EVALUATION OF JOINT FORMULATION OF ANILOFOS (Aniloguard) AND 2,4-DEE FOR THE CONTROL OF WEEDS 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

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Vellanikkara - Thrissur

1995

DECLARATION

I hereby declare that this thesis entitled **"Evaluation of joint formulation of Anilofos (Aniloguard) and 2,4-DEE for the control of weeds 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

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ACKNOWLEDGEMENT

It is with deep sense of gratitude that I express my heartfelt thanks and indebtedness to **Dr.(Mrs.). P.Sreedevi**, Associate Professor of Agronomy, Directorate of Extension, Mannuthy and Chairperson of my Advisory Committee for her valuable guidance, sustained interest and unfailing help during the period of this investigation and preparation of manuscript. I am deeply obliged to her for the constant encouragement, timely suggestions and constructive criticisms received from her during the period of study.

I express my sincere gratitude to **Dr.E.Tajuddin**, Director of Extension i/c formerly Head of the Department of Agronomy, College of Horticulture for the whole hearted co-operation rendered to me through out the study.

The sincere help received from **Dr.R.Gopinathan**, Associate Professor, Department of Agronomy and member of my Advisory Committee is thankfully acknowledged.

Let me place on record my heartfelt thanks to **Sri.S.Krishnan**, Assistant Professor, Department of Agricultural statistics for his estimable help in the statistical analysis and preparation of thesis.

I am extremely thankful to **Dr.Jayakumar**, Associate Professor, ARS, Mannuthy for providing me all facilities to conduct the research work at the station.

With all regards, I sincerely acknowledge the generous help received from the staff of the Department of Agronomy, College of Horticulture and also the staff and labourers of the ARS, Mannuthy during the period of investigation.

A word of thanks to Sri.P.B.Bhashajan, Farm Assistant, AICRP on Weed Control and Smt.Joice T.John, Technical Assistant, Department of Agricultural Statistics for their timely help.

The research fellowship offered by M/s. Gharda Chemicals, Bombay, during the period of the study is gratefully acknowledged.

It is with immense pleasure that I thank all my friends who have contributed in someway or other towards the completion of my research work.

My sincere thanks to Mr.Joy and Smt.Malathy for their neat typing and prompt service.

I will always remain beholden to my parents, sister and brother for their boundless affection, maximum help and inspiration through out my endeavours.

Above all, I thank God Almighty, for showering his choicest blessings without which all the efforts would have been in vain.

JIJIMOL P. KURIAN

Dedicated to
My Loving Parents

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Introduction

INTRODUCTION

Rice plays a unique role in meeting the food requirements of more than half of the world population. In India rice occupies an area of 39.04 million hectares, with a production of 72 million tonnes (Venkataramani, 1994). Rice is the principal crop in Kerala, where it is grown in an area of 5.41 lakh hectares with an annual production of 10.86 lakh tonnes (FIB, 1994).

During the first crop season (virippu), direct seeding is a common practice among farmers to take the advantage of early rains for crop establishment. The dry seeded rice begins its life cycle as a dry crop, but as the rainy season proceeds water accumulates in the field and the crop finishes its life cycle as a wet land crop. In dry seeding, a much wider range and intensity of weed problem can be expected than in transplanting or wet seeding because of the differences in land preparation, lack of standing water at the initial stages of crop growth and simultaneous emergence and growth of weeds and rice. The grassy weeds appear along with the germinating seeds of the crop and constitute the major portion of the weed population. Hence heavy infestation of weeds is a serious threat to the rice growers during the first crop season.

Appropriate weed control technology has a direct bearing on the success of the dry-seeded crop. Crop loss due to weed infestation is more severe in tropical regions as in Kerala, where grain yield reduction is reported to vary from 28 to as high as 88 per cent (Sankaran, 1990).

Weed free condition upto sixty days is essential for getting good yields in dry sown rice (Sankaran and De Datta, 1985). Though manual weeding is considered the best, the method is uneconomical and is becoming difficult day-by-day due to scarcity of labour particularly at the peak period of requirement. Moreover, handweeding becomes difficult due to morphological similarity of grassy weeds and rice crop especially during early growth stages (Sharma *et al.*, 1977). Effective weed control through pre-emergence herbicides assume importance for obtaining higher rice yields by the efficient utilization of costly inputs.

At present, most of the available herbicides provide only a narrow spectrum of weed control. Satisfactory control of weeds could not be achieved with singular pre-emergence application of butachlor and thiobencarb in rice (IRRI, 1980). Besides, repeated use of a single herbicide may help to develop genotypes resistant to that particular herbicide. At this juncture, use of herbicide mixtures holds promise to cater to the needs of the rice farmers.

Different herbicides and their combinations are recommended elsewhere in various systems of rice culture. Herbicide combinations provide prolonged and wider spectrum of weed control than singular application even at the reduced dose due to additive or synergistic effects. Moreover, in combination the application rates are usually lower than that of herbicides applied alone and thus economical. Combination of phenoxy's with a grass weed killer had been reported to increase the spectrum of weed control (De Datta *et al.*, 1971).

In the case of tank mix combinations several difficulties are encountered in compatability, application and efficiency. However with respect to ready mix formulations broad spectrum of weed control can be obtained economically, minimising operational hazards than tank mix applications.

Information regarding the effect of different herbicide combinations, their phytotoxicity to rice seedlings and weed control efficiency in dry sown rice are limited. Hence the study was undertaken with the following objectives.

1. To study the efficacy of joint formulation of anilofos (aniloguard) and 2,4-DEE in controlling weeds associated with dry-sown rice.
2. To find out the optimum dose and time of application of joint formulation of anilofos (aniloguard) and 2,4-DEE in dry-sown rice.
3. To find out the economics of herbicide use in comparison with the conventional method of weed control in dry-sown rice culture.

Review of Literature

REVIEW OF LITERATURE

Dry sown rice is exposed to severe competition from weeds as they extend a formidable competition for nutrients, water and light. The success of dry sown crop mainly depends on the appropriate weed control technology. Thus effective weed control through herbicides assumes importance for achieving high production utilising the high cost inputs in full by the rice crop.

Herbicide discovery and development is a continuing process because there is always a need for newer herbicides to meet the changing weed situations in agricultural systems, to achieve greater efficacy and economy in chemical weed control and to minimise risks to the environment through toxicity and residues. Also the efficiency of a herbicide in controlling weeds depends on the weed spectrum, herbicide dose, time and method of application. Hence a brief review is made on the nature of weed spectrum in rice field, the competition between crop and weed and their effects on growth and yield. Literature on the different aspects of chemical control of weeds in rice using anilofos, 2,4-DEE, butachlor and mixture of anilofos and 2,4-DEE is also reviewed.

2.1 Weed spectrum in dry-sown rice

Weeds are more serious in the production of dry sown rice than in other cultures. A much wider range and intensity of weed problems can be expected in dry-sown rice. About 350 species in more than 150 genera and 60 plant families have been reported as weeds of rice (De Datta, 1977; Barret and Seaman, 1980).

Pande and Bhan (1966) reported that grassy weeds constitute the major weed population in upland paddy. Cyperaceae rank next in abundance with more than 50 species reported as weeds of rice (Holm *et al.*, 1977).

Chatterjee *et al.* (1971), Misra and Roy (1971) and Mukopadhyay *et al.* (1972) reported that *Echinochloa colona* (L) Link, *Echinochloa crusgalli* (L) Beauv, *Cynodon dactylon* (L) Pers, *Eleusine indica* (L) Gaertn. *Ipomoea sp.*, *Fimbristylis miliaceae*(L) Vahl, *Commelina benghalensis* L, *Phyllanthus niruri* (L) and *Amaranthus sp.* were the major weeds in upland rice irrespective of edaphic differences.

Nair *et al.* (1974) reported from their studies in direct-seeded rice fields of Kerala that the important weeds consisted of *Echinochloa crusgalli, Cyperus sp., Fimbristylis miliaceae* and *Monochoria vaginalis*. The predominant weed species found in the rice fields of Mannuthy, Kerala, under semi-dry conditions included *Cynodon dactylon, Cyperus iria, Cyperus difformis, Amaranthus viridis, Tridax procumbens, Ageratum conyzoides* and *Phyllanthus niruri* (Nair *et al.*, 1979).

General weed flora recorded (AICRP WC, 1986a) in direct sown rice of Tamil Nadu were *Echinochloa colona, Echinochloa crusgalli, Brachiaria platyphylla* in grasses, *Cyperus iria, Cyperus difformis, Scirpus sp.* and *Fimbristylis miliaceae* in sedges, *Marselia quadrifolea, Ludwigia parviflora, Eclipta alba* and *Ammania baccifera* in broad leaved weeds.

Cruz *et al.* (1986) noticed *Cyperus rotundus, Digitaria sp., Cynodon dactylon, Echinochloa colona, Eleusine indica* and *Dactyloctenium aegyptium* in upland rice. Experiments conducted at Regional Agricultural Research Station, Pilicode in rice under semi-dry system identified *Echinochloa crusgalli, Echinochloa colona, Ischaemum rugosum, Cyperus sp., Marselia quadrifolia* and *Eichornia crassipus* as predominant weeds (Sudhakara and Nair, 1986).

Singh *et al.* (1987) observed *Echinochloa colona, Dactyloctenium aegyptium, Cyperus rotundus, Cyperus iria* and *Trianthema monogyna* as major weeds in upland rice. Major weeds in dry sown rice in Kerala comprised of *Isachne miliaceae, Echinochloa colona, Saccolepis interrupta* among grasses and *Cyperus iria* among sedges (Jayasree, 1987 and Palaikudi, 1989). Dicot weeds were very few in number and the main species present were *Alternanthera sessilis, Ludwigia sp.* etc.

According to Moody (1989) grasses were predominant in upland rice and about 140 species were observed in South and South East Asian countries. Of these, *Dactyloctenium aegyptium, Digitaria sp., Echinochloa colona, Eleusine indica, Imperata cylindrica, Rottboellia cochin chinensis* were more important on a global basis. *Cyperus rotundus, Echinochloa colonum, Cleome viscosa* were the dominant weed species in semi-dry rice (Bhargavi and Reddy, 1990).

In Tamil Nadu Kandaswamy and Palaniappan (1990) surveyed weeds of direct sown rice, 60 days after sowing in 3 cropping seasons. The major grasses were *Echinochloa colona, Echinochloa crusgalli* and *Chloris barbata.* The most common sedges were *Cyperus rotundus, Cyperus iria* and *Fimbrystylis miliaceae.* Robinson and Selvaraj (1991) found *Echinochloa colona, Cyperus difformis, Panicum sp., Ludwigia parviflora, Cynotis axillarise* in semidry rice.

Cyperus sp., Isachne sp., Echinochloa sp., and *Saccolepis interrupta* were reported as the major weeds in rice fields of Onattukara region in Kerala

(Varughese and Pillai, 1991). Tiwari *et al.* (1991) noticed *Cyperus rotundus, Echinochloa colona, Phyllanthus niruri, Trianthema monogyna, Commelina benghalensis* and *Digitaria sanguinalis* in direct seeded rainfed rice in Uttar Pradesh.

Ramamoorthy (1991) and Pandey *et al.* (1991) reported *Echinochloa colona, Cyperus rotundus* and *Eclipta alba* as major weeds in upland rice. Major weeds in broadcast seeded semi-dry rice of Raipur were *Echinochloa colonum, Echinochloa crusgalli, Ischaemum rugosum, Eleusine indica, Cyperus iria, Cyperus difformis, Fimbrystylis sp., Eclipta alba* and *Cassulia auxillaris* (Chandrakar *et al.*, 1993). *Cyperus rotundus, Echinochloa crusgalli, Cynodon dactylon, Cleome viscosa* and *Euphorbia hirta* were the dominant weed species in semi-dry rice at Tirupathi (Bhargavi and Reddy, 1993).

The review clearly indicated that the weed spectrum in dry-sown rice is diverse and varies with the locations. Grasses constitute the major weed flora in dry-sown rice. Among grasses *Echinochloa colona* was the most serious. *Echinochloa crusgalli* was more confined to semi dry conditions. Among sedges *Cyperus rotundus* is most serious in uplands while *Cyperus iria* is more common in semi dry conditions.

2.2 Crop weed competition in rice

The crop plants face a greater set back due to the competition by the weeds in the field especially at seedling stage. The weeds compete with the crop for light, air, water and nutrients and they also adversely affect the microclimate around the plant, harbour disease causing organisms and pests, increase cost of production and lower the quality and quantity of crop produce.

In rice, the crop-weed competition varies with the system of rice culture, method of planting, cultivar and the cultural practices. Greater crop weed competition in direct seeded rice than in transplanted rice has been reportd by several workers (Smith Jr. 1983; ICAR, 1990).

2.2.1 Critical period of crop weed comptition

Critical period of crop weed competition refers to a particular length of time in the life cycle of crop during which the presence of weeds above a certain density will cause significant yield reduction. Weeds are to be controlled within this period. 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 critical period for rice weed control is the first 40 days (Arai, 1967). The longest period of weed competition that the rice crop can tolerate without significant yield reduction was upto 30 days after sowing and this degree of competition between rice plants and weeds depends on the growth characteristics, time of weed emergence and weed density (Nair *et al.*, 1975).

Sharma *et al.* (1977) found the critical period to be between 10-12 days after emergence for direct seeded rice in India. In upland rice the critical period of weed competition varies from 2-6 weeks after emergence (Sashi *et al.*, 1983). According to Ghosh *et al.* (1977) the critical period of weed infestation in rice vary from 10 to 30 or 40 days after seeding in upland rice.

Based on the study conducted at Vellayani, Kerala, the critical period of weed infestation in a short duration direct-sown rice under semi-dry condition was

21 to 40 days of sowing (KAU, 1984). Varshney (1985) mentioned that the critical period of weed competition for upland rice was upto 40 days after sowing.

Sankaran and De Datta (1985) have suggested a weed free period of 50 days after seeding in upland rice. According to Shelke *et al.* (1986) the critical period of weed removal in upland rice lies between 15 to 30 days after sowing. Competition from weeds during the first 15 days after sowing had no significant effect on grain yield of rice, while competition beyond 15 days after sowing caused drastic reduction in grain yield of rice (Singh *et al.*, 1987). In upland direct seeded rice the competitive period was identified to be 4 weeks after sowing (Tiwari *et al.*, 1991).

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-seeded rice this period may extend to 45-55 days of sowing.

2.2.2 Effect of weeds on rice growth and yield attributes

a) Dry matter production

Severe weed infestation in upland rice was found to depress the total dry matter production of rice (Chakraborthy, 1973). Nakayama (1978) observed a reduction in the dry matter of rice from 2.2 to 3.4 g/plant due to weed competition. Crop dry matter was negatively correlated with weed dry weight or weed density (Patel *et al.*, 1985). Jayasree (1987) also noticed a negative correlation between the dry matter production of crops and weeds at all stages of the crop with higher correlation at initial stages.

Weed dry matter at harvest was highest for unweeded check resulting in grain yield reduction (Purushothaman *et al.*, 1988). Singh *et al.* (1988) and Nair *et al.* (1979) also reported lowest crop dry matter in weedy check with lowest grain yields. 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 hand weeding was done (Palaikudy, 1989).

b) Plant height

Weeds significantly reduced the plant height, Mukopadhay and Bag (1967) and Sreedevi (1979). However Noda *et al.* (1968) and Jayasree (1987) reported increased plant height due to competitive stress in unweeded plants.

Mc Gregor *et al.* (1988) studied the impact of 10, 50, 100 and 150 plants/m^2 densities of *Brachiaria platyphylla* in rice and found that densities of 100 and 150 plants/m^2 reduced the height of rice. High weed density and weed competition reduced the height of the crop (Palaikudy, 1989). Reduction in plant height and tiller number due to heavy weed infestation was also observed by Jayakumar (1991).

ii) Yield attributes

Ravindran *et al.* (1978) recorded lowest values for yield attributing characters such as number of panicles/m^2, spikelets/panicle and 1000 grain weight in the unweeded control. In direct seeded semi-dry rice the number of filled grains/panicle was considerably reduced due to uncontrolled weed growth (Sreedevi, 1979).

Moorthy (1980) noticed a reduction in number of panicles/m^2 to the extent of 32 per cent in unweeded plots over hand weeded (twice) plots. Sashi *et al.* (1983) recorded more number of filled grains per panicle by maintaining weed-free condition upto 45 days after sowing. According to Gupta (1984) the percentage of mature grains per panicle was adversely affected by grassy weeds.

Kumar and Gautam (1986) reported an increase in the number of panicles/m^2 and filled grains/panicle in the herbicide treated plots over the control plot. Singh *et al.* (1987) and Singh and Dash (1989) noticed negative correlations between weed dry weight and crop dry weight, leaf area index of rice, number of panicles/m row, number of fertile grains/panicle and grain yield.

Weeds affected the growth and yield of dry-sown rice mainly through lower number of panicles, seed setting, 1000 grain weight and panicle length (Fang and Wang, 1990). Azad *et al.* (1990) recorded higher 1000 grain weight in all the weed control treatments including handweeding over unweeded check. Productive tillers were more in effective weed control treatments over unweeded control (Swamy *et al.*, 1993).

2.2.3 Yield reduction due to weed competition

The yield losses 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 dependidng upon the intensity of weed infestation (Mukopadhyay, 1965; Bhan, 1966). Chang (1973) mentioned that reduction in yield due to weeds varied with weed species, weed density, crop season, soil fertility and rice variety. As per IRRI (1973) 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.

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 unpuddled rice, in Orissa. Yield losses in rice increased as weed population increased irrespective of soil fertility levels (Okafor and De Detta, 1976).

De Detta (1979) found that 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 seeded dry rice. 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 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). Studies at RARS, Pattambi revealed that the weed growth in early stage reduced the crop yield more severely than in the late stage and grasses were more harmful in reducing the yield of rice followed by broad leaved weeds and sedges (KAU, 1982). Weeds cause 10-15 per cent yield losses, without any visible symptoms in rice (Rao, 1983). According to Bhan and Malik (1986) *Echinochloa crusgalli* causes severe loss in rice. Competition for four weeks in upland direct seeded rice by *Echinochloa,* reduced the rice yield by 40 per cent (Mandal, 1990).

According to Budhar *et al.* (1991) grain yield increased significantly due to weed control treatments over no weeding. Vaishya *et al.* (1992) reported an yield reduction of 68 per cent in upland direct seeded rice.

The above review clearly reveal the magnitude of yield loss due to weed infestation in dry sown rice. To avoid this serious loss proper and timely weed control is quite imperative.

2.2.4 Nutrient uptake by crop and weeds

Weeds have larger requirement of nutrients and have higher mineral nutrient content than crop plants (Singh *et al.*, 1986). According to Jayakumar *et al.* (1987) weeds grow faster than crop plants and absorb the available nutrients earlier, thus depriving the crop plants of the nutrients. Such high depletion of nutrients by weeds was also reported earlier by Mukopadhay *et al.* (1972) and Kakati and Mani (1977).

Shetty and Gill (1974) revealed that weeds were more efficient in N uptake than the crop. Mani (1975) also reported more competition for N in limiting crop yields. Severe weed competition depletes 30 to 37 kg N/ha (Mukopadhay *et al.*, 1971). Nitrogen uptake by rice was inversely proportional to N uptake by weeds as per Mallappa (1973).

Sreedevi (1979) reported highest N removal by weeds in unweeded control (33.5 kg N/ha), while in hand weeded plots it was only 2.58 kg/ha. Similar results were observed by Nanjappa and Krishnamoorthy (1980), where the weeds in weedy check removed 42.0 kg N/ha compared with only 10.5 kg N/ha in weed free plot. They also reported the highest N uptake of 98.4 kg/ha by the crop in weed free plot and 45 per cent reduction in N uptake by the crop in unweeded check.

Chakraborthy (1981) observed a weed removal of 30.4 kg N and 18.2 kg P_2O_5/ha and a marked reduction in dry matter production of rice. Among the various systems of rice culture weeds accumulated more N in direct sown rice. According to Singh and Sharma (1984) N and P content of weed population were higher than those of rice plants at different growth stages under weed infested condition, while in rice most of the N was accumulated after the control of weeds. Pandey and Thakur (1988) reported an uptake of 35 kg N/ha by weeds due to weed infestation in upland rice. Katheresan and Veerabhadran (1991) found that in the unweeded control the monocot weeds removed 5.2 kg N/ha while dicot weeds removed 27.5 kg N/ha at 40 DAS. According to Ghosh and Mittra (1991) increasing rates of N promoted weed growth and drymatter at harvest in upland rice.

For successful upland rice production, higher phosphorus availability is inevitable. But the availability of this nutrient is reduced in upland, owing to faster and larger depletion by competing weeds (Alkamper, 1976). In semi-dry system of cultivation also, as the initial period of growth is as in the upland condition, weed infestation and thereby the depletion of nutrients will be more. This necessitates timely and effective weed control for achieving higher yields. Mukopadhay *et al.* (1972) recorded increased yield through increased availability and uptake of P by adopting suitable weed control measures.

Sreedevi (1979) recorded the highest P uptake of (5.13 kg/ha) by weeds in unweeded control while in weed free plot it was only 0.19 kg/ha in direct seeded unpuddled rice. Kaushik and Mani (1980) also reported a depletion of 5.8 kg P/ha through weeds in similar situation.

2.3 Chemical weed control in dry-sown rice

Chemical weed control through pre-emergence herbicides and their combination with phenoxyacids help to achieve weed free condition during critical periods of weed competition. Chemical control of weeds in direct sown rice assumes importance because of the scarcity of labour and peak periods of requirement along with its high cost (Nair *et al.*, 1974; Subramanian and Ali, 1985). The literature on the effect of the test herbicides viz. anilofos, 2,4-DEE, butachlor and mixture of anilofos and 2,4-DEE are reviewed in this chapter.

2.3.1 Anilofos

Anilofos, is a selective pre-emergence rice herbicide effective against annual grasses, sedges and broad leaved weeds. This promising new herbicide has been under intensive trials under different agroclimatic conditions in India and elsewhere.

Langeluddekke *et al.* (1981) recommended anilofos at 0.3 kg/ha for the control of *Echinochloa crusgalli* and indicated that it can be applied even upto 2-3 leaf stage. Anilofos at 0.6 kg/ha controlled barnyard grass better under low land conditions in Philippines (IRRI, 1983).

Ali and Rajan (1985) reported that *Echinochloa crusgalli* in transplanted rice in the monsoon and winter season was effectively controlled by pre-emergence application of 0.45 kg anilofos/ha, followed by one late hoeing. Babu and Singh (1985) observed no significant difference in yield with the use of anilofos @ 0.2 to

0.4 kg/ha in drilled rice at Uttar Pradesh. At Pantnagar, anilofos at 0.3 kg/ha increased number of panicle/m^2 and filled grains per panicle in direct sown rice (Kumar and Gautam, 1986). Among the several herbicides evaluated under Coimbatore conditions, anilofos at 0.4 kg/ha recorded the lowest weed density (AICRP WC, 1986a) under transplanted conditions. It was similar to handweeding twice with good persistence upto 60 DAT and good weed control efficiency (88.4%).

Anilofos applied at 0.4 kg/ha at 4 DAT produced grain yield on par with weed free check (Singh and Hari Om, 1986). When anilofos was applied at 0.45 kg/ha the number of weeds were lower as reported by Rao and Rao (1986).

Moorthy and Manna (1988) recorded highest grain yield with the application of anilofos at 1.5 kg/ha under upland conditions. Anilofos at 0.3 and 0.4 kg/ha could not effectively act against broadleaved weeds in direct seeded rice (Misra *et al.*, 1988). As per Pandey and Thakur (1988) anilofos at 0.3 and 0.5 kg/ha applied 4 DAT significantly reduced nutrient depletion by weeds.

Patro *et al.* (1989) found that the pre-emergence application of anilofos at 0.5 kg/ha efficiently controlled the total weed growth in terms of weed population and dry weight of weeds which in turn favoured better crop growth and highest yields. Anilofos at 0.4 and 0.6 kg/ha at 4, 7 or 10 days after planting gave good control of grasses and some broad leaved weeds and resulted in increased grain yields. Application of anilofos at 0.6 kg/ha on 7 or 10 DAP proved more effective than its lower dose of 0.4 kg/ha or treatment of butachlor 1.5 kg at 2 DAP (Munegowda *et al.*, 1990).

Sankaran *et al.* (1990) found in a rice-rice-green gram cropping system that for both the rice crops anilofos at 0.4 kg/ha followed by one hand weeding gave higher weed control efficiency and higher grain yield. Singh *et al.* (1990) reported that in direct seeded upland rice anilofos application produced highest grain yield significantly over oxadiazon and pendimethalin.

As per Gill *et al.* (1991) anilofos 0.3 - 0.5 kg/ha applied pre and post emergent (7 DAT) resulted in lowest weed dry weight and increased grain yield from 2.6 - 4.2 t/ha to 3.6 - 7.9 t/ha. Lower weed population and dry weight was observed with anilofos 0.4 to 0.6 kg/ha in low land rice (Budhar *et al.*, 1991).

According to Chinnamuthu (1990) application of anilofos at 0.4 kg/ha followed by one handweeding at 40 DAS recorded least NPK removal by weeds and highest NPK uptake by crop. Velayudham and Jayakumar (1993) noticed effective control of *Echinochloa crusgalli* with anilofos at 0.3 and 0.45 kg/ha. Chandrakar *et al.* (1993) reported that in brodcast seeded semi dry rice, anilofos at 0.4 kg/ha either as granules or as spray proved equally effective in controlling grassy weeds and sedges.

2.3.2 2,4-DEE

Phenoxy acids and their derivatives are the important group of organic herbicides, because of their selectivity and outstanding ability to be translocated within plants. They show a good degree of selectivity between the susceptible broad leaf weeds and the tolerant grasses, thus facilitating their use in monocot crops.

At most of the stages of crop growth the total dry matter of weeds were kept low when granular and spray formulations of 2,4-DEE was applied at 0.8 kg/ha (Singh and Bhandari, 1985). Reports from Viswa-Bharati (ISWS, 1985) showed that granular application of 2,4-DEE at 1.0 kg/ha applied at 3 DAT was effective in suppressing annual grasses at germinating stage, whereas Kumar and Gautam (1986) reported lower rice grain yield with 2,4-DEE application. As per Shivamadiah *et al.* (1987) highest net return and better weed control in upland rice could be obtained by the application of 2,4-DEE @ 0.8 kg/ha.

Bhargavi and Reddy (1990) reported that application of 2,4-DEE at 0.9 kg/ha as pre and early post emergence gave effective control of 27 weed species dominated by *Cyperus rotundus, Echinochloa colonum* and *Cleome viscosa* in semi dry rice. 2,4-DEE at 0.8 kg/ha gave effective weed control in transplanted rice (Joy *et al.*, 1991). Janardhan *et al.* (1993) found that 2,4-DEE at 1.5 - 2.5 kg/ha reduced weed dry weight at harvest and increased rice grain yield in transplanted rice.

2.3.3 Butachlor

Butachlor is a selective pre-emergence herbicide used for the control of many annual grasses, sedges and some broad leaved weeds. Best results were obtained when applied at 1-2 kg ai/ha (Moody, 1977). Nizam *et al.* (1981) reported that application of butachlor at 2 kg ai/ha in dry seeded unpuddled rice gave excellent weed control and better bioefficiency. Better weed control and higher grain yield with pre-emergence herbicide butachlor had been reported by Singh and Dash (1986) in upland rice.

Butachlor @ 1.5 kg ai/ha when applied one day after sowing gave effective control of *Echinochloa spp*. in semi-dry rice (KAU, 1986). At IRRI an experiment in upland rice showed poor control of grasses with butachlor (IRRI, 1977). Bhol and Singh (1987) also reported poor control of grassy weeds with butachlor due to rapid decomposition of the chemical by ultra violet light under irrigated conditions and quick degradation by soil microbes.

Rao and Rao (1990) found that application of butachlor 1.5 kg ai/ha on 3 DAS was found to be useful in controlling *Echinochloa colonum* without any phytotoxic effect on rice seedlings. According to Joseph *et al.* (1990) butachlor 1.5 kg ai/ha controlled broad leaved weeds and sedges.

Emmanuel (1991) observed no inhibition of rice seed germination with the application of butachlor. Results of the trial conducted at Rice Research Station, Kayamkulam, Kerala, under dry sown condition showed that pre-emergent spray of butachlor at 1 kg ai/ha immediately after seeding rice effectively controlled weeds [illegible] (Varughese and Pillai, 1991). Kamble *et al.*

Anilofos + 2,4-DEE Mixtures

Langeludukke *et al.* (1981) reported effective broad spectrum weed control with a mixture of anilofos and 2,4-DEE at 6-10 DAT. Arosin (15% anilofos, 15% 2,4-D) and rogue (34.77% butachlor + 23.17% 2,4-D) applied at 0.6 and 1.6 kg/ha respectively gave excellent control of grasses, broad leaved weeds and sedges in transplanted rice for more than 40 DAT (Pamplona and Evangelista, 1981).

Bhan and Pal (1982) observed better control of barnyard grass and *Cyperus difformis* with 50 per cent dose of anilofos in combination with 2,4-DEE. Anilofos at 0.2 kg ai/ha + 2,4-DEE at 0.4 kg ai/ha followed by 1 late hoeing gave an effective broad spectrum weed control and high paddy yield (Ali and Rajan, 1985).

Anilofos 0.3 kg ai/ha mixed with 2,4-DEE at 0.4 kg ai/ha was equally effective in controlling weeds as that of butachlor (1.25 kg/ha) mixed with 2,4-DEE at 0.6 kg/ha (AICRP WC, 1986b). Anilofos @ 0.3 kg/ha and 2,4-DEE @ 0.8 kg/ha gave yields more than 3 t/ha as per Kumar and Gautam (1986). With the application of anilofos + 2,4-DEE, there was a significant reduction in nutrient depletion by weeds.

Pandey and Thakur (1988) reported that 0.3 kg anilofos + 0.8 kg 2,4-DEE/ha was as effective as hand weeding in controlling *Cyperus rotundus* in upland rice. Grain yield was also increased by 19 per cent.

Srinivasan and Pothiraj (1989) reported that pre-emergence application of anilofos 0.3 kg + 2,4-DEE 0.51 kg/ha effectively controlled *Echinochloa sp.*

Application of anilofos 0.4 kg/ha followed by 2,4-DEE @ 0.8 kg/ha gave broad spectrum of weed control with incommittant increase in weed control efficiency (Chinnamuthu, 1990).

Ranganayaki (1990) observed that anilofos @ 0.3 kg/ha + 2,4-DEE 0.4 kg/ha applied upto 9 DAT provided broad spectrum of weed control than singular application and the grain yield was comparable with hand weeding. Broard spectrum weed control with the highest weed control efficiency and lowest weed index was observed with anilofos + 2,4-DEE (0.3 + 0.4 kg/ha) as readymix and was comparable with handweeding (Jayakumar and Sree Ramalu, 1992). The same treatment registered better growth, yield and yield parameters in transplanted rice.

According to Dhiman *et al.* (1993) anilofos + 2,4-DEE at 0.4 + 0.5 kg/ha recorded higher panicles/m^2, panicle weight and lower weed drymatter in transplanted rice. In transplanted rice broad spectrum weed control with highest weed control efficiency and lowest weed index was observed with anilofos + 2,4-DEE at 0.3 + 0.4 kg/ha (Velayudham and Jayakumar, 1993). Studies at Rice Research Station, Moncompu, Kerala (Syriac *et al.*, 1993) revealed that pre-emergent application of anilofos + 2,4-DEE produced higher grain yields and low weed dry weight. Combination of anilofos at 0.3 kg/ha + 2,4-DEE at 0.4 kg/ha applied at 10 DAS provided good control of weeds and higher grain yields in wet seeded rice (Sreedevi and Thomas, 1993).

Materials and Methods

MATERIALS AND METHODS

Field experiments were conducted in dry sown rice during the first crop season (May to September) of 1993 and 1994 to evaluate the efficiency of different doses of joint formulation as well as tank mix combination of anilofos and 2,4-DEE and singular application of anilofos, 2,4-DEE and butachlor at different time of application. The materials used and the method followed are discussed in this chapter.

3.1 Site, climate and soil

The field experiments were conducted at the Agricultural Research Station, Mannuthy under the Kerala Agricultural University, Vellanikkara, Thrissur. The station is located at 12°32' N latitude, 74°24' E longitude and at an altitude of 22.23 M above MSL. The region enjoys typical humid tropical climate.

The soil of the experimental field was sandy loam in texture. The physical and chemical composition of soil in the field are given in Table 1.

The study was conducted during the first crop season (May to September) of 1993 and 1994. The details of the meteorological observations recorded during the experimental period are presented in Tables2a and 2b and illustrated in figures (1a and 1b). The experimental field of 1993 was under cucurbitaceous vegetable for the previous summer season while the experimental field of 1994 was under bulk crop of rice during the previous season.

Table 1. Physico-chemical characteristics of the soil in the experimental field

Particulars	Value	Rating	Method employed
A. Mechanical composition			
Sand %	65.76		Robinson's International Pipette
Silt %	18.50		method (Piper, 1942)
Clay %	16.00		
Texture	Sandy loam		
B. Chemical composition	Value	Rating	
Total N (%)	0.129		Micro-kjeldahl method (Jackson, 1973)
Available P (kg/ha)	29.82	High	Bray I extractant, chlorostannous reduced molybdophosphoric blue colour method (Jackson, 1973)
Available K (kg/ha)	175.12	Medium	Neutral normal ammonium acetate extract, flame photometry (Jackson, 1973)
pH	5.12	Strongly acidic	1:2.5 soil-water suspension, using a pH meter (Jackson, 1973)

Table 2a. Meterorological data (weekly average) for the experimental period (24.5.1993 to 10.9.1993)

Standard week No.	Month and date	Temperature °C		Total rainfall (mm)	Bright sunshine hours	Relative humidity (%)	
		Maximum	Minimum			FN	AN
21	May 21-27	34.5	24.4	6.0	6.6	88	62
22	May 28-June 3	32.8	20.8	103.8	4.3	90	69
23	June 4-10	29.6	23.3	236.6	1.8	95	80
24	June 11-17	29.2	23.8	237.9	1.9	95	81
25	June 18-24	30.4	24.5	85.5	4.4	94	73
26	June25-Jul 1	29.2	23.6	186.4	2.9	94	82
27	Jul 2-8	28.6	22.7	188.9	2.0	95	78
28	Jul 9-15	28.7	22.6	167.8	1.8	92	83
29	Jul 16-22	28.9	22.9	128.1	2.8	94	76
30	Jul 23-29	28.0	23.1	101.0	2.9	94	80
31	Jul 30-Aug 5	29.1	23.7	96.4	3.6	95	76
32	Aug 6-12	29.9	28.5	54.9	4.6	95	75
33	Aug 13-19	29.2	23.1	66.3	3.3	93	78
34	Aug 20-26	29.8	23.2	61.9	5.6	96	74
35	Aug 27-Sep 2	29.8	23.5	33.6	6.5	95	73
36	Sep 3-9	29.4	23.0	23.7	3.9	93	75

Table 2b. Meterorological data (weekly average) for the experimental period (23.5.1994 to 6.9.1994)

Standard week No.	Month and date	Temperature °C		Total rainfall (mm)	Bright sunshine hours	Relative humidity (%)	
		Maximum	Minimum			FN	AN
21	May 21-27	33.9	25.3	3.5	7.60	89	62
22	May 28-June 3	30.2	22.8	171.8	2.80	95	80
23	June 4-10	26.6	22.9	280.0	0.08	96	93
24	June 11-17	28.4	22.7	219.2	0.72	97	84
25	June 18-24	30.9	23.7	66.6	5.80	96	70
26	June25-Jul 1	29.5	22.7	253.8	2.70	96	80
27	Jul 2-8	29.7	22.8	77.0	3.20	96	82
28	Jul 9-15	28.8	22.0	311.5	1.10	97	88
29	Jul 16-22	29.9	21.9	293.7	1.00	97	84
30	Jul 23-29	28.22	22.7	219.3	1.40	96	88
31	Jul 30-Aug 5	27.4	22.1	352.9	1.30	97	88
32	Aug 6-12	30.4	23.7	32.4	3.50	94	73
33	Aug 13-19	31.0	22.9	46.0	5.00	95	69
34	Aug 20-26	30.1	22.7	80.6	2.00	94	72
35	Aug 27-Sep 2	29.6	22.5	166.9	1.70	97	81
36	Sep 3-9	30.3	23.1	99.2	5.30	96	73

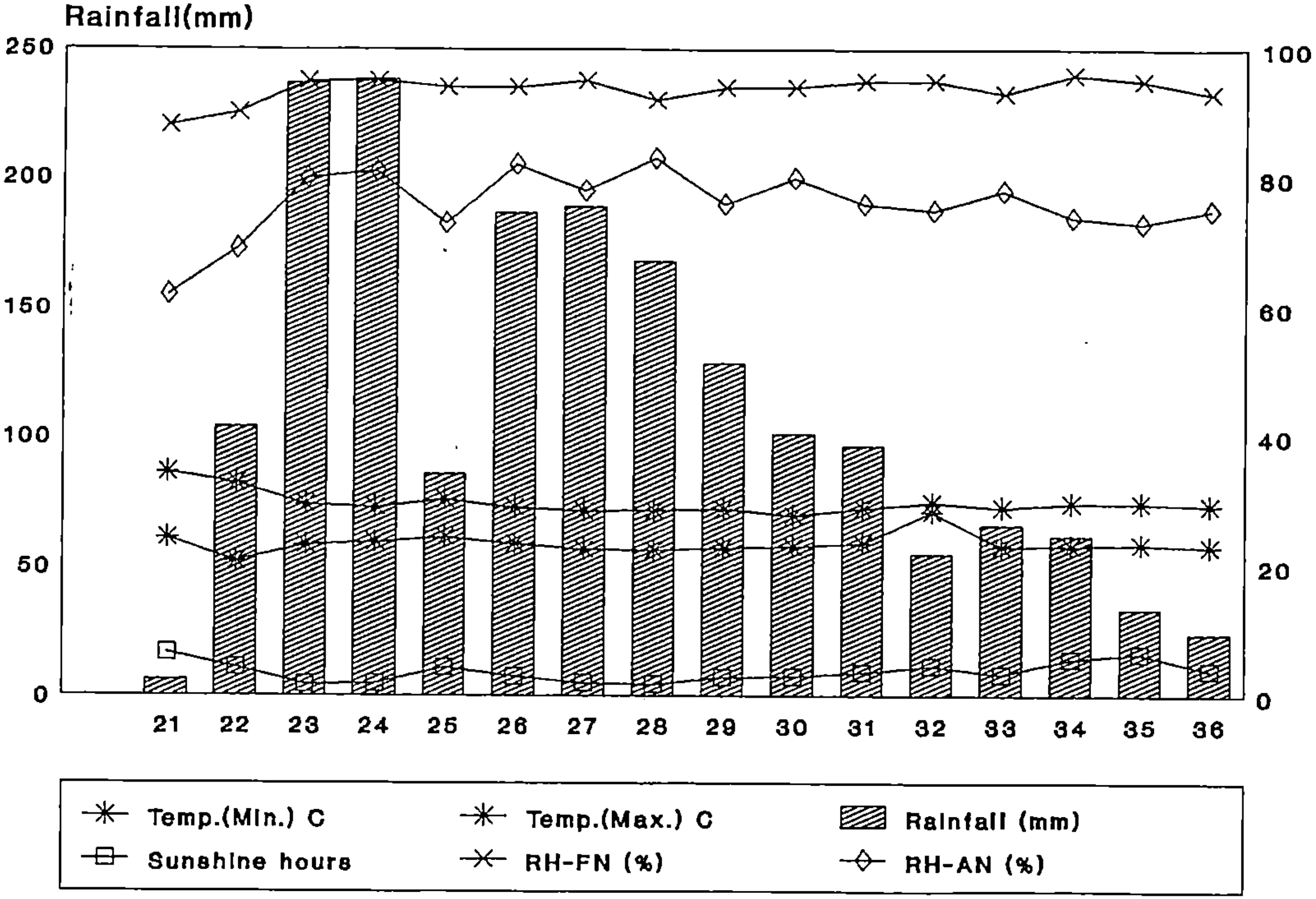

Fig. 1a. Meteorological data (Weekly average) during the crop period, 1993

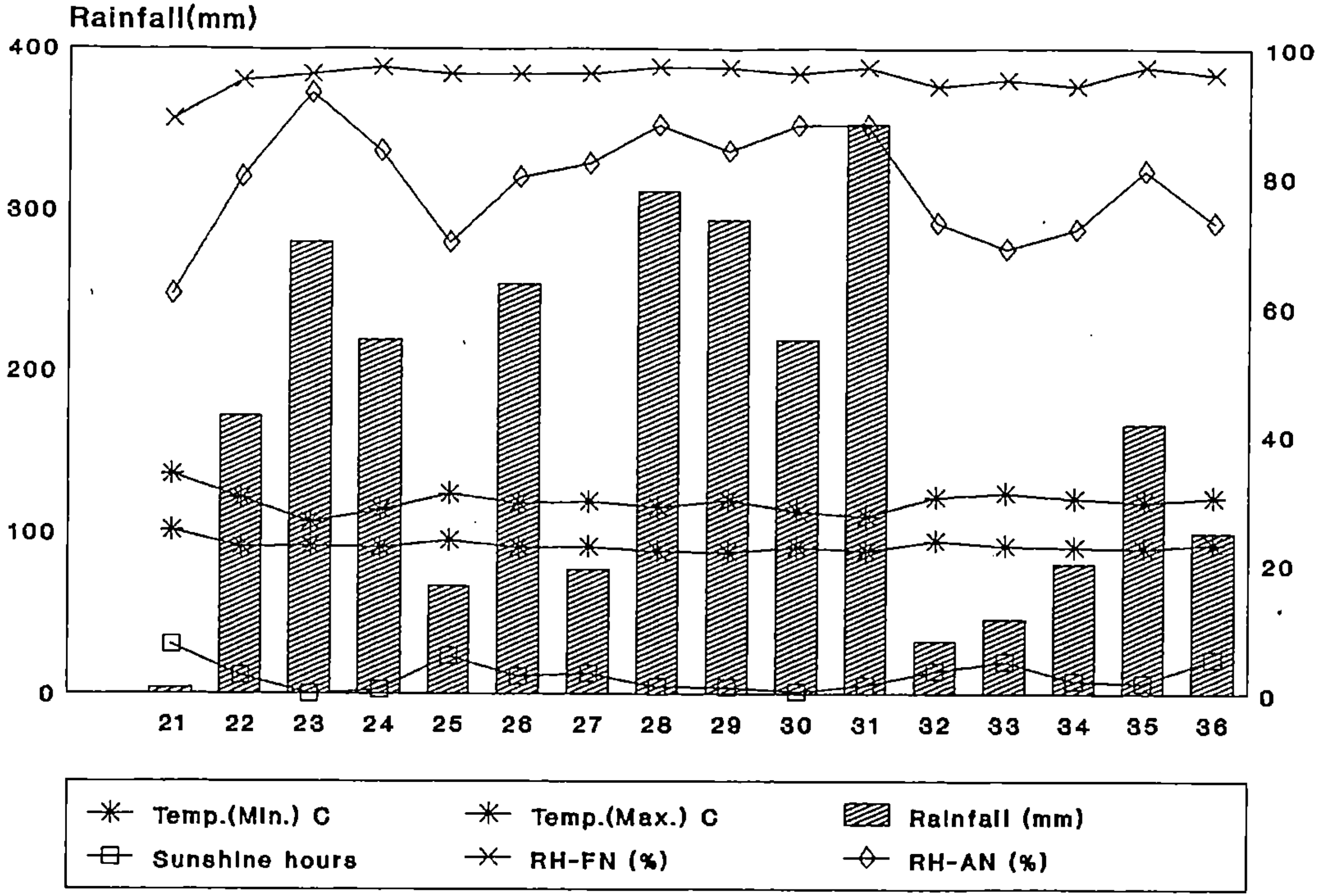

Fig. 1b. Meteorological data (Weekly average) during the crop period, 1994

3.2 Treatments

The treatments consisted of five different pre-emergence herbicides, viz. tank mix of anilofos and 2,4-DEE, joint formulation of anilofos and 2,4-DEE, singular application of anilofos, 2,4-DEE and butachlor and four different time of application of the above herbicides ie. zero, three, six and nine days after sowing. In addition an unweeded control and a hand weeded control (two hand weedings at 20 and 40 DAS) were also included for comparison.

Main plot treatments - Time of application

Sub plot treatments - Weed control treatments

Treatments	Subplot treatment	Main plot	Notation
1	2	3	4
1. Anilofos + 2,4-DEE	0.3 + 0.45 kg a.i./ha	0 DAS	M_1T_1
2. " "	"	3 DAS	M_2T_1
3. " "	"	6 DAS	M_3T_1
4. " "	"	9 DAS	M_4T_1
5. Joint formulation	0.3 kg a.i./ha	0 DAS	M_1T_2
6. "	"	3 DAS	M_2T_2
7. "	"	6 DAS	M_3T_2
8. "	"	9 DAS	M_4T_2
9. "	0.45 kg a.i/ha	0 DAS	M_1T_3
10. "	"	3 DAS	M_2T_3
11. "	"	6 DAS	M_3T_3

Contd.

1	2	3	4
12. "	"	9 DAS	M_4T_3
13. Anilofos	0.3 kg a.i/ha	0 DAS	M_1T_4
14. "	"	3 DAS	M_2T_4
15. "	"	6 DAS	M_3T_4
16. "	"	9 DAS	M_4T_4
17. "	0.45 kg a.i/ha	0 DAS	M_1T_5
18. "	"	3 DAS	M_2T_5
19. "	"	6 DAS	M_3T_5
20. "	"	9 DAS	M_4T_5
21. 2,4-DEE	0.4 kg a.i/ha	0 DAS	M_1T_6
22. "	"	3 DAS	M_2T_6
23. "	"	6 DAS	M_3T_6
24. "	"	9 DAS	M_4T_6
25. "	0.6 kg a.i/ha	0 DAS	M_1T_7
26. "	"	3 DAS	M_2T_7
27. "	"	6 DAS	M_3T_7
28. "	"	9 DAS	M_4T_7
29. Butachlor	1.25 kg a.i/ha	0 DAS	M_1T_8
30. "	"	3 DAS	M_2T_8
31. "	"	6 DAS	M_3T_8
32. "	"	9 DAS	M_4T_8
33. Hand weeded Control			HW
34. Un weeded Control			UWC

3.3 Design and layout

1. Design	:	Split plot design
2. Replication	:	3
3. Gross plot size	:	5.5 x 4.5 m^2 1m strip along the 5.5 m side for distruc tive sampling
4. Border	:	0.5 m on all sides
5. Net plot size	:	3.5 x 3.5 m^2 = 12.25 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 ingred-ient
Joint formulation of anilofos and 2,4-DEE	Aniloguard plus	Gharda chemicals	56% EC
Anilofos	Aniloguard	Gharda Chemicals	30% EC
2,4-DEE	Agrodone concentrate	Agromore Ltd.	34% WSC
Butachlor	Butachlor 50 EC	Pest Control Co.	50% EC

3.5 Herbicide application

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

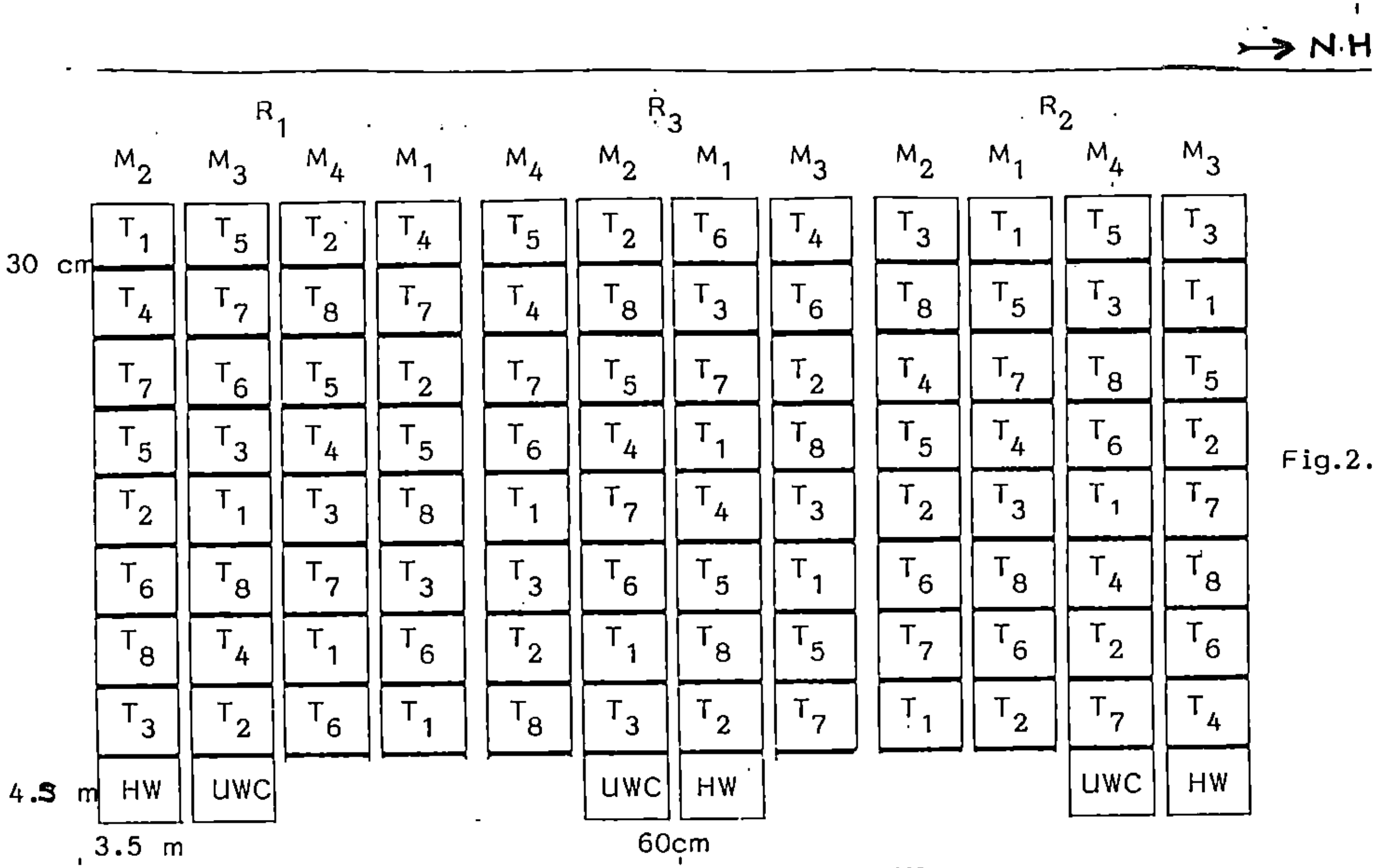

Fig.2. PLAN OF LAYOUT

A. MAIN PLOT TREATMENTS
DAYS AFTER SOWING (DAS)

M_1 – 0 DAS
M_2 – 3 DAS
M_3 – 6 DAS
M_4 – 9 DAS

B. SUB PLOT TREATMENTS

T_1 – Anilofos + 2,4-DEE (0.3+0.45 kg a.i./ha)
T_2 – Joint formulation (0.3 kg a.i./ha)
T_3 – Joint formulation (0.45 kg a.i./ha)
T_4 – Anilofos (0.3 kg a.i./ha)
T_5 – Anilofos (0.45 kg a.i./ha)
T_6 – 2,4-DEE (0.4 kg a.i./ha)
T_7 – 2,4-DEE (0.6 kg a.i./ha)
T_8 – Butachlor (1.25 kg a.i./ha)

HW – Handweeded control UWC – Unweeded control

3.6 Variety

Rice variety Jyothi was used for the study. This variety with a duration of 110-125 days has red, long and bold grains. This is moderately tolerant to brown plant hopper and blast and is specially suited for dry seeding.

3.7 Field culture

During the first year of study, the crop was sown on 24th May 1993 while in the second year on 23rd May 1994.

The fields were ploughed twice under dry conditions and brought to a fine tilth. All the weeds and stubbles were removed from the field. Dry seeds were dibbled at a spacing of 20 x 15 cm, after the basal application of fertilizers. All the cultural operations except weed control were done uniformly in all plots as per the package of practice recommendations (KAU, 1993). Herbicides were applied as per the treatments. The fields were flooded four weeks after sowing with the onset of monsoon. However, during the first year of study proper and adequate flooding could not be retained for long due to the slightly elevated nature of the plot.

The crop raised in 1993 was harvested on September 10th 1993, while that raised in 1994 was harvested on September 6th, 1994 when 80 per cent of the grain had matured.

Fertilizer used

The following fertilizers were used for the experiment:

Urea	- 46% N
Mussoriephos	- 20% P_2O_5
Muriate of potash	- 60% K_2O
Fertilizer schedule	- 90, 45, 45 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. Full dose of phosphorus was applied 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 the sampling units in four locations in each plot using an iron quadrat of 50 cm x 50 cm (0.25 m^2) size. 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 15, 30, 45, 60 DAS.

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 unit in each plot were uprooted, air dried, then dried in a hot air oven at 70°C. Dry weight of the weeds was recorded in g/m² at 30 and 60 days after sowing.

c) Phytotoxicity

The weeds were observed for phytotoxic symptoms like scorching, retarded growth etc. due to herbicide application and toxicity rating was done using 0-9 scale (Gupta, 1993).

d) Weed control efficiency

The weed control efficiency of 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/m²)

Y = Dry matter production of weeds in the respective treatments (g/m²)

3.8.2 Observations on crop

a) Phytotoxicity

The rice seedlings were also observed for any phytotoxic symptoms like scorching, retarded growth etc. due to herbicide application. Toxicity rating was done using 0-9 scale (Gupta, 1993).

b) Crop growth characters

i) Dry matter production

Three plants were collected from the sampling units, oven dried and the dry matter production was recorded in g/m^2. The observations were taken at 30 and 60 DAS and also at harvest.

ii) Plant height

The plant height in cm was recorded at 30 DAS and at harvest. The height was measured from the bottom of the culm to the tip of the longest leaf or tip of panicle whichever was longer.

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 hill.

ii) Length of panicle

The length from the neck to the tip of five panicles were measured and the average length was 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 from the net plot 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) Weed index

Weed index of different treatments were calculated using the formula (Gill and Vijayakumar, 1969).

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

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

Y = yield obtained from 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, 1973)
2. Phosphorus - Vanadomolybdophophoric yellow colour method - Spectronic 20 (Jackson, 1973)
3. Potassium - Triple acid extract method, using flame photometer (Jackson, 1973)

The analysis of weed and crop samples taken at 30, 60 DAS and harvest were done. At harvest the analysis of crop was done separately for grain and straw. The nitrogen, phosphorus and potassium removed by crop and weeds were calculated by multiplying the dry matter of the crop and weeds with the respective nutrient content and expressed in kg/ha.

3.10 Statistical analysis

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

Analysis of variance for the data on weed population and weed dry matter production were carried out after transforming the data to $\sqrt{x+0.5}$ for those with zero values and to $\sqrt{x}$ for those without zero values.

The relative economics of different weed control operations were compared by calculating the additional cost for the operation over and above the unweeded control. Benefit cost analysis pertaining to each treatment was also made.

Results and Discussion

RESULTS AND DISCUSSION

The results of the two field experiments conducted to evaluate the joint formulation of anilofos (aniloguard) and 2,4-DEE for weed control in dry-sown rice during 1993 and 1994 are presented and discussed in this chapter under the following heads:

4.1 Studies on weed
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
4.3 Studies on nutrient uptake
4.3.1 Removal by weeds
4.3.2 Uptake by crop
4.4 Economics

4.1 Studies on weeds

4.1.1 Weed spectrum

The weed flora found in the experimental field during both the years

(1993 and 1994) are presented in Appendix Ia and Ib. Weeds that appeared in the experimental field during 1993 were mainly of upland nature since the field was under vegetable cultivation during the previous summer season. The main weed flora belonged to Poaceae family. The important among them were *Cynodon dactylon, Digitaria sanguinalis, Eleusine indica, Panicum repens* and *Dactyloctenium aegyptium.* Cyperaceae family ranked next comprising of *Cyperus rotundus* and *Cyperus iria. Cleome viscosa, Ageratum conyzoides* and *Euphorbia hirta* were the major dicot weeds.

During the second year the experiment was laid out in another plot which was under bulk crop of rice during the previous season. Grasses and sedges constituted the major portion of the weed flora. Among the grasses *Isachne miliaceae, Saccolepis interrupta* and *Echinochloa colona* and among sedges *Fimbrystylis miliaceae* and *Cyperus iria* were the major ones. Though broadleaved weeds were less, *Monochoria vaginalis* predominated. Considerable reduction in the weed population was noticed in the second year.

Irrespective of the stages, the proportion of grasses were higher than sedges and broad leaved weeds. The observation that grassy weeds constitute the major weed population in dry-sown rice was reported by Nair *et al.* (1979), Sudhakara and Nair (1986), Moody (1989) and Suja (1989). The presence of *Cynodon dactylon, Digitaria sp.* and *Eleusine indica* were earlier reported by Cruz *et al.* (1986) and Moody (1989). Jayasree (1987), Palaikudy (1989) and Varughese and Pillai (1991) reported the presence of *Isachne sp.* and *Saccelepis interrupta* under semi-dry conditions.

Predominance of sedges in rice fields was reported by Holm *et al.* (1977), Cruz *et al.* (1986), Singh *et al.* (1987), Varughese and Pillai (1991) and Chandrakar *et al.* (1993). The presence of *Fimbrystylis miliaceae* in rice had also been observed by Nair *et al.* (1979), Kandaswamy and Palaniappan (1990) and Chandrakar *et al.* (1993). Occurrence of *Cleome viscosa* in dry seeded rice was noticed by Bhargavi and Reddy (1993).

4.1.2 Weed population

As different herbicides having pre-emergence to early post-emergence action were included in the study, the herbicides in relation to the time of application or the interaction effect of herbicides and time of application .re projected and discussed in the chapter.

In the second year of study no weeds were noticed in the first stage of observation i.e., 15 DAS.

4.2.2.1 Grasses

The predominant grassy weed during the first year was *Cynodon dactylon* whereas during the second year *Isachne miliaceae* dominated.

a) *Cynodon dactylon* (Tables 3 and 4)

Among the different herbicides tested, plots treated with butachlor @ 1.25 kg a.i./ha recorded the lowest number of *Cynodon dactylon* at 15 and 60 DAS. At 30 and 45 DAS the lowest weed count was noticed in those plots were 2,4-DEE @ 0.6 kg a.i./ha and joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha were applied. They were similar to butachlor application @ 1.25 kg a.i./ha at both the

Table 3. Effect of herbicides and time of application on the population of *Cynodon dactylon** (plants/m²) (1993)

Treatments	15 DAS	30 DAS	45 DAS	60 DAS
M_1 (0 DAS)	2.55	4.17	4.22	4.37
M_2 (3 DAS)	3.39	4.12	4.36	4.14
M_3 (6 DAS)	3.22	4.12	4.13	4.39
M_4 (9 DAS)	3.96	4.41	4.15	4.47
SEm±	0.050	0.044	0.064	0.049
CD (0.05)	0.17	0.15	NS	0.17
T_1 Anilofos + 2,4-DEE (0.3 + 0.45 kg a.i/ha)	3.89	4.12	4.51	4.55
T_2 Joint formulation (0.3 kg a.i/ha)	3.51	4.68	4.45	4.31
T_3 Joint formulation (0.45 kg a.i/ha)	2.92	4.35	3.96	4.52
T_4 Anilofos 0.3 kg a.i/ha	2.79	4.21	4.25	4.31
T_5 Anilofos 0.45 kg a.i/ha	3.26	4.33	4.04	4.53
T_6 2,4-DEE 0.4 kg a.i/ha	4.02	4.12	4.27	4.37
T_7 2,4-DEE 0.6 kg a.i/ha	3.27	3.83	4.22	4.27
T_8 Butachlor 1.25 kg a.i/ha	2.57	3.99	4.03	3.90
HW	2.79	1.71	2.56	3.71
UWC	4.03	5.71	5.94	6.02
SEm±	0.130	0.086	0.073	0.077
CD (0.05)	0.37	0.24	0.21	0.22

Stages of observation	Subplot
15 DAS	T_8 T_4 T_3 T_5 T_7 T_2 T_1 T_6
30 DAS	T_7 T_8 T_1 T_6 T_4 T_5 T_3 T_2
45 DAS	T_3 T_8 T_5 T_7 T_4 T_6 T_2 T_1
60 DAS	T_8 T_7 T_2 T_4 T_6 T_3 T_5 T_1

* Transformed data: $\sqrt{x}$ transformation

Table 4. Interaction effect of herbicides with time of application on the population of *Cynodon dactylon** (1993) (plants/m²)

Treatments	15 DAS	30 DAS	45 DAS	60 DAS
$M_1 T_1$	2.78	3.98	3.71	4.72
$M_1 T_2$	3.19	4.92	3.79	4.26
$M_1 T_3$	3.44	4.81	4.19	4.76
$M_1 T_4$	1.61	4.06	4.85	4.36
$M_1 T_5$	2.33	4.58	3.99	4.63
$M_1 T_6$	3.36	4.08	4.35	4.29
$M_1 T_7$	2.08	3.44	4.71	4.10
$M_1 T_8$	1.61	3.50	4.18	4.23
$M_2 T_1$	5.20	4.01	5.77	4.61
$M_2 T_2$	3.59	3.59	4.73	3.96
$M_2 T_3$	2.75	4.89	3.93	4.35
$M_2 T_4$	3.05	3.95	4.12	4.07
$M_2 T_5$	2.84	4.27	3.69	4.25
$M_2 T_6$	4.34	4.24	4.93	4.46
$M_2 T_7$	3.58	3.69	3.95	3.83
$M_2 T_8$	1.75	3.99	3.73	3.84
$M_3 T_1$	3.83	3.88	4.60	4.53
$M_3 T_2$	3.39	4.94	4.06	4.48
$M_3 T_3$	2.63	4.04	3.92	4.76
$M_3 T_4$	2.07	3.93	4.01	3.89
$M_3 T_5$	3.68	3.72	4.38	4.54
$M_3 T_6$	3.87	4.12	3.92	4.34
$M_3 T_7$	3.55	4.08	4.15	4.64
$M_3 T_8$	2.70	4.22	3.98	3.97
$M_4 T_1$	3.78	4.62	3.96	4.33
$M_4 T_2$	3.85	4.89	5.23	4.56
$M_4 T_3$	2.87	3.68	3.79	4.19
$M_4 T_4$	4.41	4.90	4.03	4.89
$M_4 T_5$	4.17	4.76	4.08	4.71
$M_4 T_6$	4.49	4.04	3.88	4.37
$M_4 T_7$	3.87	4.12	4.05	4.49
$M_4 T_8$	4.20	4.29	4.21	3.57
SEm±	0.260	0.172	0.145	0.154
CD (0.05)	0.74	0.48	0.41	0.44

*Transformed data: $\sqrt{x}$ transformation stages. However hand weeded plots gave the lowest count at all stages except at 15 DAS and unweeded control recorded highest number of *Cynodon dactylon*.

Observation on the interaction effect of herbicides with the time of application in almost all stages revealed that application of butachlor @ 1.25 kg a.i./ha at 3 DAS was comparable with its application at 0 DAS, 2,4-DEE @ 0.6 kg a.i./ha 0 DAS and anilofos @ 0.45 kg a.i./ha 3 DAS with respect to the control of *Cynodon dactylon*. Comparable values were also noticed in plots treated with joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 DAS. Handweeding was superior to the herbicides only at 30 and 45 DAS. This is because of the two weeding operations given on 20th and 40th DAS.

b) *Isachne miliaceae* (Tables 5 and 6)

Of the different herbicides tested anilofos @ 0.45 kg a.i./ha was found to be more effective in controlling *Isachne miliaceae* at all stages of observation. At 30 DAS it was comparable with butachlor @ 1.25 kg a.i./ha and tankmix application of anilofos @ 0.3 kg a.i./ha and 2,4-DEE @ 0.45 kg a.i./ha, followed by its joint formulation @ 0.3 kg a.i./ha. However, at 45 and 60 DAS effect of anilofos @ 0.45 kg a.i./ha was similar to joint formulation of anilofos and 2,4-DEE @ 0.3 kg a.i./ha and buatchlor @ 1.25 kg a.i./ha. Unweeded control recorded the highest population of *Isachne miliaceae* at all stages.

On perusal of interaction effect of herbicides and time of application at 30 DAS tank mix application of anilofos @ 0.3 kg a.i./ha and 2,4-DEE @ 0.45 kg a.i./ha at 3 and 6 DAS, its joint formulation @ 0.3 kg a.i./ha at 6 and 9 DAS, butachlor @ 1.25 kg a.i./ha at 0 and 3 DAS, anilofos @ 0.45 kg a.i./ha at 3 and 6

Table 5. Effect of herbicides and time of application on the population of *Isachne miliaceae** (plants/m²) (1994)

Treatments	30 DAS	45 DAS	60 DAS
M_1 (0 DAS)	2.28	2.83	3.02
M_2 (3 DAS)	1.77	1.86	2.36
M_3 (6 DAS)	1.61	2.04	2.39
M_4 (9 DAS)	2.07	2.11	2.44
SEm±	0.056	0.111	0.110
CD (0.05)	0.19	0.383	0.38
T_1 Anilofos + 2,4-DEE (0.3 + 0.45 kg a.i/ha)	1.20	2.47	2.91
T_2 Joint formulation (0.3 kg a.i/ha)	1.43	1.31	1.87
T_3 Joint formulation (0.45 kg a.i/ha)	1.69	1.91	2.16
T_4 Anilofos 0.3 kg a.i/ha	1.64	1.86	2.41
T_5 Anilofos 0.45 kg a.i/ha	0.92	1.28	1.58
T_6 2,4-DEE 0.4 kg a.i/ha	3.54	3.64	3.85
T_7 2,4-DEE 0.6 kg a.i/ha	3.44	3.67	3.79
T_8 Butachlor 1.25 kg a.i/ha	0.99	1.53	1.87
HW	1.20	1.72	2.23
UWC	4.86	6.82	7.42
SEm±	0.105	0.197	0.169
CD (0.05)	0.297	0.56	0.48

Stages of observation	Subplot
30 DAS	T_5 T_8 T_1 T_2 T_4 T_3 T_7 T_6
45 DAS	T_5 T_2 T_8 T_4 T_3 T_1 T_6 T_7
60 DAS	T_5 T_2 T_8 T_3 T_4 T_1 T_7 T_6

* Transformed data: $\sqrt{x + 0.5}$ transformation

Table 6. Interaction effect of herbicides with time of application on the population of *Isachne miliaceae** (1994): Plants/m²

Treatments	30 DAS	45 DAS	60 DAS
$M_1 T_1$	2.39	3.06	3.37
$M_1 T_2$	2.65	2.65	2.97
$M_1 T_3$	2.65	3.12	3.22
$M_1 T_4$	2.26	2.92	3.20
$M_1 T_5$	0.71	1.18	1.67
$M_1 T_6$	3.80	3.54	3.75
$M_1 T_7$	3.08	4.06	4.31
$M_1 T_8$	0.71	2.12	1.69
$M_2 T_1$	0.71	2.06	2.63
$M_2 T_2$	1.65	1.18	1.89
$M_2 T_3$	1.94	2.18	2.25
$M_2 T_4$	1.65	1.44	2.33
$M_2 T_5$	0.71	1.32	1.58
$M_2 T_6$	4.06	3.71	3.59
$M_2 T_7$	2.70	3.25	3.34
$M_2 T_8$	0.71	0.71	1.28
$M_3 T_1$	0.71	2.39	2.90
$M_3 T_2$	0.71	0.71	1.46
$M_3 T_3$	1.18	1.18	1.71
$M_3 T_4$	0.71	1.18	1.72
$M_3 T_5$	0.71	0.71	1.40
$M_3 T_6$	3.23	3.37	3.61
$M_3 T_7$	3.80	4.06	4.41
$M_3 T_8$	1.86	2.12	1.94
$M_4 T_1$	0.99	2.39	2.76
$M_4 T_2$	0.71	0.71	1.16
$M_4 T_3$	0.99	1.18	1.45
$M_4 T_4$	1.94	1.91	2.38
$M_4 T_5$	1.57	1.91	1.67
$M_4 T_6$	3.08	4.29	4.47
$M_4 T_7$	4.17	3.33	3.09
$M_4 T_8$	3.08	1.17	2.56
SEm±	0.209	0.394	0.339
CD (0.05)	0.59	1.11	0.96

*Transformed data : $\sqrt{x+0.5}$ transformation

DAS and anilofos @ 0.3 kg a.i./ha at 6 DAS gave nil values for *Isachne miliaceae*. In the subsequent stages also joint formulation of anilofos and 2,4-DEE @ 0.3 kg a.i./ha at 6 and 9 DAS gave the lowest count of *Isachne miliaceae*. Butachlor @ 1.25 kg a.i./ha at 3 DAS was also similar to these formulation at all the stages. Irrespective of the stages these herbicides were superior to hand weeding.

c) Total grass weed population (Tables 7, 8a and 8b)

During the first year the effect of herbicides on total grass weed population was significant at 15 DAS only. Plots treated with butachlor @ 1.25 kg a.i./ha gave lesser number of weeds and was found to be comparable with anilofos @ 0.3 kg a.i./ha and joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha.

In the second year of study anilofos @ 0.45 kg a.i./ha recorded the lowest count at 30 DAS and was similar to the application of butachlor @ 1.25 kg a.i./ha followed by joint formulation of anilofos and 2,4-DEE @ 0.3 kg a.i./ha and @ 0.45 kg a.i./ha. Herbicides butachlor @ 1.25 kg a.i./ha, anilofos @ 0.45 kg a.i./ha and joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha were found to be equally effective at 45 DAS. At 60 DAS grass weeds were lowest in the plots treated with butachlor @ 1.25 kg a.i./ha, followed by higher and lower doses of the joint formulation of anilofos and 2,4-DEE i.e. 0.45 kg a.i./ha and 0.3 kg a.i./ha.

During the first year of study interaction effect of herbicides and time of application was significant only at 15 and 45 DAS. At both these stages butachlor @ 1.25 kg a.i./ha 3 DAS was effective in controlling grasses. At 45 DAS joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 DAS also gave comparable values in controlling grasses.

Table 7. Effect of herbicides and time of application on the total grass weed population* (plants/m²)

Treatments	15 DAS 1993	30 DAS 1993	30 DAS 1994	45 DAS 1993	45 DAS 1994	60 DAS 1993	60 DAS 1994
M_1 (0 DAS)	3.54	5.24	3.06	5.67	3.71	6.65	3.99
M_2 (3 DAS)	4.40	5.18	2.94	5.56	3.51	6.36	3.61
M_3 (6 DAS)	4.16	5.17	2.58	5.37	3.62	6.54	3.63
M_4 (9 DAS)	5.08	5.49	2.76	5.46	3.55	6.75	3.57
SEm±	0.134	0.037	0.038	0.114	0.041	0.185	0.056
CD (0.05)	0.46	0.13	0.13	NS	NS	NS	0.19
T_1 Anilofos + 2,4-DEE (0.3 + 0.45 kg a.i/ha)	4.82	5.11	3.09	5.68	3.52	6.91	3.93
T_2 Joint formulation (0.3 kg a.i/ha)	4.66	5.65	2.59	5.72	3.33	6.64	3.15
T_3 Joint formulation (0.45 kg a.i/ha)	3.88	5.16	2.62	5.36	2.99	6.68	3.24
T_4 Anilofos 0.3 kg a.i/ha	3.79	5.33	2.74	5.54	3.46	6.48	3.66
T_5 Anilofos 0.45 kg a.i/ha	4.27	5.11	1.66	5.34	2.91	6.48	3.44
T_6 2,4-DEE 0.4 kg a.i/ha	5.11	5.41	4.21	5.45	4.36	6.81	4.86
T_7 2,4-DEE 0.6 kg a.i/ha	4.29	5.11	3.90	5.50	5.48	6.39	4.79
T_8 Butachlor 1.25 kg a.i/ha	3.56	5.32	1.84	5.52	2.74	6.21	2.54
HW	5.13	3.21	1.20	5.32	1.60	6.50	2.30
UWC	10.08	10.42	4.36	11.04	6.32	12.13	6.92
SEm±	0.169	0.134	0.113	0.117	0.138	0.159	0.093
CD (0.05)	0.48	NS	0.32	NS	0.39	NS	0.26

Stages of observation	Subplot 1993	Subplot 1994
15 DAS	T_8 T_4 T_3 T_5 T_7 T_2 T_1 T_6	—
30 DAS	NS	T_5 T_8 T_2 T_3 T_4 T_1 T_7 T_6
45 DAS	NS	T_8 T_5 T_3 T_2 T_4 T_1 T_6 T_7
60 DAS	NS	T_8 T_2 T_3 T_5 T_4 T_1 T_7 T_6

* Transformed data : $\sqrt{x}$ transformation

Table 8a. Interaction effect of herbicides with time of application on the total grass weed population* (1993). Plants/m²

Treatments	15 DAS	45 DAS
$M_1 T_1$	3.81	5.25
$M_1 T_2$	4.27	5.27
$M_1 T_3$	4.29	5.89
$M_1 T_4$	2.42	6.22
$M_1 T_5$	3.42	5.61
$M_1 T_6$	4.21	5.25
$M_1 T_7$	3.22	5.62
$M_1 T_8$	2.67	6.21
$M_2 T_1$	6.15	6.83
$M_2 T_2$	4.61	5.89
$M_2 T_3$	3.78	5.16
$M_2 T_4$	3.89	5.39
$M_2 T_5$	4.04	4.89
$M_2 T_6$	5.85	6.13
$M_2 T_7$	4.66	5.23
$M_2 T_8$	2.28	4.95
$M_3 T_1$	4.57	5.47
$M_3 T_2$	4.67	5.46
$M_3 T_3$	3.69	5.21
$M_3 T_4$	3.22	5.22
$M_3 T_5$	4.44	5.47
$M_3 T_6$	4.78	5.09
$M_3 T_7$	4.38	5.70
$M_3 T_8$	3.58	5.33
$M_4 T_1$	4.76	5.16
$M_4 T_2$	5.08	6.24
$M_4 T_3$	3.75	5.15
$M_4 T_4$	5.65	5.33
$M_4 T_5$	5.20	5.39
$M_4 T_6$	5.61	5.35
$M_4 T_7$	4.91	5.45
$M_4 T_8$	5.69	5.59
SEm±	0.339	0.234
Cd (0.05)	0.96	0.66

* Transformed data : $\sqrt{x}$ transformation

Table 8b. Interaction effect of herbicides with time of application on the total grass weed population* (1994). Plants/m²

Treatments	30 DAS	45 DAS	60 DAS
$M_1 T_1$	2.76	3.82	4.39
$M_1 T_2$	3.78	3.82	3.57
$M_1 T_3$	3.82	3.62	4.18
$M_1 T_4$	2.76	3.97	4.39
$M_1 T_5$	1.80	2.28	3.07
$M_1 T_6$	4.24	4.89	4.94
$M_1 T_7$	3.60	4.88	5.01
$M_1 T_8$	1.71	2.42	2.38
$M_2 T_1$	3.25	3.69	3.80
$M_2 T_2$	2.66	3.25	3.25
$M_2 T_3$	3.05	3.22	3.42
$M_2 T_4$	2.76	3.03	3.48
$M_2 T_5$	2.00	3.22	3.45
$M_2 T_6$	4.00	4.35	4.85
$M_2 T_7$	3.60	4.89	4.57
$M_2 T_8$	2.22	2.42	2.08
$M_3 T_1$	2.55	4.27	4.19
$M_3 T_2$	1.67	3.22	2.72
$M_3 T_3$	2.15	2.83	2.77
$M_3 T_4$	3.15	3.22	2.49
$M_3 T_5$	1.27	3.21	3.69
$M_3 T_6$	4.24	3.43	4.52
$M_3 T_7$	3.85	5.65	4.96
$M_3 T_8$	1.71	3.13	2.72
$M_4 T_1$	3.82	2.28	3.35
$M_4 T_2$	2.28	3.03	3.06
$M_4 T_3$	1.47	2.27	2.59
$M_4 T_4$	2.30	3.62	3.28
$M_4 T_5$	1.58	2.90	3.56
$M_4 T_6$	4.35	4.78	5.13
$M_4 T_7$	4.54	6.50	4.61
$M_4 T_8$	1.71	2.99	3.00
SEm±	0.226	0.276	0.186
CD(0.05)	0.64	0.78	0.53

* Transformed data: $\sqrt{x}$ transformation

In the second year also butachlor @ 1.25 kg a.i./ha applied at 0 or 3 DAS and joint formulation of anilofos and 2,4-DEE @ 0.45 a.i./ha at 9 DAS were comparable in bringing down the total grass population.

Effectiveness of butachlor against grasses was reported earlier by Pande (1982), KAU (1986) and Rao and Rao (1990). Munegowda *et al.* (1990), Chandrakar *et al.* (1993) etc. reported the efficiency of anilofos in controlling grasses. The beneficial effect of mixture of anilofos and 2,4-DEE in reducing grass weed population was reported earlier by Pamplona and Evangelista (1981), Langeludukke *et al.* (1981), Syriac *et al.* (1993) and Sreedevi and Thomas (1993).

4.1.2.2 Sedges

Cyperus rotundus was the major sedge during the first year whereas in the second year *Fimbrystylis miliaceae* dominated. No other sedges were noticed in the experimental field.

a) *Cyperus rotundus* (Tables 9 and 10)

Among the herbicides joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha gave lowest count of *Cyperus rotundus* at all stages except at 45 DAS. Tank mix application of anilofos @ 0.3 kg a.i./ha and 2,4-DEE @ 0.45 kg a.i./ha gave the lowest population of *Cyperus rotundus* at 45 DAS and was comparable with its joint formulation @ 0.45 kg a.i./ha.

Interaction effect of herbicides and time of application at 15 DAS revealed lowest count for *Cyperus rotundus* in plots treated with 2,4-DEE @ 0.6 kg a.i./ha at 6 DAS followed by the tank mix application of anilofos and 2,4-DEE and

Table 9. Effect of herbicides and time of application on the population of *Cyperus* sp.* (plants/m²) (1993)

Treatments	15 DAS	30 DAS	45 DAS	60 DAS
M_1 (0 DAS)	7.71	8.23	7.28	4.99
M_2 (3 DAS)	7.30	8.72	7.65	5.18
M_3 (6 DAS)	6.82	7.72	7.04	5.28
M_4 (9 DAS)	7.27	7.18	6.63	4.39
SEm±	0.139	0.285	0.224	0.343
CD (0.05)	0.48	0.99	NS	NS
T_1 Anilofos + 2,4-DEE (0.3 + 0.45 kg a.i/ha)	6.49	7.64	6.23	4.76
T_2 Joint formulation (0.3 kg a.i/ha)	6.75	7.61	6.88	4.71
T_3 Joint formulation (0.45 kg a.i/ha)	6.15	6.85	6.43	4.24
T_4 Anilofos 0.3 kg a.i/ha	8.06	8.72	7.88	5.25
T_5 Anilofos 0.45 kg a.i/ha	8.25	8.79	7.99	5.39
T_6 2,4-DEE 0.4 kg a.i/ha	7.22	7.52	6.78	4.92
T_7 2,4-DEE 0.6 kg a.i/ha	6.94	7.62	7.46	4.77
T_8 Butachlor 1.25 kg a.i/ha	8.34	8.94	7.54	5.64
HW	5.47	2.91	3.17	3.16
UWC	9.46	9.97	9.99	6.74
SEm±	0.280	0.300	0.272	0.216
CD (0.05)	0.79	0.85	0.77	0.61

Stages of observation	Subplot
15 DAS	T_3 T_1 T_2 T_7 T_6 T_4 T_5 T_8
30 DAS	T_3 T_6 T_2 T_7 T_1 T_4 T_5 T_8
45 DAS	T_1 T_3 T_6 T_2 T_7 T_8 T_4 T_5
60 DAS	T_3 T_2 T_1 T_7 T_6 T_4 T_5 T_8

*Transformed data : $\sqrt{x}$ transformation

Table 10. Interaction effect of herbicides with time of application on the population of *Cyperus sp.** (1993) (plants/m^2)

Treatments	15 DAS	30 DAS	60 DAS
M_1 T_1	7.55	8.37	4.38
M_1 T_2	6.71	7.32	5.29
M_2 T_3	6.12	7.14	4.15
M_1 T_4	6.73	8.48	4.98
M_1 T_5	8.44	8.50	5.02
M_1 T_6	10.44	9.11	6.17
M_1 T_7	7.19	8.19	4.41
M_1 T_8	8.51	8.74	5.52
M_2 T_1	7.08	8.68	5.03
M_2 T_2	6.57	7.97	3.95
M_2 T_3	6.15	8.49	4.15
M_2 T_4	9.76	8.93	5.89
M_2 T_5	7.54	8.98	5.87
M_2 T_6	6.49	8.20	4.81
M_2 T_7	8.39	9.21	6.08
M_2 T_8	6.42	9.29	5.63
M_3 T_1	5.88	7.87	5.42
M_3 T_2	7.35	8.29	4.46
M_3 T_3	6.22	5.61	4.71
M_3 T_4	7.15	8.61	5.69
M_3 T_5	7.62	8.65	5.77
M_3 T_6	5.42	7.27	5.09
M_3 T_7	5.55	6.69	4.25
M_3 T_8	9.37	8.74	6.83
M_4 T_1	5.46	5.66	4.21
M_4 T_2	6.38	6.83	5.11
M_4 T_3	6.09	6.16	3.94
M_4 T_4	8.59	8.86	4.43
M_4 T_5	9.38	9.03	4.92
M_4 T_6	6.51	5.51	3.59
M_4 T_7	6.64	6.37	4.35
M_4 T_8	9.05	9.02	4.60
SEm±	0.561	0.600	0.432
CD(0.05)	1.59	1.69	1.22

*Transformed data: $\sqrt{x}$ transformation hand weeding. Joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 3, 6 and 9 DAS and butachlor @ 1.25 a.i./ha at 3 DAS also gave comparable values. At 30 DAS though hand weeding was superior to herbicides joint formulation of anilo - fos and 2,4-DEE @ 0.45 kg a.i./ha at 6 and 9 DAS gave comparatively better control over *Cyperus rotundus*. However at 60 DAS hand weeding and both the doses of joint formulation of anilofos and 2,4-DEE i.e. 0.3 and 0.45 kg a.i./ha at the later stages of application gave comparable values with respect to population of *Cyperus rotundus*.

b) *Fimbrystylis miliaceae* (Tables 11 and 12)

At 30 DAS butachlor @ 1.25 kg a.i./ha was superior to other herbicides followed by anilofos @ 0.45 kg a.i./ha. Joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha recorded the lowest number of *Fimbrystylis miliaceae* at 45 DAS and was comparable with butachlor @ 1.25 kg a.i./ha, 2,4-DEE @ 0.4 kg a.i./ha and anilofos @ 0.45 kg a.i./ha. At 60 DAS joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha was similar to butachlor @ 1.25 a.i./ha which gave the lowest weed count.

With respect to the interaction effect of herbicides and time of application at 30 DAS, joint formulation of anilofos and 2,4-DEE @ 0.3 kg a.i./ha at 9 DAS and butachlor @ 1.25 kg a.i./ha at 0,3 and 6 DAS gave nil values for *Fimbrystylis miliaceae*. All these treatments were found to be superior to hand weeding. However at 45 DAS, higher dose of the joint formulation of anilofos and 2,4-DEE i.e. 0.45 kg a.i./ha at 9 DAS registered the lowest number of *Fimbrystylis miliaceae* and was comparable with 2,4-DEE @ 0.4 kg a.i./ha at 0 DAS, butachlor @ 1.25 kg a.i./ha at 3 and 6 DAS and hand weeding. Butachlor @ 1.25 kg a.i./ha at 0 DAS

Table 11. Effect of herbicides and time of application on the population of *Fimbrystylis miliaceae** (plants/m²) (1994)

Treatments	30 DAS	45 DAS	60 DAS
M_1 (0 DAS)	2.67	3.01	3.04
M_2 (3 DAS)	2.32	3.38	3.33
M_3 (6 DAS)	1.91	3.05	3.14
M_4 (9 DAS)	2.06	2.85	3.00
SEm±	0.157	0.082	0.08
CD (0.05)	0.54	0.28	NS
T_1 Anilofos + 2,4-DEE (0.3 + 0.45 kg a.i/ha)	2.26	3.63	3.69
T_2 Joint formulation (0.3 kg a.i/ha)	2.38	3.39	3.23
T_3 Joint formulation (0.45 kg a.i/ha)	2.56	2.62	2.58
T_4 Anilofos 0.3 kg a.i/ha	3.32	3.62	3.58
T_5 Anilofos 0.45 kg a.i/ha	1.59	2.89	2.79
T_6 2,4-DEE 0.4 kg a.i/ha	2.31	2.81	3.32
T_7 2,4-DEE 0.5 kg a.i/ha	2.63	3.37	3.54
T_8 Butachlor 1.25 kg a.i/ha	0.89	2.73	2.29
HW	2.00	2.08	2.62
UWC	3.96	4.74	4.97
SEm±	0.182	0.196	0.128
CD (0.05)	0.52	0.55	0.36

Stages of observation	Subplot
30 DAS	T_8 T_5 T_1 T_6 T_2 T_3 T_7 T_4
45 DAS	T_3 T_8 T_6 T_5 T_7 T_2 T_4 T_1
60 DAS	T_8 T_3 T_5 T_2 T_6 T_7 T_4 T_1

*Transformed data: $\sqrt{x + 0.5}$ transformation

Table 12. Interaction effect of herbicides with time of application on the population of *Fimbrystylis miliaceae** (1994) (plants/m²)

Treatments	30 DAS	45 DAS	60 DAS
$M_1 T_1$	3.68	3.79	3.93
$M_1 T_2$	3.50	3.50	3.11
$M_1 T_3$	3.12	2.65	2.14
$M_1 T_4$	3.12	3.38	3.14
$M_1 T_5$	1.32	2.92	3.06
$M_1 T_6$	2.53	1.91	2.78
$M_1 T_7$	3.37	3.19	3.29
$M_1 T_8$	0.71	2.74	2.86
$M_2 T_1$	2.39	3.97	3.63
$M_2 T_2$	2.92	3.87	3.66
$M_2 T_3$	2.86	3.54	3.38
$M_2 T_4$	3.12	3.71	3.65
$M_2 T_5$	2.49	3.33	3.22
$M_2 T_6$	2.16	2.92	3.10
$M_2 T_7$	1.91	3.80	3.71
$M_2 T_8$	0.71	1.91	2.29
$M_3 T_1$	1.18	3.24	3.49
$M_3 T_2$	2.39	3.33	3.39
$M_3 T_3$	2.79	2.39	2.14
$M_3 T_4$	3.61	3.50	3.67
$M_3 T_5$	0.99	3.12	3.09
$M_3 T_6$	1.91	3.54	3.81
$M_3 T_7$	1.71	3.39	3.83
$M_3 T_8$	0.71	1.91	1.69
$M_4 T_1$	1.79	3.50	3.69
$M_4 T_2$	0.71	2.86	2.74
$M_4 T_3$	1.47	1.91	2.68
$M_4 T_4$	3.43	3.89	3.85
$M_4 T_5$	1.56	2.18	1.81
$M_4 T_6$	2.53	2.86	3.61
$M_4 T_7$	3.50	3.08	3.31
$M_4 T_8$	1.47	2.53	2.33
SEm±	0.364	0.391	0.256
CD (0.05)	1.03	1.11	0.72

* Transformed data: $\sqrt{x + 0.5}$ transformation

gave the lowest weed count at 60 DAS and was similar to anilofos application @ 0.45 kg a.i./ha at 9 DAS and joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 6 DAS.

In general, joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha and butachlor @ 1.25 kg a.i./ha were equally effective in reducing the population of sedges in dry seeded rice. Effective control of sedges by the application of mixture of anilofos and 2,4-DEE was reported earlier by Pamplona and Evangelista (1981) and Ali and Rajan (1985). Joseph *et al.* (1990) and Robinson and Selvaraj (1991) reported the efficiency of butachlor in controlling sedges under semi-dry conditions.

4.1.2.3 Broad leaved weeds (Tables 13, 14a and 14b)

During the first year significant difference between herbicides was observed only at the initial stages of observation. Both the doses of the joint formulation i.e. 0.3 and 0.45 kg a.i./ha and butachlor @ 1.25 kg a.i./ha were found equally effective in reducing broad leaved weeds whereas, in the second year butachlor @ 1.25 kg a.i./ha was superior to other herbicides.

Observation on the interaction effect of herbicides and time of application in almost all stages revealed that butachlor @ 1.25 kg a.i./ha at 0, 3 and 6 DAS, tank mix application of anilofos @ 0.3 kg a.i./ha and 2,4-DEE @ 0.45 kg a.i./ha at 9 DAS and higher dose of joint formulation of anilofos and 2,4-DEE i.e. 0.45 kg a.i./ha at 9 DAS were equally effective in controlling broad leaved weeds. Hand weeding was superior to herbicidal treatments only during the first year, that too at 45 DAS.

Table 13. Effect of herbicides and time of application on the population of broad leaves weeds* (plants/m²)

Treatments	15 DAS 1993	30 DAS 1993	45 DAS 1993	45 DAS 1994	60 DAS 1993	60 DAS 1994
M_1 (0 DAS)	3.37	3.99	4.87	3.82	6.36	4.11
M_2 (3 DAS)	3.76	3.30	4.99	3.28	5.81	3.79
M_3 (6 DAS)	3.53	3.23	4.99	3.44	5.34	3.82
M_4 (9 DAS)	3.23	3.12	5.29	3.02	5.72	3.59
SEm±	0.139	0.181	0.125	0.086	0.279	0.058
CD (0.05)	NS	NS	NS	0.29	NS	0.20
T_1 Anilofos + 2,4-DEE (0.3 + 0.45 kg a.i/ha)	3.38	3.37	5.65	3.61	6.04	4.00
T_2 Joint formulation (0.3 kg a.i/ha)	3.01	3.59	4.71	3.87	5.71	4.27
T_3 Joint formulation (0.45 kg a.i/ha)	2.93	3.51	4.86	3.67	5.54	4.12
T_4 Anilofos 0.3 kg a.i/ha	3.59	3.69	5.29	3.78	6.00	4.19
T_5 Anilofos 0.45 kg a.i/ha	4.56	3.27	5.09	3.19	6.06	3.62
T_6 2,4-DEE 0.4 kg a.i/ha	3.58	3.62	4.77	3.17	6.11	3.55
T_7 2,4-DEE 0.6 kg a.i/ha	3.57	3.24	5.11	3.14	5.46	3.62
T_8 Butachlor 1.25 kg a.i/ha	3.16	2.99	4.82	2.67	5.55	3.24
HW	3.83	1.64	3.27	2.00	3.01	3.46
UWC	5.82	4.96	6.36	4.30	7.39	4.83
SEm±	0.219	0.215	0.155	0.143	0.189	0.091
CD (0.05)	0.62	NS	0.44	0.40	NS	0.26

Stages of observation	Subplot 1993	Subplot 1994
15 DAS	T_3 T_2 T_8 T_1 T_7 T_6 T_4 T_5	---
30 DAS	NS	---
45 DAS	T_2 T_6 T_8 T_3 T_5 T_7 T_4 T_1	T_8 T_7 T_6 T_5 T_1 T_3 T_4 T_2
60 DAS	NS	T_8 T_6 T_5 T_7 T_1 T_3 T_4 T_2

* Transformed data : $\sqrt{x}$ transformation

Table 14a. Interaction effect of herbicides with time of application on the population of broad leaved weeds* (1993) (plants/m^2)

Treatments	15 DAS	30 DAS	45 DAS
M_1 T_1	3.81	4.21	5.12
M_1 T_2	3.03	3.32	4.84
M_1 T_3	2.79	4.56	5.45
M_1 T_4	4.32	4.89	4.68
M_1 T_5	3.04	3.47	4.57
M_1 T_6	3.18	3.48	4.46
M_1 T_7	3.67	4.34	4.86
M_1 T_8	3.16	3.63	4.95
M_2 T_1	3.43	3.73	6.13
M_2 T_2	2.97	3.95	4.93
M_2 T_3	3.41	2.83	4.50
M_2 T_4	3.61	3.21	4.37
M_2 T_5	7.33	2.99	5.16
M_2 T_6	3.47	3.44	4.78
M_2 T_7	3.25	3.10	5.62
M_2 T_8	2.58	3.16	4.62
M_3 T_1	3.55	3.24	5.21
M_3 T_2	3.07	3.07	4.47
M_3 T_3	2.86	4.01	5.08
M_3 T_4	3.23	2.93	5.62
M_3 T_5	4.54	3.55	5.15
M_3 T_6	3.76	3.83	4.55
M_3 T_7	4.00	2.87	4.88
M_3 T_8	3.25	2.31	4.96
M_4 T_1	2.75	2.29	6.13
M_4 T_2	2.96	4.03	4.61
M_4 T_3	2.66	2.64	4.39
M_4 T_4	3.19	3.74	6.47
M_4 T_5	3.33	3.05	5.49
M_4 T_6	3.92	3.73	5.29
M_4 T_7	3.37	2.65	5.09
M_4 T_8	3.66	2.88	4.75
SEm±	0.437	0.430	0.310
CD (0.05)	1.24	1.22	0.88

* Transformed data: $\sqrt{x}$ transformation

Table 14b. Interaction effect of herbicides with time of application on the population of broad leaved weeds* (1994) (plants/m²)

Treatments	45 DAS	60 DAS
$M_1 T_1$	3.52	3.92
$M_1 T_2$	4.66	4.98
$M_1 T_3$	5.16	5.44
$M_1 T_4$	4.16	4.49
$M_1 T_5$	3.68	4.11
$M_1 T_6$	2.83	3.08
$M_1 T_7$	3.31	3.63
$M_1 T_8$	3.19	3.25
$M_2 T_1$	3.97	4.26
$M_2 T_2$	3.77	4.26
$M_2 T_3$	3.25	3.73
$M_2 T_4$	3.43	3.81
$M_2 T_5$	2.76	3.20
$M_2 T_6$	3.59	4.01
$M_2 T_7$	3.31	3.65
$M_2 T_8$	2.23	3.39
$M_3 T_1$	3.52	3.90
$M_3 T_2$	3.82	4.18
$M_3 T_3$	3.73	4.07
$M_3 T_4$	4.16	4.48
$M_3 T_5$	3.43	3.76
$M_3 T_6$	3.12	3.57
$M_3 T_7$	3.31	3.59
$M_3 T_8$	2.43	3.00
$M_4 T_1$	3.43	3.94
$M_4 T_2$	3.25	3.66
$M_4 T_3$	2.55	3.26
$M_4 T_4$	3.38	3.96
$M_4 T_5$	2.91	3.42
$M_4 T_6$	3.15	3.55
$M_4 T_7$	2.63	3.61
$M_4 T_8$	2.83	3.33
SEm±	0.285	0.182
CD (0.05)	0.81	0.52

* Transformed data: $\sqrt{x}$ transformation

The effectiveness of butachlor in reducing broad leaved weed was reported earlier by Nair *et al.* (1979), Sreedevi (1979) and KAU (1984). The superiority of the mixture of anilofos and 2,4-DEE in checking broadleaved weeds was reported by Jayakumar (1991) and Radhamani (1994).

4.1.2.4 Total weed population (Tables 15, 16a and 16b)

During the first year of study, higher dose of the joint formulation of anilofos and 2,4-DEE i.e. 0.45 kg a.i./ha recorded the lowest count of weeds at all stages except at 45 DAS. At 45 DAS, 2,4-DEE @ 0.4 kg a.i./ha registered the lowest total weed population. It was comparable with the higher dose of joint formulation of anilofos and 2,4-DEE i.e. 0.45 kg a.i./ha.

In the second year butachlor @ 1.25 kg a.i./ha, anilofos @ 0.45 kg a.i./ha and joint formulation of anilofos and 2,4-DEE @ 0.45 and 0.3 kg a.i./ha were more effective in reducing total weed population.

During the first year, the interaction effect of herbicides and time of application revealed the superiority of higher dose of the joint formulation of anilofos and 2,4-DEE at 9 DAS. However in the second year, irrespective of the time of application butachlor @ 1.25 kg a.i./ha registered the lowest total weed population, comparable and closely followed by the higher dose of joint formulation of anilofos and 2,4-DEE at 9 DAS.

The above results clearly indicate the added efficiency of herbicides when applied in combination rather than its singular application with respect to broad spectrum control of weeds. Similar results was reported earlier by Langluduke

Table 15. Effect of herbicides and time of application on the total weed population* (plants/m²)

Treatments	15 DAS 1993	30 DAS 1993	30 DAS 1994	45 DAS 1993	45 DAS 1994	60 DAS 1993	60 DAS 1994
M_1 (0 DAS)	9.21	10.66	4.26	10.28	6.33	10.47	6.76
M_2 (3 DAS)	9.22	10.75	3.92	10.77	5.92	10.16	6.41
M_3 (6 DAS)	8.77	9.93	3.31	10.21	6.05	9.97	6.39
M_4 (9 DAS)	9.50	9.67	3.49	10.23	5.73	10.02	5.99
SEm±	0.189	0.245	0.124	0.191	0.062	0.252	0.087
CD (0.05)	NS	NS	0.43	NS	0.22	NS	0.30
T_1 Anilofos + 2,4-DEE (0.3 + 0.45 kg a.i/ha)	8.14	9.94	4.12	10.18	6.49	10.41	6.89
T_2 Joint formulation (0.3 kg a.i/ha)	8.74	10.22	3.71	10.16	6.06	10.02	6.35
T_3 Joint formulation (0.45 kg a.i/ha)	7.93	9.39	3.65	9.82	5.79	9.71	6.09
T_4 Anilofos 0.3 kg a.i/ha	9.79	10.93	4.35	11.10	6.20	10.35	6.78
T_5 Anilofos 0.45 kg a.i/ha	10.56	10.77	2.57	10.95	5.40	10.39	5.89
T_6 2,4-DEE 0.4 kg a.i/ha	9.53	10.05	4.82	9.78	6.26	10.39	7.05
T_7 2,4-DEE 0.6 kg a.i/ha	8.98	9.83	4.88	10.38	7.18	9.73	7.11
T_8 Butachlor 1.25 kg a.i/ha	9.75	10.90	1.86	10.61	4.69	10.24	4.96
HW	14.43	7.76	3.73	11.76	4.92	13.32	7.31
UWC	23.36	24.35	9.82	26.39	14.86	26.26	16.54
SEm±	0.303	0.234	0.129	0.237	0.129	0.161	0.096
CD (0.05)	0.86	0.66	0.37	0.67	0.37	0.46	0.27

Stages of observation	Subplot 1993	Subplot 1994
15 DAS	T_3 T_1 T_2 T_7 T_6 T_8 T_4 T_5	---
30 DAS	T_3 T_7 T_1 T_6 T_2 T_5 T_8 T_4	T_8 T_5 T_3 T_2 T_1 T_4 T_6 T_7
45 DAS	T_6 T_3 T_2 T_1 T_7 T_8 T_5 T_4	T_8 T_5 T_3 T_2 T_4 T_6 T_1 T_7
60 DAS	T_3 T_7 T_2 T_8 T_4 T_5 T_6 T_1	T_8 T_5 T_3 T_2 T_4 T_1 T_6 T_7

* Transformed data: $\sqrt{x}$ transformation

Table 16a. Interaction effect of herbicides with time of application on the total weed population* (1993) (plants/m²)

Treatments	15 DAS	30 DAS
$M_1 T_1$	9.30	10.65
$M_1 T_2$	8.34	10.08
$M_1 T_3$	8.07	10.17
$M_1 T_4$	8.73	11.17
$M_1 T_5$	9.65	10.74
$M_1 T_6$	11.42	11.12
$M_1 T_7$	8.76	10.43
$M_1 T_8$	9.38	10.90
$M_2 T_1$	7.65	10.88
$M_2 T_2$	8.58	10.33
$M_2 T_3$	8.10	10.67
$M_2 T_4$	11.16	10.93
$M_2 T_5$	11.41	10.67
$M_2 T_6$	9.23	10.41
$M_2 T_7$	10.16	10.91
$M_2 T_8$	7.49	11.20
$M_3 T_1$	8.09	9.85
$M_3 T_2$	9.29	10.56
$M_3 T_3$	7.81	8.54
$M_3 T_4$	8.60	10.41
$M_3 T_5$	9.87	10.57
$M_3 T_6$	7.99	9.93
$M_3 T_7$	7.97	9.15
$M_3 T_8$	10.57	10.40
$M_4 T_1$	7.54	8.37
$M_4 T_2$	8.75	9.93
$M_4 T_3$	7.73	8.19
$M_4 T_4$	10.65	11.19
$M_4 T_5$	11.30	11.08
$M_4 T_6$	9.48	8.69
$M_4 T_7$	9.00	8.81
$M_4 T_8$	11.57	11.09
SEm±	0.606	0.468
CD(0.05)	1.72	1.33

* Transformed data: $\sqrt{x}$ transformation

Table 16b. Interaction effect of herbicides with time of application on the total weed population* (1994) (plants/m²)

Treatments	30 DAS	45 DAS	60 DAS
$M_1 T_1$	4.62	6.43	7.21
$M_1 T_2$	5.35	7.09	7.00
$M_1 T_3$	4.96	7.21	7.30
$M_1 T_4$	4.12	6.82	7.17
$M_1 T_5$	3.51	5.46	6.11
$M_1 T_6$	4.88	6.48	6.72
$M_1 T_7$	4.89	6.47	7.16
$M_1 T_8$	1.71	4.68	5.42
$M_2 T_1$	4.64	6.94	6.99
$M_2 T_2$	3.90	5.98	6.61
$M_2 T_3$	4.19	5.40	6.28
$M_2 T_4$	4.45	5.74	6.45
$M_2 T_5$	3.29	5.28	5.82
$M_2 T_6$	4.66	6.32	7.14
$M_2 T_7$	4.24	6.99	7.07
$M_2 T_8$	2.00	4.68	4.89
$M_3 T_1$	2.76	6.87	6.88
$M_3 T_2$	2.84	5.76	6.19
$M_3 T_3$	3.46	5.48	5.65
$M_3 T_4$	4.61	6.52	6.96
$M_3 T_5$	1.76	5.65	6.29
$M_3 T_6$	4.66	5.82	7.02
$M_3 T_7$	4.66	7.61	7.36
$M_3 T_8$	1.71	4.68	4.82
$M_4 T_1$	4.46	5.71	6.48
$M_4 T_2$	2.76	5.39	5.58
$M_4 T_3$	1.99	5.08	5.12
$M_4 T_4$	4.24	5.74	6.56
$M_4 T_5$	1.71	5.22	5.35
$M_4 T_6$	5.09	6.40	7.31
$M_4 T_7$	5.74	7.65	6.84
$M_4 T_8$	2.00	4.69	4.72
SEm±	0.258	0.259	0.193
CD (0.05)	0.73	0.74	0.55

* Transformed data: $\sqrt{x}$ transformation

et al. (1981), Pamplona and Evangelista (1981), Ali and Rajan (1985), Vidhya (1991), Jayakumar and Sree Ramalu (1992) and Sreedevi and Thomas (1993). Misra *et al.* (1988) and Robinson and Selvaraj (1991) reported effective control of annual weeds by butachlor.

4.1.3 Dry matter accumulation of weeds (Tables 17, 18a and 18b)

Herbicide application significantly influenced the dry matter accumulation of weeds at all stages of observation in both the years. In the first year of study application of joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha gave the lowest value for drymatter accumulation at 30 and 60 DAS followed by its tank mix application.

During the second year, dry matter accumulation was almost nil in most of the herbicide treated plots at 30 DAS. In the second year, anilofos @ 0.45 kg a.i./ha, butachlor @ 1.25 kg a.i./ha and tank mix application of anilofos and 2,4-DEE were found to be equally effective in reducing weed dry matter at 60 DAS and at harvest. Though the lower dose of joint formulation of anilofos and 2,4-DEE @ 0.3 kg a.i./ha was comparable with the above treatments at harvest, it gave slightly lower value at 60 DAS. However at both the stages the lower dose and higher dose of joint formulation of anilofos and 2,4-DEE were comparable.

In general, weed drymatter accumulation was more during the first year. This might be because of the slighly elevated nature of the field which ultimately led to improper flooding after one month.

The interaction effect of herbicides with time of application revealed that during the first year, at 30 DAS, joint formulation of anilofos and 2,4-DEE @ 0.45

Table 17. Effect of herbicides and time of application on the drymatter accumulation of weeds (g/m^2)

Treatments	30 DAS 1993	60 DAS 1993	60 DAS 1994*	Harvest 1994**
M_1 (0 DAS)	62.21	73.46	3.16 (9.48)	6.47 (41.86)
M_2 (3 DAS)	60.38	79.37	2.18 (4.25)	5.65 (31.92)
M_3 (6 DAS)	53.25	81.80	2.30 (4.79)	5.62 (31.58)
M_4 (9 DAS)	50.38	77.88	1.93 (3.22)	5.52 (30.47)
SEm±	1.926	2.87	0.121	0.138
CD (0.05)	6.69	NS	0.42	0.48
T_1 Anilofos + 2,4-DEE (0.3 + 0.45 kg a.i/ha)	45.33	75.00	2.21 (4.38)	5.58 (31.14)
T_2 Joint formulation (0.3 kg a.i/ha)	49.83	79.83	2.54 (5.95)	5.69 (32.38)
T_3 Joint formulation (0.45 kg a.i/ha)	33.33	63.92	2.57 (6.10)	5.93 (35.16)
T_4 Anilofos 0.3 kg a.i/ha	83.33	72.33	2.31 (4.84)	5.75 (33.06)
T_5 Anilofos 0.45 kg a.i/ha	83.33	80.00	1.79 (2.70)	5.06 (25.60)
T_6 2,4-DEE 0.4 kg a.i/ha	56.67	78.00	3.09 (9.05)	6.46 (41.73)
T_7 2,4-DEE 0.6 kg a.i/ha	53.58	88.83	2.76 (7.12)	7.00 (49.00)
T_8 Butachlor 1.25 kg a.i/ha	46.50	87.17	1.89 (3.07)	5.02 (25.20)
HW	4.00	46.00	2.37 (5.12)	5.90 (34.81)
UWC	97.33	126.00	5.69 (31.88)	11.40 (129.96)
SEm±	3.333	4.221	0.203	0.234
CD (0.05)	9.44	11.95	0.57	0.67

Stages of observation	Subplot 1993	Subplot 1994
30 DAS	T_3 T_1 T_8 T_2 T_7 T_6 T_4 T_5	---
60 DAS	T_3 T_4 T_1 T_6 T_2 T_5 T_8 T_7	T_5 T_8 T_1 T_4 T_2 T_3 T_7 T_6
Harvest	---	T_8 T_5 T_1 T_2 T_4 T_3 T_6 T_7

* Transformed data : $\sqrt{x+0.5}$ transformation
** Transformed data : $\sqrt{x}$ transformation
( ) Original value

Table 18a. Interaction effect of herbicides with time of application on the dry matter accumulation of weeds (1993) (g/m²)

Treatments	30 DAS	60 DAS
$M_1 T_1$	40.67	76.00
$M_1 T_2$	35.33	88.00
$M_1 T_3$	41.67	61.00
$M_1 T_4$	110.00	61.00
$M_1 T_5$	66.67	90.00
$M_1 T_6$	57.00	65.00
$M_1 T_7$	72.33	76.67
$M_1 T_8$	74.00	70.00
$M_2 T_1$	48.00	77.00
$M_2 T_2$	46.00	95.00
$M_2 T_3$	35.33	68.00
$M_2 T_4$	97.33	71.00
$M_2 T_5$	99.33	78.00
$M_2 T_6$	55.00	84.00
$M_2 T_7$	64.00	96.00
$M_2 T_8$	38.00	66.00
$M_3 T_1$	54.00	80.00
$M_3 T_2$	60.00	82.00
$M_3 T_3$	34.33	64.67
$M_3 T_4$	70.00	101.33
$M_3 T_5$	71.33	68.00
$M_3 T_6$	61.33	76.00
$M_3 T_7$	36.00	74.00
$M_3 T_8$	39.00	108.67
$M_4 T_1$	38.67	67.00
$M_4 T_2$	58.00	54.33
$M_4 T_3$	22.00	62.00
$M_4 T_4$	56.00	56.00
$M_4 T_5$	98.00	84.00
$M_4 T_6$	53.33	87.00
$M_4 T_7$	42.00	108.67
$M_4 T_8$	35.00	104.00
SEm±	6.667	8.442
CD (0.05)	18.88	23.91

Table 18b. Interaction effect of herbicides with time of application on the dry matter accumulation of weeds (1994) (g/m²)

Treatments	60 DAS **	Harvest *
$M_1 T_1$	2.97 (8.32)	5.97 (35.64)
$M_1 T_2$	3.23 (9.93)	6.17 (38.07)
$M_1 T_3$	4.45 (19.30)	6.67 (44.49)
$M_1 T_4$	2.97 (8.32)	6.23 (38.82)
$M_1 T_5$	1.94 (3.26)	5.93 (35.16)
$M_1 T_6$	3.90 (14.71)	7.67 (58.83)
$M_1 T_7$	2.74 (7.01)	8.27 (68.39)
$M_1 T_8$	3.08 (8.99)	4.83 (23.33)
$M_2 T_1$	2.11 (3.95)	5.23 (27.35)
$M_2 T_2$	2.55 (6.00)	5.30 (28.09)
$M_2 T_3$	2.31 (4.84)	6.57 (43.16)
$M_2 T_4$	2.13 (4.04)	5.27 (27.77)
$M_2 T_5$	2.46 (5.55)	5.40 (29.16)
$M_2 T_6$	2.08 (3.83)	5.13 (26.32)
$M_2 T_7$	2.46 (5.55)	8.17 (66.75)
$M_2 T_8$	1.39 (1.43)	4.10 (16.81)
$M_3 T_1$	2.28 (4.70)	5.70 (32.49)
$M_3 T_2$	2.76 (7.12)	5.83 (33.99)
$M_3 T_3$	2.03 (3.62)	5.20 (27.04)
$M_3 T_4$	2.35 (5.02)	6.47 (41.86)
$M_3 T_5$	1.49 (1.72)	4.40 (19.36)
$M_3 T_6$	2.74 (7.01)	6.67 (44.49)
$M_3 T_7$	3.37 (10.86)	6.10 (37.21)
$M_3 T_8$	1.41 (1.49)	4.57 (20.88)
$M_4 T_1$	1.49 (1.72)	5.43 (29.48)
$M_4 T_2$	1.61 (2.09)	5.47 (29.92)
$M_4 T_3$	1.47 (1.66)	5.30 (28.09)
$M_4 T_4$	1.79 (2.70)	5.03 (25.30)
$M_4 T_5$	1.29 (1.16)	4.50 (20.25)
$M_4 T_6$	3.66 (12.9)	6.37 (40.58)
$M_4 T_7$	2.46 (5.55)	5.47 (29.92)
$M_4 T_8$	1.68 (2.32)	6.57 (43.16)
SEm±	0.405	0.471
CD (0.05)	1.15	1.41

* Transformed data : $\sqrt{x}$ transformation

** Transformed data : $\sqrt{x+0.5}$ transformation

( ) Original value

kg a.i./ha at 9 DAS recorded lowest weed dry matter accumulation followed by the same chemical at 6 DAS. Hand weeding was superior to the above treatment. This is because of the weeding operation given just before the observation i.e. at 20 DAS. However at 60 DAS hand weeding was comparable with joint formulation of anilofos and 2,4-DEE @ 0.3 and 0.45 kg a.i./ha at 9 DAS, anilofos @ 3 kg a.i./ha at 0 and 9 DAS.

In the second year of study at 60 DAS anilofos @ 0.45 kg a.i./ha at 9 DAS registered the lowest drymatter accumulation and was comparable with butachlor @ 1.25 kg a.i./ha at 3 DAS, joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 and 6 DAS and lower dose of joint formulation of anilofos and 2,4-DEE at 9 DAS. However, at harvest butachlor @ 1.25 kg a.i./ha at 3 DAS recorded the lowest dry matter accumulation, comparable and closely followed by anilofos @ 0.45 kg a.i./ha at 9 and 6 DAS, higher dose of joint formulation of anilofos and 2,4-DEE at 6 and 9 DAS and lower dose of joint formulation of anilofos and 2,4-DEE at 9 and 3 DAS.

This is in conformity with the findings of Dhiman *et al.* (1993) and Syriac *et al.* (1993) where in a reduction in drymatter accumulation of weeds was observed with the combined application of anilofos and 2,4-DEE.

4.1.4 Weed control efficiency (Tables 19, 20a and 20b)

During both the year of study, significant difference was noticed between herbicidal treatments at all stages of observation. Among the herbicides, joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha recorded the highest weed control efficiency at 30 and 60 DAS and was comparable with tank mix application of the same during the first year. But in the second year butachlor @ 1.25 kg a.i./ha, anilofos @ 0.45 a.i./ha, tank mix application of anilofos and 2,4-DEE were comparable both at 60 DAS and at harvest.

Higher dose of joint formulation of anilofos and 2,4-DEE was comparable with the above treatments at 60 DAS which inturn was similar to its lower dose. On the other hand at harvest the lower dose of joint formulation of anilofos and and 2,4-DEE was comparable with the above treatments which in turn was on par with its higher dose.

The interaction effect of herbicides with time of application at 30 DAS of the first year showed that joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 DAS recorded the highest weed control efficiency followed by its application at 6 DAS and butachlor @ 1.25 kg a.i./ha at 9 DAS. At 60 DAS though singular application of anilofos @ 0.3 kg a.i./ha gave the highest weed control efficiency it was similar to the application of higher and lower dose of the joint formulation of anilofos and 2,4-DEE at 9 DAS and butachlor @ 1.25 kg a.i./ha at 3 DAS.

In the second year no weed control efficiency values were worked out at 30 DAS as most of the plots had nil value for drymatter accumulation. At 60 DAS of the second year singular application of anilofos @ 0.45 kg a.i./ha at 9 DAS recorded highest weed control efficiency whereas at harvest butachlor @ 1.25 kg a.i./ha at 3 DAS recorded the highest weed control efficiency. Hand weeding was comparable with the above treatments. However at both the stages the above treatments were comparable with the higher and lower dose of the joint formulation of anilofos and 2,4-DEE at 9 DAS.

Table 19. Effect of herbicides and time of application on the weed control efficiency (%)

Treatments	30 DAS 1993	60 DAS 1993	60 DAS 1994	Harvest 1994
M_1 (0 DAS)	46.28	45.50	61.43	54.23
M_2 (3 DAS)	47.93	41.10	82.23	61.58
M_3 (6 DAS)	54.05	39.18	77.73	62.91
M_4 (9 DAS)	56.48	41.79	83.99	64.95
SEm±	1.620	2.317	2.717	1.803
CD (0.05)	5.61	NS	9.41	6.25
T_1 Anilofos + 2,4-DEE (0.3 + 0.45 kg a.i/ha)	61.00	44.26	81.23	66.28
T_2 Joint formulation (0.3 kg a.i/ha)	56.95	39.71	75.04	62.88
T_3 Joint formulation (0.45 kg a.i/ha)	71.31	52.41	75.82	59.68
T_4 Anilofos 0.3 kg a.i./ha	27.96	46.42	79.15	61.58
T_5 Anilofos 0.45 kg a.i/ha	27.48	40.79	86.93	70.08
T_6 2,4-DEE 0.4 kg a.i/ha	51.01	42.21	62.41	54.19
T_7 2,4-DEE 0.6 kg a.i/ha	53.89	33.82	71.73	42.52
T_8 Butachlor 1.25 kg a.i/ha	59.87	35.69	86.03	70.14
HW	95.8	63.4	85.2	72.8
UWC	-	-	-	-
SEm±	2.914	3.181	4.015	3.261
CD (0.05)	8.25	9.01	11.37	9.24

Stages of observation	Subplot 1993	Subplot 1994
30 DAS	T_3 T_1 T_8 T_2 T_7 T_6 T_5 T_4	---
60 DAS	T_3 T_4 T_1 T_6 T_5 T_2 T_8 T_7	T_5 T_8 T_1 T_4 T_3 T_2 T_7 T_6
Harvest	—	T_8 T_5 T_1 T_2 T_4 T_3 T_6 T_7

Table 20a. Interaction effect of herbicides with time of application on the weed control efficiency (1993) (%)

Treatments	30 DAS	60 DAS
$M_1 T_1$	64.93	43.77
$M_1 T_2$	69.57	34.57
$M_1 T_3$	64.20	54.43
$M_1 T_4$	5.07	54.80
$M_1 T_5$	42.27	33.53
$M_1 T_6$	50.73	51.70
$M_1 T_7$	37.37	43.13
$M_1 T_8$	36.07	48.07
$M_2 T_1$	58.87	42.93
$M_2 T_2$	60.03	29.77
$M_2 T_3$	69.73	49.20
$M_2 T_4$	15.80	47.37
$M_2 T_5$	14.23	42.53
$M_2 T_6$	52.57	37.93
$M_2 T_7$	45.10	28.17
$M_2 T_8$	67.10	51.57
$M_3 T_1$	53.60	40.30
$M_3 T_2$	48.03	39.20
$M_3 T_3$	70.37	51.60
$M_3 T_4$	39.73	25.03
$M_3 T_5$	38.13	49.60
$M_3 T_6$	46.70	43.67
$M_3 T_7$	69.20	44.43
$M_3 T_8$	66.67	19.57
$M_4 T_1$	66.60	50.03
$M_4 T_2$	50.17	55.30
$M_4 T_3$	80.93	54.40
$M_4 T_4$	51.23	58.47
$M_4 T_5$	15.30	37.50
$M_4 T_6$	54.03	35.53
$M_4 T_7$	63.90	19.53
$M_4 T_8$	69.63	23.57
SEm±	5.829	6.363
CD (0.05)	16.50	18.02

Table 20b. Interaction effect of herbicides with time of application on the weed control efficiency (1994) (%)

Treatments	60 DAS	Harvest
$M_1 T_1$	66.87	68.70
$M_1 T_2$	63.20	55.97
$M_1 T_3$	57.53	50.00
$M_1 T_4$	68.73	55.17
$M_1 T_5$	83.90	60.20
$M_1 T_6$	42.60	46.77
$M_1 T_7$	74.13	23.50
$M_1 T_8$	64.47	73.53
$M_2 T_1$	84.53	67.77
$M_2 T_2$	77.60	68.23
$M_2 T_3$	80.87	51.13
$M_2 T_4$	82.63	67.27
$M_2 T_5$	77.33	67.20
$M_2 T_6$	84.50	67.10
$M_2 T_7$	76.50	24.70
$M_2 T_8$	94.07	79.23
$M_3 T_1$	81.77	61.77
$M_3 T_2$	69.00	61.37
$M_3 T_3$	71.77	69.20
$M_3 T_4$	79.97	52.87
$M_3 T_5$	91.20	74.97
$M_3 T_6$	74.13	49.47
$M_3 T_7$	59.77	57.53
$M_3 T_8$	94.27	76.10
$M_4 T_1$	91.73	66.87
$M_4 T_2$	90.37	65.93
$M_4 T_3$	93.10	68.40
$M_4 T_4$	85.27	71.00
$M_4 T_5$	95.30	77.93
$M_4 T_6$	48.40	53.43
$M_4 T_7$	76.50	64.33
$M_4 T_8$	91.30	51.70
SEm±	8.030	6.522
CD (0.05)	22.7	18.40

Higher weed control efficiency by the application of anilofos was reported by Chandrakar *et al.* (1993). Jayakumar and Sree Ramalu (1992) and Radhamani (1994) noticed increased weed control efficiency by the combined application of anilofos and 2,4-DEE.

4.2 Studies on crop

4.2.1 Phytotoxicity

The phytotoxicity rating (Appendix-2) in 0-9 scale at 15 DAS revealed that no severe phytotoxic symptoms appeared in rice following the application of the herbicides such as joint formulation of anilofos and 2,4-DEE, tank mix application of anilofos and 2,4-DEE, singular application of anilofos, 2,4-DEE and butacholor. Though, very slight yellowing was noticed in all most all treatments, the same was recouped in about 2-3 weeks. Irrespective of the time of application plots treated with joint formulation of anilofos and 2,4-DEE, the germination of the rice seeds was found to be delayed by about 2-3 days. No severe phytotoxic symptoms were noticed in the emerged seedlings.

The results reveal that all the above herbicides tested in the study are safe for use in dry seeded rice especially at Mannuthy conditions.

4.2.2 Growth characters

a) Plant population per meter row length (Table 22)

During both the years of experimentation no significant difference was observed in plant population between herbicidal treatments indicating that no stand loss was occurred by the herbicidal application.

In the second year though the interaction effect of herbicides and time of application was significant at harvest, the hand weeded plots, tank mix application and joint formulation of anilofos and 2,4-DEE and butachlor were comparable and gave almost similar values for plant population.

b) Number of tillers/m² (Tables 21 and 22)

Tiller production was significantly influenced by the herbicidal treatments only in the second year. At 30 DAS tank mix application of anilofos and 2,4-DEE recorded the highest number of tillers. It was comparable with 2,4-DEE @ 0.4 kg a.i./ha, anilofos 0.3 kg a.i./ha, butachlor @ 1.25 kg a.i./ha and 2,4-DEE @ 0.6 kg a.i./ha. At harvest also highest number of tillers noticed in the plots treated with tank mix application of anilofos and 2,4-DEE, comparable and closely followed by joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha, butachlor @ 1.25 kg a.i./ha and lower dose of the joint formulation of anilofos and 2,4-DEE i.e. 0.3 kg a.i./ha. The lower tiller number obtained in the plots treated with joint formulation of anilofos and 2,4-DEE was due to gall midge incidence at the initial stages. However the effect could be compensated subsequently as evidenced by the comparable tiller number/m² observed at harvest.

Interaction between herbicides and time of application at 30 DAS revealed that plots treated with tank mix application of anilofos and 2,4-DEE at 6 DAS registered more tillers followed by anilofos @ 0.3 kg a.i./ha at 0 DAS, tank mix application of anilofos and 2,4-DEE at 0 DAS and joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 DAS, its lower dose at 9 DAS and butachlor 1.25 kg a.i./ha at 6 DAS. At harvest tank mix application of anilofos and 2,4-DEE at 3 DAS recorded highest number of tillers and was comparable with butachlor @

Table 21. Effect of herbicides and time of application on the number of tillers/m²
(1994)

Treatments	30 DAS	Harvest
M_1 (0 DAS)	308.58	590.54
M_2 (3 DAS)	272.63	582.13
M_3 (6 DAS)	308.63	554.92
M_4 (9 DAS)	330.52	566.63
SEm±	12.004	18.781
CD (0.05)	NS	NS
T_1 Anilofos + 2,4-DEE (0.3 + 0.45 kg a.i/ha)	322.50	642.00
T_2 Joint formulation (0.3 kg a.i/ha)	286.83	593.08
T_3 Joint formulation (0.45 kg a.i/ha)	283.50	606.25
T_4 Anilofos 0.3 kg a.i/ha	315.00	523.58
T_5 Anilofos 0.45 kg a.i./ha	300.67	577.67
T_6 2,4-DEE 0.4 kg a.i/ha	317.50	510.33
T_7 2,4-DEE 0.6 kg a.i/ha	303.67	538.50
T_8 Butachlor 1.25 kg a.i/ha	311.04	597.00
HW	328.67	675.32
UWC	250.33	428.49
SEm±	7.714	22.659
CD (0.05)	21.85	64.18

Stages of observation	Subplot
30 DAS	T_1 T_6 T_4 T_8 T_7 T_5 T_2 T_3
Harvest	T_1 T_3 T_8 T_2 T_5 T_7 T_4 T_6

Table 22. Interaction effect of herbicides with time of application on the plant population/m row length and number of tillers/m² (1994)

Treatments	Plant population/m row length	No. of tillers/m² 30 DAS	No. of tillers/m² Harvest
$M_1 T_1$	5.67	352.67	622.67
$M_1 T_2$	6.00	252.00	682.67
$M_1 T_3$	5.67	249.33	670.67
$M_1 T_4$	6.67	356.00	505.67
$M_1 T_5$	6.00	328.67	637.33
$M_1 T_6$	6.00	305.00	386.00
$M_1 T_7$	6.00	314.00	536.67
$M_1 T_8$	5.67	311.00	682.67
$M_2 T_1$	5.67	272.00	736.00
$M_2 T_2$	6.67	291.33	526.67
$M_2 T_3$	5.33	274.00	528.33
$M_2 T_4$	6.67	251.33	446.00
$M_2 T_5$	6.33	228.67	569.33
$M_2 T_6$	6.67	331.67	648.67
$M_2 T_7$	5.33	236.00	504.00
$M_2 T_8$	5.33	296.00	698.00
$M_3 T_1$	6.00	357.33	634.00
$M_3 T_2$	6.00	270.67	586.00
$M_3 T_3$	5.33	258.67	564.00
$M_3 T_4$	5.33	320.67	600.00
$M_3 T_5$	4.67	296.67	518.67
$M_3 T_6$	6.67	324.00	470.67
$M_3 T_7$	6.33	318.00	642.67
$M_3 T_8$	6.00	323.00	423.33
$M_4 T_1$	6.67	308.00	573.33
$M_4 T_2$	6.33	333.33	577.00
$M_4 T_3$	6.33	352.00	662.00
$M_4 T_4$	5.67	332.00	542.67
$M_4 T_5$	5.33	348.67	585.33
$M_4 T_6$	6.00	309.33	536.00
$M_4 T_7$	6.00	346.67	470.67
$M_4 T_8$	6.00	314.17	584.00
SEm±	0.385	15.429	45.319
CD (0.05)	0.99	43.6	128.0

1.25 kg a.i./ha at 3 and 0 DAS, lower dose of joint formulation of anilofos and 2,4-DEE at 0 DAS, its higher dose i.e. 0.45 kg a.i./ha at 9 DAS. Hand weeding was comparable with the treatments. Irrespective of the stages of observation unweeded control registered the lowest number of tillers/m².

The higher tiller number observed in the plots treated with the combined application of anilofos and 2,4-DEE (tank mix as well as joint formulation), butachlor, anilofos etc. pinpoints the degree of weed control effected facilitating better performance of the crop in terms of tiller production.

c) Plant height (Tables 23 and 24)

During the first year significant difference between herbicides was observed only at harvest. Butachlor @ 1.25 kg a.i./ha registered the higher value and was comparable with tank mix application of anilofos and 2,4-DEE, which in turn was similar to the higher dose of the joint formulation of anilofos and 2,4-DEE i.e. 0.45 kg a.i./ha.

In the second year of study taller plants were observed in plots treated with joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at all the stages of observation.

The interaction effect of herbicides and time of application was significant only at harvest in both the years of study. In the first year hand weeded plots gave the highest value and was comparable with butachlor @ 1.25 kg a.i./ha at 3, 6 and 9 DAS and higher dose of the joint formulation of anilofos and 2,4-DEE at 6 and 9 DAS which in turn was similar to its lower dose at 9 DAS.

Table 23. Effect of herbicides and time of application on the plant height of rice (cm)

Treatments	30 DAS 1993	30 DAS 1994	Harvest 1993	Harvest 1994
M_1 (0 DAS)	34.32	33.73	69.02	77.47
M_2 (3 DAS)	32.92	34.02	69.95	79.53
M_3 (6 DAS)	36.19	34.39	70.45	77.85
M_4 (9 DAS)	36.70	35.49	72.73	77.43
SEm±	0.70	0.397	0.756	0.627
CD (0.05)	2.43	NS	NS	NS
T_1 Anilofos + 2,4-DEE (0.3 + 0.45 kg a.i/ha)	36.06	34.49	73.62	77.83
T_2 Joint formulation (0.3 kg a.i./ha)	34.91	35.29	69.33	78.04
T_3 Joint formulation (0.45 kg a.i/ha)	34.74	35.45	70.35	80.31
T_4 Anilofos 0.3 kg a.i/ha	35.81	33.79	70.68	77.40
T_5 Anilofos 0.45 kg a.i/ha	34.77	35.32	70.63	79.03
T_6 2,4-DEE 0.4 kg a.i/ha	34.18	34.54	69.00	76.94
T_7 2,4-DEE 0.6 kg a.i/ha	33.03	33.43	67.39	77.82
T_8 Butachlor 1.25 kg a.i/ha	36.77	32.96	75.10	77.17
HW	44.80	34.79	81.00	78.70
UWC	33.37	32.00	70.17	73.20
SEm±	0.067	0.630	1.362	0.636
CD (0.05)	NS	1.79	3.86	1.80

Stages of observation	Subplot 1993	Subplot 1994
30 DAS	NS	T_3 T_5 T_2 T_6 T_1 T_4 T_7 T_8
Harvest	T_8 T_1 T_4 T_5 T_3 T_2 T_6 T_7	T_3 T_5 T_2 T_1 T_7 T_4 T_8 T_6

Table 24. Interaction effect of herbicides with time of application on plant height at harvest (cm)

Treatments	1993	1994
$M_1 T_1$	69.90	76.90
$M_1 T_2$	63.63	78.07
$M_1 T_3$	68.73	80.70
$M_1 T_4$	70.70	75.10
$M_1 T_5$	70.93	75.07
$M_1 T_6$	67.97	76.93
$M_1 T_7$	69.33	75.27
$M_1 T_8$	71.03	80.93
$M_2 T_1$	79.37	81.57
$M_2 T_2$	70.50	76.73
$M_2 T_3$	67.20	81.43
$M_2 T_4$	70.70	81.33
$M_2 T_5$	70.50	77.60
$M_2 T_6$	68.03	79.77
$M_2 T_7$	37.77	76.37
$M_2 T_8$	79.60	81.40
$M_3 T_1$	71.80	77.33
$M_3 T_2$	69.43	79.67
$M_3 T_3$	72.23	78.53
$M_3 T_4$	66.63	76.43
$M_3 T_5$	71.03	83.43
$M_3 T_6$	65.60	74.57
$M_3 T_7$	72.10	78.43
$M_3 T_8$	73.53	74.37
$M_4 T_1$	72.10	75.53
$M_4 T_2$	73.77	77.70
$M_4 T_3$	72.23	80.57
$M_4 T_4$	74.67	76.73
$M_4 T_5$	69.87	79.23
$M_4 T_6$	73.60	76.50
$M_4 T_7$	69.27	81.20
$M_4 T_8$	76.33	71.97
SEm±	2.725	1.272
CD (0.05)	7.72	3.60

However in the second year though singular application of the higher dose of anilofos registered the highest value it was closely followed by hand weeding, joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 3 DAS and butachlor @ 1.25 kg a.i./ha at 3 DAS.

d) Crop dry matter production (Tables 25 and 26)

The dry matter production of crop was significantly influenced by weed control treatments at all the stages of observation during both the years. During the first year joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha recorded the highest dry matter production by the crop at all the stages and was comparable with its lower dose at 30 and 60 DAS. However at harvest the higher dose of joint formulation of anilofos and 2,4-DEE was similar to 2,4-DEE @ 0.4 kg a.i./ha which in turn was comparable with the lower dose of the joint formulation of anilofos and 2,4-DEE.

In the second year of study though 2,4-DEE @ 0.6 kg a.i./ha registered the highest value it was comparable with the joint formulation of anilofos and 2,4-DEE @ 0.3 and 0.45 kg a.i./ha and butachlor @ 1.25 a.i./ha. At 60 DAS higher dose of the joint formulation of anilofos and 2,4-DEE, singular application of anilofos @ 0.45 kg a.i./ha and butachlor @ 1.25 kg a.i./ha were equally effective. However at harvest singular application of anilofos @ 0.45 kg a.i./ha recorded the highest crop dry matter, comparable and closely followed by the higher and lower dose of the joint formulation of anilofos and 2,4-DEE and its tank mix application respectively. The joint formulation @ 0.3 kg a.i./ha was also similar to application of butachlor @ 1.25 kg a.i./ha.

Table 25. Effect of herbicides and time of application on the dry matter production by rice (g/m²)

Treatments	30 DAS		60 DAS		Harvest	
	1993	1994	1993	1994	1993	1994
M_1 (0 DAS)	32.71	46.84	146.25	320.21	347.50	834.17
M_2 (3 DAS)	30.00	41.93	150.10	359.58	365.83	905.08
M_3 (6 DAS)	29.89	44.45	170.94	354.38	361.04	838.54
M_4 (9 DAS)	33.75	44.26	167.39	386.25	352.71	873.23
SEm±	1.641	1.008	6.039	3.899	11.733	21.450
CD (0.05)	NS	NS	NS	13.51	NS	NS
T_1 Anilofos + 2,4-DEE (0.3 + 0.45 kg a.i/ha)	27.92	38.75	159.58	325.83	332.50	899.13
T_2 Joint formulation (0.3 kg a.i/ha)	33.75	43.71	171.67	362.92	355.83	954.79
T_3 Joint formulation (0.45 kg a.i/ha)	39.17	47.08	195.21	392.50	402.50	968.33
T_4 Anilofos 0.3 kg a.i/ha	35.83	44.25	153.33	345.83	364.17	810.00
T_5 Anilofos 0.45 kg a.i/ha	31.88	42.75	141.67	388.75	349.58	980.42
T_6 2,4-DEE 0.4 kg a.i/ha	30.42	44.84	134.17	323.75	371.25	738.75
T_7 2,4-DEE 0.6 kg a.i/ha	22.50	48.38	138.75	315.00	340.83	671.25
T_8 Butachlor 1.25 kg a.i/ha	31.25	45.21	175.00	386.25	337.50	879.38
HW	43.33	51.92	234.30	390.00	468.33	957.50
UWC	16.67	28.75	120.00	275.00	315.00	545.00
SEm±	2.266	1.758	11.069	7.388	12.782	33.196
CD (0.05)	6.42	4.98	31.35	20.93	36.20	94.02

Stages of observation	Subplot 1993	Subplot 1994
30 DAS	T_3 T_4 T_2 T_5 T_8 T_6 T_1 T_7	T_7 T_3 T_8 T_6 T_4 T_2 T_5 T_1
60 DAS	T_3 T_8 T_2 T_1 T_4 T_5 T_7 T_6	T_3 T_5 T_8 T_2 T_4 T_1 T_6 T_7
Harvest	T_3 T_6 T_4 T_2 T_5 T_7 T_8 T_1	T_5 T_3 T_2 T_1 T_8 T_4 T_6 T_7

Table 26. Interaction effect of herbicides with time of application on the dry matter production by rice (g/m²)

Treatments	30 DAS (1993)	30 DAS (1994)	60 DAS (1994)	Harvest (1994)
$M_1 T_1$	30.00	43.33	330.00	861.67
$M_1 T_2$	31.67	55.00	320.00	946.67
$M_1 T_3$	36.67	48.33	346.67	1005.00
$M_1 T_4$	43.33	40.83	285.00	785.00
$M_1 T_5$	30.00	41.67	360.00	938.33
$M_1 T_6$	41.67	44.33	330.00	525.00
$M_1 T_7$	21.67	50.00	265.00	726.67
$M_1 T_8$	26.67	51.25	325.00	885.00
$M_2 T_1$	21.67	35.83	293.33	973.17
$M_2 T_2$	30.00	34.00	405.00	845.00
$M_2 T_3$	41.67	40.83	353.33	958.33
$M_2 T_4$	38.33	40.83	355.00	808.33
$M_2 T_5$	30.00	40.00	345.00	853.33
$M_2 T_6$	21.67	50.00	340.00	975.00
$M_2 T_7$	16.67	46.27	345.00	787.50
$M_2 T_8$	40.00	47.67	440.00	1040.00
$M_3 T_1$	26.67	44.17	285.00	1021.67
$M_3 T_2$	31.67	43.33	420.00	950.83
$M_3 T_3$	36.67	44.17	435.00	828.33
$M_3 T_4$	21.67	42.50	320.00	781.67
$M_3 T_5$	32.50	54.33	415.00	1066.67
$M_3 T_6$	33.33	37.93	335.00	645.00
$M_3 T_7$	31.67	47.27	275.00	544.17
$M_3 T_8$	25.00	41.92	350.00	870.00
$M_4 T_1$	33.33	31.67	395.00	740.00
$M_4 T_2$	41.67	42.50	306.67	1076.67
$M_4 T_3$	41.67	55.00	435.00	1081.67
$M_4 T_4$	40.00	52.83	423.33	865.00
$M_4 T_5$	35.00	35.00	435.00	1063.33
$M_4 T_6$	25.00	47.10	290.00	810.00
$M_4 T_7$	20.00	50.00	375.00	626.67
$M_4 T_8$	33.33	40.00	430.00	722.50
SEm±	4.532	3.515	14.776	66.392
CD (0.05)	12.84	9.96	41.85	188.04

During the first year of investigation interaction effect of herbicides with time of application was significant only at the initial stage of observation. Though anilofos @ 0.3 kg a.i./ha at 0 DAS recorded the highest value it was comparable with hand weeding, higher and lower dose of the joint formulation of anilofos and 2,4-DEE at 9 DAS and butachlor @ 1.25 kg a.i./ha at 3 DAS.

In the second year of study both at 30 DAS and at harvest joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha was comparable with butachlor @ 1.25 kg a.i./ha at 3 DAS. At 60 DAS though highest dry matter production was observed in plots treated with butachlor @ 1.25 kg a.i./ha at 3 DAS, it was comparable with the higher dose of the joint formulation of anilofos and 2,4-DEE at 9 and 6 DAS. Hand weeding was similar to the above treatments while unweeded control recorded the lowest crop dry matter production.

The better suppression of broad spectrum of weeds by the combined application of anilofos and 2,4-DEE together with its tonic effect on the crop might have contributed to higher dry matter accumulation in rice. This is in conformity with the findings of Sreedevi and Thomas (1993) and Radhamani (1994).

4.2.3 Yield attributes

a) Effective tillers/hill (Tables 27 and 28)

With respect to the number of effective tillers/hill no significant difference was noticed between herbicides during the first year. However hand weeding gave higher number of effective tillers followed by joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha. But in the second year significant difference was observed between herbicides. Hand weeding and butachlor (@ 1.25 kg a.i./ha) applied

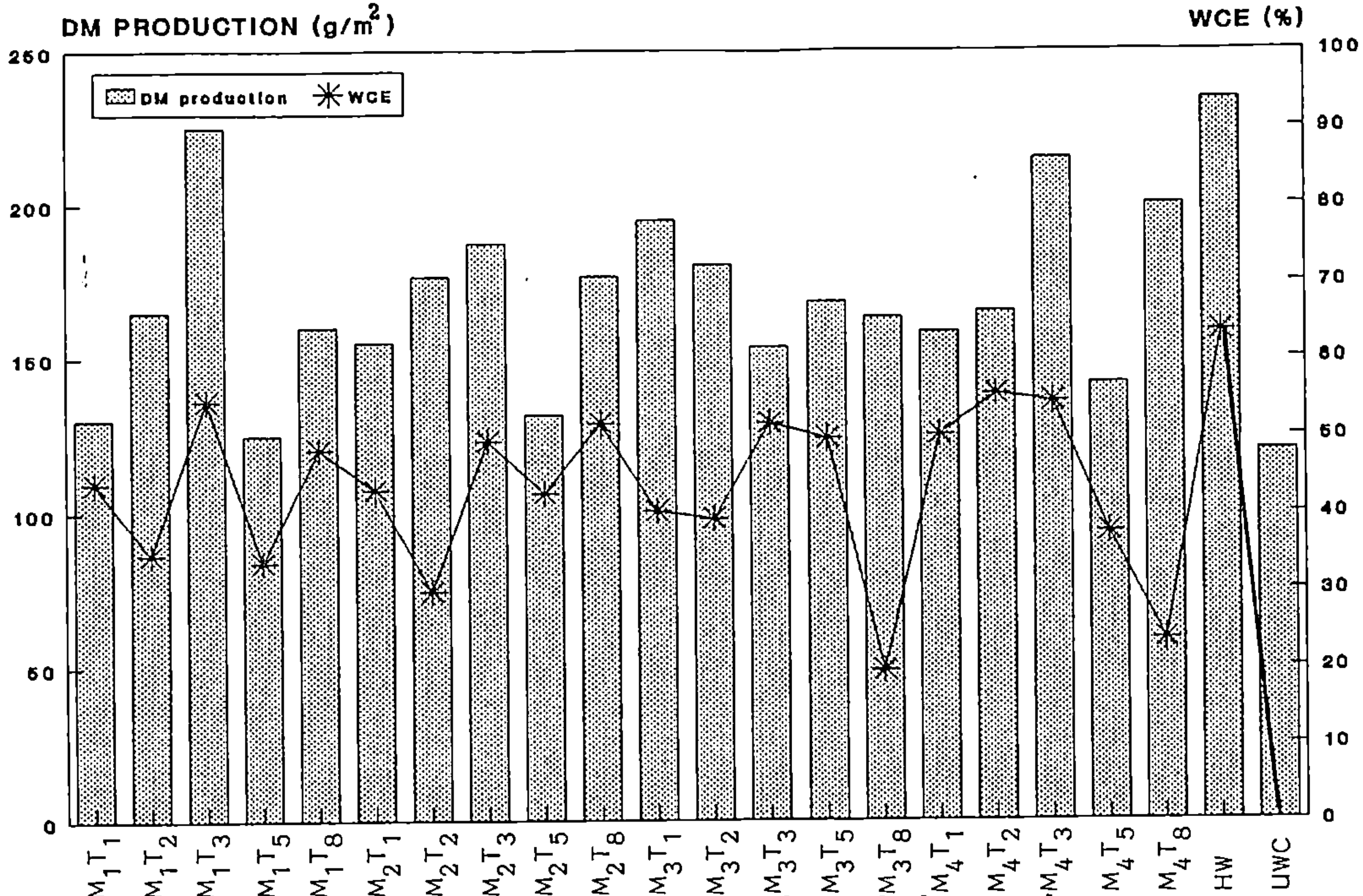

Fig.3 Dry matter production of rice and weed control efficiency at 60 DAS (1993)

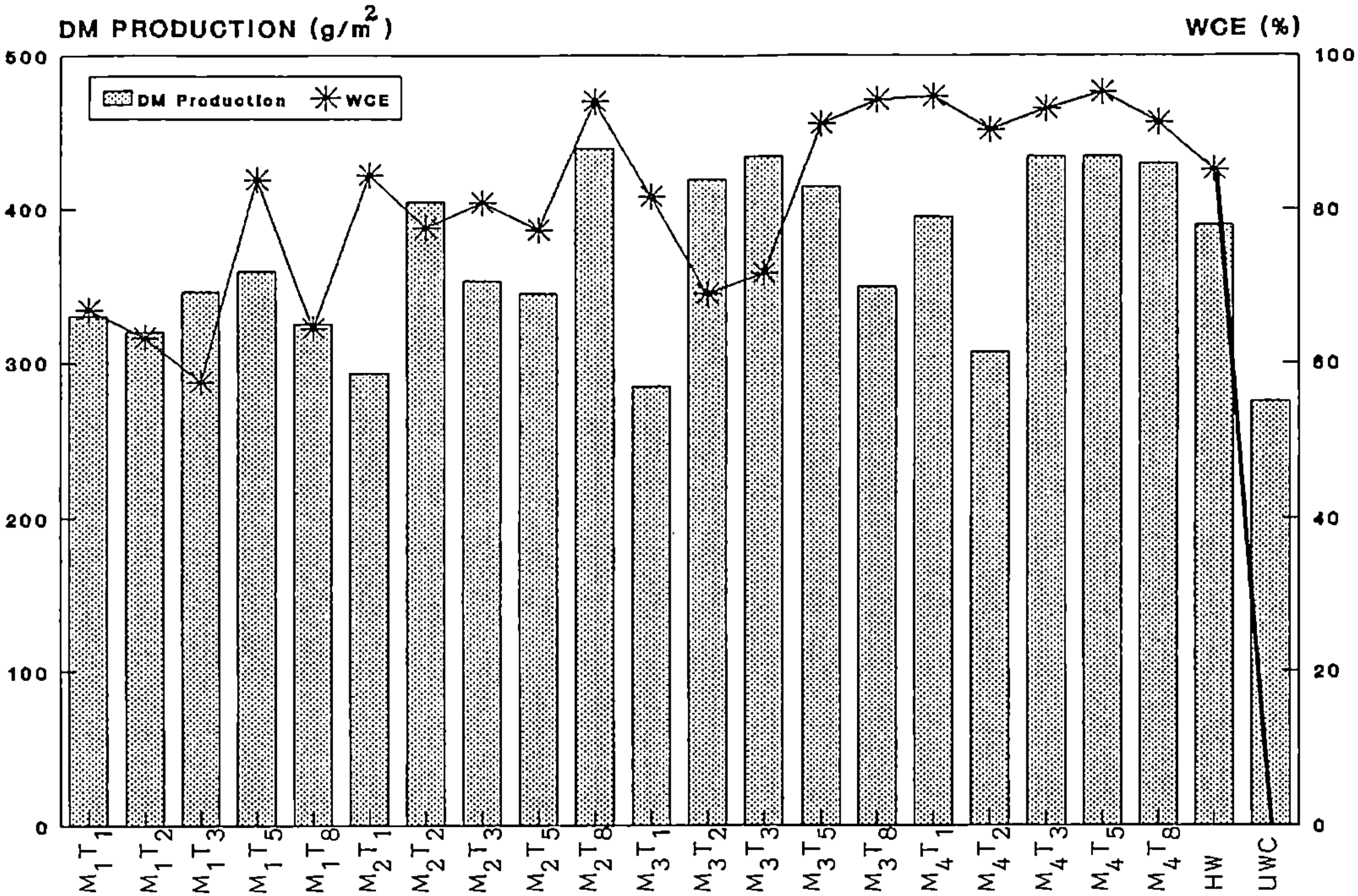

Fig. 4 Dry matter production of rice and weed control efficiency at 60 DAS (1994)

plots registered higher number of effective tillers closely followed by the lower and higher dose of joint formulation of anilofos and 2,4-DEE. Unweeded control recorded the lowest number of effective tillers.

The interaction effect of herbicides with time of application was significant only in the second year of study. Butachlor @ 1.25 kg a.i./ha at 3 DAS recorded the highest number of effective tillers. It was similar to joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 DAS, joint formulation of anilofos and 2,4-DEE @ 0.3 kg a.i./ha at 6 DAS and hand weeding.

The comparatively better control of weeds in the above treatments might have facilitated better utilization of resources resulting in the production of more effective tillers.

b) Length of panicle (Tables 27 and 28)

During both the years of experimentation though herbicidal treatments had no significant effect on the length of panicle longer panicles were noticed in hand weeded plots followed by the application of higher and lower dose of the joint formulation of anilofos and 2,4-DEE and butachlor @ 1.25 kg a.i./ha.

The interaction between herbicides and time of application was significant only in the second year wherein joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha recorded the highest value and was comparable with hand weeding and butachlor @ 1.25 kg a.i./ha. Length of panicle was lowest on unweeded plots. Suja (1989) and Varshney (1990) also observed decreased panicle length in the unweeded check.

Table 27. Effect of herbicides and time of application on the number of effective tillers/hill and length of panicle (cm)

Treatments	Effective tillers/ hill		Length of panicle	
	1993	1994	1993	1994
M_1 (0 DAS)	5.78	8.25	16.79	19.50
M_2 (3 DAS)	6.10	8.29	16.93	20.55
M_3 (6 DAS)	6.88	8.92	14.18	19.67
$0M_4$ (9 DAS)	6.40	8.25	16.54	20.03
SEm±	0.176	0.182	0.138	0.184
CD (0.05)	0.61	NS	NS	0.64
T_1 Anilofos + 2,4-DEE (0.3 + 0.45 kg a.i/ha)	6.45	8.00	16.92	19.63
T_2 Joint formulation (0.3 kg a.i/ha)	6.68	8.92	17.24	20.04
T_3 Joint formulation (0.45 kg a.i/ha)	7.13	8.58	17.03	20.38
T_4 Anilofos 0.3 kg a.i/ha	6.10	8.42	16.87	19.92
T_5 Anilofos 0.45 kg a.i/ha	5.76	8.33	16.46	20.19
T_6 2,4-DEE 0.4 kg a.i/ha	6.03	7.33	16.51	19.73
T_7 2,4-DEE 0.6 kg a.i/ha	5.67	8.42	16.89	19.94
T_8 Butachlor 1.25 kg a.i/ha	6.52	9.42	16.95	19.70
HW	8.2	9.5	20.6	21.5
UWC	4.8	7.1	15.8	17.3
SEm±	0.404	0.285	0.30	0.203
CD (0.05)	NS	0.81	NS	NS

Character	Subplot 1993	Subplot 1994
Effective tillers/hill	NS	T_8 T_2 T_3 T_4 T_7 T_5 T_1 T_6
Length of panicle	NS	NS

Table 28. Interaction effect of herbicides with time of application on number of effective tillers/hill, length of panicle (cm) and number of grains per panicle (1994)

Treatments	Effective tillers/ hill	Length of panicle (cm)	Number of grains/ panicle
$M_1 T_1$	8.67	19.57	81.00
$M_1 T_2$	9.33	19.90	77.67
$M_1 T_3$	8.00	19.00	71.33
$M_1 T_4$	9.00	20.00	93.50
$M_1 T_5$	8.33	19.37	78.83
$M_1 T_6$	5.00	18.93	80.77
$M_1 T_7$	8.67	19.80	71.50
$M_1 T_8$	9.00	19.47	72.50
$M_2 T_1$	8.67	20.43	89.00
$M_2 T_2$	8.00	20.00	72.17
$M_2 T_3$	7.33	21.07	85.83
$M_2 T_4$	7.00	20.30	78.00
$M_2 T_5$	8.00	21.47	73.17
$M_2 T_6$	9.33	19.80	78.50
$M_2 T_7$	8.00	20.20	77.00
$M_2 T_8$	10.00	21.17	81.50
$M_3 T_1$	8.33	19.07	76.00
$M_3 T_2$	9.67	19.70	90.17
$M_3 T_3$	9.33	19.77	90.83
$M_3 T_4$	9.33	19.80	81.33
$M_3 T_5$	8.33	20.07	82.83
$M_3 T_6$	7.33	19.87	83.77
$M_3 T_7$	9.97	20.20	66.00
$M_3 T_8$	9.33	18.90	75.50
$M_4 T_1$	6.33	19.47	75.83
$M_4 T_2$	8.67	20.57	89.83
$M_4 T_3$	9.67	21.67	96.83
$M_4 T_4$	8.33	19.57	96.17
$M_4 T_5$	8.67	19.87	92.17
$M_4 T_6$	7.67	20.30	84.00
$M_4 T_7$	7.33	19.57	69.00
$M_4 T_8$	9.33	19.27	75.77
SEm±	0.570	0.406	2.617
CD (0.05)	1.61	1.14	7.41

c) Grains/panicle (Table 29)

No significant difference was observed between herbicides during the first year of study. However 2,4-DEE @ 0.6 kg a.i./ha recorded higher number of grains/panicle followed by the higher dose of the joint formulation of anilofos and 2,4-DEE. In the second year though singular application of anilofos @ 0.45 kg a.i./ha registered the highest number it was comparable with the joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha.

Interaction effect of herbicides with time of application was significant only in the second year. Plots treated with the higher dose of the joint formulation of anilofos and 2,4-DEE at 9 DAS had panicles with more grains and was comparable with its lower dose at 6 DAS and hand weeded plots. The better control of weeds in these treatments might have contributed to this. Unweeded control had panicles with lowest number of grains, indicating the severity of crop weed competition in them. Similar results were observed by Sreedevi (1979) and Kumar and Gautham (1986).

d) Thousand grain weight (Table 29)

During the first year of study no significant difference was observed between treatments. However higher dose of the joint formulation of anilofos and 2,4-DEE recorded the highest value followed by its lower dose and butachlor @ 1.25 kg a.i./ha.

In the second year though singular application of anilofos @ 0.3 kg a.i./ha registered the highest value, it was comparable with its higher dose i.e. 0.45 kg a.i./ha, butachlor @ 1.25 kg a.i./ha and joint formulation of anilofos and 2,4-DEE 0.3 kg a.i./ha.

Table 29. Effect of herbicides and time of application on the number of grains/ panicle and thousand grain weight (gm)

Treatments	No. of grains/ panicle 1993	No. of grains/ panicle 1994	Thousand grain weight 1993	Thousand grain weight 1994
M_1 (0 DAS)	69.67	78.39	26.68	30.88
M_2 (3 DAS)	69.59	79.39	26.83	30.92
M_3 (6 DAS)	71.42	80.80	27.12	31.03
M_4 (9 DAS)	65.65	84.95	27.29	31.66
SEm±	1.103	1.201	0.309	0.354
CD (0.05)	3.82	4.16	NS	NS
T_1 Anilofos + 2,4-DEE (0.3 + 0.45 kg a.i/ha)	68.96	80.46	27.07	30.70
T_2 Joint formulation (0.3 kg a.i/ha)	72.62	82.46	27.17	31.06
T_3 Joint formulation (0.45 kg a.i/ha)	69.30	86.21	27.56	30.69
T_4 Anilofos 0.3 kg a.i/ha	69.08	87.25	26.56	31.76
T_5 Anilofos 0.45 kg a.i/ha	67.21	81.75	26.64	31.68
T_6 2,4-DEE 0.4 kg a.i/ha	67.83	81.76	26.60	30.44
T_7 2,4-DEE 0.6 kg a.i/ha	69.81	70.88	26.76	31.55
T_8 Butachlor 1.25 kg a.i/ha	67.84	76.32	27.20	31.12
HW	80.00	91.81	28.10	31.30
UWC	52.50	70.21	26.30	30.42
SEm±	1.742	1.309	0.276	0.312
CD (0.05)	NS	3.71	NS	0.88

Character	Subplot 1993	Subplot 1994
No. of grains/panicle	NS	T_4 T_3 T_2 T_6 T_5 T_1 T_8 T_7
Thousand grain weight	NS	T_4 T_5 T_7 T_8 T_2 T_1 T_3 T_6

Irrespective of the years the lowest thousand grain weight was observed in the unweeded control as a result of the intense weed competition throughout the growth period of the crop. Decreased test weights due to continuous weed growth were earlier reported by Azad *et al.* (1990) and Padhi *et al.* (1991).

4.2.4 Yield (Tables 30 and 31)

a) Grain yield

In general, a perusal of the grain yield data for the two years reveals very low values for grain yield in the first year. This is attributed to several reasons. During the first year the experimental plot was preceeded by summer vegetables which aggravated the problem of weeds mostly of upland nature. The slightly elevated nature of the plot had also some bearing on the subsequent weed infestation. The lower moisture status of the soil due to lack of proper flooding coupled with the high aeration facilitated a spurt in sequential weed seed germination ultimately resulting in poor yield. However in the second year the ponded water had a marked effect in reducing further germination of weeds. The reduction in weed density in rice due to submergence of water upto 15 cm was reported earlier by Bhan (1983).

During the first year, herbicides had significant effect on the grain yield. Among the herbicides joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha recorded the highest grain yield and was comparable with anilofos @ 0.45 kg a.i./ha, butachlor @ 1.25 kg a.i./ha, joint formulation of anilofos and 2,4-DEE @ 0.3 kg a.i./ha and anilofos @ 0.3 kg a.i./ha. The tank mix application of anilofos and 2,4-DEE @ 0.3 + 0.45 kg a.i./ha, was similar to the application of butachlor @ 1.25 kg a.i./ha and lower dose of the joint formulation of anilofos and 2,4-DEE i.e. 0.3 kg a.i./ha.

In the second year though singular application of anilofos @ 0.45 kg a.i./ha gave the highest grain yield it was similar to the higher dose of the joint formulation of anilofos and 2,4-DEE i.e. 0.45 kg a.i./ha, tank mix application of anilofos and 2,4-DEE (0.3 + 0.45 kg a.i./ha) and joint formulation of anilofos and 2,4-DEE @ 0.3 kg a.i./ha. Irrespective of the doses joint formulation of anilofos and 2,4-DEE was comparable with its tank mix application and butachlor @ 1.25 kg a.i./ha.

The interaction effect of herbicides with time of application during the first year revealed that anilofos 0.3 kg a.i./ha at 6 DAS recorded the highest grain yield and was comparable with higher and lower dose of the joint formulation of anilofos and 2,4-DEE at 9 DAS, butachlor @ 1.25 kg a.i./ha at 0 and 6 DAS and anilofos 0.45 kg a.i./ha at 9 DAS. In the second year joint formulation of anilofos and 2,4-DEE @ 0.3 kg a.i./ha at 6 DAS registered the highest grain yield and was comparable with its higher dose at 9 DAS and singular application of anilofos @ 0.45 kg a.i./ha at 3 DAS. During the first year hand weeding was superior to the herbicidal treatments while in the second year, the above herbicides were superior to hand weeding. During both the years unweeded control recorded the lowest grain yield.

The above results reveal that the same degree of control of weeds facilitiating better performance of the crop could be achieved with the lower dose the joint formulation i.e. 0.3 kg a.i./ha at an early stage i.e. at 6 DAS and with the higher dose of the joint formulation of anilofos and 2,4-DEE i.e.e 0.45 kg a.i./ha at a later stage i.e. at 9 DAS. In other words the lower dose of joint formulation at an earlier stage was equally effective as that of the higher dose of joint formulation at a later stage in terms of control of weeds and resultant performance of the crop. This might be due to the slight early post-emergence action of anilofos - which is a component of the joint formulation. As the weed seedlings were at the emerging stage, a lower dose of the combination could achieve effective control. With the advancement in age of weed seedlings, they became more sturdy and a higher dose of the chemical was needed to bring about the same degree of control.

The above findings pinpoints the need to increase the dose of the chemical when the application of the joint formulation is delayed after 6 DAS. This is at an advantage when spraying operation could not be done on the 6th day due to unforeseen calamities. In the context spraying can be safely advocated on the 9th day by adopting a slightly higher dose. On the other hand by strict adherance to the time of application, the dose of the chemical can be reduced. The same trend was noticed in the case of singular application of anilofos also.

Further, from both the years results, joint formulation of anilofos and 2,4-DEE was equally or more effective than the standard herbicide butachlor. This is because whatever weeds are left uncontrolled by anilofos - one of the components of the joint formulation are controlled by the other component 2,4-DEE. So by the use of the joint formulation a wide coverage control of weeds could be achieved.

The higher yields with combined application of anilofos and 2,4-DEE was reported earlier by Pandey and Thakur (1988) in transplanted rice and Radhamani (1994) in direct sown puddled rice. Syric *et al.* (1993) and Sreedevi and Thomas (1993) also reported similar results in transplanted rice, in Kerala.

Table 30. Effect of herbicides and time of application on the grain yield (q/ha) and straw yield (q/ha)

Treatments	Grain yield 1993	Grain yield 1994	Straw yield 1993	Straw yield 1994
M_1 (0 DAS)	5.76	30.31	12.08	46.97
M_2 (3 DAS)	6.04	32.76	10.44	50.31
M_3 (6 DAS)	7.89	34.39	13.36	53.11
M_4 (9 DAS)	8.29	32.18	15.43	54.93
SEm±	0.374	0.418	1.768	1.193
CD (0.05)	1.29	1.45	NS	4.13
T_1 Anilofos + 2,4-DEE (0.3 + 0.45 kg a.i/ha)	6.88	33.00	12.24	48.57
T_2 Joint formulation (0.3 kg a.i/ha)	7.53	32.61	13.24	53.91
T_3 Joint formulation (0.45 kg a.i/ha)	8.00	33.42	15.03	62.86
T_4 Anilofos 0.3 kg a.i/ha	7.17	31.64	11.02	47.86
T_5 Anilofos 0.45 kg a.i/ha	7.99	34.62	13.74	52.73
T_6 2,4-DEE 0.4 kg a.i/ha	5.49	32.18	11.45	52.52
T_7 2,4-DEE 0.6 kg a.i/ha	5.21	31.18	12.39	51.98
T_8 Butachlor 1.25 kg a.i/ha	7.69	32.11	13.47	50.21
HW	17.12	33.10	32.39	48.94
UWC	4.53	13.88	7.08	29.51
SEm±	0.626	0.768	1.319	1.603
CD (0.05)	1.77	2.16	NS	NS

Character	Subplot 1993	Subplot 1994
Grain yield	$\overline{T_3\ T_5\ T_8\ T_2}\ T_4\ T_1\ T_6\ T_7$	$\overline{T_5\ T_3}\ T_1\ T_2\ T_6\ T_8\ T_4\ T_7$
Straw yield	NS	NS

Table 31. Interaction effect of herbicides with time of application on the grain yield and straw yield (q/ha)

Treatments	Grain yield 1993	Grain yield 1994	Straw yield 1993	Straw yield 1994
$M_1 T_1$	2.98	29.37	8.84	45.70
$M_1 T_2$	8.62	28.57	12.18	43.70
$M_1 T_3$	4.28	28.30	6.55	55.23
$M_1 T_4$	4.94	28.07	14.00	46.83
$M_1 T_5$	6.65	31.57	12.34	49.00
$M_1 T_6$	4.01	34.00	17.79	50.33
$M_1 T_7$	4.50	31.03	13.57	43.57
$M_1 T_8$	10.09	31.53	11.32	41.40
$M_2 T_1$	6.01	35.93	7.34	50.90
$M_2 T_2$	4.95	31.03	11.96	60.40
$M_2 T_3$	6.52	33.73	14.98	43.53
$M_2 T_4$	6.23	32.40	7.25	45.20
$M_2 T_5$	8.43	36.73	15.50	56.87
$M_2 T_6$	5.04	34.83	6.74	45.73
$M_2 T_7$	4.34	29.40	5.80	50.33
$M_2 T_8$	6.80	34.30	13.94	53.07
$M_3 T_1$	8.86	33.47	14.01	48.97
$M_3 T_2$	7.29	37.37	11.93	51.70
$M_3 T_3$	10.87	34.37	20.39	52.80
$M_3 T_4$	11.15	36.17	8.61	48.00
$M_3 T_5$	6.92	35.90	16.32	53.33
$M_3 T_6$	5.43	32.10	10.40	57.70
$M_3 T_7$	4.51	33.50	13.12	55.50
$M_3 T_8$	8.04	31.57	12.07	56.87
$M_4 T_1$	9.65	33.23	18.76	48.70
$M_4 T_2$	9.25	33.47	17.86	59.83
$M_4 T_3$	10.33	37.27	18.20	59.86
$M_4 T_4$	6.36	29.93	14.22	51.40
$M_4 T_5$	9.94	34.30	10.82	51.70
$M_4 T_6$	7.50	27.80	10.88	56.30
$M_4 T_7$	7.50	30.77	17.09	58.53
$M_4 T_8$	5.83	30.73	16.58	49.50
SEm±	1.252	1.524	2.637	3.205
CD (0.05)	3.55	4.32	7.46	9.07

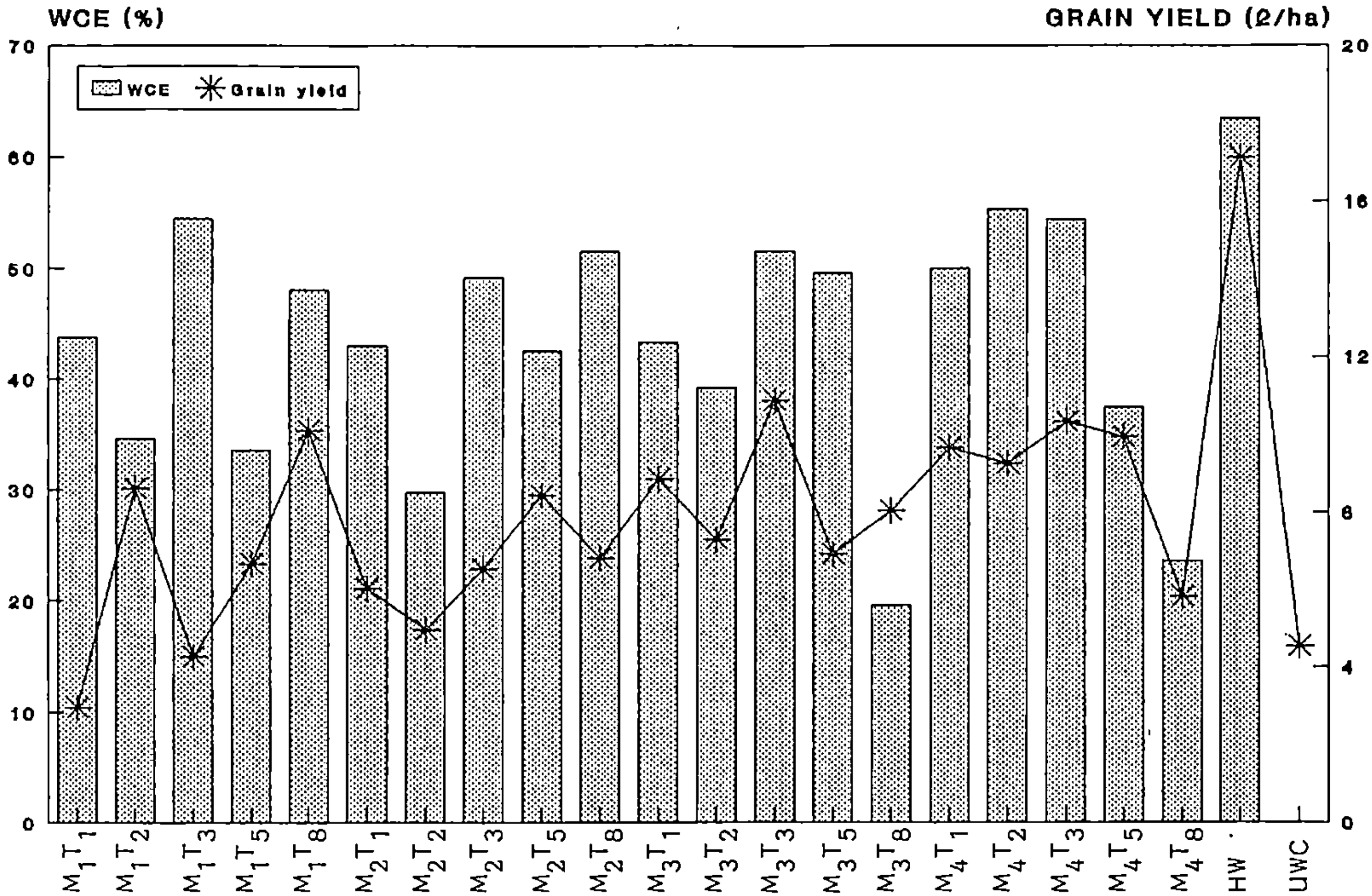

Fig.5 Grain yield and weed control efficiency at 60 DAS (1993)

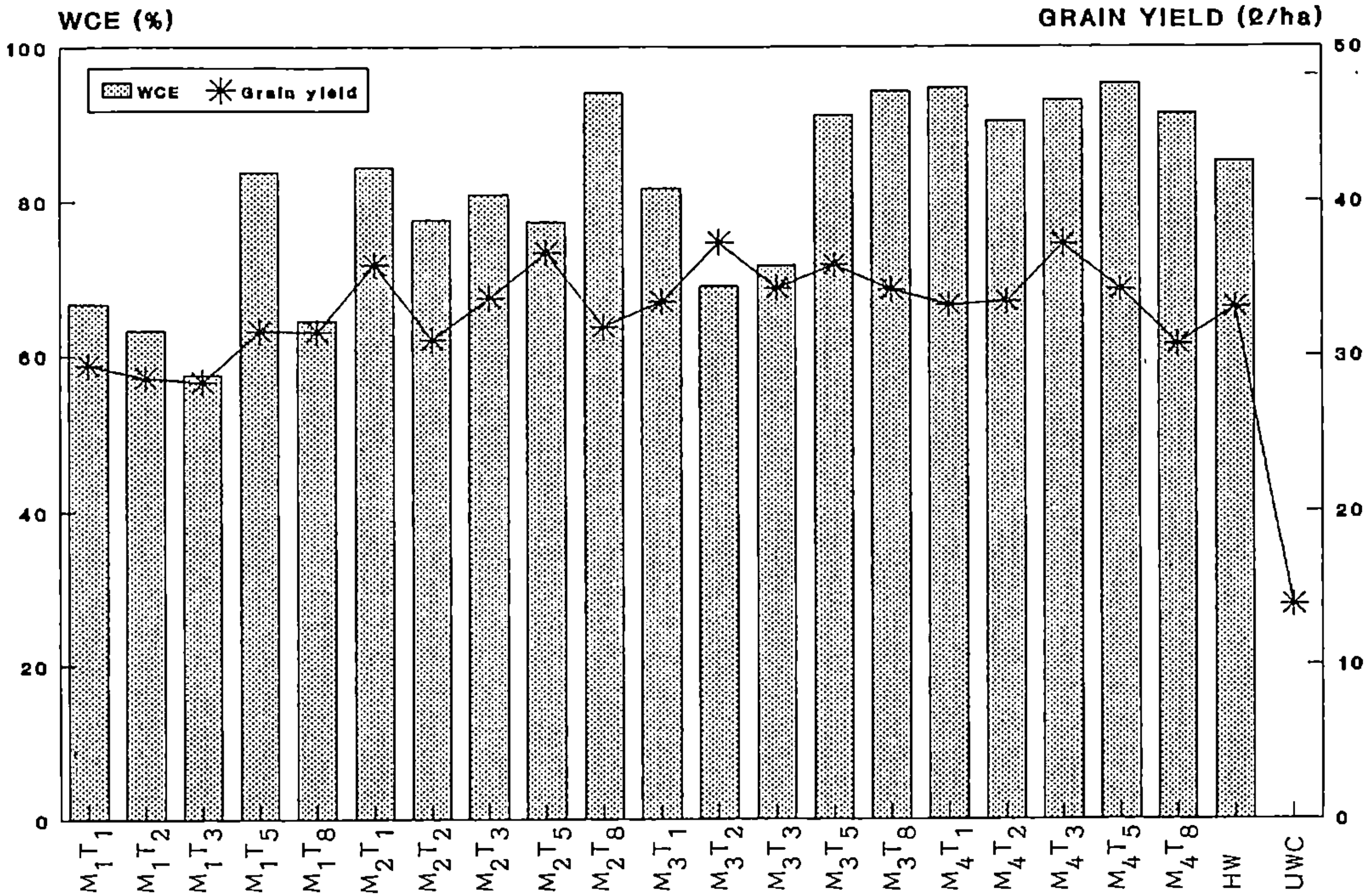

Fig.6 Grain yield and weed control efficiency at 60 DAS (1994)

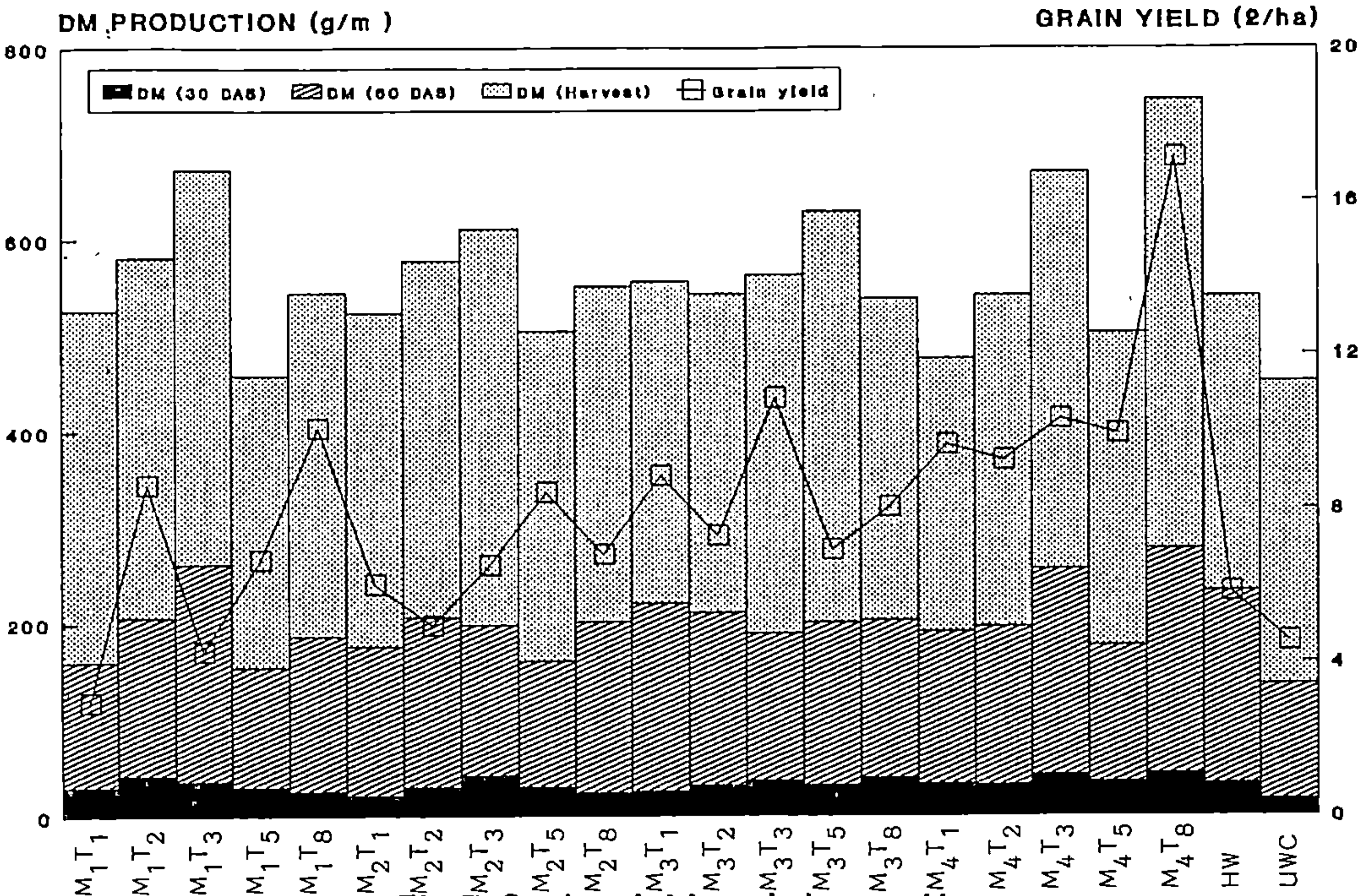

Fig.7 Grain yield and dry matter production of rice (1993)

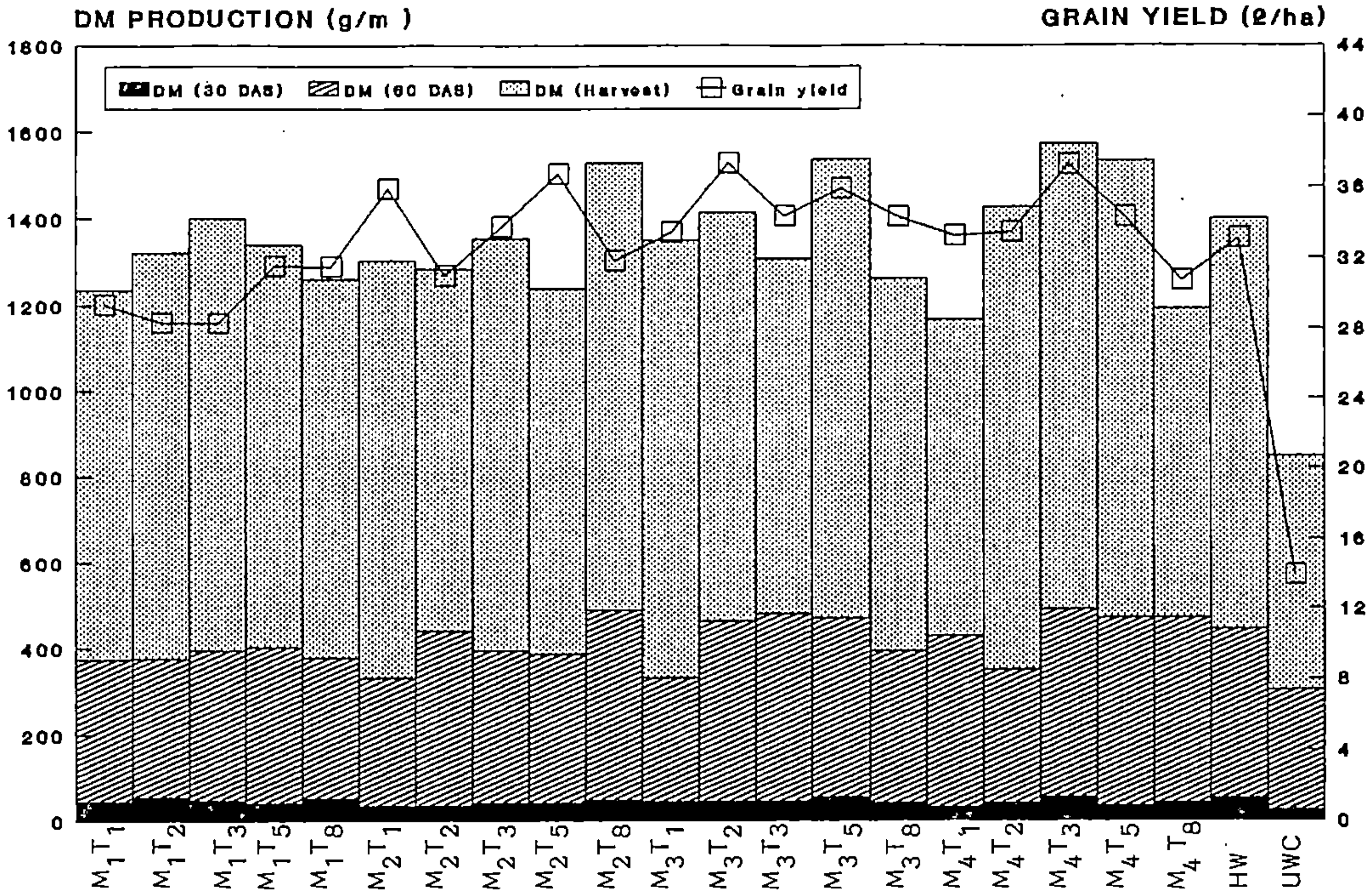

Fig.8 Grain yield and dry matter production of rice (1994)

b) Straw yield

The effect of herbicides on the straw yield was not significant during both the years. However in the first year joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha recorded higher straw yield followed by anilofos @ 0.45 kg a.i./ha and butachlor @ 1.25 kg a.i./ha. In the second year of study lower dose of the joint formulation of anilofos and 2,4-DEE registered highest straw yield followed by its higher dose i.e. 0.45 kg a.i./ha and singular application of anilofos @ 0.45 kg a.i./ha.

During the first year the interaction effect of herbicides with time of application revealed that hand weeding was significantly superior to all other treatments followed by the higher dose of the joint formulation of anilofos and 2,4-DEE at 6 and 9 DAS and its tank mix application. However in the second year lower dose of the joint formulation of anilofos and 2,4-DEE at 3 DAS gave the highest straw yield comparable and closely followed by the same at 9 DAS and its higher dose at 9 DAS. These treatments were significantly superior to hand weeding. Unweeded control recorded the lowest straw yield in both the years.

The straw yield also followed the same trend as in the case of grain yield. The severe competition of weeds in the first year resulted in poor straw yield while the better control of weeds achieved through herbicides followed by ponding of water reflected on the straw yield in the second year.

4.2.5 Weed index (Tables 32 and 33)

During both the years lowest weed index was recorded by anilofos @

Table 32. Effect of herbicides and time of application on weed index (%)

Treatments	1993	1994
M_1 (0 DAS)	67.87	11.82
M_2 (3 DAS)	66.34	4.36
M_3 (6 DAS)	55.49	0.39
M_4 (9 DAS)	33.85	7.08
SEm±	2.384	1.628
CD (0.05)	8.26	5.64
T_1 Anilofos + 2,4-DEE (0.3 + 0.45 kg a.i/ha)	61.08	4.78
T_2 Joint formulation (0.3 kg a.i/ha)	58.84	5.72
T_3 Joint formulation (0.45 kg a.i/ha)	56.57	6.40
T_4 Anilofos 0.3 kg a.i/ha	60.08	11.25
T_5 Anilofos 0.45 kg a.i/ha	54.64	1.28
T_6 2,4-DEE 0.4 kg a.i/ha	68.98	9.17
T_7 2,4-DEE 0.6 kg a.i/ha	70.41	10.96
T_8 Butachlor 1.25 kg a.i/ha	56.53	7.03
HW	-	-
UWC	73.50	58.06
SEm±	3.299	2.146
CD (0.05)	9.35	6.08

Year	Subplot
1993	T_5 T_8 T_3 T_2 T_4 T_1 T_6 T_7
1994	T_5 T_1 T_2 T_3 T_8 T_6 T_7 T_4

Table 33. Interaction effect of herbicides with time of application on weed index (%)

Treatments	1993	1994
$M_1 T_1$	82.93	16.30
$M_1 T_2$	56.90	17.30
$M_1 T_3$	75.93	19.30
$M_1 T_4$	72.03	18.80
$M_1 T_5$	61.90	8.63
$M_1 T_6$	77.27	1.53
$M_1 T_7$	73.83	10.17
$M_1 T_8$	42.23	8.57
$M_2 T_1$	66.43	-2.90
$M_2 T_2$	72.33	10.23
$M_2 T_3$	64.80	3.90
$M_2 T_4$	65.60	6.20
$M_2 T_5$	52.53	-4.60
$M_2 T_6$	71.47	-0.80
$M_2 T_7$	75.53	15.00
$M_2 T_8$	62.07	7.83
$M_3 T_1$	49.67	1.87
$M_3 T_2$	58.70	-7.87
$M_3 T_3$	39.03	2.10
$M_3 T_4$	38.10	-4.67
$M_3 T_5$	60.17	-3.93
$M_3 T_6$	69.00	7.10
$M_3 T_7$	74.57	7.77
$M_3 T_8$	54.73	0.77
$M_4 T_1$	45.27	3.83
$M_4 T_2$	47.43	3.20
$M_4 T_3$	46.53	-6.10
$M_4 T_4$	64.60	13.43
$M_4 T_5$	43.97	0.77
$M_4 T_6$	58.20	19.67
$M_4 T_7$	57.70	10.93
$M_4 T_8$	67.10	10.97
SEm±	6.599	2.15
CD (0.05)	18.7	6.08

0.45 kg a.i./ha and was comparable with the higher and lower dose of the joint formulation of anilofos and 2,4-DEE, its tank mix application and butachlor @ 1.25 kg a.i./ha.

In the first year of study, interaction effect of herbicides with time of application revealed that though anilofos @ 0.45 kg a.i./ha at 6 DAS recorded the lowest weed index value it was comparable with higher and lower dose of the joint formulation of anilofos and 2,4-DEE at 9 DAS, its tank mix application at 9 DAS and butachlor @ 1.25 kg a.i./ha at 0 DAS. However in the second year joint formulation of anilofos and 2,4-DEE @ 0.3 kg a.i./ha at 6 DAS registered lowest weed index comparable and closely followed by its higher dose at 9 DAS and anilofos @ 0.3 kg a.i./ha at 6 DAS.

On perusal of the weed index values, the negative values observed in the second year highlights, the efficiency of herbicides in controlling weeds followed by the submergence in keeping up the weed free condition till harvest resulting in higher yields.

4.3 Studies on nutrient uptake

4.3.1 Removal by weeds (Table 34, 35a and 35b)

a) Nitrogen

During the first year, significant difference between herbicides in nitrogen removal by weeds was noticed only in the initial stages. At 30 DAS joint formulation of anilofos and 2,4-DEE @ 0.45 a.i./ha recorded the lowest value followed by its tank mix application which in turn was comparable with butachlor @ 1.25 kg a.i./ha and joint formulation of anilofos and 2,4-DEE @ 0.3 kg a.i./ha. At 60 DAS

Table 34. Effect of herbicides and time of application on the removal of nitrogen by weeds (kg/ha

Treatments	30 DAS 1993	60 DAS 1993	60 DAS 1994*	Harvest 1994
M_1 (0 DAS)	7.65	8.22	1.41 (1.49)	4.71
M_2 (3 DAS)	7.37	9.39	1.09 (0.60)	3.66
M_3 (6 DAS)	6.45	8.14	1.14 (0.80)	3.67
M_4 (9 DAS)	6.59	8.33	1.01 (0.52)	3.56
SEm±	0.793	0.059	0.036	0.252
CD (0.05)	NS	NS	0.13	0.87
T_1 Anilofos + 2,4-DEE (0.3 + 0.45 kg a.i/ha)	5.69	6.92	1.13 (0.78)	3.81
T_2 Joint formulation (0.3 kg a.i/ha)	6.71	8.54	1.19 (0.92)	3.96
T_3 Joint formulation (0.45 kg a.i/ha)	3.30	7.35	1.81 (0.89)	3.89
T_4 Anilofos 0.3 kg a.i/ha)	10.20	8.53	1.13 (0.78)	3.69
T_5 Anilofos 0.45 kg a.i/ha)	10.20	7.77	1.05 (0.60)	3.36
T_6 2,4-DEE 0.4 kg a.i/ha	7.50	8.42	1.41 (1.49)	4.31
T_7 2,4-DEE 0.6 kg a.i/ha	5.75	9.34	1.26 (1.09)	4.81
T_8 Butachlor 1.25 kg a.i/ha	6.36	9.31	0.96 (0.42)	3.37
HW	1.37	4.57	1.21 (0.96)	1.45
UWC	11.75	17.43	2.99 (8.44)	4.42
SEm±	0.889	0.807	0.075	0.327
CD (0.05)	2.52	NS	0.21	0.93

Stages of observation	Subplot 1993	Subplot 1994
30 DAS	T_3 T_1 T_7 T_8 T_2 T_6 T_5 T_4	
60 DAS	NS	T_8 T_5 T_4 T_1 T_3 T_2 T_7 T_6
Harvest	---	T_5 T_8 T_4 T_1 T_3 T_2 T_6 T_7

* Transformed data : $\sqrt{x + 05}$ transformation

( ) Original value

Table 35a. Interaction effect of herbicides with time of application on the removal of nitrogen by weeds (1993) (kg/ha)

Treatments	30 DAS	60 DAS
$M_1 T_1$	6.80	8.50
$M_1 T_2$	4.60	9.33
$M_1 T_3$	3.43	6.60
$M_1 T_4$	19.10	6.77
$M_1 T_5$	5.37	12.23
$M_1 T_6$	6.77	8.50
$M_1 T_7$	6.63	7.47
$M_1 T_8$	8.47	7.07
$M_2 T_1$	5.27	7.37
$M_2 T_2$	6.63	13.00
$M_2 T_3$	4.07	7.23
$M_2 T_4$	9.50	8.17
$M_2 T_5$	17.93	8.23
$M_2 T_6$	6.07	8.10
$M_2 T_7$	6.03	10.80
$M_2 T_8$	3.43	6.67
$M_3 T_1$	4.93	6.90
$M_3 T_2$	7.70	6.57
$M_3 T_3$	2.40	9.67
$M_3 T_4$	6.07	12.33
$M_3 T_5$	8.67	9.50
$M_3 T_6$	8.23	7.30
$M_3 T_7$	4.57	6.67
$M_3 T_8$	9.07	12.27
$M_4 T_1$	5.80	5.40
$M_4 T_2$	7.90	5.27
$M_4 T_3$	3.30	5.90
$M_4 T_4$	7.70	6.87
$M_4 T_5$	8.83	9.10
$M_4 T_6$	8.97	9.77
$M_4 T_7$	5.77	12.43
$M_4 T_8$	4.97	11.23
SEm±	1.779	1.614
CD (0.05)	5.04	4.57

Table 35b. Interaction effect of herbicides with time of application on the nitrogen removal by weeds (1994) (kg/ha)

Treatments	30 DAS*	Harvest
$M_1 T_1$	1.41 (1.49)	4.29
$M_1 T_2$	1.41 (1.49)	5.01
$M_1 T_3$	1.76 (2.60)	5.67
$M_1 T_4$	1.37 (1.38)	3.67
$M_1 T_5$	1.08 (0.67)	4.83
$M_1 T_6$	1.69 (2.36)	5.06
$M_1 T_7$	1.29 (1.16)	6.27
$M_1 T_8$	1.29 (1.16)	2.88
$M_2 T_1$	1.09 (0.69)	3.40
$M_2 T_2$	1.22 (0.99)	3.37
$M_2 T_3$	1.15 (0.82)	4.43
$M_2 T_4$	1.06 (0.62)	3.46
$M_2 T_5$	1.15 (0.82)	3.99
$M_2 T_6$	1.02 (0.54)	2.81
$M_2 T_7$	1.10 (0.71)	6.24
$M_2 T_8$	0.90 (0.31)	1.56
$M_3 T_1$	1.14 (0.80)	4.31
$M_3 T_2$	1.28 (1.14)	3.60
$M_3 T_3$	0.96 (0.42)	2.85
$M_3 T_4$	1.08 (0.67)	4.58
$M_3 T_5$	1.14 (0.80)	2.37
$M_3 T_6$	1.24 (1.04)	5.11
$M_3 T_7$	1.52 (1.81)	3.52
$M_3 T_8$	0.78 (0.11)	3.03
$M_4 T_1$	0.87 (0.26)	3.23
$M_4 T_2$	0.90 (0.31)	3.85
$M_4 T_3$	0.85 (0.22)	2.62
$M_4 T_4$	1.00 (0.50)	3.04
$M_4 T_5$	0.81 (0.16)	2.26
$M_4 T_6$	1.69 (2.36)	4.24
$M_4 T_7$	1.14 (0.80)	3.22
$M_4 T_8$	0.84 (0.21)	6.03
SEm±	0.149	0.635
CD (0.05)	0.42	1.79

* Transformed data : $\sqrt{x + 0.5}$ transformation
( ) original value

though no significant difference was noticed between herbicides comparatively lower values for nitrogen removal were observed in tank mix application of anilofos and 2,4-DEE and joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha.

In the second year almost all the treatments recorded nil value for dry matter accumulation of weeds in the initial stage. Hence no values were recorded for nitrogen removal at 30 DAS. At 60 DAS butachlor @ 1.25 kg a.i./ha recorded the lowest nitrogen removal and was comparable with anilofos @ 0.45 and 0.3 kg a.i./ha and tank mix application of anilofos and 2,4-DEE (0.3 + 0.45 kg a.i./ha). However the tank mix application of anilofos and 2,4-DEE was similar to its joint formulation at 0.45 and 0.3 kg a.i./ha. The same trend was noticed at harvest also, wherein butachlor @ 1.25 kg a.i./ha was comparable with anilofos at 0.45 and 0.3 kg a.i./ha, tank mix application of anilofos and 2,4-DEE and both the doses of joint formulation of anilofos and 2,4-DEE.

The interaction effect of herbicides with time of application during the first year at 30 DAS revealed that joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 6, 9 and 0 DAS and butachlor@ 1.25 kg a.i./ha at 3 DAS were equally effective in reducing nitrogen removal by weed. At 60 DAS joint formulation of anilofos and 2,4-DEE @ 0.3 kg a.i./ha at 9 DAS, its tank mix application at 9 DAS, higher dose of the joint formulation of anilofos and 2,4-DEE at 9 DAS and butachlor @ 1.25 kg a.i./ha at 3 DAS were comparable. Hand weeding was comparable with the above treatments. Similar trend was noticed in the second year also both at 60 DAS and at harvest.

The lower values of nitrogen removal by the above treatments follow the same trend as in the dry matter accumulation of weeds.

b) Phosphorus (Tables 36 and 37)

In the first year of study significant difference between herbicides was noticed only at 30 DAS. Lowest phosphorus removal was recorded with joint formulation @ 0.45 kg a.i./ha and was similar to its tank mix application and butachlor @ 1.25 kg a.i./ha. However in the second year both at 60 DAS and at harvest anilofos @ 0.45 and 0.3 kg a.i./ha, joint formulation of anilofos and 2,4-DEE @ 0.3 and 0.45 kg a.i./ha, tank mix application of anilofos and 2,4-DEE and butachlor @ 1.25 kg a.i/ha were comparable.

During the first year the interaction effect of herbicides with time of application was significant only at the initial stage. At 30 DAS hand weeding recorded the lowest phosphorus removal by weeds and was comparable with the joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 and 6 DAS and butachlor @ 1.25 kg a.i./ha at 3 and 9 DAS. Results of the second year revealed that both doses of the joint formulation of anilofos and 2,4-DEE i.e. 0.3 and 0.45 kg a.i./ha at later stages of application, anilofos @ 0.45 kg a.i./ha at 9 DAS, butachlor @ 1.25 kg a.i./ha at 3 DAS were equally effective in reducing phosphorus removal by weeds.

This retains the same trend of dry matter accumulation of weeds in the above treatments.

c) Potassium (Tables 38 and 39)

During the first year at 30 DAS joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha recorded the lowest potassium removal by weeds and was

Table 36. Effect of herbicides and time of application on the removal of phosphorus by weeds (kg/ha)

Treatments	30 DAS	60 DAS		Harvest
	1993	1993	1994*	1994
M_1 (0 DAS)	2.39	2.64	0.82 (0.17)	0.49
M_2 (3 DAS)	1.85	2.77	0.75 (0.06)	0.39
M_3 (6 DAS)	1.56	2.61	0.76 (0.08)	0.32
M_4 (9 DAS)	1.78	2.73	0.75 (0.06)	0.34
SEm±	0.104	0.274	0.005	0.027
CD (0.05)	0.36	NS	0.02	0.09
T_1 Anilofos + 2,4-DEE (0.3 + 0.45 kg a.i/ha)	1.37	2.06	0.75 (0.06)	0.37
T_2 Joint formulation (0.3 kg a.i/ha)	1.78	2.51	0.77 (0.09)	0.34
T_3 Joint formulation (0.45 kg a.i/ha)	1.14	2.53	0.78 (0.11)	0.40
T_4 Anilofos 0.3 kg a.i/ha	2.94	2.34	0.76 (0.08)	0.31
T_5 Anilofos 0.45 kg a.i/ha	2.61	2.94	0.74 (0.05)	0.29
T_6 2,4-DEE 0.4 kg a.i/ha	1.98	2.82	0.82 (0.17)	0.42
T_7 2,4-DEE 0.6 kg a.i/ha	1.75	3.26	0.78 (0.11)	0.62
T_8 Butachlor 1.25 kg a.i/ha)	1.59	3.04	0.75 (0.06)	0.32
HW	0.45	2.50	0.76 (0.08)	0.59
UWC	3.89	3.98	1.29 (1.16)	1.24
SEm±	0.192	0.363	0.014	0.039
CD (0.05)	0.54	NS	0.04	0.11

Stages of observation	Subplot 1993	Subplot 1994
30 DAS	T_3 T_1 T_8 T_7 T_2 T_6 T_5 T_4	---
60 DAS	NS	T_5 T_8 T_1 T_4 T_2 T_3 T_7 T_6
Harvest	---	T_5 T_4 T_8 T_2 T_1 T_3 T_6 T_7

* Transformed data : $\sqrt{x+0.5}$ transformation
( ) Original value

Table 37. Interaction effect of herbicides with time of application on the removal of phosphorus by weeds (kg/ha)

Treatments	30 DAS (1993)	60 DAS* (1994)	Harvest (1994)
$M_1 T_1$	1.33	0.77 (0.09)	0.45
$M_1 T_2$	1.63	0.81 (0.16)	0.40
$M_1 T_3$	1.73	0.92 (0.35)	0.54
$M_1 T_4$	4.70	0.79 (0.12)	0.42
$M_1 T_5$	2.17	0.75 (0.06)	0.36
$M_1 T_6$	2.23	0.89 (0.29)	0.54
$M_1 T_7$	2.67	0.79 (0.12)	0.86
$M_1 T_8$	2.70	0.80 (0.14)	0.31
$M_2 T_1$	1.13	0.74 (0.05)	0.29
$M_2 T_2$	1.90	0.75 (0.06)	0.32
$M_2 T_3$	1.23	0.75 (0.06)	0.50
$M_2 T_4$	3.00	0.74 (0.05)	0.29
$M_2 T_5$	3.20	0.77 (0.09)	0.36
$M_2 T_6$	1.57	0.74 (0.05)	0.27
$M_2 T_7$	1.57	0.76 (0.08)	0.91
$M_2 T_8$	1.17	0.72 (0.02)	0.20
$M_3 T_1$	1.23	0.75 (0.06)	0.35
$M_3 T_2$	1.67	0.78 (0.11)	0.29
$M_3 T_3$	0.93	0.73 (0.03)	0.29
$M_3 T_4$	1.83	0.76 (0.08)	0.30
$M_3 T_5$	1.93	0.72 (0.02)	0.24
$M_3 T_6$	2.20	0.78 (0.11)	0.45
$M_3 T_7$	1.33	0.82 (0.17)	0.39
$M_3 T_8$	1.37	0.71 (0.004)	0.24
$M_4 T_1$	1.77	0.73 (0.03)	0.37
$M_4 T_2$	1.90	0.72 (0.02)	0.33
$M_4 T_3$	0.67	0.72 (0.02)	0.27
$M_4 T_4$	2.23	0.74 (0.05)	0.22
$M_4 T_5$	3.13	0.71 (0.004)	0.19
$M_4 T_6$	1.93	0.85 (0.22)	0.44
$M_4 T_7$	1.43	0.75 (0.06)	0.34
$M_4 T_8$	1.13	0.75 (0.06)	0.52
SEm±	0.384	0.038	0.079
CD (0.05)	1.09	0.10	0.22

* Transformed value : $\sqrt{x + 0.5}$ transformation
( ) original value

comparable with its tank mix application and butachlor @ 1.25 kg a.i./ha. At 60 DAS joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha was similar to anilofos @ 0.3 and 0.45 kg a.i./ha, tank mix application of anilofos and 2,4-DEE and joint formulation of anilofos and 2,4-DEE @ 0.3 kg a.i./ha. In the second year at 60 DAS butachlor @ 1.25 kg a.i./ha registered the lowest potassium removal by weeds and was similar to anilofos @ 0.45 and 0.3 kg a.i./ha and tank mix application of anilofos and 2,4-DEE which in turn was comparable with joint formulation of anilofos and 2,4-DEE at 0.3 and 0.45 kg a.i./ha. However at harvest anilofos @ 0.45 kg a.i./ha, butachlor @ 1.25 kg a.i./ha and joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha were equally effective in reducing potassium removal by weeds.

The interaction effect of herbicides with time of aplication during the first year reveals that at 30 DAS though hand weeding recorded lowest potassium remnoval by weeds it was comparable with higher dose (0.45 kg a.i./ha) of the joint formulation of anilofos and 2,4-DEE at 9 DAS and its lower dose at 0 DAS. At 60 DAS joint formulation of anilofos and 2,4-DEE @ 0.3 kg a.i./ha at 9 DAS recorded the lowest potassium removal by weeds and was comparable with its higher dose at 0 and 6 DAS, and hand weeding. Similar trend was noticed in the second year of study at 60 DAS and at harvest.

With respect to potassium removal by weeds also the trend in dry matter accumulation was retained. The results conformed the findings of Vidhya (1991) and Radhamani (1994) wherein lowest nitrogen, phosphorus and potassium removal by weeds were observed with the combined application of anilofos and 2,4-DEE.

Table 38. Effect of herbicides and time of application on the removal of potassium by weeds (kg/ha)

Treatments	30 DAS 1993	60 DAS 1993	60 DAS 1994*	Harvest 1994
M_1 (0 DAS)	17.64	23.53	1.51 (1.78)	7.87
M_2 (3 DAS)	18.17	24.62	1.00 (0.50)	6.52
M_3 (6 DAS)	15.52	22.20	1.09 (0.69)	5.91
M_4 (9 DAS)	16.90	21.99	0.97 (0.44)	5.58
SEm±	1.525	1.599	0.47	0.322
CD (0.05)	NS	NS	0.16	1.12
T_1 Anilofos + 2,4-DEE (0.3 + 0.45 kg a.i/ha)	14.27	21.20	1.10 (0.71)	6.31
T_2 Joint formulation (0.3 kg a.i/ha)	17.75	22.37	1.19 (0.92)	6.72
T_3 Joint formulation (0.45 kg a.i/ha)	9.89	19.50	1.25 (1.06)	6.25
T_4 Anilofos 0.3 kg a.i/ha	23.03	20.61	1.09 (0.69)	6.91
T_5 Anilofos 0.45 kg a.i/ha	25.31	23.40	0.93 (0.36)	4.84
T_6 2,4-DEE 0.4 kg a.i/ha	16.46	27.38	1.45 (1.60)	8.20
T_7 2,4-DEE 0.6 kg a.i/ha	14.95	25.59	1.24 (1.04)	7.51
T_8 Butachlor 1.25 kg a.i/ha	14.82	24.63	0.91 (0.33)	4.97
HW	1.04	11.90	1.43 (1.54)	2.36
UWC	31.60	41.50	3.20 (97.4)	5.22
SEm±	2.236	1.547	0.096	0.515
CD (0.05)	6.33	4.38	0.27	1.46

Stages of observation	Subplot 1993	Subplot 1994
30 DAS	$T_3\ T_1\ T_8\ T_7\ T_6\ T_2\ T_4\ T_5$	---
60 DAS	$T_3\ T_4\ T_1\ T_2\ T_5\ T_8\ T_7\ T_6$	$T_8\ T_5\ T_4\ T_1\ T_2\ T_7\ T_3\ T_6$
Harvest	---	$T_5\ T_8\ T_3\ T_1\ T_2\ T_4\ T_7\ T_6$

* Transformed data : $\sqrt{x+0.5}$ transformation
( ) Original value

Table 39. Interaction effect of herbicides with time of application on the removal of potassium by weeds (kg/ha)

Treatments	30 DAS (1993)	60 DAS (1993)	60 DAS* (1994)	Harvest (1994)
$M_1 T_1$	13.73	27.93	1.39 (1.43)	7.79
$M_1 T_2$	8.03	22.13	1.57 (1.96)	8.48
$M_1 T_3$	13.08	16.90	2.16 (4.16)	7.89
$M_1 T_4$	29.27	18.50	1.34 (1.29)	8.53
$M_1 T_5$	18.08	29.03	1.04 (0.58)	6.35
$M_1 T_6$	15.03	28.17	1.91 (3.15)	9.52
$M_1 T_7$	20.00	25.90	1.24 (1.04)	9.66
$M_1 T_8$	23.90	19.70	1.47 (1.66)	4.72
$M_2 T_1$	15.30	22.67	1.04 (0.58)	6.11
$M_2 T_2$	13.43	32.23	1.17 (0.87)	6.03
$M_2 T_3$	10.77	24.47	0.99 (0.48)	8.51
$M_2 T_4$	28.77	19.27	0.93 (0.36)	5.78
$M_2 T_5$	29.57	19.70	1.11 (0.73)	5.31
$M_2 T_6$	15.60	22.83	0.93 (0.36)	7.26
$M_2 T_7$	19.57	26.17	1.07 (0.64)	9.94
$M_2 T_8$	12.36	29.60	0.76 (0.08)	3.20
$M_3 T_1$	15.63	19.93	1.07 (0.64)	6.39
$M_3 T_2$	17.07	23.23	1.19 (0.92)	6.48
$M_3 T_3$	10.57	17.37	0.95 (0.40)	4.47
$M_3 T_4$	15.80	26.63	1.14 (0.80)	8.24
$M_3 T_5$	23.27	24.40	0.85 (0.22)	3.71
$M_3 T_6$	20.43	27.33	1.35 (1.32)	8.96
$M_3 T_7$	9.27	18.73	1.50 (1.75)	5.58
$M_4 T_1$	12.40	14.27	0.91 (0.33)	4.95
$M_4 T_2$	32.47	11.87	0.87 (0.26)	6.09
$M_4 T_3$	5.13	19.27	0.89 (0.29)	4.12
$M_4 T_4$	18.27	18.03	0.94 (0.38)	5.09
$M_4 T_5$	30.33	20.47	0.71 (0.004)	3.98
$M_4 T_6$	14.77	31.20	1.60 (2.06)	7.08
$M_4 T_7$	10.97	31.57	1.16 (0.83)	4.87
$M_4 T_8$	10.87	29.27	0.71 (0.004)	8.49
SEm±	4.472	3.094	0.192	1.031
CD (0.05)	12.67	8.76	0.54	2.92

* Transformed data : $\sqrt{x + 0.5}$ transformation
( ) original value

4.3.2 Nutrient uptake by crop

a) Nitrogen (Tables 40 and 41)

At all stages of observation during both the years joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha registered the highest nitrogen uptake by crop. It was comparable with its lower dose and butachlor @ 1.25 kg a.i./ha in almost all the stages.

During the first year of study the interaction effect of herbicide with time of application was noticed only at the initial stage of observation. Hand weeded plots gave the highest value and was comparable with the joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 and 6 DAS and tank mix application of anilofos and 2,4-DEE at 9 DAS. In the second year at 60 DAS anilofos @ 0.45 kg a.i./ha at 9 DAS recorded the highest nitrogen uptake value and was comparable with joint formulation of anilofos and 2,4-DEE @ 0.3 kg a.i./ha at 6 DAS, hand weeding, higher dose of the joint formulation of anilofos and 2,4-DEE at 6 and 9 DAS and tank mix application of anilofos and 2,4-DEE at 9 DAS. At harvest, joint formulation of anilofos and 2,4-DEE @ 0.3 kg a.i./ha at 9 DAS gave the highest nitrogen uptake value followed by its higher dose at 9 DAS, hand weeding and butachlor @ 1.25 kg a.i./ha at 3 DAS.

The same treatments recorded the lowest nitrogen removal by weeds indicating the better utilization of the nutrient by the crop as evidenced by higher values of dry matter production.

Table 40. Effect of herbicides and time of application on the uptake of nitrogen by rice (kg/ha)

Treatments	30 DAS		60 DAS		Harvest	
	1993	1994	1993	1994	1993	1994
M_1 (0 DAS)	6.95	12.35	27.54	57.75	30.31	71.59
M_2 (3 DAS)	5.68	11.54	27.33	64.63	35.21	79.73
M_3 (6 DAS)	6.30	12.67	32.22	64.58	31.15	88.09
M_4 (9 DAS)	7.19	12.69	30.37	72.09	33.11	92.45
SEm±	0.521	0.578	1.674	1.405	1.860	3.280
CD (0.05)	NS	NS	NS	4.87	NS	11.36
T_1 Anilofos + 2,4-DEE (0.3 + 0.45 kg a.i/ha)	6.52	11.87	34.52	63.93	32.78	84.27
T_2 Joint formulation (0.3 kg a.i/ha)	7.13	13.98	32.53	68.43	33.31	92.17
T_3 Joint formulation (0.45 kg a.i/ha)	8.69	15.66	35.48	76.70	42.69	89.28
T_4 Anilofos 0.3 kg a.i/ha	6.92	11.42	26.16	64.23	29.20	78.05
T_5 Anilofos 0.45 kg a.i/ha	6.23	10.68	26.11	68.76	28.02	83.06
T_6 2,4-DEE 0.4 kg a.i/ha	6.43	11.26	23.48	52.65	30.69	77.42
T_7 2,4-DEE 0.6 kg a.i/ha	4.21	11.56	26.17	54.86	30.68	76.19
T_8 Butachlor 1.25 kg a.i/ha	6.11	12.07	30.48	68.54	32.19	83.28
HW	11.00	16.07	53.10	82.30	59.40	98.60
UWC	3.03	5.82	9.00	42.60	22.00	24.60
SEm±	0.543	0.844	2.333	2.714	3.047	3.749
CD (0.05)	1.54	2.39	6.61	6.16	8.63	10.62

Stages of observation	Subplot 1993	Subplot 1994
30 DAS	$T_3\ T_2\ T_4\ T_1\ T_6\ T_5\ T_8\ T_7$	$T_3\ T_2\ T_8\ T_1\ T_7\ T_4\ T_6\ T_5$
60 DAS	$T_3\ T_2\ T_1\ T_8\ T_4\ T_5\ T_7\ T_6$	$T_3\ T_5\ T_8\ T_2\ T_4\ T_1\ T_7\ T_6$
Harvest	$T_3\ T_2\ T_1\ T_8\ T_6\ T_7\ T_4\ T_5$	$T_2\ T_3\ T_1\ T_8\ T_5\ T_4\ T_6\ T_7$

Table 41. Interaction effect of herbicides with time of application on the uptake of nitrogen by rice (kg/ha)

Treatments	30 DAS (1993)	60 DAS (1994)	Harvest (1994)
$M_1 T_1$	7.00	63.17	70.77
$M_1 T_2$	8.17	56.47	63.26
$M_1 T_3$	7.27	68.27	81.48
$M_1 T_4$	8.60	54.70	68.22
$M_1 T_5$	5.60	62.07	69.10
$M_1 T_6$	9.03	53.87	71.50
$M_1 T_7$	4.33	44.50	64.45
$M_1 T_8$	5.63	58.93	83.93
$M_2 T_1$	4.70	54.70	82.73
$M_2 T_2$	6.03	71.97	86.62
$M_2 T_3$	7.87	76.17	89.82
$M_2 T_4$	8.97	64.40	67.27
$M_2 T_5$	5.43	57.93	88.24
$M_2 T_6$	4.07	55.63	74.47
$M_2 T_7$	3.00	56.17	55.62
$M_2 T_8$	5.33	80.07	93.06
$M_3 T_1$	5.17	56.87	92.08
$M_3 T_2$	6.13	82.30	96.18
$M_3 T_3$	9.20	81.23	84.91
$M_3 T_4$	2.90	60.43	88.94
$M_3 T_5$	7.03	71.87	80.11
$M_3 T_6$	7.23	56.43	90.52
$M_3 T_7$	5.87	50.53	93.06
$M_3 T_8$	6.87	57.00	78.89
$M_4 T_1$	9.20	80.97	91.49
$M_4 T_2$	8.20	62.97	122.62
$M_4 T_3$	10.43	81.13	100.91
$M_4 T_4$	7.20	77.40	87.77
$M_4 T_5$	6.83	83.17	94.78
$M_4 T_6$	5.40	44.67	73.18
$M_4 T_7$	3.63	68.23	91.65
$M_4 T_8$	6.60	78.17	77.23
SEm±	1.085	4.437	7.498
CD (0.05)	3.07	12.31	21.23

b) Phosphorus (Tables 42 and 43)

During both the years of study significant difference between herbicides was noticed among herbicides only at 30 and 60 DAS with respect to phosphorus uptake. Joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha registered the highest phosphorus uptake value at all stages except at 60 DAS of the second year. At 60 DAS it was comparable with butachlor @ 1.25 kg a.i./ha which recorded the highest value.

In the first year the interaction effect of herbicides with time of application was significant only at 30 and 60 DAS. At 30 DAS joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 3 DAS gave the highest phosphorus uptake value followed by anilofos @ 0.3 kg a.i./ha at 0 DAS, joint formulation of anilofos and 2,4-DEE at 0.45 kg a.i./ha at 9 DAS and hand weeding. However at 60 DAS hand weeding recorded the highest value followed by higher dose of the joint formulation of anilofos and 2,4-DEE at 0 DAS and its lower dose at 6 DAS. In the second year joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 DAS registered the highest phosphorus uptake value. At 30 DAS the above treatment performed better than hand weeding which was comparable at 60 DAS.

The trend observed in nitrogen uptake by rice was retained in the case of phosphorus uptake also. The same treatments gave lower phosphorus removal by weeds facilitating higher phosphorus uptake and dry matter production by rice.

c) Potassium (Tables 44 and 45)

Regarding potassium uptake by rice significant difference between herbicides was noticed only at the initial stages of observation during both the years.

Table 42. Effect of herbicides and time of application on the uptake of phosphorus by rice (kg/ha)

Treatments	30 DAS 1993	30 DAS 1994	60 DAS 1993	60 DAS 1994	Harvest 1993	Harvest 1994
M_1 (0 DAS)	2.30	1.04	8.22	7.54	10.71	9.57
M_2 (3 DAS)	2.03	0.89	10.13	8.83	12.04	9.76
M_3 (6 DAS)	2.26	0.89	10.43	9.58	14.44	10.72
M_4 (9 DAS)	2.26	0.95	9.68	11.15	13.39	10.71
SEm±	0.116	0.032	0.459	0.226	0.773	0.230
CD (0.05)	NS	NS	NS	0.78	NS	0.79
T_1 Anilofos + 2,4-DEE (0.3 + 0.45 kg a.i/ha)	2.19	0.91	10.26	8.35	11.31	9.62
T_2 Joint formulation (0.3 kg a.i/ha)	2.62	0.92	11.12	9.18	11.83	10.49
T_3 Joint formulation (0.45 kg a.i/ha)	2.89	1.09	12.63	10.47	15.79	10.14
T_4 Anilofos 0.3 kg a.i/ha	2.65	0.92	8.96	9.27	11.63	9.45
T_5 Anilofos 0.45 kg a.i/ha	2.14	0.89	7.58	10.13	12.49	10.59
T_6 2,4-DEE 0.4 kg a.i/ha	2.06	0.88	8.43	7.61	13.99	10.45
T_7 2,4-DEE 0.6 kg a.i/ha	1.28	0.99	8.15	8.31	13.53	10.92
T_8 Butachlor 1.25 kg a.i/ha	1.89	0.94	9.79	10.90	10.60	9.84
HW	3.00	1.08	18.00	12.90	20.03	10.67
UWC	0.70	0.55	7.10	6.30	6.73	4.30
SEm±	0.193	0.034	0.669	0.383	1.264	0.458
CD (0.05)	0.55	0.09	1.89	1.09	NS	NS

Stages of observation	Subplot 1993	Subplot 1994
30 DAS	T_3 T_4 T_2 T_1 T_5 T_6 T_8 T_7	T_3 T_7 T_8 T_2 T_4 T_1 T_5 T_6
60 DAS	T_3 T_2 T_1 T_8 T_4 T_6 T_7 T_5	T_8 T_3 T_5 T_4 T_2 T_1 T_7 T_6
Harvest	NS	NS

Table 43. Interaction effect of herbicides with time of application of the uptake of phosphorus by rice (kg/ha)

Treatments	(1993) 30 DAS	(1993) 60 DAS	(1994) 30 DAS	(1994) 60 DAS
$M_1 T_1$	2.37	9.50	1.10	6.27
$M_1 T_2$	3.23	9.99	1.28	7.83
$M_1 T_3$	2.13	14.93	1.19	7.90
$M_1 T_4$	3.40	3.90	0.83	6.23
$M_1 T_5$	1.37	5.03	0.91	9.03
$M_1 T_6$	2.67	7.06	0.89	7.60
$M_1 T_7$	1.37	6.13	0.98	7.83
$M_1 T_8$	1.89	9.20	1.17	7.63
$M_2 T_1$	1.70	9.97	0.84	6.73
$M_2 T_2$	2.17	13.92	0.71	10.53
$M_2 T_3$	3.67	13.87	0.95	8.73
$M_2 T_4$	2.63	9.53	0.91	8.97
$M_2 T_5$	1.97	7.90	0.88	8.27
$M_2 T_6$	1.67	7.23	1.02	7.47
$M_2 T_7$	1.17	8.10	1.03	8.50
$M_2 T_8$	1.30	10.53	0.84	11.47
$M_3 T_1$	2.27	11.99	0.96	9.27
$M_3 T_2$	2.77	10.83	0.85	9.80
$M_3 T_3$	2.50	10.27	0.93	11.60
$M_3 T_4$	1.54	12.13	0.97	9.27
$M_3 T_5$	2.53	9.60	1.08	10.17
$M_3 T_6$	2.18	9.43	0.66	8.77
$M_3 T_7$	1.50	10.80	0.88	6.90
$M_3 T_8$	2.80	8.40	0.84	10.90
$M_4 T_1$	2.43	9.57	0.74	11.13
$M_4 T_2$	2.30	9.73	0.85	8.53
$M_4 T_3$	3.27	11.43	1.29	13.63
$M_4 T_4$	3.02	10.29	1.00	12.60
$M_4 T_5$	2.67	7.80	0.69	13.07
$M_4 T_6$	1.73	10.00	0.97	6.60
$M_4 T_7$	1.07	7.57	1.11	10.00
$M_4 T_8$	1.60	11.03	0.91	13.60
SEm±	0.384	0.725	0.069	0.767
CD (0.05)	1.09	2.05	0.20	1.75

Table 44. Effect of herbicides and time of application on the uptake of potassium by rice (kg/ha)

Treatments	30 DAS		60 DAS		Harvest	
	1993	1994	1993	1994	1993	1994
M_1 (0 DAS)	7.38	14.55	55.48	71.06	78.45	113.11
M_2 (3 DAS)	6.13	12.64	52.20	80.15	79.29	129.42
M_3 (6 DAS)	6.83	13.90	56.73	78.49	82.74	141.88
M_4 (9 DAS)	6.66	13.41	66.90	86.70	82.63	137.03
SEm±	0.355	0.340	4.074	1.139	4.106	3.879
CD (0.05)	NS	1.18	NS	3.94	NS	13.44
T_1 Anilofos + 2,4-DEE (0.3 + 0.45 kg a.i/ha)	6.04	12.31	56.76	72.78	75.70	127.60
T_2 Joint formulation (0.3 kg a.i/ha)	7.43	13.51	59.78	81.58	79.49	136.95
T_3 Joint formulation (0.45 kg a.i/ha)	8.72	15.19	68.74	89.63	92.08	136.01
T_4 Anilofos 0.3 kg a.i/ha	7.59	13.68	57.64	77.67	84.50	122.93
T_5 Anilofos 0.45 kg a.i/ha	6.58	13.18	50.65	89.11	78.90	133.27
T_6 2,4-DEE 0.4 kg a.i/ha	6.43	13.66	48.26	69.99	84.51	132.77
T_7 2,4-DEE 0.6 kg a.i/ha	4.89	14.40	51.91	67.45	76.21	127.08
T_8 Butachlor 1.25 kg a.i/ha	6.29	13.05	68.88	84.63	74.83	126.30
HW	9.60	16.40	102.7	98.90	107.70	129.3
UWC	3.50	7.50	35.80	55.00	67.10	43.3
SEm±	0.678	0.623	5.104	2.153	4.866	3.860
CD (0.05)	1.92	NS	14.46	6.09	NS	NS

Stages of observation	Subplot 1993	Subplot 1994
30 DAS	T_3 T_4 T_2 T_5 T_6 T_8 T_1 T_7	NS
60 DAS	T_8 T_3 T_2 T_4 T_1 T_7 T_5 T_6	T_3 T_5 T_8 T_2 T_4 T_1 T_6 T_7
Harvest	NS	NS

Table 45. Interaction effect of herbicides with time of application on the uptake of potassium by rice (1994) (kg/ha)

Treatments	30 DAS	60 DAS	Harvest
$M_1 T_1$	14.24	72.60	116.07
$M_1 T_2$	16.86	72.63	108.17
$M_1 T_3$	15.80	77.10	139.40
$M_1 T_4$	12.37	65.80	111.57
$M_1 T_5$	12.23	82.73	112.97
$M_1 T_6$	14.03	73.70	118.03
$M_1 T_7$	15.00	55.67	108.87
$M_1 T_8$	15.83	68.27	90.60
$M_2 T_1$	11.66	63.60	143.80
$M_2 T_2$	10.78	86.83	154.69
$M_2 T_3$	12.53	81.23	106.23
$M_2 T_4$	12.43	82.73	113.93
$M_2 T_5$	11.93	79.47	141.17
$M_2 T_6$	15.03	71.27	116.77
$M_2 T_7$	13.83	74.87	128.20
$M_2 T_8$	12.90	101.20	130.60
$M_3 T_1$	14.50	64.37	133.80
$M_3 T_2$	14.02	96.50	137.50
$M_3 T_3$	14.52	97.17	137.23
$M_3 T_4$	13.53	72.07	135.83
$M_3 T_5$	17.63	89.83	150.50
$M_3 T_6$	11.30	70.27	151.30
$M_3 T_7$	14.33	60.50	137.20
$M_3 T_8$	11.37	77.27	151.67
$M_4 T_1$	8.83	90.53	116.73
$M_4 T_2$	12.38	70.37	147.43
$M_4 T_3$	17.89	103.00	161.17
$M_4 T_4$	16.40	90.07	130.37
$M_4 T_5$	10.93	104.40	128.43
$M_4 T_6$	14.27	64.73	144.97
$M_4 T_7$	14.47	78.77	134.83
$M_4 T_8$	12.10	91.77	132.33
SEm±	1.246	4.307	7.719
CD (0.05)	3.52	12.19	21.8

Joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha registered the highest potassium uptake by the crop. The same combination was similar to butachlor @ 1.25 kg a.i./ha at 60 DAS and the lower dose of the joint formulation of anilofos and 2,4-DEE @ 0.3 kg a.i./ha.

Interaction effect of herbicides with time of application was observed only in the second year. At 30 DAS joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 DAS gave the highest value and was comparable with its lower dose at 0 DAS and butachlor @ 1.25 kg a.i./ha at 0 DAS. Though singular application of anilofos @ 0.45 kg a.i./ha at 9 DAS registered the highest value at 60 DAS, it was comparable with joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 DAS and butachlor @ 1.25 kg a.i./ha at 3 DAS. At harvest higher dose of the joint formulation at 9 DAS recorded the highest value.

The uptake of potassium also followed the trend in uptake of nitrogen and phosphorus. The same treatments recorded the lowest values for nitrogen, phosphorus and potassium removal by weeds and consequent reduction in the competition by weeds, resulting in higher nitrogen, phosphorus and potassium uptake as well as dry matter production by the crop. This is in accordance with the findings of Pandey and Thakur (1988) and Radhamani (1994) wherein higher nutrient uptake was observed with the application of mixture of anilofos and 2,4-DEE.

4.4 Economics (Table 46)

In the first year, highest total return was obtained from hand weeded plots. Joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 6 DAS had the next highest total returns, followed by its application at 9 DAS. During the second year joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 DAS gave the highest total returns followed by singular application of anilofos @ 0.45 kg a.i./ha at 3 DAS and joint formulation of anilofos and 2,4-DEE @ 0.3 kg a.i./ha at 6 DAS. The lowest total return was recorded by the unweeded control.

With regard to the benefit cost ratio, hand weeded plots gave the highest value followed by higher dose of the joint formulation of anilofos and 2,4-DEE i.e. 0.45 kg a.i./ha at 6 DAS in the first year. However in the second year application of the joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 DAS recorded the highest value followed by its lower dose at 6 DAS. Unweeded control gave the lowest benefit cost ratio.

Irrespective of the year cost of cultivation was more in hand weeded plots compared to that in herbicide treated plots. During the first year due to the subsequent weed infestation consequent to lack of proper flooding one month after seeding the crop, yield was comparatively lower in the herbicide treated plots. However inspite of the highest cost of cultivation hand weeded plots recorded more grain and straw yields and hence highest total return of Rs.7727.20/ha. In the second year joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 DAS gave the highest total return of Rs.16342.50/ha. Though the application of joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha was costlier than its lower dose i.e. 0.3 kg a.i./ha, the higher yield obtained in them led to higher benefit cost ratio. However cost of the joint formulation was less compared to other herbicides making it more economical over the other herbicides tested and manual method of weed control.

Table 46. Economics of weed control operations

Treatments	Total cost of cultivation 1993	1994	Total returns 1993	1994	Benefit cost ratio 1993	1994
$M_1 T_1$	7151.30	8362.10	1601.20	12760.70	0.22	1.53
$M_1 T_2$	6808.90	8022.50	3560.40	12352.70	0.52	1.54
$M_1 T_3$	6889.90	8103.50	1808.00	13191.40	0.26	1.63
$M_1 T_4$	6926.90	8137.70	2602.00	12448.10	0.38	1.53
$M_1 T_5$	7066.90	8277.70	2982.20	13706.70	0.42	1.66
$M_1 T_6$	6847.50	8061.10	2626.20	14566.40	0.38	1.81
$M_1 T_7$	6946.10	8159.70	2435.60	13104.90	0.35	1.61
$M_1 T_8$	7096.90	8310.50	3932.60	13086.30	0.55	1.57
$M_2 T_1$	7151.30	8362.10	2390.20	15210.30	0.33	1.82
$M_2 T_2$	6808.90	8022.50	2441.80	14451.30	0.36	1.80
$M_2 T_3$	6889.90	8103.50	3154.40	13938.70	0.45	1.72
$M_2 T_4$	6926.90	8137.70	2449.00	13660.00	0.36	1.68
$M_2 T_5$	7066.90	8277.70	3769.00	15935.90	0.53	1.93
$M_2 T_6$	6847.50	8061.10	2051.20	14455.70	0.29	1.79
$M_2 T_7$	6946.10	8159.70	1766.00	13140.40	0.25	1.61
$M_2 T_8$	7096.90	8310.50	3155.20	13839.70	0.44	1.67
$M_3 T_1$	7151.30	8362.10	3778.80	14293.30	0.52	1.71
$M_3 T_2$	6808.90	8022.50	3141.40	15720.70	0.46	1.95
$M_3 T_3$	6889.90	8103.50	4892.20	14880.70	0.71	1.84
$M_3 T_4$	6926.90	8137.70	4033.80	15052.70	0.58	1.85
$M_3 T_5$	7066.90	8277.70	3381.60	15395.40	0.47	1.86
$M_3 T_6$	6847.50	8061.10	2461.00	14567.00	0.36	1.81
$M_3 T_7$	6946.10	8159.70	2402.60	14825.00	0.35	1.82
$M_3 T_8$	7096.90	8310.50	3377.60	15182.60	0.48	1.83
$M_4 T_1$	7151.30	8362.10	4395.80	14197.60	0.61	1.69
$M_4 T_2$	6808.90	8022.50	4123.80	15162.10	0.61	1.89
$M_4 T_3$	6889.90	8103.50	4555.00	16342.50	0.66	2.02
$M_4 T_4$	6926.90	8137.70	3045.60	13390.30	0.44	1.65
$M_4 T_5$	7066.90	8277.70	3847.60	14769.00	0.54	1.78
$M_4 T_6$	6847.50	8061.10	3120.40	13122.40	0.46	1.63
$M_4 T_7$	6946.10	8159.70	3617.20	14221.10	0.52	1.74
$M_4 T_8$	7096.90	8310.50	3071.20	13920.70	0.43	1.68
HW	9226.90	11310.50	7727.20	14176.20	0.84	1.25
UWC	6526.90	7710.50	1925.40	6663.60	0.29	0.86

Summary

SUMMARY

A field experiment was conducted at the Agricultural Research Station, Mannuthy under the Kerala Agricultural University, during the first crop season of 1993 and 1994 to evaluate the joint formulation of anilofos (aniloguard) and 2,4-DEE for the control of weeds in dry sown rice. The experiment was laid out in split plot design with three replications. The treatments consisted of five different pre-emergence herbicides viz. tank mix application of anilofos and 2,4-DEE, joint formulation of anilofos and 2,4-DEE, anilofos, 2,4-DEE and butachlor in the sub plots. These herbicides were tried at different levels such as 0, 3, 6 and 9 days after sowing in the main plots. Unweeded and hand weeded controls were also included for comparison. The important findings of the experiment are given below.

The weed spectrum of the experimental field comprised mainly of grasses and sedges. The main weed species found during the first year were *Cynodon dactylon, Digitaria sanguinalis, Eleusine indica, Cyperus rotundus, Cyperus iria, Cleome viscosa* and *Ageratum conyzoides*. In the second year *Isachne miliaceae, Saccolepis interrupta, Echinochloa colona, Fimbrystylis miliaceae* and *Cyperus iria* predominated.

Among the different weed control treatments application of butachlor @ 1.25 kg a.i./ha upto 3 DAS was more effective in reducing the population of *Cynodon dactylon* and *Isachne miliaceae*. Comparable values were also obtained in plots treated with joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 DAS in almost all stages.

In both the years butachlor @ 1.25 kg a.i./ha at 3 DAS and joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 DAS were comparable in bringing down the total grass population. Among the herbicides tested joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 DAS reduced the population of *Cyperus rotundus*. It was similar to its lower dose i.e. 0.3 kg a.i./ha at later stages of application and butachlor @ 1.25 kg a.i./ha at 3 DAS. The above treatments were effective in reducing the population of *Fimbrystylis miliaceae*.

With respect to the control of broadleaved weeds in almost all stages butachlor @ 1.25 kg a.i./ha at 0, 3 and 6 DAS, tank mix application of anilofos and 2,4-DEE at 9 DAS and joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 DAS were found to be equally effective. In the first year joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 DAS recorded the lowest total weed population. During the second year though butachlor @ 1.25 kg a.i./ha at 3 DAS registered the lowest total weed population it was comparable with joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 DAS.

Dry matter accumulation by weeds was lowest in hand weeded plots at 30 and 60 DAS in the first year followed by joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 DAS. In the second year butachlor @ 1.25 kg a.i./ha at 3 DAS, both the doses of the joint formulation of anilofos and 2,4-DEE @ 0.45 and 0.3 kg a.i./ha at later stages of application were found to be equally effective in reducing dry matter accumulation by weeds.

In the first year hand weeded plots recorded the highest weed control efficiency at 30 and 60 DAS. Among the herbicides, joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 DAS recorded the highest weed control efficiency at 30 DAS while singular application of anilofos @ 0.3 kg a.i./ha gave the highest value at 60 DAS. During the second year at 30 DAS, complete control of weeds could be achieved in the above treatments indicating cent per cent weed control efficiency. However at 60 DAS singular application of anilofos @ 0.45 kg a.i./ha at 9 DAS registered the highest weed control efficiency. At both these stages the above treatments were comparable with the higher and lower dose of the joint formulation of anilofos and 2,4-DEE at 9 DAS.

No severe phytotoxic symptoms were noticed in rice consequent to the application of the herbicides and hence no stand loss. In the second year at 30 DAS tank mix application of anilofos and 2,4-DEE at 6 DAS gave the highest number of tillers/m^2. At harvest the same at 9 DAS gave the highest number.

In the first year taller plants were observed in hand weeded plots. It was comparable with butachlor @ 1.25 kg a.i./ha at 3, 6 and 9 DAS and joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 6 and 9 DAS. However anilofos @ 0.45 kg a.i./ha at 6 DAS registered the highest value in the second year closely followed by hand weeding and joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 3 DAS.

Joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 DAS recorded the highest dry matter production in rice in almost all stages during both the years.

Hand weeding, butachlor @ 1.25 kg a.i./ha and joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 DAS were comparable with respect to effective tillers/hill. Similar trend was noticed in the case of panicle length also.

Number of grains/panicle was more in plots treated with joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 DAS, its lower dose at 6 DAS and hand weeded plots. Thousand grain weight also followed the similar trend.

During the first year anilofos @ 0.3 kg a.i./ha at 3 DAS recorded the highest grain yield and was similar to the higher and lower dose of joint formulation of anilofos and 2,4-DEE i.e. 0.45 and 0.3 kg a.i./ha at 9 DAS and butachlor @ 1.25 kg a.i./ha at 0 and 6 DAS. However hand weeding was superior to the herbicidal treatments. In the second year joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 DAS and anilofos @ 0.45 kg a.i./ha at 3 DAS were also comparable with it. Similar trend was noticed in the case of straw yield as well.

In the first year at 30 DAS joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 6, 9 and 0 DAS recorded the lowest nitrogen removal by weeds followed by butachlor @ 1.25 kg a.i./ha at 3 DAS. Joint formulation of anilofos and 2,4-DEE @ 0.3 kg a.i./ha at 9 DAS recorded the lowest value at 60 DAS. Butachlor @ 1.25 kg a.i./ha at 3 DAS and hand weeding were comparable with it. Similar trend was noticed in the second year also.

During the first year hand weeding registered the lowest P removal at 30 DAS and was similar to joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 and 6 DAS, butachlor @ 1.25 kg a.i./ha at 3 and 9 DAS. In the second year both the doses of the joint formulation of anilofos and 2,4-DEE at 0.3 and 0.45 kg a.i./ha at 9 DAS, butachlor @ 1.25 kg a.i./ha were comparable.

Joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 DAS, its lower dose at 9 DAS, butachlor @ 1.25 kg a.i./ha at 3 DAS and hand weeding were comparable and recorded lower potassium removal by weeds.

In the first year joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 DAS recorded highest nitrogen uptake by the crop followed by its application at 6 DAS in almost all the stages. However in the second year joint formulation of anilofos and 2,4-DEE @ 0.3 kg a.i./ha at 6 DAS, higher dose of the joint formulation at 9 DAS and hand weeding were equally effective and recorded higher nitrogen uptake by rice.

With regard to P uptake by the crop during both the years joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 DAS and hand weeding were similar and gave higher values. Potassium uptake also followed the same trend.

During the first year hand weeded plots recorded the highest total returns and benefit cost ratio followed by the joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 6 DAS. In the second year joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 DAS gave the highest total returns and benefit cost ratio. In general, among the herbicides tested the higher dose of the joint formulation of anilofos and 2,4-DEE i.e. 0.45 kg a.i./ha was more economical in terms of total returns and benefit cost ratio.

Plate 1. View of the plots showing different treatments

a) Joint formulation of anilofos and 2,4-DEE at 0.3 kg a.i./ha at 9 DAS

b) Joint formulation of anilofos and 2,4-DEE at 0.45 kg a.i./ha at 9 DAS


Anilo plus
0·5 kg/ha
9 DAS


R_3 M_3 T_5
Anilo 0·45 kg/h
9 DAS

2. c) Tank mix application of anilofos (0.3 kg a.i./ha) and 2,4-DEE (0.45 kg a.i./ha) at 9 DAS

d) Butachlor at 1.25 kg a.i./ha at 3 DAS


R1 M3 T1
Anilo+2, 4 DEE
0·3+0·45 kg/ha
9 DAS


R2 M1 T6
But 1·25 kg/ha
3 DAS

3. e) Hand weeded control

f) Un weeded control


R3
HW


R2
UWC

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*Originals not seen

Appendices

APPENDIX-Ia

Weed flora of the experimental field (1993)

Scientific name	Common name	Family
A. Monocots		
(i) Grasses		
1. *Cynodon dactylon* (L) Pers.	Bermuda grass, Star grass Karuka (M)	Poaceae
2. *Dactyloctenium aegyptium* (L.) Beaur	Crows foot grass	Poaceae
3. *Digitaria sanguinalis* (L.) Scop.	Crab grass, Couch Kattam gula (M)	Poaceae
4. *Echinochloa colona* (L.) Link	Jungle rice Kavada (M)	Poaceae
5. *Eleusine indica* (L.) Gaertn	Fowl foot grass Kattuchama (M)	Poaceae
6. *Isachaemum rugosum* Salisb	Padappanpullu (M)	Poaceae
7. *Panicum repens* L.	Torpedo grass Inchipullu (M)	Poaceae
(ii) Sedges		
1. *Cyperus iria* L.	Yellow nut sedge Manjakora (M)	Cyperaceae
2. *Cyperus rotundus* L.	Purple nut sedge Nut grass Muthanga (M)	Cyperaceae
(iii) Other monocots		
1. *Commelina benghalensis* L.	Hairy wandering jew Vazhapadatti (M)	Commelinaceae
B. Dicots		
1. *Cleome viscosa* L.	Kattukadukku (M)	Capparaceae
2. *Emilia sonchifolia*	Moyal cheviyan (M)	Compositae
3. *Euphorbia hirta* L.	Gargen surge Asthama weed	Euphorbiaceae
4. *Ludwigia parviflora* (Roxb.)	Neergrambu (M)	Onagraceae

APPENDIX-Ib

Weed flora of the experimental field (1994)

Scientific name	Common name	Family
A. Monocots		
i) Grasses		
1. *Echinochloa colona* (L.) Link	Jugle rice Kavada (M)	Poaceae
2. *Echinochloa crusgalli* (L.) Beauv.	Barn yard grass Kavada (M)	Poaceae
3. *Isachne miliacea* Roth	Changalipullu (M)	Poaceae
4. *Ischaemum rugosum* Salisb	Padappanpullu (M)	Poaceae
5. *Saccolepis interrupta* (Willd.) Stapf	Pollakkalla (M)	Poaceae
(ii) Sedges		
1. *Cyperus iria* L.	Yellow nut sedge Manjakora (M)	Cyperaceae
2. *Fimbristylis miliacea* (L.) Vabl	Mung (M)	Cyperaceae
(iii) Broad leaved weeds		
1. *Ammania baccifera* Linn	Blistering Ammania Kalloorvanchi (M)	Lytheraceae
2. *Dopatrium junceum* (Roxb.) Bunch Ham *ex* Benth		Scrophulanaceae
3. *Eriocaulon quinquangulare* L.		Eriocacelaceae
4. *Monochoria vaginalis* (Burm.f.) Presl. *ex* Kunth.	Neelolpalam (M)	Pontederiaceae
5. *Sphaeranthus indicus* Linn.	Adakkamanian (M)	Compsitae
6. *Sphenochlea zeylanica* Gaertn.		Sphenocleaceae

APPENDIX-IIa

Treatment effects on rice in the visual scoring scale of 0 to 9

Treatments	1993	1994
$M_1 T_1$	2	2
$M_1 T_2$	2	1
$M_1 T_3$	3	2
$M_1 T_4$	2	2
$M_1 T_5$	3	1
$M_1 T_6$	3	2
$M_1 T_7$	3	3
$M_1 T_8$	4	2
$M_2 T_1$	2	6
$M_2 T_2$	2	2
$M_2 T_3$	3	2
$M_2 T_4$	2	1
$M_2 T_5$	2	2
$M_2 T_6$	3	3
$M_2 T_7$	3	2
$M_2 T_8$	3	2
$M_3 T_1$	2	1
$M_3 T_2$	3	1
$M_3 T_3$	3	2
$M_3 T_4$	3	1
$M_3 T_5$	3	1
$M_3 T_6$	3	1
$M_3 T_7$	2	3
$M_3 T_8$	3	1
$M_4 T_1$	2	2
$M_4 T_2$	2	1
$M_4 T_3$	2	1
$M_4 T_4$	3	1
$M_4 T_5$	2	1
$M_4 T_6$	2	2
$M_4 T_7$	2	2
$M_4 T_8$	2	1

0 - No injury, normal
1 - Slight stunting, injury or discolouration
2 - Stand loss, stunting or discolouration
3 - Injury more pronounced but not persistent
4 - Moderate injury recovery possible
5 - Injury more persistent, recovery doubtful
6 - Near severe injury, no recovery possible
7 - Severe injury, stand loss
8 - Almost destroyed, a few plants surveyed
9 - Very few plants alive

APPENDIX-IIb

Treatment effects on weed in the visual scoring scale of 0 to 9

Treatments	1993	1994
$M_1 T_1$	5	7
$M_1 T_2$	5	7
$M_1 T_3$	6	8
$M_1 T_4$	4	8
$M_1 T_5$	4	8
$M_1 T_6$	3	6
$M_1 T_7$	4	6
$M_1 T_8$	4	8
$M_2 T_1$	5	9
$M_2 T_2$	4	9
$M_2 T_3$	6	9
$M_2 T_4$	4	9
$M_2 T_5$	4	9
$M_2 T_6$	5	6
$M_2 T_7$	4	6
$M_2 T_8$	4	9
$M_3 T_1$	6	8
$M_3 T_2$	5	9
$M_3 T_3$	7	9
$M_3 T_4$	5	8
$M_3 T_5$	5	8
$M_3 T_6$	6	7
$M_3 T_7$	6	6
$M_3 T_8$	4	9
$M_4 T_1$	6	8
$M_4 T_2$	6	9
$M_4 T_3$	6	9
$M_4 T_4$	4	7
$M_4 T_5$	4	7
$M_4 T_6$	6	6
$M_4 T_7$	6	7
$M_4 T_8$	5	4

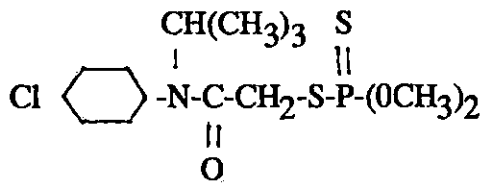
0 - No control
1 - Very poor control
2 - Poor control
3 - Poor to defecient control
4 - Deficient control
5 - Deficient-moderate
6 - Moderate control
7 - Satisfactory
8 - Good control
9 - Good to excellent control

APPENDIX-III

Details of the herbicides used in the experiment

I. ANILOFOS

Chemical Name : S-[N-(4-chlorphenyl)-N-isopropyl carbomoyl methyl-]-0,0-dimethyl dithiophosphate

Structural Formula : 

Family/group : Organo phosphorus

Manufacturer : Gharda Chemicals Ltd.

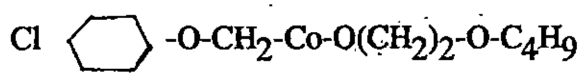
Trade Name : Aniloguard 30 EC

Molecular weight : 367.5

Mode of action : Selective herbicide, absorbed through the roots, and, to some extent, through the leaves

2. 2,4-DEE

Chemical Name : 2-butoxyethyl (2,4 dichlorophenoxy) acetate

Structural Formula : 

Family/group : Phenoxy acid

Manufacturer : Agromore Ltd

Trade Name : Agrodone concentrate 48 (34% WSC)

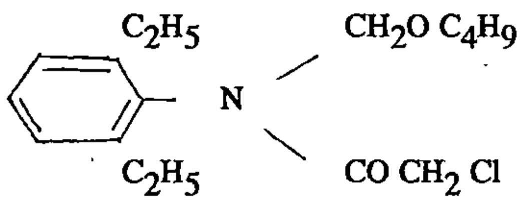
Molecular weight : 321.2

Mode of Action : Affects plant growth, meristematic cell division and root. Influence nitrogen metabolism and enzyme activity

3. BUTACHLOR

Chemical Name : N-(butoxymethyl)-2 chloro 2'-6'-diethyl acetanilide

Structural Formula :



Family/group : Amide

Manufacturer : Pest Control Co.

Trade Name : Butachlor 50 EC

Molecular weight : 311.9

Mode of action : Selective, systemic herbicide. Inhibit early seedling growth, especially root growth. probably associated with an interference with cell division, cause cell enlargement. Inhibit nucleic acid and protein synthesis.

4. Joint formulation of anilofos and 2,4-DEE

Anilofos (24%) + 2,4-DEE (32%) prepared as EC by Gharda Chemicals Ltd., Bombay.

APPENDIX-IV
Nitrogen content of weeds at different stages (%)

Treatments	30 DAS 1993	60 DAS 1993	60 DAS 1994	Harvest 1994
$M_1 T_1$	1.80	1.10	1.82	1.20
$M_1 T_2$	1.33	1.06	1.46	1.26
$M_1 T_3$	1.37	1.00	1.36	1.30
$M_1 T_4$	1.73	1.13	1.59	0.93
$M_1 T_5$	0.80	1.36	1.12	1.36
$M_1 T_6$	1.13	1.30	1.56	0.83
$M_1 T_7$	1.00	1.16	1.16	0.66
$M_1 T_8$	1.13	1.03	1.32	1.23
$M_2 T_1$	1.13	1.00	1.62	1.16
$M_2 T_2$	1.43	1.35	1.68	1.20
$M_2 T_3$	1.05	1.06	1.50	1.00
$M_2 T_4$	1.00	1.13	1.35	1.20
$M_2 T_5$	1.87	1.10	1.32	1.35
$M_2 T_6$	1.25	1.00	1.40	1.00
$M_2 T_7$	1.00	1.16	1.16	0.66
$M_2 T_8$	0.90	1.16	1.34	0.93
$M_3 T_1$	0.93	0.80	1.61	1.26
$M_3 T_2$	1.25	0.80	1.61	1.06
$M_3 T_3$	0.65	1.47	1.07	1.00
$M_3 T_4$	0.85	1.35	1.40	1.10
$M_3 T_5$	1.23	1.40	1.12	1.13
$M_3 T_6$	1.37	1.00	1.46	1.10
$M_3 T_7$	1.30	0.90	1.61	0.93
$M_3 T_8$	1.40	1.06	0.70	1.50
$M_4 T_1$	1.17	0.80	0.77	1.10
$M_4 T_2$	1.40	1.00	0.80	1.30
$M_4 T_3$	1.43	1.10	0.77	0.93
$M_4 T_4$	1.30	1.23	0.94	1.23
$M_4 T_5$	0.90	1.06	0.80	1.00
$M_4 T_6$	1.70	1.13	1.82	1.03
$M_4 T_7$	1.33	1.23	1.32	1.05
$M_4 T_8$	1.63	1.10	0.70	1.45
HW	1.27	1.03	1.00	1.00
UWC	1.23	1.36	1.96	1.35

APPENDIX-V

Phosphorus content of weeds at different stages (%)

Treatments	30 DAS 1993	60 DAS 1993	60 DAS 1994	Harvest 1994
$M_1 T_1$	0.33	0.35	0.09	0.13
$M_1 T_2$	0.47	0.37	0.16	0.10
$M_1 T_3$	0.44	0.27	0.18	0.12
$M_1 T_4$	0.43	0.40	0.18	0.11
$M_1 T_5$	0.29	0.41	0.06	0.11
$M_1 T_6$	0.39	0.37	0.20	0.09
$M_1 T_7$	0.35	0.30	0.20	0.12
$M_1 T_8$	0.37	0.28	0.20	0.14
$M_2 T_1$	0.23	0.23	0.08	0.10
$M_2 T_2$	0.43	0.24	0.12	0.12
$M_2 T_3$	0.48	0.28	0.06	0.11
$M_2 T_4$	0.34	0.32	0.05	0.10
$M_2 T_5$	0.31	0.37	0.10	0.12
$M_2 T_6$	0.26	0.34	0.10	0.09
$M_2 T_7$	0.33	0.31	0.10	0.13
$M_2 T_8$	0.29	0.35	0.10	0.12
$M_3 T_1$	0.19	0.30	0.10	0.12
$M_3 T_2$	0.29	0.31	0.11	0.08
$M_3 T_3$	0.28	0.15	0.05	0.12
$M_3 T_4$	0.25	0.27	0.16	0.09
$M_3 T_5$	0.25	0.41	0.04	0.12
$M_3 T_6$	0.27	0.34	0.20	0.10
$M_3 T_7$	0.35	0.36	0.20	0.10
$M_3 T_8$	0.23	0.27	0.10	0.11
$M_4 T_1$	0.33	0.20	0.07	0.13
$M_4 T_2$	0.34	0.42	0.04	0.11
$M_4 T_3$	0.31	0.28	0.04	0.10
$M_4 T_4$	0.42	0.32	0.05	0.11
$M_4 T_5$	0.32	0.29	0.00	0.10
$M_4 T_6$	0.33	0.39	0.20	0.11
$M_4 T_7$	0.35	0.45	0.10	0.12
$M_4 T_8$	0.33	0.46	0.20	0.12
HW	0.20	0.60	0.14	0.10
UWC	0.37	0.34	0.20	0.12

APPENDIX-VI

Potassium content of weeds at different stages (%)

Treatments	30 DAS	60 DAS		Harvest
	1993	1993	1994	1994
$M_1 T_1$	3.25	3.67	1.50	2.20
$M_1 T_2$	2.30	2.50	1.90	2.13
$M_1 T_3$	3.25	2.70	2.10	1.80
$M_1 T_4$	2.67	2.90	1.40	2.25
$M_1 T_5$	2.70	2.50	0.70	1.85
$M_1 T_6$	2.57	3.03	2.10	1.57
$M_1 T_7$	2.77	3.37	1.50	1.40
$M_1 T_8$	2.97	2.90	1.80	2.00
$M_2 T_1$	3.40	2.90	1.07	2.23
$M_2 T_2$	2.85	3.37	1.50	2.17
$M_2 T_3$	3.10	3.55	0.70	1.96
$M_2 T_4$	2.70	2.70	0.50	2.00
$M_2 T_5$	3.00	2.50	0.90	1.77
$M_2 T_6$	2.76	2.73	0.80	1.65
$M_2 T_7$	3.10	2.76	0.90	1.47
$M_2 T_8$	3.40	2.70	1.30	1.83
$M_3 T_1$	2.97	2.50	1.10	1.90
$M_3 T_2$	2.75	3.00	1.10	1.60
$M_3 T_3$	3.10	3.70	0.70	1.67
$M_3 T_4$	2.20	2.77	0.90	1.97
$M_3 T_5$	3.20	2.73	0.40	1.87
$M_3 T_6$	2.90	3.25	1.90	2.20
$M_3 T_7$	2.50	2.57	1.60	1.50
$M_3 T_8$	3.00	3.15	0.00	1.65
$M_4 T_1$	3.10	2.20	0.70	1.70
$M_4 T_2$	2.60	2.15	0.50	2.00
$M_4 T_3$	2.60	3.50	0.50	1.50
$M_4 T_4$	3.00	3.40	0.50	2.00
$M_4 T_5$	3.10	2.73	0.00	1.95
$M_4 T_6$	2.87	3.65	1.40	1.70
$M_4 T_7$	2.70	2.93	1.40	1.60
$M_4 T_8$	3.03	2.87	0.00	1.95
HW	1.55	2.00	1.70	1.60
UWC	3.75	3.27	2.30	2.10

APPENDIX-VII

Nitrogen content of rice at different stages (%)

Treatments	30 DAS		60 DAS		Harvest			
					Grain		Straw	
	1993	1994	1993	1994	1993	1994	1993	1994
$M_1 T_1$	2.4	2.9	2.4	1.9	1.2	1.1	0.8	0.8
$M_1 T_2$	2.0	3.2	1.9	1.8	1.1	1.1	0.8	0.8
$M_1 T_3$	2.0	3.0	2.1	2.0	1.1	1.2	1.0	0.9
$M_1 T_4$	2.0	2.1	1.4	1.9	0.9	1.2	0.9	0.8
$M_1 T_5$	1.8	2.6	1.8	1.8	1.2	1.2	0.7	0.7
$M_1 T_6$	2.1	2.4	1.6	1.7	1.4	1.2	1.3	0.6
$M_1 T_7$	2.1	2.2	2.2	1.7	1.5	1.1	0.9	0.8
$M_1 T_8$	2.1	2.5	1.8	1.8	1.4	1.5	0.9	1.0
$M_2 T_1$	2.2	3.2	2.2	1.8	1.5	1.1	1.2	0.8
$M_2 T_2$	2.0	3.2	2.0	1.8	1.3	1.3	1.2	0.8
$M_2 T_3$	2.1	2.8	1.6	2.1	1.4	1.3	1.1	1.2
$M_2 T_4$	2.3	2.7	1.9	1.8	1.4	1.2	0.8	0.7
$M_2 T_5$	1.8	2.5	1.8	1.7	1.6	1.5	0.8	0.6
$M_2 T_6$	1.9	2.4	1.9	1.7	1.4	1.2	0.8	0.8
$M_2 T_7$	1.8	2.6	1.8	1.7	1.3	1.3	1.1	0.7
$M_2 T_8$	2.1	2.7	1.8	1.8	1.4	1.5	1.1	0.9
$M_3 T_1$	2.0	2.9	2.2	1.9	1.2	1.3	0.9	0.9
$M_3 T_2$	1.9	3.2	2.0	2.0	1.3	1.4	0.9	0.9
$M_3 T_3$	2.5	3.0	2.2	1.8	1.3	1.2	1.2	0.8
$M_3 T_4$	1.4	2.7	1.6	1.9	1.0	1.2	1.2	0.8
$M_3 T_5$	2.0	2.5	1.8	1.7	1.0	1.2	0.6	0.6
$M_3 T_6$	2.0	2.7	1.7	1.7	1.4	1.3	0.8	0.7
$M_3 T_7$	1.9	2.1	1.6	1.8	1.3	1.3	1.4	0.9
$M_3 T_8$	1.7	2.7	1.8	1.7	1.4	1.3	1.1	0.6
$M_4 T_1$	2.7	3.3	2.0	2.0	1.4	1.3	1.1	1.1
$M_4 T_2$	2.6	3.2	1.9	2.1	1.4	1.5	0.8	1.2
$M_4 T_3$	2.5	3.3	1.5	1.9	1.6	1.5	1.2	1.1
$M_4 T_4$	2.0	2.8	1.7	1.9	1.3	1.4	0.9	0.9
$M_4 T_5$	2.1	2.4	2.1	1.9	1.2	1.4	1.1	0.9
$M_4 T_6$	2.2	2.5	1.8	1.5	1.4	1.1	0.8	0.7
$M_4 T_7$	1.8	2.7	2.2	1.8	1.4	1.4	0.8	0.9
$M_4 T_8$	2.0	2.8	1.7	1.8	1.4	1.6	0.8	0.8
HW	2.5	3.0	2.3	2.0	1.7	1.5	1.3	1.1
UWC	1.8	2.0	0.8	1.5	0.9	0.9	0.7	0.6

APPENDIX-VIII

Phosphorus content of rice at different stages (%)

Treatments	30 DAS 1993	30 DAS 1994	60 DAS 1993	60 DAS 1994	Harvest Grain 1993	Harvest Grain 1994	Harvest Straw 1993	Harvest Straw 1994
$M_1 T_1$	0.78	0.26	0.73	0.19	0.26	0.14	0.30	0.10
$M_1 T_2$	0.75	0.23	0.62	0.25	0.28	0.15	0.27	0.09
$M_1 T_3$	0.57	0.26	0.71	0.23	0.26	0.15	0.37	0.08
$M_1 T_4$	0.65	0.18	0.42	0.22	0.31	0.16	0.23	0.08
$M_1 T_5$	0.44	0.23	0.37	0.25	0.24	0.15	0.33	0.10
$M_1 T_6$	0.64	0.20	0.62	0.23	0.25	0.14	0.26	0.12
$M_1 T_7$	0.62	0.20	0.54	0.30	0.29	0.16	0.39	0.12
$M_1 T_8$	0.80	0.23	0.60	0.24	0.30	0.15	0.30	0.09
$M_2 T_1$	0.79	0.23	0.66	0.23	0.27	0.15	0.33	0.09
$M_2 T_2$	0.72	0.21	0.82	0.27	0.28	0.16	0.30	0.10
$M_2 T_3$	0.90	0.25	0.75	0.25	0.31	0.15	0.40	0.10
$M_2 T_4$	0.69	0.22	0.67	0.25	0.31	0.16	0.34	0.09
$M_2 T_5$	0.65	0.24	0.60	0.25	0.30	0.16	0.26	0.10
$M_2 T_6$	0.76	0.21	0.65	0.22	0.30	0.16	0.35	0.11
$M_2 T_7$	0.67	0.22	0.66	0.25	0.32	0.15	0.30	0.09
$M_2 T_8$	0.57	0.18	0.58	0.26	0.24	0.15	0.30	0.10
$M_3 T_1$	0.84	0.22	0.61	0.33	0.28	0.14	0.40	0.10
$M_3 T_2$	0.84	0.19	0.60	0.23	0.32	0.16	0.40	0.10
$M_3 T_3$	0.61	0.24	0.69	0.27	0.32	0.16	0.40	0.10
$M_3 T_4$	0.70	0.21	0.72	0.29	0.23	0.15	0.40	0.10
$M_3 T_5$	0.74	0.20	0.56	0.24	0.30	0.16	0.40	0.10
$M_3 T_6$	0.61	0.18	0.66	0.26	0.31	0.17	0.45	0.10
$M_3 T_7$	0.47	0.19	0.54	0.25	0.31	0.16	0.40	0.09
$M_3 T_8$	0.71	0.20	0.51	0.31	0.31	0.15	0.30	0.11
$M_4 T_1$	0.76	0.24	0.62	0.28	0.28	0.14	0.30	0.11
$M_4 T_2$	0.71	0.19	0.59	0.28	0.27	0.16	0.40	0.10
$M_4 T_3$	0.77	0.24	0.54	0.31	0.35	0.17	0.40	0.11
$M_4 T_4$	0.81	0.18	0.61	0.30	0.34	0.16	0.30	0.11
$M_4 T_5$	0.77	0.20	0.56	0.30	0.28	0.16	0.40	0.09
$M_4 T_6$	0.67	0.21	0.60	0.23	0.25	0.16	0.40	0.11
$M_4 T_7$	0.55	0.21	0.62	0.27	0.31	0.14	0.40	0.12
$M_4 T_8$	0.63	0.23	0.55	0.32	0.31	0.15	0.30	0.11
HW	0.66	0.21	0.74	0.30	0.38	0.16	0.34	0.11
UWC	0.41	0.19	0.59	0.23	0.23	0.14	0.26	0.08

APPENDIX-IX

Potassium content of rice at different stages (%)

Treatments	30 DAS		60 DAS		Harvest			
					Grain		Straw	
	1993	1994	1993	1994	1993	1994	1993	1994
$M_1 T_1$	2.1	3.3	3.2	2.2	0.5	0.4	1.9	2.3
$M_1 T_2$	2.3	3.1	2.6	2.3	0.4	0.4	2.0	2.3
$M_1 T_3$	2.1	3.3	3.7	2.3	0.5	0.4	2.4	2.3
$M_1 T_4$	2.2	3.0	3.9	2.3	0.5	0.4	2.4	2.1
$M_1 T_5$	2.2	3.1	3.7	2.3	0.5	0.4	2.4	2.1
$M_1 T_6$	2.3	3.2	3.5	2.2	0.4	0.4	2.1	2.1
$M_1 T_7$	2.2	3.0	4.4	2.1	0.5	0.4	2.5	2.2
$M_1 T_8$	2.0	3.1	4.0	2.1	0.4	0.4	2.1	1.9
$M_2 T_1$	2.1	3.3	4.1	2.2	0.4	0.4	2.3	2.5
$M_2 T_2$	2.1	3.2	3.7	2.1	0.4	0.4	2.3	2.4
$M_2 T_3$	2.3	3.1	3.7	2.3	0.6	0.4	1.9	2.2
$M_2 T_4$	2.3	3.0	3.2	2.3	0.5	0.4	2.3	2.2
$M_2 T_5$	2.1	3.0	3.2	2.3	0.5	0.4	2.2	2.2
$M_2 T_6$	2.1	3.0	3.1	2.1	0.4	0.4	2.2	2.2
$M_2 T_7$	2.1	2.9	3.7	2.2	0.5	0.4	2.1	2.3
$M_2 T_8$	2.0	2.7	3.3	2.3	0.4	0.4	2.1	2.4
$M_3 T_1$	2.2	3.3	3.5	2.3	0.6	0.4	2.3	2.5
$M_3 T_2$	2.1	3.2	3.1	2.3	0.4	0.4	2.4	2.4
$M_3 T_3$	2.2	3.3	3.1	2.2	0.4	0.4	2.5	2.4
$M_3 T_4$	2.1	3.3	4.0	2.2	0.3	0.4	2.3	2.2
$M_3 T_5$	2.3	3.3	2.8	2.2	0.5	0.4	2.2	2.5
$M_3 T_6$	2.2	2.9	3.5	2.1	0.4	0.4	2.2	2.4
$M_3 T_7$	2.0	3.0	2.7	2.2	0.4	0.4	2.0	2.2
$M_3 T_8$	2.2	2.7	4.2	2.2	0.5	0.4	2.7	2.4
$M_4 T_1$	2.1	2.8	3.9	2.3	0.4	0.4	2.7	2.1
$M_4 T_2$	2.1	2.9	4.0	2.3	0.5	0.5	2.2	2.2
$M_4 T_3$	2.3	3.3	3.8	2.4	0.5	0.4	2.4	2.4
$M_4 T_4$	2.1	3.1	3.9	2.1	0.4	0.4	2.4	2.2
$M_4 T_5$	2.2	3.1	3.9	2.4	0.3	0.4	2.3	2.2
$M_4 T_6$	2.1	3.0	4.0	2.2	0.4	0.4	2.4	2.4
$M_4 T_7$	2.2	2.8	3.8	2.1	0.5	0.4	2.3	2.3
$M_4 T_8$	2.2	3.0	4.5	2.1	0.3	0.4	2.1	2.3
HW	2.0	3.1	4.3	2.3	0.7	0.5	2.3	2.4
UWC	2.0	2.6	3.0	2.0	0.4	0.4	2.1	2.0

APPENDIX-X(a)(i)
Cost of cultivation excluding cost for weed control (Rs./ha) 1993

Particulars	Cost of materials	Labour charges: Tractor	Men	Women	Total
1. Land preparation tractor 10 hrs + 10 M + 3 W	-	1400.00	400.00	90.00	1890.00
2. Seed (80 kg)	480.00	-	-	-	520.00
Dibbling (25 W)	-	-	-	750.00	750.00
3. Fertilizer					
Urea (198 kg/ha)	554.40	-	-	-	554.40
Mussorie phos (225 kg/ha)	405.00	-	-	-	405.00
MOP (75 kg/ha)	352.50	-	-	-	352.50
Application (3 M)	-	-	120.00	-	120.00
4. Plant protection					
Metacid (500 ml)	195.00	-	-	-	195.00
Spraying (1 M)	-	-	40.00	-	40.00
5. Water management (4 M)	-	-	160.00	-	160.00
6. Harvest operation (20 W)	-	-	-	600.00	600.00
Threshing (20 W)	-	-	-	600.00	600.00
Cleaning & drying (2 M + 10 W)	-	-	80.00	300.00	380.00
Total	1986.90	1400.00	800.00	2340.00	6526.90

<u>Seeds</u>

Paddy seed @ Rs.6/kg

<u>Insecticides</u>

Metacid @ Rs.195/500 ml

<u>Fertilizers</u>

Urea @ Rs.2.80/kg
Mussorie phos @ Rs.1.80/kg
MOP @ Rs.4.70/kg

<u>Labour charges</u>

Men Rs. 40/day
Women Rs.30/day
Tractor Rs.140/hr

APPENDIX-Xa(ii)
Cost of cultivation excluding cost for weed control (Rs./ha) 1994

Particulars	Cost of materials	Labour charges Tractor	Men	Women	Total
1. Land preparation (tractor 10 hrs + 10 M + 3 W)	-	1500.00	500.00	120.00	2120.00
2. Seed (80 kg)	520.00	-	-	-	520.00
Dibbling (25 W)	-	-	-	1000.00	1000.00
3. Fertilizer					
Urea (198 kg/ha)	693.00	-	-	-	693.00
Mussorie phos (225 kg/ha)	450.00	-	-	-	450.00
MOP (75 kg/ha)	300.00	-	-	-	300.00
Application (3 M)	-	-	150.00	-	150.00
4. Plant protection					
Dimecron 250 ml	127.50	-	-	-	127.50
Application (1 M)	-	-	50.00	-	50.00
5. Water management (4 M)	-	-	200.00	-	200.00
6. Harvest operation (20 W)	-	-	-	800.00	800.00
Thrushing (20 W)	-	-	-	800.00	800.00
Cleaning & drying (2 M + 10 W)	-	-	100.00	400.00	500.00
Total	2090.50	1500.00	1000.00	3120.00	7710.50

<u>Seeds</u>

Paddy seeds @ 6.50/kg

<u>Insecticides</u>

Dimecron @ Rs.225/lit

<u>Fertilizers</u>

Urea @ Rs.3.50/kg
Mussorie phos @ Rs.2.00/kg
MOP @ Rs.4.00/kg

<u>Labour charges</u>

Men @ Rs.50/day
Women @ Rs.40/day
Tractor @ Rs.150/hr

APPENDIX-Xb
Economics of different treatments

Treatments	Cost of weed control operations (Rs./ha)		Total cost of cultivation (Rs./ha)		Return from grain yield		Return from straw yield		Total return	
	1993	1994	1993	1994	1993	1994	1993	1994	1993	1994
$M_1 T_1$	624.40	651.60	7151.30	8362.10	894.00	9104.70	707.20	3656.00	1601.20	12760.70
$M_1 T_2$	282.00	312.00	6808.90	8022.50	2586.00	8856.70	974.40	3496.00	3560.40	12352.70
$M_1 T_3$	363.00	393.00	6889.90	8103.50	1284.00	8773.00	524.00	4418.40	1808.00	13191.40
$M_1 T_4$	400.00	427.20	6926.90	8137.70	1482.00	8701.70	1120.00	3746.40	2602.00	12448.10
$M_1 T_5$	540.00	567.20	7066.90	8277.70	1995.00	9786.70	987.20	3920.00	2982.20	13706.70
$M_1 T_6$	320.60	350.60	6847.50	8061.10	1203.00	10540.00	1423.20	4026.40	2626.20	14566.40
$M_1 T_7$	419.20	449.20	6946.10	8159.70	1350.00	9619.30	1085.60	3485.60	2435.60	13104.90
$M_1 T_8$	570.00	600.00	7096.90	8310.50	3027.00	9774.30	905.60	3312.00	3932.60	13086.30
$M_2 T_1$	624.40	651.60	7151.30	8362.10	1803.00	11138.30	587.20	4072.00	2390.20	15210.30
$M_2 T_2$	282.00	312.00	6808.90	8022.50	1485.00	9619.30	956.80	4832.00	2441.80	14451.30
$M_2 T_3$	363.00	393.00	6889.90	8103.50	1956.00	10456.30	1198.40	3482.40	3154.40	13938.70
$M_2 T_4$	400.00	427.20	6926.90	8137.70	1869.00	10044.00	580.00	3616.00	2449.00	13660.00
$M_2 T_5$	540.00	567.20	7066.90	8277.70	2529.00	11386.30	1240.00	4549.60	3769.00	15935.90
$M_2 T_6$	320.60	350.60	6847.50	8061.10	1512.00	10797.30	539.20	3658.40	2051.20	14455.70
$M_2 T_7$	419.20	449.20	6946.10	8159.70	1302.00	9114.00	464.00	4026.40	1766.00	13140.40
$M_2 T_8$	570.00	600.00	7096.90	8310.50	2040.00	9879.70	1115.20	3960.00	3155.20	13839.70
$M_3 T_1$	624.40	651.60	7151.30	8362.10	2658.00	10375.70	1120.80	3917.60	3778.80	14293.30
$M_3 T_2$	282.00	312.00	6808.90	8022.50	2187.00	11584.70	954.40	4136.00	3141.40	15720.70
$M_3 T_3$	363.00	393.00	6889.90	8103.50	3261.00	10654.70	1631.20	4226.00	4892.20	14880.70
$M_3 T_4$	400.00	427.20	6826.90	8137.70	3345.00	11212.70	688.80	3840.00	4033.80	15052.70
$M_3 T_5$	540.00	567.20	7066.90	8277.70	2076.00	11129.00	1305.60	4266.40	3381.60	15395.40
$M_3 T_6$	320.60	350.60	6847.50	8061.10	1629.00	9951.00	832.00	4616.00	2461.00	14567.00
$M_3 T_7$	419.20	449.20	6946.10	8159.70	1353.00	10385.00	1049.60	4440.00	2402.60	14825.00

$M_3 T_8$	570.00	600.00	7096.90	8310.50	2412.00	10633.00	965.60	4549.60	3377.60	15182.60
$M_4 T_1$	624.40	651.60	7151.30	8362.10	2895.00	10301.30	1500.80	3896.00	4395.80	14197.30
$M_4 T_2$	282.00	312.00	6808.90	8022.50	2775.00	10375.70	1348.80	4786.40	4123.80	15162.10
$M_4 T_3$	363.00	393.00	6889.90	8103.50	3099.00	11553.70	1456.00	4788.80	4555.00	16342.50
$M_4 T_4$	400.00	427.20	6926.90	8137.70	1908.00	9278.30	1137.60	4112.00	3045.60	13390.30
$M_4 T_5$	540.00	567.20	7066.90	8277.70	2982.00	10633.00	865.60	4136.00	3847.60	14769.00
$M_4 T_6$	320.60	350.60	6847.50	8061.10	2250.00	8618.00	870.40	4504.00	3120.40	13122.00
$M_4 T_7$	419.20	449.20	6946.10	8159.70	2250.00	9538.70	1367.20	4682.40	3617.20	14221.10
$M_4 T_8$	570.00	600.00	7096.90	8310.50	1746.00	9526.30	1325.60	4394.40	3071.60	13120.70
HW	2700.00	3600.00	9226.90	11310.50	5136.00	10261.00	2591.20	3915.20	7727.20	14176.20
UWC	-	-	6526.90	7710.50	1359.00	4302.80	566.40	2360.80	1925.40	6663.60

	1993	1994		
Price of paddy/kg	Rs.3.00	Rs.3.10	Cost of Anilofos	Rs.280/lit
Price of straw/kg	Rs.0.80	Rs.0.80	Cost of 2,4-DEE	Rs.170/lit
2 Hand weeding 90 W	Rs.30/W	Rs.40/W	Cost of Butachlor	Rs.182/lit
Spray application 3 M	Rs.40/M	Rs.50/M	Cost of joint formulation of anilofos + 2,4-DEE	Rs.300/lit
Cost of cultivation excluding cost for weed control	Rs.6526.90	Rs.7710.50		

ABSTRACT

An experiment was conducted at the Agricultural Research Station, Mannuthy during the first crop season of 1993 and 1994 to evaluate the joint formulation of anilofos (aniloguard) and 2,4-DEE for the control of weeds in dry-sown rice. The treatments included joint formulation of anilofos and 2,4-DEE (0.3 and 0.45 kg a.i./ha), anilofos (0.3 and 0.45 kg a.i./ha), 2,4-DEE (0.4 and 0.6 kg a.i./ha), butachlor (1.25 kg a.i./ha) and tank mix application of anilofos (0.3 kg a.i./ha) and 2,4-DEE (0.45 kg a.i./ha). Unweeded and hand weeded control were included for comparison. The experiment was laid out in split splot design, replicated thrice.

The main weed species found during the first year were *Cynodon dactylon, Digitaria sanguinalis, Eleusine indica, Cyperus rotundus, Cyperus iria, Cleome viscosa* and *Ageratum conyzoides*. In the second year *Isachne miliaceae, Saccolepis interrupta, Echinochloa colona, Fimbrystylis miliaceae* and *Cyperus iria* predominated.

The population of grasses were reduced by the application of butachlor @ 1.25 kg a.i./ha at 3 DAS and joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 DAS. The same treatments were equally effective in lowering the number of sedges and broadleaved weeds. With respect to weed control efficiency hand weeding was superior to the herbicides during the first year. However during the second year joint formulation of anilofos and 2,4-DEE recorded the highest weed control efficiency followed by hand weeding.

No severe phytotoxic symptoms and stand loss were observed consequent to the application of the herbicides. Tank mix application of anilofos and 2,4-DEE recorded the highest number of tillers/m^2. Joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha recorded the highest dry matter production by the crop.

Yield attributing characters and yield were higher in plots with joint formulation of anilofos and 2,4-DEE @ 0.45 kg a.i./ha at 9 DAS. The same treatment was more economical over other herbicides in terms of total returns and benefit cost ratio.