RELATIVE EFFECTIVENESS OF OXADIAZON AND THIOBENCARB ON GROWTH AND YIELD PARAMETERS OF EARLY RICE CULTIVARS (*Oryza sativa* L.)

THESIS

Submitted to the
Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur,
in partial fulfilment of the requirements
for the Degree of

MASTER OF SCIENCE

IN

AGRICULTURE
(AGRONOMY)

By
PRAYAG GIRI GOSWAMI

DEPARTMENT OF AGRONOMY
JAWAHARLAL NEHRU KRISHI VISHWA VIDYALAYA
COLLEGE OF AGRICULTURE
JABALPUR, M. P.

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CERTIFICATE-I

This is to certify that the thesis entitled "RELATIVE EFFECTIVENESS OF OXADIAZON AND THIOBENCARB ON GROWTH AND YIELD PARAMETERS OF EARLY RICE CULTIVARS (Oryza sativa L.)" submitted in partial fulfilment of the requirements for the degree of Master of Science in Agriculture of the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of the bonafide research work carried out by Shri PRAYAG GIRI GOSWAMI under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma (certificate awarded etc.) or has been published/published part has been fully acknowledged. All the assistance and help received during the course of the investigations have been duly acknowledged by him.

(H.C. Jain)
Chairman of the Advisory Committee

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

Chairman	(Dr. H.C. Jain)	------------
Member	(Dr. B.L. Mishra)	------------
Member	(Dr. S.K. Shrivastava)	------------
Member	(Dr. A.K. Khare)	------------

CERTIFICATE-II

This is to certify that the thesis entitled " RELATIVE EFFECTIVENESS OF OXADIAZON AND THIOBENCARB ON GROWTH AND YIELD PARAMETERS OF EARLY RICE CULTIVARS (*Oryza sativa* L.)" submitted by Shri PRAYAG GIRI GOSWAMI to the J.N. Krishi Vishwa Vidyalaya, Jabalpur in partial fulfilment of the requirements for the degree of M.Sc. (Ag.), in the Department of Agronomy has been approved by the Student's Advisory Committee and External Examiner(s) after an oral examination on the same.

External Examiner

Major Advisor (Dr. R.C. Jain) ----------------

Head of Department (Dr. S.S. Solanki) ----------------

Director of Instructions (Dr. S.N. Dubey) ----------------

ACKNOWLEDGEMENTS

The author takes this opportunity to express his deepest sense of gratitude and venerable regards to his Guide Dr. M.C. Jain, Assistant Professor, Department of Agronomy for his able guidance, valuable suggestions and constructive criticism during the course of investigation and preparation of this manuscript.

The author express his deep gratitude to the members of the Advisory Committee Dr. B.L. Mishra (Statistics), Dr. A.K. Shrivastava (Agri Botany) and Dr. A.K. Khare (Soil Sci. & Agril.Chem.) for their timely and valuable suggestions.

The author is thankful to Dr. S.P. Kurchania, Agronomist, Weed Control Scheme, Dr. S.S. Solanki, Head, Department of Agronomy, the Dean, College of Agriculture and the Director of Instructions, JNKVV, Jabalpur for extending necessary facilities during the course of investigation.

Author's thanks are due to Dr. J.P. Tiwari (Plant Physiologist) and Dr. S.K. Agrawal (Statistics) for their kind help and timely guidance during preparation of this manuscript.

The author is highly obliged to Shri K.K. Trivedi and all staff members of the Department of Agronomy for their kind guidance; Field staff of Weed Control Scheme for their kind help and his colleagues, S/Shri R.S. Rajput, K.Cholo, R.S. Pandey and Gure Kumsa for their co-operation during the course of investigation.

The author also obliged to the Govt.of M.P. for giving him an opportunity for further study as in-service candidate with financial assistance.

Last but not least, author is feeling glorious to express his gratitude towards his wife Smt. Bhagwati, whose affectionate encouragement and sacrifice made him mettlesome to complete this pain-staking task.

PGGoswami

P.G. Goswami

Jabalpur
Dt. 25 Sept.1987.

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CHAPTER I

INTRODUCTION

I N T R O D U C T I O N

The grain yield of rice in Madhya Pradesh is very low due to various constraints. The weed flora of rice are one of the major problems amongst them as more than 60 per cent area of rice is grown during Kharif under upland and direct seeded conditions. These conditions are congenial for most of the weeds associated with upland rice and cause severe crop losses due to severe crop weed competition. Losses have been varying from 10 to 70 per cent (Mani *et al.*, 1968; Shetty, 1973). Rice crop belongs to C_3 type plants and its associated weeds belong to C_4 having faster and vigorous growth. Thus, they are better equipped to compete for nutrients, light, moisture and space as compared to rice crop.

Extensive studies on weed control have shown that direct seeded rice can yield as high as transplanted rice crop, provided the crop is grown under weed free environment. The conventional methods of weed control viz. hand weeding, hand pulling and other potential cultural practices are efficient and effective methods against weeds despite they are labour consuming much tedious and even impractical during certain periods. Non availability of labour in time and/or continuous rains which coincides with the weeding schedules may aggravate the problem. These methods do not account for early weed competition with the result crop has to face the problem of grassy weeds. Moreover, the grassy weeds are not easily distinguished from rice seedling in the early stage and continue to stress upon rice crop till they are weeded out. Weeds also regenerate after post operations from the cut portions and new flushes of weeds, too emerge after such operations. Thus, cultural methods are not weed-proof to give a season long weed control under upland conditions.

Despite , several limitations of cultural methods the changing methodology viz. multiple cropping system, high doses of fertilizers and short statured or low syncronous tillering types cultivars necessitate the use of only potential chemical measures for weed control under upland rice conditions.

Herbicides provide an alternative method where cultural and mechanical methods of weed control are not possible and impracticable. Newly synthesized selective herbicides have opened new horizons for efficient control of weeds in rice fields. However, herbicides may vary with respect to mode of action and susceptibility to rice varieties. A single herbicide may not be suitable for weed control in all the varieties.

Rice varieties vary significantly in their tolerance to different herbicides, Badea et al. (1970), Bueno and Cabanilla (1971) and Ali & Sankaran (1974). Chang (1971) reported that Japonica variety chianung - 242 is more resistant to herbicide roundup than others. Hence, the susceptibility of a particular variety to a herbicide would not preclude the use of this chemical in other varieties of the same crop.

Amongst existing rice herbicides, oxadiazon and thiobencarb are widely adopted and recommended for weed control in direct seeded upland rice cultivation in rice growing areas of the world. The tolerance of direct seeded early rice cultivars to these newly introduced herbicides have not been tested in Madhya Pradesh. Hence, keeping the above facts in view, the present investigation was planned to evaluate the relative effectiveness of oxadiazon and thiobencarb to control weeds and on tolerance of early rice varieties under Jabalpur conditions, during Kharif, 1986. The objectives of study were as under :

1. To evaluate the efficacy of herbicides for weed control under upland rice conditions.
2. To determine the effect of herbicides on growth and yield parameters of rice cultivars.
3. To evaluate suitable herbicide for a particular early rice variety under Jabalpur conditions.
4. To determine efficient weed control method under upland conditions.
5. To determine the most economical method of weed control suitable for early rice cultivars.

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CHAPTER II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The relavent literature available on associated weeds of rice, crop weed competition, weed control techniques and varietal tolerance have been reviewed in the following pages.

2.1. Associated weeds of rice

Sahu & Jena (1968) observed 52 weed species in low land rice field. Out of them 17 were broad-leaved, 23 grasses and 12 were sedges.

Mukopadhyay et al. (1972) reported that out of 19-21 weed species present, grasses comprised of 85-89 per cent of the total weed population and 91.96 per cent of the total dry matter.

Patil & Chauhan (1972) observed that in rice field of Chattisgarh sedges comprised of Cyperus sp., C. iria L., C. bulbous L., grasses, Echinochloa crusgalli L., Eleusine indica Gaertn., Sehima nevrosum, Dichanthium annulatum Stapf. and broad-leaved Commelina bengalensis L., Eclipta alba Hassk, Cynotis axillaris Room & Sch and Eichhornia crassipes, respectively.

Ghosh et al. (1974) reported that pre dominant weeds present in the rice field are Cyperus rotundus L. Echinochloa spp., Cynodon dactylon Pers. Eclipta alba Hassk., Ammania baccifera L. and Portulaca oleracea L.

Maiti (1974) inferred that there was infestation of all categories of weeds namely grasses, sedges and broad-leaved weeds in the direct seeded rice. These were 5 species of grasses, 3 species of sedges and 2 species of broad-leaved of which sedges and broad-leaved were more prominent in density than grasses.

Raju (1980) reported that the major weed species associated with upland rice in order to dominance were Echinochloa colonum L., Corchorus olitorious L., Commelina jacobi (L) Hassk., Phyllanthus niruri L., Hibiscus micranthus L., Aeschinomene indica L. consisting 75.8% of the total weed flora.

Guha et al. (1982) and Kolhe (1982) working independantly at Kharagpur on the weed flora studies in rice and reported that Cyperus spp., Lincernia cilita, Ludwigia parviflora Roxb. were the pre dominating weeds in rice fields.

Sharma (1982) reported that upland rice had to face competition mainly with Cyperus iria L. (23.06%), Cyperus rotundus L. (14.19%), Echinochloa crusgalli Beauv. (15.22%), Phyllanthus niruri L. (14%), Phyllanthus simplex L. (5.7%), Eclipta alba Hassk. (6.44%), Caesulia axillaris Roxb. (3.55%) and other monocot and dicot weeds were 7.66 and 10.18 per cent, respectively. The total monocot weeds consisted more than 60 per cent of the total weed flora.

Murthy & Manna (1984) conducted a study at CRRI and observed that in a typical agro eco-system of rice culture, 97 to 100 of the weeds, were sedges. The weed flora was composed of three major weeds viz., Fimbristylis spp., Cyperus defformis L. and Scirpus supinis L. The sedge C.defformis L. was the most dominant with 44 per cent of total weed infestation.

The five years study on weed flora at Jabalpur revealed a complex weed eco-system which consisted of *Cyperus* spp. (112m^{-2}), *Echinochloa* spp. (67m^{-2}), *Phyllanthus niruri* L. (49m^{-2}), *P. simplex* Retz. (17m^{-2}), *Commelina* spp. (18m^{-2}), *Corchorus* spp. (16m^{-2}), *Caesulia axillaris* Roxb. (10m^{-2}), *Paspalum distichum* L. (10m^{-2}), *Hibiscus micranthus* L. (9m^{-2}), *Eclipta alba* Hassk. (8m^{-2}), *Saccharum spontanium* L. (7m^{-2}), *Cynotis axillaris* Schultf. (6m^{-2}), *Alysicarpus* spp. (6m^{-2}), *Ageratum conyzoides* L. (2m^{-2}) and others (44m^{-2}) (Anon., 1984).

The major weeds of experiment at Jabalpur were consisted of *Cyperus iria* L., *C. rotundus* L., *Commelina communis* L., *Echinochloa crusgalli* Beauv. *Digitaria adscendens* Henr. *Paspalum distichum* L., *Cynodon dactylon* Pers., *Corchorus olitorious* L., *Eclipta alba* Hassk. and *Alternanthera sessilis* D.C. (Anon., 1986).

2.2. Crop weed competition

Plant competition is a natural force where-by crop and weed plants tend to attain a maximum combined growth and yield with the development of each species being to some extent at the expence of the other.

From the reviews of research work in India and abroad revealed that weeds cause considerable damage in growth and yield parameters of rice crop.

Datta (1959) observed 5 to 30 per cent losses in rice yield due to severe weed competition in Maharashtra and Gujrat and from 50 to 60 per cent in Kangra district of Punjab.

Gautam (1970) reported that weed infestation period in transplanted rice causes reduction in number of tillers, effective tillers, panicle length, grains per panicle, test weight and finally the yield.

Direct seeding can give an equally high grain yield as transplanting, iff weeds are effectively controlled (Anon., 1971).

Dwivedi (1974) reported that weed population reduced significantly the plant height, number of effective tillers, panicle length and test weight of rice.

Shetty & Gill (1974) observed that crop weed association under high weed intensity asserts some antagonistic effects, incapacitating both crop and weed to utilize the nutrient resources to expected levels.

Ghosh et al. (1976) found that weeds could be permitted with the crop at the most for 10 DAS. Any further competition is likely to reduce the yield significantly. The period between 10 to 35 DAS appeared the most vulnerable when serious reduction in yield occured in the weedy plot.

Weeds were reported to cause reduction of 17 to 35 per cent (De Dutta, 1981 & Anon., 1981) and a loss of 26 to 50 kg of available nitrogen (Mani et al., 1968) during crop season under direct sowing.

Nanjappa & Krishnamurty (1981) observed that the weed population and dry matter production did not differ significantly in association with the rice varieties.

Venugopal et al. (1983) reported that dominance of different weed groups was more or less similar in both cultivars but weed number and dry matter were reduced in Tellahamsa as compared to IR-50. Tellahamsa was 13.5 cm taller than IR-50 at 60 daystage. Obviously, shading effect might have been more in Tellahamsa limiting the growth of weeds. Singlacher et al. (1978) also made similar findings.

2.3. Weed control techniques

2.3.1. Hand weeding

Mukhopadhyay et al. (1956) reported that hand pulling and hand weeding controlled the weeds effectively but there was regeneration of weeds under these treatments.

Bhardwaj & Verma (1961) inferred that hand weeding is a time consuming, expensive and laborious method of weed control. Hence, it can not be employed on intensive scale, though it gave 27.71 per cent higher grain yield over unweeded control.

Sahu & Jena (1968) reported that hand weeding resulted in better growth in height, more effective tillers, longer ear head and more fertile grains and have higher yield of grain and straw/ha.

Bisen & Patel (1973) observed that hand weeding was the most effective method in reducing the dry weight of weeds/ha. and increased 59 per cent grain yield over no weeding.

Number of total and effective tillers per plant, length of panicle, spikelets per panicle and test weight were increased due to one hand weeding (Singh *et al.*, 1976).

Patel & Patel (1981) inferred that hand weeding recorded the minimum weed population and dry weight of weeds with maximum weed control efficiency i.e. 89.62 & 90.16 per cent in 1976 and 1980, respectively.

2.3.2. Herbicidal treatments

Pre emergence herbicide butachlor, thiobencarb, molinate and oxadiazon applied either alone or in combination with 2,4-D are widely recommended for weed control in rice (Ali & Sankran, 1977).

Nair *et al.* (1977) reported that oxadiazon and thiobencarb can easily be used for weed control in direct seeded (flooded) rice and thiobencarb shows considerable promise as effective herbicide. However, majority of herbicides showed phytotoxicity on crop due to rainfall herbicide interaction (Murthy & Dubey, 1980).

Studies on weed control conducted at Jabalpur revealed that none of the herbicides could control all the weeds found in the complex rice-wheat ecosystem owing to various types of weed species present in the field. Benthiocarb 2 kg, oxadiazon 1.5 kg as pre emergence and propanil 3 kg post emergence can be used for control of specific weeds only (Anon., 1984).

2.3.2. 1. Oxadiazon

Verma & Bhardwaj (1981) found reduced number of grains per panicle due to spraying of oxadiazon.

Varying degree of leaf scorch or local necrosis might occur particularly with liquid formulation of oxadiazon which adversely affected the leaf area of rice crop, but use of granules minimized this (Cook & Simonds, 1970).

Manna et al. (1974) while evaluating new chemical for weed control in rice reported that herbicides cobex, Avirosan and oxadiazon at 2 kg/ha gave best weed control. The crop stand as well as yield were low due to periodical stages. Data on dry weight of weeds revealed that cobex & Avirosan gave best weed control followed by oxadiazon. Avirosan and oxadiazon produced toxicity on rice and ultimately grain yield was affected greatly.

Subbiah et al. (1975) conducted experiments at Tamil Nadu Agril. University in both kharif and rabi season. Results revealed that in both seasons oxadiazon controlled the weeds effectively and recorded more grain yield as compared to other herbicide treatments.

Tosh (1975) reported that oxadiazon 1 kg as pre emergence was highly selective in controlling grasses, sedges and broad-leaved weeds with no adverse effect on upland rice.

Bhagat et al. (1977) tested eight new herbicides to control weeds in upland rice. They reported that oxadiazon at 1 kg/ha as pre emergence was significantly more effective than other herbicides and controlled weeds other than Cyperus rotundus L.. Yield of rice was found equal to those from hand weeded plots.

Perret & Simond (1977) summarized the results of 18 experiments with oxadiazon at 0.5 to 0.6 kg as pre emergence and concluded that it was most effective in controlling weeds over other herbicides and hand weeding in rice crop.

Ali *et al.* (1977) reported that pre emergence oxadiazon at 1 kg/ha controlled the annual weeds in direct seeded rice, but caused about 5% mortality to rice seedlings. However, tillering in rice was better and yield was comparable with hand weeded treatment.

Ali *et al.* (1977) tested oxadiazon at 0.75 & 1.25 kg/ha applied at 6 days after transplanting with hand weeding and butachlor. Results reveated that hand weeding gave highest yield followed by oxadiazon and butachlor. These treatments showed low weed population as well as low weed biomass per unit area and consequantly, more productive tillers in rice. Oxadiazon at 0.75 kg gave higher yield than at 1.25 kg/ha, where higher dose of oxadiazon caused reduction in grain yield due to a reduction in the number of productive tillers.

Tiwari *et al.* (1980) reported that oxadiazon 1.5 kg/ha as pre plant in 500 liter water was most efficient to control weed growth as compared to other eight herbicides for both leguminous and graminaceous weeds in sorghum, maize, ragi, kodo, soybean, groundnut, urid and mung crops. The weed biomass recorded at final stage was the lowest in oxadiazon.

Murthy & Dubey (1980) reported that oxadiazon 1 kg/ha showed moderate weed control as compared to hand weeding with highest phytotoxicity among other herbicides and reduced a considerable germination of crop. The yield from oxadiazon was low due to toxicity on crop, though its weed control efficiency was higher (83%) as compared to other herbicides.

Venugopal _et al._ (1983) observed that oxadiazon was extremely phytotoxic to rice under broad-casting method and at the same time did not control weeds effectively, resulting in poor growth and yield of rice as compared to transplanted method.

Trivedi _et al._ (1984) reported that pre emergence oxadiazon 1 kg/ha controlled most of the weeds effectively except _Eclipta alba_, _Cyperus rotundus_ and _Cynodon dactylon_ with maximum weed control efficiency and highest grain yield amongst other herbicides.

Tiwari _et al._ (1984) observed highest weed control efficiency in oxadiazon 1 kg/ha as pre emergence and controlled sedges, grasses and dicot weeds in paddy nursery.

Murthy & Manna (1984) reported that oxadiazon showed greater phytotoxicity than other herbicides and gave lower yield. Also it was reduced the panicle weight (1.53g) as compared to thiobencarb (1.65g). The weed control efficiency was 68 per cent.

Amongst herbicides, oxadiazon 1 kg had higher weed control efficiency and controlled most of weeds except _Cyperus rotundus_, _Cynodon dactylon_ and _Paspalum distichum_ and gave maximum yield. It did not show any adverse effect on crop growth and yield parameters however, gave harmonal effect and increased the plant height, leaf area and grain yield of the rice crop (Anon., 1986).

2.3.2. II. Thiobencarb

Patro & Tosh (1971) observed that thiobencarb 2kg/ha applied at 6 days after sowing controlled effectively grassy weeds up to 45 daystage without causing any phytotoxicity to rice crop. Thiobencarb 1.5 kg/ha resulted 41.54 q/ha grain yield as against 20.84 q/ha from unweeded control and 44.12 q/ha from three hand weedings.

Shridhar (1974) reported that thiobencarb 1.5 kg 6 days after seeding was effective against weeds with low weed biomass and weed counts and gave maximum grain and straw yield as compared to hand weeding and other treatments.

Out of the new herbicides benthiocarb (G) proved quite effective against burn yard grass and gave higher yield compared with hand weeding (Anon., 1976).

Benthiocarb 3 kg/ha 2 days after germination gave the highest response and hand no phytotoxicity on succeding cowpea (fodder) crop, and at 2 kg/ha 3 days after germination was not adequate in upland rice (Anon., 1975).

Leclair (1977) found that thiobencarb (Saturn) gave excellent control of Echinochloa spp. but adversely affected to yield attributes of rice.

Chella & Gill (1979) observed that benthiocarb at 2.5 kg/ha applied at 3 days after transplanting did not show any phytotoxic effect on crop and gave maximum grain yield.

Tiwari et al. (1984) reported that benthiocarb controlled only Echionchloa crusgalli on sandy clay loam soils of Jabalpur but failed to control dicot weeds, sedges, Cynodon dactylon and Digitaria adscendens .

Thiobencarb controlled effectively grassy weeds only and was failed to control broad-leaved weeds effectively. It did not show any adverse effect on growth and yield of crop however, induced some harmonal effect towards greater plant height and leaf area index of rice (Anon., 1986).

2.4. Varietal tolerance to herbicides

Badea *et al*. (1970) reported that rice varieties differ significantly in their tolerance to herbicides. Such findings are also made by Bueno and Cabanilla (1971).

Chang (1971a) reported differential response of herbicides by rice cultivars. He found that Japonica variety - Chianung-242 is more tolerant to a herbicide round-up than other varieties tested.

Chang (1971b) observed that application of thiobencarb at 3 kg at 4 days after transplanting caused little or no toxicity to bushy India T.N.1 and tall growing Japonica Variety Chianung-242.

Indica varieties are more susceptible to 2,4-D than Japonica types (Anon., 1973).

Sankaran & Ali (1974) reported that the rice varieties greatly differ in their tolerance to herbicide. Plants with erect, green and thick leaved exhibited mild chlorosis than spreading, thin and light green leaves. At normal dose of benthiocarb the mean mortality percentage varied from 12.2 to 56.7 per cent. Both tolerant and susceptible varieties were found in tall and dwarf Indicas where as the dwarf mutants and Japonica derivates were less tolerant. Variety BEB-24 independantly behaved as high tolerant to benthiocarb (3 kg/ha) but on crossing with T.N.1 the resultant progeny Krishna was medium tolerant. Thus, they concluded that in hybrid varieties the tolerance seems to be dependant on their parents. They also observed that benthiocarb was highly selective to IR-20, S.R. 26B, BAM-3, BEB-24, Kannki and IET-849 whereas propanil did well on ADT-27, Karikalam, Karuna, Ponni, Jagannath, Krishna, Cauvery, IR-5 & IR-8.

Ali & Sankaran (1976) reported differential response of Indica (Tall & dwarf) and Japonica cultivars to butachlor and benthiocarb applied to direct seeded (upland) rice at 6 days after sowing.

Ali & Sankaran (1977) summaried result of experiments conducted in USA, Japan, Korea, Phillipines, Germany and India and concluded that rice varieties significantly differ in their tolerance to herbicides. This phenomenon was exhibited under both transplanted and direct seeded conditions, but more often noted in direct seeded low land condition. Varietal tolerance and susceptibility of rice depend partly on plant morphology and physiology, adhaphic and climatic factors and doses of herbicides.

Gill & Mehara (1981) inferred that cultivars differed with regard to their genetic constitution at the molecular level and may show differential response to same herbicide. They reported that most of the Indica cultivars were susceptibile to butachlor as compared to Japonica cultivars and interaction between herbicides and Indica rice cultivars was not significant. where as, thiobencarb 1.5 kg/ha was well tolerated by all rice cultivars.

Venugopal et al. (1983) reported that phytotoxicity of herbicide was more pronounced in broad casting than transplanting method. There was significant interaction between cultivars and weed control treatments on degree of weed control, whereas cultivars and weed control treatments were found not significant.

In a study of varietal susceptibility at Jabalpur experimental results revealed that none of varieties was susceptible to any herbicides. However, significant variations among the varieties were found for seeding emergence per cent at 15 DAS but it was not significant at 25 DAS. The interaction of weed control methods and varieties was not significant on the plant height, effective tillers, ear weight and length, number of grains per ear, crop dry weight and grain yield of rice (Anon., 1986).

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CHAPTER III

MATERIAL AND METHODS

MATERIALS AND METHODS

The method followed and material used during the course of investigation in the field as well as in the laboratory are being presented in this chapter.

3.1. Experimental site

The experiment was conducted at Adhartal Farm under the Scheme, All India Coordinated Research Project on Weed control, Indian Council of Agriculture Research, Department of Agronomy, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, during *Kharif*, 1986.

3.2. Climate

The climate of Jabalpur is semi-arid and tropical with hot dry summers and cool winters. Jabalpur is situated between 22°49' and 24°8' North latitude and 78°21' to 80°58' East longitude and an altitude of 411.78 meters above the mean sea level. The tropic of cancer passes through the middle of district. Jabalpur falls under the Rice-Wheat Agroclimatic zone of Madhya Pradesh. 'The average maximum temperature during the month of May and June varies between 45.5°C to 46.4°C. January is the coldest month of the year with an average maximum temperature of 24.4°C and the lowest temperature being 10°C. The average humidity of the tract is 73.95 per cent.'

3.3. Season

The seasonal conditions prevailing during the growth period of crop was normal. The weekly meteorological data on temperature, rainfall and relative humidity during crop season were obtained from observatory, Adhartal Farm and is portrayed in Table 1 and depicted in Fig. 1.

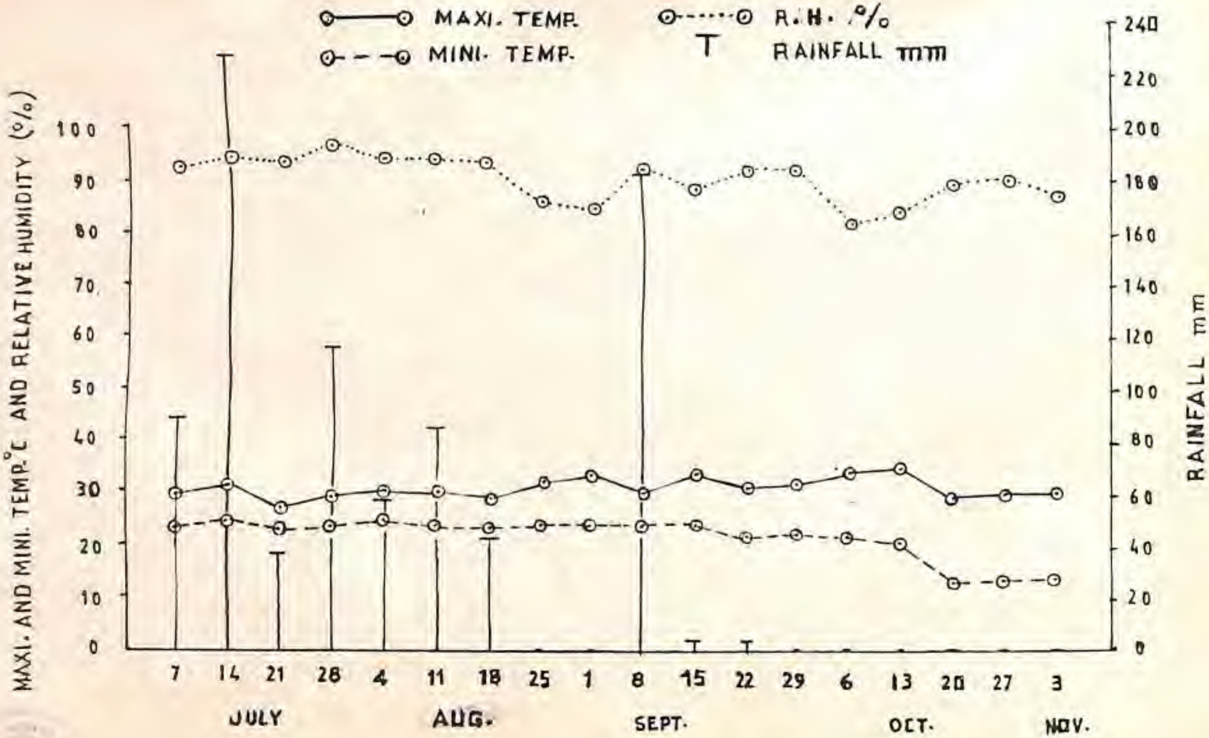
Table 1 : Weekly meteorological data during the crop season

Month	Dates (weeks)	Mean temperature (^oC)		Relative humidity (%)	Rain fall (m.m.)
		Min.	Max.		
July 86	7-13	29.7	23.6	92	87.3
	14-20	31.0	24.4	94	227.8
	21-27	27.0	22.8	93	37.0
	28-03	28.8	23.3	96	116.3
Aug. 86	04-10	31.3	24.5	94	57.7
	11-17	30.0	23.6	94	84.4
	18-24	28.7	23.1	93	42.7
	25-31	31.8	23.2	86	-
Sept.86	01-07	33.2	23.7	84	-
	08-14	29.9	23.4	92	172.8
	15-21	33.7	23.6	88	3.8
	22-28	30.4	21.5	92	3.3
Oct. 86	29-05	31.8	22.1	92	-
	06-12	33.8	21.6	82	-
	13-19	34.2	20.2	85	-
	20-26	29.6	12.8	89	-
	27-02	29.9	14.0	90	-
Nov. 86	03-09	29.6	14.3	87	-
	Total				833.1

3.4. Soil

To find out the textural class and fertility status of soil, the samples were collected randomly from different places in each replication from 30 cm depth with the help of soil auger. Composite sample was prepared. Then the soil from the

FIG.1: METEOROLOGICAL DATA OF 1986 (JULY 1986 TO NOV. 1986)



composite sample was drawn and was subjected to analysis for different physico-chemical properties of the soil.

Table 2 : Physico-chemical properties of the soil of experimental area

Constituents	Value	Inter pretations	Method of analysis
<u>Mechanical analysis</u>			
Sand %	57.125	Sandy loam	International Pipette method(Piper, 1950)
Silt %	27.600		
Clay %	17.275		
<u>Chemical analysis</u>			
Organic carbon %	0.45%	Low	Walkley and Black rapid titration method (Piper, 1960)
Available N kg/ha	207.0	Low	Alkaline permangnate method(Subbiah and Asija, 1956)
Available P_2O_5 kg/ha	60.0	High	Colorimeter(Olsen <u>et al.</u> 1954)
Available K_2O kg/ha	443.0	High	Flame photometer method (Chapman and Pratt, 1961)
Soil pH	7.4	Slightly alkaline	Glass electric pH meter (Piper, 1967)
Electrical conductivity (M.mhos/cm at 25^oC)	0.38	Normal	Solubridge method (Black, 1965)

The data presented in the Table 2 showed that soil of experimental area was sandy loam in texture. The soil was poor in nitrogen, high in phosphorus and potash and low in organic carbon. The soil was slightly alkaline in reaction.

3.5. Topography

The topography of the field was fairly uniform with slight gradient towards South-West direction. The drainage channels were made to facilitate proper drainage. They were also utilized for irrigation purposes.

3.6. Previous history of the field

The field was under Rice - wheat rotation since last five years. Rice and wheat crops were fertilized each with 80 : 50 : 30 and 100 : 60 : 40 kg/ha of nitrogen, phosphorus and potash, respectively every year.

3.7. Experimental techniques

The field was laid out in split-plot design with 4 replications. The treatments alongwith the notations used are given as detailed below :

A - Main plot treatment (Weed control techniques)

Treatments	Notation
Unweeded control	W_1
Hand weeding once 20 DAS	W_2
Oxadiazon 1 kg/ha pre em.	W_3
Thiobencarb 2 kg/ha pre em.	W_4

B - Sub plot treatment (Varieties)

CRM - 13-32-41	V_1
JR - 75	V_2
Purva	V_3
IR - 36	V_4

Pusa - 33		V_5
Cauvery		V_6

Total treatments - 24

Total number of plots - 96

Area of main plot - (29.5 m x 3 m) 88.5 m^{-2}

Area of sub plot - Gross (4.5m x 3m) 13.5 m^{-2}

Net (4 m x 2.2 m) 8.8 m^{-2}

Allies between replication = 1.0 meter

Allies between main plot = 0.5 meter

Allies between sub plot = 0.5 meter

Other details :

Row spacing	-	20 cm
Method of sowing	-	Drilling
Seed rate	-	100 kg/ha
Fertility level	-	60 : 40 : 30 NPK
Date of sowing	-	12.7.86
Date of pre em. application of herbicides	-	13.7.86

3.8. Characteristics of varieties

(V_1) CRM - 13-32-41 : (IET - 5770) it is evolved from the cross between NSN 200 x Padma at Central Rice Research Institute, Cuttack. It is early maturing (80 days) dwarf variety. The panicle length of this variety is 14.8 cm long with short and bold grains having test weight of 19.5g per 1000 grains. The yield potential of this variety ranges between 32 to 37 q/ha.

(V_2) JR-75 : It is evolved from cross between IR-20 x Lalu - 14 x JR - 20-1 at J.N.K.V.V., Jabalpur. It is early maturing (85 days) dwarf variety with coarse long grains and 23.8g test weight of thousand grains. The yield potential of this variety is 35 to 40 q/ha.

(V_3) Purva : (JR-16-15-1-1) It is evolved from cross between CR-44-35 x JR-2-331 at J.N.K.V.V., Jabalpur. It is early maturing (80-90 days) dwarf variety having brown colour panicle with fine, selender long grains and test weight of 23.2 g/1000 grains. The yield potential ranges between 30-40 g/ha.

(V_4) IR-36 : It is evolved from cross between IR-1561' IR-24^4 " Oryza nivara "' CR-94-1. It is early to medium duration (115 days) variety with profuse tillering and dark green colour having weight of 21g per 1000 grains. The yield potential of this variety ranged between 40-50 q/ha.

(V_5) Pusa-33 : It is evolved from cross between improved Savarmati - 370 x IR-8 at IARI in 1977. It is dwarf statured and attains a height of 90-95 cm and matures in 110 days. It has long selender and fine grains and the yield potential is 45-50 q/ha.

(V_6) Cauvery : (IET-355) It is developed from cross between T.N.1 x TKM-6 at Hyderabad. It is early maturing (105 days) variety with an yield potential of 35-45 q/ha and test weight of 21.5g. It is susceptible to blast and moderately resistant to stem borer having suitability under upland rainfed conditions.

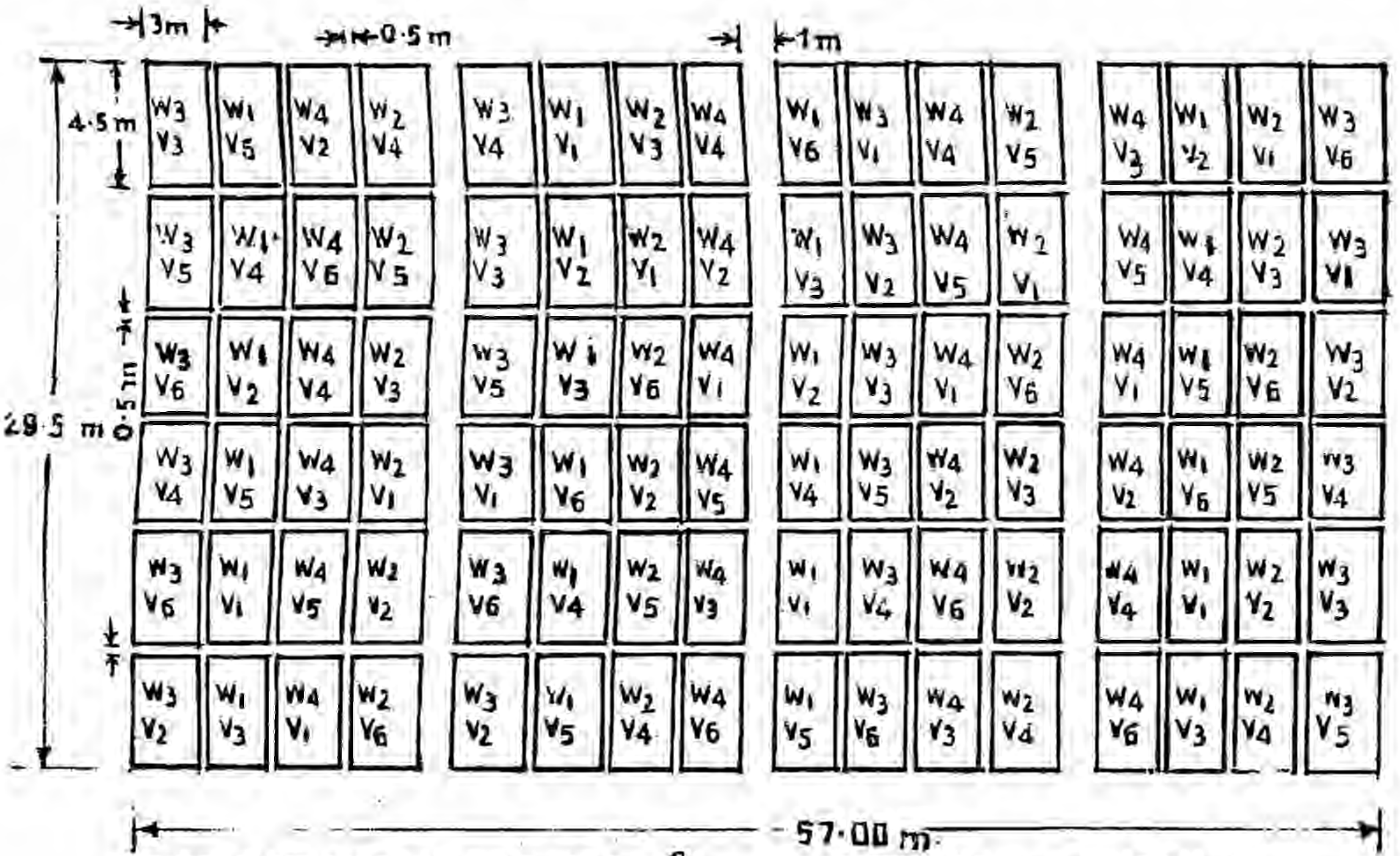
3.9. <u>Details of field preparation and fertilizer application</u>

The experimental field was harrowed three times by spring tined cultivator and finally levelled with wooden planker

FIG. 2

LAY OUT PLAN OF EXPERIMENT

SPLIT PLOT DESIGN



GROSS PLOT SIZE – 3m × 4.5 = 13.5 m^2

NET PLOT SIZE – 2.2 × 4.0 = 8.8 m^2

AREA OF MAIN PLOT = 3 × 29.5 = 88.5 m^2

AREA OF 1 REPLICATION 13.5 × 29.5 = 398.25 m^2

EXPT. AREA = 0.16315 ha
= 0.4159 ACRE

DATE OF SOWING – 12-7-86

DATE OF PRE-Em. – 13-7-86

before sowing. The field was then laid out according to plan of layout (Fig.2) by marking corners of the required dimensions. Field was provided with appropriate drainage channels in between the replications and main plots.

Then the half quantity of nitrogen and full quantity of phosphorus and potashic fertilizers was drilled properly after making the lines 20 cm apart in each main plot, manually.

3.10. Seed treatment and sowing

In order to protect seeds from fungal diseases, clean and bold seeds were treated with organic mercuric fungicide (Parasan) 2.5g per kg before sowing. Sowing was done manually by drilling in 20 cm rows. Then seeds were covered thoroughly with loose soil with a sickle.

3.11. Application of weed control treatments

3.11.1. Unweeded control For this treatment, the weeds were allowed to grow with rice crop and no weed control technique was employed.

3.11.2. Hand weeding once It is most coventional method for weed control in rice crop. One hand weeding was done at 20 days after sowing.

3.11.3. Herbicides Both herbicides oxadiazon and thiobencarb were applied one day after sowing as pre emergence. The spraying of herbicides was done by mixing the herbicide with 600 liter of water/ha. The quantity of water and herbicides for one main plot was dissolved separately. Spraying was done with Maruti foot sprayer using flat nozzle and spray solution for individual main plot was prepared a-fresh separately. After completing the spray in all replications sprayer was washed thoroughly with detergent powder and finally rinsed with fresh water.

Then another herbicide was sprayed uniformly.

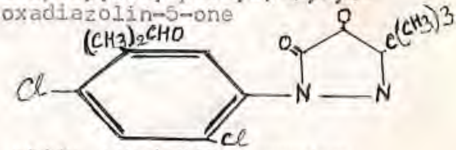
3.12. Characteristics of herbicides

3.12.1. Oxadiazon

Trade name — Ronstar

Chemical name — 2-tert-butyl-4-(2,4-dichloro-5-isopropyloxy phenyl)-1,3,4-oxadiazolin-5-one

Structural formula -



Properties It is odourless, white crystalline powder. Negligible soluble in water but soluble in all organic solvents.

Effectiveness It is selective, pre and post emergence herbicide. It shows promise for controlling annual grasses and broad-leaved weeds is several crops like rice - cotton, soybean, sunflower, sugarcane and peanut. Rate varies from 0.75 to 4 pounds a.i./ha depending on crop and weeds.

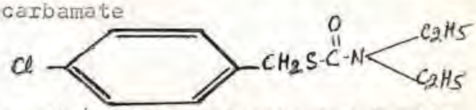
Mode of action It is principally a pre emergence herbicide shows some activity as early post emergence. Absorption is more efficient through roots than the foliage. In very susceptible species, the compound may be translocated to roots when applied post emergence, contact action by affecting the young shoot as it grows through the treated zone (Pre em.) and by complete coverage (post em.).

3.12.2. Thiobencarb

Group - Thiocarbamate

Trade name - Saturn, Bolero

Chemical name - S-(4-Ch-lorobenzyl) - N, N-diethyl thiocarbamate

Structural formula 

Properties It is soluble in all organic solvents but hardly soluble in water (30 ppm) at 20°C and appears as light yellow liquid.

Effectiveness It is selective, pre seeding and post emergence herbicide and most effective against various graminaceous weeds. It possesses a high intergeneric selectivity between rice plants and graminaceous weeds.

Mode of action It is growth inhibition type herbicide which kills the weeds by inhibiting formation and elongation of stems and leaves of weeds. It exhibits herbicidal efficacy mainly by inhibiting protein synthesis and does influence their respiration and photosynthesis in weeds. When it is applied in high concentration on weeds, it causes scorching of seedlings by contact action.

3.13. Split application of nitrogen

The remaining half quantity of nitrogen was applied by broad casting as urea fertilizer on 6.8.86 just before the tillering stage. The quantity for one main plot was calculated and spreaded uniformly in each main plot.

3.14. Irrigation

The experimental field was irrigated twice by canal water, during dry spell.

3.15. Plant protection

Plant protection measures were adopted to control insect and pests. An attack of white aphids (Sogottela furciferera Horwath.) was observed in all the plots. Ekatin 25 EC 2 Ml. per liter of water was sprayed on 12.8.86 for effective control.

3.16. Watching

Due to differential maturity of rice varieties bird attack was protected by watchman carefully.

3.17. Harvesting

Harvesting was done of ripened varieties. First two border rows from both side in length and 0.25 meter from both side in the width were removed leaving a net plot area of $8.8m^2$. The net plot was harvested by manual labourers with the help of sickles from the uniform height and crop biomass was kept in the plots for two days for sundrying.

Table 3 : Date of harvesting and threshing of different varieties

Varieties	Date of harvesting	Maturity duration	Date of threshing
CRM 13-32-41	29.9.86	80	4.10.86
JR-75	08.10.86	90	13.10.86
Purva	08.10.86	90	13.10.86
IR-36	05.11.86	117	10.11.86
Pusa-33	05.11.86	117	10.11.86
Cauvery	20.10.86	102	25.10.86

3.18. Threshing and winowing

After sun drying for five days, bundels were made and weighed in kg per net plot. Then bundels of each net plot were threshed separately by beating with sticks. The grains were cleaned with hand fan (Supa) and grain yield was recorded accurately in kg per net plot.

3.19. Weed studies

3.19.1. Associated weed flora

All the weed species associated with upland rice were identified and recorded according to their coteledons and families.

3.19.2. Population and relative density of weeds

The population of associated weeds with upland rice were recorded three times at 20, 35 and 50 days after sowing. The total number of weeds were recorded from each plot by quadrate count method by throwing a quadrate of $0.25m^{-2}$ randomly at four places. The weeds were grouped according to their nature of cotyledons i.e. sedges, grasses and broad-leaved weeds.

Then, relative density of weed species was worked out on hectare basis at 20 and 50 days stage as per formula proposed by Mishra (1968).

$$\text{Relative density} = \frac{\text{Number of individuals of the same species}}{\text{Number of individuals of all species}} \times 100$$

3.19.3. Growth study of weeds

The study were made with regard to height and LAI of 4 dominant weed species viz. *Cyperus* spp., *Cynodon dactylon*, *Commelina communis* and *Echinochloa* spp. at 35 and 50 DAS. The random sampling procedure was adopted in order to select unbiased and real representative plants for study. The weed plants samples containing five plant of each concerned species were uprooted.

Height

The hight of 5 plants of each species was measured in centimeter from ground level upto the longest tip and then mean height was recorded.

Leaf Area Index

Length and width of five leaves of the respective species on five plants were measured in centimeter from each plot. Number of leaves were counted on five plants of individual species.

Then, LAI was worked out as per formula proposed by Lazorov (1965).

$$LAI = \frac{L \times W \times K \times N \times n}{P}$$

whereas - L = Mean length of leaves

W = Mean width of leaves

K = Constant (0.67)

N = Number of leaves per plant

n = Number of plant/m^{-2}

p = Ground area

3.19.4. Dry matter of weeds

Before harvest of the crop, all associated weeds were collected randomly from a $0.25m^{-2}$ quadrat at four places in each plot. Weeds were kept in paper bags, species wise saparately viz. *Cyperus* spp. *Cynodon dactylon*, *Commelina communis*, *Echinochloa* spp., *Eclipta alba* and other weed species. Then, weeds were dried in oven at 60°C for 24 hours and weighed in gram/m^{-2}. By adding the dry matter of different weed species, total dry matter of weeds was computed.

3.19.5. Weed control efficiency

The weed control efficiency was computed for weed control techniques only because they were applied in main plot. Different weed control techniques were compared with unweeded control and efficiency was calculated by formula given :

$$\text{Weed control efficiency} = \frac{\text{Dry weight of control plot} - \text{Dry weight of treated plot}}{\text{Dry weight of control plot}} \times 100$$

3.20. Crop studies

3.20.1. Pre harvest study

3.20.1.1. Plant population

Plant population was recorded from five fixed places marked by fixing pegs on either side of the meter row length in each plot. Observations were recorded at 12, 24, 36 and 60 days after sowing, during the different stages of growth.

3.20.1.2. Seedling mortality count

The number of plants per meter row length at 12 DAS from each treatment were considered as initial plant stand.

The number of plants per meter row length at 24 DAS were considered as final plant stand after treatment, which were substracted from initial plant stand (12 DAS) for mortality of seedlings per meter row length. Then, the mortality percentage was worked out.

3.20.1.3. Crop growth study

In order to study the influence of weed control techniques and varieties on growth and development of rice, observations were recorded at four time i.e. 24, 36, 60 DAS and at harvest on samples of five plants per plot. Unbiased samples were taken randomly by uprooting the plants from each plot and the study were made on following parameters.

3.20.1.3a. Plant height

Four observations on plant height was recorded on five plants per plot in centimeter from ground level upto the longest leaf tip and then mean plant height was computed.

3.20.1.3b. Leaf Area Index

The length of randomly selected five leaves was measured in centimeter from the base of the leaf to the longest tip and width was measured from the widest portion of leaf. The number of leaves per plant in each five plants per plot were also counted then, mean of length width and number of leaves per plant was computed at different stages of growth.

The LAI was calculated as per formula proposed by Lazorov (1965).

$$LAI = \frac{L \times W \times K \times N \times n}{p}$$

Whereas, L = Length of leaves (cm)
W = Width of leaves (cm)
K = Constant, 0.66 (Lazorov, 1965)
N = Number of leaves per plant
n = Number of plants/m^{-2}
p = Ground area

3.20.3c. Plant biomass

During the different stages of growth, the plant samples were washed thoroughly with water to remove the soil from roots and kept in paper bags separately. Then, dried in oven at 60^{o}C for 24 hours and constant weight was recorded in gram per plant.

3.20.1.4. Number of effective and ineffective tillers

Total tillers were recorded from the five plants per plot. Ear bearing tillers were recorded as effective tillers. The ineffective tillers were calculated by substracting the ear bearing tillers from the total tillers and then mean number of effective and ineffective tillers per plant were computed.

3.20.2. Post harvest study

3.20.2.1. Panicle length

Length of five randomly selected panicles was measured in centimeter from the ring at the base to the tip of the panicle. Then, mean length in centimeter per panicle was worked out.

3.20.2.2. Panicle weight

The weight of planicles of five plants was recorded. Then, mean panicle weight was calculated in gram/panicle.

3.20.2.3. Grain weight per panicle

Panicles were threshed and clean grains were weighed on electric balance to record the total grain weight and mean grain weight per panicle in gram.

3.20.2.4. Number of fertile and sterile grains per panicle

The sound grains were considered as fertile grains while, unfilled grains were as sterile and both were counted from the panicles of five plants per plot. Then, mean of fertile and sterile grains per panicle was recorded.

3.20.2.5. Sterility percentage

Sterility percentage was worked out by the formula given below :

$$\text{S.P.} = \frac{\text{Number of sterile grains}}{\text{Number of sterile grains} + \text{number of fertile grains}} \times 100$$

3.20.2.6. Test weight

Random samples were taken from the threshed grains and 1000 grains per plot were counted and then weight was recorded in gram.

3.20.2.7. Crop biomass

The harvested plants from each net plot were tied in separate hundels and weight was recorded in kilogram and later on converted to q/ha.

3.20.12. Grain yield

After threshing and cleaning the grains, per plot yield was recorded in kilogram and later on converted into q/ha.

3.20.13. Straw yield

The grain yield per plot was deducted from the total biomass and thus straw yield was calculated in kilogram and then calculated in terms of q/ha.

3.20.13. Harvest Index ratio

The harvest index ratio was calculated by using formula proposed by Singh and Stoskopf, (1971).

$$H.I. = \frac{\text{Economical yield}}{\text{Biological yield}} \times 100$$

3.21. Economics of weed control treatments

Comparative economics of different weed control techniques was worked out in comparison to unweeded control as mentioned below :

$$\text{Extra income due to control} = \text{Cost of extra yield obtained due to weed control over unweeded control} - \text{Cost of herbicides used + application charges}$$

The economics was worked out on the basis of labour requirement for hand weeding operation, cost of herbicides and their application charges and the return from produce at prevailing market rates. The requirement of labour for hand weeding and spraying in a hectare area was calculated on the basis of time taken for application of concerning treatment.

3.22. Statistical analysis

The data on weed count and rice plant population count showed considerable variation, hence subjected to square root transformation i.e. $\sqrt{x + 1/2}$ before analysing statistically. Comparison were made on transformed data back on original scale. The normal data was analysed by the method of analysis of variance as described by Fisher (1957).

A N O V A

Source of variation		df
Replications (R)		(r - 1)
Main plot treatments (P)		(p - 1)
Error (a)		(r - 1 (p - 1)
Sub plot treatments (Q)		(q - 1)
Interaction (P x Q)		(p - 1) q - 1)
Error (b)		p (r - 1) (q - 1)
Total	RPQ	rpq - 1

The significant differences between mean were determined by using critical differences at 5 per cent level of significance, which were calculated as given below :

(i) SE(d) between two main plot treatment means $= \sqrt{\frac{2Ems\ (a)}{r \times q}}$

CD(5%) = SE(d) x t (5%) at Error (a) df

(ii) SE(d) between two sub plot treatment means $= \sqrt{\frac{2Ems\ (b)}{r \times p}}$

CD(5%) = SE(d) x t (5%) at Error (b) df

(iii) SE(d) between two main plot treatment means at the same or different levels of sub plot means $= \sqrt{\dfrac{2[(q-1)Ems(b) + Ems(a)]}{r \times q}}$

CD(5%) = SE(d) x t (5%) (Weighted)

$$\text{Weighted } t = \frac{(q-1)Ems(b)t(b) + Ems(a)t(a)}{(q-1)Ems(b) + Ems(a)}$$

(iv) SE(d) between two sub plot treatment means at the same or different level of main plot treatment means $= \sqrt{\dfrac{2\ Ems(b)}{r}}$

CD(5%) = SE(d) x t (5%) at Error (b) df

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CHAPTER IV

EXPERIMENTAL RESULTS

EXPERIMENTAL RESULTS

This chapter deals with the varietal tolerance and effectiveness of herbicides on weeds. The data were analysed statistically and the findings of the investigation have been presented as weed and crop study, respectively.

4.1. WEED STUDY

4.1.1. Associated weed flora

The weed flora of the experimental field are presented in Table 4.

Table 4 : Weed flora of the experimental field

Botanical name	Local Name	Family
Monocot		
Echinochloa crusgalli (L) Beauv.	Sawan/Barn yard grass	Graminae
Echinochloa Crusgalli var. Oryzicola Ohwii.	-	Graminae
Cynodon dactylon (L) Pers.	Doob/Barmuda grass	Graminae
Paspalim distichum L.	Knot grass	Graminae
Digitaria adscendens Henr.	-	Graminae
Commelina communis (L) Hassk.	Kan Kawa	Commelinaceae
Cyperus rotundus L.	Motha/purple sedge	Cyperaceae
Cyperus iria L.	Rice flat sedge	Cyperaceae
Cyperus difformis L.	Umbrella plant	Cyperacear
Dicot		
Eclipta alba Hassk.	Ghamara/Falsedaisy	Compositae
Caesulia axillaris Roxb.	Bilja	Compositae
Ludwigia parviflora Roxb.	-	Onagraceae
Phyllanthus niruri L.	-	Euphorbiacae
Trianthema monogyana (L.) Mant.	-	Aizoaceae
Sesbania aculeata Pers.	Jayanti	Papilionaceae
Ageratum conyzoides L.	-	Agavaceae
Physalis minima L.	Rasbhari/Mokoia	Solanaceae
Lindenbergia indica L.	-	Scrophulariaceae

The table 4 shows that there were nine monocotyledonous and nine dicotyledonous weeds present in the field. Among which the mono cotyledonous flora were consisted of five genera of grassy weeds, three sedges and one broad-leaved type from three families. Where-as dicotyledonous were comprised from nine different generas of eight families.

4.1.2. Population and Relative Density of weeds

The dominant weeds prevailed in the experimental field and their relative density at 20 and 50 DAS are presented in Table 5.

Table 5 : Population and relative density of dominant weeds

Botanical name	20 DAS		50 DAS	
	Population /ha	Relative density %	Population /ha	Relative density %
Monocot				
Cyperus spp.	1352083.4	59.22	1340208.3	60.16
Commelina communis	245000.0	10.73	208229.2	9.35
Cynodon dactylon	188750.0	8.26	186041.7	8.35
Echinochloa spp.	167187.0	7.32	111458.3	5.00
Total	1953020.9	85.53	1845937.5	82.86
Dicot				
Eclipta alba	18708.3	8.19	97708.3	4.38
Other weed spp.	143125.0	6.25	283854.2	12.74
Grand total	2283229.2	99.97	2227500.0	99.98

Data show that monocot weeds consisted of 85.53 and 82.86 per cent of total weed population (22.83 & 22.27 lakhs/ha) at 20 and 50 DAS, respectively.

The density of *Cyperus* spp. was the highest i.e. 59.22 and 60.16 per cent of the total weed flora at 20 and 50 daystages. The population of *Commelina communis* ranked second (10.73) followed by *Cynodon dactylon* (8.26%) and *Echinochloa* spp. (7.32%) at 20 days after sowing. At 50 daystage, the density of *Commelina communis* and *Echinochloa* spp. showed reduction (9.35 and 5.0 P.C.) but *Cynodon dactylon* remained unaffected.

Amongst dicot weeds *Eclipta alba* showed reduction (4.38%) at 50 DAS as compared to 20 daystage (8.19%). Other dicotyledonous weed species were increased just twice 12.74% at 50 daystage which were only 6.25% at 20 DAS.

4.1.3. Population of weeds

The population of dominant weeds viz. *Cuperus* spp. *Cynodon dactylon*, *Commelina communis*, *Echinochloa* spp. *Eclipta alba* and other weed species as affected by different treatments are presented in Table 6.

4.1.3. (i) *Cyperus* spp.

Data (Table 6) clearly show that both herbicides decreased the *Cyperus* sp. population (63.33 & 72.16 m^{-2}) signfiicantly as compared to unweeded plot (202.83 m^{-2}). Oxadiazon controlled the weed population more efficienty than thiobencarb, although they were statistically at par at 20 daystage.

At 35 DAS, the population of *Cyperus* spp. was reduced significantly by all the methods of weed control. Hand weeding (19.37 m^{-2}) ranked superior followed by oxadiazon (50.08 m^{-2})

Table 6 : Population of dominant weeds m^{-2} as influenced by weed control methods and varieties at different stages of growth

Treatment	Cyperus spp.			Cynodon dactylon			Commelina communis			Echinochloa spp.		
	20 DAS	35 DAS	50 DAS	20 DAS	35 DAS	50 DAS	20 DAS	35 DAS	50 DAS	20 DAS	35 DAS	50 DAS
Unweeded control	14.08 (202.83)	17.72 (315.41)	18.75 (331.33)	4.68 (22.58)	5.02 (27.33)	5.19 (27.33)	5.29 (29.58)	5.35 (29.83)	5.50 (31.46)	5.15 (27.17)	5.01 (25.42)	4.98 (25.00)
Hand Weeding once 20 DAS	14.08 (202.83)	4.31 (19.37)	5.48 (33.25)	4.68 (22.58)	1.43 (2.21)	1.99 (4.21)	5.29 (29.58)	1.41 (2.21)	2.04 (5.37)	5.15 (27.17)	1.43 (2.21)	2.86 (8.67)
Oxadiazon 1 kg/ha	7.80 (63.33)	6.95 (50.08)	7.16 (52.87)	4.46 (21.00)	4.75 (23.25)	4.86 (23.95)	4.02 (17.17)	4.03 (17.50)	4.03 (19.12)	1.97 (4.21)	1.70 (3.20)	2.03 (4.33)
Thiobencarb 2 kg/ha	8.22 (72.16)	8.97 (83.95)	10.77 (120.95)	3.87 (15.50)	4.52 (21.04)	4.29 (18.92)	4.49 (21.91)	4.74 (23.33)	4.60 (21.96)	2.84 (8.33)	2.46 (6.42)	2.57 (6.58)
SEm ±	0.66	0.49	0.71	0.32	0.14	0.15	0.27	0.24	0.23	0.18	0.09	0.16
CD at 5%	2.12	1.57	2.28	-	0.45	0.47	0.87	0.77	0.74	0.55	0.29	0.52
CRM 13-32-41	10.19 (120.00)	9.38 (116.00)	10.29 (134.68)	4.27 (19.00)	3.86 (17.19)	4.08 (18.37)	4.57 (22.50)	4.17 (20.56)	4.33 (22.10)	3.57 (14.05)	2.41 (7.87)	2.99 (10.31)
JR-75	10.86 (129.50)	9.73 (124.12)	10.31 (133.31)	4.68 (25.00)	4.08 (18.87)	4.00 (18.06)	5.00 (26.87)	3.68 (16.43)	4.11 (19.43)	4.15 (20.18)	2.72 (9.69)	3.02 (10.75)
Purva	11.02 (135.25)	9.15 (110.25)	10.05 (131.37)	4.50 (20.87)	4.06 (19.25)	4.06 (18.93)	4.82 (24.50)	4.07 (20.00)	3.98 (18.25)	3.55 (14.00)	2.62 (9.12)	3.08 (11.18)
IR-36	10.81 (137.37)	9.71 (120.85)	10.71 (138.87)	4.37 (20.12)	3.75 (16.31)	4.01 (17.62)	4.43 (21.00)	3.63 (15.56)	3.96 (17.37)	4.18 (21.25)	2.67 (9.62)	3.17 (11.81)
Pusa-33	11.80 (153.00)	9.70 (118.37)	10.30 (127.81)	4.25 (18.87)	3.87 (17.62)	4.65 (18.75)	5.16 (28.37)	3.87 (17.81)	4.09 (18.81)	3.47 (13.87)	2.77 (10.00)	3.14 (11.44)
Cauvery	11.97 (140.00)	9.27 (113.67)	10.68 (141.56)	4.48 (20.87)	3.98 (19.00)	4.18 (19.87)	4.68 (24.12)	3.89 (19.00)	4.19 (20.81)	3.75 (16.50)	2.74 (9.50)	3.16 (11.38)
SEm ±	0.46	0.31	0.30	0.16	0.16	0.15	0.27	0.23	0.22	0.14	0.13	0.12

Original data are given in parenthesis

and thiobencarb (83.95 m^{-2}). The same trend was noted at 50 DAS, whereas the varietal and interaction effects with weed control techniques were not significant.

4.1.3. (ii) Cynodon dactylon

The density of C. dactylon shows that there was not significant reduction in population due to any weed control treatment at 20 DAS. Later on at both the stages hand weeding reduced the population more efficiently. The varietal effects and interactions were not significant on this weed.

4.1.3. (iii) Commelina communis

Data recorded in Table 6 clearly show significant reduction in population of Commelina communis under oxadiazon treatment, but thiobencarb could not reached upto the level of significance at 20 and 35 daystages. However, significant reduction (21.96 m^{-2}) at 50 DAS was noted as compared to unweeded control (31.46 m^{-2}). The hand weeding was highly significant to minimize the population at later stages. The variations due to varieties and interaction were not significant.

4.1.3. (iv) Echinochloa spp.

The density of Echinochloa spp. varied significantly under all the weed control treatments at all dates but the varietal and interaction differences were not significant. The data in Table 6 revealed that both pre emergence herbicides had pronounced effect in reduc-ing the population of Echinochloa spp. at 20 daystage. The effect of hand weeding (2.21 m^{-2}) and oxadiazon (3.2 m^{-2}) was at par and both were significantly

Table 7 : Population of *Eclipta alba*, other weed spp. and total weeds m^{-2} as influenced by weed control methods and varieties at different stages of growth

Treatment	*Eclipta alba*			Other weed spp.			Total weed population		
	20 DAS	35 DAS	50 DAS	20 DAS	35 DAS	50 DAS	20 DAS	35 DAS	50 DAS
Unweeded control	5.03 (25.83)	3.36 (11.67)	3.33 (11.37)	4.73 (23.08)	5.14 (26.83)	4.75 (23.00)	18.09 (331.08)	20.81 (436.04)	21.15 (449.93)
Hand weeding once 20 DAS	5.03 (25.83)	1.70 (3.17)	2.81 (8.33)	4.73 (23.08)	7.65 (58.62)	7.64 (59.33)	18.09 (331.08)	8.20 (69.04)	10.84 (119.25)
Oxadiazon 1 kg/ha	3.61 (13.67)	3.41 (12.46)	3.33 (11.58)	1.85 (3.58)	2.09 (4.79)	2.96 (9.37)	11.00 (123.71)	10.50 (111.45)	11.04 (120.95)
Thiobencarb 2 kg/ha	3.03 (9.50)	2.92 (9.08)	2.73 (7.62)	2.67 (7.33)	3.04 (9.92)	4.65 (21.83)	11.41 (133.91)	12.31 (153.91)	14.17 (199.91)
SEm ±	0.20	0.22	0.32	0.25	0.19	0.16	0.73	0.34	0.67
CD 5%	0.63	0.71	-	0.81	0.61	0.52	2.34	1.10	2.14
CRM-13-32-41	4.26 (19.00)	2.81 (9.25)	3.64 (9.94)	3.48 (14.00)	4.49 (23.75)	4.98 (28.85)	14.17 (208.87)	13.20 (194.62)	14.26 (224.56)
JR-75	4.45 (21.37)	2.90 (9.44)	3.02 (9.44)	3.58 (15.50)	4.47 (25.81)	4.95 (27.35)	14.81 (238.18)	13.44 (204.37)	14.30 (218.31)
Purva	4.17 (19.00)	2.82 (8.75)	3.10 (10.13)	3.41 (13.25)	4.37 (16.50)	4.86 (26.69)	14.56 (221.75)	12.64 (186.75)	13.96 (216.68)
IR-36	4.16 (18.75)	2.93 (9.50)	3.00 (9.28)	3.62 (15.25)	4.77 (17.94)	5.08 (29.43)	14.47 (230.12)	12.78 (190.12)	14.39 (224.37)
Pusa-33	4.14 (18.25)	2.89 (9.56)	2.96 (9.25)	3.36 (13.62)	4.83 (20.87)	5.18 (30.31)	15.21 (245.12)	13.33 (190.37)	14.20 (218.62)
Cauvery	3.90 (16.00)	2.74 (8.31)	3.18 (10.63)	3.53 (14.00)	4.26 (15.38)	4.96 (27.75)	14.71 (231.50)	12.55 (189.43)	14.68 (232.37)
SEm ±	0.13	0.13	0.12	0.14	0.17	0.15	0.40	0.30	0.44

Original data are given in parenthesis

superior than thiobencarb (6.42 m^{-2}) and unweeded plot (25.41 m^{-2}) at 35 DAS. At 50 daystage, oxadiazon had minimum population (4.33 m^{-2}) which was at par to thiobencarb (6.58 m^{-2}) and significantly superior over hand weeding (8.67 m^{-2}) and unweeded control (25.0 m^{-2}).

4.1.3. (v) Eclipta alba

Data (Table 7) revealed that none of the weed control treatments was able to control population of Eclipta alba for a long time effectively. Although at 20 daystage both pre emergence herbicides viz. oxadiazon (13.67 m^{-2}) and thiobencarb (9.5 m^{-2}) minimized the population significantly as compared to unweeded plot (25.83 m^{-2}). But at later stages they were at par. Hand weeding had significantly lower population at 35 daystage, while at 50 DAS, it was also at par to no weeding. The varietal effects and interaction were not significant on population of Eclipta alba.

4.1.3. (vi) Other weed spp.

The population of other weed species was significantly reduced by oxadiazon at all the dates of measurements. The data in Table 7 indicate that thiobencarb also controlled the other weed population significantly upto 35 daystage, but at later stage it was (21.83 m^{-2}) at par with control plot (23.0 m^{-2}). The hand weeding treatment had the highest weed population at later stages which was significantly greater in number (59.33 m^{-2}) over control plot. Effects of varieties and interaction of variety x weed control techniques were not significant.

4.1.3. (vii) Total weed spp.

At 20 DAS, the intensity of total weed flora was significantly lower under oxadiazon(123.71 m^{-2}) and thiobencarb (133.91 m^{-2}) than unweeded control (331.08 m^{-2}). While, hand weeding was not applied upto this stage. At 35 DAS, hand weeding ranked first to minimize weed population (69.04 m^{-2}) followed by oxadiazon (111.45 m^{-2}) and thiobencarb (153.91 m^{-2}). The highest population was noted in unweeded plot (436.04 m^{-2}). The same trend was noted at 50 daystage. The influence of varieties & varieties x weed control methods interaction were not significant at all the intervals on total weed population.

4.1.4. Grwoth study of weeds

4.1.4(a) Height

4.1.4a. I. Cyperus spp.

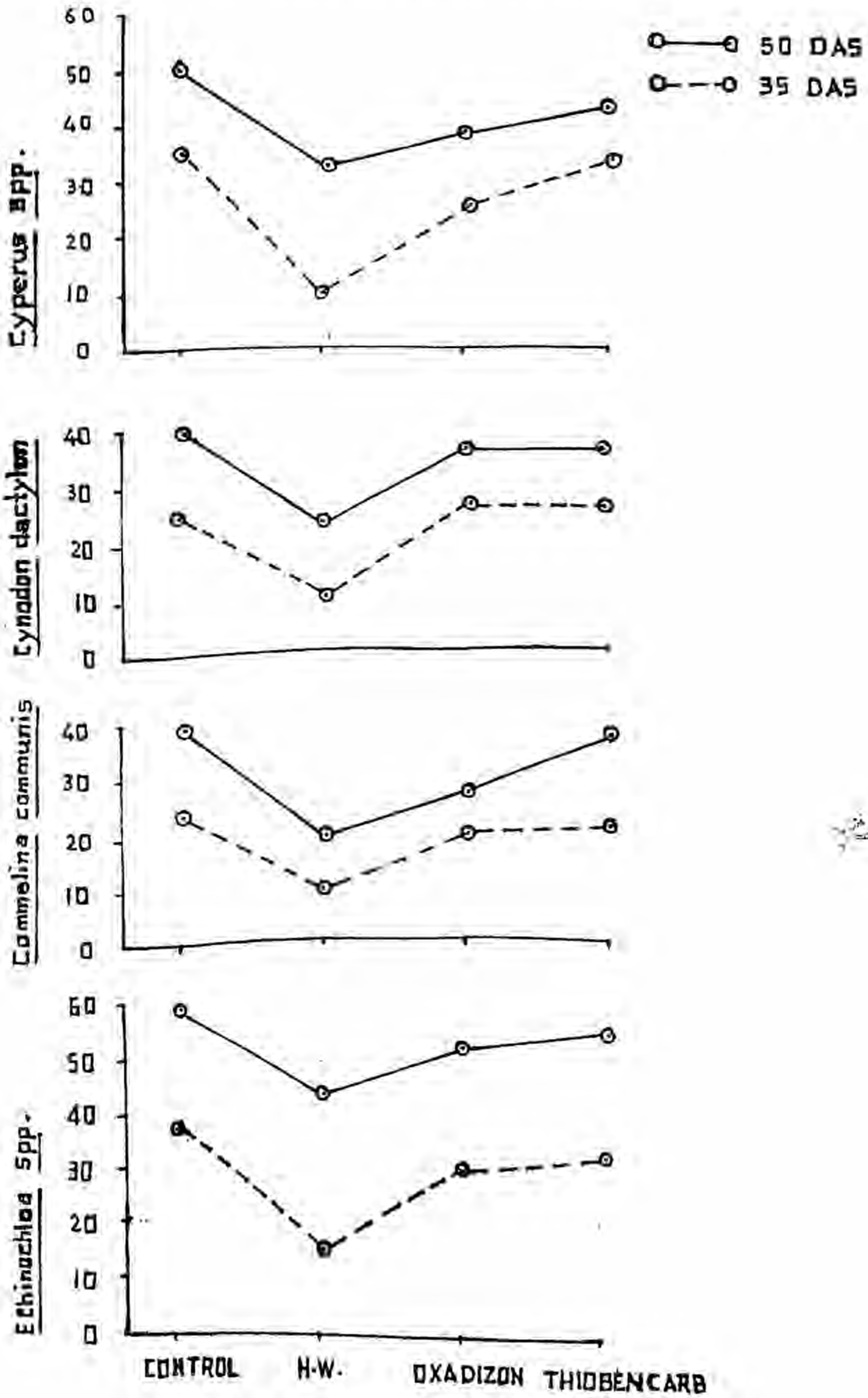
Cyperus height varied significantly due to weed control treatments at 35 and 50 daystages. Data (Table 8 & Fig.3) indicate that the minimum height was recorded under hand weeding (9.37 cm) followed by oxadiazon (25.05 cm) and thiobencarb (33.63 cm) as compared to unweeded control (35.37 cm) at 35 daystage. The same trend was found at 50 daystage, though in hand weeding treatment, height was considerably increased.

The effect of varieties was not significant. However, early maturing varieties having faster growth, supressed the height of Cyperus spp. as compared to varieties with medium maturity. The interaction of weed control techniques and varieties was not significant in this regard.

Table 8 : Plant height (cm) of dominant weeds as influenced by weed control methods and varieties

Treatment	Cyperus spp.		Cynodon dactylon		Commelina communis		Echinochloa spp.	
	35 DAS	50 DAS	35 DAS	50 DAS	35 DAS	50 DAS	35 DAS	50 DAS
Unweeded control	35.37	49.95	24.73	39.71	22.90	39.31	37.89	58.66
Hand weeding once	9.37	32.34	9.68	23.12	8.83	18.84	14.83	42.80
Oxadiazon 1 kg/ha pre emergence	25.05	38.46	25.39	35.51	19.78	36.25	29.54	50.70
Thiobencarb 2kg/ha pre emergence	33.63	43.43	25.94	35.34	20.83	36.84	31.58	54.08
SEm ±	0.90	0.78	0.43	1.20	0.70	1.40	1.05	1.56
CD 5%	2.85	2.50	1.37	3.80	2.25	4.50	3.36	4.98
CRM 13-32-41	25.85	39.92	21.66	32.96	17.37	33.96	27.95	50.04
JR-75	26.46	39.20	20.96	34.36	18.22	32.91	28.26	50.52
Purva	26.14	39.95	21.65	32.11	17.83	32.74	28.71	51.63
IR-36	25.49	41.48	21.57	34.25	18.51	31.19	28.55	51.88
Pusa-33	25.81	42.05	21.26	31.96	18.25	32.80	28.60	51.82
Cauvery	25.45	41.61	21.54	34.60	18.67	33.28	27.90	53.48
SEm ±	1.12	1.35	0.89	1.67	0.61	1.31	0.75	1.70

FIG. 3: PLANT HEIGHT OF DOMINANT WEEDS AS INFLUENCED BY WEED CONTROL METHODS



4.1.4a. II. Cynodon dactylon

The height of Cynodon dactylon did not reduce under oxadiazon and thiobencarb treated plots at both the stages. While, hand weeding significantly decreased it (9.68 & 23.12 cm) as compared to unweeded control (24.73 & 39.71 cm) at 35 and 50 daystages.

The varietal effects and interaction with weed control treatments were not significant at any stage.

4.1.4a.III. Commelina communis

Height of Commelina communis was reduced significantly under hand weeding (8.83 cm) followed by oxadiazon (19.78 cm). But thiobencarb (20.83 cm) was at par with unweeded plot (22.90 cm) at 35 daystage. At 50 DAS, significant reduction in height was noted under hand weeding only while, oxadiazon as well as thiobencarb remained at par with control plot.

The varietal effects and interaction were not significant.

4.1.4a. IV. Echinochloa spp.

Data (Table 8 & Fig. 3) indicate that height was significantly reduced by all weed control treatments. The plant height under hand weeding, oxadiazon and thiobencarb was 14.83, 29.54 and 31.58 cm respectively. While, in unweeded plot it was 37.38 cm at 35 daystage. At 50 DAS, hand weeding and oxadiazon had significantly short statured plants (42.8 & 50.7 cm), but thiobencarb could not reduce height upto level of significance (54.08 cm) as compared to unweeded plot (58.66 cm).

While, the influence of varieties and interaction was not significant on height of Echinochloa spp. at both stages.

4.1.4b. Leaf Area Index

4.1.4b. I. Cyperus spp.

Data recorded in Table 9 & Fig. 4 show that amongst weed control techniques, hand weeding significantly reduced the leaf area index (0.021) followed by oxadiazon (0.146) and thiobencarb (0.426). LAI was maximum under unweeded plot (0.803) at 35 daystage. The same trend was found at 50 days after sowing.

The effects of varieties as well as interaction between weed control techniques x varieties were not significant. However, it was observed that early maturing varieties reduced the leaf area index to the greater extent as compared to medium duration varieties.

4.1.4b. II. Cynodon dactylon

The leaf area index of Cynodon dactylon was significantly reduced under hand weeded treatment at both stages. While, under herbicidal treatments it was not reduced.

The varietal effects and interaction of weed control techniques x varieties were also not significant.

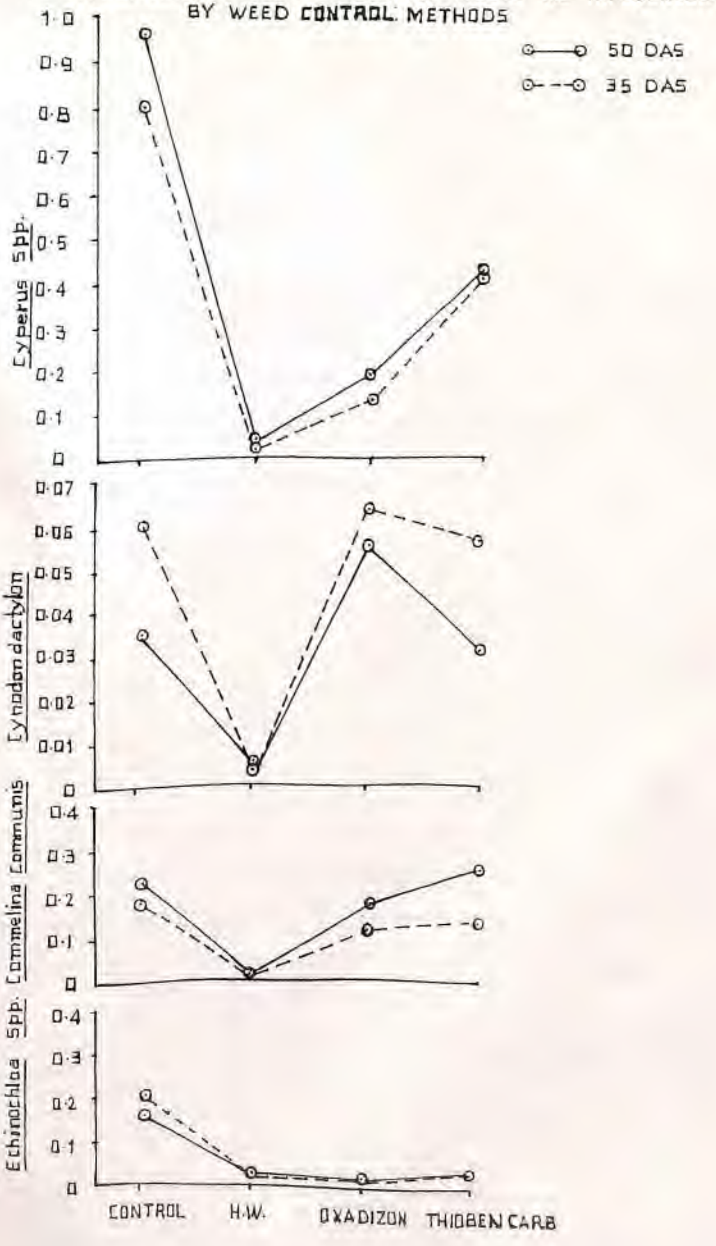
4.1.4b. III. Commelina communis

The leaf area index of Commelina communis was reduced significantly by all the weed control techniques upto 35 daystage. While, at 50 DAS, hand weeding and oxadiazon had significantly lower LAI (0.012 & 0.165) as compared to control and thiobencarb

Table 9 : LAI of dominant weeds as influenced by weed control methods and varieties

Treatment	Cyperus spp.		Cunodon lactylon		Commelina communis		Echinochloa spp.	
	35 DAS	50 DAS	35 DAS	50 DAS	35 DAS	50 DAS	35 DAS	50 DAS
Unweeded control	0.803	0.958	0.060	0.035	0.191	0.227	0.210	0.161
Hand weeding once	0.021	0.041	0.003	0.004	0.011	0.012	0.027	0.032
Oxadiazon 1 kg/ha pre emergence	0.146	0.186	0.063	0.035	0.107	0.165	0.022	0.023
Thiobencarb 2 kg/ha pre emergence	0.426	0.428	0.056	0.030	0.127	0.243	0.033	0.037
SEm ±	0.031	0.042	0.005	0.003	0.012	0.014	0.004	0.008
CD at 5%	0.101	0.137	0.016	0.011	0.038	0.046	0.013	0.025
CRM 13-32-41	0.285	0.394	0.048	0.030	0.105	0.174	0.065	0.061
JR-75	0.289	0.376	0.049	0.031	0.101	0.154	0.075	0.066
Purva	0.274	0.365	0.043	0.033	0.119	0.157	0.071	0.063
IR-36	0.341	0.428	0.038	0.027	0.110	0.168	0.080	0.061
Pusa-33	0.315	0.419	0.038	0.098	0.104	0.153	0.072	0.062
Cauvery	0.346	0.437	0.057	0.035	0.100	0.166	0.078	0.066
SEm ±	0.022	0.032	0.005	0.004	0.013	0.015	0.007	0.005

FIG. 4: LEAF AREA INDEX OF DOMINANT WEEDS AS INFLUENCED BY WEED CONTROL METHODS



plot which had LAI of 0.227 and 0.243, respectively.

As regard to varieties (Table 9) they did not cause significant variation in LAI and interaction with weed control treatments.

4.1.4b. IV. Echinochloa spp.

The significant reduction in LAI was noted at both the intervals by all weed control techniques. However, the effects of varieties and their interactions with weed control treatments were not significant on LAI of Echinochloa spp.

4.1.4c. Dry matter accumulation

4.1.4c. I. Cyperus spp.

Table 10 ~~and Fig. 5~~ showed that hand weeding and oxadiazon decreased the dry matter of Cyperus spp. more efficiently (4.66 & 9.91g). While, it was maximum under unweeded control (24.24g). Thiobencarb could not control the dry matter efficiently (21.78g) and was at par to unweeded plot.

As regard varieties, early cultivars viz. CRM 13-32-41, JR-75, Purva and Cauvery recorded more dry matter i.e. 16.47, 17.37, 16.03 and 14.15g m^{-2}, respectively. While medium varieties IR-36 and Pusa-33 had the lower dry weight (12.86 & 13.99g). IR-36 smothered the weeds significantly and produced less dry matter as compared to CRM 13-32-41, JR-75, Purva and Cauvery but it was at par with pusa-33.

The variety x weed control treatment interaction on dry matter production was not significant.

4.1.4c. II. Cynodon dactylon

The dry matter of C.dactylon was significantly lower under hand weeding (1.8g) as compared to herbicidal treatments. The variations due to varieties and weed control treatments x varieties interactions were not significant.

4.1.4c. III. Commelina communis

Data in Table 10 & Fig.5 revealed that hand weeding reduced the dry weight of Commelina communis (1.38g) efficiently. Amongst herbicides, oxadiazon (46.68g) significantly minimized the dry matter production, but thiobencarb (85.21g) was ineffective as compared to unweeded control (75.84g).

The varieties and their interaction effects with weed control treatments were not significant on dry matter at harvest.

4.1.4c. IV. Echinochloa spp.

All the weed control techniques decreased the dry matter yield of Echinochloa spp. significantly. Hand weeding was the superior, followed by oxadiazon and thiobencarb (6.1, 6.71 and 10.07g) as compared to unweeded control (53.92g).

The variation due to varieties and interaction between weed control treatment and varieties were not significant.

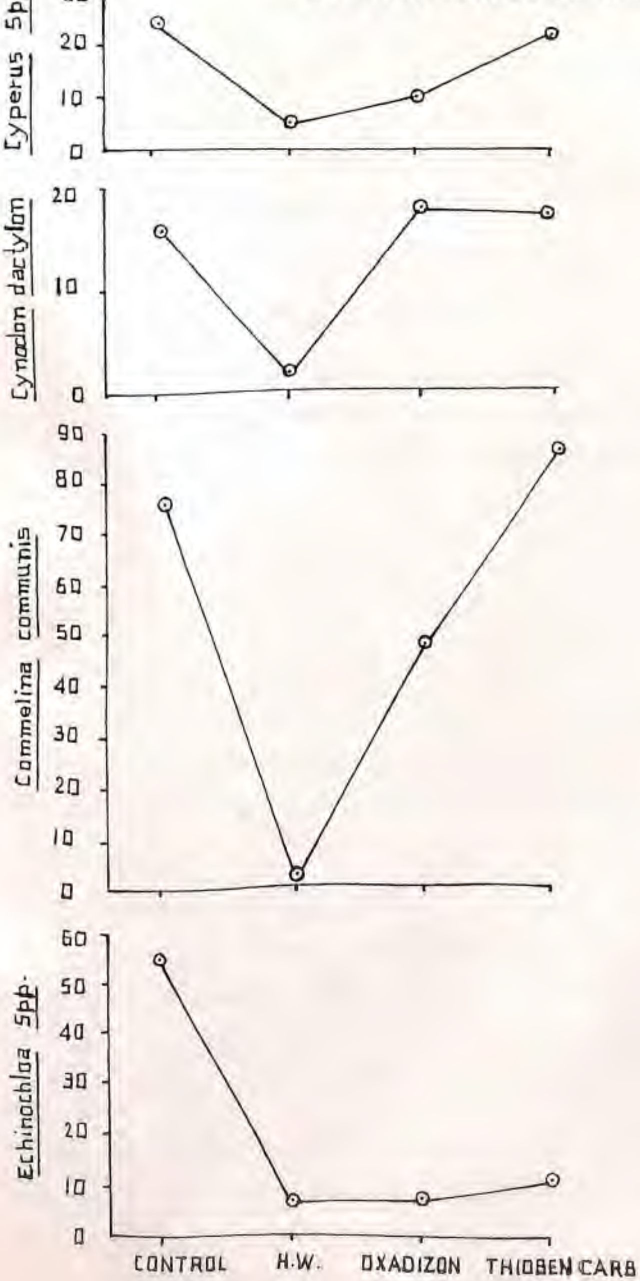
4.1.4c. V. Eclipta alba

Data in Table 10 showed that hand weeding only effectively controlled the dry matter of Eclipta alba (0.73g). While,

Table 10 : Dry matter accumulation of different weed spp. gm^{-2} as influenced by weed control methods and varieties at harvest

Treatment	Cyperus spp.	Cynodon dactylon	Commelina communis	Echinochloa spp.	Eclipta alba	Other weed spp.	Total dry matter	Weed control efficiency (%)
Unweeded control	24.24	15.08	75.84	53.92	1.37	10.21	181.68	-
Hand weeding once	4.66	1.80	1.38	6.10	0.73	6.43	21.12	88.37
Oxadiazon 1 kg/ha pre emergence	9.91	17.56	46.68	6.71	1.35	8.26	90.52	50.18
Thiobencarb 2 kg/ha pre emergence	21.78	17.10	35.21	10.07	1.32	7.90	143.47	21.03
SEm ±	0.87	0.60	2.77	1.70	0.07	0.83	2.15	-
CD at 5%	2.83	1.90	8.85	5.42	0.23	2.65	6.87	-
CRM 12-32-41	16.47	12.79	47.85	16.96	1.11	8.15	103.35	-
JR-75	17.37	13.80	59.53	16.27	1.10	8.09	116.19	-
Purva	16.03	14.98	47.70	16.77	1.00	7.60	104.09	-
IR-36	12.86	13.72	53.76	21.55	1.25	8.90	112.05	-
Pusa-33	13.99	11.77	47.51	23.22	1.33	7.76	105.79	-
Cauvery	14.15	11.66	57.45	20.44	1.18	8.75	113.73	-
SEm ±	1.04	0.83	4.66	2.11	0.11	0.99	4.47	-
CD at 5%	3.01	2.40	-	-	0.32	-	-	-

FIG.5: DRY MATTER ACCUMULATION OF DOMINANT WEEDS AS INFLUENCED BY WEED CONTROL METHODS



oxadiazon and thiobencarb (1.35 & 1.32g) were ineffective as compared to unweeded plot (1.37g).

As regard the varietal effects, Purva reduced the dry weight significantly over Pusa-33, other varieties were at par. While the interaction of varieties with weed control techniques did not reduce the dry weight, significantly.

4.1.4c. VI. Other weed spp.

The other weeds mainly consisted of dicot weeds were controlled significantly under hand weeding (6.43g). While, thiobencarb and oxadiazon (7.9 & 8.26g) did not differ significantly as compared to unweeded control (10.21g). The effects of varieties and interaction with weed control treatments were not significant.

4.1.4c. VII. Total weed

The total weed dry matter recorded in Table 10 indicate that hand weeding was highly significant in controlling the weed growth and accumulation of dry matter (21.12g) followed by oxadiazon and thiobencarb (90.52 & 143.47g) as compared to unweeded plot (181.68g).

As regard varieties, CRM 13-32-41, Purva and Pusa-33 showed considerable smoothering effect (103.35, 104.9 & 105.79) but could not differ significantly including their interaction with weed control treatments.

4.1.5. Weed control efficiency

The hand weeding ranked first (Table 10) with 21.12g^{m-2}

weed dry weight and 88.37 per cent weed control efficiency. Amongst herbicides, oxadiazon was more efficient as compared to thiobencarb, the dry matter production was 90.52 and 143.47 gm^{-2} under the former and latter with weed control efficiency of 50.18 and 21.03 per cent, respectively.

4.2. CROP STUDY

4.2.1. Pre harvest study

4.2.1.1. Plant population

The population of crop was considerably less (Table 11) under herbicidal treated plots at 12 DAS. The plant stand of thiobencarb treated plots was significantly less (46.2) than untreated plots (81.79), but under oxadiazon treatment (74.5) it was statistically at par.

Amongst varieties, they varied widely at 12 daystage. Cauvery, Purva and CRM 13-32-41 varieties were at par with regard to population per meter row length, but these were higher as compared to Pusa-33 and JR-75. The interaction of varieties with weed control techniques on plant population was not significant.

At 24 DAS the population density of 56.33 and 40.16 per meter row length under oxadiazon and thiobencarb treated plots was significantly lower than hand weeded plots (74.83). However, oxadiazon registered significantly higher (56.33) plant stand than thiobencarb.

Table 11 : *Plant population and total tillers and mortality percentage of rice as influenced by weed control methods and varieties*

Treatment	Rice plant population m^{-1} row length		Mortality per cent at 24 DAS	Total tillers m^{-1} row length	
	12 DAS	24 DAS		36 DAS	60 DAS
Unweeded control	9.02 (81.79)	8.79 (77.58)	5.14	10.08 (102.50)	9.64 (93.78)
Hand weeding once	9.02 (81.83)	8.63 (74.83)	8.55	11.35 (100.16)	11.14 (125.65)
Oxadiazon 1 kg/ha pre emergence	8.59 (74.50)	7.74 (56.33)	24.38	10.81 (118.58)	10.53 (113.75)
Thiobencarb 2 kg/ha pre emergence	6.75 (46.20)	6.27 (40.16)	13.07	9.30 (82.41)	8.83 (78.81)
SEm ±	0.17	0.18		0.22	0.24
CD at 5%	0.55	0.48		0.73	0.78
CRM 13-32-41	8.50 (73.56)	7.80 (62.12)	15.55	9.76 (96.62)	9.40 (89.68)
JR-75	8.13 (67.18)	7.78 (62.12)	7.53	10.25 (106.62)	9.43 (90.16)
Purva	8.56 (74.43)	8.01 (66.00)	11.32	9.75 (96.25)	9.58 (92.90)
IR-36	8.20 (69.25)	7.78 (62.37)	9.93	11.44 (121.00)	11.31 (130.52)
Pusa-33	7.90 (63.75)	7.29 (54.50)	14.50	10.07 (102.62)	10.15 (104.44)
Cauvery	8.80 (78.31	8.07 (66.25)	15.40	10.65 (114.87)	10.34 (110.37)
SEm ±	0.10	0.11		0.18	0.17
CD at 5%	0.30	0.32		0.58	0.48

Original data are given in parenthesis

Table 12 : Total tillers m^{-1} of different rice varieties as influenced by weed control treatments at 60 DAS

Treatment	Unweeded control	Hand weeding	Oxadiazon	Thiabencarb	Mean
CRM 13-32-41	9.95 (99.68)	10.46 (110.06)	9.04 (81.93	8.15 (67.06)	9.40 (89.68)
JR-75	8.95 (80.43)	10.11 (102.81)	10.53 111.00)	8.25 (166.43)	9.43 (90.16)
Purva	9.43 (89.37)	10.32 (107.31)	9.75 (96.50)	8.83 (78.43)	9.58 (92.90)
IR-36	10.38 (109.18)	12.97 (168.68)	12.15 (148.36)	9.76 (95.68)	11.31 (130.52)
Pusa-33	9.54 (91.68)	11.47 (131.93)	10.46 (110.25)	9.13 (83.93)	10.15 (104.44)
Cauvery	9.58 (92.37)	11.50 (133.43)	11.26 (134.31)	9.01 (81.37)	10.34 (110.31)
Mean	9.64 (93.78)	11.14 (125.65)	10.53 (113.75)	8.83 (78.81)	

	SEm ±	CD at 5%
Weed control methods	0.24	0.78
Varieties	0.16	0.48
Two weed control methods at the same or different levels of varieties	0.35	1.05
Two varieties at the same or different levels of weed control methods	0.34	0.98

significantly lower than hand weeding and oxadiazon treatments. Purva had maximum tiller population in hand weeding which was significantly higher than thiobencarb, but was at par to oxadiazon treated plots. The same trend was followed by IR-36, Pusa-33 and Cauvery, respectively.

4.2.1.2. Seedling mortality

The mortality percentage data in Table 11 indicate that oxadiazon had greater mortality in comparison to thiobencarb and hand weeding. The mortality wad 24.38, 13.07, 8.55 and 5.14 per cent under oxadiazon, thiobencarb, hand weeding and unweeded plots, respectively.

Regarding varietal treatments the highest mortality was noted in CRM 13-32-41 and Cauvery (15.55 and 15.4 per cent) followed by Pusa-33, Purva, IR-36 and JR-75 (14.5, 11.32, 9.93 and 7.53 per cent).

4.2.1.3. Crop growth study

4.2.1.3a. Plant height

Data (Table 13) revealed that herbicides significantly reduced the plant height in comparison to hand weeded plot at 24 day-stage. While, height of plant in both oxadiazon and thiobencarb plots was at par.

Early maturing varieties i.e. CRM 13-32-41, JR-75, Purva and Cauvery produced significantly taller plants than Pusa-33 and IR-36 varieties of medium duration.

Varieties differed significantly in plant height under different weed control treatments at 24 DAS (Table 13).

Table 13 : Plant height (cm) of different rice varieties as influenced by weed control treatments at 24 days after sowing

Varieties/ Weed control	Control	Hand weeding	Oxadiazon	Thiobencarb	Mean
CRM 13-32-41	23.75	24.90	22.50	19.50	22.66
JR-75	28.00	25.55	22.15	23.85	24.88
Purva	25.05	25.70	25.00	22.40	24.53
IR-36	23.95	24.55	19.10	19.60	21.80
Pusa-33	23.70	23.10	20.70	20.05	21.88
Cauvery	25.45	24.40	22.45	20.80	23.27
Mean	24.98	24.70	21.98	21.03	

	SEm ±	CD 5%
Weed control methods	0.59	1.88
Varieties	0.25	0.80
Two weed control methods at the same or different levels of varieties	0.62	1.90
Two varieties at the same or different levels of weed control methods	0.50	1.44

Data postulated in Table 13 revealed that plants of rice varieties were taller under hand weeded plot. CM 13-32-41 and Purva were significantly taller in oxadiazon treated plot than thiobencarb. JR-75 and IR-36 were taller under thiobencarb as compared to oxadiazon. While, the height of Pusa-33 and Cauvery was also more in oxadiazon treated plot as compared to thiobencarb, but the differences were not significant.

At 36 DAS, plant height did not vary significantly among different weed control treatments. Though, it was maximum under hand weeding (36.54 cm) followed by unweeded control, thiobencarb and oxadiazon treated plot i.e. 36.02, 34.00, 31.29 cm, respectively (Table-16).

Amongst varieties, Purva had significantly greater height (38 cm) over all other varieties. While, JR-75 and Cauvery were at par. Pusa-33 was also at par with height of Cauvery but was significantly lower than JR-75. While IR-36 was significantly taller than CM 13-32-41, but was shorter than height of other four varieties. However, the interaction effect on plant height was not significant at this stage.

Plant height varied significantly among all treated plots at 60 DAS and was greater in thiobencarb followed by hand weeding and oxadiazon, respectively.

The early maturing varieties were significantly taller than medium varieties.

Plant height of different varieties was influenced significantly due to interaction of varieties x weed control treatments at 60-days measurement (Table 14).

Table 14 : Plant height (cm) of different rice varieties as influenced by weed control treatments at 60 days after sowing

Varieties / W.C. methods	Control	Hand weeding	Oxadiazon	Thiobencarb	Mean
CRM 13-32-41	54.00	54.85	51.85	60.70	55.35
JR-75	57.90	60.85	53.40	65.05	59.30
Purva	58.45	57.45	58.65	57.35	57.97
IR-36	40.45	40.85	39.15	42.95	40.85
Pusa-33	44.70	40.85	39.15	43.40	40.85
Cauvery	47.95	45.00	42.45	44.45	44.96
Mean	50.57	49.74	46.89	52.31	

	SEm ±	CD 5%
Weed control methods	0.68	2.17
Varieties	0.78	2.21
Two weed control methods at the same or different levels of varieties	1.50	4.36
Two varieties at the same or different levels of weed control methods	1.56	4.45

Height of varieties viz. CRM 13-32-41, JR-75, Pusa-33 and IR-36 was more under thiobencarb treated plots followed by hand weeding and oxadiazon. While, the plant height of Purva and Cauvery was maximum under oxadiazon and hand weeding, respectively.

Plant height at harvest was maximum under hand weeding which was at par to thiobencarb and both proved significantly superior to oxadiazon treated plots.

Pusa-33 was significantly taller as compared to other varieties besides Cauvery. The lowest plant height was noted in CR-13-32-41 and JR-75, whereas Purva and IR-36 were at par.

The early varieties attained maximum height under thiobencarb treated plots while inturn medium were --- taller under hand weeding (Table 15).

Table 15 : Plant height (cm) of different rice varieties as influenced by weed control treatments at harvest

Varieties /W.C. methods	Control	Hand weeding	Oxadiazon	Thiobencarb	Mean
CRM 13-32-41	56.50	56.02	51.90	60.80	56.31
JR-75	58.30	61.35	54.00	65.25	59.72
Purva	58.55	58.80	58.45	58.85	58.66
IR-36	62.05	65.72	56.10	57.40	60.32
Pusa-33	65.30	65.05	64.20	63.10	64.12
Cauvery	58.35	64.20	61.95	63.75	62.06
Mean	59.84	61.86	57.77	61.52	

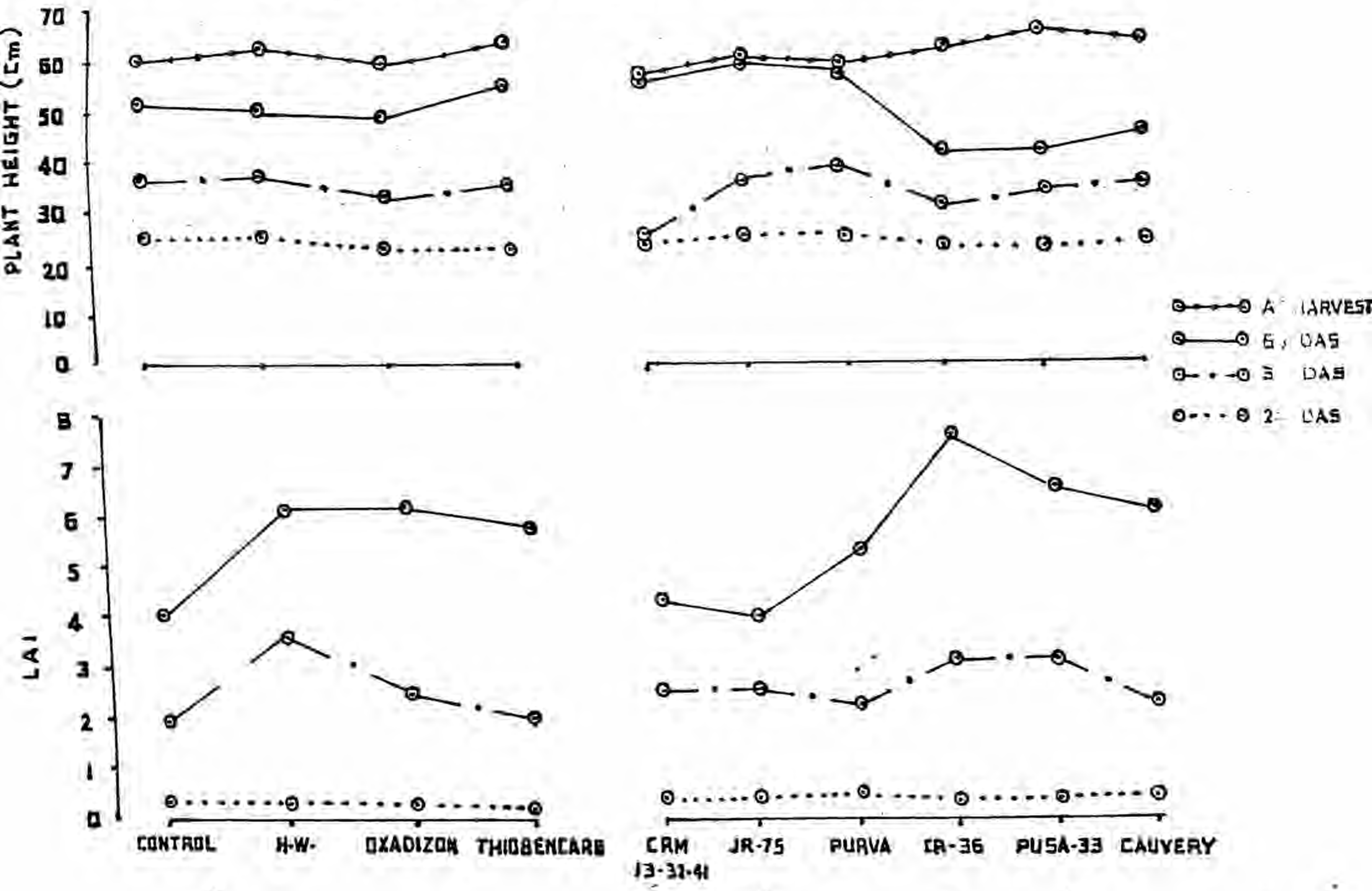
	SEm ±	CD 5%
Weed control methods	0.56	1.78
Varieties	0.98	2.78
Two weed control methods at the same or different levels of varieties	1.83	5.24
Two varieties at the same or different levels of weed control methods	1.96	5.56

Data appended in Table 16 indicated that the plant height of IR-36 under thiobencarb and oxadiazon treated plots was at par,

Table 16 : Plant height and LAI of rice as influenced by weed control treatments and varieties at different stages of growth

Treatment	Plant height (cm)				Leaf area index		
	24 DAS	36 DAS	60 DAS	At harvest	24 DAS	36 DAS	60 DAS
Unweeded control	24.98	36.02	50.57	59.84	0.41	2.05	4.17
Hand weeding once	24.70	36.54	49.74	61.86	0.40	3.70	6.25
Oxadiazon 1 kg/ha pre emergence	21.98	31.29	46.89	57.77	0.23	2.51	6.25
Thiobencarb 2 kg/ha pre emergence	21.03	34.00	52.31	61.53	0.19	2.03	5.78
SEm ±	0.59	1.52	0.68	0.55	0.02	0.28	0.30
CD at 5%	1.88	–	2.17	1.78	0.06	0.89	0.95
CRM 13-32-41	22.66	24.90	55.35	56.31	0.30	2.46	4.32
JR-75	24.88	35.81	59.30	59.73	0.33	2.51	3.94
Purva	24.53	38.00	57.97	58.66	0.34	2.10	5.28
IR-36	21.50	29.90	40.85	60.32	0.26	3.10	7.52
Pusa-33	21.88	33.57	40.85	64.41	0.31	3.07	6.48
Cauvery	23.27	34.56	44.96	62.06	0.32	2.22	6.14
SEm ±	0.25	0.53	0.78	0.98	0.02	0.23	0.38
CD at 5%	0.80	1.70	2.21	2.78	–	0.64	1.08

FIG. 6 : PLANT HEIGHT AND LAI OF RICE AS INFLUENCED BY WEED CONTROL TREATMENTS AND VARIETIES AT DIFFERENT STAGES OF GROWTH



Cauvery and Purva was at par while, CRM 13-32-41 was at par to JR-75 and Purva, but JR-75 had significantly lower LAI than Purva.

The data of Table 17 revealed that rice varieties differed significantly as regards LAI under different weed control treatments.

Table 17 : LAI of different rice varieties as influenced by weed control treatments at 60 days after sowing

Varieties/W.C. methods	Control	Hand weeding	Oxadiazon	Thiobencarb	Mean
CRM 13-32-41	2.83	3.85	5.01	5.60	4.32
JR-75	2.53	4.32	4.80	4.10	3.94
Purva	3.84	4.58	5.93	6.75	5.28
IR-36	5.43	10.53	7.80	6.23	7.52
Pusa-33	5.69	8.16	4.86	7.20	6.48
Cauvery	4.70	5.95	9.13	4.78	6.14
Mean	4.17	6.25	6.25	5.78	

	SEm ±	CD 5%
Weed control methods	0.30	0.95
Varieties	0.38	1.08
Two weed control methods at the same or different levels of varieties	0.72	2.10
Two varieties at the same or different levels of weed control methods	0.76	2.16

Varieties CRM 13-32-41 and Purva had higher LAI in thiobencarb treated plots followed by oxadiazon and hand weeded plots. The variation in LAI of CRM 13-32-41 for different weed control techniques was not significant. The LAI of Purva was significantly higher in thiobencarb treated plot as compared to hand weeded plots, but was at par to oxadiazon. Variety JR-75 exhibited maximum LAI under oxadiazon treatment followed by hand weeding and thiobencarb. LAI of Pusa-33 under hand weeding and thiobencarb treatment was of the same order and both were significantly higher than oxadiazon. IR-36 under oxadiazon and thiobencarb treated plots exhibited similar LAI but both were significantly lower than hand weeded plots.

4.2.1.3c. Plant biomass

Data (Table 20) revealed that plant biomass at 24 DAS was significantly lower in herbicidal treated plots as compared to hand weeding. Among herbicides oxadiazon gave significantly lower plant biomass than thiobencarb.

The plant biomass of variety Purva was significantly higher than JR-75 and was at par with other varieties. The interaction between varieties and weed control treatments was not significant.

Plant biomass at 36 DAS increased rapidly under thiobencarb treated plot (0.42 g $plant^{-1}$) and was comparable to hand weeding (0.41 g $plant^{-1}$). Thiobencarb proved significantly superior to oxadiazon treated plot (0.3 g $plant^{-1}$).

The variations in biomass amongst varieties revealed that Pusa-33 gave maximum (0.44 g) biomass which was noted

[illegible]

[illegible]

[illegible]

Table [illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

Data shown in Table 18 revealed that interaction of varieties with weed control treatments was significant on plant biomass at 60-day-stage measurement.

Plant biomass of [illegible] 15-27-41 varied significantly due to weed control treatments. Thiobencarb had maximum biomass followed by oxadiazon and hand weeding treatments. [illegible]-75 had significantly higher plant biomass under thiobencarb than under hand weeding and oxadiazon, while the latter two were not much different in biomass. Surya and Cauvery gained significantly more plant biomass in oxadiazon plot than hand weeding. While, the plant biomass of these two varieties under thiobencarb plot was on par with oxadiazon and hand weeded treatments. The plant biomass of [illegible] and [illegible] did not varied significantly among weed control treatments, but maximum was in hand weeding followed by thiobencarb and oxadiazon treated plots.

At harvest, the plant biomass under all weed control treatments was similar. Thiobencarb, hand weeding and oxadiazon plots registered biomass yield of 4.20, 4.01 and 3.95 g $plant^{-1}$, respectively and was greater than unweeded control.

Among varieties, significantly higher plant biomass was recorded in [illegible]. Biomass of [illegible] was significantly lower than [illegible] but it was higher than remaining four varieties. The plant biomass of [illegible]-75, Surya and Cauvery was at the same magnitude. While, [illegible]-15-27-41 exhibited significantly lower plant biomass than all other varieties.

Table 19 : Plant biomass of different rice varieties as influenced by weed control treatments at harvest (g plant^{-1})

Varieties /W.C. methods	Unweeded Control	Hand weeding	Oxadia-zon	Thioben-carb	Mean
CRM-13-32-41	1.55	2.57	2.88	2.23	2.31
JR-75	2.00	2.71	3.49	5.20	3.33
Purva	2.39	3.40	3.75	4.82	3.59
IR-36	3.11	5.38	4.90	3.87	4.14
Pusa-33	4.50	5.80	5.30	5.37	5.36
Cauvery	2.22	4.14	3.73	4.03	3.53
Mean	2.63	4.01	3.95	4.26	

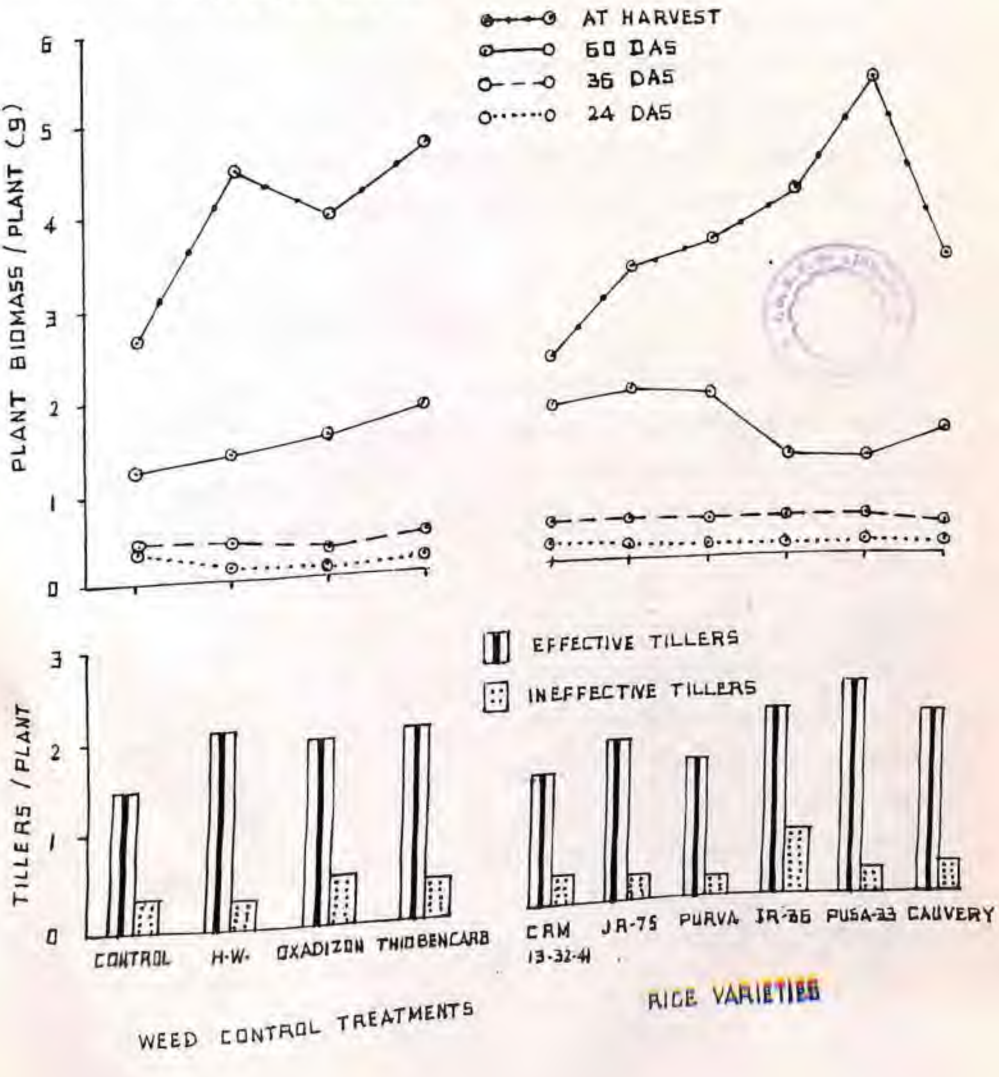
	SEm ±	CD 5%
Weed control methods	0.25	0.80
Varieties	0.21	0.60
Two weed control methods at the same or different levels of varieties	0.48	1.39
Two varieties at the same or different levels of weed control methods	0.42	1.21

The data shown in Table 19 indicate significant response of varieties under different weed control treatments. The plant biomass of CRM 13-32-41 was maximum under oxadiazon treated plots closely followed by hand weeding and thiobencarb, although, the differences were not significant. Varieties JR-75 and Purva had significantly higher plant biomass in thiobencarb plots followed by oxadiazon and hand weeded plots. The biomass yield under latter two did not differ significantly. The plant

Table 20 : Plant biomass and tillers of rice as influenced by weed control methods and varieties

Treatment	Plant biomass/plant (g)				Tillers/plant	
	24 DAS	36 DAS	60 DAS	At harvest	Effective	Ineffective
Unweeded control	0.13	0.38	1.24	2.63	1.47	0.34
Hand weeding once	0.13	0.41	1.42	4.01	2.07	0.29
Oxadiazon 1kg/ha pre em.	0.10	0.30	1.55	3.95	1.98	0.44
Thiobencarb 2kg/ha pre em.	0.12	0.42	1.82	4.26	2.00	0.35
SEm ±	0.003	0.02	0.08	0.25	0.11	0.02
CD 5%	0.009	0.06	0.25	0.80	0.36	0.08
CRM 13-32-41	0.12	0.36	1.72	2.31	1.35	0.26
JR-75	0.11	0.39	1.86	3.33	1.80	0.27
Purva	0.13	0.37	1.79	3.59	1.54	0.21
IR-36	0.12	0.39	1.13	4.14	2.09	0.69
Pusa-33	0.12	0.44	1.15	5.36	2.38	0.31
Cauvery	0.12	0.32	1.41	3.53	2.11	0.39
SEm ±	0.004	0.02	0.07	0.20	0.08	0.03
CD 5%	0.011	0.06	0.21	0.60	0.25	0.10

FIG. 7 : PLANT BIOMASS AND TILLERS OF RICE AS INFLUENCED BY WEED CONTROL METHODS AND VARIETIES



biomass of Purva under thiobencarb and oxadiazon treatments was almost same. IR-36 gave maximum biomass (5.38 g/plant) in hand weeded plots which was at par with oxadiazon. It was significantly higher than thiobencarb treated plot. The biomass of Pusa-33 and Cauvery did not differ due to weed control treatments. Plant biomass of treated plots was significantly higher than untreated plots under all the varieties.

4.2.1.4. Effective tillers

Effective tillers number/plant were increased significantly in treated plots as compared to unweeded plot (Table 20). The number of effective tillers were higher in hand weeded plot followed by thiobencarb and oxadiazon treated plots but all these were at par.

The variation amongst varieties revealed that effective tillers per plant were significantly higher in Pusa-33 as compared to other varieties. The effective tillers were at par in Cauvery and IR-36, which were significantly higher than CRM 13-32-41, JR-75 and Purva varieties. The effective tillers of JR-75 and Purva were almost equal. The lowest numbers was noted in CRM 13-32-41 and it was significantly poor in comparison to all other varieties. Interaction of varieties and weed control treatments was not significant as regards effective tiller numbers.

4.2.1.5. Ineffective tillers

Ineffective tillers per plant were increased significantly in condition of thiobencarb treated plots as compared to hand weeding. Among [illegible] treatments the ineffective tillers per plant were significantly higher in condition as compared to thiobencarb.

Dominant variety IR-36 produced significantly more ineffective tillers per plant as compared to other varieties. The ineffective tillers were of the same order in IR-[illegible], Cauvery and Rasi-11. The significantly minimum number of ineffective tillers were noticed in Surya, CO 13-IR-41 and Rasi-11.

Table II.1. Ineffective tillers (per plant) of different rice varieties as influenced by weed control [illegible]

Varieties / Weed control method	Unweeded control	Hand weeding	[illegible]	Thiobencarb	Mean
CO. 13-IR-41	0.20	0.20	0.30	0.33	0.26
IR-75	0.20	0.30	0.30	0.30	0.27
Prasad	0.25	0.20	0.20	0.30	0.21
IR-36	1.15	0.97	0.50	0.50	0.68
Rasi-11	0.20	0.20	0.40	0.30	0.30
Cauvery	0.85	0.20	0.75	[illegible]	[illegible]
Mean	0.35	0.28	0.40	0.38	

	SE ±	CD 5%
Weed control methods	0.025	[illegible]
Varieties	0.035	0.10
Same weed control methods at the same or different levels of varieties	0.087	0.19
Two varieties at the same or different levels of weed control methods	0.071	[illegible]

Data (Table 21) indicated that variety CRM 13-32-41 did not differ significantly in ineffective tiller production under different weed control treatments, however, they were noted maximum in thiobencarb followed by oxadiazon and hand weeded plots. JR-75 produced significantly more tillers under thiobencarb followed by hand weeding and oxadiazon plots. The innefective tillers tillers of JR-75 were significantly lower under oxadiazon as compared to thiobencarb. While, in Purva and Pusa-33 they were at par, however, ineffective tillers in Pusa-33 was considerably more in oxadiazon treated plots. IR-36 and Cauvery produced more ineffective tillers under oxadiazon followed by unweeded, hand weeded and thiobencarb treated plots. Cauvery and IR-36 were at par under thiobencarb and hand weeded plots and these were significantly lower than oxadiazon treated plots.

4.2.2. Post harvest study

4.2.2.1. Panicle length

Data (Table 22) revealed that the panicle length under hand weeding, oxadiazon and thiobencarb plots was increased significantly as compared to control plots. It was highest in thiobencarb followed by hand weeding and oxadiazon, though the differences in length were not significant.

Amongst varieties, the highest panicle length was noted in Purva (16.64 cm) which was at par to Pusa-33 and Cauvery. They produced significantly longer panicle length than CRM 13-32-41

JR-75 and IR-36 varieties giving 11.95, 14.89 and 15.94 cm, respectively. The panicle length of CRM 13-32-41 was lowest amongst all the varieties.

Table 22 : Panicle length (cm) of different rice varieties as influenced by weed control treatments

Varieties/W.C. methods	Unweeded control	Hand weeding	Oxadiazon	Thiobencarb	Mean
CRM 13-32-41	10.25	12.42	12.70	12.16	11.95
JR-75	13.63	14.47	14.52	16.92	14.89
Purva	15.94	17.08	16.71	16.85	16.64
IR-36	15.50	16.68	16.08	15.52	15.94
Pusa-33	16.18	16.68	16.43	16.64	16.48
Cauvery	14.93	16.78	16.15	16.83	16.17
Mean	14.45	15.69	15.43	15.82	

	SEm ±	CD 5%
Weed control methods	0.17	0.55
Varieties	0.21	0.59
Two weed control methods at the same or different levels of varieties	0.40	1.16
Two varieties at the same or different levels of weed control methods	0.41	1.18

Panicle length of CRM 13-32-41 was significantly lower under unweeded plots as compared to treated plots (Table 22). It was noted highest in oxadiazon followed by hand weeding and thiobencarb treated plots. The panicle length of JR-75 was significantly higher under thiobencarb as compared to unweeded control. Oxadiazon and hand weeding exhibited ears of same length. Purva and IR-36 produced maximum panicle length under hand weeded treatment which was significantly higher than unweeded control and at par with oxadiazon and thiobencarb treated plots. The panicle length of both the varieties was at par under oxadiazon and thiobencarb plots. The differences in panicle length of pusa-33 was not significant due to weed control treatments. Panicle length of Cauvery under thiobencarb, hand weeding and oxadiazon treated plots was at par, but significantly higher than unweeded control.

4.2.2.2. Panicle Weight

Data recorded in Table 24 revealed that panicle weight of rice increased significantly under hand weeding and herbicidal plots as compared to untreated plot. The maximum panicle weight was recorded in thiobencarb which was at par to hand weeding and oxadiazon treated plots.

As regard the panicle weight of different varieties, pusa-33 recorded highest and the lowest panicle weight was noted in CRM 13-32-41. The panicle weight of JR-75, Purva, IR-36 and Cauvery was at par. The interaction of varieties with weed control treatments was not significant.

4.2.2.3. Fertile grains

Data (Table 24) revealed that number of fertile grains per panicle were maximum under hand weeding, which were at par to thiobencarb and oxadiazon treated plots. The number of fertile grains in treated plots were significantly higher than untreated plots.

Fertile grains in [illegible], Sowmya had [illegible] were at par, while, the number of fertile grains in [illegible] 33-87-41, [illegible]-75 and [illegible] were almost equal, but were significantly lower than [illegible] and Sowmya.

The variety x weed control interaction was significant.

Table 23 : Fertile grains per panicle of different time varieties as influenced by weed control treatments

Varieties / W.C. methods	Unweeded control	Hand weeding	Basalin-[illegible]	Trickler-[illegible]	Mean
[illegible] 33-87-41	37.20	58.17	49.75	49.73	48.21
[illegible]-75	36.00	51.30	39.20	41.25	41.[illegible]
[illegible]	31.10	49.13	39.28	40.17	43.0[illegible]
TR-30	47.80	61.55	51.37	[illegible]	[illegible]
[illegible]-1	[illegible]	61.55	53.[illegible]	58.17	48.62
Sowmya	37.05	61.[illegible]	51.80	57.70	52.77
Mean	[illegible].17	51.70	49.[illegible]	51.18	

	S.Em ±	CD at 5%
Weed control methods	1.80	5.14
Varieties	[illegible]	[illegible]
The weed control methods at the same or different levels of varieties	[illegible]	11.73
The varieties at the same or different levels of weed control methods	[illegible]	11.70

The [illegible] presented in Table 23 [illegible] significantly [illegible] fertile grains [illegible] [illegible] which in turn were at par. The fertile grains in Purva did not vary under all weed control treatments, amongst which maximum were under thiobencarb followed by hand weeded and oxadiazon treated plots. IR-36 had almost equal fertile grains under hand weeding and oxadiazon which were significantly higher than thiobencarb and untreated plots. The fertile grains in Pusa-33 were at par in each weed control treatments, however, maximum were under oxadiazon followed by hand weeding, thiobencarb and untreated plot. Cauvery produced significantly greater number of fertile grains under thiobencarb, hand weeding and oxadiazon as compared to untreated plot, while the fertile grains among former three were at par.

4.2.2.4 Infertile grains

Infertile grains per panicle increased significantly due to herbicidal treatments than hand weeding (9.98). The infertile grains were more in thiobencarb (12.24) than oxadiazon (11.39) but they were at par (Table 24).

Regarding varieties, the infertile grains were significantly higher in CRM 13-32-41 (18.28) than other varieties. JR-75 had significantly higher infertile grains than four other varieties except CRM 13-32-41. The infertile grains in Cauvery were significantly lower than CRM 13-32-41 and JR-75 and higher than Purva, IR-36 and Pusa-33. Whereas the latter three varieties were at par.

Table 24 : Sink parameters and sterility percentage of rice as influenced by weed control methods and varieties

Treatment	Panicle length (cm)	Panicle weight (g)	Grain weight/ panicle (g)	Test weight (g)	Grain/panicle		Sterility percentage
					Fertile	Infertile	
Unweeded control	14.45	1.36	1.18	21.98	42.17	8.08	16.08
Hand weeding once	15.69	2.15	1.94	22.04	53.50	9.98	15.72
Oxadiazon 1 kg/ha pre emergence	15.43	2.10	1.90	21.95	49.22	11.39	16.79
Thiobencarb 2 kg/ha pre emergence	15.82	2.32	2.12	21.98	53.45	12.24	18.63
SEm ±	0.17	0.14	0.13	0.13	1.79	0.33	-
CD 5%	0.55	0.43	0.40	-	5.74	1.04	
CRM 13-32-41	11.95	1.25	1.10	19.58	48.84	18.28	27.23
JR-75	14.89	1.90	1.73	23.70	43.61	14.04	24.35
Purva	16.64	1.98	1.78	23.32	45.02	8.09	15.23
IR-36	15.94	1.96	1.77	20.95	50.43	6.90	12.03
Pusa-33	16.48	2.89	2.61	22.73	58.62	6.38	9.82
Cauvery	16.17	1.93	1.74	21.62	50.99	8.85	14.79
SEm ±	0.21	0.13	0.13	0.13	2.02	0.82	
CD 5%	0.60	0.39	0.37	0.38	5.68	2.33	

Table 25 : Infertile grains (per panicle) of different rice varieties as influenced by weed control treatments

Varieties / W.C. methods	Unweeded control	[illegible]	[illegible]	Thioben-carb	Mean
IR 13-32-41	15.62	21.40	25.00	19.10	18.28
[illegible]-78	9.23	16.10	[illegible]	18.38	[illegible]
[illegible]	7.27	9.72	[illegible]	6.90	8.97
[illegible]	9.30	6.28	7.05	7.30	6.40
[illegible]-73	6.28	6.12	7.77	[illegible]	6.33
[illegible]	[illegible]	9.83	8.43	11.70	9.55
Mean	[illegible]	[illegible]	11.99	[illegible]	

	SEm ±	CD 5%
Weed control methods	0.52	[illegible]
Varieties	0.82	[illegible]
Two weed control methods at the same or different levels of varieties	1.30	[illegible]
Two varieties at the same or different levels of weed control methods	1.55	[illegible]

Table 25 reveals that the infertile grains in IR 13-32-41 [illegible]

[illegible] weeding,
[illegible] showed wider varieties in
[illegible] control treatments. [illegible]
[illegible] in all treated plots, [illegible]
[illegible] significantly higher than unweeded plot.

[illegible]. Sterile spikelets

[illegible] revealed that [illegible] sterile
[illegible] plots [illegible]
[illegible] (15.78 and 15.00%),
[illegible] treatment
[illegible].

[illegible]
[illegible]
[illegible]
[illegible].

[illegible]. Seed weight

[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
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[illegible]

[illegible]
[illegible]

[illegible] (23.37 g). [illegible], Co-36 and [illegible] differed significantly amongst themselves and exhibited [illegible], [illegible], 20.95 and 19.58 g 1000 grain weight, respectively.

4.2.1.7. Grain yield

Data (Table 26) [illegible] band seeded plot produced significantly [illegible] grain yield (17.25 q/ha) [illegible] (15.44 q/ha) and [illegible] ([illegible] q/ha). [illegible] yield from [illegible] plot [illegible] significantly [illegible] and [illegible] the yield of [illegible] ([illegible] q/ha).

Variety [illegible] grain yield ([illegible] q/ha) [illegible]

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[illegible]

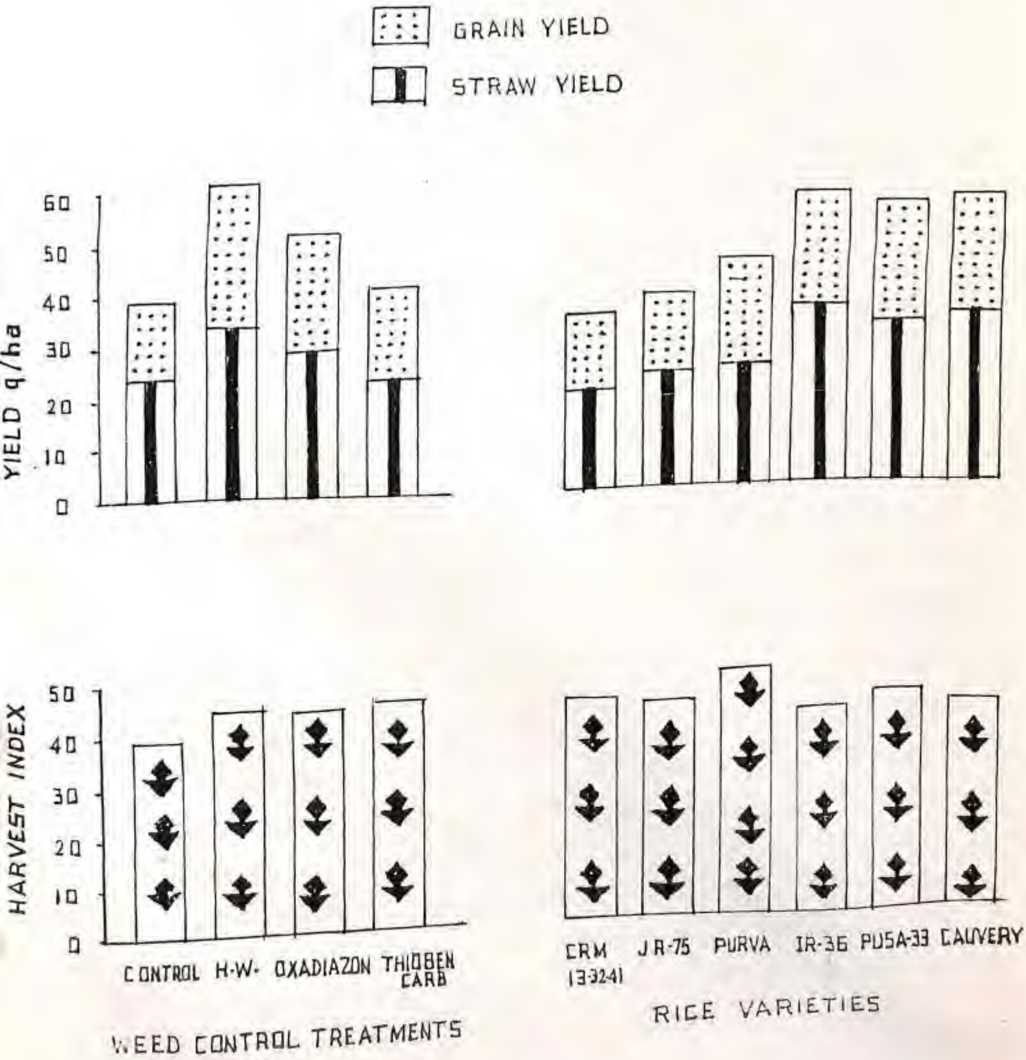
4.2.1.8. Straw yield

[illegible]

Table 26 : Yield parameters of rice as influenced by weed control methods and varieties

Treatment	Yield q/hectare			Harvest index (%)
	Grain	Straw	Crop biomass	
Unweeded control	15.11	23.89	39.01	38.73
Hand weeding once	27.25	34.54	61.82	44.22
Oxadiazon 1 kg/ha pre emergence	22.94	29.28	52.21	43.93
Thiobencarb 2kg/ha pre emergence	18.32	23.10	40.95	44.73
SEm ±	1.03	1.76	2.65	
CD 5%	3.30	5.64	8.50	
CRM 13-32-41	15.40	19.61	35.01	43.98
JR-75	16.36	22.27	37.92	43.14
Purva	22.06	23.24	45.30	48.69
IR-36	23.58	35.02	58.65	40.20
Pusa-33	24.26	32.12	56.39	43.02
Cauvery	23.78	33.95	57.74	41.18
SEm ±	0.92	1.62	2.39	
CD 5%	2.61	4.61	7.65	

FIG. 8 : GRAIN YIELD, STRAW YIELD AND HARVEST INDEX OF RICE AS INFLUENCED BY WEED CONTROL TREATMENT AND VARIETIES



As regards varieties, straw yields of medium maturing varieties were significantly higher than early maturing ones. Among medium duration varieties, IR-36 produced higher straw yield (35.02 q/ha) which was at par with Cauvery (35.95 q/ha) and Pusa-33 (32.12 q/ha). While, in early varieties, Purva recorded (23.24 q/ha) higher straw yield and it was at par with CRM 13-32-41 and JR-75 (19.61 and 22.27 q/ha).

The interaction of varieties with weed control techniques was not significant.

4.2.13. Crop biomass

Data presented in Table 26 showed that the highest crop biomass was obtained from hand weeding (61.82 q/ha) which was significantly higher than herbicidal and unweeded plots. The crop biomass under oxadiazon plots was 52.21 q/ha and it was significantly more than thiobencarb and untreated plots (40.95, 39.01 q/ha) and the latter two were at par.

Regarding varietal treatments it was noted that medium duration varieties yielded higher crop biomass as compared to early varieties. Amongst medium varieties IR-36 recorded maximum crop biomass (58.65 q/ha) and it was at par with Cauvery and Pusa-33 o.e. 57.74 and 56.39 q/ha . While, Purva had the highest crop biomass (45.30 q/ha) amongst early cultivars which was superior to JR-75 (37.92 q/ha). The lowest biomass was noted in CRM 13-32-41 (35.01 q/ha) which was at par with JR-75 (37.92 q/ha).

The interaction effect of varieties with weed control treatments was not significant on crop biomass.

4.2.2.8. Harvest Index

The data recorded in Table 26 indicated that harvest index under thiobencarb treatment was the highest (44.73) followed by hand weeding, oxadiazon and unweeded plot (44.22, 43.93, 38.73%).

As regard varieties, harvest index was the highest in Purva (48.69) followed by CRM 13-32-41, JR-75, Pusa-33 and Cauvery (43.98, 43.14, 43.02, 41.18). The lowest HI was recorded under IR-36 (40.2).

4.2.2.9. Economics of treatments

Table 27 : Economics of different weed control treatments adopted in main plots

Treatment	Extra yield over control (q/ha)		Extra return over control (Rs./ha)	Extra cost of Treatment (Rs./ha)	Net Profit (Rs./ha)
	Grain	Straw			
Unweeded control	-	-	-	-	-
Hand weeding once	12.14	10.65	2156.65	1249.50	907.15
Oxadiazon 1 kg/ha pre emergence	7.83	5.39	1374.75	450.00	924.75
Thiobencarb 2kg/ha pre emergence	3.21	- 0.79	530.60	434.00	96.60

Note : Rice = Rs. 168/q
Straw = Rs. 11/q
85 labours/ha for hand weeding
3 Labours/ha for herbicide spraying

Labour charges= Rs.14.70/day
Oxadiazon = Rs.100/L (Assumed)
Thiobencarb = Rs. 96/L
Hire of sprayer = Rs.6/day.

Table 21 illustrates that [illegible] [illegible] [illegible] the highest [illegible] (Rs. [illegible]/ha) [illegible] [illegible] seedling (Rs. 307.15/ha) and [illegible] (Rs. [illegible]/ha). The seedling gave higher [illegible] of Rs. 1356.05/ha [illegible] [illegible] and [illegible] gave only Rs. 1374.75 and 891.15/ha over [illegible] [illegible].

CHAPTER V

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the herbicide was short lived in the soil and rapidly degraded with the result late flushes of weed were not controlled effectively. Amongst cultural methods hand weeding was efficient due to removal of weeds physically at an early stage and due to exhaustion in energy including smothering effect of crop at later stage. More weeds regenerated due to breakage in links of tubers which profusely tillered and developed into a new plants later on (Mukhopadhyay et al. 1986). Unweeded control registered highest weed density because no such control measures was adopted due to which greater mean weed intensity was recorded.

The population of Cynodon dactylon was not inhibited significantly by any of the weed control techniques at an early stage. Hand weeding was not conducted upto 20 daystage, hence hand weeded plot was at par to unweeded treatment. Thiobencarb herbicide checked the intensity of Cynodon dactylon significantly at latter stages (kulmi & Jain, 1985). This might be due to its slow activity (short lived herbicide) and due to supression effect of crop on weeds owing to the vigorous growth of rice crop. On the contrary oxadiazon proved ineffective in controlling, the Cynodon sp. density significantly at all stages (Tiwari et al., 1984). All herbicide showed pronounced effect on activity growing weed in the early phase of growth but the weed density increased due to deactivation in the soil at mid growth stage. Trivedi et al. (1984) supported the above findings. Hand weeding being potential method, controlled the weeds efficiently due to removal of weeds physically from the active side and later on population was not recovered due to

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were supressed efficiently due to lush crop growth which failed to attain potential growth. Sahu & Jena (1968) corroborated the similar findings.

Gross intensity of weed flora was affected significantly by weed control techniques at all dates of measurement. Amongst herbicides, oxadiazon controlled the total weed population efficiently due to broad spectrum effect on weed flora, besides _Cynodon dactylon_ and _Eclipta alba_. These results are in confirmity with that of Trevedi _et al._ (1984) and Subbaih _et al._ (1975). Thiobencarb also markedly reduced the weed population significantly. But it was not as effective as oxadiazon (Bhagat _et al._, 1977 and Perret & Simonds, 1977). The poor crop stand under thiobencarb treated plot from the beginning and its low persistence in the soil including, ineffectiveness shown against broad-leaved weeds, perhaps was responsible in increasing the weed population of total weed flora (Murthy & Dubey, 1980). Hand weeding proved versatile method in controlling the weeds population at 35 daystage. While, at 50 DAS due to soil disturbance, many tiny weeds emerged in the inter row spaces, however, their growth was checked due to lush growth of crop (Patel & Patel, 1981).

The weed population was not found to vary significantly in association with rice varieties (Nanjappa & Krishnamurty, 1981). Generally the weeds emerged within 30 days mostly, during the critical periods and upto this stage there was no marked variation among varietal canopy which could impose differential shading effect on weed density significantly.

5.1.3. Height of dominant Weeds

Height of Cyperus spp. showed declining trend significantly under herbicidal treatments due to greater growth inhibition caused by phytotoxic effect of herbicides on actively growing plants (Kulmi & Jain, 1985). While, Cyperus spp. plants were dwarfed in hand weeded plots due to loss in the energy of tubers owing to the nipping of primary shoots. Tall plants were noted in control plots due to severe mutual crop weed competition.

Height of Cynodon dactylon was controlled effectively in hand weeded plot at both the stages of growth. Because primary tillers alongwith rhizomes were removed during weeding operation at 20 DAS, which depleted the food reserve of Cynodon dactylon. Due to depressing effect of crop, plant height did not recover at lat-er stages. While, height was not affected by herbicides due to their ineffectiveness against Cynodon sp.(Anon, 1984). It produced greater height at 35 daystage than in unweeded control. Greater height might have been resulted due to available nutrients, more space and some growth stimulating activity of herbicide. On the other hand, at 50 daystage, height declined due to smo-thering effect of crop on weeds. Height increased in control plot due to crop weed competition for light and space.

The height of Commelina communis declined significantly in hand weeding due to mechanical injury to surface feeding roots. Newly emerged weeds could not recover at lat-er stages due to competitive effect of crop on weeds. Height varied significantly under oxadiazon due to toxic effect on <u>Commelina communis</u> plants. Oxadiazon toxicant was absorbed by intact plants from the early stage due to which, plants could not put forth greater height. But at later stage it was increased probably due to deactivation of herbicide and reduced crop weed competition. The plant height in thiobencarb treated plot was not significant as compared to unweeded control, because it was ineffective against this weed (Anon., 1986).

<u>Echinochloa</u> height was affected significantly by oxadiazon (Kulmi & Jain, 1985). Although it inhibited the growth of weeds efficiently, however some weeds probably emerged lately from untreated zone of herbicide which escaped from complete killing and due to some physiological disturbances their height was shortened. Thiobencarb follwed the same trend, but it was not so potential as oxadiazon and failed to exhibit significant variation in height at 50 daystage (Kulmi & Jain, 1985). On the other hand, hand weeding extirpated majority of weeds and late emerged weeds from the left out portions of weeds, failed to attain normal plant height due to initial set back of mechanical operations and supression effect by crop canopy structures.

The rice varieties did not vary much in their canopy differentiations in the early stages of growth. But in turn weed growth was promoted faster than crop growth. Therefore, rice varieties could not influence plant height significantly under different weed control treatments and exhibited similar height.

5.1.4. LAI of dominant weeds

LAI of Cyperus tend to decline efficiently under oxadiazon due to inhibitiry effect on growth and reduction in plant density m^{-2} (Kulmi & Jain, 1985). Most probably the herbicide translocated better via. roots and accumulated in leaves to the toxic level which affected the leaf size, with the result LAI was reduced considerably. Thiobencarb also checked the LAI of *Cyperus* spp. by reducing the plant (Kulmi & Jain, 1985) population (Table 6) and canopy developments significantly as compared to unweeded control. while, it was most efficiently controlled by hand weeding due to extirpation of weed shoots. Due to sustained mechanical injury weed growth could not recover from the left out portion of weeds.

Leaf area index of *Cynodon dactylon* was not affected at all, by these herbicides, probably due to ineffectiveness of these herbicides against this weed (Anon, 1984). Moreover, LAI was higher in oxadiazon treated plot, than unweeded plot. This might be due to some stimulating effect of oxadiazon, on growth structures. While, in hand weeding, owing to sustained mechanical injuries to weeds, probably carried their parallel effect in reducing the weed density and leaf size, with the result LAI reduced substantially (Patel & Patel, 1981).

Commelina communis was controlled efficiently by oxadiazon at both stages. LAI also declined accordingly. Either the weeds were killed efficiently or leaf size reduced significantly due to phytotoxicity of herbicide which probably entered apoplastically and translocated in all parts of the plants.

Thiobencarb also reduced LAI upto 35 day stage, due to severe phytotoxicity. While, at later stages, LAI increased to a greater degree than unweeded control. The cause behind this accelerating effect on LAI was inefficacy of thiobencarb against this resillient weed (Tiwari <u>et al.</u>, 1984) including some stimulation effect on herbicide. While, excellent control of weeds was noted in hand weeding. Sound crop stand developed after elemination of weeds after 20 day stage which resulted in marked decrease in LAI of weeds due to smothering effect of crop.

Oxadiazon showed potential effect on <u>Echinochloa</u> density and because of deleterious effects of herbicide, LAI declined markedly. Similarly thiobencarb minimized the weed population and LAI as well significantly at both stages(Leclair, 1977). While, hand weeding caused larger reduction in LAI and plant density as compared to thiobencarb herbicide.

LAI was not affected significantly by variety x weed control methods. Because of less differentiation in crop canopy structures, depressing effect on LAI of weeds upto 35 day stage was not noticed (Table 13 & Fig. 6). Hence, weeds exhibited almost similar leaf area index under all varieties.

5.1.5. <u>Dry matter of weeds</u>

The dry matter accumulation of <u>Cyperus</u> spp. at harvest was lowest under hand weeding (Table 10). The reason for this lowest dry matter was due to removal of weed shoots physically, during weeding operations at 20 DAS. The further recovery of dry matter accumulation was inhibited by smothering effect of crop canopy. On the contrary, oxadiazon controlled the weed density efficiently which resulted in reduced weed biomass.

while, thiobencarb failed to affect the plant intensity and growth of *Cyperus* spp., hence increased dry matter yield was recorded (Anon, 1986).

Dry matter accumulation of *Cynodon dactylon* was not controlled by any of the herbicides and even produced more dry matter yield than unweeded plot. Since, *Cynodon dactylon* was a pre established weed in the field and herbicides proved ineffective. Hence, unchecked growth of weeds exhibited greater dry matter yield than no weeding treatment. While, in hand weeded plot dry matter yield was lowest due to removal of weeds at 20 DAS and they did not recover at latter stages of growth due to deprivation of weed energy and smo-thering effect of crop.

Dry matter of *Commelina communis* was lowest under hand weeding because of thorough up-rooting and removal of weeds with *Khurpi* during weeding operation. Though, the second flush of weeds croppedin, but due to smo-thering effect of crop, dry weight remained lowest. Amongst herbicides, oxadiazon checked the growth and density of *Commelina communis* from the early stage significantly, hence lowest dry matter was recorded under this treatment. While, thiobencarb checked the density of weeds differentially, but also affected the crop severely. Because of greater intruption for space and light for longer period in poor crop stand, weed growth was vigorous which resulted in much higher dry matter yield as compared to unweeded control.

Biomass of *Echinochloa* spp. was affected greatly by weed control measures. Both the herbicides viz. oxadiazon and thiobencarb decreased the intensity of weed from the beginning stage due to which dry matter yield decreased amicably. The similar findings regarding oxadiazon and thiobencarb were corroborated by Tosh (1975) and Anon (1976), respectively. While, in hand weeded plot due to extirpation of weeds physically by *Khurpi* at 20 DAS, weed dry weight was lowest.

Eclipta alba remained unaffected by both the herbicides and due to unchecked growth and density of weeds, dry matter increased substaintially (Anon, 1984). Removal of first flush of weeds in hand weeded plots and smoothering effect of crop at subsequent stage, resulted in lowest biomass yield of *Eclipta alba*.

The dry weight of other weed species was considerably affected by both the herbicides, however, no significant differences exhisted, as compared to unweeded control. Other weeds were mostly dicotyledonous which cropped in the field a fortnight latter , after herbicidal treatment. Hence, upto this stage, due to slow degradation of herbicides, the weed growth was not inhibited adequately and thus, dry weight increased considerably. The dry matter yield in hand weeded plot was lowest although, the population of other weed species was highest Table 7). Due to low weed stress at 35 DAS, crop obtained luxurant growth which checked the growth and dry matter accumulation of future flushes of weeds by smo-thering action. These findings are in agreement to the findings obtained under, Jabalpur conditions (Anon, 1986).

Total biomass of all weeds was lowest in hand weeding, probably due to efficient extermination effect. Bisen & Patel (1973) reported the similar findings. The removal of weeds physically at 20 DAS reduced the biomass drastically. Crop attained good growth in the weed free environment which counteracted the growth of late flushes of weeds due to smo-thering effect. Therefore, resulting dry matter yield was lowest.

Amongst herbicides, oxadiazon decreased the weed biomass efficiently due to pronounced effect over weeds, as compared to thiobencarb. The similar findings are reported by Subbiah et al. (1975) and Murthy & Dubey (1980). Dry matter yield under thiobencarb was more than oxadiazon probably due to its ineffectiveness against Commelina communis, Cyperus rotundus, Cynodon dactylon and other dicot weeds (Anon, 1986). Hence, over all production of dry matter was enormously high, under thiobencarb which could not provide satisfactory weed control (Murthy & Dubey, 1980).

Varieties showed differential smo-thering effect on weeds due to canopy differentiation which influenced the dry matter yield of Cyperus spp. greatly (Table 10). It recorded relative density of about 60 per cent (Table 5). The early varieties viz. CRM 13-32-41, JR-75 and Purva showed rapid growth with greater height from the begining up to 60 daystage. Ultimately, the dry matter of dominant Cyperus spp. was significantly reduced under these varieties due to severe crop weed competition and smothering effect as compared to medium dwarf cultivars. Later cultivars failed to inhibit the growth of Cyperus spp. with the result, registered greater dry matter yield. Almost similar results were reported by Singlacher et al. (1978) and Venugopal et al. (1983).

was affected significantly. Amongst herbicides, oxadiazon resulted significantly lower density than hand weeding. While, the density under thiobencarb plot was very poor and was lowest than both oxadiazon and hand weeding estimated at 24 DAS. Intensity of rice declined substantially under oxadiazon, probably due to its contact action on intact plants (Kulmi & Jain, 1985) and prolong persistance. Leaf scorching and pronounced neck injury of intact seedlings caused greater mortality of large number of seedlings (Anon, 1986 and Venugopal et al., 1983). However, rice seedlings recovered from herbicical stress at latter stage of growth and levelled off with hand weeded plot.

Under thiobencarb, the germination of rice inhibited initially, probably due to some physiological disorders caused by herbicidal toxicant which was available sufficiently in the soil at early stage. Ultimately, plant stand of thiobencarb treated plot reduced significantly (Leclair, 1977) than oxadiazon.

The rice population m^{-1} row length was maximum under hand weeded plot at all stages of estimation. It was not deleterious to plant stand, hence exhibited uniform rice population (Sahu & Jena, 1968).

The intensity of rice varieties declined at 24 DAS, due to subsiquent mortality caused by herbicides. The results are in confirmity with the findings of Manna et al. (1974). Varieties besides IR-36 and Pusa-33 registered declining trend in plant number due to mortality caused by crop weed interaction at 60 DAS. While, IR-36 and Pusa-33 of medium duration showed greater resistance to weed competition hence remained unaffected. The differential varietal resistance have been reported by several scientists (Anon., 1986). The highest population m^{-1} row length was noted under IR-36, followed by Cauvery, Pusa-33 Purva, JR-75 and CRM 13-32-41 due to their genetical characteristics, respectively.

The interaction of varieties with weed control treatments was significant as regards tiller population m^{-1} row length at 60 DAS. The herbicidal effect might have caused differential response of varieties, as regards tiller population. Lowest density of rice was noted (Table 12) under thiobencarb plot as compared to hand weeding and oxadiazon. The tiller numbers under oxadiazon was on par to hand weeding in all the varieties besides CRM 13-32-41, which exhibited significantly higher tiller number under hand weeded plot. The tillers of JR-75, IR-36 and Cauvery were influenced significantly by herbicides, greater in oxadiazon than thiobencarb. The susceptibility of these cultivars to different herbicides might be due to differential responses. Gill & Mehara (1981) and Ali & Sankaran (1976) supported the above findings.

5.2.2. Seedlings mortality

The highest mortality was noted under oxadiazon treated plots due to phytotoxic effect. Oxadiazon molecule severely scorched the leaves thereby reducing the photosynthetic area which perhaps resulted in the greater mortality of the seedlings. The intact seedlings in oxadiazon herbicide could not survive and resulted in 24.38 per cent mortality of seedlings at 24 DAS. The similar mortality of rice seedlings have also been reported by Anon., (1986). However, greater number of seedlings recovered from herbicidal stress at latter stages, most probably due to deactivation of herbicides. While, under thiobencarb the seed germination and seedling emergence was inhibited upto very late stage due to prolonged persistance of herbicide in the soil. The another reason might be some physiological disorders, caused by toxic effect of herbicide to newly developing seedlings. The mortality of seedlings touched the level of 13.07 per cent under thiobencarb treated plots. Sankaran & Ali (1974) and Anon. (1986) corroborated the similar findings. Hand weeded and unweeded plots also exhibited 8.55 and 5.14 per cent mortality, being very lower than herbicides. The moderate mortality in hand weeding treatment was due to soil disturbances, during its operation and mechanical injury to surface feeding roots. Moderate mortality under unweeded plots was affected due to greater weed stress on crop only.

The varieties showed considerable mortality due to differential tolerance shown by rice cultivars to herbicides (Chang, 1971), cultural practices and due to inheritent genetic charactersitics. Interaction of varieties x weed control techniques failed to cause variation in plant number significantly at 12 and 24 daystages of crop measurements.

5.2.3. Crop growth study

The growth parameters of rice crop such as plant height, LAI, and plant biomass were significantly reduced due to phytotoxic effect of oxadiaozn (Venugopal *et al.*, 1983 and

Anon, 1986). Differential yellowing and necrosis of leaves was affected by oxadiazon. Cook & Simonds (1970) confirmed the above findings. Growth parameters were lagging behind as compared to hand weeded treatment. Amongst the growth parameters, LAI and plant biomass recovered at latter stage, and were at par to hand weeding, but the height remained sustained. This greater LAI and plant biomass were the out come to some hormonal effect of oxadiazon on plant growth (Anon., 1986). Whereas, reduction in height was probably due to less crop weed competition.

Thiobencarb reduced both plant height and LAI significantly, probably due to late emergence and low crop stand. Although, the leaf area per plant and leaf size were higher under thiobencarb however, it was not reflected in LAI. The biomass per plant was equal to hand weeding at 36 DAS. At latter stages thiobencarb also showed hormonal effect on rice crop which probably enhanced greater plant height and biomass yield (Anon., 1986). But LAI remained lowest due to poor canopy differentiation as compared to hand weeding treatment.

Hand weeding exhibited better growth with regard to plant height and LAI at each stage of measurement (Sahu & Jena, 1966). While, in unweeded plot, the growth parameters were almost equal to hand weeding and even higher than herbicides at early stage. But at latter stage, they declined significantly, besides plant height due to severe plant stress.

Early varieties exhibited greater plant height than medium duration varieties up to 60 daystage (Table 16). On the contrary at harvest medium varieties like Pusa-33 and Cauvery exhibited taller plants than early varieties. Due to shorter life span early varieties exhibited faster growth than medium varieties. On the other hand due to longer life span, medium varieties developed slowly in height initially and attained greater height towards maturity, due to prolonged standing in the field. Genetic charactersitics of varieties were another reason for inducing greater plant height.

The LAI of different varieties did not vary significantly upto 24 DAS, because almost similar coleoptilar plant stand was exhibited at this stage. But at latter stages, due to induced tillering of rice cultivars, LAI varied significantly. Because of maximum tillering and greater leaf size, LAI was greater in IR-36 and Pusa-33 as compared to rest of the varieties. While, early cultivars produced less number of tillers, hence registered low LAI as compared to multi-tillering varieties.

The plant biomass was maximum under Purva and Pusa-33 up to 36 daystage probably due to vigorous plant growth. But at 60 daystage, it was significantly higher under early maturing varieties. Because at this stage they started showing differentiation towards boot stage and panicle initiation. Hence, accumulated more dry matter than medium varieties having slower growth due to longer life span. The same results were corroborated by Anon., (1986).

The variation in plant height of rice varieties under different weed control techniques was significant at 24 DAS.

The plant height of most of the varieties was lower under herbicides as compared to hand weeding due to phytotoxic effect of herbicides on seedlings. The phytotoxicity hindered the chlorophyl assimilation process of plant and probably created some physiological disturbances, thus resulting, plants could not recoup their growth as compared to hand weeded plot (Kulmi & Jain, 1985). The varieties viz. CRM 13-32-41 and Purva were taller under oxadiazon than thiobencarb due to their differential tolerance (Bueno & Cabanilla, 1971). While, other varieties exhibited equal tolerance (Venugopal et al., 1983). LAI and plant biomass did not vary significantly at 24 daystage due to insignificant growth.

The varietal tolerance became more apparent due to advance in age of the crop up to 60 DAS. Plant height of CRM 13-32-41 was maximum under thiobencarb, whereas, JR-75 showed significantly lowest plant height under oxadiazon treatment, at 60 DAS and at harvest. Oxadiazon was absorbed from soil due to contact action by plants which probably inhibited shoot development resulting dwarf plants. IR-36 exhibited tallest plants under hand weeding at harvest. While, the interaction with other varieties failed to differ significantly at both the stages (Venugopal et al., 1983).

Biomass yield of Purva and IR-36 was similar under all treatments perhaps due to their similar behaviour for herbicides and cultural operations. However, CRM 13-32-41 and JR-75 produced greater plant biomass under thiobencarb probably due to their reletively significant tolerance to herbicide. At harvest, JR-75 and Purva exhibited greater biomass under thiobencarb, While IR-36 gave higher biomass under hand weeded plot. The remaining varieties yielded almost similar plant biomass under all treatments showing equal tolerance of varieties to herbicides and hand weeding.

LAI of CRM 13-32-14, JR-75 and Purva was at par probably due to their similar tolerance. While, LAI varied widely under Pusa-33 and IR-36. Cauvery showed greater tolerance to oxadiazon which resulted in highest LAI than thiobencarb and hand weeded plots. Ali & Sankran (1976) and Gill & Mehara (1981) also concluded the similar responses to herbcides.

The variations in plant height, plant biomass and LAI of different cultivars under particular treated plot at different stages also involved the factors like crop weed competition, crop stand and control of weeds, respectively.

5.2.4. Effective and ineffective tillers

Both herbicides increased the effective tillers as well as ineffective tillers per plant. Oxadiazon as pre emergence was phytotoxic to rice plant which resulted in higher number of ineffective tillers in proportion to effective tillers per plant as compared to thiobencarb and hand weeding treatments (Ali et al., 1977). Thiobencarb yielded better tiller number than oxadiazon (Anon., 1986) but was found inferior than hand weeding. Whereas hand weeding produced more effective tillers and lower ineffective tillers per plant. The same results are corroborated by Sahu & Jena (1968).

Pusa-33 produced highest number of effective tillers followed by Cauvery, IR-36, CRM 13-32-41, Purva and JR-75, respectively. While, the ineffective tillers per plant were highest under IR-36 and Cauvery. The reason for this differential production of effective and ineffective tillers was, due to genetical characteristics of varieties and cumulative effect of herbicidal toxicity.

The interaction of varieties with herbicides did not influence the effective tillers production (Anon., 1986) on the contrary, exhibited greater number of ineffective tillers per plant. IR-36 and Cauvery exhibited more ineffective tillers under oxadiazon than thiobencarb. The profuse tillering of these varieties upto latter stage, and susceptibility to oxadiazon, might be probable reasons for this differential response (Badea <u>et</u> <u>al</u>., 1970). While, other varieties showed the almost similar tolerance, with regard to production of ineffective tillers per plant (Anon., 1986).

5.2.5. <u>Yield attributing parameters</u>

Various agronomic parameters of yield viz. panicle length, weight, fertile and infertile grains, grain weight per panicle and sterility percentage varied significantly under different treatments. While, thousand grain weight remained unaffected. Amongst herbicides, oxadiazon alleviated the characters like panicle length (15.43 cm) panicle weight(2.1g) (Murthy & Manna, 1984) grain weight (1.9g) fertile grains (49.22) and test weight (21.95g). Because the rice plants absorbed the toxicant along with weeds in a lesser extent. which probably affected the growth and development of rice crop and carried their cumulative adverse effect on sink parameters with highest sterility per cent (16.79). Thiobencarb elevated the panicle length (15.82 cm), panicle weight (2.32g), grain weight (2.12g) and sterile grains (18.63%) (Anon., 1986). Thiobencarb delayed the germination and panicle initiation of rice due to toxic effect, ultimately the sterility was higher in this treatment. Whereas, hand weeding had higher fertile and lower sterile grains and higher test weight (Sahu & Jena, 1968) as compared to both the herbicides.

Varieties differed significantly in yield parameters. Extra early varieties viz. CRM 13-32-41 and JR-75 produced shorter panicle length, reduced grain weight and higher sterile grains as compared to Purva, IR-36, Pusa-33 and Cauvery (Anon., 1986). The varietal characteristics were responsible for these variations in yield attributes.

The interaction of varieties with herbicides was significant, on fertile grains and panicle length per panicle. JR-75, produced highest fertile grains on longest panicle under thiobencarb, but IR-36 inturn exhibited lowest. The differential genetical consititution of varieties at the molecular level, might have shown this differential tolerance to the same herbicide (Gill & Mehara, 1981). Purva yielded lowest fertile grains in oxadiazon plot. While, other varieties showed almost similar tolerance in relation to production of panicle length, fertile grains and sterile grains under all treated plots (Anon., 1986).

5.2.5. Yield attributes and harvest index

The relative effectiveness and proficiency of weed control techniques applied for controlling the weeds, can be judged from the production of grain, straw and crop biomass, collectively.

Data in (Table 26) elucidated that the yield of grain and crop biomass decreased by oxadiazon as compared to hand weeding (Ali et al., 1977). Oxadiazon, adversely affected the growth and development of crop from the beginning stage, due to phytotixicity affecting most of the parameters viz. plant population, plant height, effective tillers, fertile grains, panicle length, weight, grain weight, and 1000 grain weight declined with increased in sterility percentage (16.79). Ultimately the grain yield of rice (21.94 q/ha) decreased (Manna & Dubey, 1974; Ali et al., 1977; Murthy & Dubey, 1980 and Murthy & Manna, 1984) leading more straw yield to the extent of 43.93 harvest index. Compositively the yield of biomass affected by the lower ratio of grain yield and decreased significantly as compared to hand weeding. Whereas, straw yield was on par to hand weeding. The crop biomass, grain and straw yield decreased significantly, under thiobencarb treated plots as compared to oxadiazon (Subbiah et al., 1975) and hand weeding. Though, thiobencarb increased the panicle length, grain weight per panicle, fertile grains and plant biomass significantly and also increased the harvest index (44.73). But, due to the lowest plant population and LAI with higher ineffective tillers and sterility percentage (18.63), the yield of grain, straw and crop biomass decreased significantly.

whereas hand weeding recorded the highest grain and straw yield, including crop biomass (Sahu & Jena, 1968 and Anon, 1986) due to reduced weed competition among all weed control techniques. The grain, straw and crop biomass yield of unweeded plot was less due to severe crop weed competition stress.

Regarding the grain, straw and crop biomass yield of varieties, it is apparent from the (Table 26) that the yield increased along with maturity of varieties, other than Pusa-33. Because early maturing varieties enjoyed lesser photo period due to their shorter duration and cloudy weather, during rainy season. Hence, they produced lower yield as compared to varieties with medium duration. The harvest index of early varieties was more as compared to medium one, probably due to their varietal characteristics and shorter life span.

5.2.7. Economics of treatments

The oxadiazon was most profitable herbicide amongst weed control techniques which gave maximum income (Rs.924.75/ha) as compared to hand weeding (Rs.907.15) and thiobencarb (Rs.96.60/ha) (Anon, 1986). Although, oxadiazon was on par to hand weeding as regards profit/ha. however, due to low cost involved under herbicidal treatment, its net profit touched the highest level (Table 27). On the contrary hand weeding produced greater grain yield, but, due to much cost involved in weeding operations its net profit declined considerably (Verma & Bhardwaj, 1961). It ranked second in profit after oxadiazon treatment. Whereas thiobencarb involved low treatment cost, but due to decline grain and straw yield, the net profit declined drastically (Rs. 96.60/ha).

CHAPTER VI

SUMMARY, CONCLUSIONS AND SUGGESTIONS

SUMMARY, CONCLUSIONS AND SUGGESTIONS

5.1. Summary

The investigation entitled, "Relative effectiveness of oxadiazon and thiobencarb on growth and yield parameters of early cultivars of rice" was carried out on sandy loam soil having low organic matter and nitrogen, high phosphorus and potassium with alkaline reaction (pH 7.4) at Adhartal Farm, Department of Agronomy, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.), during *Kharif* 1986-87.

The experiment was laid out in split-plot design with four replications, having 24 treatments. The main plot treatments comprised of four weed control techniques viz. unweeded control, hand weeding once at 20 DAT, oxadiazon 1 kg/ha and thiobencarb 2 kg/ha, both applied as pre emergence. The sub plot treatments consisted of six early rice varieties i.e. CRM 13-32-41, JR-75, Purva, IR-36, Pusa-33 and Cauvery, respectively. Herbicidal treatments were compared with hand weeding and unweeded control treatments, respectively.

The sowing was done on 12th July, 1986, in straight rows, 20 cm apart. The seed rate of 100 kg/ha was used. The crop was supplied with 80 kg nitrogen 50 kg phosphorus and 30 kg of potash through urea, DAP and muriate of potash. Herbicides were applied one day after sowing as pre emergence spray. The biometric observations regarding weeds were taken, on dominant weeds with respect to density, plant height, LAI and weed biomass, measured prior to harvest. The study was also made on crop density, plant height, LAI, plant biomass, effective and ineffective tillers per plant, and yield attributing characters viz. panicle length, weight, grain weight per panicle, number of fertile and infertile grains, 1000 grain weight, grain yield, straw yield and crop biomass. The data were analysed statistically and important findings have been summarised as under.

6.1.1. Effect on weed growth

Amongst herbicides, oxadiazon proved potential on plant population as well as on growth of weeds. It controlled the weed flora efficiently due to broad-spectrum effect. The pre-dominant weeds viz. sedges, grasses and broad-leaved weeds besides, _Cynodon dactylon_ and _Eclipta alba_ were affected significantly. On the contrary, thiobencarb proved ineffective on the growth and yield attributes of most of the weeds. However, it showed marked effect on _Echinochloa_ spp. a predominant rice weed. The effect on _Cyperus_ spp. was intermediate and quite low on _Cynodon dactylon_ and other broad-leaved weeds. It failed to control the growth of _Commelina communis_ at all stages. Whereas, conventional method like hand weeding was found superior as compared to either of the herbicides. It gave efficient control with regard to density m^{-2}, and growth of weeds including dry matter accumulation.

Varieties did not show differential response as regards plant density, plant height, LAI and weed biomass. Like-wise no interaction of weed control techniques with varieties was noted at all parameters of weed study.

6.1.2. Effect on growth and yield parameters of rice

6.1.2.1. Effect on crop growth

Oxadiazon showed much phytotoxicity on rice seedlings which reflected in slower growth and reduced plant density. Phytotoxicity was noticed with bending of leaves and twisting of neck of seedlings. Scorching and chlorosis was apparent at early stages of growth. However, the recovery to normal growth was attained within a fortnight after treatment. Significantly dwarf plants were observed under oxadiazon which reduced LAI and plant biomass upto 36 day-stage, however, plants recovered at lat-er stages and were at par to hand weeded plot. Whereas, thiobencarb caused delayed germination, slow down the plant growth and reduced seedling stand. The affected seedlings showed dark green colour, thickened leaves bent from mid lamina due to plugging of the meristimetic tissues which dwarfened the plants at 36 day-stage. However, recovery in plant height and biomass was greater than hand weeding at lat-er stages. Whereas, LAI remained lowest due to poor crop stand as compared to oxadiazon and hand weeded treatment. Both herbicides facilitated greater crop growth as compared to unweeded control. While, hand weeding was superior with regard to plant population, height, LAI and biomass, respectively.

The different varieties were almost similar in growth characteristics at early stage, but they varied significantly at later stages. Early cultivars grew faster initially as compared to medium ones. While, medium varieties developed gradually and slowly upto 60 day-stage.

All varieties showed much better growth under hand weeding. Oxadiazon exhibited shorter plants. LAI and plant biomass remained unchanged under all varieties and was comparable with that of hand weeding treatment. While, thiobencarb increased the plant height and biomass of all varieties. But LAI and plant stand reduced significantly.

6.1.2.2. Effect on yield attributing characters

The yield attributes viz. effective tillers, panicle length, weight, grain weight and fertile grains per panicle increased, by all the treatments as compared to untreated control. The potentiality of thiobencarb was established on most of the sink parameters and proved much superior, than oxadiazon. Later herbicide showed pronounced phyto-toxicity on sink parameters and proved inferior to hand weeded treatment. Whereas, hand weeding elevated the yield attributing characters remarkably.

Varieties showed significant difference in sink parameters. CRM 13-32-41, JR-75 and IR-36 cultivars yielded lower number of effective tillers and reduced panicle length and weight. Grain weight, fertile grains also showed decline as compared to Purva, Cauvery and Pusa-33 cultivars, respectively. The varieties differed significantly in test weight. Amongst cultivars, JR-75 and Purva exhibited greater test weight as compared to Pusa-33, IR-36, Cauvery and CRM-13-32-41 cultivars, respectively. The production of infertile grains and sterility percentage were highest under early varieties than medium varieties.

The interaction effect of weed control techniques with varieties was significant on production of ineffective tillers, panicle length, fertile grains and infertile grains per panicle. Varieties such as CRM 13-32-41, JR-75, IR-36 and Pusa-33, responded well to oxadiazon and Purva and Cauvery to thiobencarb. Whereas, all varieties exhibited better response, under hand weeding treatment.

6.1.2.3. Effect on yield attributes

Herbicidal treatments viz. oxadiazon and thiobencarb reduced the grain, straw and crop biomass yield of rice, significantly as compared to hand weeded treatment. Amongst herbicides, oxadiazon proved potential herbicide and increased the grain, straw and crop biomass yield significantly than thiobencarb. Thiobencarb gave poor performance with slightly increased grain and crop biomass yield and reduced straw yield as compared to unprotected plots. Whereas, hand weeding gave highest grain, straw and crop biomass yield over all other treatments.

Medium varieties, Pusa-33, IR 36 and Cauvery gave higher grain and straw production as compared to Purva, JR-75 and RP 13-32-41 of early maturity, respectively.

The interaction of varieties with different weed control techniques was not significant.

6.1.2.4. Harvest Index

Due to enhanced sink parameters, the grain and crop biomass ratio was quite narrow under thiobencarb treated plots, which resulted in maximum harvest index closely followed by hand weeding and oxadiazon. Whereas, due to greater phyto-toxicity on yield attributing characters, the harvest index was lowest under oxadiazon treated plots.

Early varieties with shorter life span, accumulated less straw yield as compared to medium varieties. Hence, early varieties showed higher HI than medium ones. Varieties Purva exhibited highest HI while lowest harvest index was noted under IR-36. While, HI was almost similar under rest of the varieties.

6.1.2.5. Economics

Hand weeding gave significantly maximum grain and straw yield, resulting highest gross return as compared to other weed control treatments. But, due to high cost involved in weeding operation, hand weeding proved less economical method than oxadiazon, where, the gross returns were less, but due to lower cost of oxadiazon treatment, it reflected in more profit than hand weeding. On the other hand, due to poor grain and straw yield, thiobencarb gave marginal profit inspite of low cost of treatment.

6.2. Conclusions

After summerising the results of the experiment, broad conclusions drawn are :-

1. The associated weed flora of upland rice was Cyperus spp., Cynodon dactylon, Commelina communis, Echinochloa spp. and Eclipta alba. Direct seeded rice crop had to compete mainly with these weeds being the predominant weeds of upland fields.

2. One hand weeding at 20 DAS gave excellent control of weeds with maximum grain and straw yield of rice.

3. Oxadiazon 1 kg/ha as pre emergence proved potential herbicide and controlled the sedges, grasses and broad-leaved weeds with 50.18 per cent weed control efficiency.

4. Thiobencarb 2 kg/ha as pre emergence gave moderate weed control with 21.03 per cent weed control efficiency and controlled Echinochloa spp. effectively. But it failed to control broad-leaved weeds and had adverse effect on rice crop with lowest net profit (Rs. 96.60/ha).

5. The weed density and dry matter yield did not differ significantly in association of rice varieties.

6. All the rice varieties exhibited better tolerance to oxadiazon and gave higher grain and straw yield as compared to thiobencarb. However, the interaction was not significant.

7. Oxadiazon proved economical and convenient method of weed control for early rice cultivars with highest net profit (Rs. 924.75/ha) under upland conditions closely followed by hand weeding (Rs. 907.15/ha). But with local labour available hand weeding will be more economical with higher yield.

Further suggestions

1. The experiment should be repeated to confirm the above findings.
2. The herbicides should be tested with their lower and higher levels.
3. Post emergence application of herbicide granules needs to be tested.
4. Other potent rice herbicides should also be tested alongwith oxadiazon and thiobencarb herbicides.
5. The rice herbicides should be evaluated on medium to late varieties under both upland and transplanted conditions.
6. Thiobencarb should be tested one week after sowing as early post emergence.

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APPENDICES

APPENDICES

Mean sum of square for population of dominant weeds/m^{-2} at different stages

Source of variation	df	Cyperus spp.			Cynodon dactylon			Commelina communis			Echinochloa spp.		
		20 DAS	35 DAS	50 DAS	20DAS	35 DAS	50 DAS	20 DAS	35 DAS	50 DAS	20 DAS	35 DAS	50 DAS
Replication	3	15.20	5.85	1.33	0.68	0.75	0.25	3.70	2.31	0.85	0.13	0.66	0.68
W.C.methods	3	295.46	870.44	759.07	3.55	67.19	50.65	9.46	72.11	52.32	63.23	64.02	40.15
Error (a)	9	10.56	5.79	12.20	2.51	0.45	0.53	1.80	1.40	1.29	0.72	0.19	0.63
Varieties	5	3.19	1.06	1.06	0.41	0.27	0.08	1.19	0.70	0.29	1.56	0.27	0.09
W.C. x Var.	15	0.58	0.67	2.24	0.79	0.48	0.32	1.65	0.51	0.31	0.45	0.17	0.14
Error (b)	60	3.40	1.56	1.48	0.45	0.44	0.38	1.18	0.83	0.78	0.84	0.28	0.25

Source of variation	df	Eclipta alba			Other weed species			Total weed population		
		20 DAS	35 DAS	50 DAS	20 DAS	35 DAS	50 DAS	20 DAS	35 DAS	50 DAS
Replication	3	2.69	4.22	2.13	2.73	2.45	4.35	8.29	2.91	0.92
W.C.methods	3	24.60	15.24	2.55	51.27	145.97	90.73	380.31	725.50	556.35
Error (a)	9	0.92	1.15	0.97	1.35	0.88	0.63	12.88	2.82	10.80
Varieties	5	0.52	0.09	0.10	0.16	0.48	0.20	2.12	1.99	0.90
W.C. x Var.	15	0.35	0.23	0.14	0.11	0.32	0.18	1.71	1.25	1.75
Error (b)	60	0.29	0.29	0.24	0.32	0.49	0.38	2.65	1.52	3.18

Mean sum of square of dominant weeds at different stages

For height

Source of variation	df	Cyperus spp. 35 DAS	Cyperus spp. 50 DAS	Cynodon dactylon 35 DAS	Cynodon dactylon 50 DAS	Commelina communis 35 DAS	Commelina communis 50 DAS	Echinochloa spp. 35 DAS	Echinochloa spp. 50 DAS
Replication	3	6.29	33.41	3.30	72.17	7.04	13.23	6.80	70.32
Weed control methods	3	3386.97	1246.37	1478.78	1222.91	953.85	2123.40	2209.40	1074.84
Error (a)	9	19.18	14.72	4.41	34.50	11.25	48.28	26.45	58.36
Varieties	5	2.18	21.31	1.22	22.54	3.35	13.43	1.91	23.24
Weed control x Varieties	15	6.01	10.25	5.22	15.71	3.12	12.23	5.07	32.62
Error (b)	60	19.91	29.42	12.80	44.80	6.09	27.57	8.81	46.70

For LAI

Source of variation	df	Cyperus spp. 35 DAS	Cyperus spp. 50 DAS	Cynodon dactylon 35 DAS	Cynodon dactylon 50 DAS	Commelina communis 35 DAS	Commelina communis 50 DAS	Echinochloa spp. 35 DAS	Echinochloa spp. 50 DAS
Replication	3	0.009	0.109	0.0001	0.0002	0.0019	0.0027	0.0010	0.0014
Weed control methods	3	2.896	3.896	0.0192	0.0108	0.1204	0.2666	0.2011	0.1032
Error (a)	9	0.024	0.044	0.0006	0.0002	0.0035	0.0005	0.0004	0.0014
Varieties	5	0.014	0.013	0.0009	0.0007	0.0008	0.0001	0.0019	0.0001
Weed control x Varieties	15	0.011	0.014	0.0006	0.0003	0.0016	0.0017	0.0016	0.0002
Error (b)	60	0.007	0.016	0.0004	0.0003	0.0031	0.0036	0.0084	0.0004

Mean sum of square for dry matter of weeds at harvest (g) m^{-2}

Source of variation	df	Cyperus spp.	Cynodon dactylon	Commelina communis	Echinochloa spp.	Eclipta alba	Other weeds	Total weeds
Replication	3	4.99	4.84	56.31	70.8	0.01	24.66	41.72
W.C.methods	3	2113.07	1379.79	34131.51	12934.28	2.30	56.62	116277.82
Error (a)	9	18.84	8.52	184.00	68.98	0.13	16.35	110.82
Varieties	5	48.43	25.96	463.50	136.54	0.55	4.32	478.36
W.C. x Var.	15	27.98	14.92	333.84	117.73	0.34	8.27	395.25
Error (b)	60	16.77	11.03	348.81	71.03	0.20	15.56	320.51

Mean sum of square for :-

Source of Variation	df	Rice population/m^{-1} row length				Crop plant height			
		12 DAS	24 DAS	36 DAS	60 DAS	24 DAS	36 DAS	60 DAS	At harvest
Replication	3	1.33	1.83	2.47	0.40	2.25	116.44	120.33	35.04
W.C.methods	3	28.14	32.84	24.09	24.51	92.82	136.15	124.95	84.36
Error (a)	9	0.74	0.86	1.26	1.42	8.36	55.95	11.13	7.42
Varieties	5	1.72	1.21	6.61	8.71	27.55	115.38	1136.64	124.68
W.C. x Var.	15	0.21	0.27	0.84	1.06	4.89	7.30	25.48	33.93
Error (b)	60	0.18	0.216	0.54	0.46	1.04	5.49	9.77	15.44

Mean sum of square for :-

Source of Variation	df	Crop LAI 24 DAS	Crop LAI 36 DAS	Crop LAI 60 DAS	Biomass/plant 24 DAS	Biomass/plant 36 DAS	Biomass/plant 60 DAS	At harvest	Effective tillers	Ineffective tillers
Replication	3	0.020	1.57	3.19	0.0006	0.0092	0.233	0.51	0.308	0.044
W.C.methods	3	0.326	23.37	14.82	0.0061	0.0707	0.459	12.95	1.83	0.093
Error (a)	9	0.008	2.10	1.87	0.0017	0.0065	0.149	1.50	0.31	0.015
Varieties	5	0.014	29.66	2.87	0.0006	0.0246	1.692	16.20	2.39	0.475
W.C. x Var.	15	0.007	8.08	1.11	0.0002	0.0077	0.393	1.64	0.22	0.055
Error (b)	60	0.006	2.33	0.83	0.0002	0.0074	0.086	0.73	1.13	0.020

Mean sum of square for :-

Source of variation	df	Panicle length	Panicle weight	Fertile grains	Infertile grains	Grain wt./ panicle	Test weight	Grain yield	Straw yield	Crop biomass
Replication	3	0.60	0.12	49.01	5.22	0.11	1.12	0.86	0.77	0.77
W.C.methods	3	9.20	4.32	683.98	79.39	4.12	0.04	15.72	5.26	20.97
Error (a)	9	0.71	0.44	77.35	2.54	4.38	0.41	1.79	0.58	1.31
Varieties	5	50.43	4.39	452.63	356.70	3.71	39.20	9.80	5.62	13.75
W.C. x Var.	15	1.63	0.47	165.72	20.33	0.41	0.41	2.66	0.33	0.71
Error (b)	60	0.709	0.305	64.53	10.90	0.27	0.28	6.37	0.24	0.43

VITA

The Author was born on 25th June, 1956 at Village Bhuwani, Tehsil and District Shivpuri (M.P). He completed the Higher Secondary education from Bhartiy Vidyalaya, Shivpuri in the year 1973. He took admission for B.Sc.(Ag) In College of Agriculture Gwalior and completed it in 1977, securing an OGPA of 3.47 out of 4.00 scale. Then in the same month he joined the service as Upper Division Teacher in Bhartiy Vidyalaya, Shivpuri and served for ten months. He was appointed as Agriculture Development Officer in Agriculture Department of Madhya Pradesh in 1978 and served as Agriculture Extension Officer, Agriculture Field Officer (on deputation, UCO Bank) and Garden Superintendent. In the year 1984 he got promotion as Senior Agriculture Development Officer. Same time he was selected for Post Graduate Qualification under World Bank Scheme and he got admission in the Department of Agronomy, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur as in-service candidate. He obtained an OGPA of 3.40 out of 4.00 scale and is going to accomplish the same by submitting this thesis in partial fulfilment of the requirement for M.Sc.(Ag) degree.