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COMPARATIVE EFFICIENCY OF HERBICIDES AND
CULTURAL METHODS ON GROWTH, YIELD
ATTRIBUTES AND YIELD OF DWARF WHEAT
(*Triticum aestivum* L.) VAR. WH-147

THESIS

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By
VIVEK KUMAR MANTRI

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, "COMPARATIVE EFFICIENCY OF HERBICIDES AND CULTURAL METHODS ON GROWTH, YIELD ATTRIBUTES AND YIELD OF DWARF WHEAT (Triticum aestivum L.) VAR. WH-147" 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 VIVEK KUMAR MANTRI 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.

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THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

- Chairman (Dr. H.C. Jain)
- Member (Dr. J.P. Tiwari)
- Member (Dr. M.S. Johar)
- Member (Dr. S.K. Agrawal)

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CERTIFICATE - II

This is to certify that the thesis entitled, "COMPARATIVE EFFICIENCY OF HERBICIDES AND CULTURAL METHODS ON GROWTH, YIELD ATTRIBUTES AND YIELD OF DWARF WHEAT (Triticum aestivum L.) VAR. WH-147" submitted by Shri VIVEK KUMAR MANTRI to Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, in partial fulfilment of the requirements for the degree of M.Sc. (Ag.) in the Department of Agronomy has, after evaluation, been approved by the external examiner and by the student's advisory Committee after an oral examination on the same.


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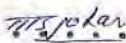
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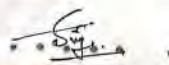
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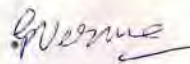
Dr. S.K. Agrawal

..  ..

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

..  ..

Director of Instructions (Dr. G.P. Verma)

..  ..

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Vivek
(Vivek Kumar Mestri)

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Herbicides either as pre-emergence or POE proved efficacious and proved much superior to no weeding and cultural treatments. Isoproturon PE registered low dry matter accumulation of weeds with high weed control

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CHAPTER I

INTRODUCTION

Wheat is the most important crop of the world. In terms of both area and production, India today ranks fourth among the wheat growing countries of the world. During 1985-86 the wheat occupied an area of 23.07 million hectares in India with an production of 46.89 million tonnes per year. While in M.P. wheat is grown in 3.60 million hectares with an annual production of 4.13 million tonnes. The average yield of wheat in M.P. is 11.46 q/ha being very low as compared to the average yield of 20.32 q/ha of the country.

The constraints of low yield may be attributed to the non-adoption of new production technology, which involves the use of high yielding varieties, costly inputs such as judicious use of fertilizers and timely irrigation. The crop had to face the weed competition during the growth cycle of the wheat crop. The weeds compete for nutrients, space, light and moisture during the growth cycle of the crop. Apart from these, resilient enemies, i.e. grassy and nongrassy weeds, reduce the yield of wheat, considerably. The improved technology would certainly fail in boosting the yield of wheat if weeds are not controlled properly in time.

The severe infestation of weeds like Phalaris minor, Avena spp., Chenopodium album, Trifolium flagiferum are posing a great threat to wheat cultivation in India and M.P. in particular. The introduction of wild oats (Avena ludoviciana) and canary grass (Phalaris minor Retz.) in dwarf wheat reduce the potential yield by nearly 50 per cent (Hooda et al., 1974). Various researchers estimated losses to the tune of 10 to 82 per cent depending upon the nature of weed flora and relative intensity of weeds (Mukhopadhyay et al., 1962; Gill and Brar, 1973 and Pandey et al., 1981).

Apart from resilient enemies, the other dominant weeds which invade wheat crop includes Anagalis arvensis, Medicago denticulata, Melilotus alba, Gynodon dactylon, Cichorium intybus, Convolvulus arvensis, Paspalum spp., Sonchus arvensis and Digitaria sp. etc. Thus they are causing much damage to wheat crop in wheat dominant areas.

Control of grassy and non-grassy weeds is one of the most important steps in crop production. Most of the farmer's time is spent in the battle against weeds. The farmers have been compelled to resort to special attention in controlling these resilient enemies of dwarf wheat. It is thus felt essential to realise the pressure of grassy weeds in wheat crop. Unless weed competition is lessened, it is impossible to harness the full yield potential from dwarf wheat.

Different methods in vogue are prevalent for controlling the weeds in wheat fields in India. Since ancient times, farmers adopted conventional methods in controlling the weeds in wheat crop. With the advancement of knowledge and availability of better tools, the methodology of weed control changed altogether. It is even asserted that many age old practices such as hand weeding, hand hoeing and intercultivation by implements are primarily intended to keep the weed population under control. These techniques did not work well in case of perennial weeds such as Cirsium arvensis and Convolvulus arvensis etc.

Closer planting at 15 cm, with 50 per cent higher seed rate and cross geometry have shown distinct advantage in reducing the stand of Phalaris minor in dwarf wheat at a number of places in the country. Although cultural methods are quite effective in controlling the menaces of Phalaris minor Retz, as well as other weed flora, but due to unavailability of required labour to all farmers at right time and unfavourable weather conditions to perform manual operations, lot of damage is done to wheat crop. Valuable plant nutrients are also depleted if weeding is done 2 to 3 weeks later of weed growth in wheat crop.

Therefore, any modification of the environment through cultural manipulation may have intense ecological implications on the weed associated with the wheat crop.

Information on manipulation of crop densities through enhanced seed rate so as to obtain optimum plant stand for getting the smothering effects of crop on weeds is available. Varying results on this aspects are reported by many weed agronomists in the country. Increased seed rates than normal have given economic results, despite of the costs involved due to increased seed rate.

The cost of controlling the weeds and the losses from failure to control them are born in mind by many farmers. Therefore concentration on non-monetary inputs like plant spacing, seed rate, cross sowing, sowing time, synchronizing with the environmental conditions in such a way that it becomes most favourable for wheat crop and least to weeds. The results obtained in the country reveal that combination of higher seed rates and cross sowing not only suppressed the weed growth effectively, but in contrast, increased the yield of wheat crop simultaneously. Although, several methods for controlling the weeds in wheat crop are available, but none of them is without drawbacks. These methods are tedious, costly and time consuming and needs so much manpower than the work is often abandoned during the peak period of labour requirement. Beside aforesaid limitation, these cultural methods disturb the soil crust scatter the weed seeds, breakup the dormancy, damage surface feeding roots and increase the risk of excessive dehydration and erosion by exposing and loosening the soil.

To overcome these difficulties met with the traditional methods, weed control by chemicals is resorted to, which is effective, easier, cheaper and many times faster than the traditional methods. The efficacy of these chemicals depend on their properties and behaviour to activate the soil type, soil moisture, rainfall, temperature and pH of the soil. Thus a particular type of herbicide is, therefore, able to work well under a given set of conditions. Different formulations of these herbicides are available for controlling grassy and nongrassy weeds in wheat such as isoproturon, 2,4-D EE and fluoroxyppy etc. Isoproturon (Nocilon) a member of the substituted ureas characterised for their broadest spectrum in inhibiting the grassy weeds and was tested primarily to control grassy weeds in dwarf wheat, but its efficiency to control weeds was high for wild oats and broad leaved weeds. Whereas an age old herbicide 2,4-D controls mostly broadleaf weeds in cereals and its range of action is limited. Most recently Dow Chemical Company has developed a new formulation named as 'Starane-2' and proposed for killing dominant weed flora in wheat crop.

These herbicides have shown great promise as selective grass killer in cereals either applied as pre- or post-emergence or applied mixed with fertilizer which would prove effective in eliminating the weeds in the early and mid growth stages of the wheat crop. The competability of these herbicides with fertilizers need to be tested for economic returns.

Under semi-arid tropical conditions, the favourable temperature and illumination regime, not only provide scope for multiple cropping but also favour rapid multiplication of weed growth which would compete with food crops. In India till today not much have been achieved in controlling the grassy and nongrassy weeds by traditional herbicides and new herbicides. Efficacy of the new herbicides depend upon the interaction of agroclimatic condition of the place. It is of paramount importance to collect precise and accurate information regarding their suitability, selectivity, their time of application, dosage and combination to control weed spectrum as well as their effect on plant growth, yield attributing characters, yield and quality etc. of wheat crop. It is thus considered essential to evaluate potential herbicide as well as appropriate cultural method for their effectiveness against obnoxious weeds.

Keeping the above facts in view the present investigation entitled, " Comparative efficiency of herbicides and cultural methods on growth, yield attributes and yield of dwarf wheat (Triticum aestivum L.) var. MH-47" was carried out during Habi 1988-89 with the following objectives :-

- (1) To find out the most effective herbicide or cultural method of weed control in dwarf wheat.

- (2) To find out the effect of different weed control treatments on growth and yield attributes of dwarf wheat.
- (3) To evaluate the effect of weed control treatments on density and dry matter accumulation of weeds.
- (4) To study the effect of close row spacing, high seed rate and bidirectional sowing on the density of weeds and their relative effects on wheat crop.
- (5) To find out the most economical method of weed control.
- (6) To evaluate the compatibility aspects of herbicides with fertilizers on growth, yield and economic return of the wheat crop.

CHAPTER II

REVIEW OF LITERATURE

Relevant literature available on crop weed association and weed control devices prompted by dramatic growth of herbicide research followed by technological developments in cultural methods in wheat crop have been reviewed in this chapter.

2.1 Crop weed association :

It is the coexistence between crop and weeds so that they prevail in the similar ecosystem. The requirement of weeds for their growth and development i.e. nutrient, moisture, light etc. are similar to the crop. The associated weeds may be similar in their morphological features i.e. P. minor and Avena ludoviciana in wheat.

Khanda and Dhadke (1980) reported that weed flora and their intensity in wheat fields in Punjab and Haryana were recorded. Weed flora i.e. P. minor, A. ludoviciana, P. parviflora, Melilotus indica, Anagalis arvensis and Convolvulus arvensis, and Avena fatua were noted among monocots and only Argemone mexicana in dicots.

Wick (1985) reported major weeds of the experimental field viz. Trigonotis portulacastrum L., Echinochloa



colonom L., Dactyloctenium aegyptium L., Cyperus rotundus L., Diosora arvensis, Parthenium hysterophorus and Convolvulus arvensis.

Jain (1987) postulated that the experimental area was infested with Phalaris minor Retz., Chenopodium album, Portulaca oleracea, Trifolium flagiferum, Digitaria, Cyperus rotundus Pers., Melilotus alba and other weeds.

Tiwari and Bisen (1987) studied crop weed competition at Jabalpur in 1979-82 and reported in crop of wheat, gram, peas, linseed and safflower infested with P. minor, Chenopodium album, Melilotus spp., Echinochloa spp., Trifolium Flagiferum, Portulaca oleracea, Rumex dentatus, Solanum nigrum and Paspalum distichum.

2.2 Crop weed competition :

Crop competition is one of the cheapest and most useful methods a farmer can use. Plant competition is a natural force whereby 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 expense of the other. The competition between weeds and crop is severe when individual species competing are alike in growth habits, method of reproduction and demand upon the similar environment in which they are nurtured. Often it means using the best crop production methods -

methods so favourable to the crop that weeds are crowded out. Weed demands immense amount of light, space, water and nutrients than crop under similar and ecological niches ultimately the crop growth and yield of wheat are reduced drastically due to severity of weed competition.

2.3.1 Effect on crop growth :

From the reviews of research work done in India and abroad, it is postulated that weeds cause considerable damage in growth and yield attributes of wheat crop. In general, increase in weed intensity results in reduced growth and yield of crops. Frequently, correlation coefficients as high as 0.8 were obtained between these two variables (Burnside and Wicks, 1969).

Bowden and Fridsen (1967) observed that at density of 190 plants per square meter of A. fatua, tillering of wheat was negligible and this competition was more under fertilized condition than under unfertilized one.

Gill and Brar (1972 and 1975) from P.A.U. Ludhiana reported that crop heavily infested with P. minor reduced the height of wheat plant and number of tillers per meter row length.

Reduced number of spikelets and grain yield of wheat was reported due to heavy infestation by grassy weeds in wheat crop (Kilsifield, 1973).

Woods et al. (1974) reported that higher density of 160 plants/m² of wild oats completely checked the tillering of wheat.

Prabhakar Shetty et al. (1977) observed that infestation of Cynodon dactylon significantly reduced the plant height, number of heads per plant, number of seeds per head and 1000-grain weight to the extent of 65 per cent reduction in yield,

Significant reduction in number of panicles per square meter in wheat with the infestation of wild canary grass (Phalaris cumsonianus) was observed (Tosh and Mishra, 1977).

Magrin et al. (1984) reported that infestation with Chenopodium album, Amaranthus and Polygonum spp. caused tiller reduction due to weed competition at 35-40 days after sowing and reduced the number of grain/spike, but not grain weight.

2.2.2 Effect on yield :

Mani et al. (1968) while summarising the research work of the country, reported 10 to 85 per cent reduction in grain yield of wheat due to presence of weeds. The Phalaris minor Retz. caused 45 per cent reduction in grain yield. The reduction depends upon the intensity of infestation.

Rea and Sharda (1970) observed that losses in yield due to weed competition in wheat crop were to the tune of 80 per cent.

The losses brought about by Phalaris minor Retz., in grain yield of wheat depends upon the degree of infestation. The infestation of crop with Phalaris minor Retz. and Avena fatua L. caused 45 to 50 per cent reduction in grain yield (Anonymous, 1972).

Negi and Bhan (1974) postulated that Phalaris minor Retz. alone reduced the wheat yield by 33 per cent, while reduction of 17 per cent yield was noted under other weeds. If grassy and nongrassy weeds were allowed to stress upon wheat crop, then the wheat yield reduction will be to the level of 22.6 q/ha.

Gill and Walla (1979) reported P. minor Retz. to be the major weed in irrigated wheat in Punjab. It has been reported to reduce the wheat yield by 51 per cent.

Katyal et al. (1980) reported that the weed infestation is an important factor in reducing the wheat yields. Losses caused due to grassy and broad leaved weeds in wheat may range from 34 to 50 per cent.

2.3 Weed control technique :

Control of weeds could be accomplished either by means of cultural methods including different cropping practices such as methods of planting crops, crop density and geometry and use of selective herbicides.

2.3.1 Cultural methods :

Infestation of weeds could be reduced to a maximum degree by a number of cultural operations, which are within the reach of the farmer.

2.3.1.1 Hand weeding :

Gill and Brar (1973) reported that at Punjab Agriculture University, Ludhiana, heavily infested wheat variety Kalyansona with Phalaris minor gave 2.4 tonnes per hectare yield. While one hand weeded plot yielded 2.65 tonnes of grain yield per hectare.

According to Hooda et al. (1974) the most suitable time to commence first hand weeding in case of dwarf wheat and tall wheat is about 3 to 4 weeks after sowing and moreover just after first irrigation. They further reported that two hand weeding at 3 and 6 weeks after sowing proved to be as effective as nitrogen and triallate herbicides and attained decreased dry matter accumulation of Phalaris minor after two hand weeding.

Shivkumar (1982) reported that two hand weeding, at 4 and 6 weeks after sowing controlled weeds satisfactorily and gave grain and straw yields parallel to weed free condition.

Mishra et al. (1981) reported that highest grain yield was obtained from hand weeding four weeks after sowing.

Tiwari and Eisen (1987) reported that hand weeding increased average grain yield from 2.78 to 3.54 t/ha. Weeding also increased crop biomass.

Singh et al. (1984) reported that hand weeding 35 days after sowing produced significantly higher yield of grain and straw. Yield increased due to significant increase in number of effective tillers and 1000 grain weight.

2.3.1.2 Row spacing :

Randhawa et al. (1977) reported that closer row spacing significantly increased grain yield of wheat. Sowing rate, sowing date, row spacing interaction were not significant. Straw yield decreased similarly from 8.62 to 6.3 t/ha.

Dhillon and Klov (1978) reported that cv. WG-737 at 100 kg/ha in straight rows and in cross rows gave grain yields of 4.01 and 4.59 t/ha on sandy-loam soils, at Ludhiana.

Muhammad (1978) observed that when wheat was grown at row spacing of 6, 12, 18 or 24 cm, grain yield was highest with 18 cm spacing.

Singh et al. (1978) concluded that better grain yield of wheat could be obtained by sowing of crop in cluster squares (20 x 20 cm) than rows 20 cm apart and broadcasting.

Dhillon and Klov (1981) reported that substantial grain yield increased by sowing half the seed and fertilizer in one direction and other half in rows at right angle, giving a spacing of 22.5 x 22.5 cm thereby intercepting more light which carried their parallel effect in increasing the growth and yield of wheat crop.

Nageshwar (1982) reported that cross sowing with normal seed rate produced highest grain yield of wheat under late sown conditions.

Prakash et al. (1986) reported that sowing crosswise at distance of 22.5 x 22.5 cm gave the highest yield (4.82 t/ha) which was related to large number of spikes/m of row length and a low weed dry weight.

Field investigations on unidirectional and bidirectional sowing of wheat were conducted on a loamy and irrigated soil. Walia and Chema (1986) found that bidirectional sowing of wheat significantly increased the grain yield (10%), number of productive tillers (11%), number of grains/ear (9%) and LAI (12%) as compared to sowing in East-West direction and also noted to be better than sowing in the North-South direction.

Singh et al. (1987) reported that highest grain yield of wheat is recorded with cross sowing at normal seed rate 100 kg/ha.



2.3.1.3 Seed rates :

Adamczewski and Walczak (1976) studied the effect of sowing rates of wheat in yield and weed control efficiency. They concluded that there were no significant effect on grain yield due to rates of seeding.

Suryanarayanan (1977) reported that increase in grain yields of wheat cv. Sonalika with increasing sowing rates from 80 to 160 kg/ha were ascribed to increase in the number of ear-bearing tillers and 1000 grain weight.

Atterde and Khuspe (1979) observed the effect of sowing rates of 100, 150 or 200 kg/ha and N rates of 80, 120, 160 or 200 kg/ha on wheat cv. NI-917, NI 747-19, Kalyansona and Sonalika were studied in 1970-71 at Pune. Sowing rate only affected the number of effective tillers/plant and the highest values were obtained with 100 kg seed/ha.

Smid and Jenkinson (1979) observed that when winter wheat were sown at 34, 67, 101, 134 or 168 kg/ha yields were highest at 134 kg/ha seed. Sowing rates did not affect lodging. As seeding rates increased, the increase in the number of ears/ha was greater than the accompanying decrease in grains/ear, giving a net overall yield increase.

Harris (1981) observed that when sowing rates of 148, 190 or 281 kg seed/ha were compared in 1978 and 1979, the yield of winter wheat increased with increasing seeding rate.

Kalita and Choudhary (1984) reported that the increasing seed rate increased the number of ears/m. The yield of both grain and straw were significantly increased with the increasing seed rate. 120 kg seed/ha produced the highest yields.

Shaktawat (1983) reported that common practice and 15 cm spacing with 150 kg seed/ha increased the grain and straw yield by 25.1 (41.3%) and 31.1 q/ha (34.4%) over unweeded check, respectively.

2.3.2 Chemical methods :

The growing impact of herbicides use in modern agriculture had created new interests and opened up new facets of research in cereal crops to the best competitive advantages.

For obtaining higher yields, chemical methods are the only surest and potential methods of weed control if applied at right time and in proper dose, according to the nature of cotyledons and intensity of the weeds.

2.3.2.1 Isoproturon :

Kassabian (1977) reported that isoproturon at 0.75 or 1.75 kg per hectare as PE gave most promising results in wheat crop and reduced dry matter accumulation of weeds.

Tiwari and Mehrotra (1978) observed adverse effect of weed on quantity and quality of the produce. They have also

reported that application of isoproturon improves the growth and yield side-by-side improving the nutrient standard of the crop. The crop responded favourably to herbicides application and gave higher grain yield of better quality owing to inhibition of weed growth and prevention of the losses of moisture and nutrients.

Gill and Walla (1980) reported that isoproturon as PE 1.25 kg/ha gave effective control of wild oats and associated broad leaved weeds and recorded maximum grain yield to the extent of 44.50 g/ha.

Shivkumar (1982) reported that isoproturon at 1 kg/ha as pre-emergence application gave highest grain yield of wheat as compared to other herbicides.

Bhan et al. (1982) reported that application of isoproturon 1 kg/ha increased the grain yield significantly over weedy check.

Gangrade (1982) reported that pre-emergence application of isoproturon at 1.5 kg/ha provided excellent control of Phalaris minor and other broad leaved weeds which in turn gave higher grain yield of dwarf wheat.

Yadav et al. (1984) reported that different formulations of isoproturon controlled Phalaris minor and other weeds effectively and gave significantly higher yield than the unweeded control.

All (1985) reported that pre-emergence application of isoproturon (0.25 and 0.5 kg/ha) was selective to wheat. Higher dose of isoproturon was effective in controlling the major and other annual broad-leaved and grassy weeds.

Singh (1986) observed that isoproturon 1 kg/ha as pre-emergence proved much potential in eliminating the weed intensities to the extent of 89.28 per cent over no weeding.

Balyan (1987) reported that isoproturon at 1 kg/ha gave grain yield 5.3 t/ha and excellent weed control in wheat.

Mirkamal (1987) reported that isoproturon at 2.5 kg/ha pre-emergence gave 82 per cent control of P. brachystachys but the resultant crop damage prevented any significant increase in grain yield.

Singh et al. (1987) observed that effective suppression of the weed flora was achieved with 1 kg isoproturon/ha pre-emergence and recorded highest (3.1 t/ha) grain yield of wheat crop.

2.3.2.2 2,4-D :

Sharma et al. (1970) reported that 2,4-D at 1 kg/ha was applied two months after sowing of wheat. The amine formulation was the most effective treatment which produced the highest grain yield and gave upto 40 per cent control of Cyperus rotundus.

Bhardwaj and Verma (1971) reported that post emergence application of sodium salt 2,4-D 1.12 kg/ha proved most effective for the control of weeds except grasses and gave significantly 19 per cent higher yield than control.

Salontai (1971) observed that 2,4-D at 1 kg/ha with urea at concentration of 1 to 5% effectively controlled the weeds and obtained higher yield (due to increased number of grains per ear and 1000 grains weight) when applied at the beginning of the late jointing stage, 4 per cent being considered optimum.

Jain et al. (1974) reported that 2,4-D alone at 0.25 to 0.50 kg/ha increased grain yield by 5 to 20 per cent with an addition of 3 per cent urea, by 20 to 30 per cent.

Verma et al. (1975) reported that 2,4-D at 0.8 kg/ha + 3% urea solution applied at 4 to 6 week leaf stage gave effective weed control and increased the yield by 26.2 per cent as compared to unweeded control.

Rao and Patel (1976) observed that 2,4-D at recommended dose gave effective control of weeds in wheat crop.

Chikulaev (1977) reported that application of 1.2 kg 2,4-D amine/ha to spring wheat gave effective control of weeds except Mulgedium taticum and Sonchus arvensis and increased the grain yields by 120 kg/ha.

Singh et al. (1984) reported that 2,4-D controlled broad leaved weeds effectively.

Five herbicides were evaluated for their weed control efficiency and influence on grain yield (Kumar et al., 1986). The results revealed that all the herbicides caused significant reduction in dry matter production of weeds. Highest grain yield was obtained with 2,4-D 1.5 kg/ha + 3% urea, which was highest as compared to all the treatments. The lowest yield of 14.99 g/ha was obtained with weedy check.

2.3.2.3 Fluroxypyr :

Singh (1986) reported that Starane-2 controlled broad-leaf weeds effectively at 1.5 to 2.5 kg/ha. The sedges and grasses were not controlled.

Experiment on 'Integrated Weed Control in wheat' elucidated that fluroxypyr alone at all the rates significantly reduced the broad leaved weeds as compared to control (Anonymous, 1987).

Kozieki (1987) reported that application of Fluroxypyr in winter wheat and winter and spring barley for the control of G. sparine and Avena spp. caused slight acceptable visual crop damage. Double rate of Fluroxypyr did not affect crop yields.

Singh et al. (1987) reported that fluroxypyr was superior to 2,4-D in improving the growth, yield attributes and yield of wheat. Fluroxypyr at higher rates of 0.4 and 0.6 kg/ha recorded higher values of yield attributes and yield than lower rate of 0.2 kg/ha.

Singh et al. (1987) reported that fluroxypyr was found most effective in reducing the population and dry weight of weeds. Effectiveness of fluroxypyr increased with the increase in rates from 0.2 to 0.6 kg/ha.

* * *

CHAPTER III

MATERIALS AND METHODS

Details of materials used and techniques employed during the course of present investigation are described as follows :

Experimental site :

The field experiment was conducted at the Agricultural Research Farm, Adhartal, under All India Co-ordinated Research Project on weed control of Department of Agronomy, J.N.E.V.V., Jabalpur, during Rabi season, 1988-89.

Climatic conditions :

The climate of Jabalpur is typically semi-humid and sub-tropical with severe winters and summers. It is situated at 23.09°N latitude and 79.58° East longitude. Its altitude is 411.78 meter above the mean sea level. Jabalpur falls under the Rice-Wheat Zone of Madhya Pradesh. The average rainfall is about 1400 mm, which is mostly received between June to September and very little (75 to 175 mm) in October to May.

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 this tract is 73.95 per cent.

Season :

Seasonal variations observed during the growth period played an important role in the development of wheat crop which had great influence on the yield of crop.

The monthly meteorological data on temperature, rainfall and relative humidity during the crop season of 1988-89 is obtained from the All India Co-ordinated Research Project on Agro-Meteorology, J.N.K.V.V., Jabalpur and is portrayed in Table 1.

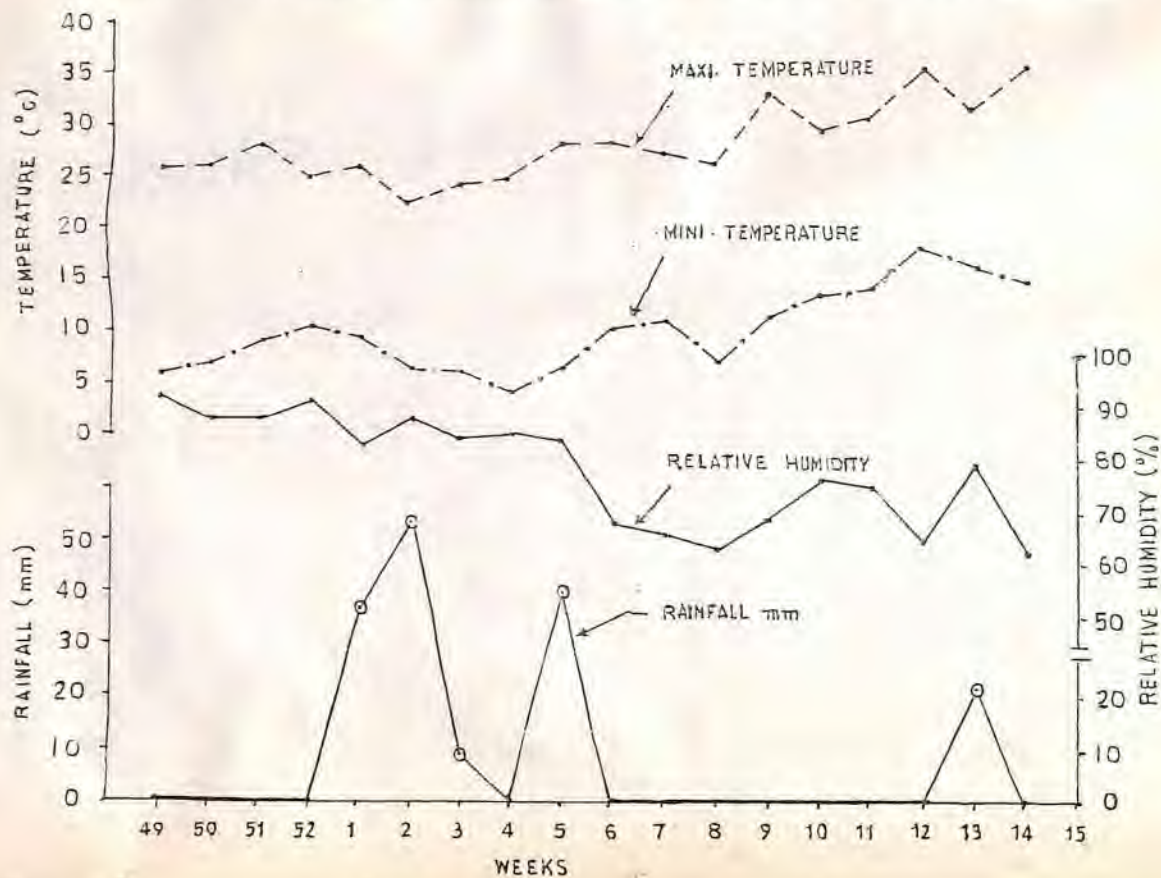
From the perusal of the data in Table 1 it is revealed that the season was quite abnormal for the growth and development of wheat crop. The data showed wider fluctuations in temperature, humidity and rainfall than normal. Rains accompanied with strong wind during the months of December, January and March which caused severe lodging of wheat crop. The mean maximum and minimum temperature existed during the crop season was 28.03°C and 10.18°C, respectively. The temperature was almost constant upto February and thereafter it started rising. The mean relative humidity recorded was 50 per cent. The total rainfall recorded was 38.8 mm during the crop growth period.

All climatic parameters influenced the weed growth as well as crop growth. The crop had to face the problem of weeds since germination to maturity of the crop. Mixed weed flora suppressed the growth and development of wheat crop.

Table 1 : Weekly meteorological data on temperature, rainfall and relative humidity during crop season (Rabi 1988-89)

Month	Standard week	Date	Temperature (°C)		Rain-fall (mm)	Relative humidity (%)
			Max.	Min.		
December 1988	49	3-9	26.7	8.1	-	91
	50	10-16	27.3	9.0	-	84
	51	17-23	25.2	4.7	-	90
	52	24-31	26.9	7.4	-	88
January 1989	1	1- 7	24.7	13.0	35.6	91
	2	8-14	23.0	11.4	52.6	94
	3	15-21	23.7	10.5	8.4	92
	4	22-28	24.6	12.2	-	93
	5	29- 4	24.6	10.7	39.2	92
February 1989	6	5-11	27.5	10.2	-	79
	7	12-18	25.6	7.0	-	82
	8	19-25	29.6	9.3	-	74
	9	26- 4	29.6	11.1	-	63
March 1989	10	5-11	32.7	13.6	-	71
	11	12-18	35.9	14.7	-	63
	12	19-25	36.1	15.1	-	59
	13	26- 1	35.3	20.0	21.6	68
April 1989	14	2- 8	36.7	14.4	-	69

FIG-1: WEEKLY METEOROLOGICAL OBSERVATIONS DURING RABI SEASON (DECEMBER 88 TO APRIL 1989)



Soil :

To know the initial fertility status and textural class of the soil, samples from the different parts of the experimental area were collected randomly from 15 cm depth. The composite soil samples were prepared replication-wise. Then the soil samples were drawn from the composite samples and were analysed for the physico-chemical properties of the soil, in the Soil Science Department.

The soil of the experimental area was classed as sandy-clay loam in texture. Results of the physical and chemical analysis are furnished in the Table 2.

Table 2 : Physico-chemical properties of the soil

Constituent	Amount	Range	Method
(A) <u>Physical :</u>			
Sand	52.6	Sandy-clay-loam	International Pipette Method (Piper, 1967).
Silt	22.8		
Clay	25.1		
(B) <u>Chemical :</u>			
Available nitrogen kg/ha	240	Low	Alkaline Permanganate Method (Jackson, 1967).
Available Phosphorus kg/ha	12.8	Medium	Colorimeter (Olsen <i>et al.</i> , 1954).
Available Potassium kg/ha	309	High	Flame Photometer (Chapman and Pratt, 1961).
Organic carbon	0.60	Medium	Walkley and Black Method (Black, 1965).
pH	7.2	Neutral	pH meter (Piper, 1967).
Electrical conductivity (mmhos/cm at 25°C)	0.20	Normal	Conductivity meter (Black, 1965)

Topography of the field :

The topography of the field was fairly uniform having mild slope towards West.

Previous history of the experimental area :

The field was under transplanted paddy under paddy-wheat rotation before experimentation. The previous crop was supplied with recommended doses i.e. 120 kg nitrogen, 50 kg phosphorus and 40 kg K_2O /ha through urea, superphosphate and murate of potash, respectively.

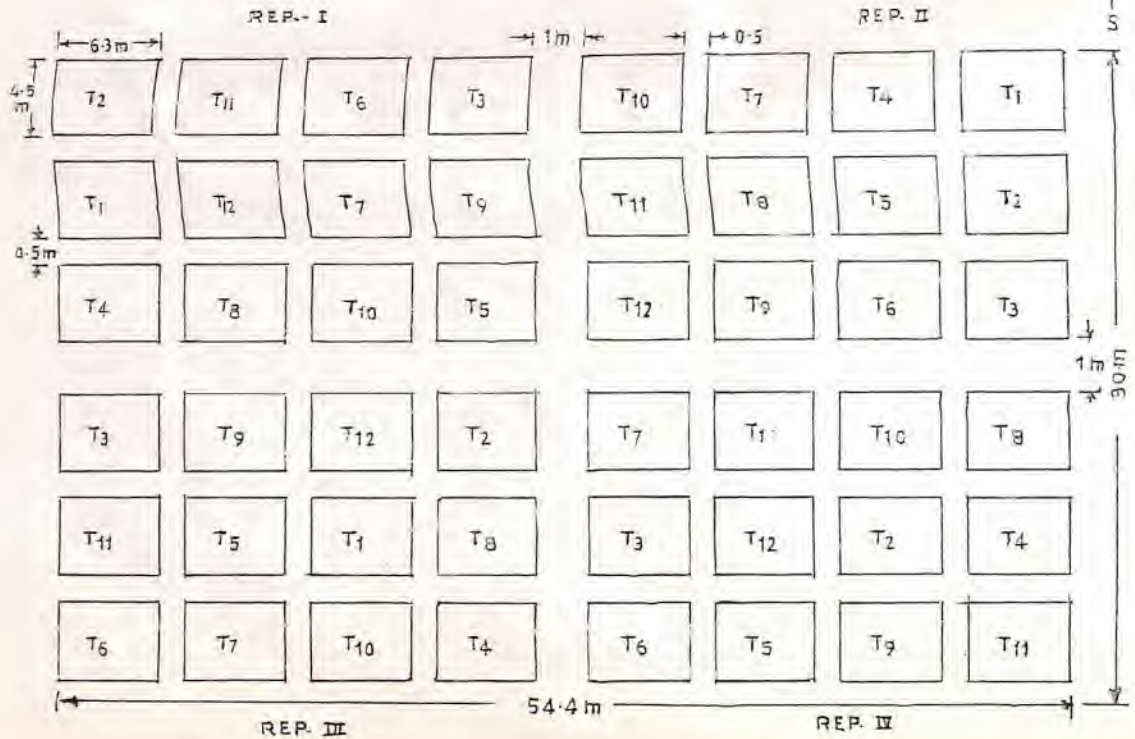
Field preparation :

The field was severely infested with grassy and non-grassy weeds. Therefore the field was cross plowed with mouldboard plow and was disced twice so as to break the clods. The field was finally levelled with the help of Escort Grader cum Leveller so as to obtain the good tilth. In the well prepared field layout was done as per plan of experiment.

The sowing was done according to the treatments. Irrigation channels, main as well as subsidiary ones were drawn with the help of spade between two replications and plots, so as to facilitate irrigation water in the experimental area.

Experimental Techniques : The experimental techniques are detailed as below :

FIG.2 : PLAN OF EXPERIMENT



Procedure :

After obtaining a desirable tillth, the field was laid-out as per plan of experiment. A day before sowing, field was divided into four replications and each replication was further divided into twelve plots. The allocation of the treatments was done with the help of the random numbers.

Details of Experiment :

- | | | | |
|----|-----------------------------|---|-----------------------------|
| 1. | Experimental design | : | Randomized Block Design |
| 2. | Replication | : | Four |
| 3. | Gross plot size | : | 6.3 m x 4.5 m = 28.35 sq.m. |
| 4. | Net plot size | : | 5.4 m x 3.6 m = 19.44 sq.m. |
| 5. | Allies between plots | : | 0.5 m |
| 6. | Allies between replication: | : | 1.0 m |
| 7. | Total number of plots | : | 48 |
| 8. | Total number of treatments: | : | 12 |

Treatment Details :

The details of the treatment are given below :

- | | |
|----------------|--|
| T ₁ | - Unweeded control - Normal practice |
| T ₂ | - Hand weeding once at 30 DAS (N.P.) |
| T ₃ | - Fluroxypyr 0.75 kg/ha POE 20 DAS (N.P.) |
| T ₄ | - Isoproturon 1 kg/ha PE (N.P.) |
| T ₅ | - Isoproturon 1 kg/ha PE mixed with recommended dose of single superphosphate (N.P.) |
| T ₆ | - 2,4-D 28, 0.75 kg + 3% Urea POE 30 DAS (N.P.) |
| T ₇ | - Solid planting at 15 cm with normal seed rate |

- T₈ - Solid planting at 15 cm with 50% higher seed rate than normal.
- T₉ - Bidirectional sowing at row width of 15 cm with normal seed rate.
- T₁₀ - Bidirectional sowing at row width of 15 cm with 50% higher seed rate than normal.
- T₁₁ - Bidirectional sowing at row width of 22.5 cm with normal seed rate.
- T₁₂ - Bidirectional sowing at row width of 22.5 cm with 50% higher seed rate than normal.

Normal Practice (NP) :

- Seed rate : 100 kg/ha
- Row spacing : 22.5 cm
- Fertilizer : 120 kg N, 60 kg P₂O₅, 40 kg K₂O/ha.

Irrigation :

One light irrigation (Plawa) was given immediately after sowing to facilitate uniform germination. In all, five irrigations were given with an interval of 20 days, commencing from 19 days after sowing during the life span of wheat crop.

Fertilizer application :

The recommended dose of 120 kg nitrogen, 60 kg phosphorus and 40 kg potassium was supplied through urea, ammonium phosphate and murate of potash in all the plots, besides treatment T₅ where phosphorus requirement was met through single superphosphate. While nitrogen and potassium requirement of T₅

treatment was accomplished through urea and murate of potash fertilizers.

Half quantity of nitrogen, full dose of phosphorus and potassium was placed in furrows opened manually for this purpose at the time of sowing, while in treatment T₅, single superphosphate was broadcasted after blending with Isoproturon herbicide and was incorporated properly into the soil before sowing, T₅ received half quantity of nitrogen and full dose of potassium at the time of sowing in furrows opened manually. Rest of the quantity of nitrogen was topdressed as urea in two splits ($\frac{1}{2}$ quantity at first irrigation and the other at second irrigation).

Seed rate and sowing :

Normal seed rate of 100 kg/ha and 50 per cent higher seed rate than normal with good germination percentage was utilized for sowing. Sowing was done in solid rows and bidirectional sowing with differential spacing i.e. 15 cm and 22.5 cm. Sowing was done manually in furrows and seed was covered with soil.

Variety :

Wheat cultivar WH 147, a high yielding and early maturing variety was selected for sowing. The genotype was developed at Haryana Agriculture University from the cross (E 4870 x C 303) x (S 339 x V 181). It is a two gene dwarf



variety and is highly susceptible to yellow rust. Its grains are amber, medium bold and hard. It matures in 105 to 115 days.

Table 3 : Schedule of operations for wheat crop

Operations	Date
Field preparation	26.11.88
Layout of experiment	2.12.88
Date of sowing	3.12.88
<u>Irrigation :</u>	
(a) First irrigation	21.12.88
(b) Second irrigation	12.1.89
(c) Third irrigation	2.2.89
(d) Fourth irrigation	22.2.89
(e) Fifth irrigation	14.3.89
<u>Herbicide application</u>	
Pre-emergence application (PE)	
Isoproturon 1 kg/ha alone	5.12.88
Isoproturon 1 kg/ha mixed with single superphosphate	3.12.88
Post emergence application (POE)	
Fluroxypyr POE	23.12.88
2,4-D EE POE	2.1.89
Hand weeding once 30 DAS	2.1.89
Top dressing of Urea - 1st split	24.12.88
Top dressing of Urea - 2nd split	15.1.89
Weed biomass	21.3.89
Harvesting	5.4.89
Threshing	19.4.89

Herbicidal application :

The three herbicides used in the experiment are commercially available as Nocilon (Isoproturon 75% WP) Agromore (2,4-D EE) and Fluroxypyr (Starane).

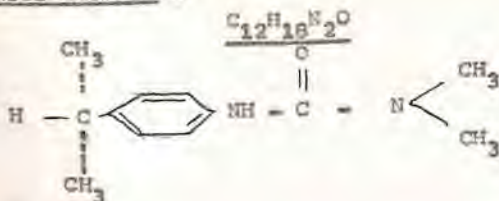
Table 4 : Common name, trade name and chemical composition of the herbicides used

Common name	Trade name	Chemical composition
Isoproturon	Nocilon	3-(4-Isopropylphenyl)-1-1-dimethyl urea
2,4-D EE	Agromore	2,4-Dichloro phenoxy ethyl ester
Fluroxypyr	Starane	4-amino-3,5-dichloro-6-fluro-2 pyri-dyloxy-acetic acid.

Properties of Herbicides :Isoproturon (Nocilon) :

Isoproturon was discovered in 1970 by French Principals M/s Roche-Poulenc Agrochimie, the fifth largest Agro-Chemical Company of the world. It is a herbicide belonging to the family of substituted ureas.

Chemical name : 3-(4-isopropylphenyl)-1-1 dimethyl urea.

Structural formula :Properties :

It is creamy white powder. Melting point is about 158-159°C without decomposition. It is soluble in water at 20°C temperature (70 g/litre at 20°C) methonal dichloromethonal benzene and hexone.

Effectiveness :

It is a selective pre or post emergence herbicide. It controls several broad leaved and numerous grassy weeds in crop like rye, potato, soyabean, maize, sugercane, rice, wheat and barley.

Mode of action :

Isoproturon enters mainly through the roots, although small quantities can be absorbed by the leaves in dry period. It is still effective although only very slowly. It enters with the process of photosynthesis. When applied as pre-emergence under moderately moist condition, incorporating isoproturon into the soil tend to reduce its efficacy. It is absorbed by the soil colloids and this is why the textural and

mechanical composition of the soil governs the dose required. The activity of isoproturon is favoured by a high soil moisture content which improves the movement of the product in the roots.

In contrast to the hormone weed killer, isoproturon is effective even at relatively low temperature. Its action is not affected by light intensity.

Fluroxypyr (Starane) :

It is a product obtained from Dow Chemical Pacific Limited and is under testing stage of a number of places in the country. It is a readily translocatable non-phenoxy herbicide exhibiting a high degree of activity as post emergence foliar applications to a broad spectrum on broad leaved plants. In susceptible species it induces characteristic auxin type responses, frequently within a few hours of application. It is a new selective herbicide which is extremely effective for the control of several major economical important broad-leaved weeds in cereals and shows considerable promise for the control of deep rooted perennials such as Convolvulus arvensis, Calystegia sepium and Rumex spp.

Mode of action :

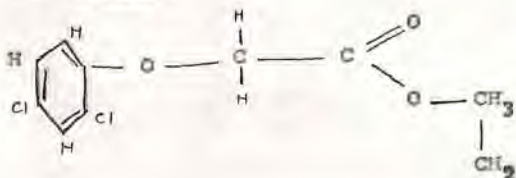
Fluroxypyr is not metabolised in plants but, for the major part undergoes biotransformation with one or more undetermined biological agent to form conjugates which can be converted to fluroxypyr by acid hydrolysis.

Aerobic conditions, studies have shown that fluroxypyr undergoes microbial degradations. The principal degradation products being the 2-pyridinol, 4-amino-3, 5-dichloro-6-fluro-2-methoxy pyridine and CO_2 .

Degradation of fluroxypyr under anaerobic condition occurs at a very much slower rate than under aerobic conditions. This fact supports the conclusion that the degradation observed under aerobic conditions is primarily microbial in nature.

- Trade name : Agronore (2,4-D EE)
 Common name : 2,4-D Ethyl ester
 Chemical name : 2,4-Dichloro phenoxy ethyl ester

Structural formula :



Properties :

2,4-D ester compounds are only slightly soluble in water, but they are soluble in some petroleum oils. Esters are usually sold as liquids. When mixed with water, the emulsifying agent keeps the tiny, oil-like droplets suspended for a time. Water is in the continuous phase and oil droplets are dispersed. Thus it is an oil-in water (O/W) type of emulsion.

Effectiveness :

2,4-D is a selective, translocated herbicide controls effectively annual broad leaved weeds in most of the crops. It is most phototoxic in young, rapidly growing weeds. This is used mainly as post emergence at the rates ranging between 1 to 1.5 kg/ha.

Mode of action :

Ethyle ester of 2,4-D when applied to the plant they act as a hormone and stimulate the growth of epidermal and cortical cells, thus photosynthesis is stimulated. As a result of accelerated respiration, carbohydrate are depleted. Ultimately phloem vessels are crushed, photosynthetic activity is inhibited, complete growth is arrested, transport of nutrient from roots is impeded resulting in the death of the plant.

Methods of herbicide application :

Isoproturon 1 kg/ha was mixed with single superphosphate and uniform application of isoproturon. P-mixture was done on respective plots and was incubated into the soil manually. Other herbicides were formulated in 600 litres of water per hectare for pre and post emergence applications. The required quantity of each herbicide was dissolved separately in required quantity of water and sprayed uniformly over the plots. Spray solution was prepared fresh for 4 plots as per respective treatment. After finishing the spraying of one herbicide in

four replications, sprayer was washed with detergent and thoroughly flushed with water several times.

Maruti foot sprayer was used for spraying. The spraying was done with flat fan nozzle in grass plot. The pattern of spraying was across the rows. Herbicides were applied with backward movement from one end to the other. Uniform pressure in the sprayer was maintained and solution was kept agitated during the spray.

Interculture :

Hand weeding was done at 30 days after sowing in respective plots in four replications. The weeding was done manually with the help of Khuroi.

Plant protection measure :

No incidence of pests and diseases was noticed during the life span of the crop, hence no control measures were adopted.

Harvesting :

Harvesting was done on 5th April, 1989, manually with the help of sickles. Border rows lengthwise and breadwise 45 cm were (2 rows from 22.5 cm row spacing and 3 rows from 15 cm row spacing) harvested first leaving the net plot of 19.44 sq. m. (5.4 m x 3.6 m). After harvesting bundles were made and labelled properly. The crop biomass was recorded and bundles were brought to the threshing floor for processing.

Threshing :

The threshing was done by beating the ear heads with wooden sticks manually, treatmentwise and grain yield was recorded as per net plot.

Pre-Harvest Studies

Weed studies :

Associated weeds of wheat crop in the experimental area were recorded at 15 days after sowing and at harvest in all the treatments. The density of Phalaris minor Retz. and other associated weeds was recorded by quadrats count method (Mishra, 1968). The quadrats of 0.25 m^2 was thrown randomly at four places in each plot and the weed count was recorded. The total weed population as well as specieswise number of individuals per square meter were also worked out.

Leaf area index :

The mean leaf area of Phalaris minor retz. was obtained by recording length and width of the five leaves from five selected plants. From each plot leaves of five plants were counted. The leaf area was computed by the formula given by Anikiew and Kutusov (1961) and LAI per plant was assessed by further multiplication by number of green leaves per plant as given below :

$$\text{Length} \times \text{breadth} \times 0.67 \times \text{No. of leaves/plant.}$$

The LAI was worked out by the following formula -

$$LAI = A/P = \frac{L \times W \times K \times N \times D}{P}$$

$$LAI = \frac{\text{Mean length of leaf} \times \text{Mean width of leaf} \times \text{Constant} \times \text{No. of leaves/plant} \times \text{Number of plants/sq.m} = A}{\text{Ground area (P)}}$$

Where,

LAI = Leaf area index

Constant = 0.67 for Phalaris minor Retz.
(Anikiew and Kutuzov)

Relative density :

The total number of weeds (species wise) were recorded in each plot by throwing quadrat of 0.25 m² randomly at four places. The relative weed density was computed as per the formula proposed by Mishra (1968).

$$\text{Relative density} = \frac{\text{No. of individuals of the same species}}{\text{No. of individual of all species}} \times 100$$

Dry weight accumulation of weed :

Before harvest of the crop the associated weeds (Phalaris minor and all other weeds) of wheat crop were collected randomly from a 0.25 m² quadrat at four places in each plot and were kept separately in paper bags for sun-drying. The weeds were dried in oven at 60°C and the constant weight was recorded and the dry matter accumulation by weed per m² was computed in gram.

Weed control efficiency :

Weed control efficiency is the efficiency of any treatment for controlling the weeds in comparison to unweeded control. The following formula was used to work out the weed control efficiency in percentage.

$$WCE = \frac{DWC - DWT}{DWC} \times 100$$

Where,

WCE = Weed control efficiency

DWC = Dry weight of weeds in control plots

DWT = Dry weight of weeds in treated plots.

Crop Studies

Growth characters :

Biometric observations were recorded during the growth of the crop for studying the influence of various treatments, on the growth attributes of the crop.

Plant population :

Plant population was recorded at 15 DAS (days after sowing) by quadrat count method. The quadrat of 0.25 m² size was thrown at four places randomly in each plot and the crop seedling per m² were recorded.

Plant height (cm) :

Plant height of the five randomly selected plants were

measured from the base upto the longest leaf tip. The mean height of five uprooted plants was recorded in centimeters per plant at 25, 50, 75 days after sowing and finally at harvest. The data was put to statistical analysis.

Number of tillers per plant :

Number of tillers per plant was counted from these five selected plants which were taken for plant height at 25, 50, 75 DAS and at harvest. Final data on effective tillers per plant was analysed.

Leaf area index :

Length of the five leaves randomly selected from the same five plants were recorded from the base of the auricle upto the tip of the leaf and the width of the same leaves, was measured at the widest portion of the leaves. Number of leaves of all five plants were counted. The leaf area index was worked out as per formula proposed by Owen (1968).

$$LAI = A/P = \frac{L \times W \times K.N.n.}{P (100 \times 100)}$$

Where,

- LAI = Leaf area index
- A = Leaf area in square centimeters
- P = Ground area
- L = Length of leaf (cm)
- W = Width of leaf (cm)

K = Constant 0.95 (Owen, 1968).

N = Number of leaves per plant

n = Number of plants per m².

Effective tillers per plant :

The ear bearing tillers were counted from randomly selected five plants at harvest. The effective tillers were deducting from total number of tillers per plant at harvest.

post Harvest Studies

Yield attributing characters :

Ear length (cm) : Length of the five randomly selected ears from five selected plants were recorded from the ring at the base upto the tip of the ear excluding awns in centimeter. The mean length of ear head was worked out by calculating the average.

Weight per ear (g) : The weight of five randomly selected ears was recorded and mean ear weight was calculated in grams per ear.

Grain number per ear : The clean grains obtained from the same randomly selected five ears were counted and mean grain numbers per ear was worked out.



Grain weight per ear (g) : Five selected ears from five randomly selected plants were threshed and clean grains were obtained and weighed and mean grain weight (g) per ear was computed.

Test weight (g) : Thousand grains from each treatment were counted from the pool of threshed grains and thousand seed weight in gram per plot was recorded.

Crop-shoot biomass : The harvested produce from each net plot was tied in separate bundles and dry weight was recorded in kilograms and then converted into q/ha.

Grain yield : Threshed and clean grain yield was recorded in kilograms per net plot and then converted into quintals per hectare.

Straw yield : The straw yield was estimated after deducting the grain yield per plot from the total shoot biomass in kilograms and later on converted into quintal per hectare.

Weed index : The yield reduction (%) owing to the presence of weeds was estimated using the formula developed by Gill and Kumar (1969) and expressed as weed index percentage.

$$WI = \frac{X - Y}{X} \times 100$$

Where,

WI = Weed index

X = Yield from weed free plot (taken hand weeded plot)

Y = Yield from the treatment for which WI is to be estimated.

Harvest index : The harvest index has been described by Singh and Stoskopf (1971) using the following formula -

$$\text{Harvest index} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Economics :

The economics of each treatment was worked out as per formula given below. The different treatments were compared with unweeded control to find out relative performance of the treatments.

$$\text{Additional income due to weed control} = \text{Cost of additional yield obtained due to weed control over weedy check} - \text{Cost of herbicides used + Application charges}$$

Economics of different weed control measures were worked out on the basis of labour charges for weeding operations, cost of herbicides and application charges and income from the produce at prevailing market rates.

Labour requirement : Number of productive man works units required for hand weeding and spraying herbicides were estimated on hectare basis.

Cost of input and produce cost : Cost of formulated herbicides available and application charges per hectare were taken into account for calculating the economics of the weed control treatments. Produce cost was worked out on prevailing market rates of wheat and bhusa.

Statistical analysis :

Biometric observations during the crop growth cycle and associated weeds of wheat were recorded and tabulated in a systematic manner. The data on weed count showed considerable variation, hence was subjected to square root transformation i.e. $\sqrt{x + 0.5}$ as proposed by Snedecor and Cochran (1967) before analysing statistically and comparison were made on transferred data back on original scale. The normal data was statistically analysed by the method of analysis of variance as described by Fisher (1957). F-test was applied under both the situations for testing the significance of the treatments the significant differences between treatment means were determined by using critical difference at 5 per cent level.

$$S_{Em} \pm = \sqrt{\frac{S_e^2}{r}}$$

$$S_{ED} = \sqrt{\frac{2S_e^2}{r}}$$

C.D. at 5% = $S_e d \times t$ error d.f.

Crop-shoot biomass, grain yield and straw yield was analysed by using Duncan's New Multiple Range Test. It is given by Duncan (1955).

$$SE (\bar{x}) = \sqrt{\frac{S^2}{r}}$$

Critical value = $SE (\bar{x}) \times P$ value at 5%.

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CHAPTER IV

EXPERIMENTAL RESULTS

This chapter deals with the results of the experiment carried out during Rabi 1988-89 on sandy-clay loam soils of Agriculture Research Farm, Adhartal, Jabalpur. The observations recorded from the experiment on weed population, weed dry matter accumulation, crop growth and yield were statistically analysed and the findings of the investigation are presented below.

4.1 WEED STUDY

4.1.1 Associated weed flora :

The major weed flora of the experimental field have been presented in the Table 5 according to their botanical names, local names, family and nature of cotyledons.

Table 5 : Weed flora of the experimental area

Botanical name	Local name	Family
A. <u>Monocot</u> :		
<u>Phalaris minor</u> Retz.	Chiryabajra	Gramineae
B. <u>Dicot</u> :		
<u>Medicago denticulata</u> Willd	Morera	Papilionaceae
<u>Melilotus alba</u> Desf.	Senji	Leguminosae
<u>Trifolium flagiferum</u> L.	San Methi	Leguminosae
<u>Anagalis arvensis</u> L.	Krishna Neel	Primulaceae
<u>Chenopodium album</u> L.	Bathua	Chenopodiaceae
<u>Rumex dentatus</u> L.	Banpalak	Compositae

4.1.2 Population and Relative Density of Weeds :

The weed intensity and relative density of hetero-
genous weed flora prevailed in the experimental area have
been worked out at 15 DAS and are presented in Table 6.

Table 6 : Population of dominant weeds and their relative
density in percentage

Name of weeds	Weeds/ha at 15 DAS	Relative density (%)
(A) <u>Monocot :</u>		
<u>Phalaris minor</u> retz.	8,35,830	23.02
(B) <u>Dicot :</u>		
<u>Medicago denticulata</u> Willd	6,78,950	18.70
<u>Helilotus alba</u> L.	3,68,950	10.02
<u>Trifolium flagiferrum</u> L.	6,10,000	16.80
<u>Anagalis arvensis</u> L.	3,58,330	09.87
Total		
Monocot	8,35,830	
Dicot	20,11,130	
(C) Other weed flora	7,83,540	21.58
Grand total of the weed flora	36,30,610	99.99

From the perusal of the data in Table 6 it will be seen that the weed flora mainly consisted of broadleaved weeds to the tune of 20.11 lakh/ha as against 8.35 lakh monocot weeds/ha. The total weed count of mixed weed flora was 36.30 lakhs/ha under unweeded plot. Data appended in Table 6 clearly indicated that wheat crop had to compete mainly with the most dominant weeds viz. Phalaris minor, Medicago denticulata, Trifolium flagiferum, Melilotus alba and Anagallis arvensis. The maximum relative density of Phalaris minor was 23.02 per cent, followed by Medicago denticulata (18.70%), Trifolium flagiferum (16.80%), Melilotus alba (10.02%) and Anagallis arvensis (9.87%). The relative density of other weeds comprised of Chenopodium album, Portulaca oleracea, Cynodon dactylon, Cyperus rotundus, Paspalum sp. and Rumex dentatus.

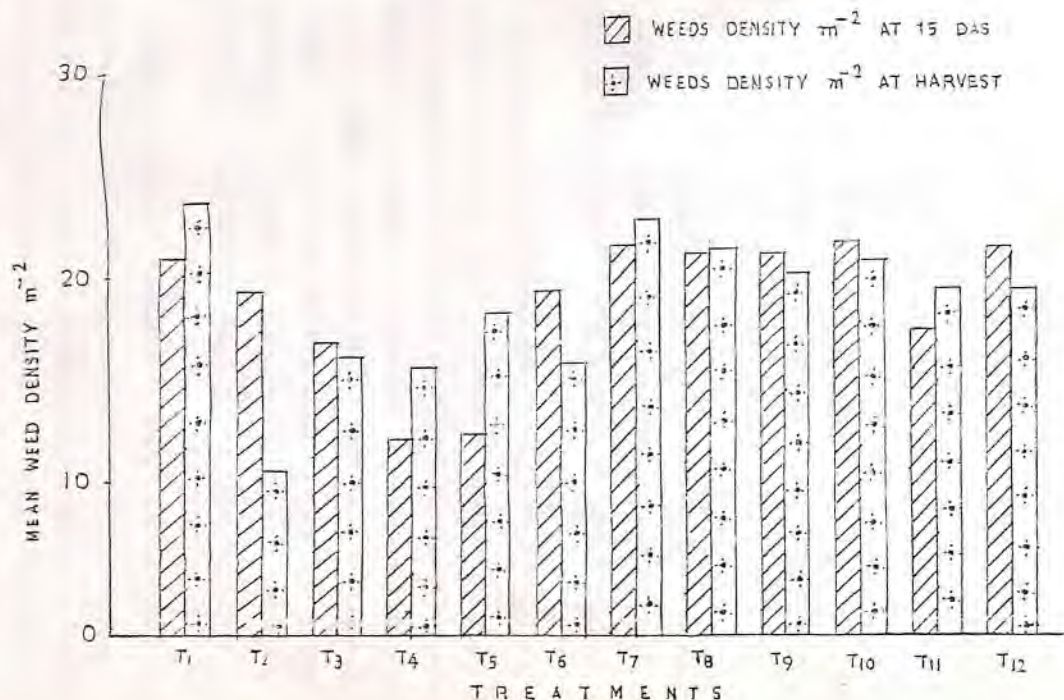
4.1.3 Mean weed intensity :

The intensity of various dominant weeds was measured by quadrat count method by throwing 0.25 m² quadrat at four places, randomly. Weed count were estimated from each plot at 15 days after sowing. Data in Table 7 ^{and Fig 3} on weed intensity estimated at 15 days was found significant. Highest weed intensity of 467.25/m² was recorded under bidirectional sowing at 15 cm distance with 50 per cent higher seed rate than normal, and lowest being 142.00 plants/m² was recorded under isoproturon (Hocilon) pre-emergence 1 kg/ha. PE treatment reduced the weed intensity to a greater extent as compared to cultural treatments.

Table 7 : Mean intensity of weeds per m² at 15 days after sowing and at harvest of wheat as influenced by different treatments

S. No.	Treatments	15 DAS	At harvest
1.	Unweeded control (Normal practice)	20,893 (437.75)	23,663 (559.75)
2.	Hand weeding at 30 DAS (Normal practice)	19,230 (374.50)	10,433 (112.50)
3.	Fluroxypyr 0.75 kg/ha 20 DAS (Normal practice)	16,743 (281.00)	16,035 (257.25)
4.	Isoproturon 1 kg/ha PE (Normal practice)	11,985 (142.00)	15,443 (240.75)
5.	Isoproturon 1 kg/ha PE mixed with superphosphate	12,268 (152.50)	18,147 (330.50)
6.	2,4-D EE 0.75 kg/ha 30 DAS (Normal practice)	19,248 (375.50)	15,637 (245.50)
7.	Closer planting at 15 cm with normal seed rate	21,350 (458.00)	22,600 (515.25)
8.	Closer planting at 15 cm with 50 per cent higher seed rate than normal	20,98 (445.00)	21,063 (445.75)
9.	Bidirectional sowing at 15 cm with normal seed rate	21,075 (451.00)	19,910 (401.25)
10.	Bidirectional sowing at 15 cm with 50 per cent higher seed rate than normal	21,415 (467.25)	20,620 (430.00)
11.	Bidirectional sowing at 22.5 cm with normal seed rate	17,243 (308.00)	19,747 (393.50)
12.	Bidirectional sowing at 22.5 cm with 50 per cent higher seed rate than normal	21,265 (453.25)	19,710 (388.50)
	SEM \pm	2.751	1.102
	CD at 5%	3.889	3.285

FIG. 3:- MEAN WEED DENSITY m^{-2} AT 15 DAS AND AT HARVEST AS INFLUENCED BY DIFFERENT TREATMENTS



Among the cultural treatments bidirectional sowing at row spacing of 22.5 cm and normal seed rate were considerably effective method in reducing the weed intensities and were found superior to all the treatments.

Hand weeding as well as POE herbicides were not given at this stage, hence the differences observed were of the same magnitude as under no weeding treatment.

Among the herbicides, PE application of isoproturon 1 kg/ha mixed with single superphosphate was found at par with plain application of isoproturon 1 kg/ha as preemergence.

Weed intensity data recorded in Table 7 was found significant at harvest. Both cultural as well as herbicidal treatments with their respective method of applications were found superior to no weeding treatment in reducing the weed population. Maximum intensity of 559.75/m² was registered by no weeding treatment and lowest being 112.5/m² recorded under hand weeding treatment which proved significantly superior over all the treatments.

Among the cultural treatments, hand weeding drastically reduced the weed population and registered 112.5 weeds/m² being lowest. While weed intensity recorded under no weeding was 559.75 weeds per m² being highest. Effect of higher density of wheat crop on weed density is quite apparent. Bidirectional sowing at 15 and 22.5 cm with normal and

50 per cent higher seed rate was found best in suppressing the weed population.

Application of herbicide as PE or POE proved potentially effective in controlling weeds. Among them isoproturon 1 kg/ha PE recorded lowest intensity of 240.75 weeds/m² and highest density of 330.5 weeds/m² were recorded under isoproturon 1 kg/ha PE application when applied with superphosphate. Isoproturon 1 kg/ha blended with superphosphate was significantly inferior to all the herbicidal treatments and POE application of 2,4-D EE and fluroxypyr was found at par with isoproturon 1 kg/ha when sprayed alone.

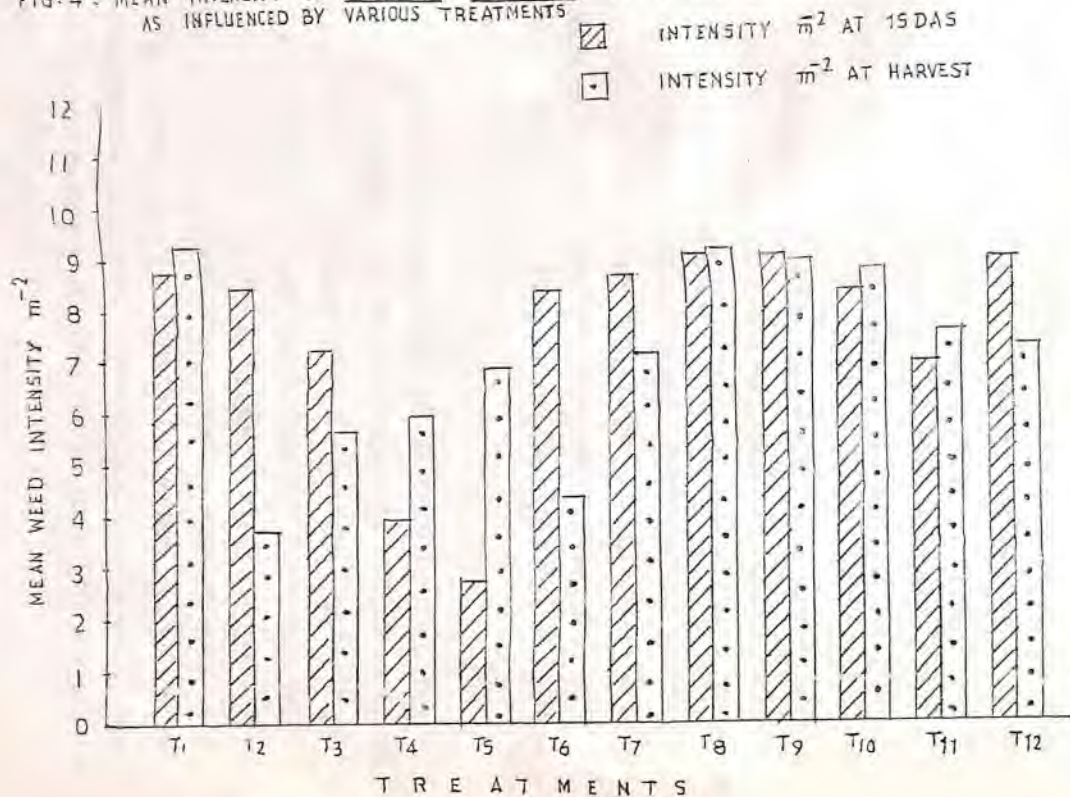
4.1.3.1 Mean intensity of *Trifolium flagiferum* :

Evaluation of data in Table 8 and Fig.4 on weed intensity of *Trifolium* spp. at 15 days was significant. Hand weeding, fluroxypyr 0.75 kg/ha and 2,4-D EE 0.75 kg/ha were not conducted upto this stage hence registered almost same density of *Trifolium* as obtained under no weeding. Highest intensity of 8.99/m² was noted at 15 cm row spacing with 50 per cent higher seed rates and was at par with bidirectional sowing at 22.5 cm sowing with 50% higher seed rate. While lowest intensity of 2.72/m² was recorded under isoproturon PE 1 kg/ha mixed with single superphosphate which was followed closely by isoproturon 1 kg/ha PE alone giving density of 3.87/m² and established their superiority over cultural treatments and no weeding.

Table 8 : Mean intensity of Trifolium flagiferum per metre square at 15 days after sowing and at harvest

Treatments		15 DAS		At harvest	
T ₁	Unweeded control (Normal practice)	8.707	(75.5)	9.325	(85.5)
T ₂	Hand weeding at 30 DAS (Normal practice)	8.395	(72.5)	3.692	(12.0)
T ₃	Fluroxypyr 0.75 kg/ha 20 DAS (Normal practice)	7.235	(53.0)	5.630	(32.0)
T ₄	Isoproturon 1 kg/ha PE (Normal practice)	3.865	(12.5)	5.907	(35.5)
T ₅	Isoproturon 1 kg/ha PE mixed with superphosphate (Normal practice)	2.722	(8.5)	6.817	(47.0)
T ₆	2,4-D EE 0.75 kg/ha # 3% Urea at 30 DAS (Normal practice)	8.325	(70.75)	4.280	(18.0)
T ₇	Closer planting at 15 cm with normal seed rate	8.645	(74.5)	7.105	(56.5)
T ₈	Closer planting at 15 cm with 50% higher seed rate than normal	8.99	(82.25)	9.075	(83.0)
T ₉	Bidirectional sowing at 15 cm with normal seed rate	8.95	(81.75)	8.935	(82.5)
T ₁₀	Bidirectional sowing at 15 cm with 50 per cent higher seed rate than normal	8.26	(69.25)	8.675	(76.5)
T ₁₁	Bidirectional sowing at 22.5 cm with normal seed rate	6.88	(48.0)	7.547	(62.25)
T ₁₂	Bidirectional sowing at 22.5 cm with 50 per cent higher seed rate than normal	8.852	(78.25)	7.192	(53.0)
SEM \pm		0.697		0.739	
CD at 5%		2.076		2.202	

FIG. 4 : MEAN INTENSITY OF *Trifolium flagiferum* AT 15 DAYS AFTER SOWING AND AT HARVEST AS INFLUENCED BY VARIOUS TREATMENTS



Bidirectional sowing at 22.5 cm row spacing with normal seed rate was found superior as compared to all other cultural treatments and no weeding but significant differences were exhibited between planting at 15 cm row spacing with 50 per cent higher seed rate than normal. Apparently there were no marked variations among rest of the cultural treatments.

Density of Trifolium sp. showed wider variations due to cultural as well as herbicidal treatments applied alone and in combination with fertiliser at harvest. Data postulated in Table 8 showed that hand weeding exhibited least density ($3.69/m^2$) and was at par to 2,4-D EE 0.75 kg/ha POE but both in turn proved much superior to no weeding and rest of the cultural treatments. Maximum density of $9.325/m^2$ was noted under unweeded control.

Herbicides proved potential in reducing the weed density of Trifolium at harvest. 2,4-D EE at 0.75 kg/ha POE established its superiority over isoproturon 1 kg/ha PE alone or in combination with superphosphate and fluroxypyr 0.75 kg/ha POE in reducing the Trifolium intensity. Latter treatments failed to exhibit wider variation among themselves. On the contrary they proved superior to cultural treatments and no weeding treatment. Closer planting with normal seed rates proved better than wider row spacings with and without enhanced rates of seeding.

4.1.3.2 Mean intensity of Phalaris minor Retz:

Intensity of P. minor Retz. was affected significantly by different treatments at 15 DAS. Hand weeding and POE herbicides were not performed at 15 days stage hence exhibited same density as obtained under no weeding treatment. Maximum intensity of $11,055/m^2$ was noted under cross sowing at 15 cm with normal seed rate and lowest intensity of $5,002/m^2$ was recorded under isoproturon PE blended with single superphosphate and was found at par to PE application of isoproturon 1 kg/ha sprayed alone. Both these herbicides gave pronounced effect in reducing the weed density as compared to untreated plots and no weeding.

Among the cultural treatment bidirectional sowing at 22.5 cm with normal seed rate proved superior to all cultural treatments beside closer unidirectional planting with 50 per cent higher seed rates and unweeded plots. Latter treatments failed to give wider differences so as to obtain the level of significance. There was apparently no gain in sowing the crop either at 15 cm or 22.5 cm row distance with normal and enhanced rates in reducing the Phalaris density in the initial growth phase of the crop.

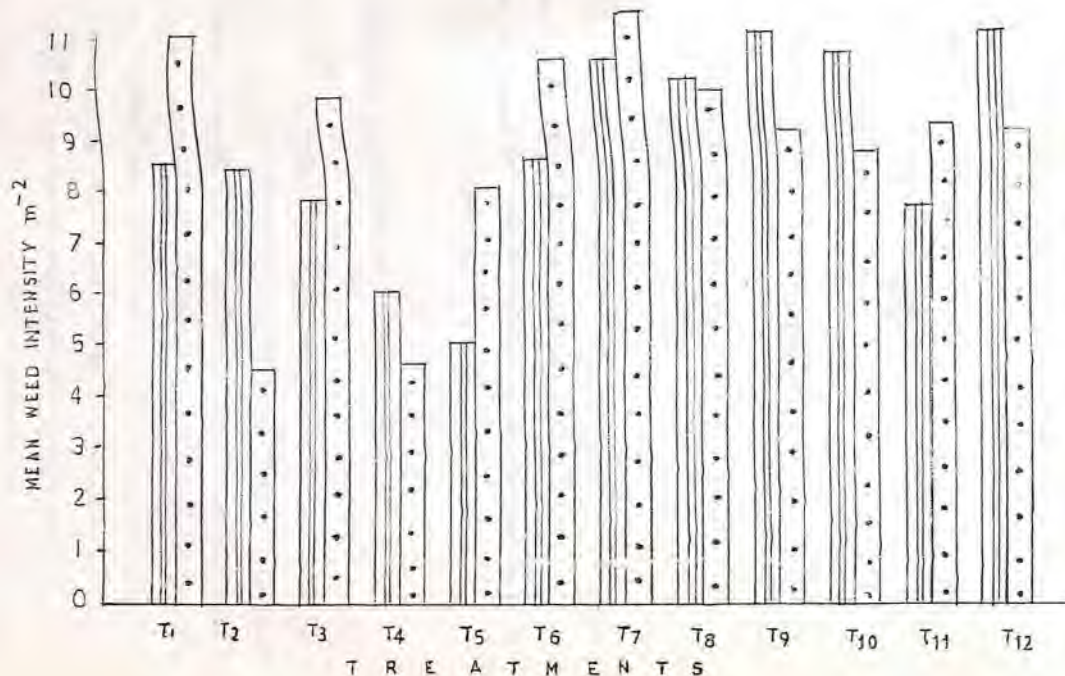
Results were found significant as regard to weed intensity of P. minor Retz. at harvest. All weed control

Table 9 : Mean intensity of Phalaris minor Retz./m² at 15 days after sowing and at harvest

Treatments	15 DAS		At harvest	
T ₁ Unweeded control (Normal practice)	8.527	(74.00)	11.427	(125.25)
T ₂ Hand weeding at 30 DAS (Normal practice)	8.485	(72.5)	4.512	(21.25)
T ₃ Fluroxypyr 0.75 kg/ha at 20DAS (Normal practice)	8.832	(64.5)	9.845	(99.0)
T ₄ Isoproturon 1 kg/ha PE (Normal practice)	6.020	(36.5)	4.632	(21.5)
T ₅ Isoproturon 1 kg/ha PE mixed with superphosphate (N.P.)	5.002	(25.0)	8.040	(65.0)
T ₆ 2,4-D EE 0.75 kg/ha + 3% Urea at 30 DAS (Normal practice)	8.60	(77.25)	10.512	(110.25)
T ₇ Closer planting at 15 cm with normal seed rate	10.51	(111.25)	11.027	(125.25)
T ₈ Closer planting at 15 cm with 50 per cent higher seed rate than normal	10.12	(107.0)	9.995	(98.5)
T ₉ Bidirectional sowing at 15cm with normal seed rate	11.05	(122.75)	9.145	(88.25)
T ₁₀ Bidirectional sowing at 15cm with 50 per cent higher seed rate than normal	10.68	(115.75)	8.742	(77.0)
T ₁₁ Bidirectional sowing at 22.5cm with normal seed rate	7.56	(60.75)	9.247	(85.75)
T ₁₂ Bidirectional sowing at 22.5 cm with 50 per cent higher seed rate than normal	11.037	(125.5)	9.100	(83.0)
SEM \pm	0.967		0.777	
CD at 5%	2.891		2.316	

FIG-5: MEAN INTENSITY OF *Phalaris minor* m^{-2} TA 15 DAYS AFTER SOWING AND AT HARVEST AS INFLUENCED BY VARIOUS TREATMENTS

□ WEED INTENSITY m^{-2} AT 15 DAS
 ■ WEED INTENSITY m^{-2} AT HARVEST





techniques were superior to no weeding, closer planting. Maximum intensity of $11.42/m^2$ closely followed by narrow planting $11.03/m^2$ intensity was recorded under no weeding and row spacing at 15 cm, while intensity of $4.51/m^2$ was noted under hand weeding.

With regard to herbicides, isoproturon PE 1 kg/ha sprayed alone was found significantly superior to herbicides and cultural treatments besides hand weeding, where the differences were almost at par.

Beside hand weeding, none of the cultural treatments proved superior to other cultural treatments. Closer planting with 50 per cent higher seed rates showed better performance than other cultural treatments.

4.1.3.3 Mean weed intensity of *Melilotus alba* :

Intensity of *Melilotus alba* was found significant as affected by different treatments at 15 DAS. Treatments which were not conducted upto this stage registered similar density of *Melilotus* sp. and were at par to unweeded control. Highest intensity of $7.347/m^2$ was noted under bidirectional planting at 22.5 cm row spacing with 50 per cent higher seed rates which was found at par to closer planting with similar conditions giving $7.062/m^2$ density. While minimum intensity of $1.982/m^2$ was recorded by isoproturon PE 1 kg/ha applied alone which was at par to isoproturon 1 kg/ha incubated with single superphosphate.

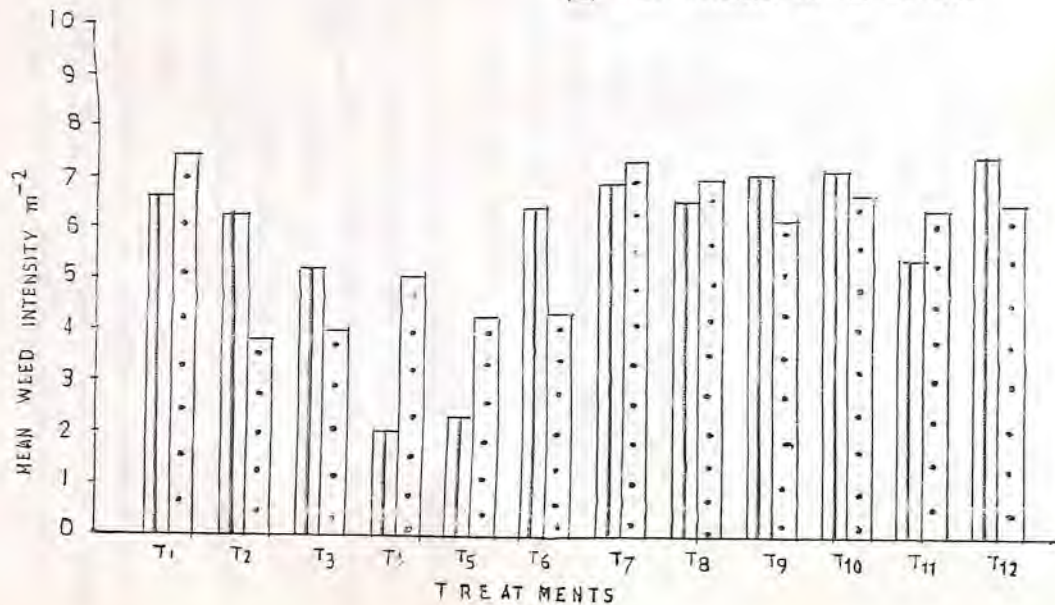
Table 10 : Mean intensity of *Melilotus alba* per m² at 15 days after sowing and at harvest

Treatments	15 DAS		At harvest	
T ₁ Unweeded control (Normal practice)	6.615	(44.00)	7.420	(55.5)
T ₂ Hand weeding at 30 DAS (Normal practice)	6.250	(39.25)	3.805	(14.50)
T ₃ Fluroxypyr 0.75 kg/ha 20DAS (Normal practice)	5.175	(26.5)	3.927	(16.25)
T ₄ Isoproturon 1 kg/ha PE (Normal practice)	1.982	(3.96)	5.005	(26.50)
T ₅ Isoproturon 1 kg/ha mixed with superphosphate (Normal practice)	2.257	(5.25)	4.197	(18.25)
T ₆ 2,4-D EE 0.75 kg/ha + 3% Urea at 30 DAS (Normal practice)	6.350	(41.5)	4.255	(19.75)
T ₇ Closer planting at 15 cm with normal seed rate	6.815	(52.0)	7.262	(52.0)
T ₈ Closer planting at 15 cm with 50 per cent higher seed rate than normal	6.445	(44.25)	6.892	(48.0)
T ₉ Bidirectional sowing at 15 cm with normal seed rate	6.987	(48.0)	6.095	(40.75)
T ₁₀ Bidirectional sowing at 15 cm with 50 per cent higher seed rate than normal	7.062	(52.5)	6.002	(44.25)
T ₁₁ Bidirectional sowing at 22.5cm with normal seed rate	5.350	(31.25)	6.362	(41.25)
T ₁₂ Bidirectional sowing at 22.5 cm with 50 per cent higher seed rate than normal	7.982	(63.75)	6.377	(42.75)
	SEM \pm	0.494	0.969	
	CD at 5%	1.473	2.898	

FIG. 6: MEAN INTENSITY OF Melilotus alba m^{-2} AT 15 DAYS AFTER SOWING AND AT HARVEST

▨ WEED INTENSITY m^{-2} AT 15 DAS

▣ WEED INTENSITY m^{-2} AT HARVEST



Among the cultural treatments bidirectional sowing at row width of 22.5 cm with normal seed rate was found significantly superior to all cultural techniques. Closer planting at row distance of 15 cm with 50 per cent higher rates of seeding proved superior as compared to rest of the cultural methods of weed control. Latter cultural treatments showed small variations in Melilotus density.

Results were also found significant as regard to weed intensity of Melilotus alba at harvest. Hand weeding once again proved superior to all other cultural treatments and no weeding, in reducing the weed population and was closely followed by herbicidal treatments. Maximum weed intensity of $7.420/m^2$ was noted under unweeded check and lowest ($3.805/m^2$) under hand weeding.

At harvest all herbicides were superior in reducing the weed population over no weeding and all cultural treatments beside hand weeding. Herbicide fluroxypyr POE recorded minimum intensity of $3.927/m^2$ was at par to isoproturon PE blended with single superphosphate, 2,4-D EE POE and isoproturon PE sprayed alone giving 4.20, 4.26 and $5.01/m^2$ density, respectively.

Hand weeding proved only an effective method in reducing the weed intensity of M. alba and found significantly superior to no weeding, closer planting at 15 cm with normal and 50%

higher seed rate than normal. Beside hand weeding, all other cultural treatments failed to exhibit wide differences in Medicago intensity. Square planting at 15 cm row distance was much superior to rest of the cultural treatments and recorded minimum density of $6.095/m^2$ among cultural methods beside hand weeding.

4.1.3.4 Mean intensity of Medicago denticulata :

Examination of the data in Table 11 and Fig. 7 would reveal that highest intensity of $9.590/m^2$ was registered under solid planting at 15 cm row spacing with 50 per cent higher seed rate and lowest ($5.722/m^2$) under isoproturon 1 kg/ha PE sprayed alone. Application of isoproturon PE 1 kg/ha proved potential in reducing the weed intensities of Medicago and gave significant differences as compared to all other treatments. PE isoproturon 1kg/ha blended with single superphosphate was found inferior to isoproturon 1 kg/ha PE applied alone. The treatments which were not conducted upto this stage showed larger variations due to environmental conditions but not due to treatments.

Among cultural treatments cross sowing at 22.5 cm row distance with normal seed rate proved much superior to narrow planting with normal and enhanced rates of seeding. Planting at 22.5 cm row distance with 50 per cent higher seed rate showed negligible effect in reducing the density of Medicago sp.

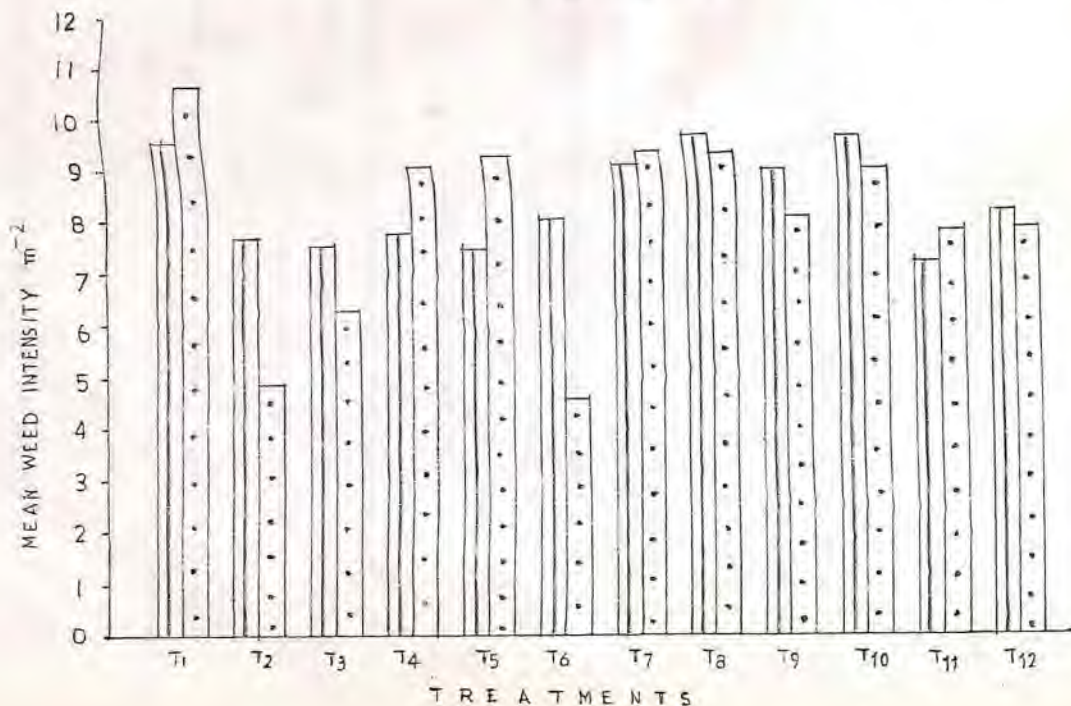
Table 11 : Mean intensity of Medicago denticulata per m²
at 15 days after sowing and at harvest

Treatments	15 DAS		At harvest	
T ₁ Unweeded control (normal practice)	9.547	(89.75)	10.657	(112.25)
T ₂ Hand weeding at 30 DAS (Normal practice)	7.650	(58.75)	4.835	(24.5)
T ₃ Fluroxypyr 0.75 kg/ha 20 DAS (Normal practice)	7.495	(56.00)	6.217	(39.5)
T ₄ Isoproturon 1 kg/ha PE (Normal practice)	5.722	(33.50)	9.067	(82.50)
T ₅ Isoproturon 1 kg/ha PE mixed with superphosphate (Normal practice)	7.437	(55.75)	9.222	(85.25)
T ₆ 2,4-D EE 0.75 kg/ha + 3% Urea at 30 DAS (Normal practice)	7.985	(65.75)	4.477	(20.0)
T ₇ Closer planting at 15 cm with normal seed rate	9.037	(82.00)	9.290	(87.25)
T ₈ Closer planting with 15 cm with 50 per cent higher seed rate than normal	9.590	(93.00)	9.270	(86.25)
T ₉ Bidirectional sowing at 15 cm with normal seed rate	7.942	(64.75)	7.965	(64.25)
T ₁₀ Bidirectional sowing at 15 cm with 50 per cent higher seed rate than normal	9.575	(92.00)	8.905	(79.50)
T ₁₁ Bidirectional sowing at 22.5 cm with normal seed rate	7.140	(52.5)	7.715	(62.75)
T ₁₂ Bidirectional sowing at 22.5 cm with 50 per cent higher seed rate than normal	9.122	(65.75)	7.817	(61.25)
	SEm \pm	1.701		1.809
	CD at 5%	0.571		0.858

FIG.7: MEAN INTENSITY OF *Medicago denticulata* m^{-2} AT 15 DAYS AFTER SOWING AND AT HARVEST AS INFLUENCED BY VARIOUS TREATMENTS

□ WEED INTENSITY m^{-2} AT 15 DAS

◻ WEED INTENSITY m^{-2} AT HARVEST



and was at par to closer unidirectional bidirectional planting with normal and 50 per cent higher seed rate and no weeding treatment.

The data recorded in Table 11 on weed intensity of Medicago denticulata was found significant at harvest. Highest intensity of 10.86/m² was recorded under unweeded control and lowest 4.48/m² under POS application of 2,4-D EE. Latter treatment was found at par to hand weeding.

Potentiality of 2,4-D EE with 3% urea was well established in Medicago density and was followed clearly by fluroxypyr 0.75 kg/ha in reducing the density of Medicago. Isoproturon PE alone or in combination with superphosphate proved ineffective in reducing the intensity.

Among the cultural treatments hand weeding was much superior method in eliminating the population of M.denticulata. Rest of the cultural methods failed to exhibit larger variations in weed density and were at par to no weeding. Bidirectional planting although caused reduction in weed density but failed to attain the significant level as compared to solid planting with normal and enhanced seed rates.

4.1.3.5 Mean weed intensity of Anagalis arvensis :

Intensity of Anagalis arvensis under different treatments, estimated at 15 DAS, was not found significant.

Data measured on weed intensity in Table 12 and Fig.8 showed larger differences in Anagalis intensity, but failed to attain the level of significance. Isoproturon PE sprayed alone and blended with superphosphate failed to show marked variations in intensity of Anagalis sp. Both POE herbicides and hand weeding were not accomplished upto this stage hence similar results were obtained.

No significant differences were observed due to different cultural treatments in Anagalis intensity. Highest intensity of $6.790/m^2$ weeds was recorded under unweeded control and lowest $4.55/m^2$ under cross sowing at 22.5 cm with normal seed rate. Latter treatment proved superior to all other cultural treatments, herbicides and no weeding treatments, respectively. In general, cross sowing at wider spacing proved better than unidirectional planting with closer planting.

Data estimated at harvest on weed intensity showed significant in plant density (Table 12 and Fig.8). Highest weed intensity of $7.39/m^2$ was recorded under unweeded check and lowest $3.475/m^2$ under hand weeding treatment.

Among the herbicides Fluroxypyr and 2,4-D EE POE recorded lowest intensity of $3.805/m^2$, respectively and were found at par to hand weeding ($3.475/m^2$). Both POE herbicides were found significantly superior to

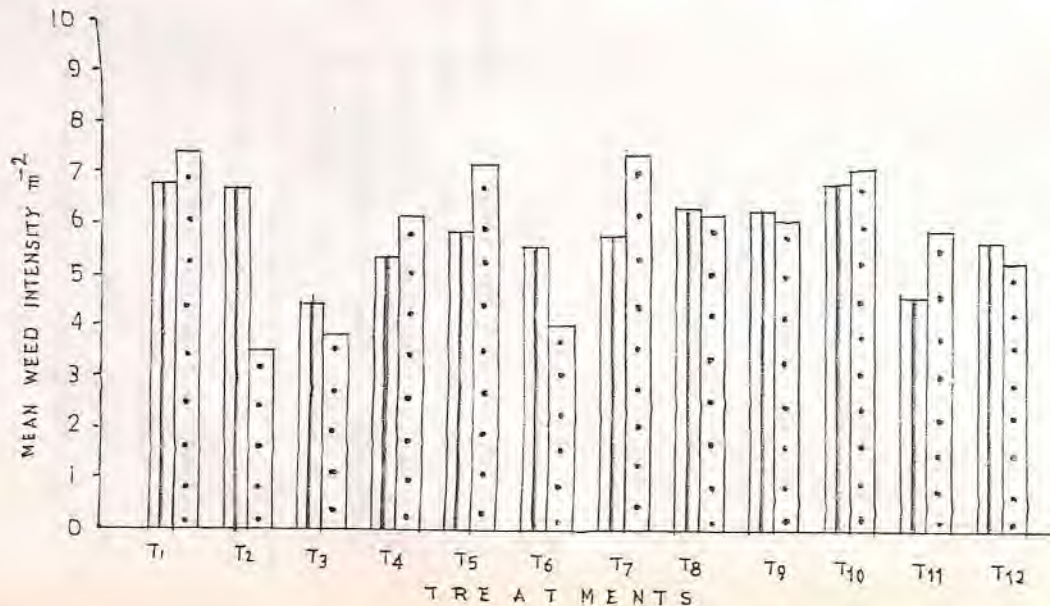
Table 12 : Mean intensity of Anagalis arvensis per m² at 15 days after sowing and at harvest

Treatments		15 DAS		At harvest	
T ₁	Unweeded control (Normal practice)	6.790	(46.00)	7.385	(55.25)
T ₂	Hand weeding at 30 DAS (Normal practice)	6.662	(44.75)	3.475	(12.50)
T ₃	Fluroxypyr 0.75 kg/ha 20 DAS (normal practice)	4.44	(19.75)	3.805	(14.25)
T ₄	Isoproturon 1 kg/ha PE (Normal practice)	5.262	(28.50)	6.110	(39.50)
T ₅	Isoproturon 1 kg/ha mixed with superphosphate	5.682	(34.25)	7.117	(52.50)
T ₆	2,4-D EE 0.75 kg/ha + 3% Urea at 30,DAS (Normal practice)	5.467	(30.00)	3.985	(16.00)
T ₇	Closer planting at 15 cm with normal seed rate	5.740	(35.00)	7.307	(53.75)
T ₈	Closer planting at 15 cm with 50 per cent higher seed rate than normal	6.247	(39.5)	6.137	(41.75)
T ₉	Bidirectional sowing at 15 cm with normal seed rate	6.177	(38.75)	6.010	(38.00)
T ₁₀	Bidirectional sowing at 22.5cm with 50 per cent higher seed rate than normal	6.762	(46.0)	7.070	(50.25)
T ₁₁	Bidirectional sowing at 22.5cm with normal seed rate	4.550	(20.75)	5.815	(34.5)
T ₁₂	Bidirectional sowing at 22.5cm with 50 per cent higher seed rate than normal	5.572	(31.25)	5.167	(27.25)
SEM \pm		0.676		0.687	
CD at 5%		-		1.988	

FIG. 8: MEAN INTENSITY OF *Aragalis arvensis* m^{-2} AT 15 DAS AFTER SOWING AND AT HARVEST AS INFLUENCED BY VARIOUS TREATMENTS

▭ WEED INTENSITY m^{-2} AT 15 DAS

◻ WEED INTENSITY m^{-2} AT HARVEST



isoproturon PE sprayed alone or applied mixed with superphosphate and incorporated into the soil. But in turn POE proved much superior to all cultural treatments beside hand weeding and bidirectional planting at 22.5 cm row distance with normal and 50 per cent higher rates of seeding. Closer planting unidirectionally proved ineffective with normal seedling rate or enhanced seed rates. Similar was the condition with bidirectional planting with row distance of 15 cm with normal and increased seeding rates.

4.1.4 Leaf area index of P. minor :

Data on mean leaf area index was found significant as influenced by different treatments at 25 DAS. Examination of data would reveal that hand weeding and 2,4-D EE POE herbicides were not conducted at the time of measurement hence effects were similar to unweeded control. Variation exhibited under them may be due to environmental effects. Maximum LAI (0.227) was noted under square planting at 15 cm with normal seed rate and lowest 0.017 under isoproturon PE applied alone, closely followed by isoproturon PE blended with superphosphate (0.028). Fluroxypyr 0.75 kg/ha though caused reduction in LAI but could not attain the significant level as compared to no weeding and cultural treatments.

Table 13 : LAI of P. minor at 25 days after sowing

Treatments	25 DAS
T ₁ Unweeded control (Normal practice)	0.225
T ₂ Hand weeding at 30 DAS (Normal practice)	0.190
T ₃ Fluroxypyr 0.75 kg/ha 20 DAS (Normal practice)	0.145
T ₄ Isoproturon 1 kg/ha PE (Normal practice)	0.017
T ₅ Isoproturon 1 kg/ha PE mixed with superphosphate (Normal practice)	0.028
T ₆ 2,4-D EE 0.75 kg/ha + 3% Urea at 30 DAS (Normal practice)	0.161
T ₇ Closer planting at 15 cm with normal seed rate	0.214
T ₈ Closer planting at 15 cm with 50 per cent higher seed rate than normal	0.192
T ₉ Bidirectional sowing at 15 cm with normal seed rate	0.227
T ₁₀ Bidirectional sowing at 22.5 cm with 50 per cent higher seed rate than normal	0.203
T ₁₁ Bidirectional sowing at 22.5 cm with normal seed rate	0.181
T ₁₂ Bidirectional sowing at 22.5 cm with 50 per cent higher seed rate than normal	0.206
SEM \pm	0.042
CD at 5%	0.125

Cultural treatments failed to show wider differences in LAI. Minimum LAI of 0.191 was recorded under cross sowing at 22.5 cm with normal seed rate and was at par to LAI under 15 cm row spacing with 50 per cent higher seed rates and hand weeding. Other cultural techniques failed to cause wider differences in LAI and were at par to no weeding treatment.

4.1.5 Dry matter accumulation of weeds :

Dry matter of weeds is the true index which provides a better evaluation of the efficiency of herbicides or cultural methods of weed control.

Data on dry weight of weeds was worked out finally at harvest on hectare basis and presented in Table 14 and Fig.9. Dry matter yield showed wider variations due to cultural and herbicidal methods and were found superior to no weeding. No weeding registered 47.44 q/ha dry matter yield being highest while 4.87 q/ha yield was noted under hand weeding treatment.

Isoproturon PE 1 kg/ha sprayed alone proved superior much among herbicides and registered lower dry matter to the tune of 10.70 q/ha and was found significantly superior to no weeding, cultural and herbicidal treatments beside hand weeding.

Table 14 : Weed control efficiency and dry matter accumulation by weeds at harvest

Treatments	Dry matter accumulation	Weed control efficiency
T ₁ Unweeded control (Normal practice)	6.815 (47.445)	-
T ₂ Hand weeding at 30,DAS (Normal practice)	2.235 (11.865)	68.73
T ₃ Fluroxypyr 0.75 kg/ha 20 DAS (Normal practice)	4.765 (22.543)	30.42
T ₄ Isoproturon 1 kg/ha PE (Normal practice)	3.288 (10.700)	52.56
T ₅ Isoproturon 1 kg/ha PE mixed with superphosphate	4.810 (22.663)	29.75
T ₆ 2,4-D EE 0.75 kg/ha + 3% Urea at 30 DAS (Normal practice)	4.633 (21.51)	32.45
T ₇ Closer planting at 15 cm with normal seed rate	5.368 (44.228)	21.49
T ₈ Closer planting at 15 cm with 50 per cent higher seed rate than normal	6.030 (37.248)	11.67
T ₉ Bidirectional sowing at 15 cm with normal seed rate	5.360 (28.495)	21.55
T ₁₀ Bidirectional sowing at 15 cm with 50 per cent higher than seed rate than normal	4.595 (21.063)	32.97
T ₁₁ Bidirectional sowing at 22.5 cm with normal seed rate	4.800 (22.745)	29.88
T ₁₂ Bidirectional sowing at 22.5 cm with 50 per cent higher seed rate than normal	4.903 (23.59)	28.38
SEM	0.354	
CD at 5%	1.056	

FIG. 9 : WEED CONTROL EFFICIENCY (%) AS INFLUENCED BY VARIOUS TREATMENTS

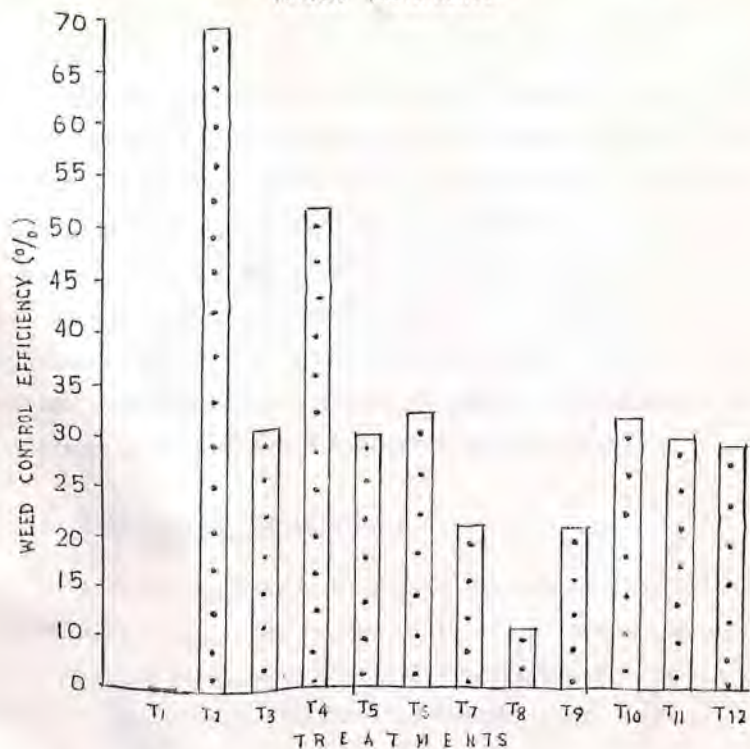
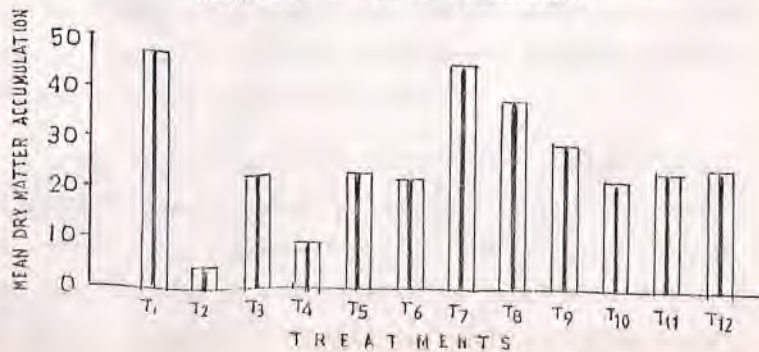


FIG. 10 : MEAN DRY MATTER ACCUMULATION OF WEEDS AT HARVEST AS INFLUENCED BY VARIOUS TREATMENTS



Dry matter accumulation under POE herbicides did not show larger variations among themselves but proved superior to no weeding, solid planting at 15 cm with normal seed rate and 50 per cent higher seed rates. Fluroxypyr and 2,4-D EE herbicides were at par to bidirectional sowing with normal and 50 per cent higher seed rates. Planting the crop bidirectionally at 15 cm and 22.5 cm proved much better as regards reduction in dry matter of weeds as compared to solid plantings with normal and increased seeding rates.

4.1.6 Weed control efficiency :

Weed control efficiency data set out in Table 14 and Figure 9 was worked out on the basis of dry matter accumulation of weeds at harvest from different treatments so as to evaluate the effective methods of weed control in wheat.

Data recorded in Table 14 and Figure 9 would reveal that highest weed control efficiency (68.73%) was noted under hand weeding and was followed closely by isoproturon PE applied alone, while lowest weed control efficiency to the tune of 11.67% was recorded under closer planting at 15 cm row spacing with higher seed rate.

The herbicides either applied as PE or POE showed wider differences in weed control efficiency. Isoproturon PE 1 kg/ha alone recorded 52.56 per cent efficiency which was much superior to other herbicidal treatments, there was no gain in applying the isoproturon with superphosphate,

Among cultural treatments, hand weeding registered highest efficiency (69.73%) and lowest weed control efficiency was noted at 15 cm row distance with higher seed rates giving 11.67 per cent efficiency only. Rest of the cultural treatments gave almost similar efficiency in controlling weeds.

4.2 CROP GROWTH STUDIES

4.2.1 Effect on crop stand :

The population of wheat crop/m² showed significant differences due to both cultural and herbicidal treatments.

An examination of the data set out in Table 15 would reveal that most of the postemergence herbicides and hand weeding treatments (T₃, T₅ & T₂) were not conducted upto this stage, hence variations detected under these treatments were merely due to environmental effects and not absolutely due to treatments. However, the crop density almost attained the same magnitude as obtained under no weeding (T₁) treatment.

Maximum density of 202,50/m² was noted under bidirectional planting with row spacing of 15 cm with 50 per cent higher rates than normal rates of seeding. While density of 134,00/m² was recorded by isoproturon PE applied mixed with superphosphate and incorporated prior to sowing of wheat crop.

Table 15 : Effect of different treatments on plant population and plant height

Treatment	Plant population per m ²	Plant height			At harvest
		25 DAS	50 DAS	75 DAS	
T ₁ Unweeded control (Normal practice)	145.25	22.85	41.22	64.00	73.20
T ₂ Hand weeding at 30 DAS (Normal practice)	158.75	25.60	35.62	55.15	68.05
T ₃ Fluroxypyr 0.75 kg/ha at 20 DAS (Normal practice)	147.25	26.02	35.07	58.55	70.55
T ₄ Isoproturon 1 kg/ha PE (Normal practice)	153.00	24.15	36.35	54.15	66.30
T ₅ Isoproturon 1 kg/ha PE mixed with superphosphate (Normal practice)	134.00	21.97	35.67	57.20	66.05
T ₆ 2,4-D EE 0.75 kg/ha +3%Urea 30 DAS (Normal practice)	168.25	26.20	37.97	57.70	69.20
T ₇ Closer planting at 15 cm with normal seed rate	148.25	27.27	39.27	64.70	73.45
T ₈ Closer planting at 15 cm with 50 per cent higher seed rate than normal	155.00	25.05	38.55	59.70	70.20
T ₉ Bidirectional sowing at 15 cm with normal seed rate	194.25	23.80	38.40	58.40	70.35
T ₁₀ Bidirectional sowing at 15 cm with 50 per cent higher seed rate than normal	202.50	26.95	40.05	62.80	73.10
T ₁₁ Bidirectional sowing at 22.5 cm with normal seed rate	188.25	25.70	38.65	60.70	74.05
T ₁₂ Bidirectional sowing at 22.5 cm with 50 per cent higher seed rate than normal	198.75	23.45	36.75	59.47	72.35
SEM \pm	12.306	0.427	1.925	1.933	2.160
CD at 5%	36.686	1.274	-	5.759	6.439

FIG. 11 : MEAN NO. OF TILLERS AND EFFECTIVE TILLERS PER PLANT AS INFLUENCED BY VARIOUS TREATMENTS.

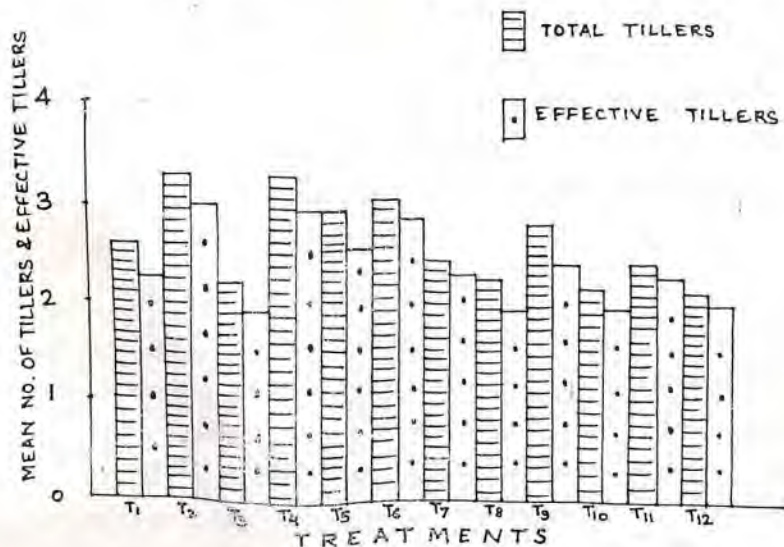
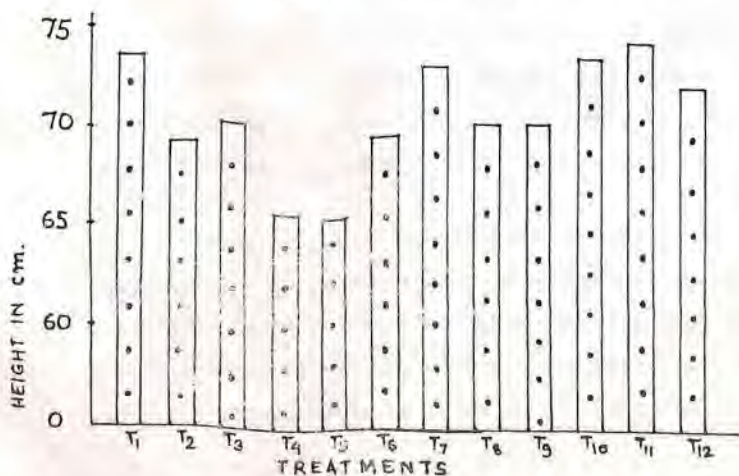


FIG. 12: MEAN PLANT HEIGHT IN cm. AS INFLUENCED BY VARIOUS TREATMENTS



Among preemergence herbicide isoproturon 1 kg/ha showed normal density and was comparable with that of no weeding treatment but when isoproturon was mixed with superphosphate at the same rates as pre-emergence caused severe reduction in crop intensity with the result registered lowest plant density.

Cultural treatments exhibited much better stand than herbicides and no weeding. Square planting with closer spacing or wider spacing invariably gave higher plant density irrespective of rates of seeding and proved much superior to solid planting under similar rates of seeding. Both cultural treatments proved much superior to herbicidal treatments and no weeding treatment.

4.2.2 Effect on plant height :

Data set out in Table 15 and Fig. 12 on periodic evaluation on plant height at 25, 50, 75 DAS and finally at harvest exhibited significant variations in plant height under different treatments beside measurement at 50 DAS.

The plant height noted at 25 DAS was found statistically significant. An examination of the data set out in Table 15 and Fig.12 would reveal that 2,4-D POE herbicide and hand weeding treatments (T_6 and T_2) were not conducted upto this stage hence variations detected under these treatments were merely

due to environmental effects and not due to treatments. However, the plant height almost attained the same magnitude as noted under no weeding (T_1) treatment.

Maximum plant height of 27.27 cm was recorded under solid row planting at 15 cm with normal seed rate, while dwarf plants (21.97 cm) were exhibited under isoproturon 1 kg/ha PE mixed with superphosphate.

Significant differences were recorded among the herbicidal treatments. POS application of fluroxypyr 0.75 kg/ha produced tallest plant (26.0 cm) among herbicides and was followed closely by no weeding, but in turn proved much superior to PE isoproturon alone or mixed with superphosphate. Isoproturon 1 kg/ha sprayed alone and blended with superphosphate produced dwarf plants as compared to no weeding and cultural treatments.

Among cultural treatments solid planting at 15 cm row distance with normal seed rate exhibited tallest plants (27.27 cm) and proved significantly superior to all other cultural treatments besides closer planting bidirectionally with 50 per cent higher seed rate. Dwarf plants (23.35 cm) were recorded under cross sowing at 22.5 cm row distance with enhanced seed rate while all other cultural treatments exhibited significantly taller plants, besides planting at 15 cm with normal seed rate.

Consistently plant height increased with the advancement in age of wheat crop. Differences in plant height were not found significant at 50 daystage. However, averages revealed that no weeding produced tallest plants (41.22 cm) closely followed by bidirectional sowing with closer planting and higher rates of seeding. Both these treatments proved superior to all other weed control treatments. Minimum plant height (35.07 cm) was noted under POE fluroxypyr at 0.75 kg/ha and was found at par to hand weeding and isoproturon 1 kg/ha blended with superphosphate.

Among the herbicidal treatments maximum plant height to the tune of 37.97 cm was recorded under POE application of 2,4-D EE with 3% urea, but failed to exhibit wider differences in plant height when compared to other herbicides and no weeding treatment.

No significant differences were detected among cultural treatments. Tallest plants (40.05 cm) were recorded under square planting at 15 cm with enhanced seed rate and lowest being 35.62 cm was noted under hand weeding, which was at par to most of the pre or post emergence herbicides.

Plant height recorded at 75 DAS was found significant. Plant height increased with the advancement in the age of the plants. Persistently tallest plants with 64.7 cm height was recorded under closer planting at 15 cm row distance with

normal seed rate. While dwarf plants (54.15 cm) were exhibited under isoproturon 7E 1 kg/ha sprayed alone and was at par to hand weeding treatment.

No significant differences exhibited between fluroxypyr and isoproturon 1 kg/ha blended with superphosphate, but proved better in height over isoproturon alone and 2,4-D EE treatments. Herbicides produced dwarf plants and were found significantly lower in height as compared to no weeding treatment.

Among the cultural treatments narrow planting at 15 cm with normal seed rate produced tall plants (64.79 cm) and were at par to no weeding but both proved significantly superior to all weed control treatments besides square planting at 15 cm with normal seed rates. Latter treatments though gave lower plant height but gave significantly more height as compared to herbicides and remaining cultural treatments including hand weeding. Rest of the cultural treatments produced same height as obtained under no weeding treatments, but in turn, proved much superior to herbicidal and hand weeding treatments as regards plant height.

The plant height showed marked variations due to cultural and herbicidal treatments at harvest. The study of the data in Table 15 would reveal that tallest plants (74.05 cm) and short statured plants (66.05 and 66.31 cm)

were recorded under isoproturon 1 kg/ha PE mixed with single superphosphate, as well as sprayed alone as PE application.

Among the herbicidal treatments no significant differences were detected as regards plant height. Maximum plant height of 70.55 cm was recorded under fluroxypyr POE 0.75 kg/ha and found at par to 2,4-D EE with 3% urea giving 69.20 cm tall plants, but both proved significantly higher in plant height as compared to rest of the herbicides.

Plant height showed marked differences due to cultural treatments. Bidirectional sowing with maximum row distance and normal seed rates produced tallest plants (74.05 cm) and was at par to solid planting at 15 cm row spacing with $\frac{1}{2}$ times seed rates, crop planting in narrow rows with higher seed rates and no weeding treatments giving 73.46, 73.10 and 73.20 cm tall plants, respectively. Overall effect of cultural treatments was more pronounced in elevating the plant heights besides hand weeding and produced taller plants than all herbicidal treatments.

4.2.3 Effect on mean number of tillers :

Number of tillers were estimated in wheat crop periodically at 25, 50, 75 daystages and at harvest. The data set out in Table 16 and Fig.11 show that tillers at 25 days after sowing were not significant. Application of 2,4-D EE 0.75 kg/ha as post emergence application and hand weeding were

not conducted at this stage hence the tiller number attained the same magnitude as that of no weeding. The treatments which were accomplished upto this stage showed larger variations in tiller count as compared to no weeding, however, the differences failed to attain the level of significance. Isoproturon 1 kg/ha PE sprayed alone registered 1.85 tillers/plant being maximum and lowest 1.40 tillers/plant were noted under unweeded control.

No significant differences were exhibited in tiller numbers due to herbicidal treatments. Isoproturon 1 kg/ha PE sprayed alone produced maximum number of tillers per plant and proved much superior to herbicides and no weeding treatments. Pre-emergence herbicides were much better than postemergence application of herbicides as regard tiller production. Cultural treatments conclusively pushed up the tiller number and established their superiority over herbicides and no weeding treatments. Square planting at 15 cm row distance with 50 per cent higher seed rate recorded highest 1.80 tillers per plant and was closely followed by square planting at 22.5 cm row distance with normal seed rate. Closer planting showed greater performance in tiller numbers as compared to POE herbicides and no weeding treatment besides PE herbicides, but registered declining trend in tiller count as compared to square planting.

Table 16 : Effect of different treatments on mean number of tillers per plant

Treatment	Days after sowing			At harvest	Effective tillers
	25	50	75		
T ₁ Unweeded control (Normal practice)	1.40	2.35	2.15	2.60	2.35
T ₂ Hand weeding at 30 DAS (Normal practice)	1.40	3.00	3.25	3.35	3.05
T ₃ Fluroxypyr 0.75 kg/ha 20 DAS (Normal practice)	1.50	2.65	2.45	2.20	1.90
T ₄ Isoproturon 1 kg/ha PE (Normal practice)	1.85	3.20	3.25	3.25	2.90
T ₅ Isoproturon 1 kg/ha PE mixed with superphosphate (Normal practice)	1.60	3.20	2.25	2.90	2.50
T ₆ 2,4-D EE 0.75 kg/ha + 3% Urea 30 DAS (Normal practice)	1.45	3.35	2.75	3.05	2.80
T ₇ Closer planting at 15cm with normal practice	1.45	2.95	2.15	2.45	2.20
T ₈ Closer planting at 15 cm with 50 per cent higher seed rate than normal	1.55	2.85	2.40	2.20	1.90
T ₉ Bidirectional sowing at 15 cm with normal seed rate	1.55	2.65	2.85	2.75	2.35
T ₁₀ Bidirectional sowing at 15 cm with 50 per cent higher seed rate than normal	1.80	2.20	2.55	2.10	1.90
T ₁₁ Bidirectional sowing at 22.5 cm with normal seed rate	1.70	2.95	2.75	2.65	2.25
T ₁₂ Bidirectional sowing at 22.5 cm with 50 per cent higher seed rate than normal	1.50	2.75	1.95	2.05	1.95
SEM \pm	0.123	0.145	0.236	0.275	0.241
CD at 5%	-	0.432	0.701	0.822	0.718

At 50 daystage tillers showed significant variations due to various treatments. All herbicides as well as cultural treatments were accomplished with the result, maximum number i.e. 3.35 tillers/plant and lowest 2.20 tillers/plant were recorded, under 2,4-D EE 0.75 kg/ha and square planting at 15 cm row distance with enhanced seed rate.

Among the herbicides, 2,4-D EE POE recorded maximum number of tillers/plant and was followed closely by isoproturon EE when sprayed alone or mixed with superphosphate. Fluroxypyr 0.75 kg/ha POE registered declining trend in tiller number as compared to herbicidal treatments. But on the other hand herbicidal treatments produced more number of tillers/plant than no weeding treatment and were at par to hand weeding.

Cultural methods also promoted more number of tillers to the tune of three tillers per plant under hand weeding treatment, closely followed by closer planting at 15 cm with normal seed rate and square planting at 22.5 cm row distance with normal seed rate and was found significantly superior to no weeding and cross sowing at 15 cm row distance with higher seed rates. Most of the herbicidal treatments were found superior to cultural treatments.

Observations recorded at 75 daystage registered larger variations in tiller count/plant. Maximum tillers i.e. 3.25 per plant were produced under hand weeding and was

found at par to isoproturon PE 1 kg/ha sprayed alone. While lowest tillers per plant (1.95) were recorded under bidirectional sowing at 22.5 cm row distance with higher seed rates.

Among the herbicidal treatments, isoproturon 1 kg/ha PE sprayed alone proved significantly superior to fluroxypyr POE, isoproturon PE mixed with superphosphate and no weeding and gave 2.45, 2.25 and 2.15 tillers/plant, respectively.

Hand weeding produced maximum number of tillers/plant (3.25 tillers) among the cultural treatments and proved significantly superior to closer planting at 15 cm row distance either with normal or 50% higher seed rates. Square planting at 22.5 cm row distance with higher seed rates recorded least number of tillers/plant and was found at par to no weeding and solid row planting giving 2.15 tillers/plant, square planting invariably proved much superior than solid planting, irrespective of narrow or wider planting with varying seed rates.

Tillers count at harvest showed significant differences due to various cultural and herbicidal treatments. Maximum number of tillers 3.30/plant were registered under hand weeding and was at par to isoproturon 1 kg/ha PE sprayed alone while lowest tillers/plant (2.05) were exhibited by square planting at 22.5 cm row distance with higher seed rates.

Among the herbicides, isoproturon PE sprayed alone was found superior to all weed control treatments and recorded 3.25 tillers/plant being maximum while lowest number of tillers 2.20/plant were recorded under fluroxypyr POE and was found inferior to isoproturon 1 kg/ha PE sprayed alone and 2,4-D EE. Most of the herbicides were superior to cultural treatments.

Among cultural treatments hand weeding gave maximum number of tillers (3.30) and was found at par to square planting at 15 cm row spacing with normal seed rate (2.75) and cross planting at 15 cm row distance with normal seed rate. All weed control treatments were found similar to no weeding treatments.

Effective tillers/plant were found significant (Table 16). Maximum effective tillers (3.05/plant) and lowest (1.90 tillers/plant) was recorded under hand weeding and square planting at 15 cm row spacing and was at par to solid planting with 50% higher seed rates than normal and fluroxypyr POE.

Among herbicides isoproturon PE sprayed alone gave maximum number of tillers/plant (2.90) while minimum 1.90 tillers/plant were recorded under fluroxypyr POE, respectively. Herbicides proved superior to most of the cultural treatments besides hand weeding treatment. Isoproturon PE sprayed alone and 2,4-D EE gave significant variations in tiller number due to unidirectional, cross planting at narrow distance with 50% higher seed rates.

As regard to cultural treatments hand weeding was found significantly superior to all weed control treatments, besides bidirectional closer sowing and normal rates of seeding but significant differences prevailed as compared to other cultural treatments.

4.2.4 Leaf area index :

Data set out in Table 17 in leaf area index were found significant at 25 and 75 days after sowing, besides at 50 days after sowing, where the differences were not found significant.

Leaf area index measured at 25 DAS was found significant. Hand weeding and 2,4-D EE POE were not accomplished upto this stage hence leaf area index attained the same magnitude as that of no weeding. Maximum LAI (2.642) was recorded under cross sowing at 15 cm row distance with 50 per cent higher seed rate while minimum LAI (1.155) was noted under isoproturon 1 kg/ha PE mixed with single superphosphate. Former treatment superceeded all herbicides and cultural treatments as regards LAI.

Isoproturon 1 kg/ha PE sprayed alone produced 1.782 LAI being highest among herbicides and proved significantly superior to isoproturon 1 kg/ha PE applied with superphosphate but was at par to fluroxypyr POE.

Table 17 : Effect of different treatments on Leaf area index

Treatments	Days after sowing		
	25	50	75
T ₁ Unweeded control (Normal practice)	1.532	3.490	2.722
T ₂ Hand weeding at 30 DAS (Normal practice)	1.627	3.675	5.257
T ₃ Fluroxypyr 0.75 kg/ha at 20 DAS (Normal practice)	1.575	3.125	3.030
T ₄ Isoproturon 1 kg/ha PE (Normal practice)	1.782	3.885	6.572
T ₅ Isoproturon 1 kg/ha PE mixed with superphosphate (Normal practice)	1.155	3.310	2.115
T ₆ 2,4-D SE 0.75 kg/ha + 3% Urea at 30 DAS (Normal practice)	1.742	4.325	4.187
T ₇ Closer planting at 15 cm with normal seed rate	1.490	3.205	2.662
T ₈ Closer planting at 15 cm with 50 per cent higher seed rate than normal	1.690	4.047	3.150
T ₉ Bidirectional sowing at 15 cm with normal seed rate	1.787	4.790	4.197
T ₁₀ Bidirectional sowing at 15 cm with 50 per cent higher seed rate than normal	2.642	3.715	3.955
T ₁₁ Bidirectional sowing at 22.5 cm with normal seed rate	2.195	5.310	3.645
T ₁₂ Bidirectional sowing at 22.5 cm with 50 per cent higher seed rate than normal	1.822	4.065	2.057
SEM \pm	0.196	0.459	0.577
CD at 5%	0.584	-	1.718

When cultural treatments were evaluated all treatments proved superior to no weeding and isoproturon 1 kg/ha applied mixed with superphosphate. Most of the cultural treatments were found better than herbicidal treatments and unweeded control as regards LAI.

LAI increased consistently with advance in age of the wheat crop, but the differences were not found significant at 50 days after sowing. Maximum LAI (5.31) was noted under 22.5 cm bidirectional sowing with normal seed rate and least LAI (3.125) was recorded under fluroxypyr 0.75 kg/ha applied as POE.

Among herbicides, 2,4-D EE POE gave higher LAI than other herbicides and were at par to no weeding, close planting with normal seed rate and cross sowing in narrow rows with higher seed rates giving 3.490, 3.205 and 3.715 LAI, respectively. Fluroxypyr POE was lowest yielder of LAI among weed control treatments. On the other hand, cultural treatments performed much better than herbicides and no weeding treatment. Cross sowing with wider row distances and normal seed rates and 50 per cent high seed rate conducive pushed up LAI to a greater degree as compared to no weeding and most of the herbicidal treatments.

LAI was found significant due to different treatments at 75 days after sowing (Table 17). Maximum LAI (6.572) was exhibited under isoproturon PE sprayed alone and minimum

2.057 LAI was recorded under cross sowing at 22.5 cm row distance with increased rates of seeding.

Among herbicides, isoproturon PE sprayed alone produced maximum LAI and produced significant differences in LAI as compared to all other treatments besides 2,4-D EE, POE. Minimum LAI (2.15) was recorded under isoproturon PE blended with superphosphate.

While among the cultural treatments hand weeding produced highest LAI (5.257) and was found significantly superior to all other cultural treatments besides cross sowing at 15 cm row spacing either with normal or higher seed rates. No significant differences were exhibited between hand weeding and bidirectional sowing with normal seed rates at a row distance of 22.5 cm but when seed rates was raised to 50 per cent higher than normal, LAI declined drastically and recorded 2.057 LAI being lowest among the weed control treatments.

4.3 YIELD ATTRIBUTING CHARACTERS

4.3.1 Mean length of earhead :

The data postulated on mean length of earhead in Table 18 was not found significant due to different weed control treatments. Longest ears were recorded under 2,4-D EE, POE while isoproturon 1 kg/ha PE sprayed alone registered 6.925 cm ear length being lowest. Fluroxypyr and

isoproturon blended with superphosphate failed to cause larger variations in ear length.

Similarly cultural treatments showed no perceptible increase in ear length, however, Table 18 revealed that maximum earlength (7.825 cm) was recorded under closer planting at 15 cm with normal seed rates and was found at par to all other weed control treatments including no weeding treatment.

4.3.2 Mean ear weight †

The data presented in Table 18 on ear weight was found statistically significant due to different treatments. Cross sowing at 22.5 cm spacing with normal seed rates recorded 2.555 g weight being maximum and proved significantly superior to no weeding giving 1.895 g weight per ear.

Among the tested herbicides no significant differences in ear weight were exhibited among themselves, besides 2,4-D SE which proved significantly superior to fluroxypyr and isoproturon 1 kg/ha applied alone as PE. But when isoproturon was applied mixed with superphosphate no measurable differences were detected in the ear weight. All herbicidal treatments displayed larger variations in ear weight as compared to no weeding treatment.

Table 18 : Mean length of earhead, number of ears per plant, number of grains per earhead, ear weight and test weight as influenced by various treatments

Treatments	Ear length	Ear weight	Per ear grain weight	No. of grain per ear	Test weight
T ₁ Unweeded control (Normal practice)	7.15	1.885	1.46	34.65	41.925
T ₂ Hand weeding at 30 DAS (Normal practice)	7.55	2.190	1.70	39.30	42.550
T ₃ Fluroxypyr 0.75 kg/ha 20DAS (Normal practice)	7.35	2.09	1.715	39.60	43.00
T ₄ Isoproturon 1 kg/ha PE (Normal practice)	6.825	2.05	1.70	38.70	42.775
T ₅ Isoproturon 1 kg/ha PE mixed with superphosphate (Normal practice)	7.45	2.295	1.83	42.40	42.725
T ₆ 2,4-D EE 0.75 kg/ha + 3% Urea at 30 DAS (Normal practice)	8.175	2.435	1.83	44.30	38.975
T ₇ Closer planting at 15 cm with normal seed rate	7.325	2.39	1.76	44.25	40.825
T ₈ Closer planting at 15 cm with 50 per cent higher seed rate than normal	7.45	2.105	1.495	39.25	41.375
T ₉ Bidirectional sowing at 15 cm with normal seed rate	7.45	2.265	1.715	37.40	43.70
T ₁₀ Bidirectional sowing at 15cm with 50 per cent higher seed rate than normal	7.475	2.465	1.945	42.15	40.675
T ₁₁ Bidirectional sowing at 22.5 cm with normal seed rate	7.775	2.555	1.980	44.35	41.95
T ₁₂ Bidirectional sowing at 22.5 cm with 50 per cent higher seed rate than normal	7.7	2.280	1.775	43.55	43.87
SEm ±	0.339	0.117	0.099	1.651	0.990
C.D. at 5%	-	0.350	0.295	4.922	-

All cultural techniques of weed control gave perceptible differences in ear weight over no weeding. Square planting at 22.5 cm with normal seed rate among cultural techniques was found significantly superior to closer planting with higher seed rates and hand weeding treatments, but was at par to cross sowing at 15 cm row distances with $1\frac{1}{2}$ times seed rates and 2,4-D EE applied POE at 0.75 kg/ha.

4.3.3 Mean number of grains per ear-head :

The number of grains per ear-head may be regarded as one of the most important yield attributing character. Significant differences were observed as regards number of grains per ear-head as affected by different weed control treatments. Data set out in Table 10 and Fig.13 clearly revealed that the number of grains per ear-head were recorded highest to the extent of 44.35 under square planting at 22.5cm with normal seed rate while 34.63 numbers per ear-head were registered with no weeding treatment and was regarded least among weed control treatments.

Different effect of herbicides was noted as regard grain production per ear-head. 2,4-D EE herbicide proved versatile and gave potential yield of 33.40 grains per ear-head, which on the other hand gave significant differences in grain numbers/ear-head as compared to isoproturon 1 kg/ha EE sprayed alone. All herbicidal treatments were found superior to no weeding.

FIG. 13 : MEAN NUMBER OF GRAINS PER EAR HEAD AS INFLUENCED BY VARIOUS TREATMENTS

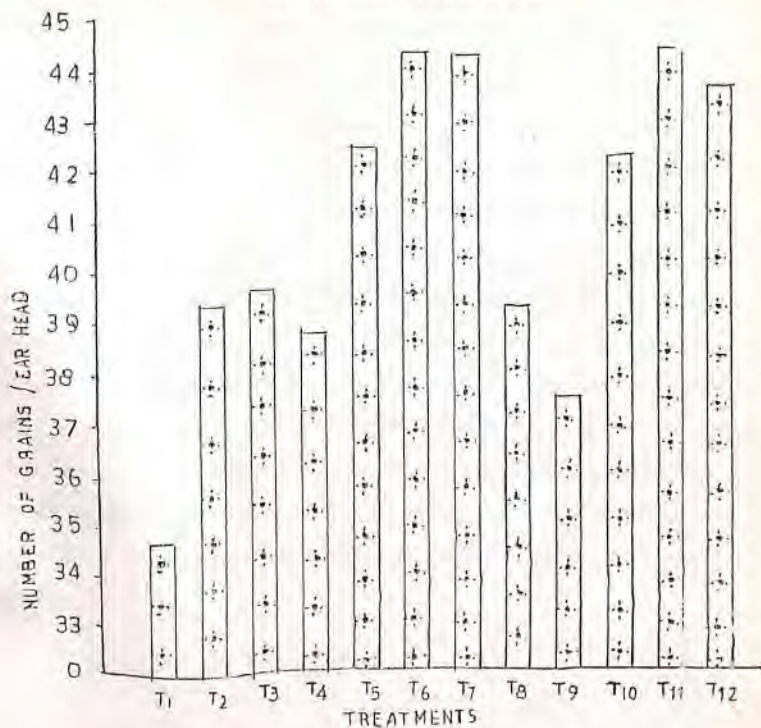
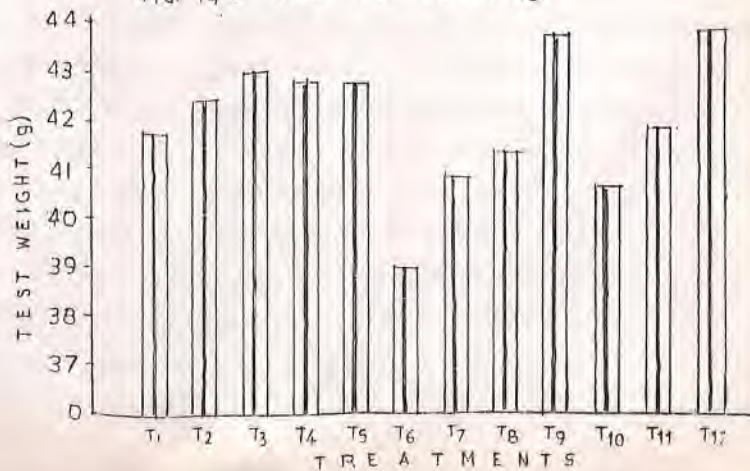


FIG. 14 : MEAN TEST WEIGHT (g)



Cultural treatments conductively pushed up number of grains/ear-head under them and were found much better than herbicides, besides 2,4-D EE. Among cultural treatments cross sowing at 22.5 cm with normal seed rate recorded maximum number of grains per ear (44.35/ear) and was found significantly superior to square planting with 15 cm row distance with normal seed rate, closer planting in narrow rows with higher seed rates and no weeding treatment, respectively. Former cultural treatment gave measurable variations over fluroxypyr and isoproturon PE application. Crossing rows at wider distances bidirectionally gave better performances than closer planting with or without higher rates of seeding.

4.3.4 Mean grain weight (g)/ear :

The data presented in Table 18 on grain weight/ear influenced significantly due to different treatments. Cross sowing with normal seed rate at 22.5 cm row distances recorded maximum grain weight/ear (1.980 g) and minimum grain weight/ear (1.460 g) was under no weeding treatment. Latter weed control treatment was at par to solid planting in narrow rows with higher rates of seeding. Rest of the herbicides and cultural treatments failed to cause significant variations in ear weight as affected by weed control treatments. Square planting was much superior than either herbicides or closer sowing as regards grain weight/ear.

4.3.5 Test weight :

Data appended in Table 18 and Fig.14 showed that weed control treatments did not influence the 1000-grain weight significantly. However, averages indicated that cross sowing at 22.5 cm with enhanced seed rate pushed up the test weight to the tune of 43.87 g being maximum and lowest 38.97 g seed weight was recorded under 2,4-D EE, POE.

No significant differences were detected among the herbicidal treatments. However, maximum grain weight (43.00g) was recorded under fluroxypyr POE, but failed to attain the level of significance. No weeding was parallel in effect as compared to all other weed control treatments with regard to test weight.

No significant differences were registered in test weight by cultural treatments. Highest grain weight (43.87 g) was registered under cross sowing at 22.5 cm with enhanced seed rates closely followed by cross sowing at 15 cm row distance with normal seed rate. Lowest grain weight to the extent of 40.675 g was recorded under cross sowing at 15 cm with higher seed rates.

4.3.6 Crop biomass :

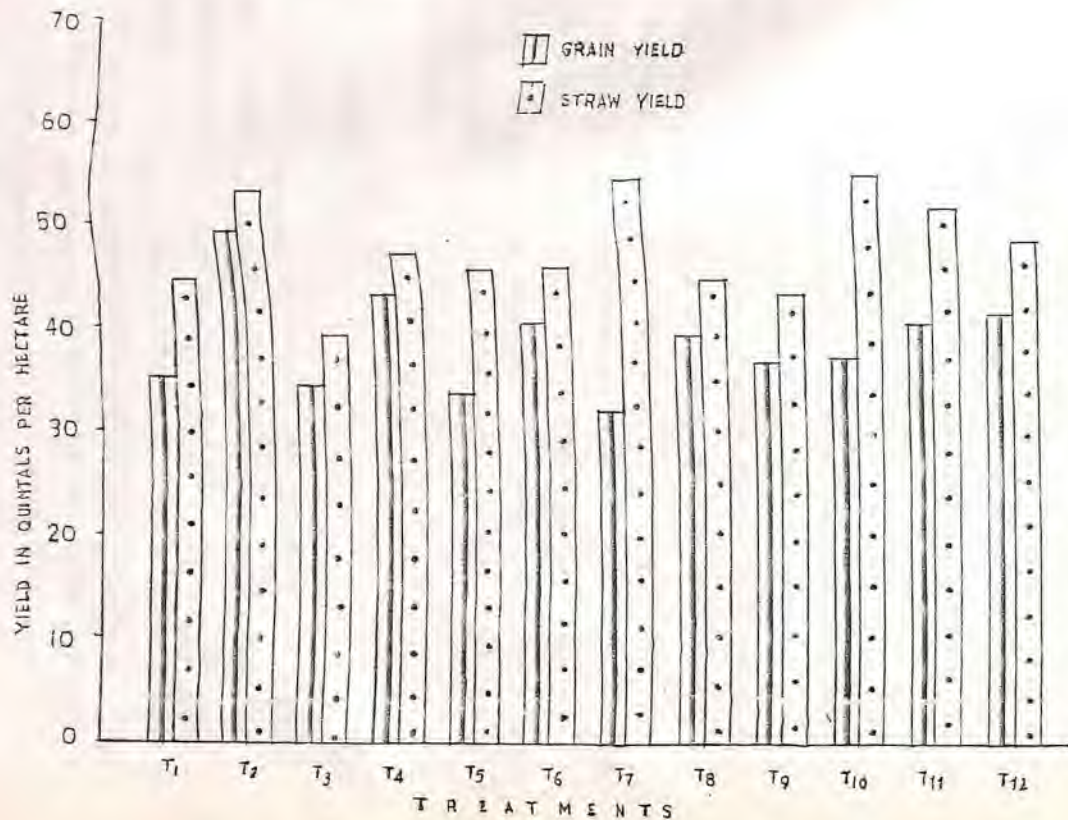
The data recorded in Table 19 and Fig.15 on crop biomass showed significant differences due to different treatments. Maximum crop biomass 101.335 g/ha was recorded under hand weeding and lowest 73.812 g/ha under fluroxypyr POE.

Table 19 : Effect of different treatments on crop biomass, grain yield, straw yield, harvest index and weed index

Treatments	*Crop shoot biomass	*Grain yield	*Straw yield	Harvest index	Weed index
T ₁ Unweeded control (Normal practice)	80.240	35.36	44.880	44.068	27.881
T ₂ Hand weeding at 30 DAS (Normal practice)	101.335	49.03	52.305	48.384	-
T ₃ Fluroxypyr 0.75 kg/ha 20 DAS (Normal practice)	73.812	34.062	39.750	46.174	30.528
T ₄ Isoproturon 1 kg/ha PE (Normal practice)	90.532	43.217	47.315	47.737	11.856
T ₅ Isoproturon 1 kg/ha PE mixed with superphosphate (Normal practice)	83.842	38.677	45.165	46.131	21.116
T ₆ 2,4-D EE 0.75 kg/ha 30 DAS (Normal practice)	87.187	40.697	46.490	46.678	16.996
T ₇ Closer planting at 15 cm with normal seed rate	77.412	34.640	54.860	44.748	29.349
T ₈ Closer planting at 15 cm 50 per cent higher seed rate than normal	84.615	39.640	44.975	46.847	19.152
T ₉ Bidirectional sowing at 15 cm with normal seed rate	79.727	36.002	43.725	45.156	26.571
T ₁₀ Bidirectional sowing at 15 cm with 50 per cent higher seed rate than normal	91.175	37.187	54.033	40.786	24.155
T ₁₁ Bidirectional sowing at 22.5 cm with normal seed rate	91.817	40.450	51.367	44.055	17.499
T ₁₂ Bidirectional sowing at 22.5 cm with 50 per cent higher seed rate than normal	84.485	41.395	43.090	48.997	15.572

*Duncan's Test is applied.

FIG. 15 : GRAIN AND STRAW YIELD (q/ha) AS AFFECTED BY DIFFERENT TREATMENTS



Among the herbicides isoproturon 1 kg/ha produced highest crop biomass i.e. 90.53 q/ha and was found significant as compared to fluroxypyr POE and 15 cm row spacing with normal seed rate. All the treatments were found superior to no weeding besides fluroxypyr POE.

When cultural treatments were evaluated, hand weeding gave recorded biomass yield of 101.335 q/ha and was noted significantly superior to 15 cm row spacing with normal seed rate, fluroxypyr POE, cross sowing at 15 cm row spacing with normal seed rates and no weeding. Hand weeding was also found significantly superior to isoproturon 1 kg/ha PE mixed with superphosphate at 17.212 critical value. All the treatments were found superior to no weeding besides closer planting with normal seed rate which produced 77.412 q/ha crop biomass.

4.3.7 Grain yield :

Data evaluated in Table 19 and Fig.15 on grain yield. Hand weeding was found superior to all the treatments and recorded maximum grain yield to the tune of 49.03 q/ha. Lowest grain yield (34.06 q/ha) was recorded under fluroxypyr PPOE and was at par to bi-directional planting at 22.5 cm row spacing with and without higher rates of seeding and solid planting at 15 cm row spacings with normal seed rates giving 34.062, 34.0 q/ha, respectively.

Grain yield was not affected significantly due to herbicidal treatments. Isoproturon PE sprayed alone gave maximum grain yield of 43,217 g/ha.

Among the cultural treatments, hand weeding proved efficacious and recorded grain yield of 49,03 g/ha being highest which in turn proved significantly superior to closer planting with normal seed rate, square planting at 15 cm row distance with normal seed rate and no weeding treatments at all critical values. It also showed its superiority over cross sowing at 15 cm row spacing with enhanced seed rate. There was apparently no advantage in cross sowing with wider row distances as compared to solid planting with normal and 50% higher rates of sowing. Besides fluroxypyr, all other herbicides potentially affected the grain production, as compared to most of the cultural treatments.

4.3.8 Straw yield :

The data postulated in Table 19 on straw yield showed significant differences due to different weed control treatments. Maximum straw production i.e. 54.86 g/ha was noted under closer planting with normal seed rate while fluroxypyr POE herbicides registered 39.75 g/ha straw yield.

Among the herbicides no significant differences were detected. Maximum straw yield (47.315 q/ha) was recorded under isoproturon PE and was found at par to all other weed control treatments.

When cultural treatments were evaluated, maximum straw yield of 54.860 q/ha was noted under closer planting with normal seed rate and proved significantly superior to cross sowing at 22.5 cm row distance with higher seed rates at all the critical values, but also found significantly superior to cross sowing at 15 cm with normal seed rates at 12.46 critical value.

4.3.9 Harvest index :

Harvest index is the ratio between economical yield and biological yield, expressed in percentages. The examination of data on harvest index appended in Table 19 would reveal that harvest index (48.99%) was recorded highest under cross sowing at 22.5 cm row distance with 50% higher seed rate. On the other hand cross sowing at 15 cm row spacing with increased seed rates than normal recorded lowest harvest index (40.79%).

Harvest index did not vary much under pre and post-emergence herbicides. However, isoproturon 1 kg/ha PE registered higher percentage of harvest index (47.73%) and

proved superior to bidirectional sowing at 15 and 22.5 cm with normal seeding rates and no weeding treatments. Rest of the herbicidal treatments pre or post emergence application and cultural treatments exhibited similar harvest index. Harvest index showed superiority over no weeding treatments when herbicidal treatments and cultural treatments were compared besides cross sowing at 15 cm spacing with normal rates of seeding.

4.4 Weed index :

Weed index is the measure of reduction in yield expressed in percentage occurred by the competition affected by presence of weeds in wheat crop. Weed index values appended in Table 19 indicated that reduction in wheat yield ranged from 11.86 to 30.53 per cent by isoproturon PE alone and fluroxypyr over hand weeding. The study further revealed that POE herbicides produced greater reduction than PE herbicides. Cultural treatments besides closer or wider rows planting registered greater weed index. Fluroxypyr and row spacing of 15 cm with normal seed rates caused severe reduction in yield over all cultural and herbicidal treatments, accordingly.

4.5 Economics :

Economics of different weed control measures was worked out after deducting expenditure from additional income accrued from weed control methods as compared to no weeding.

Results set out in Table 20 reveal that hand weeding was most outstanding among cultural methods which gave highest net profit of Rs. 3545.25 per hectare and was followed by isoproturon PE with a net profit of Rs. 2,469.25 per hectare. Hand weeding also gave profitable returns over rest of the herbicides greater in 2,4-D EE than isoproturon applied mixed with superphosphate.

Among the herbicides isoproturon PE with a net return of Rs. 2,469.05 was found superior to 2,4-D EE, POE and isoproturon mixed with superphosphate with net return of Rs. 1643.60 and 883.30 per hectare, respectively. Fluroxypyr POE herbicide was not found profitable and registered a net loss of Rs. 711.50.

Hand weeding gave a highest net return of Rs.3545.25 while cross sowing at wider spacings with normal and higher seed rates registered net profit of Rs. 1433.75 and Rs. 1359.25/ha and was followed by solid planting at 15 cm row spacing with 50% higher seed rate giving Rs. 1266.80

Table 20 : Economic analysis

Treatments	Additional yield over control (g/ha)		Addl. return over control (Rs/ha)	Cost of Treatment (Rs/ha)	Net profit (Rs/ha)
	Grain	Straw			
T ₁ Unweeded control (Normal practice)	-	-	-	-	-
T ₂ Hand weeding at 30 DAS (Normal practice)	13.67	7.43	4970.25 $\frac{14.15}{354.5}$	1425.00	3545.25
T ₃ Fluroxypyr 0.75 kg/ha 20 DAS (Normal practice)	-1.30	-5.13	-583.25	128.25	-711.50
T ₄ Isoproturon 1 kg/ha PE (Normal practice)	7.86	2.44	2812.00	342.95	2469.05
T ₅ Isoproturon 1 kg/ha PE mixed with superphosphate (Normal practice)	3.32	0.29	1169.25	285.95	883.30
T ₆ 2,4-D EE 0.75 kg/ha + 3% Urea at 30 DAS (Normal practice)	5.34	1.61	1909.25	265.65	1643.60
T ₇ Closer planting at 15 cm with normal seed rate	-0.72	9.98	-2.5	34.00	-36.5
T ₈ Closer planting at 15 cm with 50 per cent higher seed rate than normal	4.28	0.10	1500.5	234.00	1266.50
T ₉ Bidirectional sowing at 15 cm with normal seed rate	0.64	-1.15	195.25	578.00	-362.75
T ₁₀ Bidirectional sowing at 15 cm with 50 per cent higher seed rate than normal	1.83	9.15	869.25	778.00	91.25
T ₁₁ Bidirectional sowing at 22.5 cm with normal seed rate	5.09	6.49	1943.75	510.00	1433.75
T ₁₂ Bidirectional sowing at 22.5 cm with 50 per cent higher seed rate than normal	6.04	-1.79	2069.25	710.00	1353.25
Nocilon (75%)	@ Rs. 215/- per kg				
Agromore (48%)	@ Rs. 97/- per kg				
Fluroxypyr	@ Rs. 95/- per kg				
Hand weeding once	@ Rs. 1425/-				
				Labour charges for spraying @ Rs. 57/- (3 @ Rs. 19/- per day).	

net return per hectare. They proved much superior to all other cultural treatments. Bidirectional sowing at 15 cm row distance and solid planting under the same row distance proved uneconomical and registered a net loss of Rs. 362.75 and 36.50/ha, respectively. But when cross sowing was done with 50 per cent higher rates profit was marginal and proved superior to former treatments.

* * *

DISCUSSION

The results reported in the foregoing chapter on weed and crop studies as influenced by various weed control treatments are discussed in the light of recent literature available in this chapter.

5.1 WEED STUDY

5.1.1 Study of weed flora :

The data recorded in Table:5 and 6 on dominant weed flora of the experimental area revealed that the wheat crop had to face the severe competition mainly with broad leaved weeds to the density of 55.39 per cent while 23.02 per cent density was recorded under monocot weeds. The dicot weed flora composed of Trifolium flagiferum, Medicago denticulata, Melilotus alba and Anagalis arvensis in wheat crop. Among monocot weeds P. minor was the main dominant weed of wheat crop. The resilient enemy i.e. Phalaris minor density showed declining trend due to continuous use of isoproturon in wheat crop while dicot weeds were on increase due to late shifts and elimination of grassy weeds in wheat crop. Broad leaved weeds constantly increased upto latter stages of crop growth hence higher intensity was recorded. Due to similar growth habits and nature of Phalaris minor in wheat crop, competition increased manifold in the presence of dicot weeds. Similar weed study have also been reported by Anonymous:



(1982), Nageshwar and Jain (1982), Vishwakarma and Jain (1984), Tiwari and Bisen (1985) and Jain (1987).

5-1-2 Weed intensity :

An examination of the data on weed intensity revealed that weed intensities did not vary much by pre-emergence herbicides (Table-7), in the early growth studies. Isoproturon pre-emergence applied either alone or mixed with superphosphate failed to cause larger differences among themselves but proved superior to all the treatments in reducing the weed intensity. The herbicides probably were taken up apoplastically by roots, which ultimately resulted in death of the targetted plants. Significant effects of isoproturon have been reported by Kassasian (1977), Nageshwar and Jain (1982) and Vishwakarma and Jain (1984).

Post emergence herbicides as well as hand weeding treatment were not completed hence omitted from discussion.

Among the cultural treatments, cross sowing at row width of 22.5 cm with normal seed rate showed its superiority in controlling the weed flora. It may be due to sowing of crop in two direction which placed the crop in a better environment. This has also been reported by Vishwakarma and Jain (1984). At early stages of growth closer planting and no weeding exhibited similar effects in weed density. All

cultural treatments were not potential as compared to pre-emergence treatment in reducing the weed intensities at early stages of crop growth. Nageshwar and Jain (1982), Vishwakarma and Jain (1984) corroborated the above findings.

Measurement of weed intensity data at harvest was found significant. All herbicides affected the weed intensity to varying degrees but proved superior to no weeding and cultural treatments. However, the differences failed to attain the significant level. The efficacy of PE herbicides is based on the fact that they did not allow the weeds to emerge in the early stages of growth and probably succumbed due to apoplasmic movement via roots. Moreover their long persistence showed distinct advantages in reducing the weed stand. These findings are in agreement with those of Tomar et al. (1983) and Singh (1986). While POE herbicides exhibited almost similar effect as that of PE and eliminated the weed intensity effectively with least differences., 2,4-D EE + 3% urea proved much superior than fluroxypyr as POE herbicides. The weed flora was eliminated by POE herbicides efficiently. Severe chlorosis and necrosis followed immediately after post emergence application of 2,4-D EE and fluroxypyr herbicides, curtailed intensity of broad leaved weeds effectively. Singh (1986); Singh et al. (1987) AND Anonymous (1987) corroborated the above findings.

Among the cultural treatments, hand weeding proved most efficacious in exterminating the existence of weed population. It not only removed the weeds from inter spaces but efficiently removed weeds as well as from intra-spaces. Consequent upon elimination of weed intensities the crop attained luxuriant growth. The canopy developments enabled the crop to take care of the incoming weed shifts. Hand weeding was considered to be an effective method ^{of} weed control in wheat as reported by Prakash et al. (1986) and Singh (1986). Bidirectional sowing was next in order of performance in suppressing the weed population efficiently. Better effect of cross sowing was due to sowing of crop at equal distance in two directions which placed the crop in a better environment and thus the weed growth was suppressed effectively. Closer planting showed marked effect in reducing the weed stand over no weeding. It may be due to less available space for weed growth with the result weeds were suppressed by crop efficiently (Anonymous 1981).

1.3 Mean intensity of dominant weeds :

5.1.3.1 Effect on *Trifolium flagiferum* :

The intensity of *Trifolium flagiferum* differed widely by cultural and herbicidal methods at 15 day stage and at harvest. The Table-8 shows that PE herbicides which were accomplished at 15 day-stage proved superior in reducing the

weed intensities. Pre-emergence herbicides inhibited the weed germination in the initial stage due to potential entry of isoproturon alone or mixed with superphosphate. The intensity increased at subsequent stages of development i.e. at harvest due to decline in herbicidal activity and poor persistence in the soil. Most of the herbicides degraded rapidly and were used up by seedlings with the result weed shifts of Trifolium intensity cropped in at later stages of development. These findings are in agreement with the findings of Kassasian (1977), Nageshwar and Jain (1982), Vishwakarma and Jain (1984). While 2,4-D EE with 3% urea as POE at harvest showed wider differences in weed intensities and caused greater reduction in density as compared to PE isoproturon sprayed alone or mixed with superphosphate and fluroxypyr POE herbicides. The weed was highly susceptible to POE herbicides with the result population of Trifolium declined greatly.

Cross sowing and closer planting among cultural methods were not potential methods in reducing the intensity of Trifolium at both the stages, besides hand weeding and cross sowing at 22.5 cm with higher seed rate and was followed closely by solid planting with normal rates of seeding. The intensity of Trifolium was effectively eliminated by hand weeding because weeds were removed thoroughly from inter and intra-spaces with khurpi and

did not allow the late shifts to dominant over existing stand of the crop. Hand weeding was effective method of weed control in wheat as reported by Hooda et al. (1974). Similar results were also noted by Vishwakarma and Jain (1984). The population of Trifolium flagiferum was effectively reduced by closer planting with normal rates and cross sowing at 22.5 cm spacings with normal and 50% higher seed rates. In cross sowing the plants are placed at an equal row distance of 22.5 cm providing better environment for luxuriant growth of the wheat crop. The resulting lush growth of crop possibly showed smothering effect on weeds. Similar trend was also followed by closer planting. The intra spaces weeds were crowded out efficiently. Similar results were also obtained by Vishwakarma and Jain (1984).

Effect on Phalaris minor :

Cultural as well as herbicidal treatments affected significantly. The density of P. minor at 15 DAS as well as at harvest. The data portrayed in Table-9 revealed that application of herbicides showed differential performance in controlling the weed intensity. PE application of isoproturon sprayed alone or mixed with superphosphate reduced the weed intensity at 15 days. The better effect of isoproturon PE may be accounted for due to its phytotoxic effect on germinating seedlings. It also proved superior

at harvest in reducing the weed intensity. Both the POE herbicides failed in their result in reducing the weed intensity when compared with other herbicidal treatments. Pre-emergence herbicides i.e. isoproturon PE curtailed the population of P. minor due to effective entry of herbicide via coleoptile initially and probably prolonged persistence of herbicides and lush growth of wheat crop which crowded out late shifts of Phalaris intensity.

Hand weeding proved superior in eliminating the intensity of Phalaris minor. This finding have also been supported by Hooda et al. (1974), Shivkumar (1982). Cross sowing and closer planting with or without higher seed rates also reduced the weed intensity differentially. Reduction in weed density was noted with cross sowings irrespective of row distances with higher seed rates. The reduced weed intensity may be due to smothering effect and congenial environment which in turn favoured the crop stand and enabled the crop to smother the Phalaris minor density, (Anonymous, 1981).

5:13:3

Effect on Melilotus alba :

Differential responses on Melilotus alba were measured at 15 DAS and at harvest as affected by different treatments, (Table-10). Herbicides showed substantial decline in

Melilotus alba intensity initially as affected by pre-emergence herbicides, greater in isoproturon PE alone than its mixture with fertilizer. Isoproturon PE failed to inhibit the weed emergence latter due to rapid decline in herbicide concentration in the active zone, but proved superior than no weeding and cultural methods. Both POE herbicides eliminated the weeds effectively. The POE spray proved toxic to weed and eliminated the M. alba density due to rapid absorption and translocation through foliage. Similar results were also noted by Singh et al. (1987).

Cultivation practices reduced the intensity of Melilotus alba varying in the initial stage while consistently registered more weed number towards harvest, besides hand weeding. Hand weeding proved much superior among conventional methods. The superiority of hand weeding over other cultural methods was due to complete removal of weeds from inter and intrax spacings. It gave identical results as compared to PE and POE herbicides. Cross planting at wider row distances with and without higher seed rates placed the plant in a better environment at initial stage with high photosynthetic efficiency. Due to better effect of radiation which resulted in better growth of wheat crop. The lush growth most probably, was responsible for eliminating the weeds by overshadowing effect while closer planting

reduced the intensity of M. alba, but proved inferior to other cultural methods. Reduced stand under them was because of high plant population which smothered the existing weeds and inhibited the weed density. However, cross planting failed to maintain its consistency towards harvest. The weeds grew in the wider spaces, which threatened the growth of crop at latter stages.

1.3.4 Effect on Medicago denticulata :

The intensity of Medicago denticulata varied markedly under the influence of cultural and herbicidal methods at 15 DAS and at harvest. Table-11 and Fig. 7 shows that application of isoproturon PE 1 kg/ha proved potential in reducing the weed intensities of Medicago greater at the initial stage than at latter stages. Most probable reason may be that isoproturon inhibited the germination of weed seedlings and kept down the density of Medicago. The intensity trended upward at harvest due to degradation of the herbicide the data showed that both POE herbicides effectively eliminated the weed intensity. POE herbicides when sprayed alone were toxic to weeds initially and failed to maintain its consistency at latter stages. However, both herbicides eliminated the Medicago denticulata due to rapid absorption by coleoptile and effective translocation through foliage.

Application of 2,4-D SE + 3% urea reduced the density of Medicago and registered lowest intensity due to calicular translocation of herbicide via foliage. Efficacy of fluroxypyr was not well marked on Medicago.

All cultural treatments showed their superiority over unweeded control as regards control of Medicago. Hand weeding proved much potential after accomplishment at 30 DAS in eliminating the weed intensives from intra and inter spaces. Cross sowing with normal and higher seed rates reduced the weed intensity to a considerable extent. Cross sowing proved good crop stand and little or no space was left for the growth and development of weeds. Most of the weeds were crowded out by smothering effect. While solid planting showed poor effect on weed intensities. The reduced weed stand within the rows was due to over shadowing by the crop. There was negligible effect of seeding rates under normal or enhanced seed rate conditions in reducing the weed densities.

Effect on *Anagalis arvensis*

Intensity of *Anagalis arvensis* under different treatments was not influenced at 15 day stage but wider differences were obtained at harvest. Isoproturon with

with the and without superphosphate controled the density of Anagalis arvensis initially, but failed at latter stages. The herbicide was taken up in large quantities by emerging colioptile of weeds and soon its deactivation and greater utilization of the herbicide, pushed up the density of Anagalis greatly at latter stages of growth. Both POE herbicides eliminated the weed intensities of Anagalis differentially. The toxic effect on weeds may be due to fast absorption of the toxicant and translocation of herbicides to the active sites, which resorted in lower density of Anagalis sp.

Among the cultural treatments cross sowing and closer planting failed to reduce the intensity of Anagalis. The intensity of Anagalis was effectively eliminated by hand weeding because weeds were removed thoroughly from inter and intra-spaces with Khurpi and did not allow the late weed shifts to dominant over existing stand of the crop. The population of Anagalis sp. was not affected by closer planting, but cross sowing with normal and enhanced seed rates checked the growth of the weed and the density was much lower than no weeding. Cross sowing placed the plant at equi-distance thereby providing better environment for luxuriant crop growth which probably smothered the weeds effectively. Closer planting on the contrary overshadowed

to weeds hence resulting growth of the Anagalis sp. was very poor. Rates of seeding affected the density greatly and density of Anagalis showed moderate decline with 50 per cent higher seed rates.

5.1.4 Effect on LAI of Phalaris minor :

Data provided in Table-13 reveal that LAI of P. minor at 25 daystage showed wider differences due to weed control treatments. Isoproturon PE sprayed alone or mixed with superphosphate caused severe reduction in Phalaris minor density due to its potential effect on weed which probably arrested the growth of the P. minor and reduced the size of the developing leaves and thus resulting LAI was lowest among herbicides. Rest of the herbicides reduced LAI to a considerable degree due to phytotoxic action of these herbicides greater in fluroxypyr than 2,4-D EE applied as POE.

LAI under cultural treatments was not well marked, however, bidirectional planting at 22.5 cm with normal seeding rates recorded lowest LAI and was at par to hand weeding and solid planting at 15 cm row spacing with enhanced seed rates. It is evident from the Table-13 that the cultural treatments though showed differential responses in LAI but proved much better than LAI exhibited under no weeding.

1.5 Dry matter accumulation of weeds at harvest :

The result in dry matter accumulation of weeds at harvest showed wider variations due to various treatments. All treatments recorded lower dry matter production of weeds over control (47.45 g/ha).

Data appended in Table 14 and Fig. 10 showed that hand weeding recorded lowest dry matter yield while highest dry matter was exhibited under no weeding. Hand weeding exterminated the existing weeds with kharpi thus the weed free conditions favoured the growth of the crop which in turn took care of the following weed shifts by smothering effect which reflected in lowest dry matter yield under hand weeding. Hooda et al. (1974) and Jain et al. (1974) confirmed the above findings under Haryana conditions.

Herbicides which potentially affected the weed densities also reflected in much lower dry matter yield under them. Isoproturon was the only potent herbicide on weed stand with the result recorded lowest dry yield of weeds amongst herbicides. None of the other herbicides came to this level and most of them produced almost same dry yield as obtained under cross planting with varying seed rates and spacings. Differential responses of herbicides

exhibited varying dry matter accumulation. Isoproturon pre emergence inhibited the weed emergence due to efficient coleoptile uptake with the result weeds were curtailed to a considerable extent. While on the other hand isoproturon + superphosphate proved much phytotoxic to crop rather than weed due to which greater dry matter accumulated under this treatment. Post emergence herbicides were not recognised potential on all weeds besides broad leaved weeds, moreover initial weed growth and later weed shifts damaged the crop growth which could not recognised at latter stages. The weeds accumulated to a greater degree under poor growth of the crop (Singh *et al.*: 1985 and Prasad, 1984).

Cross sowing was found most effective for its efficient control of weeds. Efficiency of cross sowing was due to appropriate spacing which might have favoured the lush growth of the crop, thereby suppressing the future weed growth. While poor effect of closer planting was due to low weed control efficiency. The inter spaces weeds were not smothered properly besides intra-spacing weeds. This has the probable reason of much higher dry matter yield under solid planting irrespective of normal or 50 per cent higher seed rates. Vishwakarma and Jain (1984) supported these findings.

Weed Control efficiency :

Data set out in Table-14 on weed control efficiency was worked out on the basis of dry matter accumulation of weed measured against weedy check so as to evaluate W.C.E. at harvest. Cultural and herbicidal treatments showed differential responses as regard weed control efficiency.

Isoproturon PE sprayed alone dominated over POE herbicides and isoproturon PE mixed with superphosphate as regards weed control efficiency. This may be due to versatile effect of isoproturon PE in reducing the weed flora and growth of weeds as compared to other herbicides. It registered 52.56 per cent weed control efficiency. High-st weed control efficiency under isoproturon may be due to the better control of weeds from the beginning till harvest of the crop. Similar findings were also noted by Singh *et al.* (1985) while both post emergence herbicides and isoproturon mixed with superphosphates applied as basal showed similar effect and gave weed control efficiency in the range of 29.75 to 32.45 per cent. The potent effect of 2,4-D POE have also been reported by Kumar *et al.* (1986) and Singh *et al.* (1985). Fluroxypyr POE was effective on broad leaved weeds and proved phytotoxic to crop. Due to poor control over forthcoming weeds probably narrow down the weed control efficiency.

Among cultural methods of weed control, hand weeding gave the highest weed control efficiency (68.73%), while poor weed control efficiency (11.67%) was noted under closer planting with higher seed rate. The potential effect of hand weeding was due to elimination of weeds manually which eventually favoured the good growth of the crop. The resulting dense canopies smothered weed growth during latter stages of crop growth. Vishwakarma and Jain (1984) confirmed these findings. Cross sowing also gave moderate weed control efficiency and was found similar to POE herbicides and isoproturon applied basal after mixing with superphosphate, besides isoproturon sprayed alone as PE. The weeds were smothered differentially due to cross planting. The effect was more pronounced when density of crop was increased by higher seed rates.

Closer planting thinned the crop density within the rows due to severe mutual suppression, unchecked growth and development of weeds in the inter-spaces most probably reduced the dry matter and weed control efficiency substantially (Vishwakarma and Jain, 1984).

5.2 Crop Studies

5.2.1 Pre-harvest studies :

5.2.1.1 Crop Intensity :

Plant density showed differential responses due to cultural and herbicidal treatments (Table-15). Highest

density to the tune of 202.5 plants/m² produced by cross sowing at 15 cm with enhanced seed rate and was found at par to bidirectional planting irrespective of row distances and seeding rates while lowest density of 134.00 plants/m² was noted with isoproturon PE mixed with superphosphate. Square planting with higher seed rates affected better field emergence thus resulting density was very high. On the contrary closer planting despite of better control over inter-space weeds failed to affect the plant stand considerably. Cross sowing gave better stand as compared to closer planting due to its equi-directional planting which controlled the inter and intra space weeds efficiently by manipulating the environment, which might have favoured the crop in establishing the better stand.

Isoproturon PE sprayed alone showed no symptoms of phytotoxicity and exhibited normal crop stand, but when isoproturon was mixed with superphosphate due to severe phytotoxicity & lack of compatibility plant population declined markedly. At the time of population count, hand weeding and POE herbicides were not accomplished and registered similar densities, hence omitted from discussion.

5.2.1.2 Plant height :

Height is considered as an index of growth and was measured four times, during the life cycle of the crop

till harvest. Plant height showed wider differences due to cultural and herbicidal treatments.

Variations in plant height were observed due to application of different herbicides. At 25 days stage fluroxypyr POE proved superior than isoproturon PE either sprayed alone or mixed with superphosphate. Height declined as compared to no weeding and cultural treatments due to their phytotoxic effects. At later stages PE and POE herbicides exhibited identical plant height with progressive increase during advance in age.

All cultural treatments proved conducive in elevating the plant height and consistently recorded greater plant height. Closer planting irrespective of narrow or wider spacing produced tallest plants with normal as well as higher seed rates conditions and was at par to narrow planting with normal seed rate. Better effect of closer planting probably was due to inter and intra space competition, which included congenial environment for attaining the maximum plant height. Similar results were reported by Kolar *et al.* (1977), Vishwakarma and Jain (1984). Hand weeding which eliminated the weeds from inter and intra spaces thoroughly with Amurpi damaged severely the surface feeding roots which probably resulted in dwarf plants.

5.2.1.3 Number of tillers :

Tiller initiation is the next developing phase of wheat crop after height. Any favourable environment will bring in a greater response in the number of tillers per plant than any other growth character in the early growth stages. Tillers were measured at 25, 50, 75 daystage and finally at harvest (Table 16 & Fig. 12).

Tillers estimated at 25 daystage from seedlings failed to exhibit wider differences but registered greater differences in tiller numbers at latter growth stages due to cultural and herbicidal treatments. Tillers notably increased up to 50 daystage thereafter they declined under both cultural and herbicidal treatments, greater in cultural treatments than herbicides. 2,4-D EE registered highest tiller number (3.25/plant) at 50 days but proved somewhat phytotoxic at latter stages, while isoproturon PE sprayed alone produced maximum tillers but failed to attain the level of significance. At latter stages tiller numbers showed increasing trend upto midgrowth stage thereafter registered moderate decline towards maturity. Isoproturon PE sprayed alone controlled the weeds efficiently, hence its conducive effect was reflected in tiller initiation greatly and registered 3.25 tillers/plant being the highest

among the herbicides. Isoproturon was effective in controlling the mixed weed flora which carried their cogductive effect in final tiller yield (Kassasion, 1977). Increase in number of tillers/plant were also noted by Vishwakarma and Jain (1984). Fluroxypyr POE proved phytotoxic to the crop plant and recorded lower number of tillers per plant, hence wider differences were exhibited. Higher number of tillers were also recorded by isoproturon PE mixed with superphosphate over no weeding and other methods of weed control.

Among the cultural treatments hand weeding produced maximum number of tillers/plant. Hand weeding eliminated weeds efficiently from inter and intra spaces and had high weed control efficiency which carried its parallel effect in producing greater number of tillers/plant. These findings are corroborated by Solanki et al. (1980) and Shivkumar (1982).

Cross sowing at 15 and 22.5 cm row distance with normal seed rate maintained their superiority over other cultural treatments. As the plants were placed in a congenial environment due to effective light interception and efficient air circulation around the plants, which probably elevated the tiller production greatly while planting at 15 and 22.5 cm row distances with higher seed

rates followed the similar trend as that of cross sowing under similar conditions in the initial stage, but could not maintain its consistency for long period. Although rows were placed closer (15 cm) but the plants were spaced wider within the rows under normal and higher seed rate conditions which probably provided congenial environment for efficient photosynthetic activity of intra-plants with the result, high tiller numbers were produced as compared to no weeding. Closer planting produced more number of tillers/plant (Randhava *et al.*, 1977). Gill, and Brar (1974) elucidated that heavy infestation of weeds reduced the number of tillers/plant.

Effective tillers :

Effective tillers showed almost similar trend as reported under total tiller numbers per plant. Among the herbicides isoproturon PE sprayed alone produced maximum number of tillers/plant thus resulting effective tiller were also highest. Poor effect of fluroxypyr POE were recorded in tiller numbers/plant due to its phytotoxicity. Post emergence application of fluroxypyr probably coincided with tiller initiation which might have carried its parallel effect on ear bearing tillers at maturity.

Hand weeding among weed control treatments recorded highest effective tillers/plant. Hand weeding eliminated the weeds efficiently which initiated maximum number of total tillers thus resulting effective tillers were also highest. Similar findings are also noted by Singh et al. (1984). Low number of effective tillers were recorded under no weeding, closer and square planting with 50 per cent higher seed rates due to severe crop weed stress and less space available for normal crop growth ultimately reduced the ear bearing tillers finally. While under similar conditions sowing with normal seed rates registered greater number of effective tillers/plant.

5.2.1.4 Leaf area index :

Leaf area is the true index of all photosynthetic activity in the plant. LAI was measured three times during the life span of the crop.

Data recorded in Table 17 showed that leaf area index was affected significantly due to different cultural and herbicidal treatments besides 50 daystage. Maximum LAI was produced under square planting at 15 cm with higher rates of seeding and lowest (1.155) under isoproturon PE mixed with superphosphate at an early stage of crop growth. Lowest LAI may be due to phytotoxic effect on crop growth characters which reduced the leaf area index considerably.



Most of the cultural treatments were conducive on growth parameters than herbicides. Former treatments recorded maximum LAI but LAI alleviated under latter treatments due to phytotoxicity. Vishwakarma and Jain (1984) noted marked decline in LAI due to pre emergence application of isoproturon while at latter stages of growth LAI remained unaltered due to deactivation of toxicants besides isoproturon applied as PE and registered highest LAI. At 75 daystage isoproturon PE sprayed alone and hand weeding recorded maximum LAI as compared to all the treatments. Both these treatments were effective for eliminating the mixed weed flora thus the resulting LAI was highest due to congenial environment on growth of the crop. 2,4-D ER had shown its superiority at 50 daystage but it could not maintain its consistency at 75 days due to dropping of more leaves, LAI declined drastically thereby reducing the photosynthetic area.

Among the cultural treatments cross sowing at 15 and 22.5 cm distances with and without enhanced seed rates produced maximum LAI upto 50 days stages. The probable reason of greater LAI under cross sowing was that the plant efficiently utilized light and plant nutrients with favourable effect on growth of the plant. While 75 daystage cross sowing with 22.5 cm row spacings coupled with higher seed rates failed to maintain its superiority over other treatments. LAI showed declining trend under majority of the treatments. It may be due to narrowing of leaves of

this stage due to induced toxicity by herbicides besides isoproturon PE. LAI of wheat was increased in narrow planting treatments upto 50 daystage, this probably interacted in the production of large size and more number of leaves per plant. Similar results were also reported by Nageshwar and Jain (1982). While at 75 days less LAI was recorded which was due to more interspecific competition and mutual shading of leaves. Hand weeding produced somewhat less LAI than other cultural treatments. The probable reason is that the weeds were eliminated effectively from interspaces and damaged the surface feeding roots hence, the crop growth was affected adversely, however, LAI recouped at later stages and resulted in greater LAI.

5.2.2 Post harvest studies :

5.2.2.1 Yield attributes :

Data set out in Table 18 and yield attributing characters such as ear weight, grain weight and number of grains per ear were found statistically significant but ear length and test weight were not influenced by cultural and herbicidal methods. It would be appropriate to mention that the treatments which controlled the mixed weed flora efficiently from the initial stages accelerated the growth of wheat crop and carried their parallel effect in most of the yield attributing characters.

Post emergence application of 2,4-D EE showed marked effect in most of the yield contributing characters but failed to attain the level of significance besides number of grains per ear which was found statistically significant. Test weight was not affected markedly and was even lower as compared to cross sowing treatments. Pronounced effect of 2,4-D is observed in reducing weed intensities which in turn increased the growth attributes including number of tillers and effective tillers per plant with good weed control efficiency. These potent effects probably reflected in the production of majority of yield attributes favourably. Pre-emergence herbicides proved phytotoxic in the early stages, hence the length of the earhead and number of grains per ear declined substantially as compared to 2,4-D POE, but during the latter growth stages, crop recouped due to rapid degradation of the toxicants, which reflected in increasing the grain weight per ear head and test weight accordingly. Flurozypyr POE was phytotoxic on crop plants among POE herbicides. The poor tiller production per plant was due to its adverse effect on tiller production, however the adversity could not persist long and yield attributes increased substantially in the weed free environment.

Cross sowing among cultural treatments showed profound effects on all attributes as compared to rest of the treatments.

Significant effect of cross sowing could be attributed to its effect in controlling the P. minor among grossy weeds and broad leaved weeds through out the life cycle of wheat crop. Due to better interception of light which probably carried its distinct advantage in increasing the growth and development of wheat crop. Thus, yield attributing characters varied widely as compared to no weeding treatment. Closer planting exhibited longer and heavy ears, greater number of grains, grain weight per ear as compared to no weeding. As the closer row spacing, smothered the weed flora from intra row spaces efficiently with the result yield attributes were affected markedly under normal seed rates while closer planting with 50 per cent higher seed rates failed to give measurable response in yield attributes. The probable reason may be due to intra-specific crop weed competition. The yield attributes on the contrary were hampered due to severe intra-plant competition.

Moderate effect of hand weeding was found in production of yield attributes and gave optimum ear length ear weight, grain weight per ear, number of grains per ear and test weight. Hand weeding showed marked effect in controlling the weeds from inter as well as intra spaces of the crop plants and showed high weed control efficiency. Hand weeding damaged surface feeding roots during weeding with Khurpi which recouped in later stage of crop growth

and reflected in elevating the yield attributes. Hooda et al. (1974) and Shivkumar (1982) noted beneficial effect of hand weeding on yield attributes. Unweeded control had higher weed population hence lower values of these yield attributing characters were affected owing to severe crop-weed interference of associated weeds. Similar findings have been confirmed by Gill and Brar (1972) and Hooda et al. (1974).

5.2.2.2 Crop biomass :

Crop biomass production in quintal per hectare showed wider variations due to different herbicidal and cultural treatments. Data portrayed in Table 19 reveal that hand weeding registered 101.34 q/ha biomass yield being highest and lowest biomass was recorded under fluroxypyr POE. Former treatment was at par to cross planting at narrow and wider row spacings with and without higher seed rates than normal and hand weeding gave a response in the range of 9.52 to 27.53 q/ha biomass yield. Maximum biomass production was attained due to its favourable effect on growth attributes throughout the life span of the wheat crop which in turn elevated the yield characters greatly. Tiwari & Bisen (1987) corroborated the above findings.

Among herbicides isoproturon PE proved potential and gave 90.532 q/ha yield being the highest. As the herbicide effectively controlled the weeds which favoured

the growth and yield attributes, thereby elevating the crop biomass. Flurozypyr POE was phytotoxic to crop attributes since its accomplishment with the result crop biomass declined markedly to the tune of 91 per cent as compared to no weeding treatment while isoproturon alone or mixed with super phosphate and 2,4-D EE gave an additional yield of 10.24, 3.60 and 6.95 q/ha over unweeded control. Isoproturon potentially controlled grassy as well as non-grassy weeds. Similarly 2,4-D EE was found effective in controlling the intensity of broad leaved weeds which probably carried their conducive effect in elevating the yield attributes and biomass yield at large.

5.2.2.3 Grain yield :

The data in Table 19 and Fig. 15 elucidated significant differences in grain yield as affected by different methods of weed control. Hand weeding produced 49.05 q/ha grain yield being maximum while lowest grain yield i.e. 34.062 q/ha was recorded under flurozypyr POE. From the examination of the data it is evident that cultural methods proved superior to herbicides. Cultural methods like hand weeding markedly affected the growth and yield characters which in turn carried their profound effect on yield of wheat.

Herbicides gave promising yield besides flurozypyr POE. As the herbicides effectively controlled the weeds which

favoured the growth and yield attributes thereby elevating the yield of wheat crop. Increase in grain yield by isoproturon PE was due to efficient control over weeds which in turn enhanced the yield attributes greatly. Gill and Walla (1980), Gangrade (1982), Shivkumar (1982) corroborated the above findings. Increase in grain yield 2,4-D POE was due to effective control on broad leaved weeds which favoured the lush growth of wheat crop. Majority of yield attributes such as length of the ear, ear weight, number of grains per ear and grain weight per ear pushed up the grain yield substantially due to their additive effect. Similar findings have been reported by Bhardwaj et al. (1971), Salontai (1971), Jain et al. (1974), Verma et al. (1975) and Dhiman et al. (1985). Flurozypyr POE showed poor effect on yield despite its little effect on yield attributes. The most probable reason may be due to its phytotoxic effect on growth characters. It is evident from the weed index which was 30.53 being highest among the weed control treatments.

Highest yield of 49.03 q/ha was registered by hand weeding and was found superior to all the treatments. Weeds were removed thoroughly with Khurpi manually. Crop attained lush growth in weed free environment which simultaneously elevated the yield attributes and yield greatly. Higher grain yield was also reported under hand weeding by Chauhan

and Verma (1978), Mishra et al. (1981), Tiwari and Bisen (1987). Closer planting were failure as regards weed control. Weeds were suppressed in the intra spaces and allowed stress-free environment for weeds in the inter spaces. Due to severity of inter space weeds growth of wheat crop was affected markedly and the yield reduction was due to alleviated growth attributes despite better effect on yield attributes beside test weight which was lowest among weed control treatments. Under normal seed rates, yield attributes showed promising effect but when seed rates were pushed upto 50% higher than normal, growth and yield attributes declined due to mutual stress and severe crop-weed competition. However, increase in grain yield by cross sowing was found better than no weeding. Increase in yield by sowing half the seed and fertilizer in one direction and half in other direction at right angle with cluster row spacings of 22,5 x 22,5 cm have been corroborated by Dhillon and Klove (1981) and Sandhu et al. (1982).

5.2.2.4 Straw yield :

Data provided in Table 19 and Fig. 15 on straw yield showed wider differences in straw yield due to different methods of weed control.

All the herbicidal treatments produced more straw than no weeding beside flurozypyr POE. Isoproturon PE

sprayed alone gave highest straw yield. The potential effect of isoproturon may be due to its efficient weed control and elevated growth from the initial stages of crop till maturity. Isoproturon PE on straw production have also been reported by Vishwakarma and Jain (1984). Flurozypyr POE gave much lower straw yield due to its phytotoxic effects on growth characters. 2,4-D produced greater straw yield and was ranked second among the herbicides.

Among the cultural treatments, closer planting with normal seed rate proved outstanding and gave highest straw yield, closely followed by cross sowing at 15 cm with 50 per cent higher seed rates. Closer planting effectively reduced the weed flora from the interspacings thereby providing more room for development of wheat crop initially resulted in maximum straw production. But when cluster sowing was adjusted with 50 per cent higher seed rates straw production declined due to severe mutual suppression in both the directions (Randhawa et al., 1971) despite efficient weed control. While hand weeding which registered the highest crop biomass and grain yield gave moderate straw yield only. Straw yield increased by hand weeding through its congenial effect on growth attributes (Singh et al., 1984).

5.2.2.5 Harvest index :

An examination of the harvest index data in Table 19 revealed that cross sowing at 22.5 cm with 50 per cent higher seed rates was highest (49.8) while lowest harvest index to the tune of 40.78 under cross sowing at 15 cm with 50 per cent higher seed rate was obtained. Maximum HI was caused due to higher grain yield and moderate crop biomass. The crop sown in cluster sowing induced greater measurable differences in attributes, thereby the resulting HI was higher. No measurable differences were exhibited among the herbicides with regards to harvest index. Isoproturon PE gave an index of 47.73 being highest among the herbicides. Isoproturon Pe sprayed alone was found conducive to growth attributing characters, which gave promising yield return with the result harvest index increased substantially.

Cross sowing (22.5 cm x 22.5 cm) gave highest index under maximum seeding rates. Hand weeding recorded maximum grain as well as crop biomass yield with the result harvest index was affected substantially. Conducive effect of hand weeding was apparent on growth attributes due to efficient weed control which reflected in greater HI.

5.2.2.6 Weed index :

It is the reduction in yield due to the presence of weeds in comparison to hand weeded plot and expressed in

percentage. Weed index values in Table 19 revealed that highest percentage reduction in wheat yield was exhibited under fluroxypyr 0.75 kg/ha POE closely followed by solid row planting with normal seed rates, no weeding and bi-directional planting at 15 cm with normal seed rates giving 29.35, 27.88 and 26.57 per cent index, respectively. As fluroxypyr was phytotoxic on growth since it was applied as POE most probably due to its higher concentration which alleviated most of the growth and yield attributes due to which great reduction was noted in yield. Koziebi (1987) reports slight acceptable visual crop damage. Seeding with normal seed rates showed no distinct advantages either planting wheat crop in closer rows or cluster rows (15 x 15 cm). Majority of weed escapes were responsible from inter row spacings which caused severe reduction in yield due to competition stress on crop plants. Though the yield attributes trended upwards besides test weight which was lowest among weed control treatments due to which reduction was maximum. Similar trend was followed by no weeding and cross sowing with narrow rows under normal seeding rates.

Herbicides either as pre-emergence or POE proved efficacious and proved much superior to no weeding and cultural treatments. Isoproturon PE registered low dry matter accumulation of weeds with high weed control

efficiency reflected in lower weed index. Mixed application of isoproturon with super phosphate was also good despite its adverse effect on growth and some of the yield attributes i.e. length of the ear head and number of grains per ear, which recorded an index of \bar{x} 21.12% and was at par to most of the cultural treatments besides narrow planting.

Among cultural treatments cross planting with 22.5 cm rows with and without enhanced seed rates, both through their beneficial effects on growth and yield characters which alleviated the weed index greatly. The weed index thus exhibited was comparable with isoproturon PE applied alone. Cross planting smothered the weeds efficiently which pushed up the growth and yield attributes to obtain the highest level of productivity. These findings are corroborated by Prakash et al. (1986), Wallia and Chema (1986).

CHAPTER VI

SUMMARY, CONCLUSION AND SUGGESTION FOR FUTURE WORK

The present investigation entitled "Comparative efficiency of herbicides and cultural methods on growth, yield attributes and yield of dwarf wheat (Triticum aestivum L.) var. WH-147" was conducted on sandy clay-loam soil with average fertility at the Agricultural Research Farm, Adhartal under All India Co-ordinated Research Project on weed control of Department of Agronomy, J.N.K.V.V., Jabalpur, during Rabi season, 1988-89.

The study was conducted with 12 treatments, replicated four times. Variable tested were, hand weeding, closer planting (15 cm) with normal and 50 per cent higher seed rates, bidirectional sowing at 15 cm and 22.5 cm with normal and 50 per cent higher seed rates among cultural treatments. Three herbicides viz. isoproturon 1 kg/ha PE sprayed alone, and 1 kg/ha applied mixed with superphosphate, fluroxypyr 0.75 kg/ha, 2,4-D EE 0.75 kg/ha + 3% urea both POE application were evaluated in wheat crop. Both cultural and herbicidal treatments were compared with unweeded control.

The wheat crop was sown on December 3, 1988 as an irrigated crop. The crop was fertilized with 120 kg nitrogen, 60 kg phosphorus and 40 kg potassium per hectare, respectively supplied through urea di-ammonium phosphate and muriate of

Potash in all plots besides phosphorus requirements of treatment T₅ was met through single superphosphate. Sowing was done under dry conditions and was irrigated upto saturation immediately. Treatments were accomplished according to the schedule of the investigation.

Different studies made during the course of investigation and results so obtained are summarised below :-

Effect on weed flora :

The predominant weed flora consisted of Phalaris minor, Trifolium flagiferum, Medicago denticulata, Melilotus alba, Anagalis arvensis with relative density of 25.02, 16.80, 18.70, 10.02, 9.87 per cent, respectively. While other weed flora attained density of 21.58 per cent only.

✓ Among herbicides, isoproturon 1 kg/ha PE proved potential in controlling weeds while among cultural treatments hand weeding effectively eliminated differential weed intensities followed by bidirectional sowing at 15 and 22.5 cm with normal and 50 per cent higher seed rates and was considered best in suppressing the weed population.

Various treatments showed differential response on LAI of Phalaris minor at 25 day stage. Isoproturon PE sprayed alone has given lowest LAI of Phalaris minor, closely followed by isoproturon PE blended with superphosphate, while cultural treatments failed to exhibit wider differences.

Minimum LAI was recorded under cross sowing at 22.5 cm with normal seed rate.

Cultural and herbicidal treatments showed differential response in dry matter production. Hand weeding was found versatile and gave weed dry matter yield as low as 4.87 q/ha, as against highest dry matter production of 47.44 q/ha under no weeding treatment. While isoproturon PE alone gave lowest dry matter yield of 10.70 q/ha amongst the herbicides.

Effect on Growth, Yield Attributes and Yield of Wheat Crop :

Effect on crop stand :

Square planting with closer spacing or wider spacing invariably gave higher plant density irrespective of rates of seeding. Maximum density to the tune of 202.50/m² was produced by bidirectional sowing at 15 cm with 50 per cent higher seed rate closely followed by bidirectional sowing at 22.5 cm with 50% higher seed rate, while lowest stand was noted under isoproturon PE mixed with superphosphate (134.00/m²).

Effect on plant height :

Cultivation practice gave significantly greater height (74.05 cm) under cross sowing at 22.5 cm with normal seed rate than PE isoproturon mixed with superphosphate

which exhibited 66.05 cm tall plants, being the lowest.

Effect on tillers :

Tiller production was not much affected in the early stages of growth but gave significantly higher tiller number at later stages of crop development. Variables such as hand weeding (3.30 tillers/plant) and isoproturon PE sprayed alone (3.25 tillers/plant) were found conducive in tiller production, while hand weeding was found at par to both POE herbicides and cross sowing at 15 and 22.5 cm with normal seed rates, exhibiting no significant differences in tiller production. However, effective tiller numbers at harvest, were affected significantly by hand weeding, isoproturon PE and 2,4-D EE POE with 5 per cent urea.

Effect on leaf area index :

Various cultural and herbicidal treatments showed significantly wider differences in leaf area index at early growth stage of wheat crop. But no consistency was maintained at mid growth stage of crop due to maximum uniform canopy attained under all the treatments which failed to exhibit wider differences in leaf area index. However, treatments trended upward at final stage of measurement, which reflected in the significantly higher LAI at later stages of crop growth. Isoproturon PE mixed with superphosphate, showed

phytotoxic symptoms and registered almost less LAI at all stages of growth.

Effect on yield attributes :

Yield attributes were affected significantly by various treatments, except length of ear head and test weight, which showed similar response. 2,4-D EE POE gave greater values of the parameters among the herbicidal treatments except test weight. While among the cultural treatments cross sowing at 22.5 cm with normal seed rate showed pronounced affect in producing the maximum yield attributes. No weeding was noted for poor effects as regard to yield attributing characters. Isoproturon PE sprayed alone and fluroxypyr POE produced similar effects in yield characters.

Crop biomass, grain and straw yield :

Cultural and herbicidal application, increased the crop biomass and grain yield over no weeding, besides fluroxypyr POE herbicide. Hand weeding and isoproturon PE were found effective in all growth parameters, which reflected in the greater biomass and grain production of wheat crop. Closer planting with normal seed rate pushed up the straw production substantially on the contrary, fluroxypyr POE at 0.75 kg/ha yielded lowest.

Harvest index :

Harvest index was recorded highest under cross sowing at 22.5 cm row distance with 50% higher seed rate followed by hand weeding and isoproturon PE spraying alone while lowest harvest index was registered by 15 cm row spacing with 50% higher seed rate than normal.

Weed index :

Reduction in the wheat yield ranged from 11.86 to 30.53 per cent by isoproturon PE alone and fluroxypyr POE over hand weeding. POE herbicides produced greater reduction than PE herbicides. Closer planting with normal seed rate caused severe reduction in yield over cultural treatments.

Economics :

Maximum profit (3545.25) was obtained due to hand weeding, closely followed by isoproturon PE (2469.05). Fluroxypyr POE, cross sowing and narrow planting at 15 cm with normal seed rate were not found profitable and recorded net loss of Rs. 711.50, 382.75, 36.5, respectively over unweeded control.

Conclusion :

- From the present investigation, it is concluded that -
- (1) Wheat crop had to compete mainly with Trifolium flagiferum, Phalaris minor, Medicago denticulata, Melilotus alba, Anagalis arvensis being the predominant weeds.

- (2) Hand weeding followed by isoproturon PE sprayed alone gave excellent control of broad leaved weed and grassy weeds, which resulted in maximum grain production with highest net return.
- (3) Fluroxypyr POE was found toxic to the crop plant, hence lowest yield was recorded.
- (4) Cross sowing with wider row distance proved best method of sowing for highest grain production.

Suggestion for further work :

- (1) Combined effect of herbicide with varying seed rate, sowing method in controlling the problematic weeds, need to be explored.
- (2) Different doses of herbicides need to be evaluated as PE and POE applications in wheat crop.
- (3) Potent cultural methods such as cross sowing, radial planting, closer planting need to be tested under different varieties with variable seed rates.
- (4) Cultural cum herbicidal treatments should be evaluated in an integrated manner for higher economic returns.

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APPENDICES

Mean sum of square for

Source of variation	d.f.	15 DAS	At harvest
I Intensity of total weed at 15 DAS and at harvest of crop			
Replication	3	7.999	7.363
Treatment	11	47.12	53.926
Error	33	6.81	4.857
II Intensity of <u>Trifolium flagiferum</u>			
Replication	3	1.641	2.164
Treatment	11	17.262	13.687
Error	33	1.941	2.183
III Intensity of <u>Phalaris minor</u> Retz.			
Replication	3	9.203	11.464
Treatment	11	15.642	19.566
Error	33	1.941	2.183
IV Intensity of <u>Melilotus alba</u>			
Replication	3	7.742	4.723
Treatment	11	13.039	8.097
Error	33	0.978	3.754
V Intensity of <u>Medicago denticulata</u>			
Replication	3	8.221	4.063
Treatment	11	5.445	14.358
Error	33	1.804	1.473

Source of variation	d.f.	15 DAS	At harvest			
VI Intensity of <i>Anagalis arvensis</i>						
Replication	3	16.573	14.289			
Treatment	11	2.497	7.805			
Error	33	1.833	1.887			
VII LAI of <i>Phalaris minor</i> at 25 DAS						
Replication	3	0.031				
Treatment	11	0.0200				
Error	33	0.0071				
VIII Dry matter accumulation by weeds at harvest						
Replication	3	1.981				
Treatment	11	5.512				
Error	33	0.502				
IX Mean sum of squares for plant population and plant height at various growth stages of wheat						
Source of variation	d.f.	Plant population	Plant height (DAS)			At harvest
			25	50	75	
Replication	3	147.76	0.307	2.538	14.712	3.483
Treatment	11	2244.523	9.734	14.735	42.787	40.541
Error	33	605.757	0.731	14.823	14.925	18.665
X Mean sum of squares for tillers at various growth stages of wheat crop						
Source of variation	d.f.	Tillers / DAS			at Harvest	Effective tillers
		25	50	75		
Replication	3	0.029	0.054	0.032	0.005	0.026
Treatment	11	0.088	0.472	0.709	0.770	0.660
Error	33	0.061	0.084	0.222	0.304	0.233

XI Mean sum of squares for leaf area index at various growth stages of wheat crop

Source of variation	d.f.	Leaf area index/DAS		
		25	50	75
Replication	3	0.408	0.997	0.702
Treatment	11	0.527	1.528	6.742
Error	33	0.152	0.841	1.30

XII Mean sum of squares for length of ear-head, ear weight, number of grains per ear-head, grain weight per ear, test weight.

Source of variation	d.f.	Length of ear-head	Ear weight	No. of grains/earhead	Grain weight/ear	Test weight
Replication	3	0.60	0.183	0.048	5.343	4.665
Treatment	11	0.467	0.152	0.094	40.253	7.659
Error	33	0.055	0.039	0.039	10.907	3.922

XIII Mean sum of squares for crop biomass, grain yield and straw yield

Source of variation	d.f.	Crop biomass	Grain yield	Straw yield
Replication	3	216.407	46.751	124.260
Treatment	11	224.941	72.023	89.980
Error	33	143.392	55.451	67.880

Number of Means for ranges

Crop biomass in g/ha

	1	2	3	4	5	6	7	8	9	10	11
3.6											
2.315		5.915									
0.513		2.028	6.428								
3.242		3.755	6.07	9.67							
1.003		4.245	4.758	8.073	10.673						
0.13		1.133	4.375	4.888	7.203	10.803					
3.227		3.357	4.36	7.602	8.115	10.43	14.03				
2.69		5.917	6.047	7.05	10.292	10.805	13.12	16.72			
0.643		3.333	6.56	6.69	7.693	10.935	11.348	13.363	17.363		
0.642		1.285	3.975	7.202	7.332	8.335	11.57	12.69	14.405	18.005	
9.518	10.16	10.803	13.493	16.72	16.85	17.851	21.09*	21.608*	23.923*	27.523*	
Critical value	17.212	18.110	18.619	19.068	19.157	19.637	19.816	19.996	20.116	20.236	20.325

Number of means for range
Grain yield g/ha

	1	2	3	4	5	6	7	8	9	10	11
0.578											
0.72		1.298									
0.642		1.362	1.94								
1.185		1.827	2.547	3.125							
1.49		2.675	3.317	4.037	4.615						
0.963		2.453	3.638	4.28	5.00	5.578					
0.81		1.773	3.263	4.448	5.09	5.81	6.388				
0.247		1.057	2.02	3.51	4.695	5.337	6.057	6.635			
0.698		0.945	2.70	3.663	5.153	6.338	6.98	7.70	8.278		
1.822		2.52	2.76	3.577	4.54	6.03	7.215	7.857	8.577	9.155	
5.813		7.635	8.333	8.58	9.39	10.353	11.843	13.028	13.670*	14.39*	14.968*
Critical value	10.703	11.262	11.578	11.858	12.100	12.211	12.323	12.435	12.510	12.584	12.640

* = Significant

Number of means for ranges
Straw yields in g/ha

	1	2	3	4	5	6	7	8	9	10	11
	3.34										
	0.635	3.975									
	1.155	1.79	5.13								
	0.095	1.25	1.885	5.225							
	0.19	0.285	1.44	2.075	5.415						
	1.325	1.515	1.61	2.765	3.4	6.74					
	0.825	2.15	2.34	2.43	3.59	4.325	7.565				
	4.052	4.817	6.202	6.392	6.487	7.642	8.277	11.617			
	0.938	4.99	5.815	7.14	7.33	7.425	8.58	9.215	12.555		
	1.728	2.666	6.718	7.543	8.818	9.058	9.153	10.308	10.943	14.283*	
	0.827	2.555	3.493	7.545	8.37	9.695	9.885	9.98	11.135	11.77	15.11*
Critical Value	11.842	12.46	12.810	13.119	13.387	13.510	13.634	13.757	13.84	13.922	13.984

* = Significant

V I T A

The author saw the light on January 6 in the year 1963 in Dhule.

He passed his Higher Secondary School Certificate Examination in First Division from M.D. Jain Higher Secondary School, Banawad, in the year 1981.

He took admission to the College of Agriculture, Indore, J.N.K.V.V., Jabalpur and accomplished his graduation with First Division in the year 1986.

For his postgraduation, he enthusiastically took admission to the Department of Agronomy in the College of Agriculture, Jabalpur. He earned an O.C.G.A. of 3.40 out of 4.00 scale and is now going to accomplish the same by submitting this thesis in partial fulfilment of the requirement for the award of M.Sc. (Ag.) degree.