CHAPTER II

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The up to date studies conducted in relation to weed control in different Rabi crops viz., wheat, gram, lentil, linseed and mustard in India and abroad are reviewed.

Attempts have been made to collect literature on various aspects of crop weed competition and methods of weed control related to different Rabi crops.

As weeds form an integral part of biotic community of each and every agro-ecosystem and become a competitor with the crops for most of the biotic factors required for growth. Knowledge on the compositio of weed flora in a particular crop and their correct identification provides a ground necessary to formulate effective measures for their management. Hence efforts have also been made to review the weed flora associated with rabi crops.

Weeds compete with crop for moisture, light and nutrients. The water requirement of some of the weed species is twice or thrice than the crops with which they are associated. They also interfere with agricultural operations and thereby increased the cost of labour, reduce the effectiveness of equipments reduce the quality and finally the yield of crop. These also reduce the fertility of soil and cause depreciation of land value.
2.1 Losses caused by weeds

Robinson *et al.* (1973) are of the view that the competition between weeds and crop plants are more during their vegetative phase.

Kausar *et al.* (1975) found that grain yield were more depressed when weed polulation was high and stands 6 to 8 weeks than 3 weeks.

Mani *et al.* (1975) reported that 5 to 8 weeks period was very crucial for nutrient competition. The extent of nitrogen removed by weed growth within 5 to 6 weeks worked out to be about 80 per cent of the amount removed by the crop during this period.

Singh *et al.* (1975) observed that weeds offered significant competition with crop and caused significant reduction to the extent of 39-59 per cent in grain yield at I.A.R.I., New Delhi.

Gill (1979) observed that some grassy weeds caused losses in grain yield from 15 to 50 per cent in the usual occurrence.

2.2 Cultural method

Cultural methods of weed control are directed to complete removal of weeds from soil or towards such severe mutilation that further growth is either impossible or weakened.
The weed competition with crop is reduced to minimum either by hand weeding or other interculture implements. Removing of weeds by hand is the oldest recognized method but this is expensive and time consuming.

Tiwari and Parihar (1993) reported that hand weeding is the most effective method of weed control. But single hand weeding is not sufficient for controlling all types of weeds throughout the crop season. Late emerged weeds competed successfully with crop and finally reduced the crop yield.

Jain and Choubey (1969) reported that manual removal of weeds in oilseed crops is difficult, time consuming and costly. Results showed that on an average, labour requirement for a single hand weeding at 30 DAS was 450 man-hours per hectare. Furthermore, hand weeding is also too much time consuming to prevent substantial field losses from weed competition.

2.3 Chemical control

The discovery of selective hormone-type weed killers excited the agricultural world. Hormones are the substances which are capable of modifying the growth of the plants. In order to overcome the difficulties met with the traditional methods (hand weeding) of weed control the control of weeds by chemicals is much easier, cheaper and many times faster than the traditional methods.
Humbest (1970) expressed his view about the chemical weed control. In this age of mechanization, hand weeding is expensive and it is waste of human energy. He also expressed that if a farmer has proper herbicides and complete knowledge about its use, it is very easy to control weeds effectively than hand weeding or hoeing by man.

Mani (1971) stated that chemical weed control was very effective in controlling weeds in modern agriculture, the development of intensive and multiple system of cropping where time and labour is very important factor. The advantage in using chemicals is timely control of weeds on a large scale at a reasonable cost.

2.4 WHEAT

2.4.1 Weed flora

A survey by Gill and Brar (1975) at Punjab revealed that about 10 per cent of wheat crops was found badly infested by *Phalaris minor* Retz. (Canary grass) or *Avena fatua* L. (Wild oat) or both.

Ashraf and Sen (1979) recorded Chenopodium album, Chenopodium murale, Echinops echinatus, Asphodelus tenuifolius, Amaranthus hybridus, Trianthema protulacastrum among dicots and Digitaria adscendens and Cyperus rotundus among monocots as important associated weeds of wheat crops at Jodhpur.

Gill (1979) reported that wheat crops mostly infested with broad-leaved weeds and grassy weeds especially Phalaris minor Retz. and Avena fatua L. on alluvial soils at Ludhiana. About 28 per cent of wheat area was badly infested with grassy weeds only.

A survey of 400 randomly selected fields in North-West India revealed that the wheat fields were badly infested with major monocot weeds viz., Phalaris minor Retz. and Avena fatua L. besides predominantly dicot weeds such as Chenopodium album L., Medicago denticulata Willd., Melilotus alba L. and Anagallis arvensis L. (Khendal, 1980).

Tiwari (1980) observed Phalaris minor Retz., Rumex dentatus L., Chenopodium album L., Vicia sativa L., Medicago denticulata Willd. and Trifolium flagiferum L. as dominant weeds of wheat crop in Sagar division in M.P.

Dhiman and Kairon (1982) noted that the wheat fields were infested with Phalaris minor Retz. (24%), Chenopodium album L. (34%), Lathyrus aphaca L. (23%), Vicia hirsuta L. (7%) and other weeds to the extent of 19% at Hisar.
In a world wide survey, Kouch and Hess (1982) observed that the associated weeds of wheat crop were *Avena fatua*, *Cheopodium album*, *Phalaris* spp., *Polygonum* spp., *Stellaria media*, *Spergula arvensis*, *Agropyron repens* and *Convolvulus arvensis*.

Pandey and Singh (1983) found that wheat crop was infested with *Chenopodium album* L. (12.3%), *Anagallis arvensis* L. (27.4%), *Phalaris minor* Retz. (22.3%) as major weeds besides *Melilotus* spp., *Cynodon dactylon* L., *Cyperus rotundus* L., *Avena fatua* L. and *Vicia sativa* L.

Gill (1984) recorded *Phalaris minor* Retz. as dominant weed in wheat fields in Punjab to the tune of 64.5% along with predominant broad-leaved weeds viz. *Chenopodium album* L. *Melilotus* spp., *Anagallis arvensis* L. and the percent intensity varied from 0.7 to 15.9, 5.5 to 14.3 and 1.4 to 9.1 of the total weed population, respectively.

Mohammad Ali (1984) noted *Echinochloa coloenum* L. and *Dactyloctenium aegyptium* L. among grasses and *Cyperus rotundus* L. in sedges and *Digera arvensis* Frosk., *Parthenium hysterophorus* L., *Convolvulus arvensis* L. and *Trianthema portulacastrum* L. among broad-leaved weeds as the major weeds associated with wheat crop at Coimbatore.

Wheat crop in Himachal Pradesh was mainly infested with *Phalaris minor*, *Avena fatua*, *Avena ludoviciana*, *Lolium temulentum* among grassy weeds while at some places *Anagallis arvensis* and
Medicago denticulata were the major dicot weeds (Anonymous, 1985).

Tiwari and Trivedi (1985) noted that the wheat crop was severely infested with Phalaris minor Retz., Melilotus alba Desr., Rumex dentatus, Portulaca oleracea L., Chenopodium album L., Digitaria adscendens Henr, Cyperus rotundus L., Paspalum distichum L. and Cynodon dactylon Pers.

Tiwari and Bisen (1985) observed that Phalaris minor Retz. (615/m²), Melilotus spp. (48/m²), Portulaca oleracea L. were the important weeds and the total weed population was 976 weed plants/m².

Jain et al. (1985) noted that the dominant weed flora consisted of Phalaris minor Retz., Melilotus album L., Chenopodium album L., Trifolium flagiferum L. and Cynodon dactylon on medium black soils of Jabalpur.

At Almora, Kamtaprasad 1985) observed that wheat crop was heavily infested by grassy as well as broad-leaved weeds. The predominant weeds were Avena fatua L., Phalaris minor Retz., Polygonum spp. and Stellaria media L.

Shaktawat (1987) reported Chenopodium murale, Chenopodium album, Convolvulus arvensis, Amaranthus spp., Anagallis arvensis, Fumaria parviflora, Melilotus alba, Melilotus indica, Spergula arvensis and Vicia faba as the major broad-leaved weeds in wheat crop at Udaipur.

Thakur and Singh (1989) reported that the *Phalaris minor*, *Lolium temulentum* and *Avena ludoviciana* constituted about 70 per cent of the total weed flora while *Convolvulus arvensis* and *Vicia faba* were the major broad-leaf weeds at Palampur.

Kurchania et al. (1990 a) found that the major weed flora of wheat at Jabalpur comprised of *Phalaris minor* Retz. (304.5/m²), *Medicago denticulata* Willd (69/m²), *Trifolium flagiferum* (17.6/m²) and *Melilotus alba* (10.9/m²).


2.4.2 Crop weed competition

Weeds cause considerably damage in growth, yield attributes and yield of wheat crops. The competition between weed
and crop becomes more severe when species competing are morphologically similar in growth habit and exist under the same habitat. The effect of weed competition on wheat crops is reviewed by number of workers as below:-

Russel and Watson (1940) reported from Rothamsted in U.K. that the yield of wheat was inversely related to number of weeds and that the crop was ill-fitted to stand against the competition of weeds.

The crop weed competition was more severe under fertilized conditions and tillering of wheat was negligible with intensity of 196 plants/m² of Avena fatua. The number of tillers per plant in the mixed stand of wheat and Phalaris minor reduced drastically as compared to their tiller number in the pure stand (Bowden and Friesen, 1969).

Negi and Bhan (1974) noted that the Phalaris minor Retz. alone reduced the wheat yield by 33 per cent while reduction of 17 per cent was observed under other weeds. They predicted the yield reduction to the extent of 22.6 quintals per hectare of grassy and non-grassy weeds were allowed to stress upon wheat crop.

Kolar et al. (1977) reported that severe weed competition caused 40 per cent reduction in grain yield. The growth parameters viz. height and tillers were also adversely affected.
Tosh and Mishra (1978) observed significant reduction in number of effective tillers/m² in wheat due to infestation of *Phalaris minor* Retz.

Rao and Bhardwaj (1979) recorded losses in wheat crop to the tune of 80 per cent as a result of severe weed competition.

Katyal *et al.* (1980) reported that mixed infestation of grassy and broad-leaved weeds reduced the grain yield of wheat by 40 per cent, while yield losses due to grassy weeds alone were about 37 per cent.

Ramchandra *et al.* (1981) noted that due to competition for moisture, light, nutrients and space, the grain yield of wheat was affected adversely depending on the habit, growth rate, density of crop and type of weeds especially in early stages of development.

Dhaiman and Kairon (1982) expressed that acquired morphological advantages by high yielding dwarf varieties of wheat crop such as synchronous and high tillering capacity were successfully exploited to reduce the weed competition.

Modgal and Singh (1983) at Palampur worked out the losses in grain yield of wheat to the extent of 20 to 25 per cent depending upon the intensity and type of weeds.
Growth analysis of weeds under irrigated wheat crop revealed that *Phalaris minor* had higher IVI value (101.65) followed by *Chenopodium album* (39.72), *Portulaca oleracea* (30.16), *Trifolium flagiferum* (27.66), *Rumex dentatus* (6.0) and *Melilotus parviflora* (3.52). The wheat plant showed higher rate of photosynthesis and dry matter production per plant as compared to *Phalaris minor* (Anonymous, 1984).

Tayebi and Dudhane (1985) noted at Salmadevi Agricultural Research Farm, Kalol that weeds were the serious problem in reducing the yield of wheat.

Saeed et al. (1987) observed that individual weeds, when allowed to compete with the wheat crop, brought about substantial decrease in grain yield with maximal depression in *Chenopodium album* L. *Chenopodium murale* L., having a density of 248 plants per square metre. The critical weed crop competition period was observed from 6 to 8 weeks after sowing.

Rajput et al. (1987) reported from Sindh, Pakistan that allowing weeds to grow in crops up to 30 days did not show any adverse effect on the growth and yield of wheat. The presence of weeds beyond 30 days was detrimental. The plant height, number of tillers, 1000 grain weight and grain yield were significantly reduced with the presence of weeds.

Shamsi and Ahmad (1987) at Lahore, Pakistan found that *Phalaris minor*, *Medicago denticulata*, *Melilotus parviflora*,...
Lathyrus aphaca and Convolvulus arvensis grown in competition with wheat individually and collectively at weed-wheat density ratio of 0 : 1, 0.5 : 1, 1 : 1, 2 : 1, 4 : 1 and 6 : 1 caused reductions in wheat biomass proportionate to their densities. According to biomass losses caused by them at equivalent density levels in most of the treatments, these weeds could be arranged in the descending order of *Medicago denticulata* > *Phalaris minor* = mixed weeds = *Melilotus parviflora* > *Lathyrus aphaca* > *Convolvulus arvensis*.

In a study to assess the losses caused by weeds in wheat it was observed that different weed species did not show their adverse effect on the grain yield considerably. However, weed competition index showed that mixed population of different species of wheat reduced the grain yield by 25.07% over weed free treatment. Most of the dicot weeds did not affect the grain yield heavily due to their poor existence in the field (Anonymous, 1987).

Sekhar et al. (1989) reported from Lahaul Valley of Himachal Pradesh that the yield of wheat reduced drastically under high hill temperate zone due to infestation of broad-leaved weed species particularly *Amaranthus viridis*, *Polygonum alatum*, *Digitaria sanguinalis* and *Gallinosoga parviflora*. 
2.4.3 Weed control methods

Verma and Raheja (1961) reported that hand weeding at 30 days after sowing reduced the weed population to the tune of 80.3 per cent and increased the grain yield of wheat by 39.3 per cent.

Dwivedi and Haripal (1979) found that weed free condition upto 21, 28 and 5 days after sowing were highly effective in increasing the grain yield. Maintaining weed free conditions beyond 42 days after sowing did not enhance the grain and straw yield appreciably.

In a study to find out most effective post emergence herbicide for control of *Phalaris minor* in wheat, it was observed that one hand weeding at 35 days after sowing produced highest yield of 1859 kg/ha followed by 1667 kg/ha under isoproturon 0.75 kg/ha post-emergence (Anonymous, 1984).

Datta et al. (1985) reported that hand weeding proved better than other treatments and it was closely followed by isoproturon 1 kg/ha as pre-emergence in respect of yield and yield attributing characters.

At Faizabad, Uttar Pradesh, hand weeding twice at 20 and 40 days after sowing recorded the highest grain yield (56.03 q/ha) of wheat which was significantly higher than the rest of the treatments (Anonymous, 1986).
Altafsher and Ahmed (1987) found that hand weeding was the best method for controlling weeds but was uneconomical as compared to use of herbicides.

Mantri et al. (1990) reported that highest weed control efficiency of 68.75 per cent was registered with hand weeding followed by isoproturon 1 kg/ha as pre-emergence (52.56%).

Jain et al. (1990) recorded the highest grain yield of wheat with two hand weeding closely followed by the use of herbicides.

Detryoux (1982) obtained excellent control of Alopecurus myosucrioide, Agrostis spica-venti and Avena fatua by application of isoproturon 1 to 1.25 kg/ha.

Nageshwar and Jain (1982) reported that application of isoproturon 1 kg/ha as pre-emergence reduced the intensity of weeds by 78.36 per cent and registered lowest dry matter of 10.15 q/ha as against 43.30 q/ha under weedy control.

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

Singh et al. (1982) from Pansnagar reported that pre-emergence application of isoproturon 1.5 kg/ha produced the
lowest population and dry matter of total weeds at 120 day stage of crop growth.

On sandy loam soils of Jabalpur, Tomar et al. (1983) reported that isoproturon 1.0 kg/ha controlled *Chenopodium album* L. (92%), *Trifolium flagiferum* L. (91.94%), *Melilotus* spp. (80.87%) and produced 2.4 q/ha weed biomass as compared to 8.3 q/ha under no weeding.

Vishwakarma and Jain (1984) found that isoproturon 1.0 kg/ha as post-emergence reduced weed dry matter of 11.28 q/ha as compared to weeded control of 38.34 q/ha.

Yadav et al. (1984) reported that application of isoproturon as Graminon at 0.75 and 1.0 kg/ha as Arelon at 0.75 and 1.0 kg/ha, as Tolkan at 1.0 kg/ha effectively controlled *Phalaris minor* and other weeds.

Pandey and Singh (1984) reported that pre-emergence application of isoproturon did not inhibit germination of either *Phalaris minor* or *Avena fatua* but they died after 15 days of germination. Isoproturon 1.0 kg/ha applied either pre or post-emergence proved very effective against both *Phalaris minor* and *Avena fatua*.

Panwar et al. (1985) observed that isoproturon 1.0 kg/ha pre-emergence controlled all weeds effectively as compared to pre-emergence application of other herbicides. All the herbicides gave significantly higher yield of weedy check.
Tiwari and Trivedi (1985) stated that all herbicides including isoproturon at 1.0 kg/ha applied as pre and post-emergence controlled all types of weeds except Cynodon dactylon Pers., Cyperus rotundus and Paspalum distichum L. Herbicides showed no adverse effect on crop growth parameters.

Bhan et al. (1985) applied isoproturon at 0.5, 1.0 and 1.5 kg/ha at 2, 4 and 6 leaf stages of wheat, for control of Phalaris minor, Avena ludoviciana and Vicia sativa. They reported that reduction in dry matter production with isoproturon was maximum at 2-leaf stage. Phalaris minor and Avena ludoviciana revealed a reduction in dry matter when compared to wheat and Vicia sativa. Isoproturon did not exhibit any significant influence on the growth of Avena ludoviciana when applied at 6-leaf stage of wheat.

Verma and Chaturvedi (1985) observed effective weed control through isoproturon 1.0 kg/ha pre-emergence which was comparable to hand weeding under different crop management practices.

Dinkar and Ahuja (1987) at IARI, New Delhi reported that in wheat crop isoproturon application at 0.50 or 0.75 kg/ha proved equally effective in controlling weeds irrespective of whether applied before or after first irrigation given at 3 or 4 weeks after sowing.
Dwivedi and Patel (1987) reported that the minimum weed dry weight was obtained with the application of isoproturon 1.5 kg/ha.

Study conducted at IARI New Delhi on control of Chenopodium album and Melilotus indica by Singh et al. (1987) indicated that isoproturon 0.75 kg/ha 4 weeks after sowing was most effective in reducing the population of Chenopodium and Melilotus spp.

Shaktawat (1987) conducted experiment during Rabi 1978-79 at Udaipur with four herbicides viz., methabenz-thiazuron pre-emergence, metoxuron, isoproturon and terbutryln as post-emergence at different levels. The post-emergence application of isoproturon failed to control Phalaris minor effectively.

Isoproturon was found most effective for the control of weeds when it was applied @ 0.50 or 1.25 kg/ha as early post-emergence spray (20 to 30 days after sowing) as compared to other herbicides (Gill and Walia, 1988; Baiyan et al. 1988 and Thakur and Singh, 1988).

According to Thakur and Singh (1989) application of isoproturon 1.25 kg/ha and weed free treatmens controlled the weeds more effectively as compared to metoxuron. Isoproturon 1.25 kg/ha being at par with hand weding was significantly superior to metoxuron 1.25 kg/ha and weedy plots in reducing the dry weight of weeds at harvest.
Sekhar et al. (1989) from a study in high hill temperate zone of Himachal Pradesh reported that weedy control resulted in significantly higher weed number and dry weight (380 g/m²) irrespective of the different weed species. Isoproturon 0.75 kg/ha post-emergence (220 g/m²) was at par with isoproturon 1.25 kg/ha pre-emergence (180 g/m²), or post-emergence (220 g/m²) and two hand weeding (280 g.m²) at 4 and 7 weeks after sowing resulted in significantly lower weed number as compared to all other weed control treatments.

Singh et al. (1990) reported that isoproturon applied a day before first irrigation was more effective than its application at 30 days after sowing. Interaction of low weed population and leaf stage of wild oats increased the activity of isoproturon.

Kurchania et al. (1990 a) pointed out that isoproturon 1.0 kg/ha pre-emergence proved better than post-emergence application for control of Phalaris minor and other dicot weeds except Medicago denticulata.

Jain et al. (1990) reported that isoproturon 1.0 kg/ha pre-emergence was better than met oxuron in reducing weeds under normal as well as stale seedbed conditions.
2.4.4 Effect of isoproturon on crop growth and yield

Ammon and Krebs (1976) reported that isoproturon applied early to mid tillering, end of tillering and the start of weeding stages decreased grain yield of wheat by 12.30 per cent as compared to application made at late tiller stage.

Mishra et al. (1981) recommended application of isoproturon 1.0 kg/ha as post-emergence for effective weed control and it gave higher grain yield than other herbicides under Pantnagar Nainital conditions.

Singh et al. (1982) found that among all the herbicide treatments the highest grain yield (4355 kg/ha) and significantly higher even over weed free conditions was produced with pre-emergence application of isoproturon at 1.5 kg/ha. It was followed by pre-emergence application of isoproturon 1.0 kg/ha which was at par with weed free conditions.

Significantly higher grain yield (3380 kg/ha) was recorded under 0.5 kg isoproturon at 4 weeks followed by isoproturon 0.75 kg at 5 weeks of sowing due to significant increase in yield attributing characters and lower weed biomass per hectare (Anonymous, 1982).

Solanki and Lokras (1983 b) indicated that post-emergence application of various herbicides including isoproturon for wheat reduced the growth and 1000 seed weight and
consequently the yield as compared to their pre-emergence application under Jabalpur conditions.

Jain *et al.* (1984) on medium black soil of Mandsaur (M.P.) observed that application of 1.0 kg/ha of isoproturon increased grain yield by 44 per cent over weedy check.

Sandhu *et al.* (1985) noted that isoproturon application gave an effective control of weeds and maximum grain yield of wheat. No phytotoxic effects on crop were observed.

Kamtaprasad (1985) reported that application of isoproturon 1.0 kg/ha post emergence gave 42.99 q/ha grain yield of wheat as compared to 42.31 q/ha in weed free check and 27.95 q/ha in unweeded check. The corresponding straw yield was 84.66, 79.8 and 62.76 q/ha, respectively.

Hooda and Agarwal (1987) reported that grain and straw yield of wheat increased significantly due to post-emergence application of either isoproturon 1.0 kg/ha or other herbicides. The relative increase was more with isoproturon.

Dinkar and Ahuja (1987) reported that isoproturon applied at 0.5 or 0.75 kg/ha was equally effective in controlling weeds, but isoproturon 0.75 kg/ha applied before irrigation had a distinct depressing effect on plant height and grain yield of wheat.
Dwivedi and Patel (1987) from ICAR Research Farm, Nagaland centre, Jharnapani obtained highest grain yield with isoproturon at 1.5 kg/ha and lowest yield in unweeded check followed by one hand weeding.

Balyan et al. (1988) from Haryana Agricultural University, Hisar reported that number of panicles per metre row length of wheat were less when isoproturon 1.0 kg/ha was applied at 20 and 25 days after sowing, but did not reduce the yield significantly. Application beyond 40 days of sowing reduced the growth and grain yield of wheat significantly.

Gill and Walia (1988) at Punjab, found higher grain yield when isoproturon was applied at 0.50 kg/ha before first irrigation to the crop.

Patel (1989) found that isoproturon 1.0 kg/ha as pre or post emergence could be another suitable substitute for hand weeding from grain yield and economic point of view.

In a weed control study for two years on wheat at Jabalpur, Kurchania et al. (1990 b) observed maximum grain yield (35.4 and 53.3 q/ha) due to application of isoproturon 1.0 kg/ha as pre-emergence while the lowest yield (24.8 and 30.8 q/ha) was noted in weedy check.

Shivkumar et al. (1990) reported that among different herbicides isoproturon 1.0 kg/ha proved most effective for obtaining highest grain yield of wheat.
Ahuja and Yaduraju (1993) noted higher wheat yield with the application of isoproturon over 2,4-D but the difference was not significant.

Application of herbicide resulted marked reduction in the dry matter of weed when compared with one hand weeding and unweeded control. Isoproturon as pre emergence proved better than 2,4-D as post emergence and produced significantly higher grain yield (3236 and 29.16 q/ha) than 2,4-D (29.97 and 24.41 q/ha) during 89-90 and 90-91 respectively over weedy check (12.29 and 18.16) and one hand weeding (28.93 and 24.66 q/ha). One hand weeding, application of isoproturon and 2,4-D increased the net profit of Rs. 5898 and 3636, 4249 and 5326, and 5665 and 3783 over weedy check 2100 and 1911 (Tiwari and Parihar 1993).

Singh et al. (1991) reported significant reduction in weed biomass production and increased grain yields of wheat by isoproturon and 2,4-D as post emergence at their different doses. The highest mean grain yield was obtained with isoproturon 1.5 kg/ha (post emergence) and the lowest in unweeded check.

2.5 GRAM AND LENTIL

Mani et al. (1975) conducted trials on rabi pulses including gram, lentil and pea and reported that linuron at 0.5 kg/ha was more effective than prometryne 0.5 kg/ha pre emergence in controlling weeds especially Mililatus indica. Both herbicides resulted in yield equivalent to repeated manual weeding.
Ahlawat et al. (1978) revealed that cultural methods of weed control effectively reduced the crop weed competition in chickpea, lentil and peas. Among herbicidal treatments, prometryne at 0.5 kg/ha (pre emergence) in chickpea and lentil showed most promising results in respect of lowering the dry matter accumulation by weeds, boosting the grain production and giving higher net returns.

Ahlawat et al. (1978) conducted experiments at IARI, New Delhi during 1971-73 and 1973-74 and found that weed control through cultural methods effectively reduced the crop weed competition in bengal gram. Consequently the grain yield and net return were more under cultural treatments. Among herbicidal treatments, prometryne at 0.5 kg a.i./ha proved to be the best and may be the second best choice to control the weeds on sandy loam soils under Delhi conditions.

Chandra and Gopal Singh (1979) found that Sinbar at 3 kg/ha, sencor at 2 kg/ha could be used very effectively for control of nutgrass and legume crops can be grown at 2 to 3 months after application of Sinbar.

Tiwari and Trivedi (1986) did not observe phytotoxic effects of fluchloralin and isoproturon on growth and development of gram crop. The yields obtained under isoproturon and fluchloralin were at par with one hand weeding.
Pandey (1983) noted that Chenopodium album, Cyperus rotundus, Melilotus indica, Melilotus alba, Medicago denticulata, Anagallis arvensis, Vicia sativa, Euphorbia hirta constituted the bulk of weed populations. Besides these, other weed species which infested the field were Cirsium arvense and Sorghum halepense.

Tosh and Jena (1984) reported major weed species in the order of their abundance as Digitaria sanguinalis (L.) Scap, Dactyloctenium aegyptium Bealh., Sporobolus diander Kunth, Heliotropium indicum Linn. and Ageratum conyzoides Linn. and the relative percentage of occurrence being 38, 29, 16, 7 and 10, respectively.

Saxena et al. (1976) reported that weed reduced the yield of chickpea by 87 and 40 % in 1972-73 and 1973-74 respectively. Amongst the herbicides tested only trifluralin at 1.0 kg/ha incorporated pre-sowing increased the grain yield followed by premetlyne 0.25 kg/ha as pre-emergence.

Jai Prakesh and Pohwa (1977) reported that nitrofen 1.25 kg/ha and chloroxuron 1.0 kg/ha were most promising in controlling Chenopodium album and Convolvulus arvensis and increase the grain yield of gram over hand weeding.

Pandey (1982) found that fluchloralin 1.0 kg/ha gave best performance in gram (2125 kg/ha) over pendimethalin (1628 kg/ha).
Bisen and Tiwari (1983) found that fluchloralin 0.5 kg/ha showed significant control of Portulaca oleracea and other dicot weeds. Significantly higher grain yield of gram was observed under terbutryn 0.75 kg/ha (868 kg/ha) over one hand weeding (760 kg/ha) and 0.5 kg/ha fluchloralin (361 kg/ha).

Fluchloralin at higher rates had better control of weeds except Convolvulus arvensis L. and Lathyrus aphaca L. in gram. Fluchloralin and pendimethalin produced yield identical to hand weeding, which were found significantly better than other herbicides and weedy check (Balayan and Bhan 1984) 1.00 to 2.00 kg/ha fluchloralin incorporated into the soil before sowing gave significantly higher grain yield (2616 kg/ha) over weedy check (1053 kg/ha) as reported by Singh et al. (1987).

Malik et al. (1988) found that fluchloralin 1.0 kg/ha recorded significantly lesser weed weight of each successive delay in sowing time & proved effective against all weeds. Fluchloralin and pendimethalin 1.5 kg/ha produced statistically similar yield (1316 and 1414 kg/ha) to that of weed free treatment (1558 kg/ha).

Shaktawat and Sharma (1988) observed that fluchloralin (0.5 kg/ha) produced maximum grain yield (1410 kg/ha) closely followed by two hand weeding (1373 kg/ha) and (0.2 kg/ha) isoproturon (1093 kg/ha) in gram.
Singh and Singh (1992) reported 17.1% reduction in grain yield of gram due to competition with weeds during first 30 days of sowing, which increased to about 50%, when weeds competed with the crop for entire crop season.

Singh and Choudhary (1970) reported that knoxweed at 3 kg/ha and benfluralin 1.0 kg/ha was most effective in minimising the total number of weeds including grasses and broad leaved weeds. Maximum grain yield of gram was recorded in weed free condition (2775 kg/ha) followed by fluchloralin 0.5 kg/ha (2205 kg/ha) and weedy check (1205 kg/ha).

Choudhary and Singh (1987) observed that hand weeding twice at 25 & 45 days stage proved superior in reducing the weed density and dry matter accumulation by weeds.

Application of pendimethalin 1.5 kg/ha and oxyflurfen 0.3 kg/ha increased the number of pods per plant, number of grain per pod and gave significantly higher grain and straw yield of lentil over weedy check and hand weeding as reported by Choudhary and Singh (1987).

One hand weeding, pendimethalin (1.5 kg/ha) and fluchloralin (1.00 kg/ha) reduced the weed population, total weed density and dry matter accumulation of Chenopodium album, Melilotus indica, Anagallis arvensis, Phalaris minor and Vicia sativa (Choudhary and Singh, 1987).
Murari and Pandey (1987) reported that hand weeding increased the yield from 0.80-0.82 (no weeding) to 1.69-1.81 t/ha.

Singh and Singh (1990) reported 17.7% reduction in grain yield of lentil due to competition with weeds during first 30 days of sowing, which increased to about 69.7% when weeds competed with the crop for entire crop season.

2.6 LINSEED

2.6.1 Butachlor

Nair et al. (1974) observed that pre-emergence application of butachlor 1.5 kg/ha gave effective control of Echinocloa crusgalli, Flimbristylis wilicea and Cyperus spp.

Bueno et al. (1975) showed that butachlor EC at 2 kg/ha was effective against grasses when applied as pre-emergence.

Tozani et al. (1976) reported that butachlor alone or combined with other compounds controlled Commelina erata most effectively. Other weeds controlled include Amaranthus viridis and Eleusina indica.

Gopal Krishna et al. (1977) reported that butachlor controlled E. crusgalli, E. colonum, Cyperus spp., Panicum spp. and Cynodon dactylon.
Senthong (1986) reported butachlor at 2 kg/ha to be best in controlling weeds like *Cyperus procerus*, *Flimbristylis miliacea* and *Echinochloa colonum*.

2.6.2 Fluchloralin

Tosh and Mishra (1977) noted maximum weed control with the application of fluchloralin. Metoxuron gave maximum effective control of monocot weeds with fluchloralin. The application of fluchloralin and metoxuron each at 1 kg/ha resulted in 79 per cent and 82.1 per cent reduction in weed competition.

Sandhu and Walia (1979) indicated that fluchloralin gave an effective weed control, the pre-dominant weeds in plots were *Chenopodium album*, *Melilotus indica*, *Medicago denticulata* L. and *Trigonella polycarata*.

Gill *et al.* (1984) stated that dry matter accumulation by weeds was significantly less in treatment fluchloralin (380 kg/ha) and isoproturon (900 kg/ha) when compared to control (2160 kg/ha).

Pandey and Singh (1984) concluded from an experiment that fluchloralin followed by isoproturon gave significantly less dry weight of weeds: 0.905 g/m² and 1.035 g/m² respectively when compared to weedy check.
2.6.3 Isoproturon

Hewson (1978) reported that application of isoproturon controlled all the annual grass weeds including *Avena fatua* and many broad leaved weeds.

The results obtained from the researches carried out at Vivekanand Laboratory, Almora revealed that weed population was reduced significantly with the use of isoproturon (Anonymous, 1979).

Tomar et al. (1983) reported from an experiment consisted of treatments isoproturon 1.5 kg/ha pre-emergence, 1 hand weeding and weedy check that the isoproturon controlled 92 per cent *Chenopodium album*, 81.94 per cent *Trifolium* spp. and 80 per cent to 87 per cent other weed species.

Tiwari and Trivedi (1985) stated that isoproturon 1 kg/ha applied as pre-emergence controlled all types of weeds except *Cynodon dactylon* Pers, *Cyperus rotundus* and *Paspalum distichium* L. Herbicide showed no adverse effect on crop growth parameters.

The bioefficacy of herbicides viz., isoproturon, fluchloralin 1 kg/ha and butachlor 2.5 kg/ha as per-emergence were tested and compared with hand weeding and control in linseed crop. Isoproturon controlled all the annual weeds except *Anagallis arvensis* and perennial weeds. Fluchloralin was reported
to control annual grasses viz., *Digitaria adscendens*. Amongst dicot weeds *Medicago denticulata*, *Cichorium intybus* and *Chenopodium album* were not controlled effectively (Anonymous, 1988).

2.6.4 Effect of herbicides on yield of crop

2.6.5 Fluchloryalin

Application of fluchloryalin 1.5 kg/ha resulted in higher sunflower yield which may be compared favourably with the plots which were hand weeded four times and unweeded control (Tawa Pilot research Project (JNKVV), Powarkheda, 1974).

Pandey (1983) reported the pre-emergence application of fluchloryalin at 0.75 kg/ha gave effective control of weeds and increased the seed yield as compared to hand weeding.

Gill *et al.* (1984) reported that fluchloralinas pre-plant and isoproturon as pre-emergence gave an effective control of weeds. The highest seed yield of mustard was recorded in isoproturon 1290 kg/ha followed by fluchloryalin (1190 kg/ha).

Pandey *et al.* (1984) concluded that highest seed yield of mustard (1090 kg/ha) was recorded in weed free treatment but amongst herbicides, fluchloralain (1042 kg/ha) followed by isoproturon (1018 kg/ha) recorded the higher yield.
2.6.6 Isoproturon

The tolerance of linseed was studied against isoproturon, fluchloralin and butachlor and compared with hand weeding (30 DAS) and weedy check. The effect on crop revealed that none of the herbicides had phytotoxic effect on crop germination and growth. The seed yield was higher under butachlor (593.0 kg/ha), isoproturon (467.5 kg/ha) and fluchloralin (335.5 kg/ha) as compared to weedy check (234 kg/ha) (Anonymous, 1987).

2.6.7 Butachlor

Gill et al. (1977) reported that butachlor gave effective control over the annual weeds. On an average butachlor and propanil gave 6.87 t/ha grain yield against 6.81 and 0.32 t/ha for hand weeding (twice) and unweeded crops, respectively.

Mohammed Ali et al. (1977) observed that pre-emergence application of herbicides oxadizon (0.75 to 1.25 kg/ha) and butachlor (1 kg/ha) 6 days after sowing controlled annual weeds and improved yields.

Shahi et al. (1978) reported that butachlor was most promising in controlling Leptochloa and specially Echinocloa crusgalli and increased the grain yield by 200 kg/ha. At cost of Rs.150/ha, butachlor was cheaper than hand weeding.

Tomar et al. (1990) reported that pre-plant in corporation of fluchloralin 1.0 kg/ha gave best performance (478
kg/ha) and was comparable with one hand weeding at 30 DAS (425 kg/ha) over weedy control (290.5 kg/ha).

Angiras et al. (1991) recorded 72.36 and 59.94 per cent weed control efficiency with application of isoproturon 1.0 kg post emergence and 1.0 kg fluchloralin pre emergence respectively. All herbicidal treatments produced significantly higher seed and fibre yield over unweeded check.

2.7 MUSTARD

Mehrotra (1972) observed Cyperus rotundus, Chenopodium album, Asphodelus tenuifolius, Anagallis arvensis, Spergula arvensis and Melilotus spp. as the dominant weeds in mustard crop and their percentage intensity being 36.6, 98, 11.7, 3.9, 4.5, 28.1 and 5.2 respectively in the first year. During the second year weed infestation was comparatively lower and weed intensity being 23.6, 23.6, 22.0, 9.5, 2.4 and 18.9 per cent respectively for Cyperus rotundus, Chenopodium album, Anagallis arvensis, Melilotus sp., Convolvulus arvensis and Amaranthus viridis.

Sandhu and Walia (1979) stated that mustard crop was heavily infested with grassy as well as broad leaved weeds which caused considerably reduction in seed yield. The most important weed species were Chenopodium album L. and Avena ludoviciana Dur. (Wildoat).
Panchal et al. (1980) worked out the losses to the extent of 29 to 70% due to weeds in rape and mustard at Agriculture College, Dharwani, in Gujrat.

Garcia Torress (1981) noted Avena sterides, Phalaris minor and Anagallis arvensis as the major weeds of rape crop and yield losses caused by these weeds ranged in between 16 to 46 per cent. Similar findings were also reported by Ambasht and Chakhaiyar (1984).

Gill (1984) observed Phalaris minor, Avena ludoviciana, Chenopodium album L., Melilotus alba, Medicago denticulata and Trigonella polyecrata as dominant weeds in mustard crop at Agriculture College, Ludhiana.

The weed species associated with mustard crop at Krishi Nagar Farm, JNKVV, Jabalpur in the experimental area consisted of Anagallis arvensis, Chenopodium album, Chichorium intybus, Medicago denticulata, Melilotus spp., Portulaca oleracea, Rumex dentatus, Spergula arvensis, and Trifolium flagiferum among dicot and Cyperus rotundus, Cynodon dactylon, Phalaris minor, Digitaria adscendens among monocot weeds (Anonymous, 1988).

2.7.1 Isoproturon

Tomar et al. (1983) reported that isoproturon 1.5 kg/ha pre-emergence, controlled 92 per cent Chenopodium album, 81.94 per cent Trifolium spp. and 80 to 87 per cent other weed species.
Gill et al. (1984) recorded highest seed yield of mustard in isoproturon 0.94 kg/ha (1290 kg/ha) followed by fluchloralin 0.75 kg/ha (1190 kg/ha). These treatments produced significantly higher yield than control (920 q/ha).

Tiwari and Trivedi (1985) stated that isoproturon 1 kg/ha applied as pre-emergence controlled all types of weeds except Cynodon dactylon Pers, Cyperus rotundus and Paspalum distichum L. The herbicide had no adverse effect on crop growth parameters.

Isoproturon at 1.0 kg/ha as pre-emergence controlled all the annual weeds except Anagallis arvensis and perennials weeds. It was safer for all the oilseed crops (Anonymous, 1988).

2.7.2 Fluchloralin

Mishra and Tosh (1978) obtained effective control of weeds with the application of fluchloralin (0.43-1.0 kg/ha) in Indian mustard (Brassica juncea).

Sandhu and Walia (1979) reported significantly reduced weed biomass by herbicidal methods of weed control as compared to unweeded check and produced seed yield comparable to hand hoeing. Fluchloralin at 0.72 kg/ha and dinitramine at 0.50 kg/ha had shown promise for weed control in mustard crop.

Jai Prakash and Pahwa (1980) in a study with fluchloralin (0.24, 0.50 and 0.75 kg/ha) nitrofen and flurodifen
both at 0.5, 0.75 and 1.0 kg/ha one day after sowing obtained increased yield of raya over unweeded control.

Pandey (1983) pointed out that pre-emergence application of fluchloralin at 0.75 kg/ha, befonox at 1.6 kg/ha and nitrofen at 1.0 kg/ha to a local yellow seeded cultivar gave effective control of weeds and increased the seed yield as compared to hand weeding.

Gill et al. (1984) in an experiment at Ludhiana observed that dry matter accumulation by weeds was significantly less in plots treated with fluchloralin 0.75 kg/ha (380 kg/ha) and isoproturon 0.94 kg/ha (900 kg/ha) as compared to control (2160 kg/ha). The higher dry weight of weeds at harvest under isoproturon was because of inadequate control of later flushes of weeds.

Pandey (1984) obtained lowest weed density due to fluchloralin 1.0 kg/ha pre-planting (219.66/m²) followed by isoproturon 1.0 kg/ha pre emergence (281.33/m²). Significant reduction in weed biomass was also noticed. Amongst the herbicides fluchloralin followed by isoproturon resulted the highest seed yield.

Fluchloralin 1.0 kg/ha as pre planting controlled most of the annual weeds viz. Phalaris minor and Digitaria adscendens while Medicago denticulata, Cichorium intybus and Chenopodium album were not controlled effectively. The perennials weeds were not at all controlled by these herbicides (Anonymous, 1985).
2.7.3 Butachlor

Beuno et al. (1975) showed that butachlor EC at 2 kg/ha was effective against grasses when applied as pre emergence.

Gopal Krishna et al. (1977) reported that butachlor controlled Echinochloa crusgalli, Echinochloa colonum, Cyperus spp. Panicum spp. and Cynodon dactylon.

Mohammed Ali et al. (1977) observed that pre emergence application of butachlor (1 kg/ha) six days after sowing controlled annual weeds and improved the yield of mustard crop.

Butachlor at 2.5 kg/ha pre emergence controlled Cichorium intybus, Chenopodium album, Phalaris minor and Rumex dentatus. It had less effect on Medicago denticulata, Melilotus spp. and Trifolium flagiferum. It failed to control perennial weeds (Anonymous, 1988).

2.7.4 Hand weeding

Singh and Pandey (1973) noted hand weeding as an effective method of weed control and was comparable to application of linuron 1.0 kg/ha as pre emergence. Hand weeding gave an effective control of weeds and increased seed yield of mustard from 310 kg/ha in control plots to 370 kg/ha.

Results on weed control in mustard under AICRP showed that one hand weeding at 4 weeks of sowing was most effective in
reducing the weed population of all type of weeds in sandy-clay loam soils of Jabalpur (Anonymous, 1983).

Two hand weedings at 30 and 60 DAS gave the highest seed yield (3.29 q/ha). It was at par to herbicidal method of weed control by isoproturon (Anonymous, 1987 b).

Gill (1984) reported that hand weeding twice yielded significantly higher than no weeding and at par with fluchloralin and oxadizon.

Brar et al. (1991) observed significantly low weed population at 60 DAS in all weed control treatments except isoproturon 0.5 kg/ha applied as pre emergence than weeded control. All treatments of isoproturon and fluchloralin 0.75 and 0.50 kg plus howing gave significantly more seed yield of toria as compared to unweeded crop.

The review of these experimental findings in different crops under various agro-climatic conditions concur that the efficacy of the herbicide and their rates per hectare vary to the greater extent with respect to edaphic and climatic conditions as well as weed flora per se. The information on herbicidal weed control in pulse and oilseed crop is also meagre. Therefore, it is essential to find out the appropriate herbicide for controlling the location specific weed flora occurring in the different rabi crops grown in Sagar Division of Madhya Pradesh (India).