Chemical weed management in Mentha (*Mentha arvensis* L.) across northern eastern and central highlands of India

ABSTRACT

A field experiment was carried out during the *zaid* season of 2015 at Crop Research Farm of Sam Higginbottom Institute of Agriculture, Technology & Sciences, Allahabad to study the effect of various weed management options on weed dynamics and performance of mentha. Six treatments including hand weeding and un-weeded control were laid out in randomized block design with four replications. The results revealed that a significantly lower weed density and dry matter production, weed index and higher weed control efficiency were recorded under hand weeding which was found at par to fenoxaprop-p-ethyl 9.3% EC @ 100 ml/ha and propaquizafop 10% EC @ 75 ml/ha. The higher plant height, herbage yield (21.8 t/ha) and dry matter yield (6.00 t/ha) and oil yield (136.9 l/ha) of Mentha were also obtained with hand weeding which was found at par to fenoxaprop-p-ethyl 9.3% EC @ 100 ml/ha and propaquizafop 10% EC @ 75 ml/ha. fenoxaprop-p-ethyl 9.3% EC @ 100 ml/ha also resulted in the most effective herbicide against grassy weed and generated maximum net return (Rs. 92303/ha) and benefit: cost ratio (2.30) followed by propaquizafop 10% EC @ 75 ml/ha.

Key words: Mentha, Fenoxaprop-p-ethyl, Hand weeding, Propaquizafop 10% EC, Weed flora

1. INTRODUCTION

Mints are a group of perennial herbaceous plants, belonging to the family Lamiaceae, which yields essential oil on distillation (Harley and Brighton, 1977). The various species of mints, commercially cultivated in different parts of the world are menthol mint or Japanese mint or corn mint or field mint (*Mentha arvensis* L.), pepper mint (*M. piperita* L.), spear mint or garden mint or lamb mint (*M. spicata* L.) and bergamot mint or orange mint (*M. citrate* L.) among them Japanese mint or *Mentha arvensis*, owing to its high adaptation and cultivated most widely belts in the tropical and sub-tropical belts of the world. Its cultivation supports livelihoods of more than 1 million small-holder farmers in India (Singh *et al*., 2018). Indo-Gangetic plains of India, especially the water rich areas of Uttar Pradesh and Punjab has seen a

Comment [AA1]: Titel (Effect of Chemical Weed Control on Growth, Herb Yield and Oil Content of Japanese Mint (*Mentha arvensis* L.) Across Northern Eastern and Central Highlands of India)

Comment [AA2]: *Research Papers and Short Notes should follow the structure of Abstract, Introduction, Methodology, Results and Discussion, Conclusion, Acknowledgements, Competing Interests, Authors' Contributions, Consent (where applicable), Ethical approval (where applicable), and References plus figures and/or tables.)*

Comment [AA3]: Capital letter at the beginning of each word

Comment [AA4]: Abstract should have the following sections: Aims, Presentation of Case, Discussion and Conclusion.

Comment [AA5]: summer

Comment [AA6]: Very old

Comment [AA7]: mention the treatment of experiment

Comment [AA8]: Randomized Complete Block Design (RCBD)

Comment [AA9]: Is the experiment three or four replications?

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Comment [AA13]: pepper mint (M. piperita L.), spear mint or garden mint or lamb mint (M. spicata L.) and bergamot mint or orange mint (M. citrate L.), and menthol mint or Japanese mint or corn mint or field mint (Mentha arvensis L.) , which owing a high adaptation and cultivated most widely belts in the tropical and sub-tropical belts of the world.

phenomenal growth in production of mentha in the last couple of decades. Uttar Pradesh accounts for around 80% of Indian mint production (Lakra *et al*., 2023).

Comment [AA14]: Capital letter at the beginning of the word wherever it is found

Mentha is very slow growing during initial stages which makes it a poor competitor with weeds and frequent irrigations provide congenial environment for sprouting, growth and development of weeds. A variety of weeds infests Mentha fields. As many as 37 species of both grassy and non-grassy weeds were recorded in Mentha field (Mishra *et al*., 1973), if not controlled at critical period of crop-weed competition leads to reduction in fresh herb and essential oil. The oil yield reduction is about 60-80 per cent depending upon the density and type of weed flora (Gulati and Duhan, 1979; Randhawa *et al*., 1982; Singh, 1982). Among the production problems, weeds management is of major concern. The weeds are best managed by combining manual, mechanical and chemical control methods. The best procedure is to first apply the herbicides followed by manual or mechanical weeding at 8 to 10 weeks when mulching is applied. Gulati and Bhan (1971) observed that 40% of the total cost of cultivation accounts for weeding in Mentha. The weed problem is particularly severe after the first harvest (June-July) at the onset of monsoon with dominant species of *Eleusine indica*, *Dactyloctenium aegyptium*, *Brachiaria ramosa*, *Cynodon dactylon* and *Phyllanthus niruri.*

Comment [AA15]: hand weeding

Pre-emergence herbicides are controlling weeds in Mentha which provide only short-term control of weeds and post-emergent herbicide controls the weeds emerging later compete with the crop and reduce its productivity. Thus, the use of integrated approach is recommended for long-term control of weeds is desirable in this crop. Propaquizafop 10% EC is post emergence herbicide predominantly effective against monocot weeds in crops like soybean, black gram and onion. ~~It also said to be a powerful shield for abundant and healthy harvest produce.~~ Its mode of action helps in reduction of population of weeds or lowering the density of total weeds and weed index effectively. It is quickly absorbed by the leaves and translocated from the foliage gives it an advantage in controlling weed population effectively. By these facts and necessity of requirement of chemical approach of weed management current investigation is done for assessment of propaquizafop 10% EC for management of grassy weeds in Mentha during Zaid season across Northern, Eastern and Central highlands of India.

Comment [AA16]: A post-emergence

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2. MATERIALS AND METHODS

An experiment was conducted during summer (*zaid*) season of 2015 at Crop Research Farm of the Department of Agronomy, Sam Higginbottom Institute of Agriculture, Technology & Sciences, Allahabad situated at 25.28^{o}N latitude, 81.54^{o}E longitude and 98 m altitude above the mean sea level receives an annual rainfall of 1042 mm. The experimental soil has texture of silt loam, neutral in reaction (pH 7.5), low in organic carbon (0.40%) and medium in available nitrogen (240.0 kg/ha), medium in available phosphorus (22.5 kg/ha) and low in available potassium (95.0 kg/ha). The experiment was laid out in randomized block design with 3 repetitions. It comprised six treatments *i.e.*, propaquizafop 10% EC @ 50 ml/ha, propaquizafop 10% EC @ 62.5 ml/ha, propaquizafop 10% EC @ 75 ml/ha, fenoxaprop-p-ethyl 9.3% EC @ 100 ml/ha, hand weeding and un-weeded control. Suckers of mentha cv. 'Kosi' @ 400 kg/ha were sown manually in nursery with spacing of 45 cm row in 4-5 cm soil depth and covered with soil immediately on 7th February 2015. The nursery was transplanted to main field at 41 days after sowing. Nitrogen (50 kg/ha), phosphorus (75 kg/ha), potassium (75 kg/ha) were applied as side placement through urea, DAP and MOP, respectively. Weed density and dry weight at 15, 30, 45 and 60 days after transplanting (DAT) were observed from 1 m^2 quadrate placed at two random spots in each plot. Weed growth rate and relative growth rate of weed between 15-30, 30-45 and 45-60 were calculated on the basis of dry weight of weeds. Plant height at 15, 30, 45, and 60 DAT by five randomly selected plants in each plot. The crop was harvested from each plot on 16 July 2015 *i.e.* 115 DAT. After harvesting fresh weight of herbage was taken and then dried in sun at field and weight was recorded. To estimate oil content, 100 g of a composite sample of fresh herb under each treatment and replication was distilled in Clevenger's type apparatus (Clevenger, 1928). Economic analysis was done on the basis of prevailing market prices of inputs and output obtained from each treatment. The statistical analysis of the data was done according to the procedure given by Gomez and Gomez (1984).

Comment [AA18]: Add a Table of Physical, chemical and biological properties of experimental soil (soil texture characters)

Comment [AA19]: Randomized Complete Block Design (RCBD)

Comment [AA20]: Is the experiment three or four replications ?

Comment [AA21]: **Add a table of herbicides used includes (Commercial name, Active ingredient and concentration, Rate of use Per. h^{-1}, , Producing company)**

3. RESULTS AND DISCUSSION

Comment [AA22]: •require interpretation of the results and citing scientific references.to reinforce your discussion
•Use at least five references (2020-2024) to reinforce your discussion.

3.1 Weed dynamics

The major grassy weed species recorded in mentha field were *Echinochloa crusgalli, Brachiaria reptans, Cynodon dactylon and Sorghum halapense* etc. (Table 1). The data regarding density and dry weight of weed, weed control index and weed index are presented in Table 2, indicate that weed density was influenced non-significantly due to weed management

Comment [AA23]: *Sorghum halepense*

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options at 15, 30 and 45 DAT, however it was recorded significantly minimum under treatment hand weeding at 60 DAT, being at par to treatments fenoxaprop-p-ethyl 9.3% EC @ 100 ml/ha and propaquizafop 10% EC @ 75 ml/ha. Similarly, significantly minimum weed dry weight at 30, 45 and 60 DAT were recorded under hand weeding, but it was found at par to fenoxaprop-p-ethyl 9.3% EC @ 100 ml/ha and propaquizafop 10% EC @ 75 ml/ha, however at 15 DAT it was non-significantly differed among treatments. When compared among herbicides, fenoxaprop-p-ethyl 9.3% EC @ 100 ml/ha recorded significantly minimum density and dry weight of weed, but it was at par to propaquizafop 10% EC @ 75 ml/ha. Hand weeding had maximum weed control efficiency at 15, 30, 45 and 60 DAT, and minimum weed index followed by fenoxaprop-p-ethyl 9.3% EC @ 100 ml/ha and propaquizafop 10% EC @ 75 ml/ha. When compared among herbicides, the highest weed control efficiency and lowest weed index was recorded under fenoxaprop-p-ethyl 9.3% EC @ 100 ml/ha followed by propaquizafop 10% EC @ 75 ml/ha. The maximum weed index of 26.8% was observed in unweeded control. The low weed population in herbicide-treated plots was recorded due to long persistence of chemicals in soil, which inhibited weed seed germination. The lower dry weight of weeds in these treatments can attributed to crop competitiveness. Similarly, higher weed dry weight in weedy check was obtained due to higher weed density which compete vigorously for nutrients, space, light, water and carbon dioxide resulting in higher biomass production. The loss of yield as measured in terms of weed index was recorded maximum under un-weeded control due to heavy infestation of weeds. Karkanis *et al.* (2017) also reported that regarding the density and biomass of perennial weeds in mentha, there were no significant differences between herbicide treatments. In contrast, all herbicides reduced significantly the density and biomass of annual weeds. Similar finding was also reported by Prabhu *et al.* (2015).

Weed growth rate and relative growth rate of weed was computed maximum between 0-15 DAT and it was decreased thereafter (Fig. 1 and Fig. 2). Treatment hand weeding was proved to be the best in reducing weed growth rate and relative growth rate of weed throughout the crop growth period and it was followed by fenoxaprop-p-ethyl 9.3% EC @ 100 ml/ha and propaquizafop 10% EC @ 75 ml/ha. When compared among herbicidal treatments, fenoxaprop-p-ethyl 9.3% EC @ 100 ml/ha was proved to be the best in dropping weed growth rate and relative growth rate of weed throughout the period of investigation followed by propaquizafop 10% EC @ 75 ml/ha. A similar finding was reported by Patel (2023) in their study.

Comment [25AA]:
• require interpretation of the results and citing scientific references.to reinforce your discussion
• Use at least five references (2020-2024) to reinforce your discussion

3.2 Plant height

The data regarding plant height is presented in Table 3, indicate that The data in Table 3 indicate that a plant height at 15 and 30 DAT plant height did not vary significantly among treatments, however at 45 and 60 DAT it was found significantly maximum (38.1 and 49.5 cm, respectively) under treatment hand weeding, which was at par to fenoxaprop-p-ethyl 9.3% EC @ 100 ml/ha and propaquizafop 10% EC @ 75 ml/ha. When compared among herbicides, significantly taller plants were recorded under fenoxaprop-p-ethyl 9.3% EC @ 100 ml/ha as compared to others, but it was found at par to propaquizafop 10% EC @ 75 ml/ha, while un-weeded control recorded the shortest plants. The significant differences in plant height observed at 45 and 60 DAT reflect the cumulative effects of weed competition over time. Early in the growth cycle, weeds have minimal impact, but as they grow and compete with crops, their effects become more pronounced. Effective weed management, through hand weeding or selective herbicides like fenoxaprop-p-ethyl and propaquizafop, reduces this competition, allowing crops to grow taller. Similar finding was also reported by Gore *et al*. (2012) while working on chickpea. Karkanis *et al.* (2017) also found that the highest height at harvest stage for spearmint was recorded for pre-emergence herbicide treatments, whereas the lowest height was observed in control (untreated) plots.

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3.3 Herbage and oil yield

Among treatments, herbage yield (21.8 t/ha), dry matter yield (6.00 t/ha) and oil yield (136.9 l/ha) (Table 3) were significantly higher under treatment hand weeding as compared to others, but it was found at par to fenoxaprop-p-ethyl 9.3% EC @ 100 ml/ha and propaquizafop 10% EC @ 75 ml/ha. Oil content was however non-significant among treatments ranging 0.54 to 0.63%. Among the various herbicides, the application of fenoxaprop-p-ethyl 9.3% EC @ 100 ml/ha had significantly maximum herbage yield, dry matter yield and oil yield which was at par to propaquizafop 10% EC @ 75 ml/ha. All weed management practices were significantly superior to the unweeded control in terms of the mentioned characteristics (Table 3). The highest yields observed under hand weeding and the application of fenoxaprop-p-ethyl 9.3% EC at 100 ml/ha and propaquizafop 10% EC at 75 ml/ha could be attributed to reduced competition during critical stages of crop growth. This effective weed suppression allowed the crop to maximize its potential by absorbing adequate nutrients, light, moisture, and space, thereby enhancing photosynthesis. Karkanis *et al.* (2017) also observed that regarding the effect of herbicide application on oil content, there were no significant differences between herbicides treatments, while significant differences in oil yield between herbicide treatments were recorded. Result is also supported by Roerig *et al.* (2014). Additionally, Kumar *et al.* (2001) observed that isoproturon+pendimethalin application increased oil yield by 15.2% in *M. arvensis* and by 12.8% in peppermint, comparing to hand hoeing treatment.

3.4 Economics

The highest gross returns (Rs. 140302/ha) were recorded under hand weeding, while net return (Rs. 92303/ha) and B: C ratio (2.30) was recorded maximum under fenoxaprop-p-ethyl 9.3% EC @ 100 ml/ha followed by hand weeding regarding net return (Rs. 91793/ha) and by propaquizafop 10% EC @ 75 ml/ha regarding B:C ratio (2.28) (Table 3). The higher gross return from hand weeding was attributed to the increased herbage and ultimately oil yield. In contrast, the higher gross and net returns, along with the B:C ratio under the herbicidal treatments, were due to the combination of higher yields and reduced cultivation costs. While the use of herbicides raised cultivation expenses, an effective herbicide that controls weeds efficiently can enhance yields by reducing crop-weed competition, thereby compensating for the higher cost of the herbicide. Patel *et al.* (2024) observed similar findings in their study on chickpea, reporting comparable results regarding the impact of weed management options on economics.

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4. CONCLUSION

Based on the study, it can be concluded that the herbicide application of fenoxaprop-p-ethyl 9.3% EC @ 100 ml/ha as post emergence followed by propaquizafop 10% EC @ 75 ml/ha as post emergence proved to be the most effective in reducing weed density, weed dry matter production, and weed index while no phytotoxicity was reported on mentha crop. Additionally, this treatment showed higher weed control efficiency, resulting in improved growth, yield and profitability of mentha.

REFERENCES

Comment [28AA]: References must be listed at the end of the manuscript and numbered in the order that they appear in the text. Every reference referred in the text must also present in the reference list and vice versa. All references should follow the style of journal.

Comment [29AA]: Most of the References are very old.

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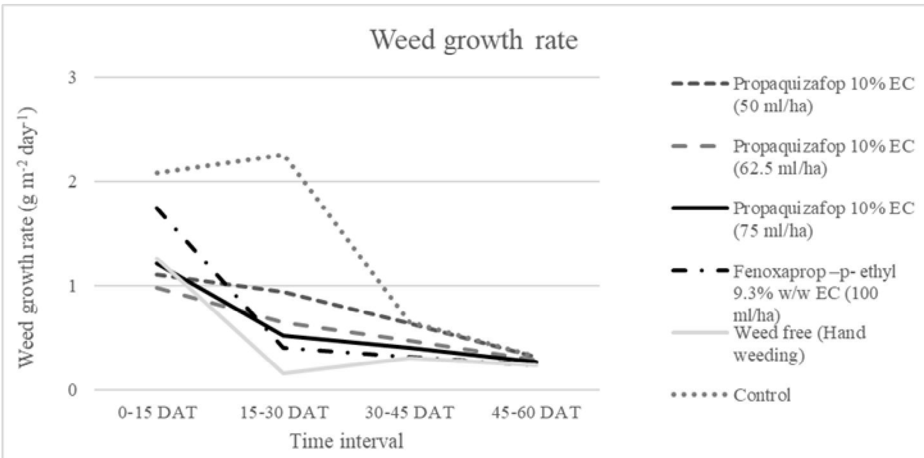

Fig. 1: Effect of weed management options on weed growth rate under mentha cultivation

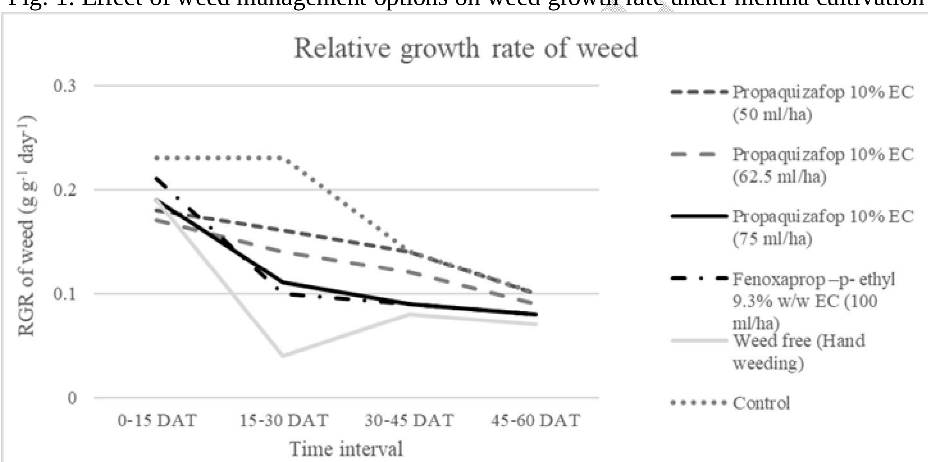

Fig. 2: Effect of weed management options on relative growth rate of weed under mentha cultivation

Table 1. Weed flora present in experimental field during Zaid season of 2015

S.No.	Name of the weed	Common name/ Hindi name	English name	Family	Habitat
	Broad Leaf weeds				
1.	*Anagallis arvensis*	Krishanneel	Scarlet pimpernet	Primyleceae	Annual
2.	*Rumex dentatus*	Jangli palak	Patience dock	Polipoyonaceae	Annual
3.	*Euphorbia hirta*	Badi duddhi	Asthma Weed	Euphorbiaceae	Annual
4.	*Euphorbia microphylla*	Chhoti duhi	-	Euphorbiaceae	Annual
5.	*Phyllanthus niruri*	Hazardana	Seed under leaf	Phyllanthaceae	Annual
6.	*Launea asplanifolia*	Jangali gobhi	Dandelion	Compositae	Biennial
7.	*Chenopodium album*	Bathua	Lambes guarter	Chenopodiaceae	Annual
8.	*Parthenium histerophorus*	Congress ghas	White top	Compositae	Annual
	Narrow leaf weeds				
1.	*Echinochloa crusgalli*	Kayada, Sawank	Common barnyardgrass	Poaceae	Annual
2.	*Brachiaria reptans*	Lemon grass	Running grass	Poaceae	Annual
3.	*Cynodon dactylon*	Doob ghass	Barmuda grass	Poaceae	Perennial
4.	*Sorghum halapense*	Johnson grass	Johnson grass	Poaceae	Perennial
	Sedges				
1.	*Cyperus rotundus*	Motha	Purple nut seed	Cyperaceae	Perennial

Table 2. Effect of weed management options on weed dynamics and weed indices under mentha cultivation

Treatment	Weed density (No./m^2)				Weed dry weight (g/m^2)				Weed control index (%)				Weed index (%)
	15 DAT	30 DAT	45 DAT	60 DAT	15 DAT	30 DAT	45 DAT	60 DAT	15 DAT	30 DAT	45 DAT	60 DAT	
Propaquizafop 10% EC @ 50 ml/ha	140.25	77.00	57.25	32.25	16.56	33.96	43.70	47.54	46.63	34.79	23.05	21.15	15.7
Propaquizafop 10% EC @ 62.5 ml/ha	86.50	69.75	49.25	32.25	14.77	33.47	39.55	43.04	52.32	35.73	30.36	28.61	11.7
Propaquizafop 10% EC @ 75 ml/ha	145.0	66.25	48.75	31.75	18.15	28.85	35.90	40.55	41.59	44.60	36.78	32.74	6.3
Fenoxaprop-p-ethyl 9.3% EC @ 100 ml/ha	121.0	52.25	47.75	28.00	26.17	26.14	34.30	39.08	16.13	49.81	39.60	35.18	4.4
Hand weeding	112.25	44.00	47.50	27.75	18.85	24.83	30.65	34.81	39.37	52.32	46.03	42.26	-
Control	94.25	107.50	85.00	35.50	31.25	52.08	56.79	60.29	-	-	-	-	26.8
SEm±	25.88	25.65	16.93	2.26	7.11	7.70	6.15	6.58	-	-	-	-	-
LSD (P=0.05)	NS	NS	NS	4.82	NS	16.41	13.10	14.03	-	-	-	-	-

Table 3. Effect of weed management options on performance of mentha

Treatment	Plant height (cm)				Herbage yield (t/ha)	Dry matter yield (t/ha)	Oil content (%)	Oil yield (l/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	B:C ratio
	15 DAT	30 DAT	45 DAT	60 DAT								
Propaquizafop 10% EC @ 50 ml/ha	19.3	25.7	34.4	41.4	18.4	4.87	0.56	103.3	38629	105854	67225	1.74
Propaquizafop 10% EC @ 62.5 ml/ha	18.6	26.0	36.7	47.9	19.3	4.95	0.59	114.3	38679	117149	78469	2.03
Propaquizafop 10% EC @ 75 ml/ha	18.3	26.0	37.7	48.8	20.4	5.39	0.60	123.9	38729	127024	88295	2.28
Fenoxaprop-p-ethyl 9.3% EC @ 100 ml/ha	18.4	26.6	37.7	49.3	20.8	5.63	0.62	129.2	40077	132379	92303	2.30
Hand weeding	18.5	27.1	38.1	49.5	21.8	6.00	0.63	136.9	48509	140302	91793	1.89
Control	16.9	24.8	34.1	39.6	16.0	3.27	0.54	85.7	37309	87887	50578	1.36
SEm±	1.07	0.44	1.15	2.37	0.75	0.23	0.03	7.97	-	-	-	-
CD (P=0.05)	NS	NS	2.46	5.05	2.27	0.68	0.09	24.0	-	-	-	-