed competition

Competition from broad leaved weeds is generally less severe than from grassy weeds and will be affected by both species and number of species present The early weed competition reduces the crop yield more than late season weed growth

The critical period for rice weed control is the first 40 days (Arai, 1967) Smith (1968) reported that competition from barnyard grass (*Echinochloa crusgalli*) for 51 days or more reduced the yield of rice IR-8 can tolerate weeds between 20 and 30 days without any adverse effect on grain yield (Pagsuberon, 1970) In Japan, *Echinochloa crusgalli* was most competitive with rice at the maximum tillering or early ripening stage (Noda, 1973)

Ghosh *et al* (1977) mentioned that the critical period of weed infestation in rice was found to vary from 10 to 30 or 40 days after seeding in upland rice The longest period of weed competition that the rice crop can tolerate without significant reduction in the yield was 30 days from sowing date (Nair *et al* 1975) They also reported that the degree of competition between rice plants and weeds depends on the growth characteristics time of weed emergence and weed density

Ghosh et al (1977) reported that the presence of weeds during first 10 days after germinatin will not effect the growth and yield of the crop. But the presence of weeds from 20 days or more after germination reduced yield significantly In direct seeded rice, the most critical period is from about 10 to 12 days after sowing till the crop grows tall enough to develop a canopy to restrict sunlight to weeds Competition from weeds was most intense during the first 30 days after sowing (CIDAT, 1978) Wells and Cabradilla (1981) found that weed competition began during the first three weeks of the crop The weed growth increased exponentially during the first 60 days, reaching a maximum dry weight of 6 6 t/ha They also found that the critical period of crop-weed competition was between two and nine weeks after sowing

A study conducted at Vellayani, Kerala, revealed that the critical period of weed infestation in a short duration direct-sown rice under semi-dry condition is 21 to 40 days of sowing The shortest period of weeding for high yields is 21 to 30 days of sowing (KAU, 1984) Sankaran and De Datta (1985) have suggested a weed free period of 50 days after seeding in upland rice The critical period of weed removal in upland rice lies between 15 to 30 days after sowing (Shelke *et al*, 1986)

The initial 15 to 45 days is the critical period of weed competition in upland rice in several location (AICRIP, 1987) The critical period for weed competition in dry-seeded rice is three weeks from sowing particularly 10 to 20 days after emergence (PECWC, 1989) Monocot weeds were found to be better competitors compared to dicot weeds The number of weeds established was maximum during 11 to 40 davs after transplanting where as critical period of dry matter accumulation was 21 to 40 days Weed growth was most critical during 31 to 40 days

The review in general indicated that the critical period of weed competition in rice lies between 15 days to 30-40 days after sowing But in dry-sown rice, this period may extend to 45-55 days of sowing

2 2 2 Effect of weeds on rice growth and yield attributes

The presence of weeds may affect the dry matter production, growth of the plant and yield attributes The degree of competition between the weeds and rice depends on the growth characteristics, weed emergence period and weed density

i Rice growth

a) Dry matter production

Chakraborthy (1973) reported reduction in the crop dry matter due to weed competition Patel et al (1985) reported that crop dry matter was negatively correlated with weed dry weight or weed density Jayasree (1987) obtained maximum crop dry matter production in hand weeded and herbicide treated plots and the minimum in the unweeded check

Suja (1989) mentioned that severe weed competition and high weed density affected the crop growth and reduced the height and crop dry matter production The dry matter production by crop was higher in plots where a hand weeding or the pre-emergence herbicide was applied (Palaikudy, 1989)

b) Plant height

Rathinam and Sankaran (1974) found that the height of the plants were not influenced by different weed control methods Sreedevi (1979) reported that due to severe weed infestation, there is a reduction in the height of dry-sown rice Weeds significantly reduced the plant height in unweeded check than the herbicide treated plots (Patil et al , 1986) Palaikudy (1989) reported that high weed density and weed competition reduced the height of the crop Excellent control of wrinkle grass with oxyflourfen resulted in better plant height (Singh et al , 1990)

ii Yield attributes

Arai (1967) reported that Cyperus difformis reduced tillering, panicle numbers and spikelets/ear In dry-sown rice under semi-dry conditions, the number of filled grains/panicle was considerably reduced due to uncontrolled weed growth (Sreedevi 1979) Dang (1985) mentioned that spikelets/panicle and percentage of empty spikelets were reduced in untreated and low-dose plots The herbicide treatments increased the number of panicles/m^2 and filled grains/panicle compared with the control plot (Kumar and Gautam, 1986) Suja (1989) reported that hand weeding and effective herbicide treatments produced longer panicles and higher number of spikelets/panicle Weeds affected the growth and yield of dry-sown rice mainly through lower number of panicle, seed setting 1000 grain weight and panicle length (Fang and Wang, 1990) Varshney (1990) reported that oxyflourfen enhanced panicles/hill, length of panicle and test weight of grain

Rethinam and Sankaran (1974) reported that unweeded control recorded the lowest number of productive tillers per m^2 Sreedevi (1979) reported that the least number of productive tillers were recorded by the unweeded control plots Weeds reduced the number of total and fertile tillers (Patil et al , 1986) They also reported that weeds reduced the effective tillers in unweeded check than the treated plots Palaikudy (1989) observed reduction in the tiller number due to weed density and competition

As reported by Shaik et al (1974), 1000 grain weight was not influenced by various herbicide treatments Azad et al (1990) reported that all the weed control treatments including hand weeding produced higher 1000 grain weight as compared to unweeded check Plants in the hand weeded plots had the highest thousand grain weight than the unweeded check (Padhi et al , 1991)

The review indicated the adverse effect of severe crop-weed competition on growth (plant height and dry matter production) and yield attributes of rice

2 2 3 <u>Yield reduction due to weed-competition</u>

Severe weed competition is one of the major causes for low yield of upland rice The yield loss due to severe weed growth was estimated to be about 70 per cent in direct-seeded upland unpuddled rice and sometimes total failure of the crop depending upon the intensity of weed infestation (Mukhopadhyay 1965 Bhan, 1966)

Reduction in the yield due to weeds is often reported as more than 50 per cent in direct-seeded upland rice (Pande and Bhan, 1966 Madrid *et al* , 1972 Mukhopadhyay *et al* , 1972 and Pillai and Rao 1974) Mani *et al* (1968) reported that weeds cause considerable yield loss in India under various systems of rice cultivation ranging from 10 to 100 per cent They also observed in their review that yield losses in rice due to unweeded control varies from 9 1 to 51 4 per cent in India

Yield reduction due to weeds in direct-seeded rice was 40 to 60 per cent, even if the fields were weed free for 30 days in some cases and grass weeds reduced the rice yield to the extent of 90 per cent (IRRI, 1973) According to Mukhopadyay et al (1972) weeds removed as high as 37 1 kg of N/ha from upland rice fields resulting in yield reduction ranging from 74 to 98 per cent Chang (1973) mentioned that reduction in the yield due to weeds varied with weed species, weed density, crop season, soil fertility and rice variety Smith (1974) reported that in U S, season long competition of Echinochloa crusgalli reduced grain yields of star bonnet and blue belle cultivar to the tune of 40 per cent and 64 per cent respectively According to Pillai and Rao (1974) the extent of yield reduction due to weed incidence alone ranged between 28 to 50 per cent in direct-sown upland rice in Orissa

In Kerala, Sreedevi (1979) reported that weedy condition reduced the grain yield by 70 per cent compared to weed free check in direct sown rice In India all season weed competition reduced grain yield by 11 per cent in transplanted rice, 20 per cent in direct wet seeded rice and 46 per cent in direct dry seeded rice (De Datta, 1979) In upland rice, weeds compete severely with the crop for nutrient, light space and moisture, thus reducing the crop yield by 40 to 85 per cent (Moody, 1982)

A study at Pattambi revealed that the weed growth in early stage reduced the crop yield more severely than the late stage The study also revealed that the grasses were more harmful in reducing the yield of rice followed by broad leaved weeds and sedges (KAU, 1982) Weeds cause 10 to 15 per cent yield loss without any visible symptoms in rice (Rao, 1983) Dar *et al* (1983) estimated an yield loss of 9 to 51 per cent in paddy due to severe weed infestation In California, 90 per cent of the rice acrage was infested with barnyard grass (*Echinochloa spp*) which resulted in the yield losses of at least 30 per cent (Hill, 1984) In rice, *Echinochloa crusgalli* causes severe losses (Bhan and Malik, 1986)

In direct sown upland condition, the extent of yield reduction due to weeds is estimated to be over 50 per cent (Bhanumurthy and Subrhmanian, 1990) Heavy infestation of *Schenoplectus corymbosus* reduced the rice yield by 30 7 per cent (Patil *et al* , 1986) Competition for four weeks in upland direct-seeded rice by *Echinochoa* reduced the rice yield by 40 per cent (Mandal, 1990)

The above review clearly revealed the magnitude of yield loss due to weed infestation in dry-sown rice It clearly pointed out the necessity of appropriate weed control measures for increased grain yield

2.3 Chemical weed control in dry-sown rice

Application of pre-emergence herbicides is of special significance in dry-sown rice due to the simultaneous emergence of weeds and rice The use of pre-emergent herbicides can eliminate the competition at the initial stage itself

A number of herbicides like oxyflourfen, butachlor, benthiocarb, oxadiazon, pendimethalin, piperphos etc , have been found effective as pre-emergence herbicides in dry-sown rice The literature on the effect of the test herbicides viz , oxyflourfen, butachlor, and benthiocarb in rice are reviewed in this chapter

2 3 1 Oxyflourfen

Oxyflourfen, is a selective pre-emergence herbicide for weed control in a variety of crops and control a wide spectrum of annual broadleaved weeds and a few grasses when used at low rates (Jesinger et al 1977 and Chauhan and Rama krishnan, 1981)

The application of oxyflourfen in dry-sown rice recorded the maximum grain yield and effective weed control

(KAU, 1983 & 1984) Richardson *et al* (1976) reported that oxyflourfen has a very high level of activity and gave good control of several annual grass and broad leaved weeds as well as perennial *Allium vincale* Oxyflourfen effectively controlled all weeds throughout the growth period in upland drilled rice and was effective against *Cyperus iria* (Gidnavar, 1981) He also showed the effectiveness of oxyflourfen in controlling weeds of all kind, right from the early days to the harvest Experiment conducted at Pattambi revealed that oxyflourfen when applied at six days after sowing were effective in controlling weeds occuring in direct sown crop (KAU, 1983)

Oxyflourfen controlled the grasses effectively in direct sown rice (KAU, 1984) Ghosh and Singh (1985) reported that in upland rice oxyflourfen most effectively controlled all types of weeds from the germination stage, gave the lowest dry weight of weeds, highest number of panicles per m^2 and the highest paddy yields Oxyflourfen @ 0 2 kg a i /ha decreased the yield of grain by 91 per cent compared with hand weeding alone in upland rice (Shivamadiah *et al* , 1987) Yasin *et al* (1988) mentioned that oxyflourfen controlled *Monochoria vaginalis*, *Marsilea crenata*, *Paspalum sp* , *Echinochloa colona*, *Fimbrystylis littoralis*, *Eleusine indica* and *Cyperus iria*

2 3 2 Butachlor

Butachlor is a selective pre as well as post-emergente herbicide It is usually referred as a broad spectrum herbicide since it is found effective against many annual grasses sedges and some broad leaved weeds (Mandal, 1990)

Arai (1967) reported the effectiveness of butachlor for the control of weeds in dry-sown rice Butachlor did not effectively control the dominent sedges (Rangiah *et al*, 1974) Butachlor was proved to be a very effective herbicide for dry-sown rice particularly under upland conditions (Shivananje Gowda *et al* 1980) According to Raju and Reddy (1986a), butachlor possesses strong selectivity against *Echinochloa sp* and controls most broadleaved weeds, annual sedges and grasses in rice

Application of butachlor on the eighth day effectively controlled grasses due to the herbicidel action on the germinating weeds in direct sown rice Mohamed Ali and Sankaran, 1986) In dry-sown rice, butachlor effectively controlled broad-leaved weeds (KAU, 1989)

2 3 3 Thiobencarb

Thiobencarb is a selective, pre-seeding or pre-emergent herbicide used to control annual grasses, sedges and broadleaved weeds. Kennard (1973) stated that application of thiobencarb 12 days after sowing in dry-sown rice was effective against broadleaved weeds, sedges and annual grasses It can also control aquatic weeds in rice It is reported to be very safe to rice in dry-sown, wet sown and transplanted conditions (Rao, 1983)

Mohamad Ali and Sankaran (1986) reported that thiobencarb controlled about 95 per cent grasses, 79 per cent sedges and 78 per cent broadleaved weeds In dry-sown rice, thiobencarb was found to be more effective, where grasses and other weeds were predominant (KAU, 1986a) Lubigan and Moody (1989) reported that thiobencarb when applied at one and two leaf stages was not effective as under dry-seeded conditions

2.4 Time of application and dose of pre-emergent herbicides in rice

2 4.1 Oxyflourfen

a) Time of application

According to Takeuchi (1976), oxyflourfen has practical efficiency for weed control when applied before rice seedling tranplanting Application of oxyflourfen at the rate of 0 25 kg a i /ha five days after transplanting, repeated 15 days later if necessary, gave higher yields than other herbicides (CIDAT, 1978) The granular formulations of oxyflourfen at the rate of 0 1 kg a i /ha applied at six days after sowing was effective in control of weeds in direct sown rice (KAU, 1983)

Post-transplanting application of oxyflourfen (granules) at the rate of 0 55 kg a i /ha gave effective control of weeds in rice (Rao and Gupta, 1982) Mukhopadhyay and Mandal (1982) reported that oxyflourfen effectively controlled Echinochloa colonum, Echinochloa crusgalli, Ludwigia parviflora and sedges when applied @ 0 096-0 144 kg a i /ha at four days after transplanting Pillai et al (1983) observed that application of 0 2 kg a i /ha of oxyflourfen granules at five to six days after transplanting gave excellent weed control

Effective control of Echinochloa crusgalli, Echinochloa colonum Cyperus sp and other weeds in rice was obtained by applying 0 15 kg a i /ha of oxyflourfen within four days after transplanting (Shahi, 1985) Dawood and Balasubrahmanian (1988) reported that oxyflourfen @ 0 1 to 0 15 kg a i /ha when applied five days after transplanting gave best control of annual weeds Effective rates of oxyflourfen were 0 24 kg a i /ha when applied three days after transplanting or sowing and 0 36 to 0 48 kg a.i./ha in direct sown rice (Yasin *et al* , 1988)

b) Dose of application

Application of oxyfourfen at the rate of 0.1 and 0 216 kg a i /ha applied five days after sowing in water-sown rice showed acceptable crop tolerance and moderately good control of weeds (Baker, 1976) Chauhan and Ramakrishnan (1981) reported that oxyflourfen at 0 1 to 0.3 kg a i /ha gave appreciable control of *Chenopodium album*, *Trianthema monogyna* and *Phalaris minor* but gave poor control of *Cyperus rotundus* They also reported that oxyflourfen one per cent granules at 0 1-0 2 kg a i /ha controlled *Echinochloa* and *Cyperus sp* effectively and gave higher yields than unweeded control In transplanted rice, plots receiving oxyflourfen 0 56 kg a i /ha gave large yields as compared to other treatments (Rao and Gupta, 1981) Gidnavar (1981) reported that oxyflourfen was effective in controlling weeds of all kinds, right from early days to the harvest It was also effective on perennial weeds like *Cyperus iria* at 0 4 kg a i /ha in upland drilled rice.

According to Pillai *et al* (1983) oxyflourfen granules @ 0 15 kg a i /ha as pre-emergence treatments showed good control of weeds in rainfed transplanted rice In dry-sown rice application of oxyflourfen @ 0 24 kg a i /ha and 0 15 kg a i /ha followed by one hand weeding at 25 to 30 days after sowing was the best treatment for obtaining maximum grain yield and effective weed control (KAU, 1987) Ghosh and Singh (1985) found that in upland rice Pre-emergence application of oxyflourfen @ 0 1 kg a i /ha most effectively controlled all types of weeds from the germination stage, gave the lowest dry weight of weeds, highest number of panicles/m^2 and the highest paddy yields

Kumar and Gautam (1986) reported that application of oxyflourfen @ 0 15 kg a i /ha gave grain yield of 3 96 t/ha in direct seeded rice in puddled soil Verma *et al* (1987) observed that application of oxyflourfen @ 0 2 kg a i /ha provided good control of weeds than its lower dose in transplanted rice Vongasaraj and Price (1987) concluded that oxyflourfen @ 0 2 kg a i /ha controlled most weeds except *Monochoria Vaginalis* Glass house studies also showed that *Echinochola crusgalli*, *Leptochloa chinensis*, *Echinochloa colona*, *Ludwigia linifolia* were controlled by oxyflourfen @ 0 2 kg a i /ha

In direct seeded rice selective weed control was obtained with oxyflourfen @ 0 10 and 0 15 kg a i /ha (Mishra et al , 1988) Jiang et al (1989) reported that oxyflourfen at 0 1 kg a i /ha gave 90 to 100 per cent control of Echinochloa crusgalli, Lindernia procumbens, Rotala indica, Monochoria vaginalis, Leptochloa chinensis and Cyperus iria and at least 83 per cent control of Eleocharis acicularis and Scirpus juncoides

2 4 2 Butachlor

Application of butachlor six days after seeding completely controlled the weeds in direct-seeded lowland rice (CRRI, 1970) Pre-emergence application of butachlor at 2 kg a i /ha in dry seeded unpuddled rice gave excellent weed control and better bioefficiency (Nizam et al , 1981) Pillai et al (1983) reported that application of butachlor granules @ 1 0 kg a i /ha five to six days after transplanting gave excellent weed control and increased yield Butachlor @ 1 5 kg a i /ha when applied one day after sowing gave effective control of Echinochloa sp in semi-dry rice (KAU, 1986b) Areo and Mercada (1984) observed that application of butachlor two days before sowing provided better crop safety and improved weed control than applied six days after sowing

According to Rao *et al* (1985) butachlor @ 2 0 kg a.i./ha when applied at three days after sowing gave best control of *Echinochloa crusgalli* under upland rice condition Kumar and Gautam (1986) mentioned that butachlor granules at 1 5 kg a i./ha gave increased yields, number of panicle/m^2 and filled grains/panicle compared with control Verma *et al* (1987) reported that butachlor @ 1 5 kg a i /ha gave good control of weeds in transplanted rice of which 75 per cent were grasses, 57 per cent of which was *Echinochloa crusgalli* Selective weed control was obtained when butachlor was applied at 1 0 kg a i /ha (Mishra *et al* ,1988) Choudhary and Pradhan (1989) observed 89 4 per cent weed control when butachlor was applied at 2 0 kg a i /ha Mandal (1990) reported that butachlor when applied five to seven days after transplanting gave effective control of weeds

2.4.3 Thiobencarb

According to Sundaru (1971) the application of thiobencarb at 3 kg a i /ha gave long seasonal control of grass weeds Pande (1982) reported that thiobencarb when applied seven days after sowing @ 1 5 kg a i /ha in EC formulation gave good control of *Echinochloa spp* and annual sedges Thiobencarb when applied at six days after sowing followed by one hand weeding @ 1 0 kg a i /ha was more effective in controlling weeds and increasing grain yield (KAU, 1984 & 1986a) The reports also mentioned that broadleaved weeds were controlled by thiobencarb @ 0 15 kg a i /ha and where grasses and other weeds were present it was effective @ 1 5 kg a i /ha

Rao et al (1985) reported that application of thiobencarb at three days after sowing @ 1 87 or 2 5 kg a i /ha gave best control of Echinochloa crusgalli under upland rice conditions The effective control of Echinochloa crusgalli, Echinochloa colona, Cyperus spp and other weeds were obtained by applying thiobencarb @ 1 5 kg a i /ha within four days after transplanting (Shahi 1985) Thiobencarb 1 0 kg or 1 75 and 2 0 kg a i /ha gave effective weed control (Patil et al 1986 and Tomer, 1987) Highest weed control was obtained when butachlor was applied @ 2 to 2 5 kg a i /ha (Verma et al , 1987 and AICRIP, 1987) Shivamadiah et al (1987) found that the highest grain yields were obtained with 1 13 kg a i thiobencarb/ha + hand weeding once Mishra et al (1988) reported that the higher rate of thiobencarb (1 4 kg a i /ha) gave the best rice straw yields Thiobencarb when applied five days after transplanting rice @ 1 to 1 5 kg a i /ha gave excellent control of annual weeds

2.5 Time of application, dose and crop safety

2 5 1 Oxyflourfen

Takeuchi et al (1976) stated that oxyflourfen exhibited strong herbicidal activity in transplanted rice even at low dose and with little or no phytotoxicity to rice plants Oxyflourfen @ 0 25 kg a i /ha gave good control of weeds initially without decreasing rice seedling population (CIDAT, 1978) Pillai et al (1980) reported that in direct seeded rice, oxyflourfen granules @ 0 5 kg a i /ha applied six days after sowing caused some toxicity on the rice leaves but after a week the crop recovered The same result was observed by Singh and Ramtake (1980) when applied four days after transplanting in transplanted paddy According to Biswas and Thakur (1983), in direct seeded upland rice, oxyflourfen when applied six days after sowing was not toxic to the crop Singh and Singh (1982) reported that post-emergence application of oxyflourfen @ 0 2 kg a i /ha was phytotoxic to drilled rice According to Mukhopadhyay and Mandal (1982), due to oxyflourfen application at four days after transplanting @ 0 096-0 144 kg a i /ha in transplanted rice, the rice plants became yellow and although they recovered after two to three weeks crop yields were reduced

In irrigated wet seeded rice, oxyflourfen when applied five to six days after transplanting @ 0 2 kg a i /ha showed slight toxicity to rice and thus the yields were generally low because the crop lodged at the grain filling stage (Pillai et al , 1983 and Abud, 1981) Pre-emergence application of oxyflourfen @ 0 2 kg a i /ha controlled weeds effectively in upland rice but adversely affected germination, resulting in the poor crop stands and very low yields (Ghosh and Singh, 1985) In transplanted rice, oxyflourfen was highly toxic to the rice crop (IRRI, 1984) Oxyflourfen @ 0 1-0 2 kg a i /ha was phytotoxic to the crop and reduced rice yields (Patil et al , 1986 and Singh and Bhandari, 1985)

In upland rice, under stale bed and conventional method of land preparation, oxyflourfen @ 0 1 kg a i /ha when applied as pre-emergent was phytotoxic (Moorthy and Manna, 1988) Application of oxyflourfen as pre-emergent herbicide in transplanted as well as direct-seeded rice showed that when applied at three days after sowing or transplanting @ 0 24-0 48 kg a i /ha, it was not phytotoxic to the rice (Yasin et al , 1988)

Oxyflourfen was effective against wrinkle grass and safe to the crop However, at higher rates 0 5 kg a i /ha it showed slight toxicity to the crop during the initial growth period but afterwards the crop recovered (Singh et al , 1990) Vani (1990) observed phytotoxic effect of oxyflourfen @ 0 20 kg a i /ha on crop resulting in poor crop stand, compared to other levels ie 0 1 kg a i /ha and 0 15 kg a i /ha

2 5 2 Butachlor

Nair et al (1974) observed practically no injury to the young rice plants by butachlor application @ 1 0 kg a i /ha, but at higher rates ie @ 1 5 kg a i /ha it caused mild leaf injury if heavy rainfall occurs four to five days after sowing in upland rice Nizam et al (1981) observed that butachlor @ 2 0 kg a i /ha has no residual effect on the growth of the second crop in direct seeded bunded rice Butachlor @ 3 5 kg a i /ha was most phytotoxic to rice and it caused 50 per cent seedling mortality without affecting the final yield (Abud 1981)

Gill et al (1985) reported toxicity to rice seedling by the application of butachlor @ 1 25 kg a i /ha one day after sowing by broadcast under puddled as well as non-puddled conditions In wet seasons, butachlor was extremely toxic to rice and gave lower yields (IRRI, 1986) There was no phytotoxicity to rice seedlings with excess moisture or when rainfall occured immediately after butachlor application @ 3 6 kg a i /ha (Ali and Sankaran, 1986) Singh et al (1990) reported that butachlor @ 1 5 and 2 0 kg a.i /ha caused significant reduction in plant height and dry matter accumulation Varshney (1990) and CRRI (1970) reported no toxicity to rice when butachlor was applied six days after seedling in lowland rice

2 5 3 Thiobencarb

Nair et al (1974) reported that thiobencarb when applied @ 1 5 kg a i /ha caused leaf injury and twisting of the shoot in direct sown rice According to Sridhar et al (1976) better weed control and least phytotoxicity to rice due to thiobencarb application favoured higher tillering and production of more productive panicles Nako (1977) observed that application of thiobencarb @ 1 0 kg a i /ha did not damage rice seedlings, even with high soil moisture, when the seeds were planted 3 cm deep

Thiobencarb when applied @ 1 0 kg a i /ha caused slight scorching of the leaves in direct-seeded rice under puddled condition (Pillai et al 1980) But according to Pande (1982) thiobencarb @ 1 5 kg a i /ha in EC formulation when applied seven days after seedling does not cause any phytotoxicity to rice seedlings Lubigan and Moody (1989) stated that thiobencarb when applied at the two leaf stage reduced shoot weight and the plants survived were stunted

2.6 Nutrient uptake

2 6 1 Nutrient uptake by crop and weeds

2 6 1 1 Nitrogen

Mukhopadhyay et al (1972) reported that weeds remove as high as 31 1 kg N/ha from upland rice Mallappa (1973) observed that N uptake by rice was inversely proportional to N uptake by weeds The uptake of N by weeds was 62 1 kg/ha in unweeded plots which was nearly nine times more than when the plots were treated with chemicals or weeded manually (Sankaran et al , 1974) According to Mani (1975) weeds removed 46 6 kg N/ha in Kharif season Sreedevi (1979) reported that N removed by weeds was maximum in unweeded control (33 5 kg N/ha) as compared to hand weeded check Weeds removed 31 1 kg N/ha in unweeded plots which was nearly 10 times more than the removal of nutrients in chemical or manual weed control methods and the uptake by the crop was reduced by 50 per cent (Jayakumar et al , 1987) According to Lakshmi et al (1987), the uptake by the crop in the weed free condition was 108 7 kg/ha while in the weedy check it was 49 5 kg/ha Jayasree (1987) concluded that unweeded check gave higher N removal by weeds (99 2 kg/ha) at the harvest stage of the crop N uptake by crop showed reverse trend The maximum N uptake was observed at harvest stage (63 2 kg N/ha) and it increased with increase in the level of N applied (Pandy and Thakur, 1991)

2 6 1 2 Phosphorous

Mani (1975) reported an uptake of 12 kg P/ha by weeds due to weed infestation Sreedevi (1979) estimated maximum removal of P by weeds in weedy plots (5 1 kg P/ha) In unweeded plots, weeds removed 10 kg P/ha which was nearly 10 times more than when the plots were treated with chemicals or weeded manually and the uptake was reduced by 50 per cent (Jayakumar et al 1987) Jayasree (1987) revealed that unweeded check gave the maximum P removal (8 7 kg/ha) at harvest stage of the crop

2 6 1 3 Potassium

In Kharif season weeds removed 73 3 kg K/ha (Mani, 1975) According to Sreedevi (1979), unweeded control resulted in maximum K removal by weeds Jayasree (1987) reported that weedy plot gave maximum K removal by weeds (103 3 kg K/ha) As reported by Jayakumar et al (1987), weeds remove 32 6 kg K/ha from the unweeded plots and uptake by crop was reduced to 7 4 kg K/ha

The review clearly brought out the severe competition between the crop and weed on the uptake of major nutrients and the resultant influence on the grain yield loss in rice

The above review showed that the crop-weed competition was maximum in upland rice than any other type of cultivation Hence the control of weeds should be done at the proper time in order to have good yields

Materials and Methods

MATERIALS AND METHODS

Field experiments were conducted in dry-sown rice during the first crop seasons (May - September) of 1991 and 1992 to evaluate the efficiency of different doses and times of application of oxyflourfen compared to butachlor and thiobencarb The materials used and the methods followed are discussed in this chapter

3.1 Site, soil and climate

The field experiments were conducted in the wet lands of the Regional Agricultural Research Station, Pattambi The Research Station is situated at 10° 40 north latitude and 76° 12 east longitude at an altitude of 25 4 m above mean sea level

The soil of the experimental area was sandy loam in texture It was acidic in reaction with a pH of 5 4 Data on the mechanical composition and chemical analysis of the soil before the commencement of the experiment are given in Table 1 The details of the meteorological observations during the experimental period (1991 & 1992) are presented in Tables 2a & 2b and illustrated in Figures 1a & 1b

Table 1 Physical properties and chemical characteristics of the experimental soil

1 Physical properties

i	Mechanical composition	
	Coarse sand(%)	44 20
	Fine sand(%)	17 39
	Silt(%)	12 80
	Clay(%)	25 41
ii	Chemical characteristics	
	Total N(%)	0 12
	Available P_2O_5(%)	0 0024
	Available K_2O(%)	0 007
	pH	5 40

The area enjoys a warm humid tropical climate and receives a good amount of rainfall through South West monsoon and a smaller quantity through North East monsoon The meteorological parameters like rainfall, minimum and maximum temperature and relative humidity, pertaining to the period of experimentation were recorded from the meteorological observatory attached to the Research Station

Table 2a Mean weekly weather parameters for the cropping season 1991

Sl No	Standard Week No	Month & Week	Temperature (C) Maximum	Temperature (C) Minimum	Mean relative humidity (%)	Total rainfall (mm)	No of bright sunshine hours
1	22	May 28 3	34 1	24 3	91 0	63 8	5 9
2	23	June 4 10	28 6	23 5	95 0	322 8	0 9
3	24	11 17	30 6	23 9	92 0	268 5	2 4
4	25	18 24	30 0	23 7	92 0	88 8	2 4
5	26	25 1	28 6	22 4	94 0	204 6	1 1
6	27	July 2 8	29 6	22 8	93 0	208 1	1 8
7	28	9 15	28 8	23 0	93 0	125 6	2 4
8	29	16 22	30 1	22 0	95 0	148 7	2 1
9	30	23 29	29 4	22 1	95 0	359 4	2 4
10	31	August 30 5	28 9	22 9	94 0	169 0	2 1
11	32	6 12	29 8	22 8	94 0	46 7	2 2
12	33	13 19	28 2	21 8	95 0	288 3	0 9
13	34	20 26	29 4	21 6	94 0	60 4	2 5
14	35	September 27 2	30 8	22 5	94 0	6 6	6 9
15	36	3 9	31 7	22 4	93 0	0 0	9 3
16	37	10 16	31 8	24 0	91 0	0 0	6 4
17	38	17 23	31 8	22 4	93 0	9 6	8 0
18	39	24 30	31 7	23 9	94 0	101 3	6 5

Table 2b Mean weekly weather parameters for the cropping season 1992

Sl No	Standard week No	Month & Week	Temperature (C) Maximum	Temperature (C) Minimum	Mean relative humidity (%)	Total rainfall (mm)	No of bright sunshine hours
1	18	May 30 6	35 8	24 9	1 0	14 6	8 8
2	19	7 13	35 2	23 3	92 0	41 8	8 7
3	20	14 20	31 3	23 3	93 0	29 0	3 9
4	21	21 27	33 9	24 3	89 0	0 0	9 5
5	22	June 28 3	34 1	24 0	90 0	25 4	7 0
6	23	4 10	31 5	23 5	91 0	70 4	4 2
7	24	11 17	30 4	21 5	94 0	312 4	1 7
8	25	18 24	28 6	22 4	92 0	278 2	0 7
9	26	July 25 1	30 3	22 7	94 0	177 1	4 9
10	27	2 8	30 4	22 8	92 0	65 2	2 8
11	28	9 15	29 6	22 2	93 0	29 1	5 1
12	29	16 22	28 2	21 7	95 0	304 4	0 3
13	30	23 29	28 3	22 0	94 0	274 6	0 8
14	31	August 30 5	27 7	21 8	94 0	204 4	0 8
15	32	6 12	29 3	22 3	[illegible] 0	102 0	5 6
16	33	13 19	29 0	22 6	93 0	101 8	3 3
17	34	20 26	29 9	22 5	93 0	34 5	5 9
18	35	September 27 2	29 1	22 4	94 0	91 7	2 8
19	36	3 30	29 0	22 0	93 0	74 7	2 3

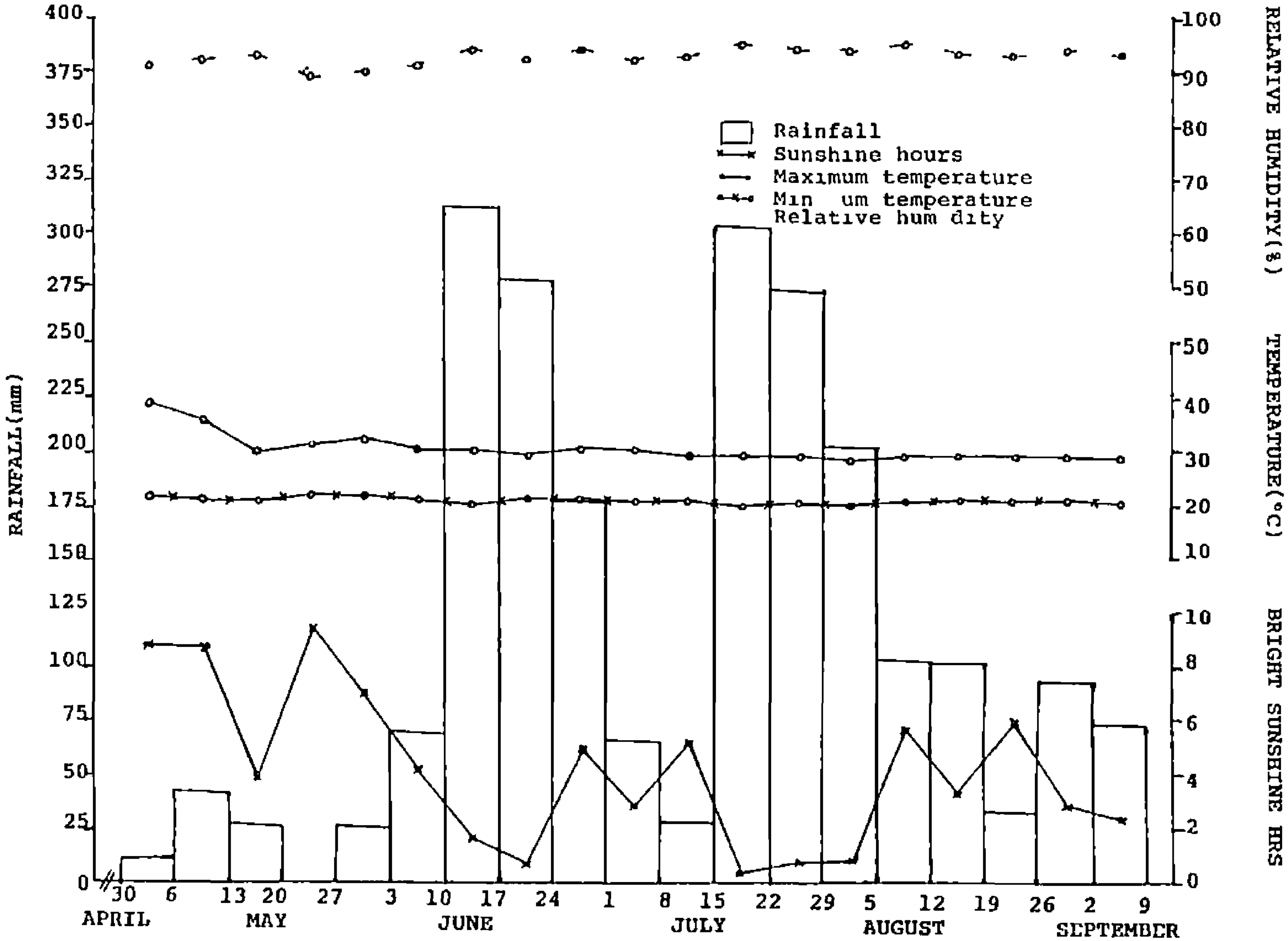


FIG 1b METEOROLOGICAL OBSERVATIONS DURING THE EXPERIMENTAL PERIOD 1992

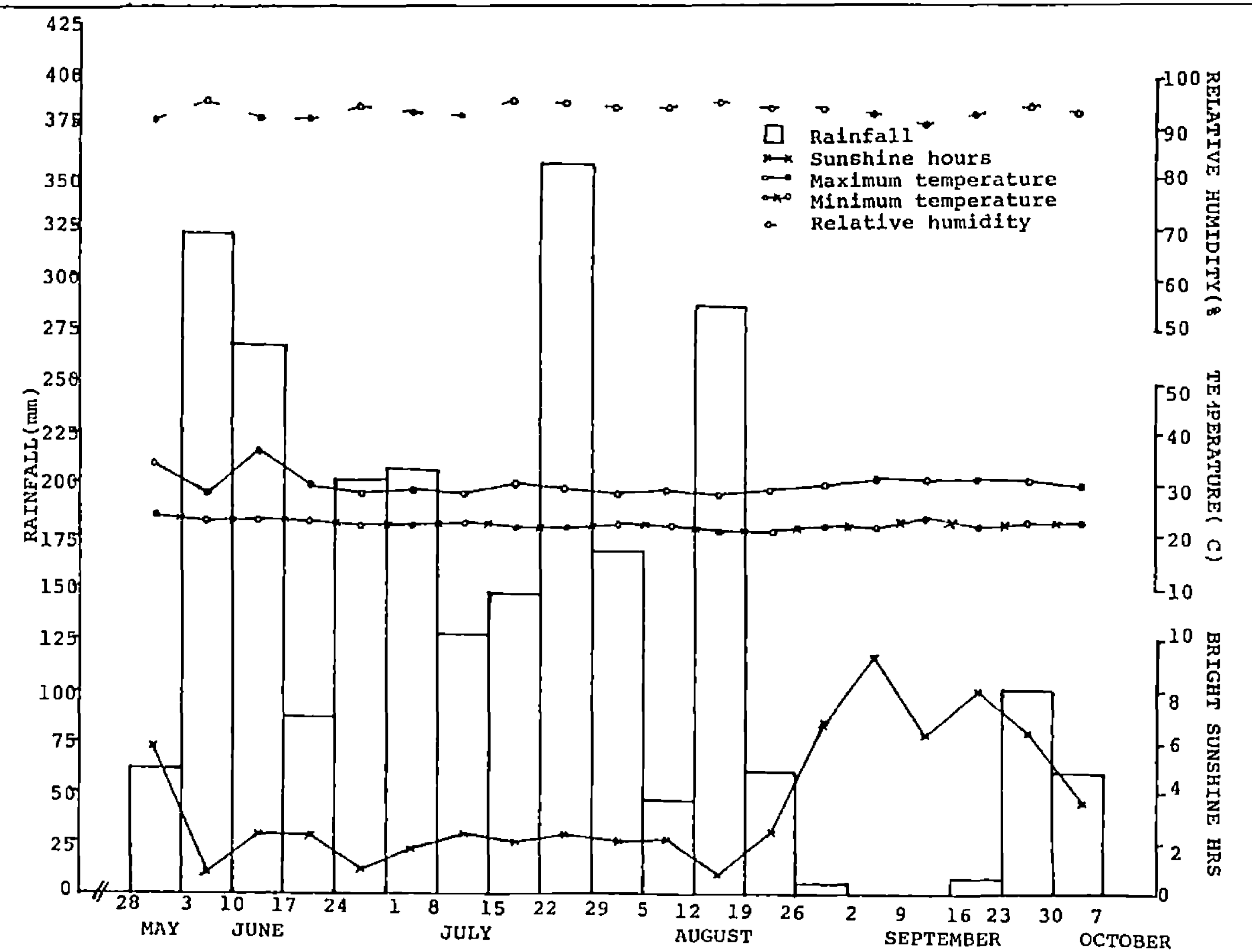


FIG 1a METEOROLOGICAL OBSERVATIONS DURING THE EXPERIMENTAL PERIOD 1991

3.2 Treatments

No of treatments - 16

T1 - Oxyflourfen @ 0 05 kg a ı./ha on the same day of sowıng

T2 - Oxyflourfen @ 0 05 kg a ı /ha three days after sowıng

T3 - Oxyflourfen @ 0 05 kg a ı./ha sıx days after sowıng

T4 - Oxyflourfen @ 0 10 kg a ı /ha on the same day of sowıng

T5 - Oxyflourfen @ 0 10 kg a ı /ha three days after sowıng

T6 - Oxyflourfen @ 0 10 kg a ı /ha sıx days after sowıng

T7 - Oxyflourfen @ 0 15 kg a ı /ha on the same day of sowıng

T8 - Oxyflourfen @ 0 15 kg a ı /ha three days after sowıng

T9 - Oxyflourfen @ 0 15 kg a ı /ha sıx days after sowıng

T10 - Oxyflourfen @ 0 20 kg a ı /ha on the same day of sowıng

T11 - Oxyflourfen @ 0 20 kg a ı /ha three days after sowıng

T12 - Oxyflourfen @ 0 20 kg a ı /ha sıx days after sowıng

T13 - Butachlor @ 1 50 kg a ı /ha on the same day of sowıng

T14 - Thıobencarb @ 1 50 kg a ı /ha on the same day of sowıng

T15 - Hand weedıng on the 20th and 40th days after sowıng

T16 - Unweeded check

3.3 Design and layout

1 Design - RBD

2 Replications - 3

3 Gross plot size - 5 x 4 m^2
(10m strip along the 5m side for destructive sampling)

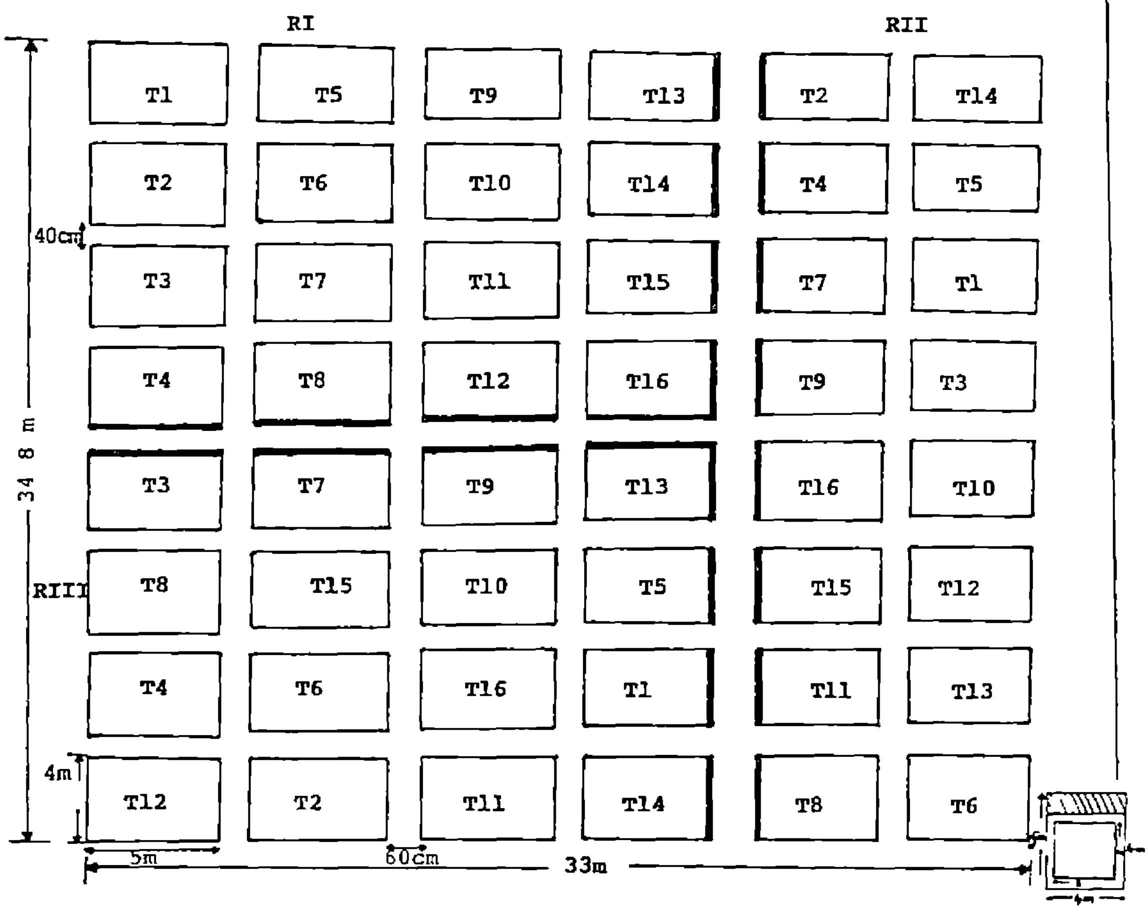
4 Border - 50 cm

5 Net plot size - 3 x 3 m^2

3.4 Herbicides

The details of herbicides used are given below

Name of herbicide	Name of commercial formulation	Name of manufacturer	Percentage of active ingredient
Oxyflourfen	Goal	Indofil chemicals	23 4% EC
Butachlor	Butachlor [redacted] 50 EC	Pest Control Co	50% EC
Thiobencarb	Saturn	Pesticides India Ltd	50% EC



A TREATMENTS

T1 OXYFLOURFEN @ 0 05 kg a i /ha 0 DAS
T2 OXYFLOURFEN @ 0 05 kg a i /ha 3 DAS
T3 OXYFLOURFEN @ 0 05 kg a i /ha 6 DAS
T4 OXYFLOURFEN @ 0 10 kg a i /ha 0 DAS
T5 OXYFLOURFEN @ 0 10 kg a i /ha 3 DAS
T6 OXYFLOUR EN @ 0 10 kg a i /ha 6 DAS
T7 OXYFLOURFEN @ 0 15 kg a i /ha 0 DAS
T8 OXYFLOURFEN @ 0 15 kg a i /ha 3 DAS
T9 OXYFLOURFEN @ 0 15 kg a i /ha 6 DAS
T10 OXYFLOURFEN @ 0 20 kg a i /ha 0 DAS
T11 OXYFLOURFEN @ 0 20 kg a i /ha 3 DAS
T12 OXYFLOURFEN @ 0 20 kg a i /ha 6 DAS
T13 BUTACHLOR @ 1 50 kg a i /ha 0 DAS
T14 THIOBENCARB @ 1 50 kg a i /ha 0 DAS

B CONTROLS

T15 HAND WEEDING
T16 UNWEEDED CHECK

FIG 2 PLAN OF LAYOUT

3.5 Herbicide application

The herbicides, as per the treatments, were sprayed uniformly on the soil surface with a knapsack sprayer fitted with flatfan nozzle Quantity of spray fluid used was 500 l/ha

3.6 Variety

Rice variety Jyothi was used for the study This variety with a duration of 100-125 days has red, long and bold grains This is moderately tolerant to brown plant hopper and blast and is susceptible to sheath blight

3.7 Field culture

The crop was sown on 28th May 1991 and 15th May 1992 during the first and second years of study respectively

The fields were ploughed twice under dry conditions and brought to a fine tilth All the weeds and stubbles were then removed from the field Dry seeds were sown broadcast at the rate of 100 kg/ha after the basal application of fertilizers All the cultural operations were done uniformly in all plots except weed control were followed as per the package of practice recommendations (KAU, 1989) Weed control treatments were given to different plots as per the treatments The fields were flooded four weeks after sowing with the onset of monsoon There was no serious incidence of any disease or pest

The crop which was raised at 1991 was harvested on September 29th 1991 and the crop which was raised at 1992 was harvested on September 2nd 1992 when 80 per cent of the grain had matured

Fertilizer used

The following fertilizers were used for the experiment

Urea - 46% N

Factomphos - 20% N 20% P_2O_5

Muriate of potash - 60% K_2O

Mussoriephos - 20% P_2O_5

Fertilizer schedule - 70 35 35 kg/ha of N, P_2O_5 and K_2O respectively

Time of application - Nitrogen was applied in three split doses Fifty per cent N was applied as basal and 25 per cent each at active tillering and panicle initiation stages Phosphorus was applied fully as basal Potash was applied, half as basal and half at panicle initiation stage

3.8 Observations

3 8 1 Observations on weeds

The observations on weeds were taken from two locations in each plot from the sampling area using a 50 cm x 50 cm (0 25 m^2) wooden quadrat The following observations were recorded -

a) Weed count

The weed count from the sampling unit in each plot was observed species wise and recorded as number/m^2 The observations were taken at 20, 30, 60, 90 DAS and at harvest The count of major weeds as well as total grass, sedge and broad leaved weeds and total weed population were recorded

b) Dry matter production

The weeds from the sampling area in each plot were uprooted, dried firstly in the shade and then in a hot air oven at 70°C and the weed dry weight was recorded in g/m^2 at 20, 30, 60, 90 DAS and at harvest

c) Weed control efficiency

The weed control efficiency of the different treatments were calculated using the formula - (Rao et al , 1976)

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

Where X = Dry matter production of weeds in the unweeded check(g/m^2)

Y = Dry watter production of weeds in the respective treatments (g/m^2)

3.8 2 Observations on crop

a) Phytotoxicity

The rice seedlings were observed for any phytotoxicity symptoms like scorching, retarded growth etc due to herbicide application

b) Crop growth characters

i Dry Matter Production

Five plants were collected from the sampling area, oven dried and the dry matter production was recorded in g/m^2

The observations were taken at 30, 60, 90 DAS and at harvest

ii Plant height

The plant height in cm was recorded at 30, 60, 90 DAS and at harvest The height was measured from the bottom of the culm to the tip of earhead

iii Number of tillers

The total number of tillers were counted from the quadrate at 30, 60 90 DAS and the average was expressed as number of tillers per m^2

c) Yield attributes

i Productive tillers

The number of productive tillers were counted from five plants and the average was expressed as number of productive tillers per plant

ii Length of panicle

The length from the neck to the tip of five panicles were measured and the average length is given in cm.

iii Number of filled grains per panicle

The total number of filled grains of all the sample panicles were separately recorded and the average was worked out

iv Thousand grain weight

One thousand grains were counted from each treatment and the weight was expressed in g

d) Yield

i Grain yield

The grains from each net plot was dried, cleaned, winnowed and the weight recorded in q/ha at 14 per cent moisture

ii Straw yield

The straw from each net plot was dried under sun and the weight recorded in q/ha

iii Harvest index

$$HI \quad \frac{Yecon}{Ybiol}$$

Where Yecon - Economic yield in q/ha

Ybiol - Biological yield in q/ha

iv Weed index

Weed index of different treatments were calculated by using the formula (Gill and Vijaya Kumar, 1969)

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

where, X - yield obtained from the hand weeded treatment in q/ha

Y - yield obtained from the respective treatments in q/ha

3.9 Chemical analysis

The samples of weeds and crops were dried separately in a hot air oven, powdered well in Wiley mill and analysed for N, P and K content

The methods used for analysis were

1 Nitrogen - Microkjeldahl Method (Jackson, 1958)

2 Phosphorus - Vanadomolybdophosphoric Yellow colour method using Colorimeter (Jackson,1958)

3 Potassium - Diacid extract method using Flame photometer (Jackson, 1958)

The crop and weed samples were analysed for N, P and K content at 30, 60, 90 DAS and at harvest At harvest stage, the grain and straw were analysed separately

The dry matter of the weeds and crops was multiplied with the respective nutrient content to arrive at the N, P and K removal by weeds and crops and expressed in kg/ha

3.10 Statistical analysis

The data were compiled, tabulated and analysed by applying the analysis of variance technique (Panse and Sukhatme, 1978) Wherever the F tests were significant appropriate critical differences (CD) were calculated to test the significance of treatment differences Co-efficient of correlation between the important characters were also worked out

Analysis of variance for the data on weed population was carried out after transforming the data to $\sqrt{x+1}$ for those with zero values and to $\sqrt{x}$ for those without zero values

3.11 Economics

The net return per rupee invested under different treatments were computed on the basis of prevailing labour charges, cost of other inputs and the market price of grain and straw at the time of harvest.

Benefit-cost ratio was calculated by using the formula

$$\text{Benefit-cost ratio} = \frac{\text{Gross return (Rs/ha)}}{\text{Total cost of cultivation (Rs/ha)}}$$

Results

RESULTS

The results of the two field experiments during 1991 and 1992 are presented in this section The data on different observations were subjected to analysis of variance and the abstract of analysis of variance is presented in Appendix X . The results are presented under the following heads

4 1 Studies on weeds

4.1 1 Weed Spectrum

4.1 2 Weed population

4.1 3 Dry matter production

4 1 4 Weed control efficiency

4 2 Studies on crop

4 2 1 Phytotoxicity

4 2 2 Growth characters

4 2 3 Yield attributes

4 2 4 Yield

4 2 5 Weed index

4 3 Studies on nutrient uptake

4 3 1 Uptake by weeds

4.3 2 Uptake by crop

4 4 Economics of weed control operations.

a) <u>Saccolepis interrupta</u> (Table 3)

Herbicide application had a significant effect on the control of *Saccolepis interrupta* At 60 and 90 DAS and at harvest, there was differences in the population of *Saccolepis sp* due to herbicide treatments Among the herbicides, the plots applied with oxyflourfen @ 0 15 kg a i /ha on the same day of sowing (T7) and 0 2 kg a i /ha at 3 DAS (T11) contained less number of *Saccolepis sp* This trend was generally observed at all stages (20, 30, 60 90 and harvest) of both the years (1991 and 1992) The incidence of *Saccolepis sp* was more during first year except at 30 DAS

b) <u>Isachne miliacea</u> (Table 4)

During first year, *Isachne miliacea* was not detected in any plots But during second year the experiment was laid out in a different plot and *Isachne miliacea* was the predominant weed species among grasses in this location

There is significant effect of treatments on *Isachne sp* population At 20 DAS, handweeded plots (T15) and plots treated with oxyflourfen @ 0 2 kg a i./ha at 3 DAS (T11) showed the least count of *Isachne sp* followed by

Table 3 Effect of treatments on the population of *Saccolepis interrupta* (No/m^2)

Treat ments	Stages of observation								
	20DAS*	30 DAS@		60 DAS		90 DAS@		Harvest	
	1992	1991	1992	1991@	1992*	1991	1992	1991*	1992@
T1	3 67(12 67)	2 43(6 0)	3 35(11 33)	3 22(10 67)	2 63(6 00)	2 83(8 0)	3 15(10 00)	2 75(6 67)	2 54(6 67)
T2	2 34(4 67)	2 76(8 0)	2 79(8 00)	3 22(10 67)	3 56(12 00)	3 22(10 67)	2 45(6 00)	2 95(8 0)	1 76(3 33)
T3	3 61(12 00)	2 15(4 67)	3 34(11 33)	3 04(9 33)	4 01(15 33)	2 55(6 67)	3 02(9 33)	2 49(5 33)	2 39(6 00)
T4	1 91(2 67)	2 43(6 0)	2 28(5 33)	3 46(12 0)	2 87(7 33)	4 25(18 67)	2 43(6 0)	3 9(14 67)	1 61(2 67)
T5	1 90(2 67)	2 28(6 67)	3 13(10 00)	3 04(9 33)	2 63(6 00)	2 76(8 0)	2 43(6 00)	2 85(7 33)	2 30(5 33)
T6	2 85(7 33)	3 64(13 33)	4 23(18 00)	4 74(22 67)	4 42(8 67)	3 43(12 0)	3 34(11 33)	3 06(8 67)	2 91(8 67)
T7	1 28(0 67)	1 80(3 33)	1 95(4 00)	2 83(8 0)	2 07(3 33)	1 41(2 0)	1 61(2 67)	1 00(0 0)	1 41(2 00)
T8	1 52(1 33)	2 28(5 33)	2 08(4 67)	3 04(9 33)	2 21(4 00)	2 55(6 67)	2 08(4 67)	2 49(5 33)	2 08(4 67)
T9	2 08(3 33)	2 76(8 0)	3 41(12 00)	3 43(12 0)	4 34(8 00)	3 25(10 67)	2 97(9 33)	2 75(6 67)	2 94(8 67)
T10	1 90(2 67)	2 28(5 33)	2 23(5 33)	3 04(9 33)	2 83(7 33)	2 39(6 0)	2 08(4 67)	2 75(6 67)	1 61(2 67)
T11	1 90(2 67)	2 00(4 0)	2 08(4 67)	2 70(7 33)	2 07(3 33)	1 61(2 67)	1 80(3 33)	1 00(0 0)	1 61(2 67)
T12	2 63(6 00)	3 04(9 33)	2 47(6 67)	5 28(28 0)	3 03(8 67)	3 80(14 67)	3 54(12 67)	3 20(9 33)	2 43(6 00)
T13	4 34(18 00)	3 04(9 33)	4 30(18 67)	5 01(25 33)	4 93(23 33)	3 46(12 0)	3 13(10 00)	3 31(10 0)	2 15(4 67)
T14	4 71(21 33)	4 55(21 33)	4 00(16 00)	6 31(40 0)	4 26(17 33)	3 82(14 67)	2 91(8 67)	3 31(10 0)	1 95(4 00)
T15	1 00(0 00)	2 00(4 0)	2 55(6 67)	3 25(10 67)	1 00(0 00)	2 64(7 83)	1 14(1 33)	3 00(8 0	1 41(2 00)
T16	6 75(44 67)	7 03(49 33)	9 76(95 33)	10 64(113 33)	7 67(62 00)	8 36(70 67)	6 10(37 33)	5 85(33 33)	3 80(14 67)
SE m+	0 20	0 28	0 21	0 26	0 26	0 54	0 25	0 26	0 26
CD(0 05)	0 58	0 80	0 62	0 75	0 75	1 56	0 73	0 75	0 75

@ Transformed value ($\sqrt{x}$) * Transformed value ($\sqrt{x+1}$) () Original value

Table 4 Effect of treatments on the population of <u>Isachne miliacea</u> 1992 (No /m^2)

Treatments	Stages of observation				
	20DAS*	30 DAS@	60 DAS@	90 DAS@	Harvest*
T1	2 75(6 67)	3 04(9 33)	3 34(11 33)	2 58(6 67)	2 74(6 67)
T2	2 88(7 33)	4 16(17 33)	4 46(20 00)	3 04(9 33)	3 11(8 67)
T3	4 03(15 33)	4 30(18 67)	4 62(21 33)	2 92(8 67)	3 10(8 67)
T4	3 20(9 33)	5 44(30 0)	5 65(32 0)	2 58(6 67)	2 51(5 33)
T5	2 24(4 0)	2 10(4 67)	2 30(5 33)	1 41(2 0)	1 90(2 0)
T6	3 87(14 0)	3 82(14 67)	3 68(22 0)	3 05(9 33)	3 17(9 33)
T7	1 73(2 0)	2 00(4 0)	2 28(5 33)	1 61(2 67)	1 00(0 00)
T8	2 38(4 67)	2 08(4 67)	2 30(5 33)	2 91(8 67)	2 38(4 67)
T9	3 58(12 0)	4 81(23 33)	3 89(15 33)	2 15(4 67)	2 85(3 33)
T10	2 51(5 33)	2 15(4 67)	3 62(13 33)	1 61(2 67)	2 63(6 0)
T11	1 00(0 00)	1 80(3 33)	2 15(4 67)	1 14(1 33)	1 00(0 00)
T12	6 07(36 0)	5 16(26 67)	5 77(33 33)	3 36(11 33)	3 76(13 33)
T13	4 87(2 67)	5 52(30 67)	6 00(36 00)	2 81(8 0)	3 39(10 0)
T14	3 87(14 0)	5 58(31 33)	5 99(36 00)	3 46(12 0)	3 39(10 67)
T15	1 00(0 00)	3 65(13 33)	4 68(22 0)	2 43(6 0)	2 38(4 67)
T16	10 15(95 33)	9 73(94 67)	8 56(73 33)	6 27(39 33)	5 50(29 33)
SE m±	0 15	0 24	0 20	0 18	0 22
CD(0 05)	0 45	0 70	0 58	0 52	0 63

@ Transformed value ($\sqrt{x}$)
* Transformed value ($\sqrt{x+1}$)
() Original value

oxyflourfen application @ 0 15 kg a i /ha on the same day of sowing (T7), oxyflourfen application @ 0 1 kg a i /ha at 3 DAS (T5), oxyflourfen application @ 0 15 kg a i /ha at 3 DAS (T8) and oxyflourfen application @ 0 2 kg a i /ha on the same day of sowing(T10) The unweeded check (T16) showed the highest weed count At all other stages, plots treated with oxyflourfen @ 0 2 kg a i /ha at 3 DAS(T11) contained the least count and the weed population was less than that observed with hand weeding (T15)

c) Total grass weed population (Saccolepis sp + Isachne sp) (Table 5)

The observations on total grass weed population was done during second year only due to the reduction in grass population during the first year

The effect of weed control treatments on total grass weed population (*Saccolepis interrupta* and *Isachne miliacea*) was significant The plots supplied with oxyflourfen @ 0 2 kg a i /ha at 3 DAS(T11) contained the lowest number of grass weeds at all stages of plant growth followed by the hand weeded plots (T15) and then the plots applied with oxyflourfen @ 0 15 kg a i /ha on the same day of

Table 5 Effect of treatments on the total grass weed population 1992 (No /m^2) (*Saccolepis interrupta* + *Isachne miliacea*)

Treatments	Stages of observation				
	20DAS*	30 DAS@	60 DAS@	90 DAS@	Harvest@
T1	4 41(18 67)	4 96(24 67)	4 24(18 00)	4 00(16 67)	3 82(4 67)
T2	3 70(12 67)	5 03(25 33)	5 81(34 00)	3 97(16 00)	4 31(18 67)
T3	5 56(30 00)	5 68(32 00)	6 04(36 67)	4 28(18 67)	4 32(18 67)
T4	3 70(12 67)	3 35(11 33)	5 07(26 00)	3 81(14 67)	2 94(8 67)
T5	3 21(9 33)	3 90(15 33)	3 73(14 00)	2 94(8 67)	3 25(10 67)
T6	7 00(48 00)	5 93(35 33)	5 87(34 67)	4 60(21 33)	4 69(22 00)
T7	2 63(6 00)	3 72(14 00)	3 90(15 33)	3 01(9 33)	2 39(6 00)
T8	3 85(14 00)	2 91(8 67)	3 12(10 00)	3 64(13 33)	3 26(10 67)
T9	4 43(18 67)	4 24(18 00)	4 69(22 00)	3 73(14 00)	3 98(16 00)
T10	2 99(8 00)	2 55(6 67)	3 34(11 33)	3 15(10 00)	2 92(8 67)
T11	1 73(2 00)	2 10(5 33)	2 66(7 33)	2 30(5 33)	2 00(4 00)
T12	7 68(58 0)	6 36(40 67)	5 88(34 67)	4 90(24 00)	4 46(20 00)
T13	6 06(36 00)	6 61(44 00)	7 83(61 33)	4 23(18 00)	3 61(13 33)
T14	5 70(32 00)	4 87(24 00)	7 16(51 33)	3 44(12 00)	3 34(11 33)
T15	1 00(0 00)	2 92(8 67)	4 68(22 00)	2 66(7 33)	2 94(8 67)
T16	11 70(136 0)	13 41(180 0)	11 48(132 0)	6 72(45 33)	6 05(36 67)
SE m±	0 21	0 25	0 22	0 81	0 21
CD(0 05)	0 61	0 72	0 63	1 57	0 59

@ - Transformed value ($\sqrt{x}$)
* - Transformed value ($\sqrt{x+1}$)
() Original value

sowing (T7) The plots treated with oxyflourfen @ 0 2 kg a i /ha at 3 DAS (T11) was comparable with oxyflourfen application @ 0 2 kg a i /ha at 3 DAS (T10), oxyflourfen application @ 0 15 kg a i /ha at 3 DAS (T8) and hand weeded plots(T15) at 30, 60 and 90 DAS respectively

4 1 2 2 Broadleaved weeds

The predominant broadleaved weeds were Ammania baccifera and Eriocaulon sp

a) Ammania baccifera (Table 6)

There was significant difference in the population of Ammania sp due to the herbicide treatments at the four growth stages studied The weed population of Ammania sp was lowest in the plots treated with oxyflourfen @ 0 15 kg a i /ha on the same day of sowing(T7) followed by plots treated with oxyflourfen @ 0 2 kg a i /ha at 3 DAS(T11) and hand weeding(T_5) At all stages, unweeded check (T16) showed the maximum weed population and the plots treated with oxyflourfen @ 0 1 kg a i /ha at 6 DAS (T6) butachlor application @ 1 5 kg a i /ha on the same day of sowing (T13) and thiobencarb application @ 1 5 kg a i /ha on the same day of sowing (T14) comes next to unweeded check.

Table 6 Effect of treatments on the population of <u>Ammania baccifera</u> 1991 (No / m^2)

Treatments	Stages of observation			
	30 DAS*	60 DAS@	90 DAS@	Harvest@
T1	2 75(6 67)	6 93(48 0)	4 85(24 0)	3 82(14 67)
T2	2 49(5 33)	5 50(30 67)	5 01(25 33)	4 16(17 33)
T3	2 07(3 33)	7 39(54 67)	6 52(42 67)	4 61(21 33)
T4	2 24(4 00)	7 74(60 0)	6 93(48 0)	5 65(32 0)
T5	2 49(5 33)	6 83(46 67)	5 23(28 0)	4 46(20 0)
T6	2 49(5 33)	8 45(72 0)	7 66(58 67)	6 42(41 33)
T7	1 41(1 0)	3 46(12 0)	2 83(8 0)	2 28(5 33)
T8	2 24(4 0)	4 47(20 0)	4 46(22 67)	4 6(21 33)
T9	2 07(3 33)	5 62(28 0)	4 76(20 0)	4 28(18 67)
T10	1 90(2 67)	5 99(28 0)	4 76(20 0)	4 28(18 67)
T11	1 0(0 0)	3 98(16 0)	3 04(9 33)	2 55(6 67)
T12	2 07(3 33)	7 83(61 33)	7 18(52 0)	5 28(28 0)
T13	2 24(4 0)	8 24(68 0)	7 75(60 0)	6 21(38 67)
T14	2 49(5 33)	7 97(64 0)	6 11(37 33)	5 03(25 33)
T15	1 41(1 0)	3 98(16 0)	3 25(10 67)	3 98(16 0)
T16	3 74(13 33)	17 31(300 0)	11 46(132 0)	9 71(94 67)
SE m±	0 17	0 26	0 30	0 20
CD(0 05)	0 49	0 75	0 87	0 57

@ Transformed value ($\sqrt{x}$)
* Transformed value ($\sqrt{x+1}$)
() - Original value

b) <u>Eriocaulon sp</u> (Table 7)

The weed control treatments experienced significant differences in the <u>Eriocaulon sp</u> population also This weed species was observed in the field after 30 days of sowing At 60 DAS, the plots treated with oxyflourfen @ 0.2 kg a i /ha at 3 DAS (T11) contained the least weed count and its effect was on par with the plots supplied with oxyflourfen @ 0 15 kg a i /ha on the same day of sowing (T7), oxyflourfen application @ 0 2 kg a i /ha on the same day of sowing (T10), oxyflourfen application @ 0 15 kg a i /ha at 3 DAS (T8) and oxyflourfen application @ 0 15 kg a i /ha at 6 DAS (T9) At 90 DAS and at harvest, the plots supplied with oxyflourfen @ 0 15 kg a i /ha on the same day of sowing (T7) contained lowest weed count followed by plots treated with oxyflourfen @ 0 2 kg a i /ha on the same day of sowing (T10) and at 3 DAS (T11) At harvest, the plots supplied with butachlor and plots supplied with thiobencarb each @ 1 5 kg a i /ha on the same day of sowing (T13 and T14) contained weed population next to that observed with unweeded check (T16)

4 1 2 3 Sedges

Due to the absence of sedges during first year, the observations were not taken <u>Cyperus rotundus</u> was the predominant weed among sedges during second year

Table 7 Effect of treatments on the population of *Eriocaulon sp* 1991 (No / m^2)

Treat-ments	Stages of observation			
	30 DAS@	60 DAS@	90 DAS@	Harvest*
T1	1 0(0 0)	5 89(34 67)	3 82(14 67)	3 82(14 67)
T2	1 0(0 0)	4 89(24 0)	4 82(23 33)	3 64(13 33)
T3	1 0(0 0)	6 32(40 0)	5 99(36 0)	5.76(33 33)
T4	1 0(0 0)	9 29(86 67)	6 37(40 67)	4 98(25 0)
T5	1 0(0 0)	7 57(57 33)	5 16(26 67)	5 02(25 33)
T6	1 0(0 0)	7 09(50 67)	5 60(31 33)	4 31(18 67)
T7	1 0(0 0)	3 04(9 33)	2 28(5 33)	2 00(4 0)
T8	1 0(0 0)	3 80(14 67)	3 82(14 67)	3 82(14 67)
T9	1 0(0 0)	3 98(19 0)	4 23(18 0)	6 64(13 33)
T10	1 0(0 0)	3 04(9 33)	3 04(9 33)	3 43(12 0)
T11	1 0(0 0)	2 83(8 0)	3 46(5 33)	2 15(4 67)
T12	1 0(0 0)	4 92(24 07)	4 38(19 2)	4 79(23 0)
T13	1 0(0 0)	22 63(512 0)	17 50(318 67)	11 50(132 67)
T14	1 0(0 0)	28 94(848 0)	17 16(294 67)	9 16(90 67)
T15	1 0(0 0)	5 09(26 67)	6 32(40 0)	6 11(37 33)
T16	1 0(0 0)	37 28(1390 67)	29 33(861 0)	14 82(220 0)
SE m±	0 0	0 65	0 23	0 26
CD (0 05)	NS	1 87	0 67	0 76

@ Transformed value ($\sqrt{x}$)
* - Transformed value ($\sqrt{x+1}$)
() - Original value
NS - Non-significant

a) Cyperus rotundus (Table 8)

At early stages (20 and 30 DAS) the plots supplied with oxyflourfen @ 0 15 kg a i /ha on the same day of sowing (T7) and hand weeding (T15) contained the lowest number of weeds followed by the plots treated with oxyflourfen @ 0 2 kg a i /ha on the same day of sowing (T10) and at 3 DAS (T11) and oxyflourfen application @ 0 1 kg a i /ha on the same day of sowing (T4) The highest number of sedges was observed in plots supplied with thiobencarb application and butachlor application @ 1 5 kg a i /ha on the same day of sowing (T14 and T13) at 20 DAS and 30 DAS respectively but only next to unweeded check (T16) At later stages (from 60th day onwards) hand weeded plots (T15) contained the least count of Cyperus sp which was followed by plots supplied with oxyflourfen @ 0 15 kg a i /ha on the same day of sowing (T7) and then oxyflourfen application @ 0 2 kg a i /ha at 3 DAS (T11)

4 1 2 Total weed population (Table 9)
(Grasses, broadleaved weeds and sedges)

There was considerable differences in the total weed population at all stages and both years due to the effect of treatments In general, the plots supplied with oxyflourfen

Table 8 Effect of treatments on the population of *Cyperus rotundus* 1992 (No /m^2)

Treat ments	Stages of observation 20DAS*	30 DAS@	60 DAS*	90 DAS@	Harvest*
T1	1 90(2 67)	2 39(6 00)	3 19(9 33)	2 55(6 67)	2 38(4 67)
T2	2 21(4 00)	2 39(6 00)	2 95(8 00)	2 43(6 00)	2 04(3 33)
T3	2 38(4 67)	3 26(10 67)	3 48(11 33)	2 87(8 67)	2 60(6 00)
T4	1 52(1 33)	1 61(2 67)	2 37(4 67)	1 95(4 00)	1 90(2 67)
T5	1 90(2 67)	1 80(3 33)	2 99(8 00)	2 30(5 33)	2 07(3 33)
T6	2 24(4 00)	2 43(6 00)	3 19(9 33)	2 54(6 67)	2 51(5 33)
T7	1 00(0 00)	1 41(2 00)	2 23(4 00)	1 41(2 00)	1 45(1 17)
T8	1 90(2 67)	1 80(3 33)	2 37(4 67)	2 54(6 67)	2 24(4 00)
T9	2 38(4 67)	2 45(6 00)	2 99(8 00)	2 64(7 33)	2 38(4 67)
T10	1 28(0 67)	1 61(2 67)	3 09(8 67)	2 28(5 33)	2 24(4 00)
T11	1 28(0 67)	1 61(2 67)	2 63(6 00)	2 15(4 67)	2 07(3 33)
T12	3 58(12 00)	2 94(8 67)	4 18(16 67)	3 02(9 33)	3 19(9 33)
T13	2 63(6 00)	2 74(8 67)	4 12(16 00)	2 81(8 00)	2 85(7 33)
T14	3 17(9 33)	3 74(14 00)	3 87(14 00)	2 58(6 67)	2 77(6 67)
T15	1 00(0 00)	2 28(5 339)	1 00(0 00)	0 81(0 67)	1 00(0 00)
T16	5 31(27 33)	5 41(29 33)	6 52(42 0)	6 19(138 33)	6 74(32 00)
SE m±	0 18	0 20	0 25	0 26	0 20
CD(0 05)	0 53	0 58	0 73	0 76	0 57

@ Transformed value ($\sqrt{x}$)
* Transformed value ($\sqrt{x+1}$)
() - Original value

Table 9 Effect of treatments on the total weed population (No/m^2) (Grasses broadleaved weeds & sedges)

Treat ments	Stages of observation								
	20 DAS*	30 DAS@		60 DAS@		90 DAS@		Harvest@	
	1992	1991	1992	1991	1992	1991	1992	1991	1992
T1	4 26(17 33)	3 68(13 67)	4 50(20 33)	12 59(158 67)	4 89(24 00)	7 79(60 67)	5 53(30 67)	5 99(36 0)	4 39(19 33)
T2	4 03(15 33)	3 64(13 67)	4 28(18 67)	8 31(69 33)	6 53(43 33)	6 82(46 67)	4 82(23 33)	6 21(38 67	3 81 14 67)
T3	7 81(60 00)	3 05(9 33)	4 90(24 00)	10 51(110 67)	5 78(34 00)	9 24(85 33)	5 14(26 67)	7 24(60 0)	4 59(21 33)
T4	3 87(14 00)	3 25(10 67)	3 88(15 33)	9 73(94 67)	4 28(18 67)	10 16(103 33)	4 07(16 67)	8 46 71 67)	3 54(12 67)
T5	4 43 18 67)	3 39(11 67)	4 64(22 0)	9 9(98 0)	4 82(23 33)	7 91(62 67)	4 14(17 33)	7 25(52 67)	3 34(11 33)
T6	7 67(5 80)	4 35(19 0)	6 72(45 33)	11 67(136 33)	7 16(51 33)	10 1(102 0)	5 74(33 33)	8 28(68 67)	4 90(24 00)
T7	1 90(2 67)	2 24(5 0)	2 36(6 00)	4 69(22 0)	3 17(10 67)	4 16(17 33)	2 87(8 67)	3 04(9 33)	3 51(12 67)
T8	4 43(18 67)	3 04(9 33)	3 69(14 00)	6 5(42 33)	4 61(21 33)	6 63(44 0)	4 32(18 67)	6 42 41 33)	4 24(18 00)
T9	3 82(14 00)	3 38 11 67	4 20(18 00)	6 78(46 0)	5 56 31 33)	6 98(48 67)	4 43(19 67)	6 20(38 67)	4 65(22 00)
T10	2 60(6 00)	2 88(8 33	3 63(13 33)	7 57(57 33)	3 52(12 67)	6 05(36 67)	4 12(17 33)	6 35 28 67	3 71(14 00)
T11	3 09 8 67)	2 24(5 0)	3 45(12 0)	5 72(32 67)	3 44(12 0)	4 31(18 67)	3 45(12 0)	3 36(11 33)	2 69(7 33)
T12	8 21 66 67)	3 55(12 67)	8 16(66 67)	10 0(100 07)	6 21(38 67)	9 25(85 67)	5 93(35 33)	7 77(60 33)	5 34(28 67)
T13	7 37(53 33)	4 36(19 0)	8 00(66 67)	24 28(589 33)	7 02(50 0)	19 86(394 67)	4 60(21 33)	13 45(181 33)	4 42(20 0)
T14	6 52(42 0)	5 06(26 33)	6 91(48 0)	31 23(975 33)	7 26 52 67)	18 72(350 67)	3 54(18 67)	11 23(126 0	5 00(25 33)
T15	1 00(0 0)	2 16(4 67)	2 69(7 33)	6 82(46 67)	4 68(22 0)	7 62(58 0)	3 24(10 67)	7 83(61 33)	3 02(9 33)
T16	12 42(153 33)	8 04(64 67)	14 09(198 67)	42 04(1768 0)	15 21(231 33)	32 67(1067 67)	8 64(74 67)	18 65(348 0)	7 42(55 33)
SE m+	0 24	0 25	0 33	0 21	0 38	0 20	0 29	0 19	0 31
CD(0 05)	0 70	0 73	0 97	0 61	1 09	0 57	0 84	0 55	0 90

@ Transformed value $\sqrt{x}$) Transformed value ($\sqrt{x+1}$) () Original value

@ 0 15 kg a i /ha on the same day of sowing (T7) contained lowest weed population followed by plots treated with oxyflourfen @ 0 2 kg a i./ha at 3 DAS (T11) and then hand weeding (T15) throughout the crop growth period This trend was consistently observed in both years Between the years, the total weed population was more during first year in all stages except at 30 DAS

4 1 3 <u>Dry matter production</u> (Table 10, Fig 3a & 3b)

The effect of treatments significantly influenced the dry matter production of weeds at all stages of observation and during both years The performance of the plots treated with oxyflourfen @ 0 15 kg a i /ha on the same day of sowing (T7) was better than the plots treated with oxyflourfen @ 0 2 kg a i /ha at 3 DAS (T11) at all stages except at 90 DAS and at harvest where the plots treated with oxyflourfen @ 0 2 kg a i /ha at 3 DAS (T11) was superior This trend was observed during both years But between years, the weed dry matter production was more during second year at all stages of observation

Table 10 Effect of treatments on weed dry matter production (g/m^2)

Treatments	20 DAS 1992	30 DAS 1991	30 DAS 1992	60 DAS 1991	60 DAS 1992	90 DAS 1991	90 DAS 1992	Harvest 1991	Harvest 1992
T1	1 6	12 7	6 7	25 3	66 0	19 0	165 3	16 3	128 0
T2	0 5	13 3	7 3	23 3	46 7	15 3	116 7	12 0	66 0
T3	6 7	10 3	8 7	24 7	64 7	14 0	122 0	11 7	98 7
T4	4 0	10 0	12 0	18 0	14 7	14 3	132 0	12 3	90 0
T5	0 13	13 0	4 0	20 0	16 0	21 0	132 7	18 7	96 0
T6	2 0	13 3	37 3	29 3	71 3	33 7	229 3	21 0	113 0
T7	0 13	1 2	2 7	5 3	11 3	4 7	36 0	2 7	24 7
T8	0 10	11 3	4 7	23 3	17 3	32 0	105 3	13 7	119 0
T9	4 0	13 0	10 7	24 7	89 3	21 7	113 3	11 0	77 0
T10	1 7	7 0	11 3	12 7	12 7	11 3	82 0	6 7	26 0
T11	0 1	1 7	4 0	6 7	12 0	4 0	39 7	2 0	24 0
T12	2 7	6 33	24 0	12 7	56 0	10 7	108 7	5 3	100 0
T13	8 0	23 0	50 0	28 7	93 3	22 7	138 7	7 0	161 3
T14	10 3	22 3	18 7	49 3	57 3	41 0	176 0	10 3	151 3
T15	0 0	0 0	5 3	6 5	2 7	4 7	14 7	2 3	28 0
T16	48 7	37 0	129 3	230 0	133 3	107 0	328 0	41 7	282 7
SE m±	1 76	1 17	3 82	2 57	2 89	1 67	16 34	1 54	8 03
CD(0 05)	5 09	3 38	11 03	7 41	6 13	4 81	47 17	4 44	23 18

FIG 3a

TREND IN WEED DM PRODUCTION AS INFLUENCED BY TREATMENTS 1991

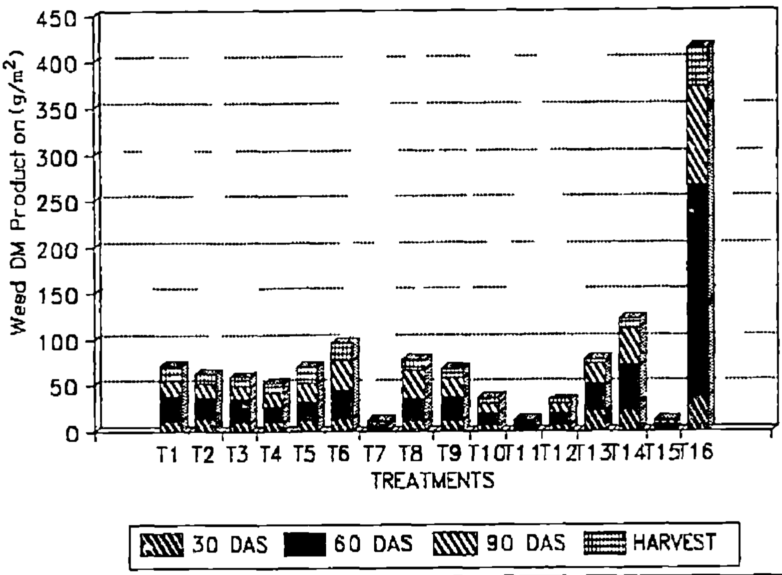


FIG 3b

TREND IN WEED DM PRODUCTION AS INFLUENCED BY TREATMENTS 1992

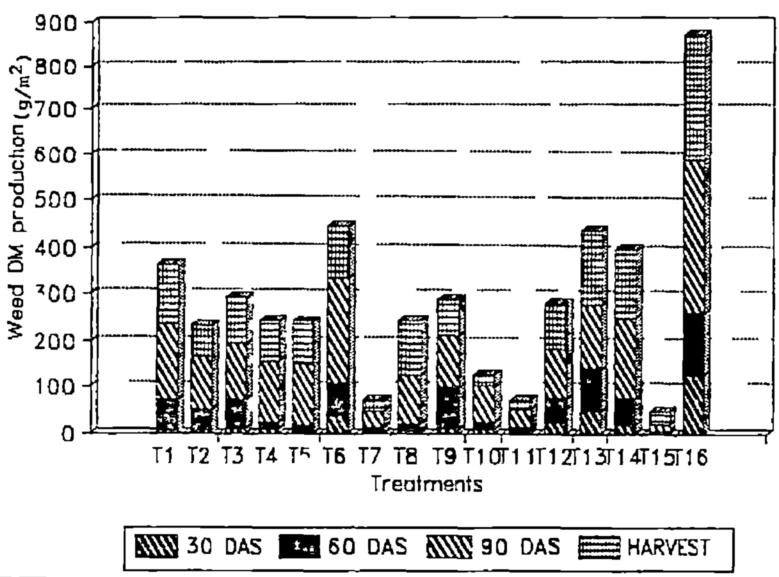


Table 11 Correlation between total weed count and dry matter at different stages

Stages	Correlation coefficient	
	1991	1992
20 DAS	--	0 8800*
30 DAS	0 9025*	0 9751*
60 DAS	0 9128*	0 7457*
90 DAS	0 9186*	0 8604*
Harvest	0 7233*	0 8722*
Critical value (15 df)	0 4820	

The correlation study between the total weed population and the dry matter production by weeds at different stages of observation during both years (Table 11) showed that there was significant positive correlation between these two parameters at all stages of observation

4 1 4 Weed control efficiency (Table 12)

Weed control efficiency differs significantly between the various weed control treatments due to the herbicide application at all stages and during both years of observation The performance of the plots treated with

Table 12 Effect of treatments on weed control efficiency(%) after angular transformation

Treatments	20 DAS	30 DAS		60 DAS		90 DAS		Harvest	
	1992	1991	1992	1991	1992	1991	1992	1991	1992
T1	85 6(96 5)	41 7(66 2)	79 5(94 8)	62 9(88 9)	33 6(50 3)	55 4(82 2)	25 5(43 1)	36 9(59 5)	32 9(43 3)
T2	90 5(98 9)	39 8(63 9)	78 7(94 2)	64 0(89 9)	44 9(64 8)	59 0(85 6)	40 5(64 7)	44 9(70 2)	49 8(76 1)
T3	66 2(86 2)	46 2(72 1)	76 6(93 3)	63 2(89 2)	34 3(51 3)	60 4(86 9)	42 0(66 7)	44 7(71 6)	40 4(64 7)
T4	73 7(91 5)	46 8(72 9)	72 3(90 6)	67 2(92 2)	69 9(89 0)	60 0(86 6)	38 9(62 8)	44 7(70 3)	43 6(68 7)
T5	93 2(99 4)	40 5(64 8)	55 0(96 9)	66 0(91 3)	68 6(87 9)	53 6(80 3)	36 5(59 2)	32 7(53 5)	41 0(65 2)
T6	81 5(95 8)	39 9(64 0)	50 5(71 3)	60 5(87 0)	27 6(45 9)	43 3(68 6)	26 9(45 2)	30 2(48 3)	36 6(59 4)
T7	90 0(100)	75 7(96 9)	87 2(97 9)	77 8(97 7)	73 5(91 5)	73 7(95 7)	63 2(80 0)	69 3(93 2)	65 9(91 3)
T8	90 3(99 7)	44 1(69 6)	82 9(96 4)	63 8(89 6)	67 1(86 9)	44 5(70 1)	43 1(67 7)	41 9(66 7)	35 1(57 6)
T9	73 7(91 5)	40 5(64 7)	74 0(91 7)	63 2(89 2)	21 5(33 1)	52 9(79 7)	40 8(65 3)	40 3(72 9)	46 5(72 5)
T10	82 9(96 4)	54 1(80 9)	73 1(91 1)	70 9(94 5)	72 1(90 5)	63 5(89 40	48 6(75 5)	57 7(84 4)	65 3(90 8)
T11	92 8(99 7)	72 8(95 4)	84 4(96 9)	75 6(97 1)	72 8(90 9)	74 3(96 3)	61 6(87 6)	72 0(95 1)	66 2(91 5)
T12	79 2(94 7)	56 0(82 9)	60 6(81 3)	70 9(94 5)	35 4(57 9)	64 2(90 0)	42 0(66 9)	60 5(86 9)	40 0(64 2)
T13	63 7(83 5)	22 4(39 7)	42 0(61 3)	51 8(78 5)	17 3(29 6)	38 1(61 6)	37 4(60 5)	48 4(74 6)	25 2(41 2)
T14	57 6(77 2)	23 4(39 7)	65 4(85 6)	51 8(78 5)	34 7(56 9)	38 1(61 6)	28 3(47 4)	48 4(74 6)	27 2(45 5)
T15	90 0(100)	90 0(100 0)	81 6(95 7)	76 3 97 2)	78 7(98 0)	73 1(95 6)	72 0(95 5)	70 6 94 1)	64 7(90 3)
SE m+	3 07	0 94	1 70	2 05	1 83	1 53	2 78	3 21	1 98
CD(0 05)	8 90	2 74	4 93	5 93	5 31	4 55	8 06	9 31	5 73

Stages of observation

() Original value in per cent

oxyflourfen @ 0 15 kg a i /ha on the same day of sowing (T7) was better in all stages than other treatments except at harvest during both years followed by hand weeding (T15) and then plots treated with oxyflourfen @ 0 2 kg a i /ha at 3 DAS (T11) Between years the maximum weed control efficiency was experienced during first year in all stages except at 30 DAS

4.2 Studies on crop

4 2 1 Phytotoxicity

The herbicide oxyflourfen showed slight scorching or burning of leaf tips at different doses only when applied at six days after sowing. But the plant recovered from these symptoms within a week Similarly butachlor and thiobencarb did not exhibit any phytotoxic symptoms and hence no data are presented

4 2 2 Growth characters

a) Height of plants (Table 13)

During both years the treatments significantly influenced the plant height due to herbicide application at

Table 13 Effect of treatment on height of rice (cm)

Treatments	Stages of observation: 30 DAS 1992	60 DAS 1992	90 DAS 1992	Harvest 1991	Harvest 1992
T1	18 5	59 4	83 1	84 3	90 0
T2	18 0	60 4	78 1	77 7	88 5
T3	19 1	62 2	88 5	80 4	82 6
T4	19 1	56 1	81 8	76 8	83 0
T5	18 2	51 8	74 1	82 1	83 5
T6	17 5	64 2	77 6	79 2	90 3
T7	19 2	62 2	88 2	87 0	85 3
T8	19 6	62 5	77 3	85 0	88 9
T9	17 6	67 7	79 1	81 2	86 3
T10	18 1	59 6	78 8	77 7	85 1
T11	18 5	58 6	79 6	73 5	86 4
T12	18 4	63 0	74 8	79 0	88 4
T13	20 2	61 6	86 7	78 5	73 0
T14	18 2	62 1	74 2	76 0	86 6
T15	18 9	59 0	76 9	75 1	86 0
T16	19 3	55 9	67 1	87 2	94 1
SE m±	0 597	0 984	1 31	2 22	1 77
CD(0 05)	NS	2 84	3 78	6 41	5 10

NS Non significant

all stages At 60 and 90 DAS, the plots treated with oxyflourfen @ 0 15 kg a i /ha at 6 DAS (T9) and oxyflourfen application @ 0 05 kg a i /ha at 6 DAS (T3) contained the tallest plants respectively At harvest, the tallest plants were noticed in the unweeded check (T16) followed by the plots treated with oxyflourfen @ 0 15 kg a i /ha on the same day of sowing (T7) during first year and the plots treated with oxyflourfen @ 0 1 kg a i /ha at 6 DAS (T6) during second year

b) Number of tillers per m^2 (Table 14)

This observation was recorded only during second year During this year, the tiller production was significantly influenced by the treatments At 30 and 90 DAS, the tiller production was highest in the plots supplied with oxyflourfen @ 0 15 kg a i /ha on the same day of sowing (T7) followed by the hand weeded plots (T15) and plots treated with oxyflourfen @ 0 2 kg a i /ha at 3 DAS (T11) at 30 and 90 DAS respectively At 60 DAS the plots supplied with oxyflourfen @ 0 2 kg a i /ha at 3 DAS (T11) contains more number of tillers and the effect was on par with hand weeded plots (T15)

Table 14 Effect of treatment on number of tillers per m^2 1992

Treatments	Stages of observation		
	30 DAS	60 DAS	90 DAS
T1	267	328	805
T2	256	432	873
T3	299	464	833
T4	257	440	787
T5	234	392	953
T6	288	512	640
T7	352	504	1174
T8	309	480	1096
T9	235	520	904
T10	331	448	1033
T11	309	544	1104
T12	256	448	740
T13	288	360	640
T14	224	384	861
T15	341	520	937
T16	224	424	567
SE m±	20 23	21 88	42 22
CD(0 05)	58 43	63 19	121 91

c) Crop dry matter production (Table 15, Fig 4a and 4b)

The dry matter production of crop was significantly influenced by weed control treatments at all stages of growth during both years The dry matter production was highest in the hand weeded plots (T15) at all stages of observation and during both years except at 60 DAS during 1991 and at harvest during 1992 The hand weeded plots follows the plots treated with oxyflourfen @ 0 2 kg a i /ha at 3 DAS (T11) in almost all stages and then oxyflourfen application @ 0 15 kg a i /ha on the same day oi sowing (T7) and these three treatments were comparable with each other Between years the crop dry matter production was maximum during second year but the difference was negligible

Table 16 Correlation between crop and weed dry matter production at different stages

Stages	Correlation coefficient	
	1991	1992
30 DAS	-0 7300*	-0 4546*
60 DAS	-0 6799*	-0 6809*
90 DAS	-0 7891*	-0 6487*
Harvest	-0 9570*	-0 8243*
Critical value (15 df)	0 4820	

Table 15 Effect of treatments on crop dry matter productıon (g/m^2).

Treat ments	Stages of observatıon							
	30 DAS		60 DAS		90 DAS		Harvest	
	1991	1992	1991	1992	1991	1992	1991	1992
T1	30 0	32 7	310 1	244 0	461 1	495 0	836 7	776 7
T2	65 7	64 0	297 3	320 0	506 7	470 0	967 3	953 3
T3	58 0	55 3	257 3	362 0	407 3	427 7	882 0	853 3
T4	34 7	32 0	301 3	220 0	427 3	520 0	834 7	873 3
T5	25 7	25 3	288 0	222 0	410 7	471 7	777 0	850 0
T6	60 7	55 3	289 3	364 0	413 3	415 0	826 7	593 3
T7	68 7	60 0	305 3	300 0	527 3	461 3	1061 7	1243 3
T8	65 3	66 7	305 3	345 3	430 7	568 7	864 7	890 0
T9	59 7	56 0	277 3	410 7	456 0	493 3	922 0	1000 0
T10	58 0	60 0	282 7	296 0	497 3	635 0	893 0	816 7
T11	88 3	89 3	353 3	440 0	527 3	656 3	1029 7	1253 3
T12	66 0	66 3	238 7	324 0	429 3	460 0	956 3	840 0
T13	40 3	41 6	277 3	332 0	429 0	405 0	912 0	733 3
T14	41 8	57 6	270 7	304 0	420 7	571 7	878 0	900 0
T15	99 0	102 7	344 0	476 0	541 3	661 7	1092 7	1066 7
T16	23 0	23 2	202 0	192 0	312 0	373 3	344 7	376 0
SE m±	3 31	3 78	22 31	13 16	38 79	21 73	50 38	63 09
CD(0 05)	9 55	10 91	64 43	37 99	112 02	62 75	145 50	182 21

FIG 4a

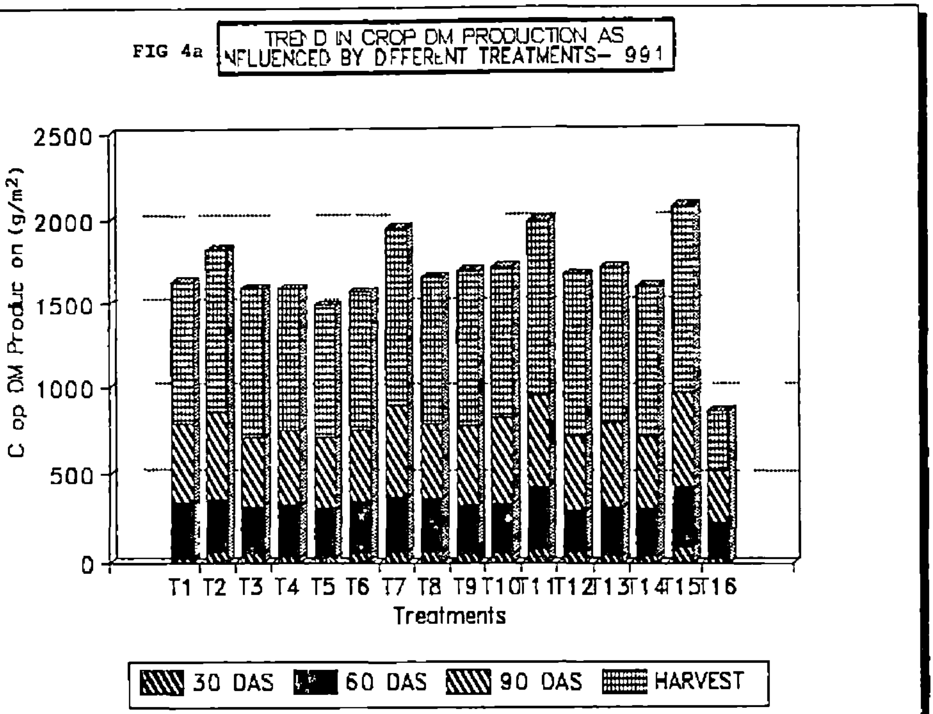
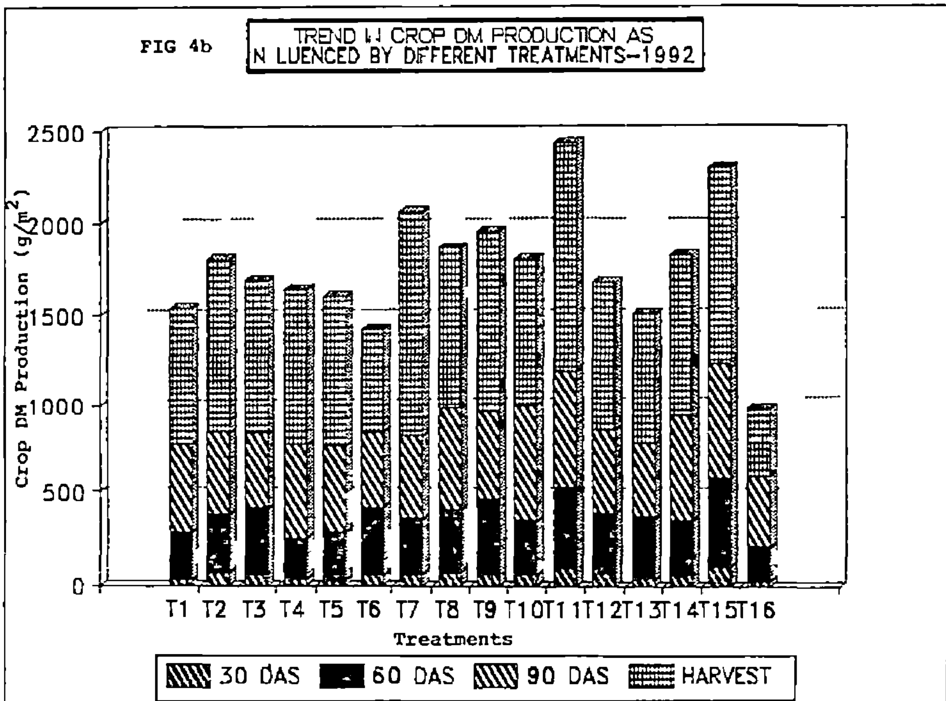

TRE D IN CROP DM PRODUCTION AS
NFLUENCED BY DFFERENT TREATMENTS- 991
C op DM Produc on (g/m²)
2500
2000
1500
1000
500
0
T1 T2 T3 T4 T5 T6 T7 T8 T9 T10 T11 T12 T13 T14 T15 T16
Treatments
30 DAS
60 DAS
90 DAS
HARVEST

FIG 4b


TREND I CROP DM PRODUCTION AS
N LUENCED BY DIFFERENT TREATMENTS-1992
Crop DM Production (g/m²)
2500
2000
1500
1000
500
0
T1 T2 T3 T4 T5 T6 T7 T8 T9 T10 T11 T12 T13 T14 T15 T16
Treatments
30 DAS
60 DAS
90 DAS
HARVEST

The correlation study between crop and weed dry matter production during both years (Table 16) showed that there is significant negative correlation between these two parameters at all stages of observation

4 2 3 <u>Yield attributes</u> (Table 17)

a) Productive tillers

The number of productive tillers differ significantly between the treatments due to herbicide application during both years During both years, hand weeded plots (T15) showed the highest number of productive tillers and the effect was comparable with the plots supplied with oxyflourfen @ 0 2 kg a i /ha at 3 DAS (T11) The number of productive tillers was lowest in the unweeded check (T16) during both years

b) Length of panicle

The length of panicle in different treatments differ significantly during first year The plots treated with oxyflourfen @ 0 2 kg a i /ha at 3 DAS (T11) contained the longest panicle and the effect was on par with that of hand weeding (T15) and plots treated with oxyflourfen @ 0 15 kg a i /ha on the same day of sowing (T7)

Table 17 Effect of treatments on yield attributes

Treatments	No of productive tillers 1991	No of productive tillers 1992	Panicle length (cm) 1991	Panicle length (cm) 1992	Number of filled grains per panicle 1991	Number of filled grains per panicle 1992	Thousand grain weight (g) 1991	Thousand grain weight (g) 1992
T1	5 17	5 53	19 7	17 5	59 1	61 3	29 5	29 5
T2	4 67	5 73	20 0	19 0	67 2	67 3	31 5	30 2
T3	5 00	5 53	20 0	18 9	69 5	64 5	31 2	29 8
T4	5 33	5 13	19 2	19 3	66 8	67 8	30 8	28 6
T5	5 33	5 47	19 4	19 2	74 8	66 1	30 8	30 0
T6	4 33	4 03	19 4	18 9	67 6	58 6	31 2	28 3
T7	6 33	6 5	20 3	19 7	88 4	86 4	32 0	30 7
T8	6 03	5 6	19 2	19 3	67 6	62 0	29 7	29 9
T9	5 00	5 67	19 7	19 1	67 8	67 0	30 2	29 5
T10	5 33	6 27	20 1	19 5	71 3	70 1	30 8	30 1
T11	7 33	7 07	20 5	19 0	89 5	87 8	32 2	30 1
T12	5 33	5 37	20 1	19 4	64 3	74 9	29 5	29 7
T13	5 00	5 50	19 1	19 4	64 3	71 5	29 5	28 8
T14	3 83	5 20	18 8	19 6	69 8	70 8	29 5	29 7
T15	7 33	7 67	20 3	20 3	90 8	88 6	32 3	31 5
T16	4 00	3 80	18 7	19 3	59 2	56 2	28 0	28 0
SE m±	0 73	0 94	0 35	0 67	2 8	2 91	0 43	0 48
CD(0 05)	1 78	2 70	0 24	NS	8 1	8 40	1 25	1 40

NS Non Significant

c) Number of filled grains per panicle

During both years, the highest number of filled grains per panicle was noticed in hand weeded plots (T15), followed by the plots treated with oxyflourfen @ 0 2 kg a i /ha at 3 DAS (T11) The number of filled grains per panicle noticed in the plots treated with oxyflourfen @ 0 15 kg a i /ha on the same day of sowing (T7) and oxyflourfen application @ 0 2 kg a i /ha at 3 DAS (T11) were on par with that observed with hand weeded plots The least number of filled grains per panicle was noticed in the unweeded check (T16)

d) Thousand grain weight

The thousand grain weight was highest in hand weeded plots (T15) during both years followed by the plots applied with oxyflourfen @ 0 2 kg a i /ha at 3 DAS (T11) and then oxyflourfen application @ 0 15 kg a i /ha on the same day of sowing (T7) The thousand grain weight noticed in these three plots were more or less similar

4 2 4 Yield (Table 18, Fig 5a & 5b)

a) Grain yield

The effect of treatments on grain yield was considerable on both years During first year (1991), the

Table 18 Effect of treatments on the yield (q/ha) and harvest index

Treatments	Grain yield 1991	Grain yield 1992	Grain yield Pooled Mean	Straw yield 1991	Straw yield 1992	Harvest index 1991	Harvest index 1992
T1	32 22	27 76	29 99	45 37	41 11	0 42	0 40
T2	32 07	30 93	31 50	40 18	41 48	0 44	0 43
T3	29 82	23 70	26 76	42 23	35 11	0 41	0 40
T4	29 82	26 22	28 02	43 70	39 26	0 41	0 41
T5	31 48	28 67	30 08	41 30	38 89	0 43	0 42
T6	27 22	23 44	25 33	41 85	35 19	0 40	0 40
T7	36 22	33 96	35 09	45 37	45 93	0 44	0 43
T8	33 89	31 52	32 71	41 48	42 96	0 45	0 42
T9	30 93	25 44	28 19	37 22	38 15	0 43	0 40
T10	32 96	34 59	33 78	42 22	47 41	0 43	0 42
T11	41 96	41 04	41 50	47 04	49 59	0 47	0 45
T12	26 85	24 82	25 84	38 33	37 79	0 41	0 40
T13	28 52	25 07	26 80	44 82	38 89	0 39	0 39
T14	29 63	26 45	28 04	8 63	40 00	0 43	0 40
T15	42 04	40 96	41 50	52 41	48 59	0 45	0 46
T16	20 56	19 70	20 13	28 85	31 48	0 42	0 38
SE m±	1 31	1 78	0 98	2 62	2 28	0 05	0 88
CD(0 05)	3 77	5 13	2 83	7 56	6 58	NS	NS

NS Non-significant

FIG 5a EFFECT OF TREATMENTS ON THE YIELD OF RICE 1991

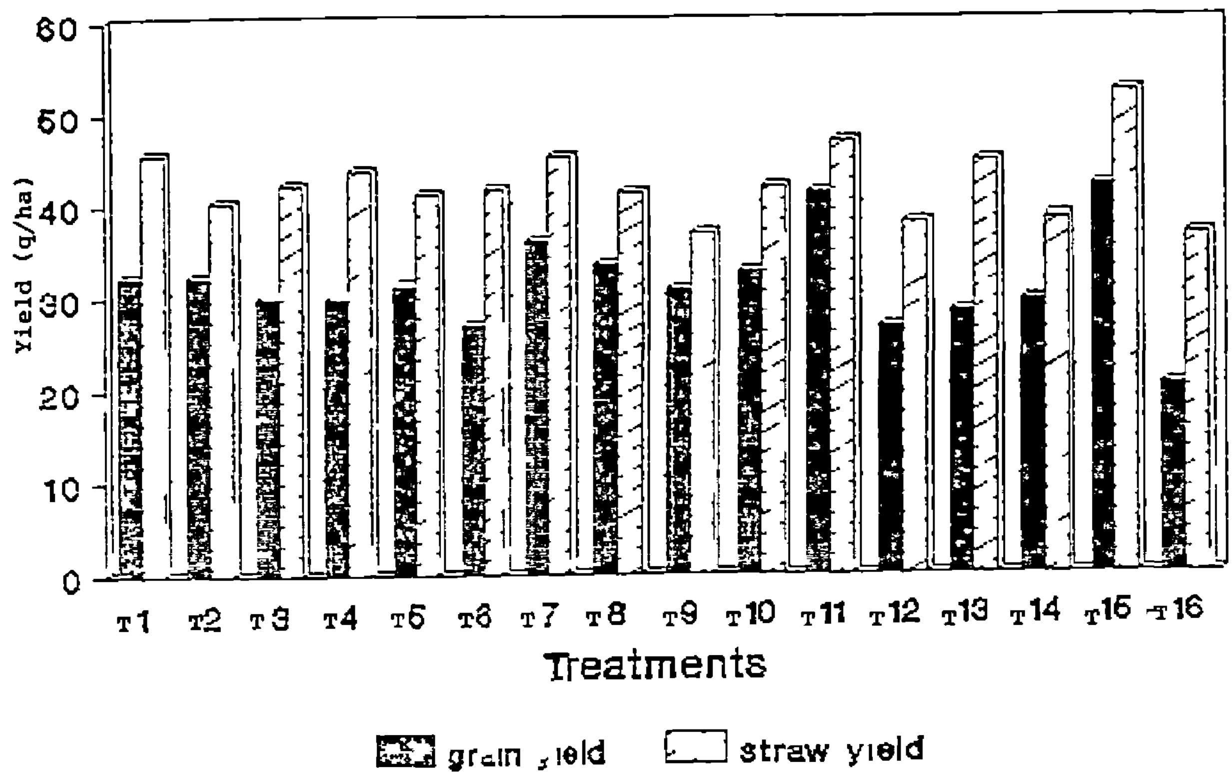
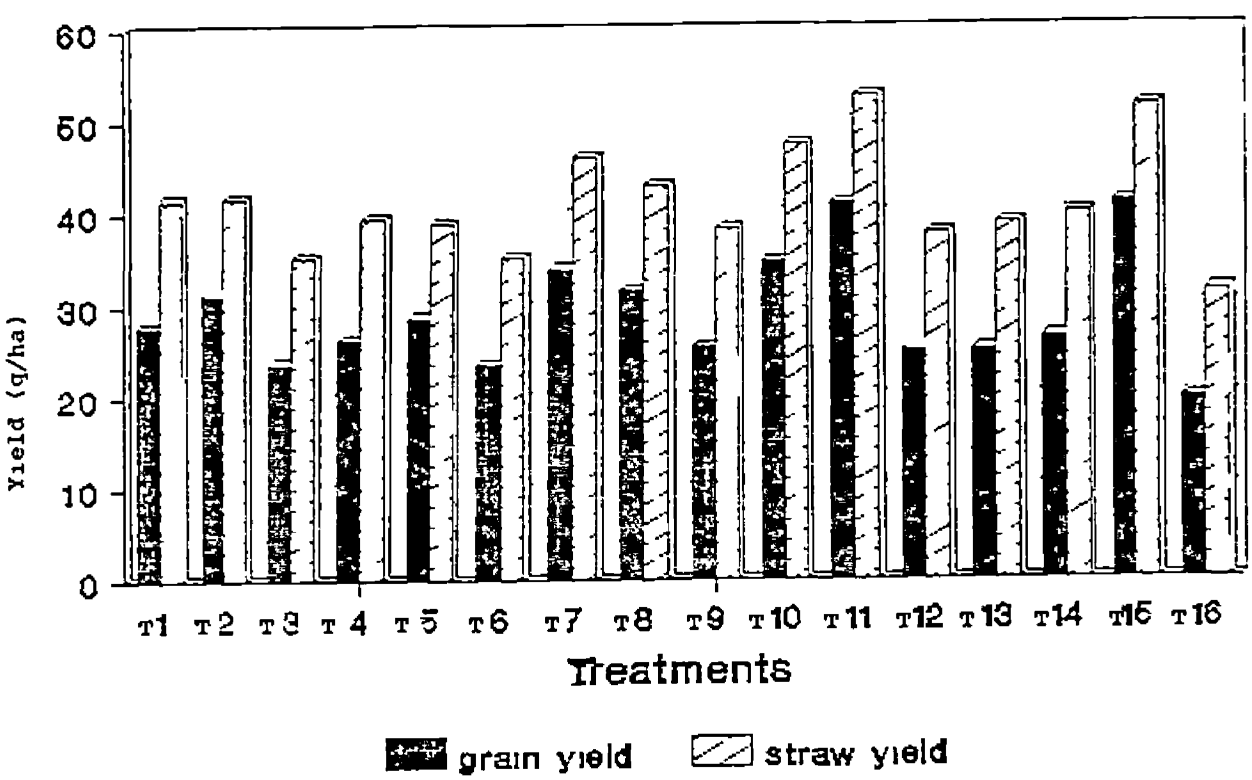


FIG 5b EFFECT OF TREATMENTS ON THE YIELD OF RICE 1992



highest yield was obtained from the hand weeded plots (T15) followed by plots supplied with oxyflourfen @ 0 2 kg a i /ha at 3 DAS (T11) and the yield levels in these two treatments were comparable During 1992, the highest yield was noticed in the plots treated with oxyflourfen @ 0 2 kg a i /ha at 3 DAS (T11) followed by hand weeded plots (T15) and the yield levels in these two treatments were comparable The lowest yield were noticed in unweeded check (T16) during both years

Table 19 Correlation between grain yield, with weed count and weed dry matter production at different stages

Stages	Correlation coefficient			
	Grain yield x weed count		Grain yield x weed dry matter production	
	1991	1992	1991	1992
20 DAS	--	-0 7213*	-	-0 5356*
30 DAS	-0 7408*	-0 6072*	-0 7985*	-0 5747*
60 DAS	-0 6272*	-0 5527*	-0 6483*	-0 7943*
90 DAS	-0 6566*	-0 6760*	-0 7052*	-0 8166*
Harvest	-0 6820*	-0 7327*	-0 7280*	-0 7687*
Critical value (15 df)	0 4820			

The correlation study between the grain yield with weed count and weed dry matter production during both years (Table 19) showed that there is significant negative correlation between the parameters at different stages of observation

The pooled mean from two years data showed that the plot treated with oxyflourfen @ 0 2 kg a i /ha at 3 DAS (T11) and hand weeded plots (T15) showed significantly higher yield and both the yield levels were similar The next highest yield was obtained with oxyflourfen application @ 0 15 kg a i /ha on the same day of sowing (T7) and its effect was on par with oxyflourfen application @ 0 2 kg a i /ha on the same day of sowing (T10)

b) Straw yield

During first year similar to grain yield straw yield was highest in the hand weeded plots (15) which can be comparable with the plots treated with oxyflourfen @ 0 2 kg a i /ha at 3 DAS (T11) During second year, the same trend was noticed The unweeded check showed the lowest yield during both the years

c) Harvest index

The harvest index was not influenced by the different weed control treatments under study during both years

4 2 5 Weed index (Table 20, Fig 6a & 6b)

During both the years, the weed index was the lowest in the plot treated with oxyflourfen @ 0 2 kg a i /ha at 3 DAS (T11) followed by the plots treated with oxyflourfen @ 0 15 kg a i /ha on the same day of sowing (T7) and oxyflourfen application @ 0 2 kg a i /ha on the same day of sowing (T10) during first and second year respectively The maximum weed index was noticed in the unweeded check during both years

4 3 Studies on nutrient uptake

4 3 1 Uptake by weeds

4 3 1 1 Nitrogen (Table 21) Fig 7

There was considerable difference in the nitrogen uptake by weeds due to weed control treatments at all stages of plant growth The nitrogen removal by weeds was the

Table 20 Effect of treatments on weed index (%) after angular transformation

Treatments	Weed Index 1991	Weed Index 1992
T1	11 7(20 2)	18 5(22 3)
T2	11 9(20 6)	14 0(28 5)
T3	15 2(26 2)	25 0(36 2)
T4	15 2(26 2)	20 8(37 1)
T5	12 7(22 0)	17 1(31 5)
T6	19 1(32 6)	25 3(38 0)
T7	5 9(10 3)	9 8(25 7)
T8	9 2(16 1)	12 8(19 5)
T9	13 5(23 4)	23 8(33 1)
T10	10 6(18 4)	8 7(22 2)
T11	0 5(0 9)	-0 26(3 6)
T12	19 6(33 5)	23 0(27 1)
T13	17 1(29 4)	22 7(38 9)
T14	15 4(26 6)	20 5(36 7)
T16	29 5(49 1)	31 0(46 8)
SE m±	1 31	1 28
CD(0 05)	4 50	3 69

() Original value in per cent

FIG 6a Effect of treatments on weed index 1991

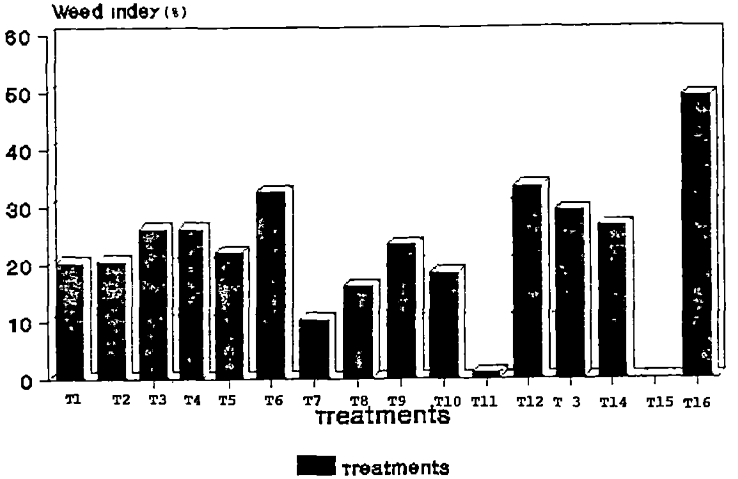


FIG 6b Effect of treatments on weed index 1992

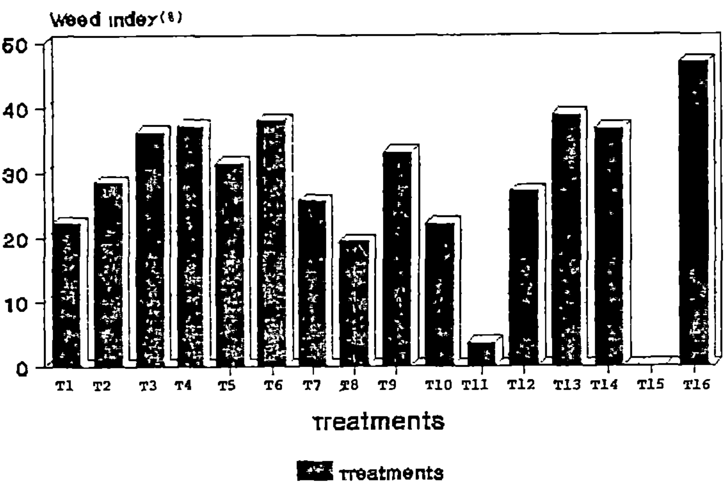


Table 21 Effect of treatments on nitrogen uptake by weeds 1992 (kg/ha)

Treatments	Stages of observation			
	30 DAS	60 DAS	90 DAS	Harvest
T1	2 0	12 3	13 9	25 6
T2	1 7	9 0	14 7	12 5
T3	2 5	14 9	12 0	19 7
T4	3 0	2 5	15 8	16 2
T5	0 7	3 3	16 7	16 3
T6	9 6	17 0	32 1	18 1
T7	0 5	1 9	3 3	2 7
T8	1 8	2 8	13 3	15 5
T9	2 6	20 7	15 9	11 6
T10	3 1	2 8	8 4	3 4
T11	0 7	2 1	3 3	2 6
T12	6 5	11 4	14 7	14 0
T13	14 8	15 8	13 1	25 8
T14	4 7	9 7	18 1	24 2
T15	1 7	0 46	1 0	3 1
T16	39 5	21 9	41 3	59 4
SE m±	0 446	0 502	2 03	1 47
CD(0 05)	1 29	1 55	5 85	4 23

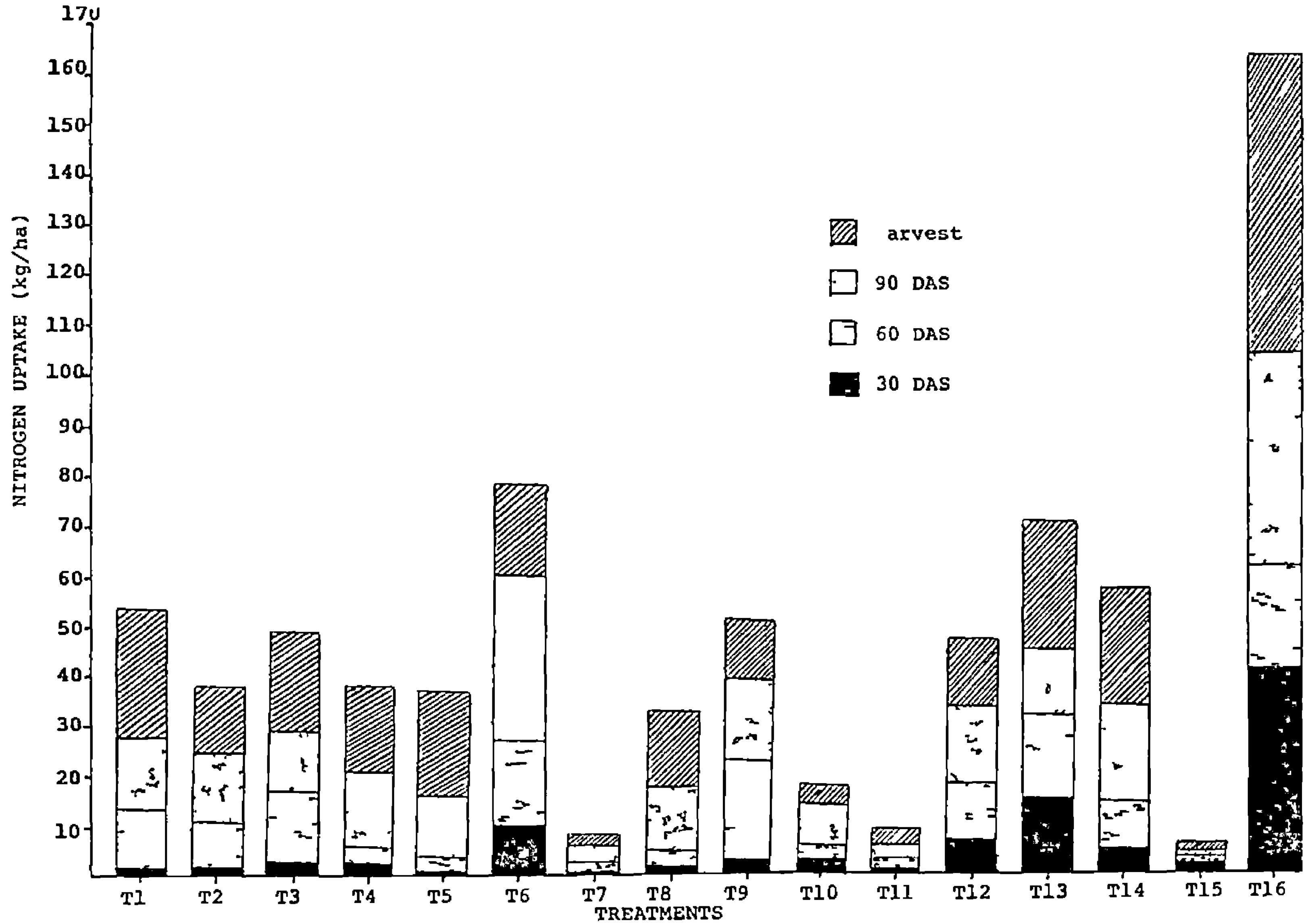


FIG 7 EFFECT OF TREATMENTS ON NITROGEN UPTAKE BY WEEDS 1992

lowest in the plots treated with oxyflourfen @ 0 15 kg a i /ha on the same day of sowing (T7) followed by hand weeded plots (T15) and oxyflourfen application @ 0 2 kg a i /ha at 3 DAS (T11) and the effects of these treatments on nitrogen removal were comparable The plots treated with butachlor @ 1 5 kg a i /ha on the same day of sowing (T13) comes next to unweeded check (T16)

4 3 1 2 Phosphorus (Table 22, Fig 8)

The phosphorus uptake by weeds was significantly influenced by the weed control treatments at all stages of observation At all stages of observation, the plots treated with oxyflourfen @ 0 15 kg a i /ha on the same day of sowing (T7) contained the minimum quantity of phosphorus uptake except at harvest, at which the plots supplied with oxyflourfen @ 0 2 kg a i /ha at 3 DAS (T11) showed the least uptake and these two treatments were comparable The uptake shown by the hand weeded plots at 60 and 90 DAS, follows the plots treated with oxyflourfen @ 0 2 kg a i /ha at 3 DAS (T11) The maximum uptake was recorded by the unweeded check (T16), followed by the plots treated with butachlor @ 1 5 kg a i /ha on the same day of sowing (T13) except at 90 DAS

Table 22 Effect of treatments on the phosphorus uptake by weeds 1992 (kg/ha)

Treat-ments	Stages of observation			
	30 DAS	60 DAS	90 DAS	Harvest
T1	0 28	1 7	3 3	3 3
T2	0 23	1 2	3 3	2 3
T3	0 35	1 3	2 2	2 7
T4	0 42	0 33	2 8	3 2
T5	0 11	0 44	2 6	2 5
T6	1 6	1 7	5 3	3 2
T7	0 09	0 10	0 77	0 80
T8	0 13	0 35	2 5	3 9
T9	0 32	0 23	2 4	2 5
T10	0 40	0 25	1 7	0 89
T11	0 11	0 21	0 91	0.78
T12	0 97	1 8	2 6	3 5
T13	2 0	1 9	3.4	5 7
T14	0 76	1 2	4 3	3 9
T15	0 22	0 10	0 27	0 91
T16	4 9	3 3	7 7	9 9
SE m±	0 087	0 082	0 14	0 28
CD(0 05)	0 25	0 24	0 41	0 82

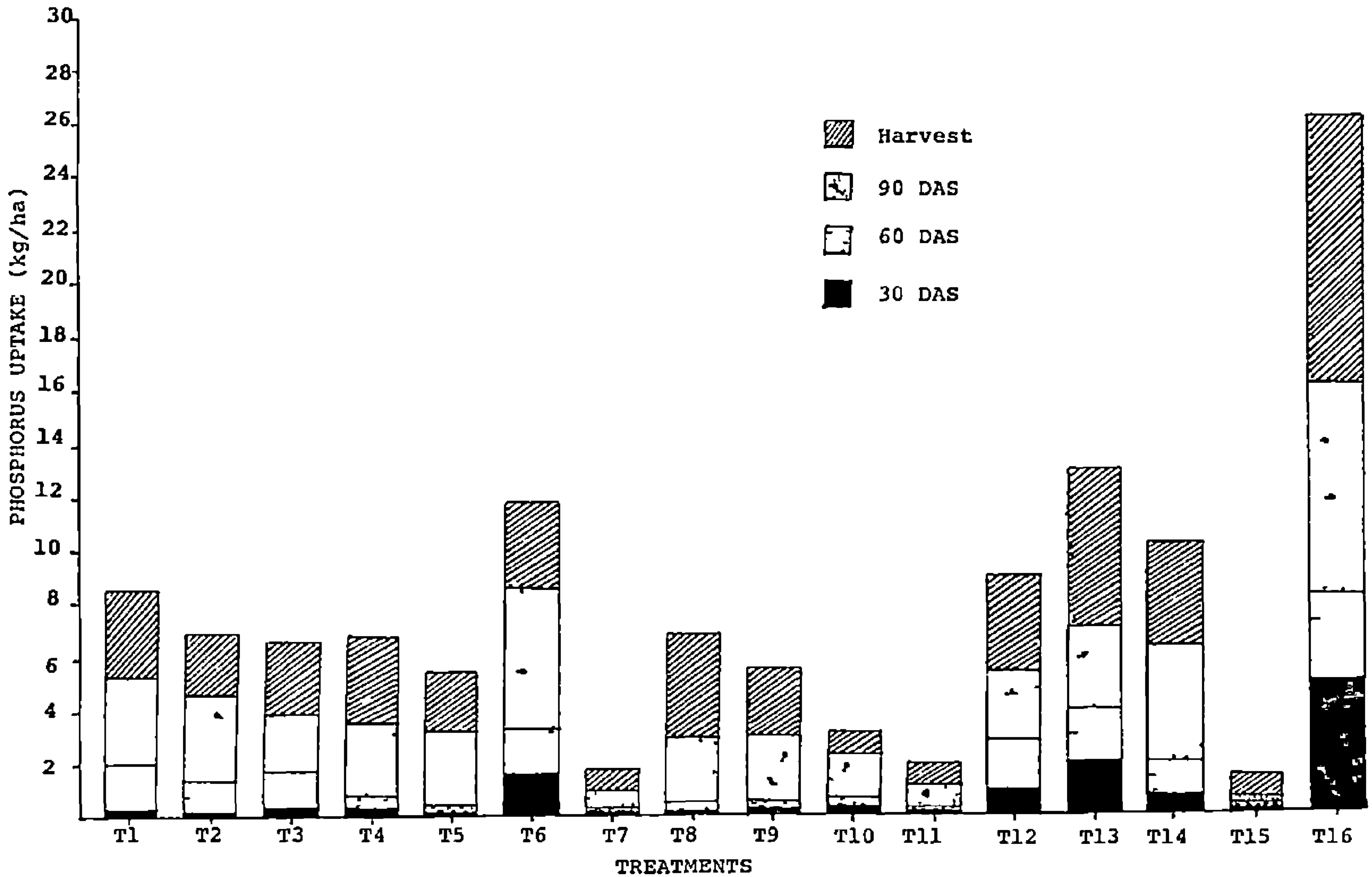


FIG 8 EFFECT OF TREATMENTS ON PHOSPHORUS UPTAKE BY WEEDS 1992

4 3 1 3 Potassium (Table 23, Fig 9)

There was considerable difference in the uptake of potassium by weeds due to various herbicide treatments The plots treated with oxyflourfen @ 0 2 kg a i /ha at 3 DAS (T11) contained the least uptake at 30 DAS and at harvest But at 60 and 90 DAS, the hand weeded plots (T15) contained less uptake of potassium, followed by the plots supplied with oxyflourfen @ 0 2 kg a i /ha at 3 DAS (T11), then oxyflourfen @ 0 15 kg a i /ha on the same day of sowing (T7) and the two treatments (T7 and T11) were comparable at all stages of observation

4 3 2 <u>Uptake by crop</u>

4 3 2 1 Nitrogen (Table 24, Fig 10)

The nitrogen uptake by rice differed due to weed control treatments Nitrogen uptake was highest in the plots treated with oxyflourfen @ 0 2 kg a i /ha at 3 DAS (T11) at all stages (90 DAS & Harvest) except at 60 DAS, at which the plots supplied with oxyflourfen @ 0 1 kg a i /ha at 6 DAS (T6) contained the highest uptake This treatment (T11) follows the hand weeded plots (T15) The lowest uptake was shown by the plot treated with oxyflourfen @ 0 05 kg a i /ha on the same day of sowing (T1), oxyflourfen

Table 23 Effect of treatments on Potassium uptake by weeds 1992 (kg/ha)

Treat-ments	Stages of observation			
	30 DAS	60 DAS	90 DAS	Harvest
T1	1 7	15 0	33 5	42 0
T2	1 3	6 0	23 9	17 3
T3	2 6	8 4	21 7	26 4
T4	2 4	2 6	29 9	23 5
T5	0 79	2 8	18 4	26 6
T6	10 3	7 3	40 0	30 7
T7	0 68	2 2	9 9	5 0
T8	0 75	3 0	29 2	36 0
T9	1 6	13 7	24 1	24 5
T10	2 1	1 6	25 7	9 3
T11	0 67	0 9	8 8	4 5
T12	6 6	9 8	27 2	22 2
T13	12 2	19 2	31 3	46 6
T14	5 7	7 3	43 7	58 2
T15	1 7	0 2	4 8	6 0
T16	26 1	31 4	91 9	107 4
SE m±	0 50	0 56	1 33	2 94
CD(0 05)	1 43	1 63	3 85	8 48

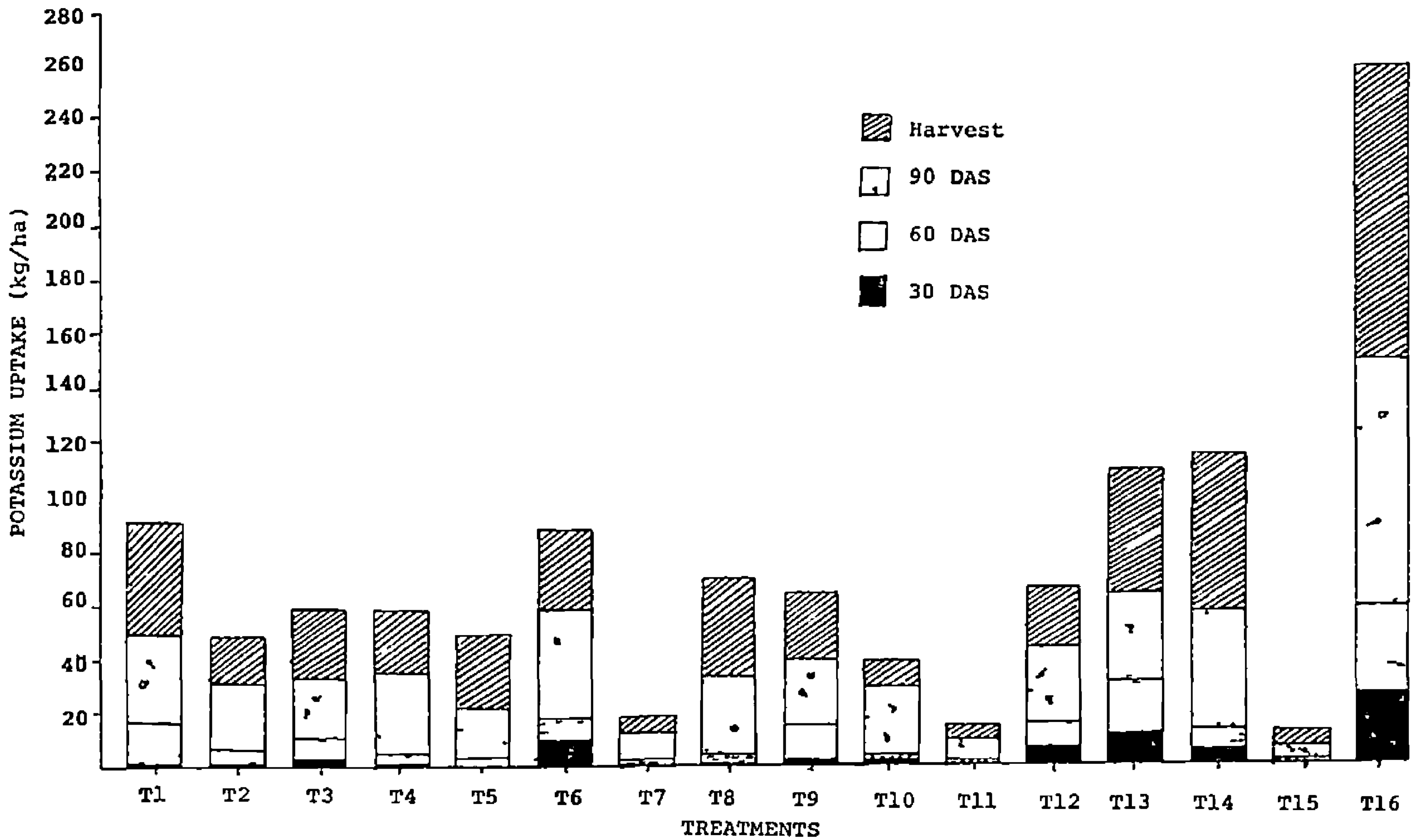


Fig 9 EFFECT OF TREATMENTS ON POTASSIUM UPTAKE BY WEEDS 1992

Table 24 Effect of treatments on nitrogen uptake by crop 1992 (kg/ha)

Treatments	Stages of observation		
	60 DAS	90 DAS	Harvest
T1	22 4	62 4	139 8
T2	37 1	39 5	176 4
T3	39 3	47 9	149 3
T4	33 3	36 4	165 9
T5	37 6	50 5	123 3
T6	70 0	34 9	106 8
T7	60 4	60 1	174 1
T8	40 6	47 8	142 4
T9	50 2	39 3	140 0
T10	41 6	74 3	110 3
T11	48 9	76 8	198 9
T12	43 9	51 5	147 0
T13	37 6	39 7	102 7
T14	43 7	63 8	121 5
T15	51 3	74 1	176 0
T16	28 6	36 6	47 0
SE m±	1 67	3 17	9 75
CD(0 05)	4 83	8 70	28 16

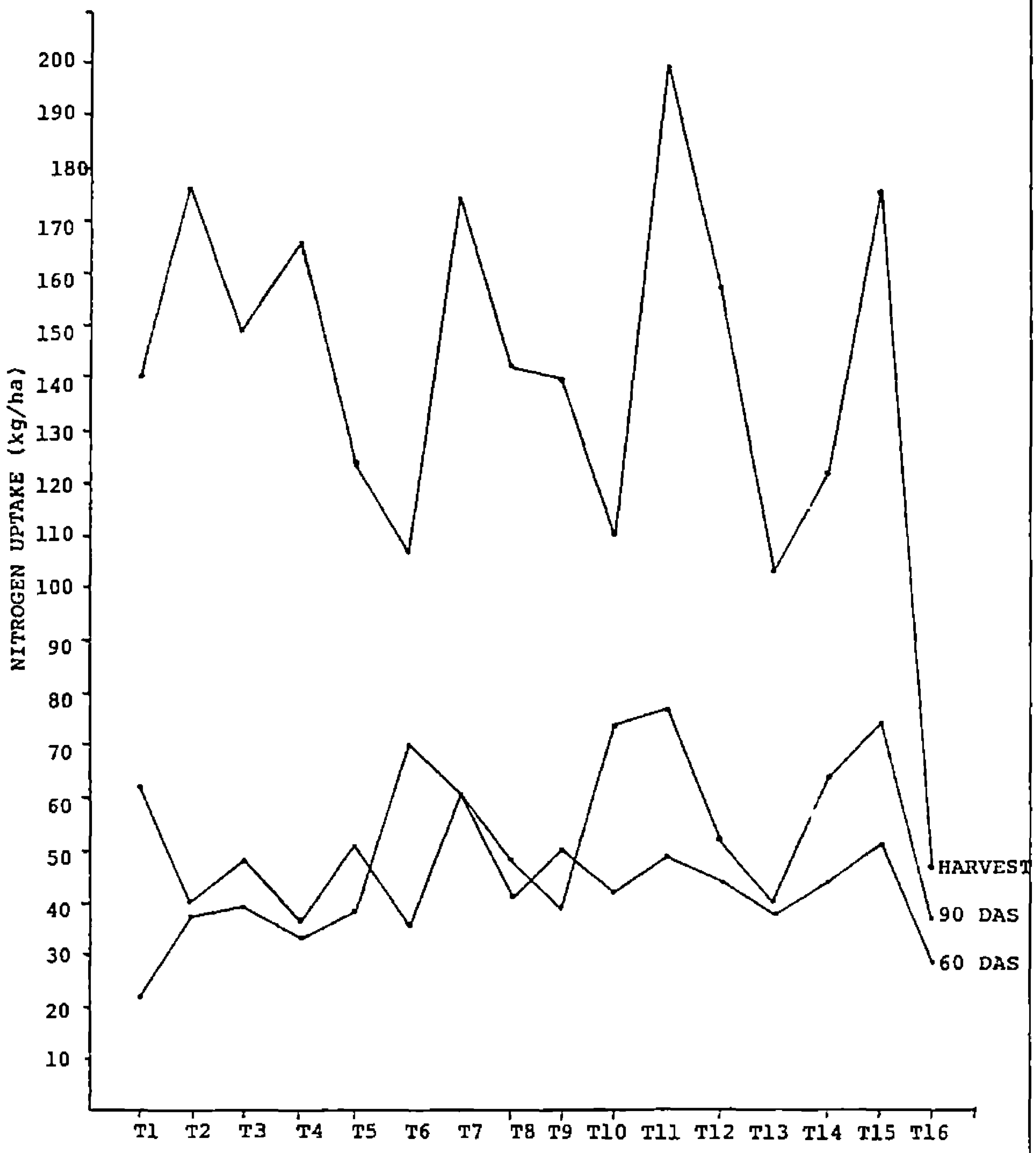


FIG 10 EFFECT OF TREATMENTS ON NITROGEN UPTAKEBY CROP 1992

application @ 0 1 kg a i /ha at 6 DAS (T6) and unweeded check (T16) at 60, 90 DAS and at harvest respectively

4 3.2 2 Phosphorus (Table 25, Fig 11)

There was considerable difference in the phosphorus uptake due to the various weed control treatments The highest removal was shown by the plots treated with oxyflourfen @ 0 15 kg a i /ha at 6 DAS (T9), oxyflourfen application @ 0 2 kg a i /ha at 3 DAS (T11) and oxyflourfen @ 0.1 kg a i /ha on the same day of sowing (T4) at 60, 90 DAS and at harvest respectively The unweeded check (T16) contained the least uptake at all stages except at 90 DAS, at which the plots treated with oxyflourfen @ 0 05 kg a i /ha at 3 DAS (T2) contained the least phosphorus uptake

4 3.2 3 Potassium (Table 26, Fig 12)

The weed control treatments significantly influenced the potassium uptake by crop at all stages of observation The highest uptake was shown by the plots supplied with oxyflourfen @ 0 2 kg a i /ha at 3 DAS (T11) at 60 DAS and at harvest The hand weeded plots (T15) contained the highest uptake at 90 DAS and these two treatments were comparable The lowest uptake was shown by the unweeded check (T16) at all stages except 90 DAS at which the plots supplied with

Table 25 Effect of treatments on phosphorus uptake by crop 1992 (kg/ha)

Treatments	Stages of observation		
	60 DAS	90 DAS	Harvest
T1	3 5	7 6	25 2
T2	6 4	5 1	28 3
T3	7 1	10 1	26 1
T4	3 9	6 3	37 1
T5	5 3	8 2	27 3
T6	7 6	10 3	18 2
T7	7 9	7 5	25 9
T8	6 5	9 0	24 5
T9	9 0	12 6	29 0
T10	5 9	9 2	24 5
T11	8 8	14 5	40 3
T12	6 7	10 8	23 5
T13	6 6	11 8	23 8
T14	7 3	7 6	27 0
T15	7 1	12 1	33 6
T16	4 1	6 2	11 0
SE m±	0 30	0 42	1 96
CD(0 05)	0 86	1 20	5 68

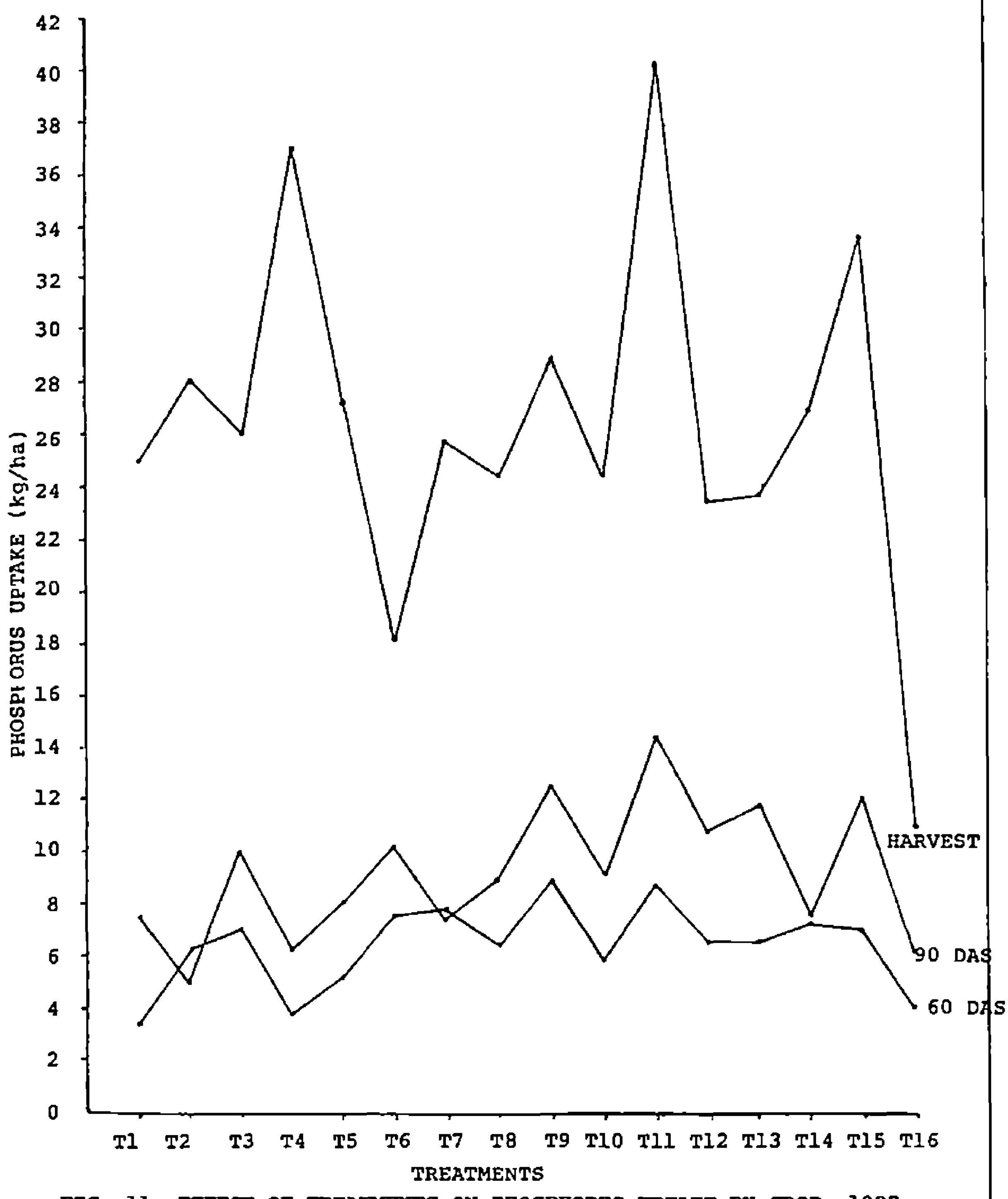


FIG 11 EFFECT OF TREATMENTS ON PHOSPHORUS UPTAKE BY CROP 1992

Table 26 Effect of treatments on potassium uptake by crop 1992 (kg/ha)

Treatments	Stages of observation		
	60 DAS	90 DAS	Harvest
T1	73 9	85 9	92 1
T2	87 5	89 0	113 8
T3	84 3	119 8	98 1
T4	58 9	106 2	108 6
T5	82 0	92 4	106 3
T6	109 8	83 0	74 3
T7	97 5	69 7	179 6
T8	105 9	87 1	111 3
T9	124 6	99 1	143 0
T10	92 7	112 2	147 2
T11	129 1	99 1	181 7
T12	89 1	98 0	108 7
T13	90 8	122 2	97 5
T14	94 2	118 1	118 8
T15	128 5	128 6	154 7
T16	57 2	104 6	45 2
SE m±	4 23	4 68	8 78
CD(0 05)	12 19	13 51	25 36

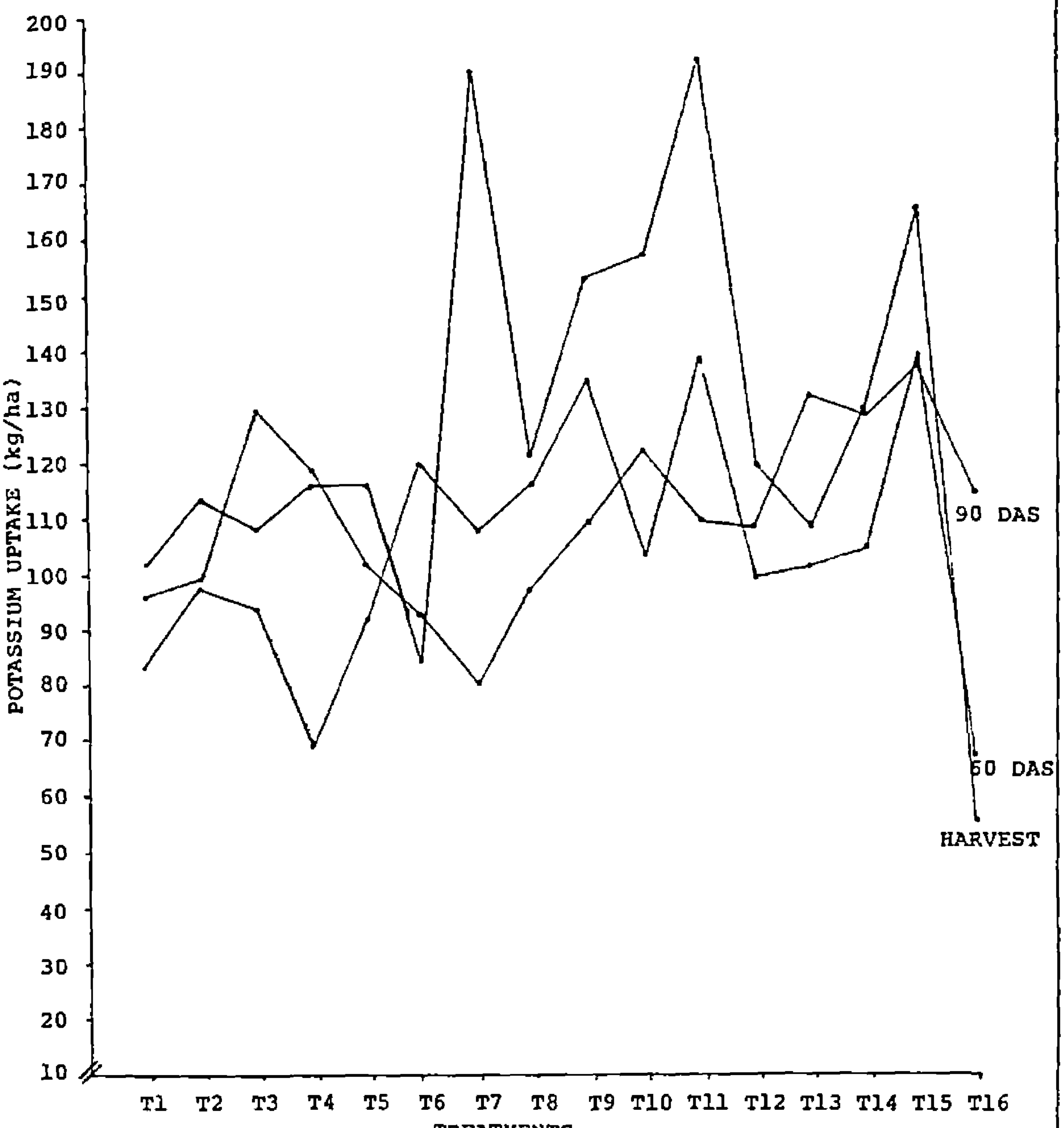


FIG 12 EFFECT OF TREATMENTS ON POTASSIUM UPTAKE BY CROP 1992

oxyflourfen @ 0 1 kg a i /ha at 6 DAS (T6) contained the least uptake

4.4 Economics of weed control operations
(Table 27 Fig 13a & 13b)

There was considerable differences in the economics of weed control operations due to the weed control treatments during both years The net profit was highest in the plots treated with oxyflourfen @ 0 2 kg a i /ha at 3 DAS (T11), followed by the plots supplied with oxyflourfen @ 0 15 kg a i /ha on the same day of sowing (T7) Compared to these treatments the unweeded plots contained lowest net profit

In terms of total returns also, the plots treated with oxyflourfen @ 0 2 kg a i /ha at 3 DAS (T11) seemed to be superior and the effect was comparable with that of the hand weeded plots (T15)

The plots treated with oxyflourfen @ 0 2 kg a i /ha at 3 DAS (T11) contained the highest benefit-cost ratio followed by the plots treated with oxyflourfen @ 0 15 kg a i /ha on the same day of sowing (T7) The unweeded check (T16) contained the least benefit-cost ratio The same trend was noticed in both the years

Table 27 Economics of rice cultivation under different weed control treatments

Treatments	Total cost of cultivation (Rs/ha) 1991	Total cost of cultivation (Rs/ha) 1992	Total returns (Rs/ha) 1991	Total returns (Rs/ha) 1992	Net profit (Rs/ha) 1991	Net profit (Rs/ha) 1992	Benefit-cost ratio 1991	Benefit-cost ratio 1992
T1	4404 20	6435 45	10119 70	13519 75	5715 50	7084 30	2 30	2 10
T2	4404 20	6435 45	10022 80	14955 50	5618 60	8520 05	2 28	2 32
T3	4355 20	6435 45	9368 30	11542 75	5013 10	5107 30	2 15	1 79
T4	4574 50	6666 95	9383 00	12780 50	4808 50	6113 55	2 05	1 92
T5	4574 50	6666 95	9857 00	13873 75	5282 50	7206 80	2 15	2 08
T6	4525 50	6666 95	8584 50	11427 75	4059 00	4760 80	1 90	1 71
T7	4744 05	6898 35	11319 70	16430 25	6575 65	9531 90	2 39	2 38
T8	4744 05	6898 35	10581 85	15258 00	5837 75	8359 65	2 23	2 21
T9	4695 05	6898 35	9651 20	12401 75	4956 15	5503 40	2 06	1 80
T10	4913 60	7129 75	10310 20	16750 75	5396 60	9621 00	2 10	2 35
T11	4913 60	7129 75	13058 40	19914 75	8144 80	12785 00	2 66	2 80
T12	4864 60	7129 75	8438 30	12113 75	3573 70	4984 00	1 73	1 70
T13	4644 20	6613 15	9004 20	12253 75	4360 00	5640 60	1 94	1 85
T14	4617 20	6586 15	9275 30	12902 50	4658 10	6316 35	2 01	1 96
T15	7252 20	10251 15	13136 10	19646 75	5883 90	9395 60	1 81	1 92
T16	4132 20	6151 65	6456 50	9652 00	2324 30	3500 35	1 56	1 57

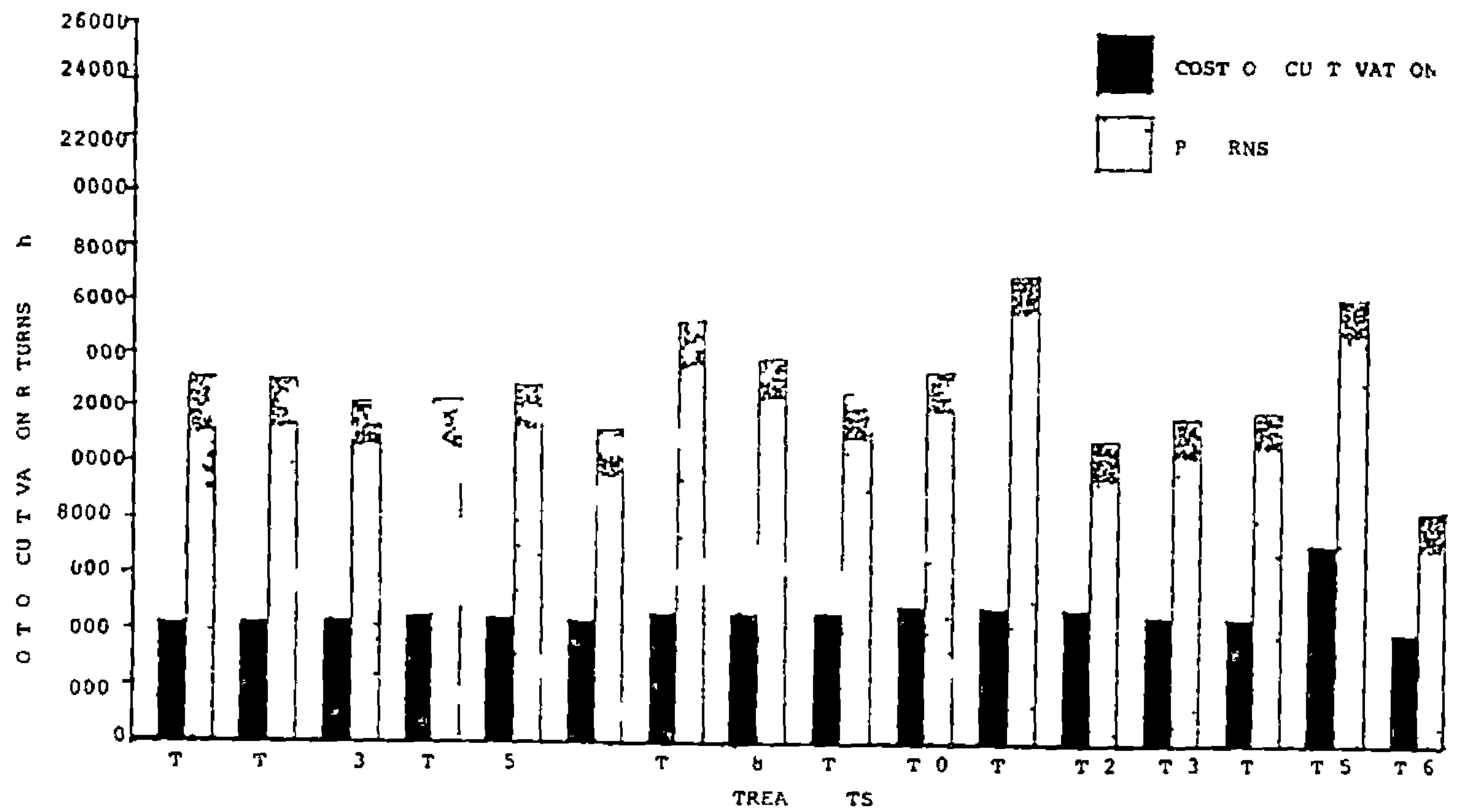


FIG 3 a EFF CT OF TREATM NT N O OF U T VAT ON AND RETURNS 1991

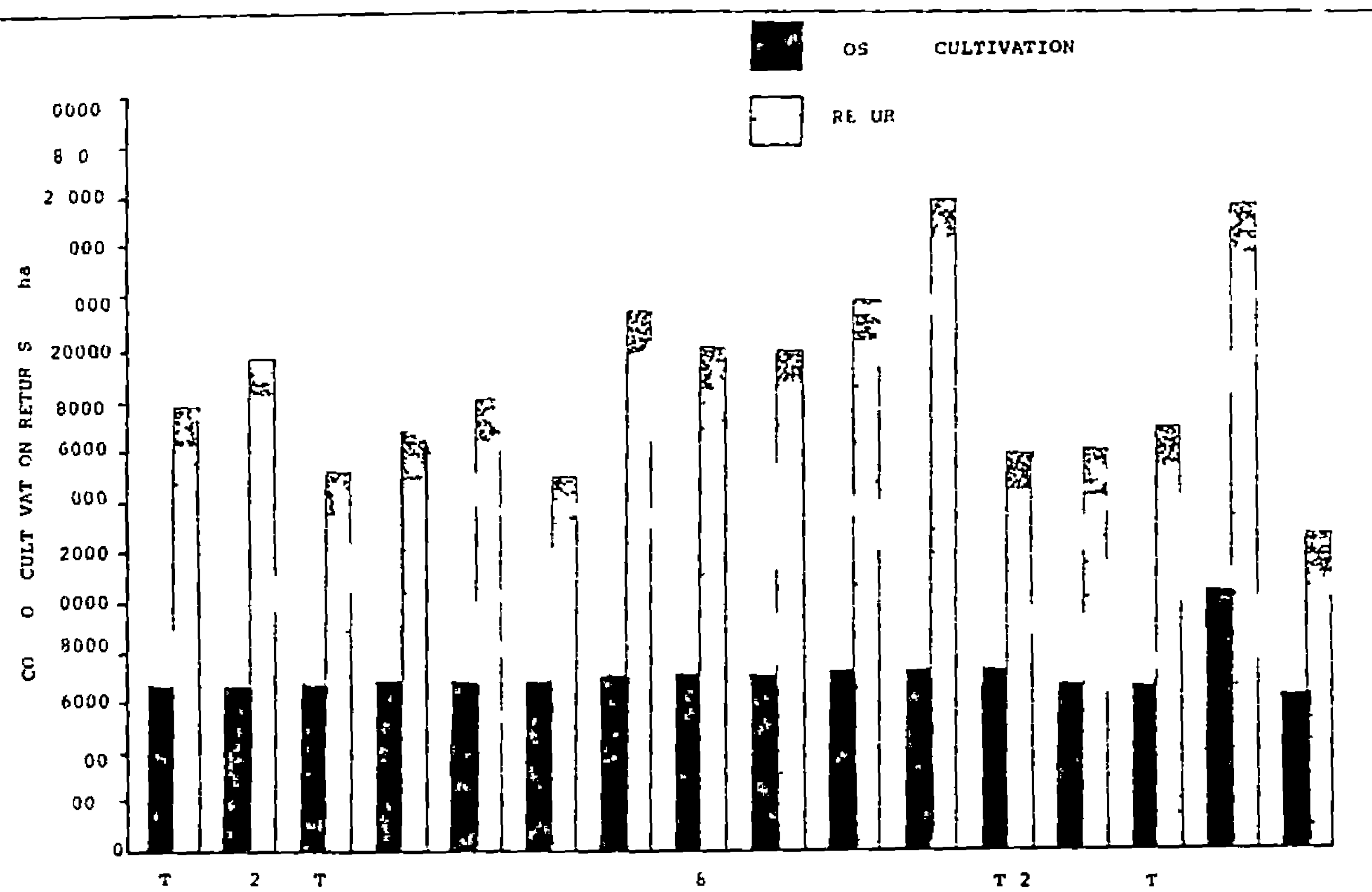


FIG 3b EF CT OF TREATMENTS ON COST OF CULTIVAT ON AND RETURNS 1992

Discussion

DISCUSSION

An experiment was conducted at the Regional Agricultural Research Station Pattambi during the virippu (first crop) seasons of 1991 and 1992 to formulate the optimum time and dose of application of the chemical oxyflourfen in dry-sown rice The results of the experiments were discussed hereunder

5.1 Studies on weeds

5 1 1 Weed spectrum

The main weed species found during 1991 and 1992 were, *Ammania baccifera*, *Alternanthera sessilis*, *Eriocaulon sp.*, *Isachne miliacea*, *Saccolepis interrupta* and *Cyperus sp* (Appendix IIa and IIb) During 1991, at 30 DAS in the weedy check, grasses comprised of 76 per cent of the total weed population whereas in the second year, grasses comprised of 91 per cent of the total weed population A critical analysis of the relative proportion of grasses and sedges to the total weed population indicated that at all stages, the population of grasses were much higher than that of sedges during second year At 60 DAS, during first year, the share of grasses and dicot weeds accounted for 6 per cent and 17 per cent respectively During first year, monocot weed accounted about 79 per cent which appeared after 30 days of sowing But towards harvest, the population of all weeds declined drastically resulting in the increased proportion of grasses in 1992 in certain plots

During 1991 only broadleaved weeds were present in the unweeded check, probably due to the absence of grass weeds Eventhough the seeding of the crop was done under dry conditions, during the latter half of the crop season the field remained flooded and resembled a wet sown rice field Moist conditions would have favoured the establishment of the dicot weeds like Ammania baccifera, Cyanotis sp etc During second year, very few broadleaved weeds were present in the unweeded check probably due to the dominance of grass weeds All the grass weeds completed their life cycle along with the crop only Thus the relative proportion of grass weeds increased at harvest stage

The observation that grassy weeds constitute the major weed population in dry sown rice was supported by Pande et al (1966) and Nair et al (1975) Predominance of Cyperus sp was also been observed by Okofor (1981) and Kandasamy (1990)

5.1 2 Weed population

5 1 2 1 Grasses (Table 3,4 & 5)

The effect of different weed control treatments on the grass weed population was significant during both years The plots treated with oxyflourfen @ 0 15 kg a i /ha on the same day of sowing and oxyflourfen application @ 0 2 kg a.i /ha at 3 DAS contained the lowest number of grass weeds in almost all stages of growth during first and second year respectively and these two treatments were comparable with hand weeding plots This is because of the fact that hand weeding was done at 20th and 40th day of sowing

During second year, among grasses, *Isachne miliacea* was a serious problem than broad leaved weeds and sedges Hence a larger proportion of total grass weed population (*Saccolepis sp* and *Isachne sp*) during second year The population of grassy weeds, especially *Isachne miliacea* was gradually increasing towards harvest compared to broadleaved weeds and sedges because all the grass weeds completed their life cycle along with the crop only There is a very good control of *Isachne miliacea* with the oxyflourfen application @ 0 2 kg a i /ha at 3 DAS or oxyflourfen application @ 0 15 kg a i /ha on the same day of sowing Butachlor and thiobencarb treated plots were inferior to the above treatments in controlling weeds.

From the two years data, it was clear that oxyflourfen application @ 0 2 kg a i /ha at 3 DAS effectively controlled grassy weeds followed by application of oxyflourfen @ 0.15 kg a i /ha on the same day of sowing These results are in line with the findings of Richardson _et al_ (1976), KAU (1984), Shahi (1985) and Verma _et al_. (1987).

5 1 2 2 Broadleaved weeds (Table 6 & 7)

During first year, oxyflourfen application @ 0 2 kg a i /ha at 3 DAS gave excellent weed control at 30 DAS and the effect was comparable with that of oxyflourfen @ 0 2 kg a i./ha on the same day of sowing and 0 15 kg a i /ha applied at the same day of sowing. At 60 DAS, application of oxyflourfen @ 0 15 kg a i /ha on the same day of sowing resulted good control of weeds and its effect was better than all the other treatments Thiobencarb and butachlor were inferior than rest of the treatments except unweeded control At 90 DAS and harvest, application of oxyflourfen @ 0.15 kg a i /ha on the same day of sowing was more effective in controlling weeds than hand weeding.

During 1992, the number of broadleaved weeds were very few in number During this year, grassy weeds formed the dominant species

It was evident from the results that application of oxyflourfen @ 0 2 kg a i /ha on 3rd DAS or the same herbicide @ 0 15 kg a i /ha at the same day of sowing give effective control throughout the growth period

5 1 2 3 Sedges (Table 8)

During first year, the sedges population was very low During second year, among the herbicidal treatments at 20 and 30 DAS, application of oxyflourfen @ 0 15 kg a i /ha at 3 DAS gave the least Cyperus sp count and its effect was comparable with hand weeding Herbicide application resulted lower weed population compared to hand weeding These results are in agreement with the findings of Rao and Gupta (1981) Hand weeded plots contained lowest number of weeds at 60 and 90 DAS and the weed population in the plots were comparable with the plots applied with oxyflourfen @ 0 15 kg a i /ha on the same day of sowing The trend of weed control due to treatments was evident upto the harvesting stage The weed population continued to remain high at all stages of growth in the unweeded check

The population of sedges was gradually increasing with age of the crop, reaching a peak between 30 and 60 days and then declining towards harvest Rao and Gupta (1981) also reported similar weed growth pattern The sedges growth pattern thus indicate that the weeds can exert severe competition to the dry-sown rice between 30th and 60th day after sowing The result of the present study is in agreement with the findings of Wells and Cabradilla (1981) and Sankaran and De Datta (1985)

From the study, it is clear that oxyflourfen application (0 15 kg a i /ha on the same day of sowing or 0 2 kg a i /ha at 3 DAS) can effectively control sedges and minimise weed competition Applications of butachlor and thiobencarb were not effective to control the sedges Similar effect of oxyflourfen to control sedges in dry-sown rice has been reported by Mukhopadhyay and Mandal (1982) Chauhan and Ramakrishnan (1981) and Varshney (1990)

5 1 2 4 Total weed population (Table 9)

The effect of oxyflourfen application (either @ 0 15 kg a i /ha on the same day of sowing or @ 0 2 kg a i /ha at 3 DAS) was consistently superior to check the weed population throughout the crop growth period in both the years The effect of this herbicide to control grassy weeds (Table 3 & 5) and sedges (Table 8) explained this It was interesting to note that the oxyflourfen treated plots contained less weeds than hand weeded plots indicating that weed control through oxyflourfen application can be a better substitute for hand weeding in dry-sown rice

The efficiency of pre-emergence application of oxyflourfen in controlling all types of weeds for prolonged periods right from the early stage of the crop can minimise weed competition and enhance crop yields This was in accordance with the findings of Shahi (1985), Maheswari (1987), Verma et al (1987) and Azad et al (1990)

5 1.3 Dry matter production of weeds (Table 10)

As in the case of weed population the weed dry matter production was also lowest in the plots treated with oxyflourfen either at 0 15 kg a i /ha on the same day of sowing or at 0 2 kg a i /ha at 3 DAS There was not much differences in weed dry matter production between hand weeded plots and oxyflourfen treated plots (0 15 kg a i /ha on the same day of sowing or 0 2 kg a i /ha at 3 DAS) At 30 DAS, weed dry matter production in the plots treated with oxyflourfen @ 0 15 kg a i /ha on the same day of sowing showed a decreased quantity of dry matter production ie 3 24 and 2 09 during first year and second year respectively compared to unweeded check At 60 DAS, the same treatment showed a decreased quantity of dry matter production ie 2 30 and 8 48 during first and second year respectively compared to the unweeded plots The weed dry matter production was highest in the unweeded check at all stages of growth period

There was significant positive correlation between weed population and weed dry matter production The correlation coefficient was highest at the early stages Oxyflourfen treated plot consistently show less weed population and less weed dry matter production throughout the crop growth period Sankaran and De Datta (1985) reported that a weed free period of 50 days after sowing is essential in dry-sown upland rice The separation of weeds in the early stages of crop growth is important to minimise weed competition and to facilitate better establishment and growth of the crop The early phase of the crop growth (the first two months) in the case of direct-sown rice would be critical and a weed control method which can minimise weed infestation during this phase would be appropriate to increase the productivity of dry-sown rice

It is evident from the present study that oxyflourfen application (0 15 kg a i /ha on the same day of sowing or 0 2 kg a i /ha at 3 DAS) can effectively check the weed growth during the early phase of crop growth period in dry-sown rice.

5 1 4 Weed control efficiency (Table 12)

Weed control efficiency, a measure of the efficiency of a particular treatment to control weeds compared to the unweeded check, differs significantly due to weed control treatments Weed control efficiency ranged from 61 6 to 100 per cent in the case of oxyflourfen at the dose (0 15 kg a i /ha on the same day of sowing) at which efficient weed control was obained, while in the case of thiobencarb and butachlor the variation was from 17 3 to 63 7 per cent only

The weed control efficiency was highest with the application of oxyflourfen @ 0 15 kg a i /ha on the same day of sowing at all stages and both the years It was also high with hand weeding as well as with oxyflourfen application @ 0 2 kg a i /ha at 3 DAS The data on weed population (Table 9) and weed dry matter production (Table 10) explained this The weed control efficiency was lowest with the plots treated with butachlor and thiobencarb @ 1 5 kg a i./ha on the same day of sowing

It ıs clear from the data that chemıcal weed control ıs more effıcıent than hand weedıng (twıce) Nako (1967) and Sreedevı (1979) reported sımılar results

5.2 Studıes on crop

5 2 1 Phototoxıcıty

Plots supplıed wıth oxyflourfen at all doses (0 05, 0 1, 0.15 and 0 2 kg a ı /ha) at 6 days after sowıng showed slıght scorchıng or burnıng of leaf tıps But these symptoms dısappeared wıthın a week These symptoms were not notıced when oxyflourfen was applıed on the same day of sowıng or on 3rd day after sowıng Other herbıcıdes dıd not cause any phytotoxıcıty symptoms These observatıons was ın accordance wıth CIDAT (1978) and Pıllaı et al (1980) But Bıswas and Thakar (1983) reported that oxyflourfen when applıed sıx days after sowıng was not toxıc to the crop

Patıl et al (1986) and Sıngh and Bhandarı (1986) reported that oxyflourfen @ 0 1-0 2 kg a ı /ha was phytotoxıc to the crop But Sıngh et al (1990) mentıoned that oxyflourfen was effectıve agaınst many grasses and safe to the crop However, at hıgher rates (0 5 kg a ı /ha) there was slight toxicity to the crop during the initial growth period but afterwards the crop recovered

The application of oxyflourfen was effective under moist condition only. But in our plots we have experienced a dry condition on the sixth day, which might have lead to slight scorching or burning of leaf tips and at that time the crop has already emerged in the plots It appears from the present study that a dose upto 0 2 kg a i /ha of oxyflourfen may not be deliterious to the crop as a mild phytotoxicity observed in the crop has disappeared soon

5 2 2 Growth characters

a) Plant height (Table 13)

During second year at 60 and 90 DAS, the tallest plants were noted in plots applied with oxyflourfen @ 0 15 kg a i /ha at 6 DAS and oxyflourfen @ 0 05 kg a i /ha 6 DAS respectively But at harvest, during both years, tall plants (87 0 cm and 94 1 cm during 1991 and 1992 respectively) were seen in the unweeded check In the unweeded check, where the weed density was generally high at all stages, the major weeds like *Isachne miliacea*, *Saccolepis interrupta*, *Ammania baccifera* and *Cyperus sp* were growing taller than the crop resulting in greater weed competition for light This situation might have induced the crop plants to grow taller for light The increased plant height in unweeded check caused lodging of the crop towards harvest stage

Increase in plant height due to increase in weed competition was earlier reported (CRRI, 1986 and Jayasree, 1987)

b) Total number of tillers per m^2 (Table 14)

Plots applied with oxyflourfen @ 0 15 kg a i /ha on the same day of sowing at 30 DAS containing highest number of tillers and its effect was comparable with hand weeded plots, oxyflourfen @ 0 2 kg a i /ha on the same day of sowing and at 3 DAS, oxyflourfen application @ 0 15 kg a i /ha at 3 DAS and oxyflourfen application @ 0 05 kg a i /ha at 6 DAS. At 60 DAS, the lowest number of tillers were observed by oxyflourfen @ 0 15 kg a i /ha on the same day of sowing The highest number of tillers were noticed in the plots applied with oxyflourfen @ 0 2 kg a i /ha at 3 DAS and its effect was on par with hand weeding

It may be noted that there was an effective weed control in plots applied with oxyflourfen (0 15 kg a i./ha on the same day of sowing or 0 2 kg a i /ha at 3 DAS) facilitating better absorption of nutrients and greater tiller production

Plants in the unweeded plots produced the minimum number of tillers at all stages The weeds competed for nutrients and space with crop, resulted in poor tillering Sridhar et al. (1976) and Palaikudy (1989) reported a reduction in the tiller production in rice due to weed competition

c) Crop dry matter production (Table 15)

The dry matter production was highest with the plants in the hand weeded plots and plots supplied with oxyflourfen (ie @ 0 15 kg a.i /ha on the same day of sowing or @ 0 2 kg a i /ha at 3 DAS) and the effect of these three treatments were more or less same A more or less similar trend was noticed in both the years It may be noted that the weed control efficiency was highest with these three treatments without much difference between them. The tiller production was also high with these treatments (Table 14) The favourable effect of these treatments to minimise the weed growth and to enhance tiller production might have caused an increased dry matter production in the plots treated with these three weed control treatments

The dry matter accumulation of the crop in the weedy check was only 23 to 58 per cent of the total dry matter accumulation by the crop in the hand weeded plots during different stages of growth. This indicated that there was severe competition between the crop and weeds in the weedy check resulting greater reduction in the crop dry matter production Dry matter production of crop during both years were comparable

Chakraborthy (1973) reported reduction in the crop dry matter production due to weed competition Jayasree (1987) observed higher crop dry matter production in hand weeded plots and minimum in unweeded check

There was significant negative correlation between crop dry matter production and weed dry matter production

5 2 3 Yield attributes (Table 16)

a) Productive tillers

During both years, the hand weeded plots contained the highest number of tillers and the effect was comparable with oxyflourfen application @ 0 2 kg a i /ha at 3 DAS The absence of weed competition in these plots enabled the crop to utilise the available nutrients more efficiently for its growth and tiller production. Plants in the weedy check on the other hand showed less number of productive tillers which was only 49 5 per cent of hand weeded plots Similar results were reported by Rethinam and Sankaran (1974), Sridhar *et al*. (1976) and Patil *et al* (1986)

b) Length of panicle

During first year, plants in plots applied with oxyflourfen @ 0 2 kg a i /ha at 3 DAS had the longest panicle The panicle length observed with plants in the hand weeded plots and the plots treated with oxyflourfen @ 0 2 kg a i /ha at 3 DAS and oxyflourfen application @ 0 15 kg a i /ha on the same day of sowing were similar Plant in the unweeded check had shortest panicle During second year, there was no significant difference between the treatments

Suja (1989), Zhi and Sheng (1990) and Varshney (1990) also observed decreased panicle length with plants in the unweeded check.

c) Number of filled grains per panicle

The hand weeded plots contained the highest number of filled grains per panicle and the effect was comparable with application of oxyflourfen @ 0 2 kg a i /ha at 3 DAS and oxyflourfen application @ 0 15 kg a i /ha on the same day of sowing. The minimum number of filled grains per panicle was shown by plants in the unweeded plots. This may be due to the severe competition exerted by weeds for nutrients in the unweeded check

Similar observations were made by Arai (1967), Sreedevi (1979), Dang (1985) and Kumar and Gautam (1986).

d) Thousand grain weight

Thousand grain weight was more with plants in the hand weeded plots followed by oxyflourfen application @ 0 15 kg a i /ha on the same day of sowing and then oxyflourfen application @ 0 2 kg a i /ha at 3 DAS and these three treatments were comparable The plants in the unweeded check had the minimum thousand grain weight during both years This may be due to the severe weed pressure throughout the growth period

The decrease in thousand grain weight due to continuous weed growth was reported by Azad et al (1990) and Padhi et al (1991).

5 2 4 Yield (Table 18)

a) Grain yield

During first year, higher yield was obtained from hand weeded plots followed by the plots supplied with oxyflourfen @ 0 2 kg a i /ha at 3 DAS During second year, the highest yield was obtained from plots treated with oxyflourfen @ 0 2 kg a i /ha at 3 DAS, followed by hand weeded plots

The grain yield was lowest in unweeded check during both the years The data on weed population and weed dry matter production revealed that the weed infestation was highest in the unweeded check The lowest grain yield in the unweeded check may be due to the fact that crop suffers severe competition due to heavy infestation of weeds especially in early stage (30 to 60 days) resulting in severe set back on growth and yield of crop Due to severe weed competition, the crops may fail to derive sufficient nutrients from soil As a result, as indicated by the data, the yield components (Table 17) especially number of filled grains per panicle, panicle length and thousand grain weight reduced drastically resulting in lower grain yield

It can be seen that oxyflourfen application @ 0 2 kg a i /ha at 3 DAS gave the highest grain yield and its effect was comparable with that of the hand weeded plots The analysis of the data on grain yield of both years separately and on pooling gave the results that the effect of these two treatments were similar

The correlation study between the grain yield with weed count and weed dry matter production during both years (Table 19) showed that there is significant negative correlation between them

From the results, it can be concluded that, a dose of oxyflourfen @ 0 2 kg a i /ha at 3 DAS gave the highest grain yield followed by oxyflourfen application @ 0 15 kg a i /ha on the same day of sowing

This results were in confirmity with the findings of KAU (1984), Ghosh and Singh (1985) and Kumar and Gautam (1986)

b) Straw yield

The highest straw yield was obtained with hand weeded plots during first year and oxyflourfen application @ 0 2 kg a i /ha at 3 DAS showed significantly superior yield during second year and the effect was on par with hand weeding The reduced weed growth in these treatments promoted greater vegetative growth by the crop

High weed pressure completely smothered the crop in weedy check and resulted in very poor yield The herbicide application reduced the density and dry matter production of weeds significantly and resulted in appreciable yield increase over unweeded check (Singh and Singh, 1982) The severe weed competition in the unweeded plots has resulted in lesser plant height and reduced tiller production which might have finally led to decreased yield as already discussed in the grain yield

Shivamadiah et al (1987) and Rao and Gupta (1981) observed decreased straw yield due to increased weed growth

c) Harvest index

Although there was significant effect of herbicides on the grain and straw yield, the harvest index in general was unaffected during both years.

5 2 5 Weed ındex (Table 20)

Weed ındex quantıfıes the reductıon ın yıeld due to weeds when compared wıth the yıeld from the hand weeded treatments Herbıcıdes applıcatıon had sıgnıfıcantly ımproved the weed ındex

The weed ındex was mınımum ın oxyflourfen @ 0 2 kg a ı /ha at 3 DAS treated plots and was superıor to the rest durıng both the years Hence ıt ıs very clear that thıs treatment whıch showed the lowest weed ındex dıd not suffer much yıeld reductıon due to lesser weed competıtıon The next lowest value was shown by oxyflourfen applıcatıon @ 0 15 kg a ı /ha on the same day of sowıng The weedy check had the greatest reductıon ın yıeld compared to hand weeded plots and hence showed the hıghest weed ındex

Sımılar reductıon ın the weed ındex was observed by several workers (Ghosh and Sıngh, 1985 Kumar and Gautam, 1986 and Sıngh et al 1990) due to severe weed competıtıon

5.3 Studıes on nutrıent uptake

5 3 1 Uptake by weeds (Table 21, 22 & 23)

The effect of the treatments on NPK removal by weeds was sımılar to that of the weed dry matter productıon

(Table 10) as there was not much variation in the respective nutrient content of the weeds at a particular stage Hence the treatments where weeds were controlled better resulted in lesser removal of N, P and K by weeds

The data showed that oxyflourfen application (@ 0 2 kg a.i /ha at 3 DAS or 0.15 kg a i /ha on the same day of sowing) was better than butachlor and thiobencarb application in reducing nutrient uptake by weeds This is a reflection of the effect of oxyflourfen in reducing the grass weed population (Table 3, 4 & 5) which accounted for major share of weedflora in the plot This reduction in the nutrient removal by weeds at early stages is more pronounced in the plots treated with oxyflourfen @ 0 2 kg a i /ha at 3 DAS or 0 15 kg a i /ha on the same day of sowing, which could control weeds effectively and this effect is reflected in the yield data (Table 18) also wherein the yield recorded by these plots were better than that of butachlor and thiobencarb applied plots

This results are in agreement with the findings of Mani (1975), Sreedevi (1979), Lakshmi _et al_ (1987) and Jayasree (1987)

5 3 2 Uptake by crop (Table 24, 25 & 26)

The results on the nutrient uptake by the crop at different stages showed that in the treatments where nutrient uptake by weeds was less (oxyflourfen application @ 0 2 kg a i /ha at 3 DAS or oxyflourfen application @ 0 15 kg a i./ha on the same day of sowing) the corresponding nutrient uptake by crop was higher This is due to the lack of nutrient competition from weeds, resulting in better growth and dry matter production of crop (Table 15)

The NPK content of the crop (Appendix VI VII & VIII) in different treatments did not show much variation between them and hence the differences in the uptake of nutrients by the crop is actually due to the differences in the dry matter production Because of the high weed pressure occured in the unweeded check, the crop take less nutrients from these plots than other treatments And hence it will affect the growth of the crop, yield components and finally yield

Similar results were obtained by Mallappa (1973), Mani (1975), Jayakumar *et al* (1987) and Jayasree (1987)

5.4 Economics of weed control operations (Table 27)

There was considerable differences in the net income obtained from the different treatments Application of oxyflourfen @ 0 2 kg a i /ha at 3 DAS gave the highest net income followed by application of oxyflourfen @ 0 15 kg a i /ha on the same day of sowing during both years The unweeded check showed the least net income during both years We can save an amount of about Rs 3000/- by using chemicals or herbicides rather than hand weeding

Though the application of oxyflourfen @ 0 2 kg a i /ha at 3 DAS was costlier than other doses of oxyflourfen the higher yield was obtained from these plots and also herbicide application was more economical than manual weed control

The various weed control treatments influenced the benefit cost ratio also The highest ratio (2 66 and 2 80 during first and second year respectively) was shown by the oxyflourfen applied plots @ 0 2 kg a i /ha at 3 DAS followed by oxyflourfen application @ 0 15 kg a i /ha on the same day of sowing

The results of the study are in agreement with the findings of Jayasree (1987) Maheswari (1987) Suja (1989) and Vani (1990)

Summary

SUMMARY

A field experiment was conducted at the Regional Agricultural research Station Pattambi under the Kerala Agricultural University during the first crop seasons of 1991 and 1992 to evaluate the optimum time and dose of application of pre-emergence herbicide oxyflourfen in dry-seeded low land rice The main objective was to obtain the maximum benefit from oxyflourfen ensuring season long weed control in dry-sown rice The experiment was laid out in randomized block design with three replications Treatments comprised of application of oxyflourfen at different doses (0 05 0 10 0 15 and 0 20 kg a i /ha) and time (on the same day of sowing 3 and 6 days after sowing) application of Butachlor @ 1 5 kg a i /ha on the same day of sowing application of thiobencarb @ 1 5 kg a i /ha on the same day of sowing and two controls (weedy check and hand weeded check) The salient findings of the experiment are summarised below

The main weed species found during the study period were *Ammania baccifera* *Eriocaulon sp* *Saccolepis interrupta* *Isachne miliacea* *Alternanthera sessilis* *Cyperus iria* and *Cyperus rotundus* During the first year broadleaved weeds were the predominant one but during the second year the grasses constituted the major weed population

Among the different weed control treatments application of oxyflourfen @ 0 15 kg a i /ha on the same day of sowing and 0 2 kg a i /ha at 3 DAS were more effective in reducing weed population The most efficient control of weeds during initial stages of the crop (upto 60 days) was obtained when the herbicide was applied on the same day of sowing @ 0 15 kg a i /ha or oxyflourfen application @ 0 2 kg a i /ha at 3 DAS However all treatments with oxyflourfen were equally effective in controlling the weeds population except when applied at 6 DAS Even though hand weeding twice was the best treatment in bringing done the weed population towards later stages it could not completely avoid weed competition during the critical stages

The application of oxyflourfen @ 0 15 kg a i /ha on the same day of sowing recorded minimum weed dry matter production during the critical stages and the effect was on par with oxyflourfen application @ 0 2 kg a i /ha at 3 DAS A significant positive correlation was found to exist between total weed population and weed dry matter production during all stages The highest weed control efficiency during critical stages was noticed in plots treated with oxyflourfen @ 0 15 kg a i /ha on the same day of sowing except at harvest at which oxyflourfen @ 0 2 kg a i /ha at 3 DAS showed the highest value

Oxyflourfen produced slight phytotoxicity symptoms on the crop when it was applied at six days after sowing But within a week the symptoms disappeared and the crop recovered High weed density and weed competition increased the height of plants while the crop dry matter production and tiller numbers were drastically reduced During early stages oxyflourfen application @ 0 15 kg a i /ha on the same day of sowing and during later stages oxyflourfen @ 0 2 kg a i /ha at 3 DAS were found to have better crop dry matter production and weed dry matter production should be less

Maximum number of productive tillers per m^2 was noticed in hand weeded treatments which was comparable with oxyflourfen application @ 0 2 kg a i /ha at 3 DAS The maximum panicle length and number of filled grains per panicle were observed in plots treated with oxyflourfen @ 0 2 kg a i /ha at 3 DAS and hand weeding respectively where hand weeding can be comparable with oxyflourfen @ 0 2 kg a i /ha at 3 DAS and 0 15 kg a i /ha on the same day of sowing The thousand grain weight was comparatively higher in hand weeded plots followed by oxyflourfen application @ 0 2 kg a i /ha at 3 DAS during both years

From the pooled analysis the maximum grain yield was recorded by both hand weeded plots and oxyflourfen applied plots @ 0 2 kg a ı /ha at 3 DAS The straw yıeld was maxımum ın the same treatments ın whıch more tıllerıng was also observed The harvest ındex was not sıgnıfıcantly ınfluenced by treatments durıng both years The negatıve values of weed ındıces obtaıned ın oxyflourfen @ 0 2 kg a ı /ha at 3 DAS ındıcated the hıgher graın yıeld ın these plots

The pattern of nutrıent uptake by weeds and crop showed opposıte trends N P and K removal by weeds were maxımum ın unweeded check whıle the correspondıng uptakes by crop were hıgher ın the plots where weeds were effectıvely controlled (oxyflourfen @ 0 15 kg a ı /ha on the same day of sowıng or 0 2 kg a ı /ha at 3 DAS)

The net returns return per rupee ınvested and benefıt-cost ratıo were maxımum ın plots treated wıth oxyflourfen @ 0 2 kg a ı /ha at 3 DAS Although the total returns from the hand weeded plot was relatıvely hıgh the hıgh cost of hand weedıng brought down the return per rupee ınvested

From the two years study ıt can be concluded that applıcatıon of oxyflourfen @ 0 2 kg a ı /ha at 3 DAS gave good weed control contrıbutıng to ıncreased yıeld ın dry-sown low land rıce

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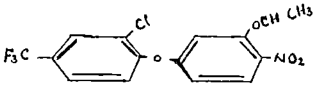
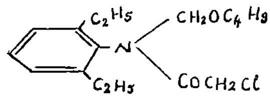
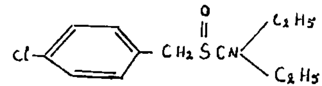
* Originals not seen

Appendices

Appendix I

<u>Details of the herbicides used in the trial</u>

No		Oxyflourfen	Butachlor	Thiobencarb
1	2	3	4	5
1	Chemical name	2-choro-1-(3-ethoxy-4 nitrophenoxy-4- (tri-fluor methyl) benzene	N - (butoxymethyl)-2-Chloro-2 , 6 - diethyl acetanilide or(N-(butoxy methyl)-2-Chloro-N-(2, 6-diethyl phenyl) acetamide	S[(4-chlorophenyl) methyl] diethyl carbamothioate or S-(4-Chloro benzyl) N, N-diethyl thio-carbamate
2	Structural formula			
3	Herbicide family	Diphenyl ethers	Amides	Thiocarbamates
4	Manufacturer	Indofil chemicals	Pest control Co	Pesticides India Ltd , Udaipur, Rajasthan
5	Trade name	Goal 23 5 EC	Butachlor 50 EC	Saturn 50 EC
6	Formulation	EC 23 5	EC 50	EC 50
7	Physical Properties	Melting point 84-85°C Physical state or Colour Orange Crystalline solid at room temperature vapour pressure 2x10^{-6}mm	Boiling point 156°C at 0 5 mm Hg Physical state Slightly sweet aromatic amber liquid Density 1 070g/ml at 25°C	Boiling point 126 to 129°C at 0 008 mm Hg Physical state Light Yellow or brownish yellow liquid

(Contd)

(Appendix I Contd)

1	2	3	4	5
		Solubility (i) Less than 0 1 ppm in water at 25°C (ii) Soluble in most organic solvents	Vapour pressure 4 5x10^{-6}mm Hg at 25°C Solubility Water-23 ppm at 24°C Souble in ether, acetone, benzene, alcohol, ethyl acetate and hexane at room temperature	Specific gravity d^{20} 1 145 to 1 180 Solubility at 20°C water -30 ppm Readily soluble in acetone,ethyl alcohol and xylene
8	Molecular formula	$C_{15} H_{11} ClF_3 NO_4$	$C_{17} H_{26} Cl NO_2$	$C_{12} H_{16} ClNOS$
9	Molecular weight	361 72	311 9	257.8
10.	Rates	Spray Goal @ 375-750 ml/ha within 2-3 days after sowing on moist soil	Approximately 1 12-4 48 kg a i /ha as a broadcast treatment depending on type of application, crops, weed, stage of growth etc	3 4 - 4 5 kg/ha
11	Mode of action	Oxyflourfen kills weed seedling through contact action and membrane disruption Since light is required for herbicide activity DPE phytotoxicity is related to the process of photosynthesis and inhibition of both electron transport and ATP synthesis	Inhibit early seedling growth especially on root growth Probably associated with an interference with cell division, cause cell enlargement Inbibit nucleic acid and protein synthesis	Inhibits protein biosynthesis and gibbrelin biosynthesis

(Contd)

(Appendix I Contd)

1	2	3	4	5
12	Method of application	A single pre-emergence application is recommended immediately after seeding before the emergence of crop and weeds when used as post-emergence application, Goal must be combined with paraquat, diuron MSMA or other suitable post-emergence herbicides	Pre-emergence soil surface treatment, application in water with transplanted rice and as a post-emergence application in combination with propanil	Pre-emergence to early post-emergence application in rice
13.	Absorption character	Absorbed mainly by the germinating weed seeds, Stolons and established weeds will not be controlled	Absorbed mainly by the germinating plant shoots secondarily by roots	Absorbed by roots, stem and leaves Tranlocated acropetally and basipetally
14	Average persistence at recommended rates	Goal can remain active for a long period of time	6 to 10 weeks, varies with soil type and climatic conditions	2 to 3 weeks under aerobic conditions and 6 to 8 months under unaerobic conditions

Source WSSA (1983) Herbicide Handbook of the Weed Science Society of America Fifth edition Weed Science Society of America Illinois pp 515

INDOFIL Goal-Oxyflourfen A quantum leap in weed control Indofil chemicals Company Nirlon House Dr Annie Besant Road P O Box No 9112 Bombay 400 025 India

Appendix IIa

Weedflora of the experimental field during 1991

Scientific name	Common name	Family
Grasses		
Saccolepis interrupta (Willd) Stapf	Pollakkalla (M)	Gramineae
Sporobolus diander Beauv	-	Gramineae
Echinochloa stagnina (Retz) Beauv	Barnyard grass	Gramineae
Echinochloa colona (L) Link	Jungle rice	Gramineae
Broadleaved weeds		
Ammania baccifera L	Nellicheera (M)	Lythraceae
Monochoria vaginalis	Carpet weed	Pontederiaceae
Eriocaulon quinquangulare L	-	Eriocaulaceae
Dopatrium junceum (Roxb) Buch Ham *ex* Benth	-	Scorphulariaceae
Ludwigia parviflora Roxb	Neergramboo (M)	Onagraceae
Cyanotis sp	-	
Sedges		
Cyperus iria L	Yellow nut sedge	Cyperaceae
Fimbrystylis miliacea (L) Vahl	Hoorah grass	Cyperaceae

(M) - Malayalam name

Appendix IIb

Weedflora of the experimental field during 1992

Scientific name	Common name	Family
Grasses		
Isachne miliacea Roth	Changalippullu(M)	Gramineae
Saccolepis interrupta (Willd) Stapf	Pollakkalla (M)	Gramineae
Echinochloa colona (L) Link	Jungle rice	Gramineae
Eleusine indica (L) Gaertn	Goose grass	Gramineae
Digitaria ciliaris (Retz) Koel	Crab grass	Gramineae
Broadleaved weeds		
Aeschenomene indica L	-	Fabaceae
Cyanotis sp	-	-
Alternanthera sessilis(L) DC	-	Amaranthaceae
Oldentandia umbellata	-	Rubiaceae
Mollugo verticillata	Carpet weed	Molluginaceae
Phyllanthus niruri L	Gripe weed	Euphorbiaceae
Mimosa pudica	Touch-me-not	Mimosaceae
Sedges		
Cyperus rotundus L	Purple nut sedge	Cyperaceae
Cyperus iria L	Yellow nut sedge	Cyperaceae
Fimbrystylis miliacea	Hoorah grass	Cyperaceae
Ferns		
Marsilia quadrifoliata L	Nalilakodiyan (M)	Marsileaceae

(M) - Malayalam name

Appendix III

Nitrogen content of weeds at different stages (%)

Treatments	Stages of observation			
	30	60	90	Harvest
T1	2 9	1 6	1 9	2 0
T2	2 8	1 8	1 9	1 9
T3	2 9	1 8	2 3	2 0
T4	2 4	2 2	1 7	1 8
T5	2 7	1 7	1 8	1 7
T6	2 5	2 2	2 5	1 6
T7	2 3	1 8	1 7	1 1
T8	3 4	1 8	1 7	1 3
T9	3 4	1 7	2 5	1 5
T10	2 6	1 8	2 2	1 3
T11	3 1	1 6	1 8	1 1
T12	2 6	1 9	2 0	1 4
T13	2 9	1 6	1 7	1 6
T14	2 4	1 8	1 7	1 7
T15	3 1	1 8	2 3	1 1
T16	3 1	1 8	1 8	2 1

Appendix IV

Phosphorus content of weeds at different stages (%)

Treatments	Stages of observation			
	30	60	90	Harvest
T1	0 41	0 25	0 20	0.26
T2	0 38	0.25	0.29	0 35
T3	0 41	0 20	0 18	0 28
T4	0 35	0 23	0 23	0 35
T5	0 41	0.28	0 19	0 26
T6	0 42	0 25	0 23	0 28
T7	0 45	0 18	0 21	0 33
T8	0 38	0 25	0 23	0 33
T9	0 40	0 25	0 21	0 33
T10	0 35	0 20	0.21	0 34
T11	0 41	0 18	0 23	0 33
T12	0 40	0 33	0 24	0 35
T13	0 38	0 20	0.24	0 35
T14	0 40	0 20	0 25	0 25
T15	0 42	0 38	0 18	0 33
T16	0.38	0 25	0 24	0 35

Appendix V

Potassium content of weeds at different stages (%)

Treatments	Stages of observation			
	30	60	90	Harvest
T1	2 6	2.3	2 0	2 5
T2	2 1	1 3	2 1	2 6
T3	3 0	1 3	1 8	2 7
T4	2 0	1 8	2 3	2 4
T5	2 9	1 8	1 4	2 8
T6	2 8	1 0	1 7	2 7
T7	2 6	1 9	2 7	2 0
T8	2 3	1 8	2 8	3 0
T9	2 0	1 5	2 1	3 3
T10	1 9	1 3	3 1	3 0
T11	2 5	0 75	2 3	1 9
T12	2 7	1 8	2 5	2 2
T13	2 3	2 1	2 3	2 9
T14	3 1	1 3	2 5	3 9
T15	3 3	0 77	3 3	2 1
T16	2 0	2 4	2 9	3 8

Appendix VI

Nitrogen content of crop at different stages (%)

Treatments	Stages of observation				
	30	60	90	Harvest	
				Grain	Straw
T1	3 5	1 8	1 3	2 5	1 1
T2	3 4	1 9	0 84	2 5	1 2
T3	3 4	1 9	1 1	2 3	1 2
T4	3 4	2 3	0 70	2 5	1 3
T5	3 4	1 8	1 1	1 9	1 0
T6	3 2	2 3	0 84	2 5	1 1
T7	3 4	1 9	1 3	1 6	1 2
T8	3 4	1 9	0 84	2 1	1 1
T9	3 4	1 8	0 79	1 6	1 2
T10	3 4	1 9	1 2	1 6	1 1
T11	3 0	1 7	1 2	2 0	1 2
T12	3 4	2 0	1 1	2 4	1 1
T13	3 4	1 7	0 98	1 6	1 2
T14	3 4	1 9	1 1	1 6	1 1
T15	3 4	1 9	1 1	2 0	1 3
T16	3 1	1 9	0 98	1 4	1 1

Appendix VII

Phosphorus content of crop at different stages (%)

Treatments	Stages of observation			
	60	90	Harvest Grain	Harvest Straw
T1	0 28	0 31	0 35	0.30
T2	0 30	0 25	0 31	0 28
T3	0 30	0 28	0 35	0 29
T4	0 25	0 29	0 32	0 27
T5	0 27	0 30	0 35	0 29
T6	0 25	0 28	0 35	0 26
T7	0 29	0 25	0 30	0 29
T8	0 28	0 26	0 30	0 25
T9	0 30	0 31	0 30	0 30
T10	0 30	0 31	0 30	0 30
T11	0 30	0.33	0 31	0 30
T12	0 30	0 33	0 28	0 28
T13	0 30	0 36	0 35	0 30
T14	0 30	0 25	0 30	0 30
T15	0 27	0 25	0 33	0 30
T16	0 29	0 32	0 30	0 29

Appendix VIII

Potassium content of crop at different stages (%)

Treatments	Stages of observation			
	60	90	Harvest Grain	Harvest Straw
T1	3.0	1.7	0.47	1.9
T2	2 7	1.9	0.43	2 0
T3	2 5	2.8	0 45	1.9
T4	2 8	2 0	0 47	2.0
T5	3 0	2 0	0 45	2 1
T6	3 0	2.0	0 45	2.1
T7	3 3	1 5	0 40	2 5
T8	3 1	1.5	0 42	2.1
T9	3 0	2.0	0 50	2.4
T10	3 1	1.8	0.45	2.4
T11	2 9	1.5	0 40	2.5
T12	2 8	2.1	0 48	2 1
T13	2 7	3.0	0 45	2 2
T14	3.1	2.1	0 48	2.2
T15	2 7	1.9	0 40	2 5
T16	3 0	2.8	0 48	1.8

APPENDIX IXa(i)

Cost of cultivation excluding cost for weed control 1991 (Rs/ha)

Particulars	Cost of input	Labour charges: Tractor	Labour charges: Men	Labour charges: Women	Total
1 Land preparation (Tractor 12hrs + 8M)	-	636 00	408 00	-	1044 00
2 Seeds (100 kg)	400 00	-	-	-	400 00
Sowing(2M+4W)		-	131 00	229 00	360 00
					760 00
3 Gap filling (9W)		-	-	459 00	459 00
4 Fertilizers					
Urea (153kg)	504 90	-		-	504 90
Mussoriephos (175kg)	150 50	-	-	-	150 50
M O P (58 3kg)	110 80	-	-	-	110 80
Application(2W)			-	102 00	102 00
					868 20
5 Harvest operations					
Harvesting (6W) &			-	324 00	324 00
Threshing (2½W)			-	135 00	135 00
Cleaning & drying (2M+4W)	-	-	108 00	224 00	332 00
					791 00
6 Other operations (1M+3W)	-		53 00	157 00	210 00
			TOTAL		4132 20

Seeds

Paddy seed @ Rs 4/kg

Fertilizers

Urea @ Rs 3 3/kg
Mussoriephos @ Rs 0 86/kg
M O P @ Rs 1 9/kg

Labour Charges (Rs)

Month	Men	Women
May 91	53	51
June 91	55	53
July 91	53	51
August 91	55	53
September 91	56	54
October 91	56	54

APPENDIX - IXa(ii)

Cost of cultivation excluding cost for weed control 1992 (Rs/ha)

Particulars	Cost of input	Labour charges: Tractor	Men	Women	Total
1 Land preparation (Tractor 12hrs + 6M)	-	642 00	321 00	-	963 00
2 Seeds (100 kg)	600 00			-	600 00
Sowing (3W)		-	-	160 50	160 50
					760 50
3 Gap filling (8W)	-	-	-	442 40	442 40
4 Fertilizers					
Urea (153kg)	459 00		-	-	459 00
Factomphos (175kg)	1225 00	-		-	1225 00
M O P (58 3kg)	378 95	-		-	378 95
Application(4W)	-	-	-	218 00	218 00
					2280 95
5 Harvest operations					
Harvesting(2M+5W)	-	-	115 80	289 50	405 30
Threshing (2M+4W)		-	115 80	231 60	347 40
Cleaning & drying (6W)	-	-		347 40	347 40
					1100 10
6 Other operations (11W)	-			604 70	604 70
			TOTAL		6151 65

Seeds	Fertilizers	Labour Charges (Rs): Month	Men/Women
Paddy seed @ Rs 6/kg	Urea @ Rs 3/kg	May 92	53 50
	Factomphos @ Rs 7/kg	June 92	55 30
		July 92	53 70
	M O P @ Rs 6 5/kg	August 92	55 55
		September 92	57 90

APPENDIX - IXb

Economics of different treatments

Treatments	Cost of cultivation excluding cost for weed control		Cost of weed control operations		Total cost of cultivation		Return from grain yield		Return from straw yield		Total return	
	1991	1992	1991	1992	1991	1992	1991	1992	1991	1992	1991	1992
T1	4132 20	6151 65	272 00	283 80	4404 20	6435 45	9666 00	12492 00	453 70	1027 75	10119 70	13519 75
T2	4132 20	6151 65	272 00	283 80	4404 20	6435 45	9621 00	13918 50	401 80	1037 00	10022 80	14955 50
T3	4132 20	6151 65	223 00	283 80	4355 20	6435 45	8946 00	10665 00	422 30	877 75	9368 30	11542 75
T4	4132 20	6151 65	442 00	515 30	4574 50	6666 95	8946 00	11799 00	437 00	981 50	9383 00	12780 50
T5	4132 20	6151 65	442 00	515 30	4574 50	6666 95	9444 00	12901 50	413 00	972 25	9857 00	13873 75
T6	4132 20	6151 65	393 30	515 30	4525 50	6666 95	8166 00	10548 00	418 50	879 75	8584 50	11427 75
T7	4132 20	6151 65	611 85	746 70	4744 05	6898 35	10866 00	15282 00	453 70	1148 25	11319 70	16430 25
T8	4132 20	6151 65	611 85	746 70	4744 05	6898 35	10167 00	14184 00	414 80	1074 00	10581 80	15258 00
T9	4132 20	6151 65	562 85	746 70	4695 05	6898 35	9279 00	11448 00	372 20	953 75	9651 20	12401 75
T10	4132 20	6151 65	781 40	978 10	4913 60	7129 75	9888 00	15565 50	422 20	1185 25	10310 20	16750 75
T11	4132 20	6151 65	781 40	978 10	4913 60	7129 75	12588 00	18675 00	470 40	1239 75	13058 40	19914 75
T12	4132 20	6151 65	732 40	978 10	4864 60	7129 75	8055 00	11169 00	383 30	944 75	8438 30	12113 75
T13	4132 20	6151 65	512 00	461 50	4644 50	6613 15	8556 00	11281 50	448 20	972 25	9604 20	12253 75
T14	4132 20	6151 65	485 00	434 50	4617 20	6586 15	8889 00	11902 50	386 30	1000 00	9275 30	12902 50
T15	4132 20	6151 65	3120 00	4099 50	7252 20	10251 15	12612 00	18432 00	524 10	1214 75	13136 10	19646 75
T16	4132 20	6151 65			4132 20	6151 65	6168 00	8865 00	288 50	787 00	6456 50	9652 00

	1991	1992
Price of paddy/kg (Rs)	3 00	4 50
Price of straw/kg (Rs)	0 10	0 25
Cost of Oxyflourfen (Goal 23 5 EC)/l (Rs)	796 00	1086 50
Cost of Butachlor (Butachlor 50 EC)/l (Rs)	136 00	130 00
Cost of thiobencarb (Saturn 50 EC)/l (Rs)	127 00	117 00

	1991	1992
2 Hand weeding	60W - 30 W @ Rs 53/W	75 W - 45 W @ Rs 55 30/W
	30 W @ Rs 52/W	30 W @ Rs 53 70/W
Spray application	3M @ Rs53/M	3M @ Rs 53 50/M

Appendix X

Abstract of analysis of variance

Character	Source	df	Mean sum of squares								
			20 DAS	30 DAS		60 DAS		90 DAS		Harvest	
			1992	1991	1992	1991	1992	1991	1992	1991	1992
1	2	3	4	5		6		7		8	
Studies on weeds											
Saccolepis interrupta count	Treat-ment	15	6 84*	5 09*	10 51*	12 29*	7 26*	7 29*	3.74*	1 29*	3 56*
	Error	30	0 12	0 23	0 14	0 20	0 19	0 26	0 19	0 20	0 20
Ammania baccifera count	Treat-ment	15	_	1 17*	_	30 95*	_	14 43*	_	9 28*	_
	Error	30		0 08		0 20		0 27		0 12	
Eriocaulon sp count	Treat-ment	15	_	_	_	321.24*	_	160 29*	_	36 57*	_
	Error	30				1 26		0 16		0 21	
Isachne miliacea count	Treat-ment	15	13 38*	_	12 46*	_	9.29*	_	4 20*	_	3 39*
	Error	30	0 07		0 18		0 12		0 10		0 14
Cyperus sp count	Treat-ment	15	3 62*	_	3 13*	_	2 20*	_	3 73*	_	3 13*
	Error	30	0.10		0 12		0 19		0 21		0 12

(Contd)

(Appendix X Contd.)

1	2	3	4	5		6		7		8	
Total grass weed count	Treat- ment	15	20 32*	–	21 11*	–	14 27*	–	19 65*	–	2 95*
	Error	30	0 13		0.19		0 14		1 96		0 13
Total weed count	Treat- ment	15	25 49*	6 02*	25 39*	326 65*	23 81*	162 34*	5 94*	44.14*	3 76*
	Error	30	0 18	0 19	0 34	0 14	0 43	0 12	0 26	0 11	0 29
Weed dry matter production	Treat- ment	15	423 36*	242.41*	1388 97*	8572 60*	4272 66*	1825 34*	17319 34*	281 82*	12995 81*
	Error	30	9 33	4 09	438 37	19 76	25 06	8 33	800 71	7 08	193.27
Weed control efficiency	Treat- ment	14	558.12*	592 77*	592 77*	–	1456 09*	–	548 56*	–	599 15*
	Error	28	28 31	8 69	8 69		10 07		23 26		11 72
Studies on crop											
rop dry matter production	Treat- ment	15	–	1391 35*	1390 24*	3999 07*	1611 20*	10677 80*	24195 47*	84146 93*	140386 10*
	Error	30		32 81	42 84	1493 10	519 20	4514 37	1416 27	7615 47	11942 80
Height of plant	Treat- ment	15	–	–	1 60*	–	41 82*	–	93 01*	50 86*	30 94*
	Error	30			1.07		2.90		5 21	14.77	9.34
Tiller number	Treat- ment	15	–	–	5186 10*	–	11928 80*	–	92939 21*	–	–
	Error	30			1228 25		1436 60		5346 80		

(Contd)

(Appendix X Contd)

1	2	3	4	5	6	7	8
Nutrient uptake							
Uptake by weeds							
Nitrogen	Treat-ment	15	_	_	283.02*	_	157 30*	_	305 92*	_	571 54*
	Error	30			0 60		0 87		12 31		6 95
Phosphorus	Treat-ment	15	_	_	4 42*	_	2 60*	_	9 89*	_	15 15*
	Error	30			0 02		0 02		0 06		0 23
Potassium	Treat-ment	15	_	_	133 72*	_	205 08*	_	1180.87*	_	1966 91*
	Error	30			0 74		0 95		5 34		25 88
Uptake by crop							
Nitrogen	Treat-ment	15	_	_	_	_	406 20*	_	_	_	4139 56*
	Error	30					8 38				285 33
Phosphorus	Treat-ment	15	_	_	_	_	7 86*	_	17 27*	_	139 76*
	Error	30					2 66		0 53		11 57
Potassium	Treat-ment	15	_	_	_	_	1413 27*	_	796 27*	_	3781 44*
	Error	30					53 42		65 61		231 31

(Contd)

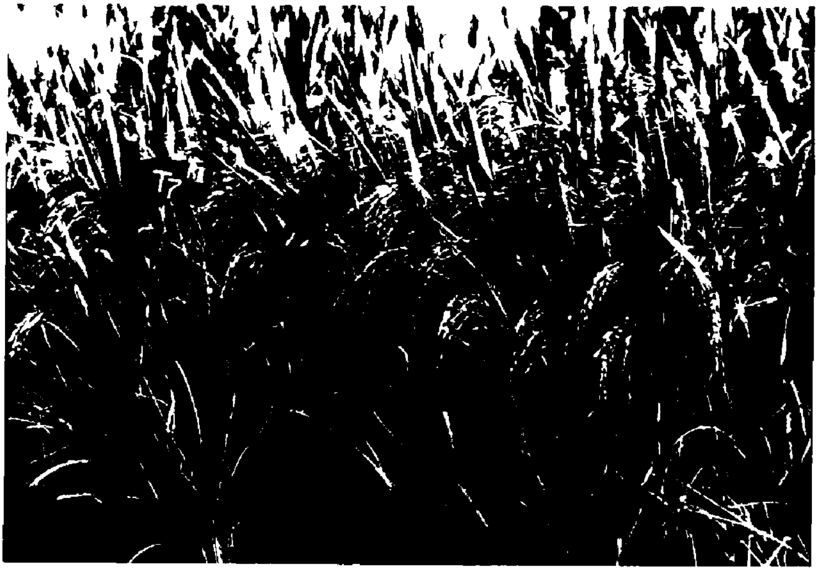
(Appendix X Contd)

Character	Source	df	1991	1992
Productive tillers	Treatment	15	3 06*	2 77*
	Error	30	1 58	1 06
Panicle length	Treatment	15	0 95*	0 998
	Error	30	0 37	1 36
Number of filled grains per panicle	Treatment	15	290 12*	293 75*
	Error	30	23 59	25 40
Thousand grain weight	Treatment	15	3 94*	2 32*
	Error	30	0 56	0 70
Grain yield	Treatment	15	112 16*	84 64*
	Error	30	9 45	5 11
Straw yield	Treatment	15	48 52*	101 26*
	Error	30	26 57	15 56
Harvest index	Treatment	15	0 0203	0 008
	Error	30	0 0077	0 0086
Weed index	Treatment	14	361 46*	327 71*
	Error	28	24 99	114 05

* Significant at 5% level

1 Plot treated with oxyflourfen @ 0 15 kg a i /ha on the same day of sowing

2 Unweeded plot



3 Plot treated with oxyflourfen a 0 15 kg a i /ha on the same da of sowing

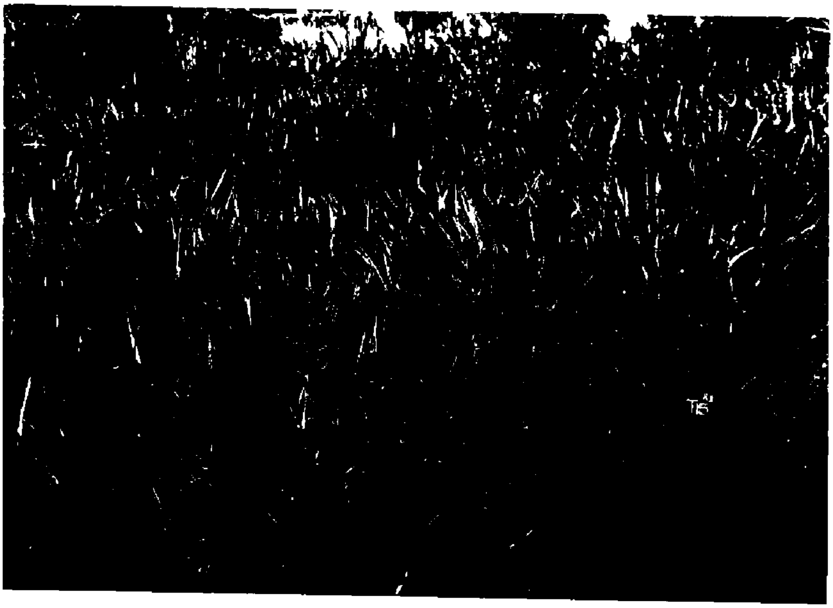
4 Unweeded plot

5 Plot treated with butachlor @ 1 5 kg a i /ha on the same day of sowing

6 Plot treated with thiobencarb @ 1 5 kg a i /ha on the same day of sowing

7 Plot treated with oxyflourfen @ 0 05kg a i /ha on the same day of sowing

8 Plot treated with oxyflourfen @ 0 2 kg a i ha at 6 DAS



9 Hand weeded plot

10 *Isachne miliacea* a weed species largely seen in the plots

EFFECT OF OXYFLOURFEN FOR WEED CONTROL IN DRY-SOWN RICE

By

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ABSTRACT OF A THESIS

Submitted in partial fulfilment of the requirement for the degree

Master of Science in Agriculture

Faculty of Agriculture
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1992

ABSTRACT

A field experiment was conducted at Regional Agricultural Research Station Pattambi of Kerala Agricultural University during the first crop seasons of 1991 and 1992 to find out the time and dose of application of oxyflourfen in dry-sown rice The treatments included different doses of oxyflourfen (0 05 0 10 0 15 and 0 2 kg a i /ha) on the same day of sowing at 3 and 6 DAS Butachlor and Thiobencarb (1 5 kg a i /ha) on the same day of sowing and two controls (weedy check and hand weeded check) laid out in randomised block design with three replications

The results showed that the count dry matter production and nutrient removal of weeds were appreciably reduced by the weed control treatments particularly by oxyflourfen application @ 0 15 kg a i /ha on the same day of sowing during initial stages and oxyflourfen application @ 0 2 kg a i /ha at 3 DAS during later stages The weed control efficiency was highest during critical stages in oxyflourfen applied plots @ 0 15 kg a i /ha on the same day of sowing and was even higher than that of hand weeding and the effect was on par with oxyflourfen application @ 0 2 kg a i /ha at 3 DAS

Oxyflourfen application @ 0 2 kg a i /ha at 3 DAS gave significantly higher values of yield attributes viz productive tillers panicle length and number of filled grains per panicle resulting in higher grain yield and the effect was on par with hand weeding These treatment showed highest straw yield also The weed index values were lower in plots where oxyflourfen @ 0 2 kg a i /ha at 3 DAS were applied In terms of returns per rupee invested also plots treated with oxyflourfen @ 0 2 kg a i /ha at 3 DAS was the best

Among the different levels of oxyflourfen a dose of 0 2 kg a i /ha at 3 DAS can be advocated for better weed control efficiency higher yield and net return