Journal of Experimental Agriculture International

Volume 46, Issue 11, Page 803-811, 2024; Article no.JEAI.127005
ISSN: 2457-0591
(Past name: American Journal of Experimental Agriculture, Past ISSN: 2231-0606)

Effect of Chemical Weed Control on Growth, Herb Yield and Oil Content of Mentha (*Mentha arvensis* L.) Across Northern Eastern and Central Highlands of India

Raj Kumar Gourav [a*], Joy Dawson [b], Manjesh Gautam [a], Ashok Kumar [a], Aditya Singh [a] and Anjali Patel [a]

[a] ICAR-Indian Agricultural Research Institute, Pusa, New Delhi- 110012, India.
[b] Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/jeai/2024/v46i113101

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/127005

Original Research Article

Received: 22/09/2024
Accepted: 25/11/2024
Published: 03/12/2024

ABSTRACT

A field experiment was carried out during the summer 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 production of mentha. In the experiment six treatments namely, 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 were laid out in Randomized Complete Block Design (RCBD) with four replications. The results revealed that a significantly lower weed density and weed dry matter

---

**Corresponding author: E-mail: chiranjilal0104@gmail.com;*

Cite as: *Gourav, Raj Kumar, Joy Dawson, Manjesh Gautam, Ashok Kumar, Aditya Singh, and Anjali Patel. 2024. "Effect of Chemical Weed Control on Growth, Herb Yield and Oil Content of Mentha (Mentha Arvensis L.) Across Northern Eastern and Central Highlands of India". Journal of Experimental Agriculture International 46 (11):803-11. https://doi.org/10.9734/jeai/2024/v46i113101.*

weight, 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.

Keywords: 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 pepper mint (*Mentha 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 (*M. arvensis* L.), which owing a 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 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).

Mentha is very slow growing during initial stages (Singh and Chhabra, 2020) 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*.

“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. The most commonly used pre-emergence herbicides in Mentha are oxyfluorfen and pendimethalin” (Asha et al., 2018; Kaur et al., 2013), while Propaquizafop 10% EC is a post emergence herbicide predominantly effective against monocot weeds in crops like soybean, black gram and onion. 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. “Continuous use of herbicides with a similar mode of action along with a narrow window of application time may lead to the development of resistant weed biotype in Mentha” (Poudel, 2022). 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 summer season across Northern, Eastern and Central highlands of India.

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 25.28oN latitude, 81.54oE 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, low in organic carbon and medium in available nitrogen, medium in available phosphorus and low in available potassium (Table 1). The experiment was laid out in Randomized Complete Block Design (RCBD) with four repetitions in plots of 25 m2. 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 . The details of herbicide applications are provided in Table 2. 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 m2 quadrate placed at two random spots in each plot, then weed control efficiency was computed based on the data recorded (eq.1). 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 (eq. 3 and eq. 4). 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, based on which weed index was calculated (eq. 2). 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).

Weed control efficiency (%) =

$$\frac{WD_c - WD_t}{WD_c} x100 \quad \text{.....(1)}$$

Where,

WD_c = weed dry weight in unweeded control (g/m^2)

WD_t = weed dry weight in treated plot (g/m^2)

$$\text{Weed index (\%)} = \frac{X - Y}{X} x100 \quad \text{.....(2)}$$

Where,

X = Crop yield from weed free plot (hand weeding)

Y = Crop yield from the treated plot for which weed index is to be worked out

$$\text{Weed growth rate (g/day/m}^2\text{)} = \frac{W_2 - W_1}{t_2 - t_1} \quad \text{.....(3)}$$

$$\text{Relative growth rate (g/g/day)} = \frac{Log_e W_2 - log_e W_1}{t_2 - t_1}$$

Where,

W_2 and W_1 = dry weight of weeds (g) at time interval
t_2 and t_1 = time interval in days

Table 1. Physical and chemical properties of experimental soil

Properties	Value (unit)
Physical properties	
Sand (%)	58.50
Silt (%)	25.10
Clay (%)	16.40
Textural class	Silt loam
Chemical properties	
Available nitrogen (kg/ha)	240
Available phosphorus (kg/ha)	22.50
Available potassium (kg/ha)	95.00
Organic carbon (%)	0.40
pH	7.5
EC (dS/m)	0.19

Table 2. The commercial name, common name, active ingredient and rate of use of herbicides used in the experiment

Active ingredient and Concentration	Commercial name	Time of application	Rate of use (ml/ha)
Propaquizafop 10% EC	Propique	Post emergence	50 ml/ha , 62.5 ml/ha ,and 75 ml/ha
Fenoxaprop-p-ethyl 9.3% EC	Whip super	Post emergence	100 ml/ha

3. RESULTS AND 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 3). The data regarding density and dry weight of weed, weed control index and weed index are presented in Table 4. indicate that weed density was influenced non-significantly due to weed management 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, EC @ 100 ml/ha was proved to be the best in dropping weed growth rate and relative growth rate of weed throughout

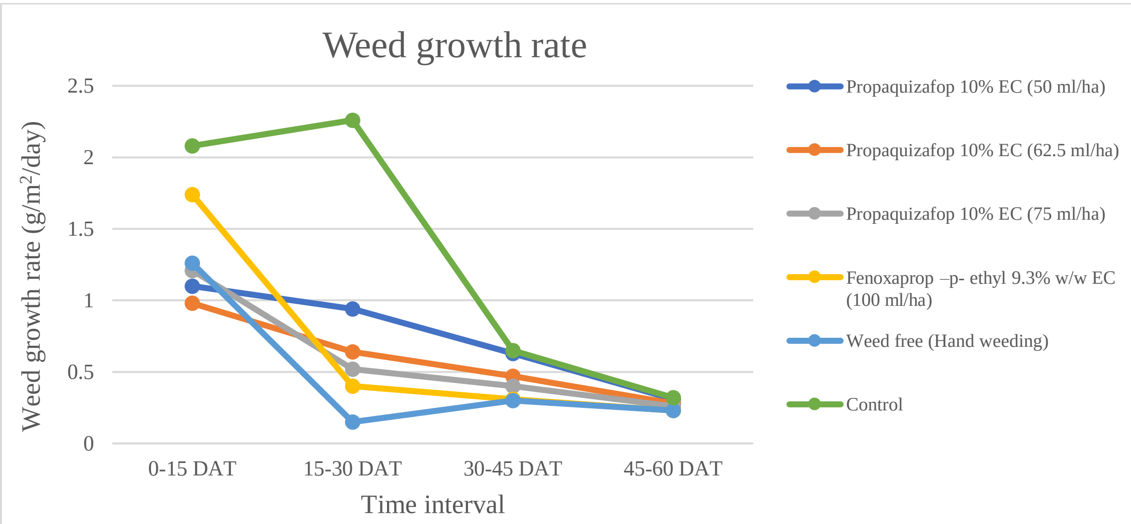

Fig. 1. Effect of weed management options on weed growth rate under mentha cultivation

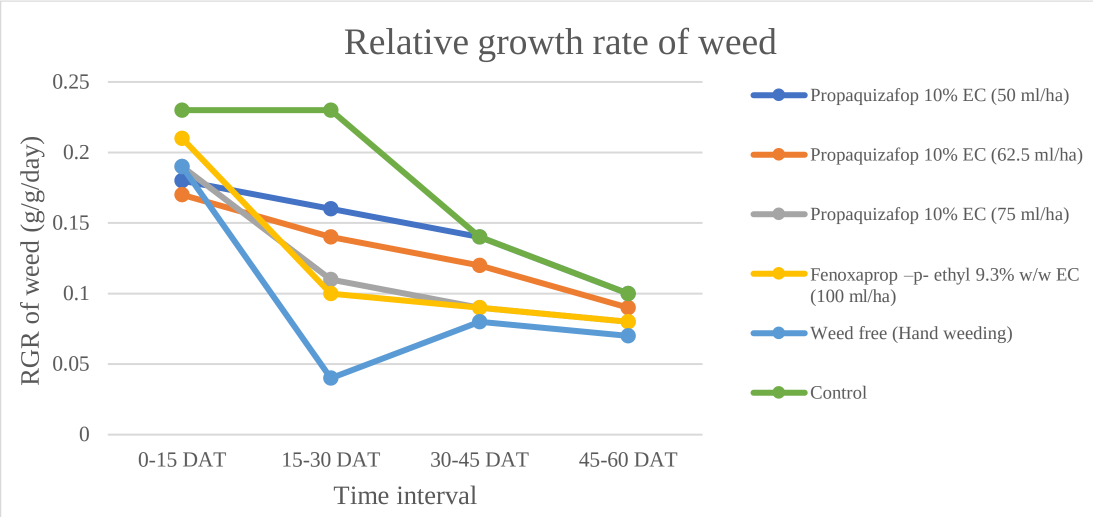

Fig. 2. Effect of weed management options on relative growth rate of weed under mentha cultivation

the period of investigation followed by propaquizafop 10% EC @ 75 ml/ha. A similar finding was reported by Patel (2023) in their study.

3.2 Plant Height

The data in Table 5, indicate that the 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.

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) 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 5). 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.

Table 3. Weed flora present in experimental field during summer 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 4. 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 5. 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)	benefit: cost 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	-	-	-	-

3.4 Economics

The highest gross returns (Rs. 140302/ha) were recorded under hand weeding, while net return (Rs. 92303/ha) and benefit: cost 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 benefit: cost ratio (2.28) (Table 5). 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 benefit: cost 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.

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. Farmers are recommended to use either fenoxaprop-p-ethyl 9.3% EC @ 100 ml/ha or propaquizafop 10% EC @ 75 ml/ha as post-emergence herbicides in their Mentha field for effective weed control, improved Mentha yield, and profitability.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during writing or editing of this manuscript. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology.

Details of the AI usage are given below:

1. ChatGPT 3.5

ACKNOWLEDGEMENTS

This study forms part of the M.Sc. (Agriculture) thesis. The authors express their gratitude to the Head of the Department of Agronomy, Sam Higginbottom Institute of Agriculture, Technology & Sciences, Allahabad, for providing essential support, facilitating the necessary resources and offering invaluable moral encouragement throughout the research process.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Asha, M. R., Biradar, I. B., Prasad, D. S., Pushpa, T. N., Kulkarni, M. S., Desai, S., & Shalini, R. M. (2018). Effect of different weed management methods on yield and quality of menthol mint (*Mentha arvensis* L.). *International Journal of Chemical Studies*, 6(5), 594–597.

Clevenger, J. F. (1928). Apparatus for determination of volatile oil. *Journal of the American Pharmacological Association*, 17, 276.

Gomez, K. A., & Gomez, A. A. (1984). *Statistical procedures for agricultural research* (2nd ed.). John Wiley and Sons, New York.

Gore, A. K., Pedde, K. C., Gokhale, D. N., & Chavan, A. S. (2012). Integrated weed management in chickpea. *Biennial Conference of Indian Society of Weed Science on "Weed Threat to Agriculture, Biodiversity and Environment"*, Kerala Agricultural University, Thrissur (Kerala), 156.

Gulati, B. C., & Bhan, V. M. (1971). Effect of pre-emergence application of terbacil on control of weed in Japanese mint. *Indian Perfumer*, 15(2), 53–59.

Gulati, B. C., & Duhan, S. P. S. (1979). Effect of time of weed removal and period of weed-free condition on the yield of herb oil and quality of oil of *Mentha arvensis* Linn. *Indian Perfumer*, 23(2), 87–90.

Harley, R. M., & Brighton, C. A. (1977). Chromosome numbers in the genus *Mentha arvensis* L. *Botanical Journal of the Linnean Society*, 74(3), 71–96.

Karkanis, A., Lykas, C., Liava, V., Bezou, A., Petropoulos, S., & Tsiropoulos, N. (2017). Weed interference with peppermint (*Mentha x piperita* L.) and spearmint

(*Mentha spicata* L.) crops under different herbicide treatments: Effects on biomass and essential oil yield. *Journal of the Science of Food and Agriculture*, 98(1), 43–50.

Kaur, T., Singh, S., Bhullar, M. S., Shergill, S. S., & Kaur, R. (2013). Effect of planting method and weed control on productivity of Japanese mint (*Mentha arvensis* L.). *Indian Journal of Agricultural Research*, 47(3), 243–247.

Kumar, K., Walia, U. S., & Brar, L. S. (2001). Bio-efficacy of herbicides in *Mentha arvensis* and *Mentha piperita*. *Indian Journal of Weed Science*, 33, 22–25.

Lakra, K., Verma, S. K., Rajpoot, S. K., & Bhushan, C. (2023). Effect of land configuration, irrigation regimes, and nitrogen application on growth, yield, and quality of Japanese mint (*Mentha arvensis*). *Indian Journal of Agronomy*, 68(3), 338–341.

Mishra, L. P., Kapoor, L. D., & Choudhri, R. S. (1973). Studies on efficacy of some herbicides on the control of weeds in Japanese mint. *Indian Journal of Agronomy*, 18(1), 10–19.

Patel, A. (2023). Effect of herbicides on weed dynamics, yield, and profitability of chickpea (*Cicer arietinum* L.) under Vertisols of Chhattisgarh plains (Ph.D. thesis). Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh.

Patel, A., Banajra, G. P., Shrivastava, G. K., Rathore, S. S., Shekhawat, K., Painkara, S. K., Lakra, A. K., & Mishra, R. K. (2024). Chemical weed management in chickpea (*Cicer arietinum*) under Vertisols of Eastern Plateau Plain Zone of India. *Indian Journal of Agronomy*, 69(2), 166–171.

Poudel, D. (2021). Effect of post-emergence herbicides on weed growth and yield of Japanese mentha (*Mentha arvensis* L.) (Ph.D. thesis). Banaras Hindu University, Varanasi-221005, India.

Prabhu, G., Srinivasan, R., Kantwa, S. R., Palsaniya, D. R., & Chaudhary, M. (2015). Weed seed bank studies in the field of fodder cowpea (*Vigna unguiculata* L.). *International Journal of Applied and Pure Science and Agriculture*, 1(5), 83–87.

Randhawa, G. S., Saini, S. S., Walia, U. S., Mahey, R. K., & Sidhu, B. S. (1982). Weed control in the first and second cutting of menthol mint (*Mentha arvensis* Linn.). *Indian Perfumer*, 26(1), 7–11.

Roerig, K. C., Curtis, D. W., Hulting, A. G., & Mallory-Smith, C. (2014). Pyroxasulfone and flumioxazin use on dormant peppermint. *Western Society of Weed Science Research Progress Report*, 10–13 March 2014, Westminster, Colorado, 55.

Singh, A. (1982). Weed control studies in mint species. *Indian Perfumer*, 26(2&4), 99–103.

Singh, A., Singh, K. B., & Singh, G. (2018). Water balance and water productivity of Japanese mint (*Mentha arvensis*) as affected by irrigation and mulching. *Indian Journal of Agronomy*, 63(1), 105–109.

Singh, J., & Chhabra, V. (2020). Effect of herbicides application on growth and yield of mentha crop. *International Journal of Scientific Research*, 9(9), 60–61.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/127005