

Weed Management in Cumin (*Cuminum cyminum* L.)

THESIS



Submitted to the

Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya

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MASTER OF SCIENCE

In

HORTICULTURE

PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS

by

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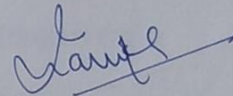
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No part of the thesis has been submitted for any other degree or diploma or has been published. All the assistance and help received during the course of this investigations has been acknowledged by the scholar.

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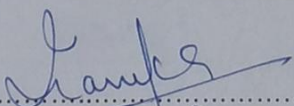
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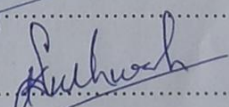


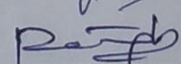
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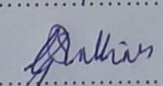
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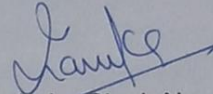
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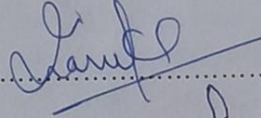


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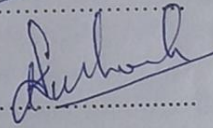
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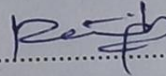
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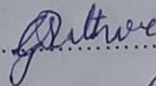
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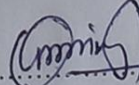
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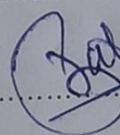
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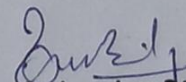
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Kg Kilogram
 Kg ha⁻¹ Kilogram per hectare
 Max. Maximum
 Min. Minimum
 Mg Milligram
 MOP Murah of potash
 M.S.S. Mean sum square
 N Nitrogen
 No. Number
 NS Non significant
 P₂O₅ Phosphorus
 R.H. Relative humidity
 Rs. Rupees
 r Coefficient of correlation
 S Sulphur
 S.E.M. Standard error of mean
 Sig. Significant
 Qm² Quintal per hectare
 Wt. Weight

ABBREVIATIONS USE IN TEXT

/	:	Per
@	:	At the rate of
%	:	Percentage
ANOVA	:	Analysis of variance
B : C	:	Benefit Cost ratio
C.D.	:	Critical difference
cm	:	Centimeter
°C	:	Degree Celsius
Cv.	:	Cultivar
D.F.	:	Degree of freedom
DAP	:	Days after planting
et al.	:	And others
Fig.	:	Figure
&	:	And
g	:	Gramme
ha.	:	Hectare
hr	:	Hour
i.e.	:	That is
R.V.S.K.V.V.	:	Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya
K	:	Potassium
Kg	:	Kilogram
Kg ha ⁻¹	:	Kilogram per hectare
Max.	:	Maximum
Min.	:	Minimum
Mg.	:	Milligram
MOP	:	Murate of potash
M.S.S.	:	Mean sum square
N	:	Nitrogen
No.	:	Number
NS	:	Non significant
P ₂ O ₅	:	Phosphorus
R.H.	:	Relative humidity
Rs.	:	Rupees
R	:	Coefficient of correlation
S	:	Sulphur
SEm	:	Standard error of mean
Sig.	:	Significant
q ha ⁻¹	:	Quintal per hectare
Viz.	:	(Videlicet) Namely
VC	:	Vermicompost

CHAPTER- I

INTRODUCTION

Cumin (*Cuminum cyminum* L) locally known as zeera is an important seed spice crop of western India particularly of Rajasthan, Gujarat and some parts of Madhya Pradesh. Cumin, an annual herbaceous plant belongs to the family Apiaceae. It is a slender much branched annual herb and grows about 25 cm in height with finally divided linear leaves. It is widely used in flavouring of food. Its seed have pleasant aromatic odour and also used in preparing chutneys, pickles, vegetables, curry powder, tomato ketch-up etc. Cumin has medicinal value and used for carminative, stimulant, stomachic, astringent and diarrhoea.

India is a major producer, consumer and exporter of spices in the world. Among seed spices cumin occupies first position in term of value and second in terms of production. It is cultivated in an area of 594 thousand hectare with the production of 394 thousand MT and productivity 0.7 ton/ha in India (NHB, 2013).

Cumin is valued for its typical pleasant aroma from its essential oil which ranges between 2.5 and 3.5 % in indigenous collections and up to 5.5 % in exotic ones. Being a short stature crop with slow initial growth, it is heavily infested with weeds. Weeds compete with crop for nutrients, moisture, sunlight and space and reduce the cumin yield by 75 % (Yadav *et al.* 2005). Therefore, it is more prone to crop weed competition. Growers often assume that removal of weeds at any time during the growing season is equally beneficial to the crop. Extent of loss caused by weed is the highest among all the loss causing agent like insect pest and disease.

The crop of cumin is favoured by farmers due to higher profit with less input cost compared to other *rabi* crops. However, due to broadcast sowing, the crop has to compete with weeds all throughout the season. The crop-weed competition has been reported to cause an average yield reduction of 64.5 percent in Rajasthan (Doval *et al.*, 1984) and 94 percent at Anand (Mehta *et al.*, 1985).

Weeds are an important factor responsible for the low productivity of cumin in India. The crop is more susceptible to weed competition during the earlier growth period, if the weed problem is not managed properly, there is strong chance of crop failure.

Herbicides are the most effective and economic weed control measures. Generally, cumin farmers control weed manually, which is labour consuming. Moreover, there is shortage of manpower during early growth stage and therefore, complete weeding is not possible. Rathore *et al.* (1990) found that pre-emergence application of pendimethalin @ 1 kg ha⁻¹ gave better performance in comparison to other treatments in cumin. However, the chemical is costly and not cost effective to farmers. Hence, the present investigation was undertaken for identifying an effective and economically viable weed management practice for obtaining higher yield of cumin.

Objectives:

1. To find out the effect of weed control treatment on growth, yield and quality of cumin.
2. To find out the effect of weed control treatment on growth of weeds in cumin crop.
3. To work out the economics of different treatments.

Chapter- II

REVIEW OF LITERATURE

The literature relevant to the “Weed management in cumin (*Cuminum cyminum* L.)” has been reviewed in this chapter. Limited work has been reported on weed management in cumin in Mandsaur agro-climatic condition hence, similar work conducted on other crops has also been included.

Bhati et al. (1989) conducted a field experiment in Jobner in the winter seasons of 1984-85 and 1985-86 to study the effects of 2 sowing methods (broadcast and line sowing) and 12 weed control on N uptake and quality of cumin (*Cuminum cyminum*). All treatments increased N uptake, protein and essential oil content of cumin over the weedy control. Yield components (umbels/plant and 1000 seed wt) were significantly and positively correlated with cumin seed yield.

Patel and Mehta (1989) reported pendimethalin and fluchloralin with or without one hand weeding were particularly effective. Pendimethalin at 0.5 kg proved the most economic treatment.

Rathore et al. (1990) conducted a field experiment in the rabi season, 1986-87, to assess the efficacies of pre-emergence. Pendimethalin at 0.75-1.50 kg/ha, and pre-sowing and pre-emergence. Fluchloralin at 1.0 kg/ha for control of a weed flora dominated by *Cynodon dactylon*, *Chenopodium* spp. and *Heliotropium elliptium* (*H. ellipticum*) in cumin (*Cuminum cyminum*) cv. UC 19 indicated that all treatments suppressed weeds and enhanced yields in comparison to the un weeded control. Best weed control and best crop yield of 1.76 q/ha was achieved with pendimethalin at 1.0 kg/ha.

Gora et al. (1996) observed oxyfluorfen markedly decreased weed dry matter. Hand-weeding was the next best treatment. Cumin dry matter yield was highest in the hand-weeded plots, which was not significantly different from the oxyfluorfen treated plots.

Choudhary (2000) conducted a field trial in Rajasthan, to determine the efficacy of various treatments for the control of weeds (*Chenopodium murale*, *Heliotropium ellipticum*, *C. album*, *Melilotus indica*, *Tribulus terrestris* and *Portulaca sp.*) in *Coriandrum sativum*. Fluchloralin, oxyfluorfen, metolachlor, pendimethalin and hand weeding gave an effective level of control of all weed species.

Kumar (2001) studied to determine the critical period in cumin during the winter seasons of 1996-97 and 1997-98 at the Research farm of Agricultural Research Station, Jalore, Rajasthan, India. *Chenopodium album*, *C. murale*, *Melilotus indica* and *Asphodelus tenuifolius* were the dominant weed species associated with the crop. Cumin seed yield loss increased with increase in the duration of crop weed competition. Cumin seed yield increased significantly with the increase in initial duration of weed-free condition. The critical period of weed-free competition was 22-39 DAS.

Senthivel (2001) reported the efficacy of four herbicides (butachlor, fluchloralin, pendimethalin and thiobencarb) at two rates (0.5 and 1.0 kg a.i./ha) and applied by different methods (pre-sowing incorporation, pre-emergence spray 3 days after sowing (DAS), dry land weeder 20 and 40 DAS, hand weeding at 20 and 40 DAS, weed-free control and unweeded control) for controlling weeds in coriander cv. C0-3 in Tamil Nadu, India. The predominant weeds were *Panicum repens*, *Cynodon dactylon*, *Cyperus rotundus*, *Celosia argentea*, *Vicoa indica*, *Trianthema portulacastrum* and *Tridax procumbens*. The weed control treatment did not affect the plant attributes (such as plant height, number of branches per plant and pod number). Grain yield was higher in weed-free control (1015 kg/ha), followed by hand weeding twice (815 kg/ha). Pendimethalin performed best in controlling weeds and yielded 715 kg/ha, followed by butachlor which recorded a yield of 692 kg/ha. Butachlor at 1.0 kg a.i./ha applied via pre-sowing incorporation was the most economical treatment for coriander, followed by once hand weeding at 40 DAS.

Kumar (2002) studied the weed management in cumin. Linuron at 0.5 kg/ha applied as pre-emergence or post-emergence 30 days after sowing and pendimethalin

at 1.0 kg/ha applied as pre emergence provided 95.7- 99.2 % weed control and had no adverse effect on cumin (*C. cyminum*) crop at any stage.

Singh et al. (2002) reported highest seed and biological yield (14.62 q/ha) was obtained in the weed free treatment. No significant differences in yield were observed between the 2 pendimethalin treatments. The maximum test weight was (17.31 g) in the weed free treatment, closely followed by pendimethalin at 1 and 1.5 kg/ha, while the lowest (15.69 g) was observed under the weedy control. Seed vigour was highest (1140.21) in the weed free control, and no significant differences were observed between the 2 pendimethalin treatments in terms of this parameter.

Dungarwal et al. (2003) evaluated various chemical and physical control treatments alone or in combination against the weeds in cumin cv. RZ-19. Pre-plant incorporation of fluchloralin (1.0 kg/ha), pre-emergence application of pendimethalin, trifluralin (1.0 kg/ha) and linuron (0.5 kg/ha) and post emergence application of linuron (0.5 kg/ha) effectively controlled weeds. However, the effectiveness of pre-plant and pre emergence herbicides was greatly improved when supplemented with one hand weeding at 30 days after sowing. Pre emergence application of linuron at 0.5 kg/ha supplemented with one hand weeding gave higher seed yield (433 kg/ha) fetching net return of Rs. 11915 /ha. This treatment was at par with post emergence application of linuron at 0.5 kg/ha which produced seed yield of 419 kg/ha with net return of Rs. 11995 /ha.

Yadav and Dahama (2003) conducted a field experiment during the winter season of 1996-97 and 1997-98 at the Agricultural Research Station, Mandor, Rajasthan, India to study the effects of planting date, irrigation and weed control measure on the yield and water use efficiency of cumin (*C. cyminum*) cv. RZ 19. Fluchloralin at 1.0 kg/ha as pre-plant incorporation resulted in a significantly higher seed yield (814 kg/ha) over weedy control and hand weeding. However, the highest seed yield (865 kg/ha) was recorded for the weed-free treatment. The greatest water use efficiency (5.83 kg/ha-mm) was obtained with planting on 15 November under weed-free conditions (7.86 kg/ha-mm), followed by fluchloralin at 1.0 kg/ha.

Patel et al. (2004) reported the influence of weed management practices and nitrogen fertilizer on yield of coriander. Pre-emergence application of oxadiazon at 0.5 kg/ha was most effective in controlling weeds, which enhanced growth and yield components and resulted in production of higher coriander seed yield (2599 kg/ha) and net monetary return of Rs. 42 354. This treatment was at par with pendimethalin.

Yadav and Sharma (2004) carried out a experiment with cumin (*C. cyminum*) cv. RZ-209 during rabi 2000-01 and 2001-02 in Jobner, Rajasthan, India, involving 10 weed control measures and 3 N levels (15, 30 and 45 kg/ha). The hand weeding twice at 25 and 50 DAS recorded the highest yield (5.50 q/ha), harvest index (40.73%), crop growth rate during 40-70 DAS and 70 DAS, and relative growth rate during 40-70 DAS. Trifluralin at 1.08 kg/ha increased seed yield by 252.9%. It was the next superior treatment with regard to yield and physiological parameters.

Yadav et al. (2004) conducted a field experiment during the rabi seasons of 2000-01 and 2001-02, at Jobner, Rajasthan, India, to evaluate the effects of different weed control and N fertilizer levels on the yield, nutrient uptake and quality of cumin cv. RZ-209. Hand weeding twice at 25 and 50 DAS was the most effective treatment, giving a seed yield of 5.50 q/ha, which was 292.90 % higher than that of the weedy control (1.40 q/ha). Among the herbicides, pre-planting application of trifluralin at 1.08 kg/ha was the best treatment (4.94 q/ha), followed by trifluralin at 2.16 kg/ha (4.85 q/ha) and pendimethalin at 1.00 kg/ha (4.8 q/ha). Hand weeding twice at 25 and 50 DAS also gave the highest straw yield of 7.97 q/ha, compared with 3.62 q/ha in the weedy control. N contents in the seed and straw of cumin and uptake of N and P were significantly improved by the different weed control treatments. The maximum protein content (17.60 %) was obtained with trifluralin at 1.08 kg/ha and the highest essential oil content (2.52 %) was obtained with pendimethalin at 1.00 kg/ha.

Sharma and Jain (2005) reported the weed-free treatment was most effective in reducing the dry weight of both monocot and dicot weeds at harvesting, recording highest weed control efficiency (95.32%) and net returns of Rs 11 300/ha, and produced significantly higher seed yield over other treatments. Among herbicides, pre-plant

fluchloralin at 1.0 kg/ha recorded lowest dry weight of both monocot and dicot weeds and highest weed control efficiency (67.73%). But pre-plant fluchloralin at 0.75 kg/ha resulted in significantly highest seed yield over all the other treatment except pre-emergence fluchloralin at 0.75 kg/ha and recorded maximum net returns of Rs 9635/ha. Pre-plant fluchloralin at 0.75 kg/ha also recorded the highest benefit: cost ratio of 3.70:1 among all the treatments including weed-free treatment.

Sagarka et al. (2005) evaluated the efficacy of an integrated approach in controlling the weeds of coriander (*Coriandrum sativum*) cv. Gujarat Coriander-1. Results reveal that integration of all herbicides with hand weeding at 30 DAS was effective in reducing total weed density and dry weight, especially *Digera arvensis* and *Aeluropus villosus*. Integration of fluchloralin at 600 g/ha and oxyfluorfen at 80 g/ha with hand weeding produced seed yields at par with the weed-free control and the highest net returns. The major weeds in the experimental field were *Cyperus rotundus* (33%), *Digera arvensis* (32%), *Aeluropus villosus* (19%) and *Dactyloctenium aegyptium* (4%).

Tewari et al. (2005) conducted a field experiment at Kanpur, Uttar Pradesh, India, to evaluate the efficacy of herbicides against weeds in coriander. The major weeds in the experimental field were *Coronopus didymus* (64.6%), *Chenopodium album* (18.4%), *Anagallis arvensis* (11.9%), *Melilotus alba* (2.4%) and *Phalaris minor* (2.6%). Pre-emergence application of pendimethalin and pretilachlor was very effective in controlling the weeds of coriander, especially *Coronopus didymus*. These treatments recorded 54.6 and 50.7% higher seed yield over the weedy control and gave the highest net returns of Rs. 17999 and 17051/ha, respectively. Allowing weed growth throughout the crop period resulted in 45.8% reduction in seed yield compared with manual weeding twice at 20 and 40 DAS.

Yadav et al. (2005) assess weed-control treatments significantly reduced the density and dry weight of weeds and nutrient depletion compared to the control. Two hand-weedings 25 and 50 days after sowing provided the best control of weeds (87.9%) resulting in the highest cumin seed yield (5.50 q/ha). The lowest weed density and dry matter and the highest weed-control efficiency (84.3%) was obtained with pre-plant

application of trifluralin at 2.16 kg/ha. Application of trifluralin at 1.08 kg/ha resulted in a seed yield of 4.94 q/ha and weed-competition index of 10.2%. Pendimethalin at 1.0 kg/ha (pre-emergence) also controlled the weeds more effectively (79.3%) compared to the application of lower rates of trifluralin and fluchloralin at 1.125 kg/ha, and resulted in 242.9% higher seed yield than the control.

Yadav et al. (2005) conducted a field experiment at Jobner (Jaipur) to study the effect of different weed control measures and nitrogen levels on growth and yield of cumin. Results showed that two hand weedings done at 25 and 50 days after sowing attained the significantly highest values of most of the growth and yield attributes of cumin. It also recorded the maximum seed (5.50 q ha⁻¹) and straw yield (7.97 q ha⁻¹) and harvest index (40.73%). Among herbicides, trifluralin at 1.08 kg a.i. ha⁻¹ (pre plant incorporation) performed the best in these attributes with a seed yield of 4.94 q ha⁻¹ and was accompanied by trifluralin at 2.16 kg a.i. and pendimethalin at 1.0 kg a.i. ha⁻¹.

Mehriya et al. (2007) reported that weed-free up to 60 DAS gave the lower mean weed density and total weed dry matter at harvest and increased yield attributes viz., mean final plant stand, umbels/plant, seeds/umbel and test weight by 157.9, 147.4, 166.2 and 37.2 %, respectively, over weedy check. The critical period of crop-weed competition was observed between 15 to 60 DAS in cumin. Weed-free environment throughout crop season produced the maximum oil and protein content, and was significantly higher compared to weedy check.

Mehriya et al. (2007) reported oxyfluorfen and oxadiargyl @ 50 g/ha applied 20 days after sowing (DAS) along with 1 hand-weeding 35 DAS caused maximum reduction in weed biomass production and nutrient depletion by weeds 90 DAS and resulted in higher weed-control efficiency. These treatments also enhanced cumin yield, essential oil content in the seed and net monetary returns. Paraquat and glyphosate applied 7 DAS failed to check depletion of nutrients by weeds significantly. Application of oxadiargyl @ 50 g/ha applied 20 DAS was found better than its application 7 DAS. Early post-emergence application of oxyfluorfen and oxadiargyl 50 g/ha followed by 1 hand-weeding computed considerably higher net returns (Rs 25 595 and 24 823/ha respectively) and benefit: cost ratio (2.92 and 2.80).

Thakral et al. (2007) evaluated the comparative economics of weed management practices in fennel (*Foeniculum vulgare* Mill.), among the herbicidal treatments, maximum dry weight of weeds was found in plots treated with isoproturon at 0.5 kg/ha and minimum in pendimethalin at 1.5 kg/ha followed by its lower dose. Oxyfluorfen at both the rates was phytotoxic to the crop. Maximum seed yield and net return was obtained when pendimethalin at 1.0 kg/ha was applied as pre-emergence supplemented with one hand weeding at 50 days after sowing followed by weed free.

Mehriya et al. (2008) conducted a field trial in India to determine the effect of different weed management practices on the yield of cumin. *Chenopodium murale*, *C. album* and *Rumex dentatus* were the predominant weeds in the experimental field. Oxyfluorfen at 50 or 75 g/ha and oxadiargyl at 50 g/ha, applied at 20 DAS, along with one hand weeding at 35 DAS, being at par among themselves, brought maximum reduction in weed biomass production of *Chenopodium* spp. as well as total weeds, thereby recording (93.9-96.2%) higher weed control efficiency. However, maximum dry weight of *R. dentatus* was reduced due to the application of paraquat at 0.4 kg/ha + one hand weeding. Integration of oxyfluorfen at 50 or 75 g/ha along with one hand weeding gave comparable seed yield to the weed-free control and consequently provided maximum B:C ratio (2.92). Oxadiargyl + hand weeding resulted in statistically at par seed yield to that obtained with the combined application of oxyfluorfen + hand weeding. Among the sole herbicidal treatments, oxyfluorfen at 50 or 75 g/ha or oxadiargyl at 50 g/ha, applied at 20 DAS, recorded higher WCE (83.3 - 88.9 %) and produced significantly higher growth and yield attributing characters, which led to higher seed yield, net returns and B:C ratio compared to fluchloralin at 1.0 kg/ha PPI.

Meena et al. (2009) reported the economic feasibility of weed management practices in terms of weed control efficiency and performance of cumin (*Cuminum cyminum*) indicated that weed free treatments resulted in maximum vegetative growth and seed yield (6.03 q/ha) followed by pre-emergence application of oxadiargyl @ 75 g/ha + hand weeding at 45 days after sowing (DAS). Maximum net returns (Rs.46,365/ha) and highest cost: benefit ratio (1:3.48) was also obtained in pre-emergence application of oxadiargyl @ 75 g/ha + hand weeding at 45 DAS.

Meena and Mehta (2009) conducted a field experiment at NRCSS, Ajmer (Rajasthan), to study the integrated weed management in coriander (*Coriandrum sativum* L.). The results revealed that pre-emergence application of oxadiargyl @ 75 g/ha + 1 hand weeding at 45 days after sowing resulted into significantly maximum vegetative growth and seed yield (1340 kg/ha) of coriander, followed by pre-emergence application of pendimethalin @ 1 kg/ha + 1 hand weeding at 45 days after sowing. Among the weed management practices, weed-free treatment was most effective in reducing the dry weight of weeds and recorded the highest weed control efficiency (85.94%), followed by pre-emergence application of oxadiargyl @ 75 g/ha + 1 hand weeding at 45 days after sowing (78.31%). However, the maximum net returns (Rs 46 561/ha) and highest benefit: cost ratio (3.22:1) were obtained under pre-emergence application of oxadiargyl @ 75 g/ha + 1 hand weeding at 45 days after sowing among all the treatments including weed-free treatments.

Meena and Mehta (2009) conducted a field experiment during rabi, at the research farm of NRCSS, Ajmer (Rajasthan) to find out most suitable and economical method of weed control in fennel (*Foeniculum vulgare*). Based on two years' study, it was revealed that besides weed free treatment, significantly highest plant height at all the growth stages, number of branches/plant, yield attributes like number of umbels/plant, number of umbellate/umbel, number of seeds/umbellate, seed and straw yields of fennel were recorded with pre-emergence (PRE) application of oxadiargyl @ 75 g/ha + one hand weeding (HW) at 45 DAS which being at par with Pre application of pendimethalin @ 1.0 kg/ha + HW at 45 DAS. Similarly, besides weed free treatment, the lowest dry weight of weed at harvest and weed index as well as highest weed control efficiency was also obtained with Pre application of oxadiargyl @ 75 g/ha (PE)+HW at 45 DAS. This treatment also exhibited highest net returns (Rs. 104310/ha) and B: C ratio.

Nagar et al. (2009 a) conducted a field experiment at Udaipur with 11 Weed and three nutrient management practices to study the effect on growth, yield and quality of coriander (*Coriandrum sativum*). Weed management practices significantly reduced

weed density, dry matter and nutrient uptake by weeds and improved growth (plant height), yield attributes (umbels/plant and weight of seeds/umbel), seed and biological yield, quality parameters (essential oil content and oil out turn) and nutrient uptake by crop as compared to control. Two hand weeding (HW) at 30 and 45 DAS resulted in maximum reduction in weed density, dry weight and nutrient depletion by weeds and gave the highest seed (1.59 t/ha) and biological yield (4.11 t/ha) of coriander. However, maximum essential oil content, oil out turn and B:C ratio (2.13) were obtained by pendimethalin 1.0 kg/ha + one hand weeding at 45 DAS. Both the treatments remained at par in reduction of weed dry matter and nutrient uptake by weeds and resulted in maximum weed control efficiency (88.50%) as compared to rest of the practices. Treatment of pendimethalin 1.0 kg/ha + one hand weeding at 45 DAS resulted in the highest seed yield, maximum weed control efficiency (88.50%) and B: C ratio (2.13). However, minimum nutrient uptake by crop and maximum nutrient removal by weeds were noted under weedy check.

Nagar et al. (2009 b) conducted a field experiment during the winter season of 2003-04 and 2004-05 at Udaipur. Among the weed management practices, hand weeding twice (HW) at 30 and 45 days after sowing (DAS) and pre-emergence application of pendimethalin at 1.0 kg/ha + hand weeding at 45 DAS were at par. These treatments significantly reduced the density and dry weight of weeds over other treatments and significantly increased yield attributes of coriander resulting in higher seed yield (1.58 and 1.57 t/ha) and net return (Rs. 23,930 and 24,072/ha) as a result of higher weed control efficiency (88.50 and 88.14%) and lower weed index (0.63% of pendimethalin + HW), respectively. *Chenopodium murale*, *Spergula arvensis* and *Melilotus indica* were the most pre-dominant weeds.

Yadav et al. (2011) revealed that highest yield attributes and yield of cumin was recorded with post emergence application of Oxadiargyl @ 50 g/ha 20 DAS + HW, being statistically at par with rest of the treatments except weedy check and post emergency application of glyphosate @ 0.5 kg/ha. The seed yield of cumin in weedy check was only 75 kg/ha which was too low compared to weed free (605 kg/ha). Thus,

weed cause great loss to seed yield of cumin. The highest net return (Rs. 41081/ha) and BCR (2.17) was recorded with application of oxadiargyl @ 50 g/ha at 20 DAS which was higher over rest of the treatments. Thus, it can be inferred that application of Oxadiargyl @ 50 g/ha at 7 DAS or 20 DAS + HW is best method of weed control for realizing higher yield.

Yadav et al. (2012) revealed that at 30 DAS response of weed control method was not noticed significant on plant height but at 60 DAS and harvest, besides weed free treatment, application of oxadiargyl @ 50 g/ha 20 DAS + HW, exhibited the highest plant height being at par with all treatments except weedy check and application of Glyphosate @ 0.5 kg/ha. similarly, besides weed free treatments the highest yield attributes and yield of cumin was recorded with post emergence application of oxadiargyl @ 50 g/ha 20 DAS + HW, being statistically at par with rest of the treatments except weedy check and post emergence application of glyphosate @ 0.5 kg/ha. The highest net return (Rs. 41081/ha) and BCR (2.17) was recorded with application of oxadiargyl @ 50 g/ha at 20 DAS which were higher over rest of the treatments.

Mehriya et al. (2013) revealed that weed-free period of 60 DAS and after or weedy up to 15 DAS gave the lower weed density, dry matter, N uptake and water use and increased yield attributes viz. mean final plant stand, umbels per plant, test weight and seed yield of cumin. These treatments were at par with complete weed-free treatment during both the years with regards to seed yield. The uptake of N by cumin and water use efficiency (WUE) was increased in weed-free period of 60 DAS and after or weedy period of 15 DAS compared to all other treatments and thus the critical period of crop weed competition was recorded between 15-60 DAS in cumin.

Yadav et al. (2013) studied the influenced of weed management practices in coriander crop. Results reveals that two hand-weeding done 20 and 40 days after sowing and pendimethalin @ 1.0 kg/ha + hand-weeding at 40 days after sowing were the most effective in reducing the density and dry weight of weeds and improving the weed-control efficiency. Oxadiargyl @ 0.06 kg/ha + hand-weeding at 40 days after

sowing represented the lowest weed density and controlled the weeds to the extent of 94.9%. Two hand-weeding done at 20 and 40 days after sowing recorded the highest plant height, umbels/plant and test weight. It also provided the maximum seed and straw yields (1.37 and 2.58 t/ha) of coriander that were 164.7 and 116.9% more than unweeded control respectively. Pendimethalin @ 1.0 kg/ha + hand-weeding at 40 days after sowing was also found equally effective in increasing the growth and yield attributes as well as yield. The highest number of branches/plant, dry matter, umbellets and seeds/umbel were obtained under this treatment. It provided the seed and straw yields of 1.36 and 2.56 t/ha, respectively, indicating an increase of 162.5 and 116.9% than unweeded control. It also recorded the highest harvest index (35.01%) and lowest weed competition index (0.73%) among all the treatments. Providing seed yields of 1.20 and 1.17 t/ha with weed competition indices of 12.3 and 14.4%, 1 hand-weeding at 20 days after sowing and pendimethalin @ 1.0 kg/ha were the next better and statistically similar treatments. The highest net returns (Rs 55,841/ha) and benefit: cost ratio (2.39) was obtained with 2 hand-weeding at 20 and 40 days after sowing treatment. Pendimethalin @ 1.0 kg/ha + hand-weeding at 40 days after sowing was found at par with hand-weeding twice fetching net returns of Rs 54,308 and benefit: cost ratio of 2.3.

CHAPTER - III

MATERIAL AND METHODS

The field experiment entitled “**Weed management in cumin (*Cuminum cyminum* L.)**” was conducted during the *rabi* season of 2013-14. Details of the materials and methods followed in the experiment are given below. The experimental materials and criteria used for treatment evaluation during the course of investigation are being presented in this chapter.

3.1 Experimental Site

The experiment was laid out at the “Research field of the Deptt. of Plantation, Spices, Medicinal and Aromatic Crops”, College of Horticulture, RVSKVV, Mandsaur (M.P.) during *rabi* season of 2013-14. Mandsaur is situated in Malwa plateau in Western part of Madhya Pradesh at North latitude of 23.45⁰ to 24.13⁰ and 74.44⁰ to 75.18⁰ East longitudes and an altitude of 435.02 meters above mean sea level. This region falls under agro climatic zone number 10 of the state.

3.2 Climate of the Region

Mandsaur belongs to sub-tropical climatic conditions having a temperature range of minimum 5⁰C and maximum 44⁰C in winter and summer, respectively. In this area most of the rainfall is received during mid June to early October with occasional shower during winter. The average annual rainfall is 917.7 mm. South-West monsoon is responsible for major part of annual precipitation. Meteorological data recorded during the period of investigation are presented in Table 1 and are graphically shown in Fig 1.

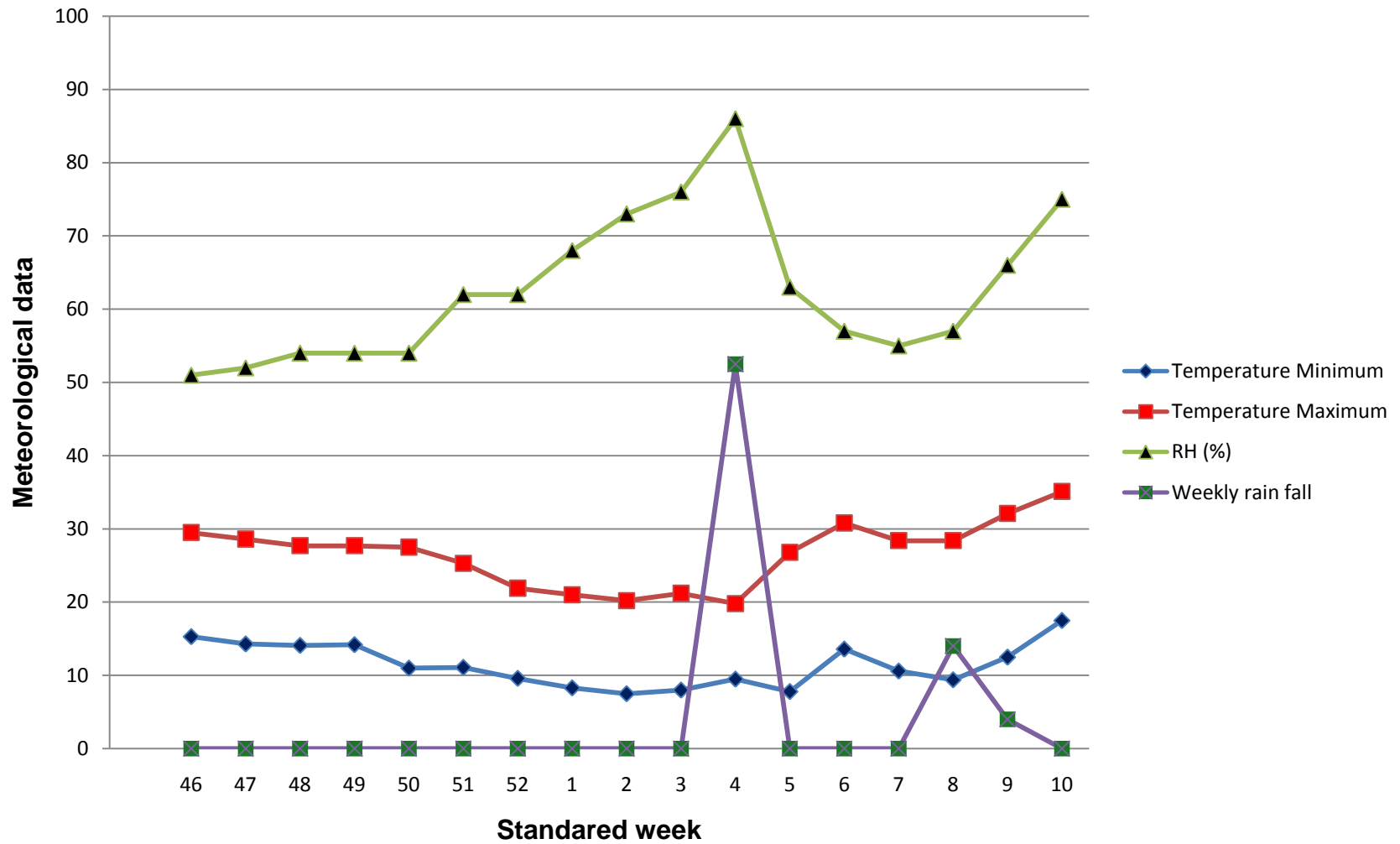
Table 1: Climatic variables for the period of investigation (November to March, 2012-13)

Week No.	Duration	Temperature		RH (%)	Weekly rainfall (mm)
		Min. ^o C	Max. ^o C		
46	11-11-13 to 17-11-13	15.3	29.5	51	-
47	18-11-13 to 24-11-13	14.3	28.6	52	-
48	25-11-13 to 1-12-13	14.1	27.7	54	-
49	2-12-13 to 8-12-13	14.2	27.7	54	-
50	9-12-13 to 15-12-13	11.0	27.5	54	-
51	16-12-13 to 22-12-13	11.1	25.3	62	-
52	23-12-13 to 29-12-13	9.6	21.9	62	-
1	30-12-13 to 5-01-14	8.3	21.0	68	-
2	6-1-14 to 12-1-14	7.5	20.2	73	-
3	13-1-14 to 19-1-14	8.0	21.2	76	-
4	20-1-14 to 26-1-14	9.5	19.8	86	52.5
5	27-1-14 to 2-2-14	7.8	26.8	63	-
6	3-2-14 to 9-2-14	13.6	30.8	57	-
7	10-2-14 to 16-2-14	10.6	28.4	55	-
8	17-2-14 to 23-2-14	9.4	28.4	57	14
9	24-2-14 to 2-3-14	12.5	32.1	66	4
10	3-3-14 to 9-3-14	17.5	35.1	75	-

3.3 Soil characteristics of the experimental site

To ascertain physico-chemical characteristics of the soil during the year of study, soil samples from 0-15 cm depth were taken from different spots of the experimental field before application of fertilizer. A representative composite sample was prepared by processing and mixing them together and the sample was analyzed for physical and chemical properties. The result of analysis, presented in Table 2, showed that the soil was light black loamy in texture, with low available nitrogen, medium in phosphorus and high in potassium status.

Fig. 1 Standarded meteorological data recorded during study period



7.	Total Number of plots	36
8.	Row to Row distance	30 cm
9.	Plant to plant distance	10 cm
10.	Replication distance	100 cm
11.	Plot border	50 cm
12.	Gross plot area	2 m x 1.8 m = 3.6 m ²
13.	Net plot area	1.9 m x 1.5 m = 2.85 m ²
14.	Date of sowing	15 th November 2013
15.	Date of harvesting	9 th March 2014

3.5 Experimental materials

3.5.1. Treatments combination

The treatment combinations were as follows:

Detail of treatment

- T₁ Weedy check (control)
- T₂ Hand weeding (40 DAS)
- T₃ Pendimethalin @ 1.0 litre ha⁻¹ pre-emergence
- T₄ Pendimethalin @ 1.2 litre ha⁻¹ pre-emergence + one hand weeding (40 DAS)
- T₅ Pendimethalin @ 1.0 litre ha⁻¹ pre-emergence + two hand weeding (40, 60 DAS)
- T₆ Oxyfluorfen @ 0.15 litre ha⁻¹ pre-emergence
- T₇ Oxyfluorfen @ 0.30 litre ha⁻¹ pre-emergence + one hand weeding (40 DAS)

- T₈ Oxyfluorfen @ 0.15 litre ha⁻¹ pre-emergence + two hand weeding
(40, 60 DAS)
- T₉ Oxadiargyl @ 0.06 litre ha⁻¹ pre-emergence
- T₁₀ Oxadiargyl @ 0.075 litre ha⁻¹ pre-emergence + one hand weeding
(40 DAS)
- T₁₁ Oxadiargyl @ 0.06 litre ha⁻¹ pre-emergence + two hand weeding
(40, 60 DAS)
- T₁₂ Weed free

3.5.2 Technical information about the herbicides

The technical information about the herbicides used is given:

Pendimethalin

Chemical name : N-(1-ethylpropyl)-3, 4-dimethyl-2, 6-dinitro benzenamine.

Trade name : Stomp

Mode of action : Inhibits germination of the seed or destroys the seedlings.

Uses : It controls most of grassy weeds and certain broad leaf weeds. It is a selective soil herbicide predominantly used for pre-emergence treatment.

Formulation : Emulsifiable concentrate (30%EC)

Oxyfluorfen

Chemical name : 2-chloro-1-(3 ethoxy-4-nitrophenoxy)-4-(trifluoromethyl) benzene.

Trade name : Goal

Mode of action : It is used as pre and post- emergence herbicide.

Uses : Selective herbicide for pre-emergence and post-emergence for the control of certain annual broad leaf and grassy weeds.

Formulation : Emulsifiable concentrate (23.5%EC)

Oxadiargyl

Chemical name : 3 [2, 4-dichloro-5(2propoxy) phenyl]-5-11-dimethyl ethyl-1,3,4-oxadiazol-2,(3H-1).

Trade name : Raft

Mode of action : The action is quick and complete when weeds young or are growing fast, diffuse rapidly in growing tip ensuring total distribution. Light is necessary for herbicidal action.

Uses : It is active during the early stages of growth of weeds.

Formulation : Emulsifiable concentrate (6%EC)

3.5.3 Experimental design and layout

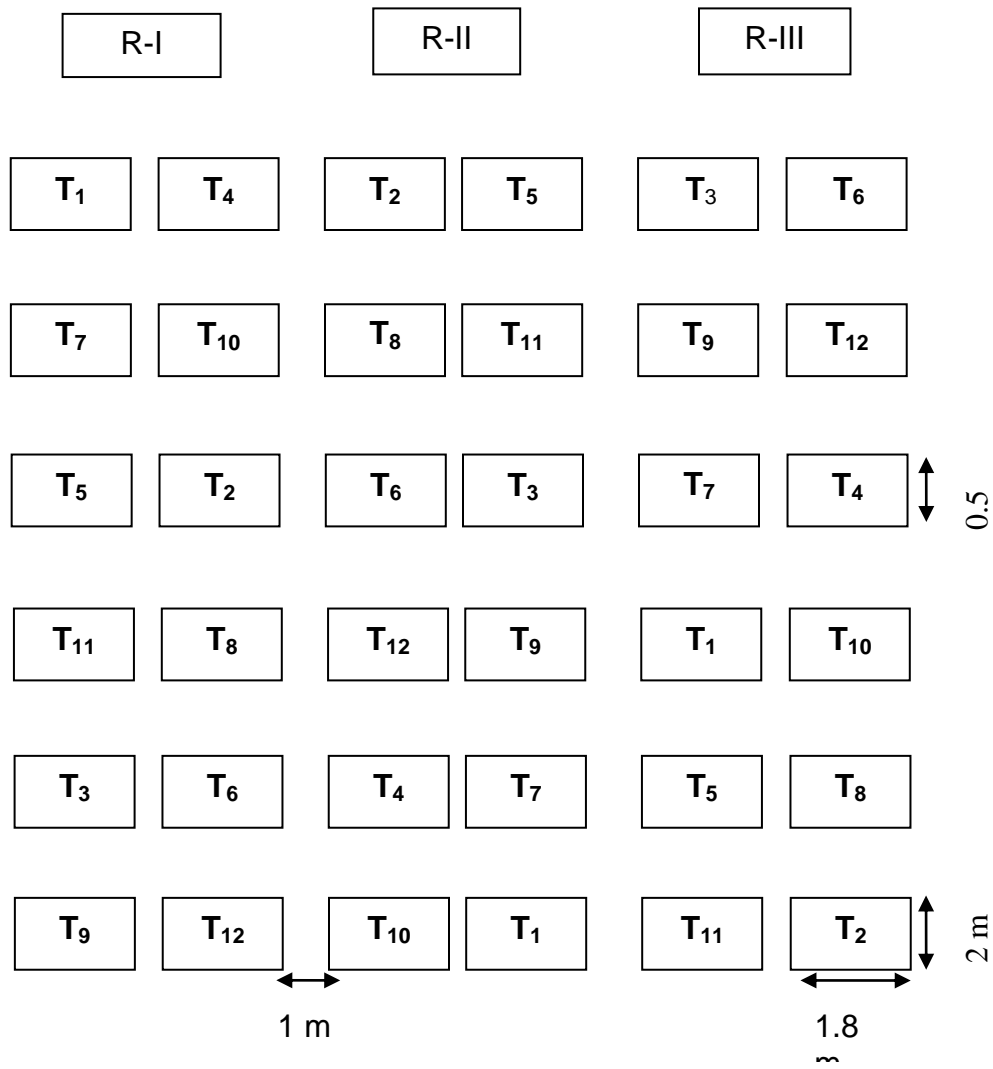
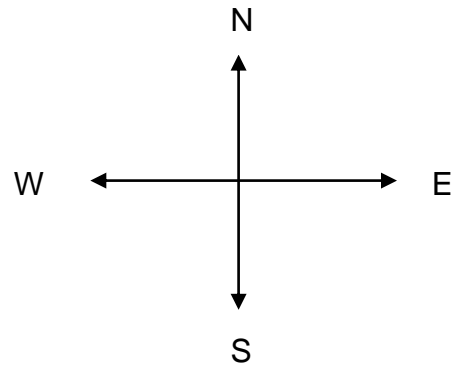
The experiment was laid out in a RBD with weed management, having three replications. The treatments were randomly allotted to different plots using random number table of Fisher and Yates (1963). The layout plan of experiment with allocation of treatments and other details of the experiments is shown in Fig 2.

3.6 Cultural operations

3.6.1 Field preparation

The field was properly ploughed by disk harrow and then pulverized by discing and harrowing. Then after, field was levelled properly with heavy wooden planker by tractor and then plots were prepared according to the layout plan.

Layout of the field experiment of cumin



3.6.2 Application of manures and fertilizers

A basal dose of well rotten farmyard manure @10 ton ha⁻¹ was incorporated in the soil before one month of sowing in addition to this, a uniform dose of 30 kg N ha⁻¹ through urea, 30 Kg P₂O₅ ha⁻¹ through (Single Super Phosphate) and 15 Kg K₂O ha⁻¹ through MOP (Murate of Potash) was applied for better growth and proper nutrition of cumin.

3.6.3 Variety used

Variety GC-4 is used in the experiment. This variety was procured from the NRCSS, Tabiji, Ajmer.

3.6.4 Seed and sowing

The pure, healthy, disease and insect free vigorous and good quality cumin seed (GC-4 cultivar) were used for sowing. Seed were treated with carbendazim (2 gm kg⁻¹ seeds) and sowing was done on 15th November 2013, using the seed rate of 12 Kg ha⁻¹ and then sown in furrows opened at 30 cm row spacing and covered with soil properly.

3.6.5 Thinning

One thinning was done at 30 DAS to remove the excess plants to maintain uniform plant spacing 10 cm.

3.6.7 Plant protection measures

In order to safe guard the plant against aphids, dimethoate (1.5%) was sprayed on the plants twice, wettable sulphur (3 g l⁻¹) was sprayed to prevent the crop from powdery mildew and dithane M-45 (0.8 kg ha⁻¹) was sprayed at flowering stage to control the crop from blight.

3.6.8 Irrigation

First irrigation was given just after sowing followed by light irrigation at 7 days after sowing to facilitate proper germination and establishment of the crop seedling. Subsequent irrigation was given almost at 20-25 days intervals as per need of the crop.

3.6.9 Harvesting

The crop was harvested with the help of sickle. The harvested material of each plot was tied in bundles, tagged and kept on the threshing floor for sun drying.

3.6.10 Threshing and winnowing

After sun drying the threshing of the individual plots was done with the help of wooden sticks and winnowed to separate seeds and straw. Seeds were weighed and plot wise samples were taken. Seeds and straw were separated for further analysis.

3.7 Observation to be taken during course of investigation

A. Growth attributes

1. Plant height (cm) at 30, 60 and at maturity
2. Number of branches plant⁻¹ at 60 and 90 DAS
3. Days to 50% flowering

B. Yield and yield attributes

1. Number of umbels per plant
2. Number of umbellets per plant
3. Test weight (g)
4. Seed yield per plant (g)
5. Seed yield (q/ha)
6. Straw yield (q/ha)
7. Harvest index (%)

C. Studies on weeds

1. Weed population/m² at 30, 60, 90 DAS and at harvest.
2. Weed dry matter g/m² at 30, 60, 90 DAS and at harvest.

3.8 Observations and procedure

Observations were recorded on the different parameters viz. growth, yield and studies on weed characters associated with cumin crop.

3.8.1 Sampling technique

Five plants randomly selected from each plot and tagged for recording observation on various characters.

3.8.2 Observation of growth attributes

1. Plant height

Five plants randomly selected from each plot were measured at 30, 60 DAS and at maturity. The plant height was measured from the ground level up to the tip of the main shoot. The average was worked out and expressed as plant height in cm.

2. Number of branches per plant

The branches from five randomly selected plants of each plot were counted at 60 and 90 DAS. The average was computed and expressed as number of branches per plant.

3. Days to 50% flowering

Three central rows were selected in each plot and dates of completion of flowering on 50% plants were recorded. Based on date, days taken to 50% flowering was worked out for each plot.

3.8.3 Observation on yield and yield attributes

1. Number of umbels per plant

Umbels of five randomly tagged plants were counted at harvest from each plot and average number of umbels plant^{-1} was calculated.

2. Number of umbellets per plant

Ten umbels were selected at random from the tagged plants at harvest and total umbellets were counted and the average umbellets plant^{-1} was worked out.

3. Test weight (g)

One thousand seeds were counted in samples taken from the finally winnowed and cleared produce of each plot after weighing. These seeds were weighed on electronic balance and the weight was recorded as test weight (g).

4. Seed yield per plant (g)

After threshing and winnowing clean seeds obtained from individual plant were weighed and the weight was recorded in g per plant.

5. Seed yield (q/ha)

After threshing and winnowing clean seeds obtained from individual plot were weighed and the weight was recorded in g per plot. This was then converted into q per hectare for calculation purpose.

6. Straw yield (q ha⁻¹)

Straw yield was calculated by subtracting the seed yield (q ha⁻¹) from the biological yield (q ha⁻¹).

7. Harvest index (%)

The harvest index was obtained by dividing the economic yield (seed yield) from total biological yield and expressed as % (Donald and Hamblin, 1976).

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (q ha}^{-1}\text{)}}{\text{Biological yield (q ha}^{-1}\text{)}} \times 100$$

3.8.2 Studies on weed

1. Weed population

The number of weeds present in 1.0 m² area of each plot selected at random, each time were counted at 30, 60, 90 DAS and at harvest. They were further classified into monocot and dicot weeds before subjecting to statistical analysis.

2. Dry weight of weeds (g)

Dry weight of weeds was recorded at 30, 60, 90 DAT and at harvest. The weeds were uprooted from the 1.0 m² area selected at random, each time and were oven dried to a constant weight at 61°C and dry weight of weeds for each treatment was recorded.

3.7. Statistical analysis:

To test the significance of variation in the data obtained, the analysis of variance technique was adopted as suggested by Panse and Sukhatme (1984). The analysis of variance for different characteristics is presented in Appendix.

The critical difference (C.D.) was calculated to assess the significance of difference between treatments, whenever the results were found significant through 'F' test, CD at

5 % level of significance was determined. S.Em. \pm and CD are calculated using the following formula.

$$\text{S.Em. } \pm = \sqrt{\frac{\text{EMS}}{r}}$$

$$\text{CD} = \text{S.Em. } \pm \times \sqrt{2} \times t_{5\%}^{-1}(\text{edf})$$

Where

EMS	:	Error mean sum of squares
r	:	Replications
$t_{5\%}(\text{edf})$:	Table value at error degree of freedom
S.Em. \pm	:	Standard error of mean
CD	:	Critical difference

CHAPTER - IV

RESULTS

The effect of weed management in cumin (*Cuminum cyminum* L.) was assessed for controlling weeds and their effects on the growth, yield, yield attributing characters of crop cumin in the present investigation which was carried out at Research Field of the Deptt. of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, Mandsaur in *rabi* season 2013 - 2014. The data recorded on weeds and crop both were analysed statistically and the tables for analysis of variance are given in appendices. The overall effects of treatments on different characters of both weeds and crop are being described in this chapter. The important results have also been illustrated with the help of suitable figures.

4.1. Growth characteristics of cumin:

4.1.1: Plant height (cm.):

Data presented in Table 3 and Fig. 3 show the plant height (cm.) of cumin recorded from 30 DAS to harvest stage and it can be observed that there is a steady and continuous increase in plant height from 30 DAS to harvest stage in all the treatments. Application of weed free treatment recorded significantly highest plant height of cumin observed at 30, 60 DAS and at harvest stage as compare to all other treatment.

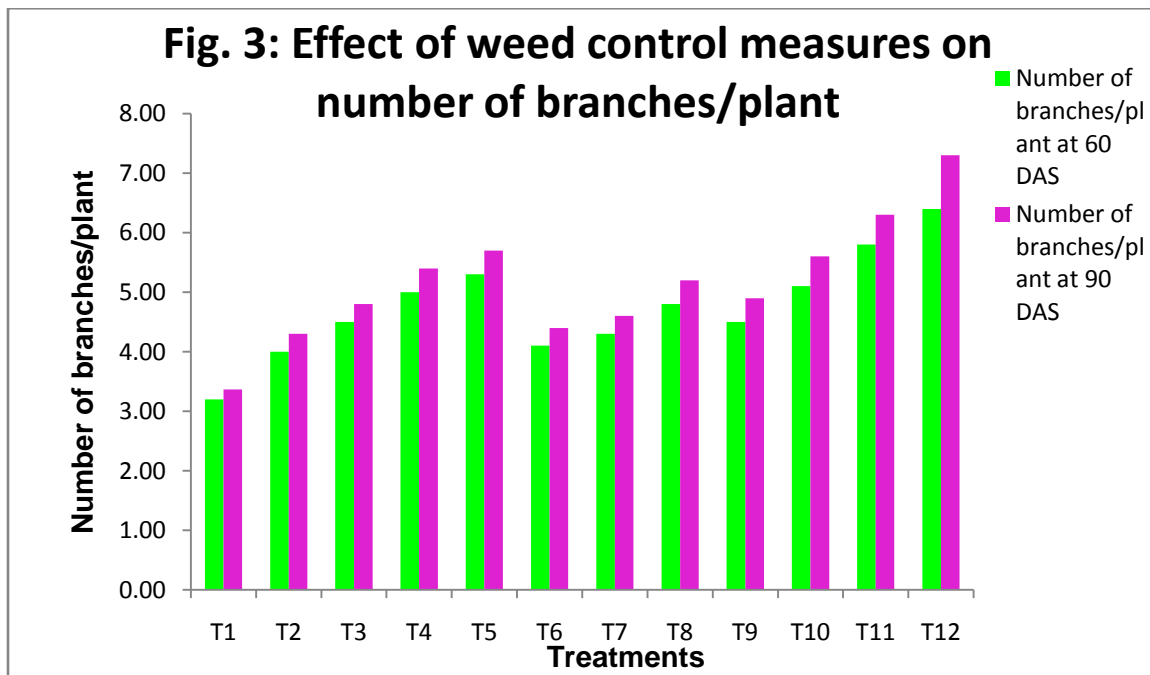
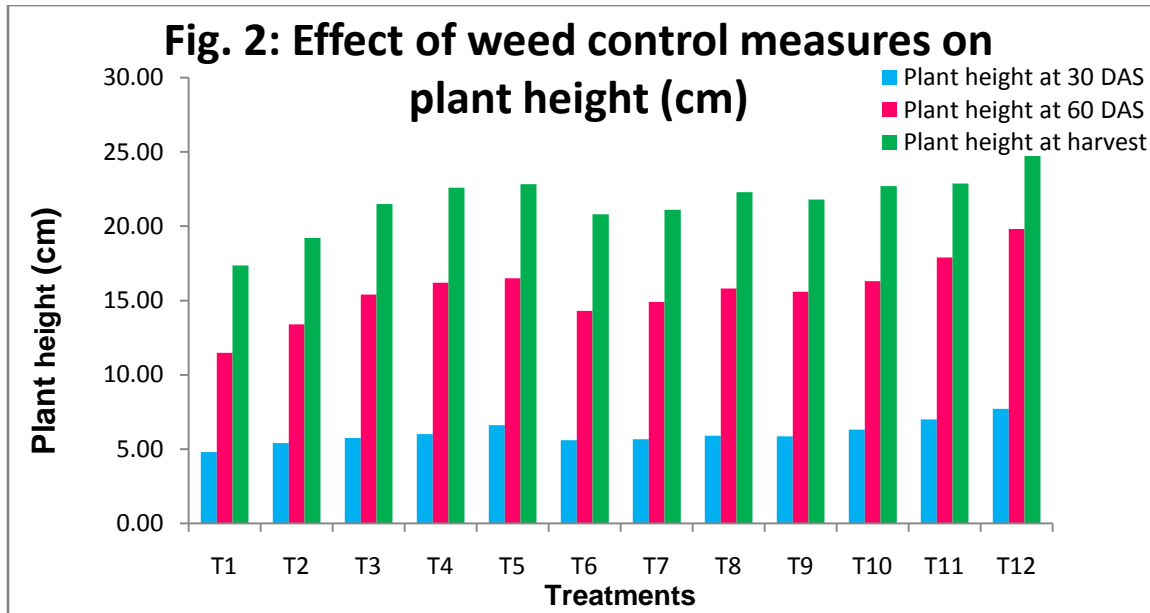
At 30 DAS, the significant maximum plant height (7.71 cm.) was recorded with the application of weed free treatment which was 60.62 per cent higher by over control.

At 60 DAS, a significant increase in plant height over control was recorded due to application of weed free treatment. Among the herbicides Oxadiargyl @ 0.06 litre ha⁻¹ PE + 2 HW (40, 60 DAS) treatment gave significantly highest plant height (17.90 cm.) which was statistically at par with Oxadiargyl @ 0.075 litre ha⁻¹ PE + 1 HW (40 DAS), Pendimethalin @ 1.2 litre ha⁻¹ PE + 1 HW (40 DAS) and Pendimethalin @ 1.0 litre ha⁻¹ PE + 2 HW (40, 60 DAS) treatments.

Similarly at harvest, weed free treatment recorded 42.53 per cent significantly higher plant height as compare to control (17.35 cm.). Among the herbicides applied, Oxadiargyl @ 0.06 litre ha⁻¹ PE + 2 HW (40, 60 DAS) gave highest plant height (22.87 cm.) which was statistically at par with all the herbicides applied.

Table 3: Effect of weed control measures on plant height (cm) in cumin

Treatment	Plant height (cm.)		
	30 DAS	60 DAS	At harvest
Weed check (control)	4.80	11.48	17.35
Hand weeding (40 DAS)	5.41	13.40	19.20
Pendimethalin @ 1.0 litre ha ⁻¹ PE	5.75	15.40	21.50
Pendimethalin @ 1.2 litre ha ⁻¹ PE + 1 HW (40 DAS)	6.00	16.20	22.60
Pendimethalin @ 1.0 litre ha ⁻¹ PE + 2 HW (40, 60 DAS)	6.61	16.50	22.83
Oxyfluorfen @ 0.15 litre ha ⁻¹ PE	5.60	14.30	20.80
Oxyfluorfen @ 0.30 litre ha ⁻¹ PE + 1 HW (40 DAS)	5.67	14.90	21.10
Oxyfluorfen @ 0.15 litre ha ⁻¹ PE + 2 HW (40, 60 DAS)	5.90	15.80	22.30
Oxadiargyl @ 0.06 litre ha ⁻¹ PE	5.85	15.60	21.80
Oxadiargyl @ 0.075 litre ha ⁻¹ PE + 1 HW (40 DAS)	6.30	16.30	22.70
Oxadiargyl @ 0.06 litre ha ⁻¹ PE + 2 HW (40, 60 DAS)	7.00	17.90	22.87
Weed free	7.71	19.82	24.73
S. Em. ±	0.21	0.65	0.63
C. D. at 5%	0.61	1.92	1.84



4.1. 2: Number of branches per plant:

A perusal of data presented in Table 4 & Fig. 3 infer that application of all the treatments significantly increased the number of branches/plant recorded at 60 and 90 DAS as compared to control. At both the stages, the maximum number of branches/plant were counted under the application of weed free treatment (6.40 & 7.30) followed by Oxadiargyl @ 0.06 litre ha⁻¹ PE + 2 HW (40, 60 DAS) which were significantly higher over Pendimethalin @ 1.0 litre ha⁻¹ PE + 2 HW (40, 60 DAS), Oxadiargyl @ 0.075 litre ha⁻¹ PE + 1 HW (40 DAS) and Oxyfluorfen @ 0.15 litre ha⁻¹ PE + 2 HW (40, 60 DAS). The magnitude of increase in branches per plant was by 9.43, 13.72 & 20.83 per cent, respectively with respect to Oxadiargyl @ 0.06 litre ha⁻¹ PE + 2 HW (40, 60 DAS) treatment.

4.1.3: Days to 50% flowering

A perusal of data presented in Table 4 & Fig. 4 reveals that the effect of weed management methods on days to 50% flowering of cumin was statistically significant. It is observed that the weed free treatment recorded the minimum days to 50% flowering (53) followed by Oxadiargyl @ 0.06 litre ha⁻¹ PE + 2 HW (40, 60 DAS) and Pendimethalin @ 1.0 litre ha⁻¹ PE + 2 HW (40, 60 DAS), which recorded values of (55) and (55) respectively. The most maximum days to 50% flowering i.e. 60 & 62 were recorded by hand weeding (40 DAS) and control.

Table 4: Effect of weed control measures on number of branches/plant and days to 50 % flowering in cumin

Treatment	Number of branches/plant		days to 50 % flowering
	60 DAS	90 DAS	
Weed check (control)	3.20	3.37	62.00
Hand weeding (40 DAS)	4.00	4.30	60.00
Pendimethalin @ 1.0 litre ha ⁻¹ PE	4.50	4.80	59.00
Pendimethalin @ 1.2 litre ha ⁻¹ PE + 1 HW (40 DAS)	5.00	5.40	56.00

Pendimethalin @ 1.0 litre ha ⁻¹ PE + 2 HW (40, 60 DAS)	5.30	5.70	55.00
Oxyfluorfen @ 0.15 litre ha ⁻¹ PE	4.10	4.40	59.00
Oxyfluorfen @ 0.30 litre ha ⁻¹ PE + 1 HW (40 DAS)	4.30	4.60	59.00
Oxyfluorfen @ 0.15 litre ha ⁻¹ PE + 2 HW (40, 60 DAS)	4.80	5.20	58.00
Oxadiargyl @ 0.06 litre ha ⁻¹ PE	4.50	4.90	58.00
Oxadiargyl @ 0.075 litre ha ⁻¹ PE + 1 HW (40 DAS)	5.10	5.60	57.00
Oxadiargyl @ 0.06 litre ha ⁻¹ PE + 2 HW (40, 60 DAS)	5.80	6.30	55.00
Weed free	6.40	7.30	53.00
S. Em. ±	0.21	0.31	0.95
C. D. at 5%	0.60	0.92	2.79

4.2 Yield and yield attributes:

4.2.1: Number of umbels per plant:

An examination of data presented in Table 5 & Fig. 5 reveals that the maximum number of umbels per plant were found with the weed free treatment (15.50) which was significantly higher over control (6.20). The application of Oxadiargyl @ 0.06 litre ha⁻¹ PE + 2 HW (40, 60 DAS) also significantly improved number of umbels per plant by 1.83 over Oxyfluorfen @ 0.15 litre ha⁻¹ PE + 2 HW (40, 60 DAS) but was at par with Pendimethalin @ 1.2 litre ha⁻¹ PE + 1 HW (40 DAS), Pendimethalin @ 1.0 litre ha⁻¹ PE + 2 HW (40, 60 DAS) and Oxadiargyl @ 0.075 litre ha⁻¹ PE + 1 HW (40 DAS) (13.50, 14.00 & 13.90), respectively .

4.2.2: Number of umbellets per plant:

It is apparent from data Table 5 & Fig. 5 that crop under the influence of weed free and Oxadiargyl @ 0.06 litre ha⁻¹ PE + 2 HW (40, 60 DAS) recorded significantly higher number of umbellets per plant over control. The aforesaid treatment increased

the number of umbellets per plant by 395.46 and 366.05 per cent, respectively over control. While, Oxadiargyl @ 0.06 litre ha⁻¹ PE + 2 HW (40, 60 DAS) was found at par with Pendimethalin @ 1.0 litre ha⁻¹ PE + 2 HW (40, 60 DAS) with respect to number of umbellets per plant.

4.2.3: Test weight (g)

A reference of data Table 5 & Fig. 6 explicit that application of weed free treatment recorded significantly highest test weight of cumin as compared to all other treatment tested. Weed free treatment gave 61 per cent higher test weight of cumin as compared to treatment control (3.00 g). Among the herbicides applied, Oxadiargyl @ 0.06 litre ha⁻¹ PE + 2 HW (40, 60 DAS) gave highest test weight (4.10 g) which was statistically at par with all the herbicides applied.

Table 5: Effect of weed control measures on number of umbels per plant, number of umbellets per plant and test weight (g) in cumin

Treatment	Number of umbels per plant	Number of umbellets per plant	Test weight (g)
Weed check (control)	6.20	18.09	3.00
Hand weeding (40 DAS)	9.50	33.36	3.40
Pendimethalin @ 1.0 litre ha ⁻¹ PE	11.50	49.56	3.60
Pendimethalin @ 1.2 litre ha ⁻¹ PE + 1 HW (40 DAS)	13.50	64.85	3.90
Pendimethalin @ 1.0 litre ha ⁻¹ PE + 2 HW (40, 60 DAS)	14.00	79.19	4.00
Oxyfluorfen @ 0.15 litre ha ⁻¹ PE	11.00	42.40	3.50
Oxyfluorfen @ 0.30 litre ha ⁻¹ PE + 1 HW (40 DAS)	11.30	45.15	3.55
Oxyfluorfen @ 0.15 litre ha ⁻¹ PE + 2 HW (40, 60 DAS)	12.53	57.87	3.80
Oxadiargyl @ 0.06 litre ha ⁻¹ PE	12.30	55.40	3.75
Oxadiargyl @ 0.075 litre ha ⁻¹ PE + 1 HW	13.90	69.39	3.95

(40 DAS)			
Oxadiargyl @ 0.06 litre ha ⁻¹ PE + 2 HW (40, 60 DAS)	14.36	84.31	4.10
Weed free	15.50	89.63	4.83
S. Em. ±	0.36	1.78	0.21
C. D. at 5%	1.04	5.23	0.61

4.2.4: Seed yield per plant (g)

A critical examination of data presented in Table 6 & Fig. 6 indicates that seed yield per plant (g) was enhanced significantly with application of weed free treatment which was 315.55 per cent higher over control. Among the herbicides application of Oxadiargyl @ 0.06 litre ha⁻¹ PE + 2 HW (40, 60 DAS) increased seed yield per plant (g) by 5.55, 20.42 and 5.55 per cent respectively as compared to Oxadiargyl @ 0.075 litre ha⁻¹ PE + 1 HW (40 DAS), Oxyfluorfen @ 0.15 litre ha⁻¹ PE + 2 HW (40, 60 DAS) and Pendimethalin @ 1.0 litre ha⁻¹ PE + 2 HW (40, 60 DAS).

Fig. 4: Effect of weed control measures on days to 50% flowering

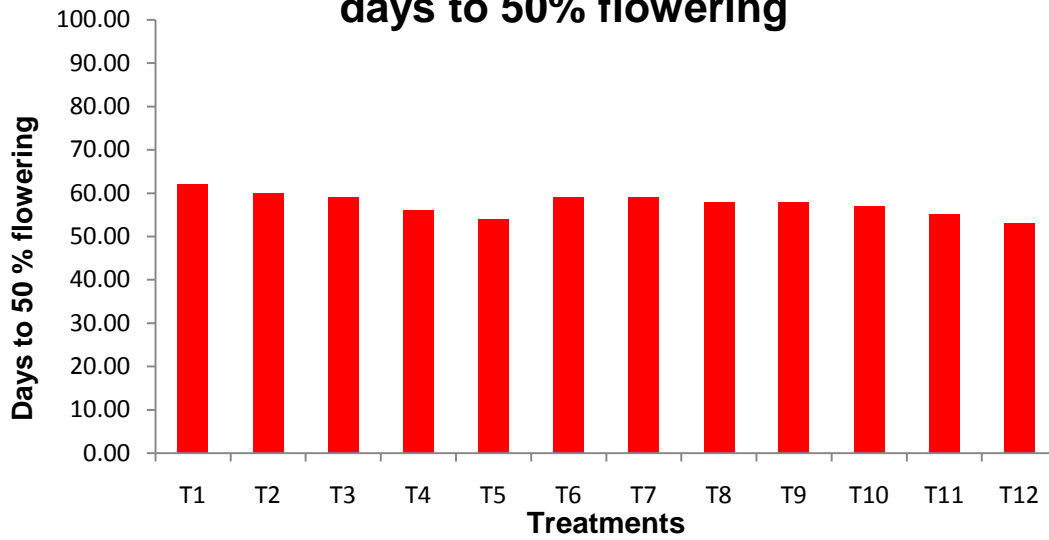
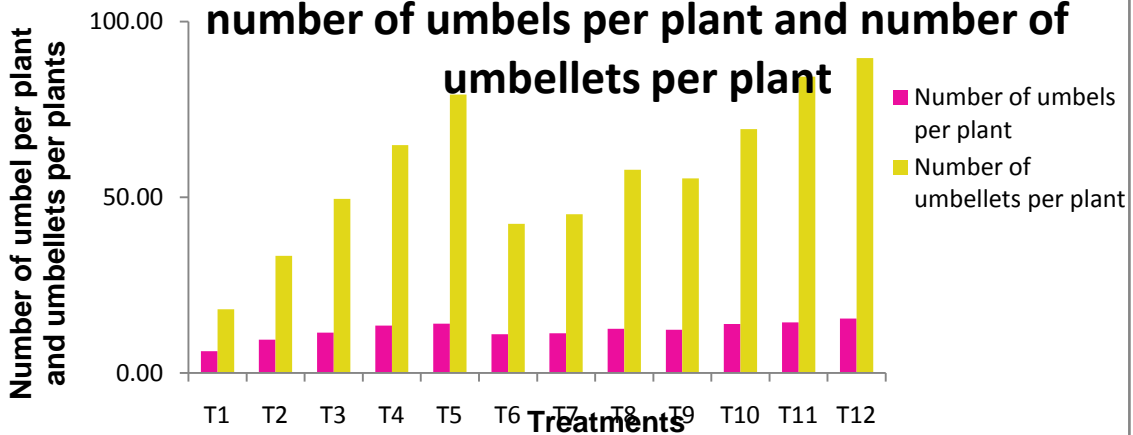


Fig. 5: Effect of weed control measures on number of umbels per plant and number of umbellets per plant



4.2.5: Seed yield (q/ha)

A perusal of data Table 6 & Fig. 7 reveals that weed free treatment significantly increased the seed yield of cumin as compared to control (2.30 q/ha). Among the herbicides applied, application of Oxadiargyl @ 0.06 litre ha⁻¹ PE + 2 HW (40, 60 DAS) obtained maximum seed yield of 5.95 q/ha which was 14.42, 25.26 and 14.42 per cent higher as compared to Oxadiargyl @ 0.075 litre ha⁻¹ PE + 1 HW (40 DAS), Oxyfluorfen @ 0.15 litre ha⁻¹ PE + 2 HW (40, 60 DAS) and Pendimethalin @ 1.0 litre ha⁻¹ PE + 2 HW (40, 60 DAS), treatments, respectively. Application of weed free treatment produced seed yield of 6.00 q/ha which was at par with Oxadiargyl @ 0.06 litre ha⁻¹ PE + 2 HW (40, 60 DAS) treatment.

4.2.6: Straw yield (q/ha)

It is evident from the data Table 6 & Fig. 7 that application of weed free treatment recorded significantly highest straw yield as compared to control (5.10 q/ha) and it was 82.35 per cent higher as compared to control. Among the herbicides, Oxadiargyl @ 0.06 litre ha⁻¹ PE + 2 HW (40, 60 DAS) gave highest straw yield (9 q/ha) which was statistically at par with all the herbicides applied.

4.2.7: Harvest index (%)

It is obvious from the data (Table 6 & Fig. 8) that application of Oxadiargyl @ 0.06 litre ha⁻¹ PE + 2 HW (40, 60 DAS) recorded significantly highest harvest index (%) of cumin (39.79%) as compared to all other treatments. But it was statistically at par with all the herbicides applied. Weed free treatment gave 26.15 per cent higher harvest index (%) compared with treatment control (31.08%).

Table 6: Effect of weed control measures on seed yield per plant (g), seed yield (q/ha), straw yield (q/ha) and harvest index (%) in cumin

Treatment	Seed yield per plant (g)	seed yield (q/ha)	Straw yield (q/ha)	Harvest index (%)
Weed check (control)	0.45	2.30	5.10	31.08
Hand weeding (40 DAS)	0.87	3.10	7.30	30.23
Pendimethalin @ 1.0 litre ha ⁻¹ PE	1.29	4.30	7.83	35.44
Pendimethalin @ 1.2 litre ha ⁻¹ PE + 1 HW (40 DAS)	1.53	5.00	8.50	37.03
Pendimethalin @ 1.0 litre ha ⁻¹ PE + 2 HW (40, 60 DAS)	1.62	5.20	8.80	37.14
Oxyfluorfen @ 0.15 litre ha ⁻¹ PE	1.05	3.60	7.30	33.05
Oxyfluorfen @ 0.30 litre ha ⁻¹ PE + 1 HW (40 DAS)	1.38	4.60	8.10	36.22
Oxyfluorfen @ 0.15 litre ha ⁻¹ PE + 2 HW (40, 60 DAS)	1.42	4.75	8.30	36.39
Oxadiargyl @ 0.06 Litre ha ⁻¹ PE	1.35	4.50	8.00	36.00
Oxadiargyl @ 0.075 litre ha ⁻¹ PE + 1 HW (40 DAS)	1.62	5.20	8.80	37.14
Oxadiargyl @ 0.06 litre ha ⁻¹ PE + 2 HW (40, 60 DAS)	1.71	5.95	9.00	39.79
Weed free	1.87	6.00	9.30	39.21
S. Em. ±	0.08	0.25	0.45	1.77
C. D. at 5%	0.23	0.73	1.33	5.18

Fig. 6: Effect of weed control measures on test weight (g) and seed yield per plant (g)

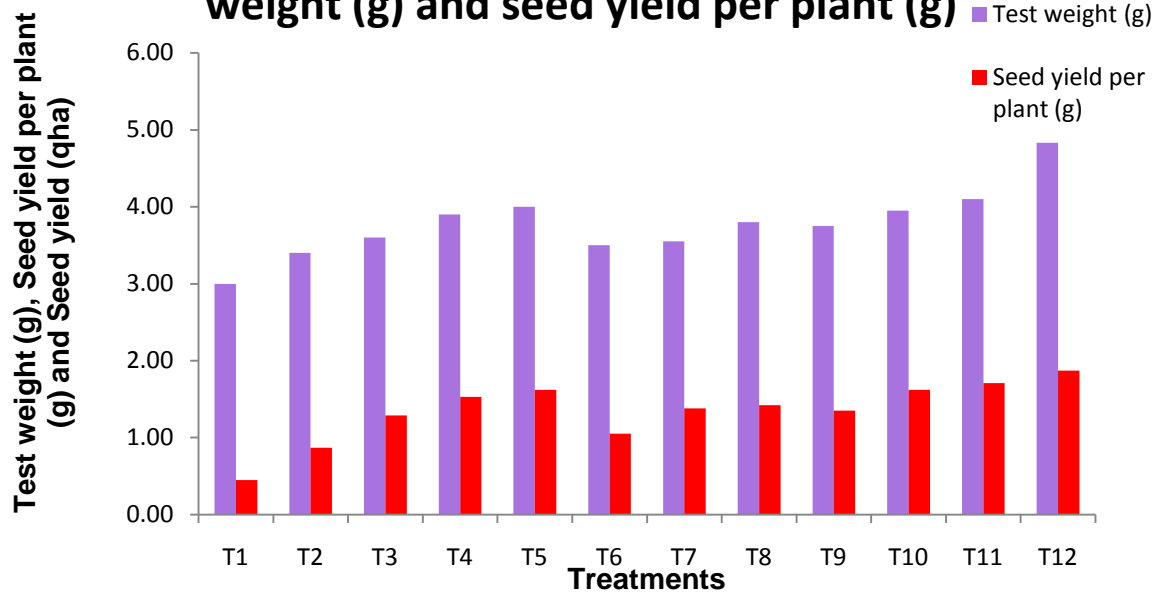
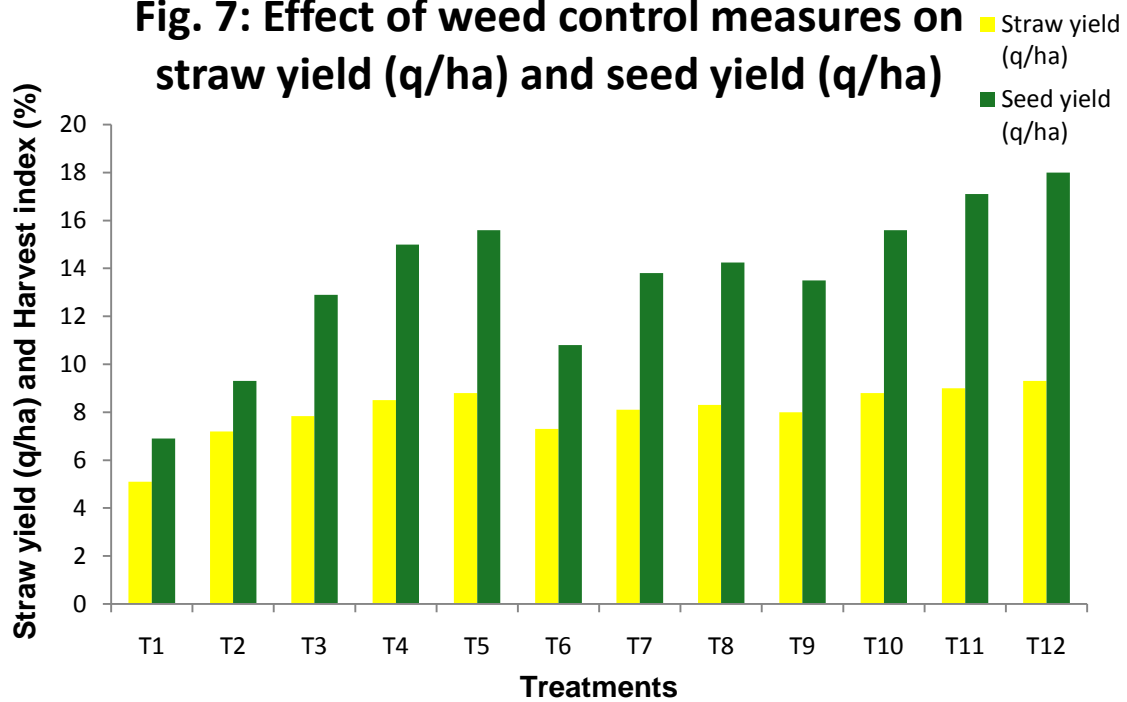


Fig. 7: Effect of weed control measures on straw yield (q/ha) and seed yield (q/ha)



4.3: Studies on weeds:

4.3.1: Weed population per metre square

An appraisal of data Table 7 & Fig. 9 reveals that at 30 DAS the minimum weed population/m² (3.0) was recorded with weed free treatment which was significantly lower by 107.5 weeds over weedy check treatment.

Further, at 60 DAS, it was observed with weed free treatment which recorded the minimum weed population/m² (3.00) followed by Oxadiargyl @ 0.075 litre ha⁻¹ PE + 1 HW (40 DAS) and Oxadiargyl @ 0.06 litre ha⁻¹ PE + 2 HW (40, 60 DAS) and recorded a value 8.00 and 8.40 respectively. The maximum weed population/m² at this stage was recorded in weedy check (130.30).

At 90 DAS, weedy check treatment gave 133.80 higher weed population/m² as compare to weed free treatment (2.00). Among the herbicides Oxadiargyl @ 0.06 litre ha⁻¹ PE + 2 HW (40, 60 DAS) gave minimum (6.00) weed population/m² as compare to all the herbicides applied.

At harvesting stage a similar trend was observed where weed free treatment recorded the minimum weed population/m² (1.00) followed by Oxadiargyl @ 0.06 litre ha⁻¹ PE + 2 HW (40, 60 DAS) and Pendimethalin @ 1.0 litre ha⁻¹ PE + 2 HW (40, 60 DAS)) which recorded a value 6.20 and 8.30, respectively. The maximum weed population/m² at this stage was recorded in control (140.10).

Table 7: Effect of weed control measures on weed population/m² in cumin

Treatment	Weed population/m ²			
	30 DAS	60 DAS	90 DAS	At harvest
Weed check (control)	110.50	130.30	135.80	140.10
Hand weeding (40 DAS)	108.20	60.30	63.20	64.50
Pendimethalin @ 1.0 litre ha ⁻¹ PE	15.60	20.80	21.30	21.60
Pendimethalin @ 1.2 litre ha ⁻¹ PE + 1 HW (40 DAS)	13.20	10.40	11.20	11.30
Pendimethalin @ 1.0 litre ha ⁻¹ PE + 2 HW (40, 60 DAS)	15.80	10.60	8.20	8.30
Oxyfluorfen @ 0.15 litre ha ⁻¹ PE	22.50	28.20	29.00	29.50
Oxyfluorfen @ 0.30 litre ha ⁻¹ PE + 1 HW (40 DAS)	21.20	18.30	19.20	19.50
Oxyfluorfen @ 0.15 litre ha ⁻¹ PE + 2 HW (40, 60 DAS)	22.30	18.50	15.10	15.30
Oxadiargyl @ 0.06 litre ha ⁻¹ PE	12.80	17.70	18.10	18.30
Oxadiargyl @ 0.075 litre ha ⁻¹ PE + 1 HW (40 DAS)	11.20	8.00	9.00	9.50
Oxadiargyl @ 0.06 litre ha ⁻¹ PE + 2 HW (40, 60 DAS)	12.60	8.40	6.00	6.20
Weed free	3.00	3.00	2.00	1.00
S. Em. ±	1.21	1.17	0.84	2.00
C. D. at 5%	3.54	3.44	2.46	2.93

Fig. 8 Effect of weed control measures on harvest index (%)

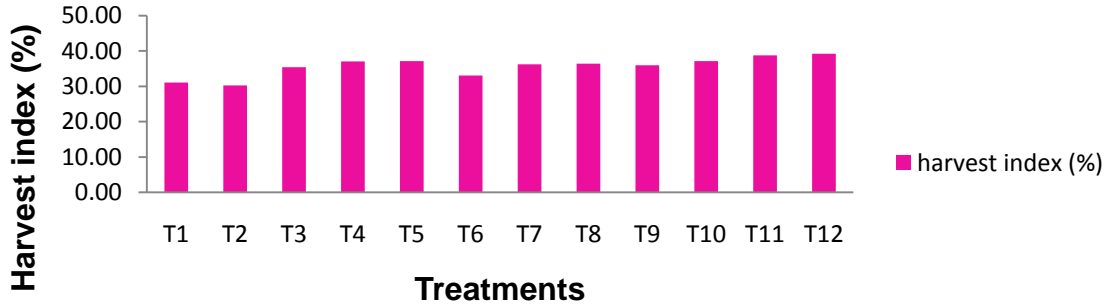
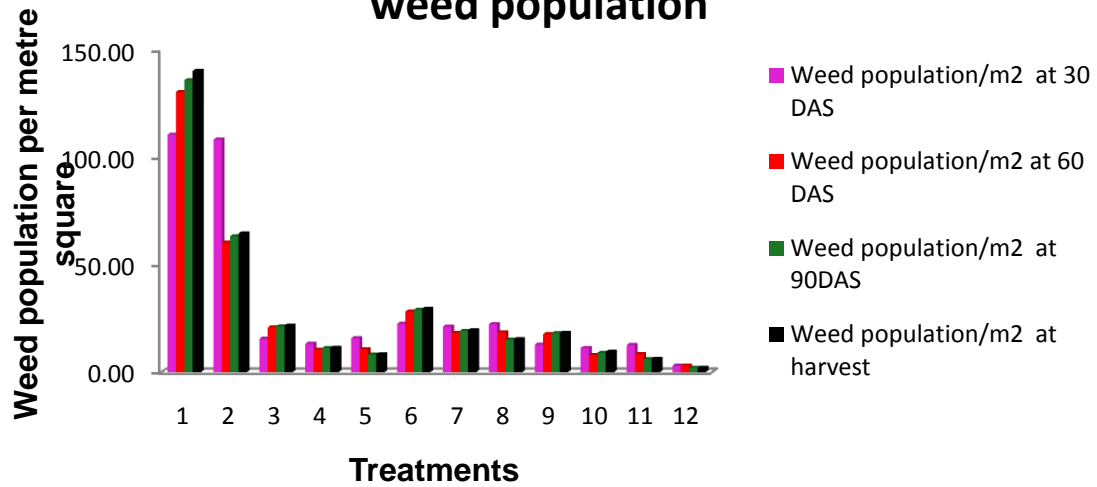


Fig. 9 Effect of weed control measures on weed population



4.3.2: Weed dry matter (g) per metre square

A perusal of data Table 8 & Fig. 10 reveals that weedy check treatment recorded significantly highest weed dry matter g/m^2 observed at 30, 60, 90 DAS and at harvest stage as compared to all other treatments. At 30 DAS weedy check treatment gave 61.30 per cent higher weed dry matter g/m^2 as compared to weed free treatment (1.00 g) but was at par with hand weeding (40 DAS) (60.50 g). Among the herbicides Oxadiargyl @ 0.075 litre ha^{-1} PE + 1 HW (40 DAS) found minimum dry matter g/m^2 (6.27 g) followed by Oxadiargyl @ 0.06 litre ha^{-1} PE + 2 HW (40, 60 DAS) and Oxadiargyl @ 0.06 litre ha^{-1} PE.

At 60 DAS weed free treatment recorded the minimum weed dry matter g/m^2 (1.20 g) followed by Oxadiargyl @ 0.06 litre ha^{-1} PE + 2 HW (40, 60 DAS) and Oxadiargyl @ 0.075 litre ha^{-1} PE + 1 HW (40 DAS) which recorded a value (8.10 g) and (8.50 g) respectively. The maximum weed dry matter g/m^2 at this stage (140.10 g) was recorded in control.

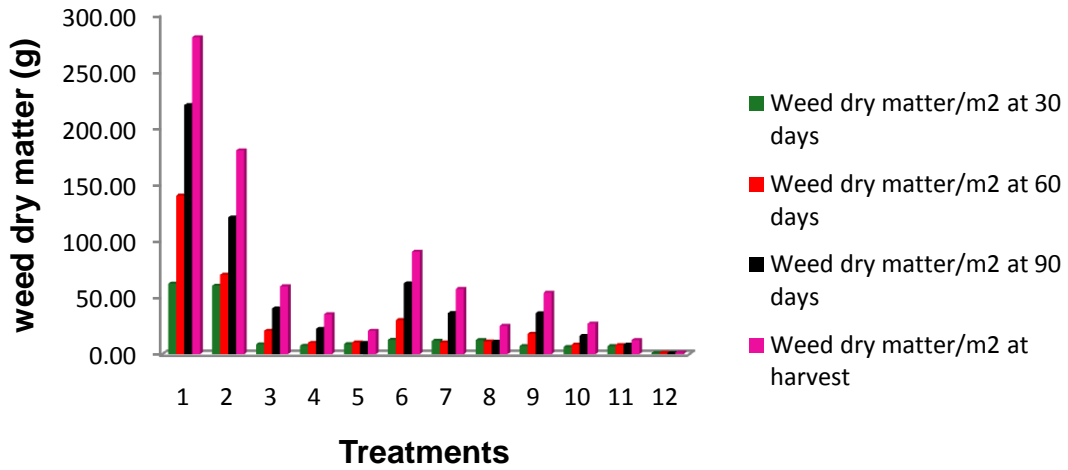
Further, at 90 DAS, it was observed that weed free treatment recorded the minimum dry matter g/m^2 of weeds as compared to all other treatments. Among the herbicides, Oxadiargyl @ 0.06 litre ha^{-1} PE + 2 HW (40, 60 DAS) recorded significantly lower dry matter g/m^2 of weeds (8.50 g/m^2) as compared to all other herbicides, applied.

At harvest stage, weed free treatment recorded the minimum weed dry matter g/m^2 (1.40 g) followed by Oxadiargyl @ 0.06 litre ha^{-1} PE + 2 HW (40, 60 DAS) and Pendimethalin @ 1.0 litre ha^{-1} PE + 2 HW (40, 60 DAS) which recorded a value (12.40 g) and (20.60 g) respectively. The maximum weed dry matter g/m^2 at this stage (280 g) was recorded in control.

Table 8: Effect of weed control measures on weed dry matter g/m² in cumin

Treatment	Weed dry matter g/m ²			
	30 DAS	60 DAS	90DAS	At harvest
Weed check (control)	62.30	140.10	220.00	280.00
Hand weeding (40 DAS)	60.50	70.20	120.80	180.00
Pendimethalin @ 1.0 litre ha ⁻¹ PE	8.73	20.60	40.40	60.00
Pendimethalin @ 1.2 litre ha ⁻¹ PE + 1 HW (40 DAS)	7.39	10.00	22.30	35.20
Pendimethalin @ 1.0 litre ha ⁻¹ PE + 2 HW (40, 60 DAS)	8.84	10.30	10.00	20.60
Oxyfluorfen @ 0.15 litre ha ⁻¹ PE	12.60	30.10	62.60	90.50
Oxyfluorfen @ 0.30 litre ha ⁻¹ PE + 1 HW (40 DAS)	11.87	10.30	36.30	57.60
Oxyfluorfen @ 0.15 litre ha ⁻¹ PE + 2 HW (40, 60 DAS)	12.48	11.20	11.00	25.00
Oxadiargyl @ 0.06 litre ha ⁻¹ PE	7.17	18.00	36.10	54.30
Oxadiargyl @ 0.075 litre ha ⁻¹ PE + 1 HW (40DAS)	6.27	8.50	16.20	27.00
Oxadiargyl @ 0.06 litre ha ⁻¹ PE + 2 HW (40, 60 DAS)	7.05	8.10	8.50	12.40
Weed free	1.00	1.20	1.00	1.40
S. Em. ±	0.71	1.05	1.74	2.25
C. D. at 5%	2.08	3.07	5.11	6.60

Fig. 10 Effect of weed control measures on weed dry matter per metre square



4.4 Economics of the different treatments for cumin production

A critical examination of data (Table 9) reveals that the highest gross return was recorded under weed free treatment (72000 Rs/ha). While among the herbicides, Oxadiargyl @ 0.06 litre ha⁻¹ PE + 2 HW (40, 60 DAS) exhibited 14.42, 25.26 and 14.42 per cent higher gross return over Oxadiargyl @ 0.075 litre ha⁻¹ PE + 1 HW (40 DAS), Oxyfluorfen @ 0.15 litre ha⁻¹ PE + 2 HW (40, 60 DAS) and Pendimethalin @ 1.0 litre ha⁻¹ PE + 2 HW (40, 60 DAS), respectively.

Similarly, application of Oxadiargyl @ 0.06 litre ha⁻¹ PE + 2 HW (40, 60 DAS) significantly increased the net return (Rs/ha) and B:C ratio as compared to control, Pendimethalin @ 1.0 litre ha⁻¹ PE + 2 HW (40, 60 DAS), Oxyfluorfen @ 0.15 litre ha⁻¹ PE + 2 HW (40, 60 DAS) and Oxadiargyl @ 0.075 litre ha⁻¹ PE + 1 HW (40 DAS). The magnitude of increase in net return with the application of Oxadiargyl @ 0.06 litre ha⁻¹ PE + 2 HW (40, 60 DAS) was in the order of Rs. 38800, Rs. 9950, Rs. 14750 and Rs. 7000/ha over control, Pendimethalin @ 1.0 litre ha⁻¹ PE + 2 HW (40, 60 DAS), Oxyfluorfen @ 0.15 litre ha⁻¹ PE + 2 HW (40, 60 DAS) and Oxadiargyl @ 0.075 litre ha⁻¹ PE + 1 HW (40 DAS), respectively. Among the herbicides applied, Oxadiargyl @ 0.06 litre ha⁻¹ PE + 2 HW (40, 60 DAS) recorded maximum B:C ratio of 1.87 which was significantly higher over control (0.39), Pendimethalin @ 1.0 litre ha⁻¹ PE + 2 HW (40, 60 DAS) (1.41), Oxyfluorfen @ 0.15 litre ha⁻¹ PE + 2 HW (40, 60 DAS) (1.26), Oxadiargyl @ 0.075 litre ha⁻¹ PE + 1 HW (40 DAS) (1.71) and weed free (1.31). But it was at par with Oxadiargyl @ 0.075 litre ha⁻¹ PE + 1 HW (40 DAS) and Oxadiargyl @ 0.06 litre ha⁻¹ PE with respect to B : C ratio.

Table 9: Economic of different treatments.

Treatment	Total cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	Benefit : cost ratio
Weed check (control)	19850.00	27600.00	7750.00	0.39
Hand weeding (40 DAS)	21850.00	37200.00	15350.00	0.70
Pendimethalin @ 1.0 litre ha ⁻¹ PE	21800.00	51600.00	29800.00	1.36
Pendimethalin @ 1.2 litre ha ⁻¹ PE + 1 HW (40 DAS)	24190.00	60000.00	35810.00	1.48
Pendimethalin @ 1.0 litre ha ⁻¹ PE + 2 HW (40, 60 DAS)	25800.00	62400.00	36600.00	1.41
Oxyfluorfen @ 0.15 litre ha ⁻¹ PE	21200.00	43200.00	22000.00	1.03
Oxyfluorfen @ 0.30 litre ha ⁻¹ PE + 1 HW (40 DAS)	24550.00	55200.00	30650.00	1.24
Oxyfluorfen @ 0.15 litre ha ⁻¹ PE + 2 HW (40, 60 DAS)	25200.00	57000.00	31800.00	1.26
Oxadiargyl @ 0.06 litre ha ⁻¹ PE	20850.00	54000.00	33200.00	1.59
Oxadiargyl @ 0.075 litre ha ⁻¹ PE + 1 HW (40 DAS)	23100.00	62400.00	39550.00	1.71
Oxadiargyl @ 0.06 litre ha ⁻¹ PE + 2 HW (40, 60 DAS)	24850.00	71400.00	46550.00	1.87
Weed free	29850.00	72000.00	39150.00	1.31
S. Em. ±		2967.09	3110.10	0.13
C. D. at 5%		8702.18	9121.61	0.38

Chapter- V

DISCUSSION

The findings of the investigation entitled “Weed management in cumin (*Cuminum cyminum* L.)” has been described and explained with support of relevant research work published by earlier workers on the subject as follows:

5.1 Growth Parameters:

Application of herbicides and weed management treatments significantly increased the plant height at different growth stages, number of branches, and reduced the duration of 50% flowering of cumin (Table 3 & 4).

It is an established fact that cumin crop is a short stature crop with slow initial growth, it is heavily infested with weeds. Weeds compete with crop for nutrients, moisture, sunlight and space and reduce the growth of cumin. Growers often assume that removal of weeds at any time during the growing season is equally beneficial to the crop. However, substantial evidences (Zimdahl, 1980) indicate that time of weed removal is important as removal per season. Weeds if not controlled cause maximum loss. The crop is more susceptible to weed competition during the early growth period and if the weed problem is not managed properly, there is strong chance of crop failure, (Meena *et al.* 2009). Generally cumin farmer control weed manually, which is labour consuming. Wherever, there is shortage of manpower during early growth stage and therefore, complete weeding is not possible. Herbicides are most effective and economic for weed control measure. The improvement in overall growth parameters of cumin plants due to weed management treatment was also noticed by Rathore *et al.* (1990), Meena *et al.* (2009) and Yadav *et al.* (2012).

5.2 Yield and Yield Parameters:

During the investigation, the cumin crop under the influence of weed management treatments recorded significant improvement in number of umbels per plant, number of umbellets per plant, test weight (g), seed yield per plant, seed yield, straw yield and harvest index (Table 5 & 6). Among the various weed management treatments, weed free found significantly superior over all other treatments tested and increased the number of umbels per plant, number of umbellets per plant, test weight (g), seed yield per plant, seed yield, straw yield and harvest index by 150, 395.46, 61, 315.55, 160.86, 82.35 and 26.15 per cent over control, respectively. While among the herbicides treatments, Oxadiargyl @ 0.06 litre ha⁻¹ PE + 2 HW (40, 60 DAS) treatment significantly increased the number of umbels per plant, number of umbellets per plant, test weight (g), seed yield per plant, seed yield, straw yield and harvest index by 131.61, 366.05, 36.66, 280, 158.69, 76.47 and 28.02 per cent over control, respectively.

The positive response of aforesaid parameter to weed management methods could be ascribed to an overall improvement in crop growth as evident from increased plant height and branches per plant at successive growth stages. The cumulative improvement in yield parameters viz. umbels per plant, umbellets per plant and test weight due to weed management at early growth stages ultimately increased the seed yield of cumin. The results are in close confirmity with the findings of Yadav *et al.* (2005), Meena *et al.* (2009) and Yadav *et al.* (2012).

The significant improvement in straw yield, biological yield and harvest index seems to be on account of overall improvement in vegetative and reproductive components of the cumin crop. These increases were ascribed due to positive effect of weed management practices on photosynthetic efficiency production and accumulation of more photosynthates, which ultimately resulted in higher translocation of metabolites. Similar improvement in seed yield, straw yield and harvest index were also recorded by Rathore *et al.* (1990), Kumar (2001), Mehriya *et al.* (2007) and Meena *et al.* (2009) in cumin crop.

5.3 Studies on weeds

Application of weed management treatments significantly reduced the number of weeds and dry matter of weeds recorded at different growth stages.

The dominant weed flora in the experimental field consisted of *Chenopodium album* L., *Chenopodium murale* L., *Cynodon dactylon* (L.)Pers, *Cyperus rotundus* L., *Melilotus alba* Desr., *Argemone mexicana* L., *Asphodelus tenuifolius* Cavan , *plantago pumila* Willd. goldan dock (*Rumex dentatus* L.), Wild on (*Asphodeuls tenuiflius* L.), and launea (*Launea asplenifonifolia* L.) However, predominant weeds were *c. murale* L., *C. album* L., *R. dentatus* L., *R. dentatus* L.

It is known fact that predominant weed flora of field gave the higher weed dry matter as compared to weed free plots. While weed free environment of crop gave highest yield of crop. Initial growth of cumin is slow and it takes time in germination and establishment. At many places, swoing of cumin is mainly done by broadcasting method in which manual control of weed is very difficult for germination and establishment, 2 irrigations during first 10 days of crop is pre-requisite and it gives chance to establish the weeds.

Further, weeds were effectively controlled under weed free and Oxydiargyl @ 0.06 kg ai/ha + 2 HW treatments and hence there was no severe competition by weeds for moisture and nutrients which resulted into induced plant height of cumin. Similar results were also reported by Rathore *et al.* (1990), Yadav *et al.* (2005), Mehriya *et al.* (2007), Meena *et al.* (2009) and Yadav *et al.* (2012).

5.4 Economics

In the present study among the different weed management methods maximum net return (Rs 46550.00) and highest benefit : cost ratio of 1.87:1 were obtained with an application of Oxadiargyl @ 0.06 litre ha⁻¹ + 2 HW (40, 60 DAS) while the minimum net return and benefit:cost ratio was recorded by weedy check.

Patel and Mehta (1989) revealed that weeds severely compete with cumin crop, which required to be controlled either by hand weeding or chemical methods. Hand weeding is costly and cumbersome, therefore, herbicide either alone or integrated with one hand weeding can be adopted most effectively for better profit.

Meena *et al.* (2009) concluded that pre-emergence application of Oxadiargyl @ 75 g/ha + hand weeding at 45 DAS is safe and economical to control weeds effectively and obtain highest benefit :cost ratio in cumin.

Yadav *et al.* (2012) reported highest benefit :cost ratio with treatment Oxadiargyl @ 50 g/ha 20 DAS (2.17) which was closely followed by treatment Oxadiargyl @ 50 g/ha 20 DAS + HW (2.06). Similar trend was also observed by Mehriya *et al.* (2007).

Table10:Correlation coefficients and regression lines showing relationship between Independent variable (x) and dependent variable (y) under different weed management method in cumin

Dependent variable (x) in cumin	Independent variable (y)	Correlation coefficient (r)	Regression line (y = a + by (x))
Branches/plant (60 DAS)	Plant height at harvest (cm)	0.941	Y = 2.111x + 11.62
Branches/plant (90 DAS)	Plant height at harvest (cm)	0.935	Y = 1.755x + 12.59
Seed yield (q/ha)	Plant height at harvest (cm)	0.970	Y = 1.734x + 13.80
Seed yield per plant (g)	Plant height at harvest (cm)	0.979	Y = 4.745x + 15.25
No. of umbels per plant	No. of branches/plant (60 DAS)	0.944	Y = 0.321x + 0.855
No. of umbellets per plant	No. of branches/plant (60 DAS)	0.979	Y = 0.039x + 2.496
Plant height at harvest	Weed Population/m ² at harvest	0.913	Y = 0.045x + 22.94
Seed yield (q/ha)	No. of umbels per plant	0.973	Y = 2.283x + 1.811
Seed yield (q/ha)	No. of umbellets per plant	0.963	Y = 19.15x - 29.17
Seed yield per plant (g)	No. of umbels per plant	0.985	Y = 6.265x + 3.694
Seed yield per plant (g)	No. of umbellets	0.945	Y = 51.49x - 11.91
	Plant height at	0.952	Y = 1.633x + 8.534

Straw yield (q/ha)	harvest (cm)		
Harvest index (%)	Seed yield(q/ha)	0.969	$Y = 0.370x - 8.669$
Harvest index (%)	Seed yield per plant (g)	0.950	$Y = 0.133x - 3.417$
No. of umbels per plant	No. of branches/plant (90 DAS)	0.931	$Y = 0.378x + 0.567$
No. of umbellets per plant	No. of branches/plant (90 DAS)	0.965	$Y = 0.046x + 2.501$
Seed yield (q/ha)	Test weight (g)	0.909	$Y = 0.380x + 2.061$
Seed yield per plant (g)	Test weight (g)	0.903	$Y = 1.025x + 2.400$
Harvest index (%)	Plant height at harvest (cm)	0.925	$Y = 0.631x - 0.848$
Days to 50% flowering	Plant height at harvest (cm)	0.933	$Y = 0.714x + 62.76$
Straw yield (q/ha)	No. of umbels per plant	0.977	$Y = 2.198x - 5.513$
Straw yield (q/ha)	No. of umbellets per plant	0.920	$Y = 17.56x - 83.54$

Dependent variable (x) in weed	Independent variable (y)	Correlation coefficient (r)	Regression line (y = a + by (x))
Weed Population/m ² at harvest	Plant height at harvest	0.913	$Y = 0.045x + 22.94$
Weed dry matter g/m ² at harvest	Weed Population/m ² at harvest	0.980	$Y = 0.467x - 4.085$
Weed dry matter g/m ² at harvest	Weed Population/m ² 30 DAS	0.939	$Y = 0.428x + 0.457$
Weed dry matter g/m ² at harvest	Weed Population/m ² 60 DAS	0.976	$Y = 0.426x - 2.127$
Weed dry matter g/m ² at harvest	Weed Population/m ² 90 DAS	0.981	$Y = 0.452x - 3.641$

CHAPTER- VI

SUMMARY, CONCLUSION AND SUGGESTION FOR FURTHER WORK

6.1 Summary

A field experiment entitled “Weed management in cumin (*Cuminum cyminum* L.)” was conducted during 2013-14 at research field of the Deptt. of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, Mandasaur. Twelve weed management treatments were laid in randomized block design with three replications. The findings of the experiment are summarized as given below:

6.1.1 Effect of weed management methods

The results of the experiment with respect to growth attributes of cumin crop revealed significant effect of weed management method on plant height, number of branches per plant and days to 50 % flowering. Weed free treatment recorded maximum plant height and number of branches at all the stages followed by Oxadiargyl @ 0.06 litre ha⁻¹ PE + 2 HW (40, 60 DAS) and minimum values recorded with Weedy check at all the stages.

Weed management method weed free treatment recorded minimum days to 50 % flowering at all the stages followed by Oxadiargyl @ 0.06 litre ha⁻¹ PE + 2 HW (40, 60 DAS) and maximum values recorded by Weedy check at all the stages.

Yield parameters and yield of the cumin were studied with respect to number of umbels per plant, number of umbellets per plant, test weight (g), seed yield per plant (g), seed yield (q/ha), straw yield (q/ha) and harvest index (%) which showed significant effect of weed management methods.

Weed management method weed free treatment recorded maximum number of umbels per plant, number of umbellets per plant, which was followed by Oxadiargyl @ 0.06 litre ha⁻¹ PE + 2 HW (40, 60 DAS). Lowest number of umbels per plant and number of umbellets per plant were measured in weedy check.

Maximum test weight was recorded in case of weed free treatment which was followed by Oxadiargyl @ 0.06 litre ha⁻¹ PE + 2 HW (40, 60 DAS). Minimum test weight was recorded in weedy check at harvest.

Maximum seed yield per plant, seed yield (q/ha), straw yield (q/ha) and harvest index (%) was observed with weed free treatment, which was followed by Oxadiargyl @ 0.06 litre ha⁻¹ PE + 2 HW (40, 60 DAS). minimum average seed yield per plant, seed yield (q/ha), straw yield (q/ha) and harvest index (%) was recorded in weed management method weedy check.

Weed studies like weed population per meter square and weed dry matter per meter square, revealed influence of weed management methods. Maximum weed population was measured in case of weedy check, which was followed by Hand weeding (40 DAS) at all different stages. Minimum weed population was with recorded weed free treatment. Highest weed dry matter was determined with weedy check, which was followed by Hand weeding (40 DAS) at all different stages.

6.2 Conclusion

On the basis of one year present experiment it may be concluded that weed free treatment resulted in realization of significantly higher growth attributes and higher yield and yield attributes followed by treatment Oxadiargyl @ 0.06 litre ha⁻¹ PE + 2 HW (40, 60 DAS).

However, application of Oxadiargyl @ 0.06 litre ha⁻¹ PE + 2 HW (40, 60 DAS) proved best treatment as it gave maximum net return of Rs 46550/ha with B:C ratio of 1.87 : 1 and seed yield 5.95 q/ha.

6.3 Suggestions for further work

- 1 The experiment may be repeated so the concrete conclusions may be drawn.
- 2 Combination of pre emergence herbicide with hand weeding if any may also be more tested.
- 3 Integrated weed management practices may be included in future research work.

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APPENDICES

Appendix - I Analysis of variance for the growth attributes of cumin under different treatments

Source of variation	d.f.	Mean sum of squares					
		Plant height (cm)			Number of braches per plant		Days to 50% flowering
		30 DAS	60 DAS	At harvest	30 DAS	60 DAS	
Replication	2	0.27	0.19	0.57	0.01	0.30	1.65
Treatment	11	1.77	13.31	11.01	2.19	3.13	20.46
Error	22	0.13	1.28	1.18	0.17	0.29	2.72
Total	35						

Appendix - II Analysis of variance for the yield and yield attributes of cumin under different treatments

Source of variation	d.f.	Mean sum of squares						
		Number of umbels per plant	Number of umbellets per plant	Test weight (g)	Seed yield per plant (g)	Seed yield (q/ha)	Straw yield (q/ha)	Harvest index (%)
Replication	2	0.40	4.11	0.02	0.00	0.00	0.08	0.78
Treatment	11	18.95	1363.93	0.60	0.47	3.45	3.79	23.68
Error	22	0.38	9.53	0.13	0.02	0.18	0.61	9.37
Total	35							

Appendix - III Analysis of variance for the studies on weeds of cumin under different treatments

Source of variation	d.f.								
		Weed population/m ²				Weed dry matter g/m ²			
		30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
Replication	2	1.08	2.75	1.75	2.75	0.32	0.17	4.41	2.02
Treatment	11	4132.85	3783.38	4211.60	4478.18	1310.22	4699.96	11912.80	19818.30
Error	22	4.38	4.13	2.11	2.99	1.51	3.29	9.12	15.19
Total	35								

Appendix-IV

General cost of cumin cultivation (Rs. ha⁻¹)

(Excluding the cost of the treatments inputs)

S.No.	Cultural practices	Cost ha ⁻¹ (Rs.)
1	Field preparation : (Ploughing + Planking)	3400
2	Application of fym	1000
3	Common dose of NPK (30:30:15 kg/ha)	2510
4	Seed (12 kg)	2040
5	Sowing of seed	800

6	Irrigation including labour charges	2600
7	Thinning	1300
8	Insecticide + Fungicides spray	1800
9	Harvesting	1400
10	Threshing + Winnowing	2000
11	Miscellaneous	1000
	TOTAL	19850

Common Cost of cultivation

19850

Appendix – V

Total cost of cultivation ha⁻¹ (Including cost of individual treatment combination)

S. No.	Treatment	Total cost under treatment (Rs. ha⁻¹)	Total cost of cultivation(Rs ha⁻¹)
1	Weedy check (control)	0.00	19850
2	Hand weeding (40 DAS)	2000	21850
3	Pendimethalin @ 1.0 litre ha ⁻¹ PE	1950	21800
4	Pendimethalin @ 1.2 litre ha ⁻¹ PE + 1 HW (40 DAS)	4340	24190
5	Pendimethalin @ 1.0 litre ha ⁻¹ PE + 2 HW (40, 60 DAS)	5950	25800
6	Oxyfluorfen @ 0.15 litre ha ⁻¹ PE	1350	21200
7	Oxyfluorfen @ 0.30 litre ha ⁻¹ PE + 1 HW (40 DAS)	4700	24550
8	Oxyfluorfen @ 0.15 litre ha ⁻¹ PE + 2 HW (40, 60 DAS)	5350	25200
9	Oxadiargyl @ 0.06 litre ha ⁻¹ PE	1000	20850
10	Oxadiargyl @ 0.075 litre ha ⁻¹ PE + 1 HW (40 DAS)	3250	23100
11	Oxadiargyl @ 0.06 litre ha ⁻¹ PE + 2 HW (40, 60 DAS)	5000	24850
12	Weed free	10000	29850

Appendix – VI

Economic of different treatment in cumin

S. No.	Treatment	Yield (q ha ⁻¹)	Gross return ha ⁻¹ @ Rs 1200/q	Cost of cultivation (Rs ha ⁻¹) (Including the cost of treatments)	Net profit (Rs ha ⁻¹)	Benefit : cost ratio
1	Weedy check (control)	2.30	27600	19850	7750	0.39:1
2	Hand weeding (40 DAS)	3.10	37200	21850	15350	0.70:1
3	Pendimethalin @ 1.0 litre ha ⁻¹ PE	4.30	51600	21800	29800	1.36:1
4	Pendimethalin @ 1.2 litre ha ⁻¹ PE + 1 HW (40 DAS)	5.00	60000	24190	33810	1.48:1
5	Pendimethalin @ 1.0 litre ha ⁻¹ PE + 2 HW (40, 60 DAS)	5.20	62400	25800	36600	1.41:1
6	Oxyfluorfen @ 0.15 litre ha ⁻¹ PE	3.60	43200	21200	22000	1.03:1
7	Oxyfluorfen @ 0.30 litre ha ⁻¹ PE + 1 HW (40 DAS)	4.60	55200	24550	30650	1.24:1
8	Oxyfluorfen @ 0.15 litre ha ⁻¹ PE + 2 HW (40, 60 DAS)	4.75	57000	25200	31800	1.26:1
9	Oxadiargyl @ 0.06 litre ha ⁻¹ PE	4.50	54000	20850	33200	1.29:1
10	Oxadiargyl @ 0.075 litre ha ⁻¹ PE + 1 HW (40 DAS)	5.20	62400	23100	39550	1.71:1
11	Oxadiargyl @ 0.06 litre ha ⁻¹ PE + 2 HW (40, 60 DAS)	5.95	71400	24850	46550	1.87:1
12	Weed free	6.00	72000	29850	39150	1.31:1

Cost of produce

Rs. 12,000/q

VITA

The author of this thesis **Lokendra Birla** was born on 5th May 1989 at Khandwa District (M.P.). He passed his Secondary Examination in the year 2005 and Senior Secondary Examination in the year 2007 from M.P. Board, Bhopal from M. D. Jain High Secondary School Sanawad, Distt. Khargone (M.P). With 67.8% and 60.66 % marks respectively.

He joined College of Horticulture, Mandasaur in 2008 and completed B.Sc. (Horti.) in the year 2012 with 1st division securing an OGPA of 7.13 on 10 point scale.

After graduation, he joined M.Sc. (Horticulture) in College of Horticulture, Mandasaur specialization in Plantation, Spices, Medicinal and Aromatic Crops. He has completed the entire course requirement for the above said Master Degree in the year 2013-14 with an OGPA of 7.20 on a 10 point scale.

He was allotted an interesting research problem entitled “**Weed management in cumin (*Cuminum cyminum* L.)**” of his choice for thesis work, which has been duly completed by him and presented in the form of this thesis.

(Lokendra Birla)