Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(2): 54-58
Received: 10-01-2019
Accepted: 12-02-2019

Yashwant Yadav
Department of Agronomy, Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Rajesh Kumar
Department of Agronomy, Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Anjali Kumari
D.A.V. Collage, Kanpur, Uttar Pradesh, India

Vishuddha Nand
Department of Agronomy, Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

SK Verma
Department of Agronomy, Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Correspondence
Yashwant Yadav
Department of Agronomy, Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Effect of weed management practices on weeds and Nitrogen removal by weeds in Japanese mint (*Mentha arvensis* L.)

Yashwant Yadav, Rajesh Kumar, Anjali Kumari, Vishuddha Nand and SK Verma

Abstract
The field experiment was conducted during summer season of 2015 and 2017 at Agronomy Research Farm of N. D. University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.), to study the "Weed management studies in Japanese mint (*Mentha arvensis* L.)". The experiment consisted of 14 treatment combination with propaquizafop - p - ethyl @ 40 g ha^{-1} as post-emergence (T_1), propaquizafop - p - ethyl @ 60 g ha^{-1} as post-emergence (T_2), propaquizafop - p - ethyl @ 80 g ha^{-1} as post-emergence (T_3), propaquizafop - p - ethyl @ 100 g ha^{-1} as post-emergence (T_4), clodinafop propargyl @ 40 g ha^{-1} as post-emergence (T_5), clodinafop propargyl @ 60 g ha^{-1} as post-emergence (T_6), clodinafop propargyl @ 80 g ha^{-1} as post-emergence (T_7), Pendimethalin @ 1000 g ha^{-1} as pre-emergence (T_8), oxyfluorfen @ 200 g ha^{-1} as pre-emergence (T_9), imazethapyr + imazamox @ 80 g ha^{-1} as post-emergence (T_{10}), imazethapyr+ pendimethal in (RM) @1000 g ha^{-1} as pre-emergence (T_{11}), imazethapyr @ 60 g ha^{-1} as post-emergence (T_{12}), Weed free (Three hand weeding at 20, 45 and 65 DAP) (T_{13}) and weedy check (T_{14}). The treatments were replicated three times in a randomized block design. All weed management practices proved effectiveness for controlling the weeds in Japanese mint and recorded significantly lesser weed density, dry weight, weed index, nitrogen removal by weeds and higher weed control efficiency over weedy check. Pre emergence application of imazethapyr + pendimethalin at 1000 g ha^{-1} was found most effective for control of all major weeds and recorded minimum weed density (29.68 and 27.11), dry matter (29.07 and 27.08g.), weed index (8.82 and 8.68%), nitrogen removal (7.19 and 5.90 kg ha^{-1}) and maximum WCE 92.76 and 93.88% during 2015 and 2017, respectively, which was significantly superior to rest of the treatments while at par with application of imazethapyr + and @ 80 g ha^{-1} as post emergence, pendimethalin @ 1000 g ha^{-1} as pre emergence and imazethapyr @ 60 g ha^{-1} as post-emergence for effective control of weeds.

Keywords: Japanese mint, herbicide, Weeds, density, dry weight, WCE, weed index, nitrogen removal

Introduction
Japanese mint (*Mentha arvensis* L.) is an essential bearing family Lamiaceae, *Mentha* species are known for kitchen and medicinal herbs since time immemorial. There are about 40 species belonging to this genus, out of which, four viz. *Mentha arvensis* L. (Japanese mint or Corn mint or Field mint), *Mentha piperita* L. (Pepper mint, Black mint, Mitcham mint), *Mentha spicata* L. (Spearmint, Garden mint or Lamb mint) and *Mentha citrate Ehrh.* (Bergamot mint or Orange mint) are cultivated commercially in different parts of the world. Among the various types of mint, only Japanese mint is cultivated in tropics and subtropics. Mints are perennial aromatic herbs with quadrangular stem and bearing leaves with essential oil present in glands located in subcuticular region. Among these four species, *Mentha arvensis* L. has erect growth and its oil contains 70-85% menthol, which is the highest among the four species. It is grown for medicinal and aromatic purposes. Brazil is the native place of Japanese mint. Commercially, Japan started producing mint around 1870. Previously, it was called Japanese mint and Japan was the leading mint producing country in the world. The production of mint was also reported in other countries of the world like China and India around 1960. Japanese mint is a long lasting, growing, hairy leaves herb that can even attain a height of 1.5 meter under favorable conditions. Mint oil is the main source of aromatic compounds such as menthol used as flavoring agent and as a constituent of medicinal preparations, especially in cough syrups, candies, beverages, chewing gums, hair lotions, toothpastes, mouthwashes and liquors. It is also employed as a soothing ingredients in cosmetic preparations, colognes, deodorants, aftershave lotions and perfume bases. The anti-microbial properties of menthol mint enhance the shelf of edible products and grains. India is the largest producer and exporter of *Mentha* oil in the world producing about 25,000 tonnes of mint oil and exporting 3,000

tonnes and earn exchange with of Rs.100 crores annually. In India, *M. arvensis* L. is cultivated in the semi- temperate regions in the foot hills of Himalayas i.e. Uttar Pradesh, Punjab, Haryana, Bihar and Assam. Among various mint species, Japanese mint accounts for 86% of total area under mint cultivation in India. The area under this crop in the country is estimated at about 2,50,000 hectares (Anonymous 2016a) [1]. Japanese mint crop requires frequent irrigations for quick sprouting and better growth which encourage the growth of weeds. Thus, the crop is affected from weeds of both winter and summer seasons. Due to poor initial growth rate, field is usually dominated by the weeds, resulting in poor quality and quantity of oil (Skrubis, 1971) [8]. Reduction in herbage yield by 80% and essential oil yield by 74% due to weedy condition has been reported by Gulati and Bhan (1971) [4]. The presence of weeds reduces the photosynthetic efficiency and crop dry matter production. The weeds, if not controlled during critical period of crop-weed competition, i.e., 30 to 45 days in cutting leads to 76 and 80% reduction in fresh herb and essential oil as compared with crop free from weeds (Singh *et al* 1993a) [10]. The weeds can be managed by cultural, mechanical and chemical methods. Manual weeding being costly and time consuming is not possible on a large scale. Moreover, peak period of weed removal from *Mentha* crop coincides with the harvesting period of many winter season crops, thus posing a serious problem of labor availability which delays the removal of weeds. Under such situation, use of herbicides for weed control holds a great promise. The chemical method involving use of selective herbicides is generally effective and economical and the farmers are adopting this method extensively. Now - a - days a number of high potency herbicide molecules have been developed which proved highly efficient to control the different types of weed flora in Japanese mint.

Material and Methods

The field experiment was conducted at Agronomy Research Farm of N. D. University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.) during summer season of 2015 and 2017. The farm is located 42 km away from Faizabad on Raebareily road at 26.47˚ N latitude and 82.12˚ E longitude and about 113 meters above the mean sea level. Summer is hot and dry. Generally, the mean maximum temperature during the hottest month (May) vary from 33.0 to 41.7 0C and minimum during the coolest month (December and January) varies from 4.5 to 8.8 ^{0}C. The soil of experimental field was Silty loam in texture, low in organic carbon and available nitrogen, medium in available phosphorus and potassium with near to neutral in reaction. The experiment consisted of 14 treatment combination with Propaquizafop - p - ethyl @ 40 g ha^{-1} as post-emergence (T_1), Propaquizafop - p - ethyl @ 60 g ha^{-1} as post-emergence (T_2), Propaquizafop - p - ethyl @ 80 g ha^{-1} as post-emergence (T_3), Propaquizafop - p - ethyl @ 100 g ha^{-1} as post-emergence (T_4), Clodinafop propargyl @ 40 g ha^{-1} as post-emergence (T_5), Clodinafop propargyl @ 60 g ha^{-1} as post-emergence (T_6), Clodinafop propargyl @ 80 g ha^{-1} as post-emergence (T_7), Pendimethalin @ 1000 g ha^{-1} as pre-emergence (T_8), Oxyfluorfen @ 200 g ha^{-1} as pre-emergence (T_9), Imazethapyr + Imazamox @ 80 g ha^{-1} as post-emergence (T_{10}), Imazethapyr+ Pendimethalin (RM) @1000 g ha^{-1} as pre-emergence (T_{11}), Imazethapyr @ 60 g ha^{-1} as post-emergence (T_{12}), Weed free (Three hand weeding at 20, 45 and 65 DAP) (T_{13}) and weedy check (T_{14}). The herbicides were applied with the help of manually operated Knapsack sprayer fitted with flat fan nozzle using 500 liters of water per hectare. Data on weeds were recorded at different growth stage of crop in each plot in two quadrates, each 50x50 cm. weeds were counted species wise and were removed for recording their total dry weight. Weed samples were sun dried before oven drying at 70 ^{0}C until constant weight was attained. Weed data were subjected to square root $\left(r = \sqrt{X + 0.5}\right)$ transformation before statistical analysis.

Results and Discussion

Weeds are considered to be major enemy of crop plants and have been found to cause considerable economic loss due to their luxuriant growth accelerating the intensity of their competition for space, CO_2, nutrients, moisture and light without leaving obvious sign of distress. Successful weed management for Japanese mint crop becomes much more important in order to exploit its maximum production potential as it is a serious constraint. The control of weeds at critical stages of crop-weed competition turns the growth factor in favor of crop plants. Better use of growth factors by Japanese mint plant in the plots receiving weed control treatments due to less crop-weed competition was reflected on plant yield characters viz., leaf to stem ratio, fresh herbage yield, oil yield. The weed flora in the experimental field was collect, identified and classified in different categories. *Echinochloa colonum and Elusine indica* of grassy group, *Cyperus rotundus* of sedges group and *Chenopodium album and Amaranthus viridis* broad leaf group and some other weeds like *Cynodon dactylon, Phyllanthus niruri, Euphorbia hirta and Boerhavia diffusa*.

Effect on total weed density and dry weight

The density and dry weight of the different weed species was recorded at 30, 60, 90 and 120 days of crop growth. The presence of the individual weed species and other weeds as well as total weeds and their dry weight was affected significantly. The data pertaining to density and dry weight of total weed as influenced by different weed management practices at various stages of crop growth is summarized in Table-1.1 and 1.2. All the weed management practices reduced the density and dry weight of total weed significantly over weedy check at all the stages of crop growth except 30 DAP, during both the years. None of the herbicides proved as effective as weed free treatment for suppressing population of total weed. Among the herbicides pre-emergence application of imazethapyr + pendimethalin @ 1000 g ha^{-1} was found most effective for reducing the density of total weed and its dry weight which was significantly superior to rest of the treatments while at par with post emergence application of imazethapyr + imazamox @ 80 g ha^{-1}, pendimethalin @ 1000 g ha^{-1} as pre emergence and imazethapyr @ 60 g ha^{-1} as post-emergence at all the stages of crop growth except 30 DAP where imazethapyr + pendimethalin @ 1000 g ha^{-1} applied as pre emergence was, at par with pre-emergence application of pendimethalin @ 1000 g ha^{-1} and oxyfluorfen @ 200 g ha^{-1} during both the years, which might be due to reason that pre-emergence application of these herbicides checked the emergence of germinated weeds seed during both the years. Almost similar results were also noticed by Shaikh *et al*. (2002) [9], Patel *et al*. (2014) [5], Yadav *et al*. (2014) [15] and Chaudhari *et al.* (2017) [2].

Weed control efficiency (%)

That weed control efficiency is a good index to evaluate the effectiveness of a weed management practices for controlling weeds. All the weed management treatments resulted in improved weed control efficiency over the weedy check. At 90 DAP weed control efficiency was found significantly higher

(92.76 and 93.88%) under imazethapyr + pendimethalin @ 1000 g ha^{-1} applied as pre emergence over rest of the treatments was at par with imazethapyr + imazamox @ 80 g ha^{-1} as post emergence (91.60 and 92.84%), pendimethalin @ 1000 g ha^{-1} as pre emergence (90.44 and 91.75%) and imazethapyr @ 60 g ha^{-1} as post-emergence (89.37 and 90.90%) during 2015 and 2017, respectively. This might be due to effective control of density and biomass of weeds. Almost similar results were obtained by Upadhyay *et al.* (2012) [12], Patel *et al*. (2014) [7], Yadav *et al.* (2015) [16] and Chaudhari *et al.* (2017) [2]

Weed index (W.I.)

The data regarding weed index presented in Table-3, indicated that the minimum value of weed index at harvest stage was recorded (6.87 and 5.99%) with imazethapyr + pendimethalin @ 1000 g ha^{-1} applied as pre emergence which was significantly lower over rest of the treatments, while maximum weed index recorded (70.65 and 70.13%) with weedy check condition during 2015 and 2017, respectively. These results may be supported by the findings Tilgam *et al*. (2015) [11]

Nitrogen removal by weeds

The data pertaining to the nitrogen removal by weeds are presented in Table-3, Nitrogen removal consistently increased with the advancement in the crop age. Nitrogen removal by weeds was found significantly higher with weedy check treatment as compared to rest of the treatments. Among the herbicides lower nitrogen removal by weeds at 90 DAP was recorded 7.19 and 5.90 kg ha^{-1} with imazethapyr + pendimethalin @ 1000 g ha^{-1} applied as pre emergence which was significantly lower and maximum removal of nitrogen 97.04 and 94.78 kg ha^{-1} was recorded in weedy check during 2015 and 2017 respectively. This is might be due to higher dry matter of weeds in weedy check condition. Walia (2009**)** also reported that weeds usually absorb mineral nutrients faster than crop plants and accumulate them in their tissues in relatively larger amounts. These results are in consonance with the findings of Dev (1988) [3], Yadav *et al.* (2013) [14], Kavita *et al.* (2014b) [6] and Jakhar *et al*. (2015) [5].

Summary and Conclusion

All weed management practices proved effectiveness for controlling the weeds in Japanese mint and recorded significantly lesser weed density, dry weight, weed index, nitrogen removal by weeds and higher weed control efficiency over weedy check. Pre emergence application of imazethapyr + pendimethalin at 1000 g ha^{-1} was found most effective for control of all major weeds and recorded minimum weed density (29.68 and 27.11), dry matter (29.07 and 27.08g.), weed index (8.82 and 8.68%), nitrogen removal (7.19 and 5.90 kg ha^{-1}) and maximum WCE 92.76 and 93.88% during 2015 and 2017, respectively, which was significantly superior to rest of the treatments while at par with application of imazethapyr +and @ 80 g ha^{-1} as post emergence, pendimethalin @ 1000 g ha^{-1} as pre emergence and imazethapyr @ 60 g ha^{-1} as post-emergence for effective control of weeds.

On the basis of results obtained in this study it may be concluded that application of imazethapyr + pendimethalin at 1000 g ha^{-1} as pre-emergence should be adopted for the effective control of weeds in Japanese mint.

Table 1: Total weed density (no. m^{-2}) as affected by different treatments at various stages of crop growth.

Treatments	30 DAP		60 DAP		90 DAP		120 DAP	
	2015	2017	2015	2017	2015	2017	2015	2017
Propaquizafop-p-ethyl @ 40 g ha^{-1} as post-emergence	13.27 (175.85)	12.68 (160.60)	11.90 (141.54)	11.39 (129.50)	10.42 (108.41)	10.03 (100.40)	9.63 (92.56)	9.23 (84.99)
Propaquizafop-p-ethyl @ 60 g ha^{-1} as post-emergence	13.40 (179.54)	12.82 (164.29)	11.66 (135.85)	11.13 (123.81)	10.15 (102.72)	9.75 (94.71)	9.34 (86.97)	8.93 (79.40)
Propaquizafop-p-ethyl @ 80 g ha^{-1} as post-emergence	12.95 (167.30)	12.33 (152.05)	11.53 (132.72)	10.90 (118.68)	9.94 (98.59)	9.53 (90.58)	9.11 (82.74)	8.69 (75.17)
Propaquizafop-p-ethyl @ 100 g ha^{-1} as post-emergence	12.65 (159.75)	12.02 (144.50)	10.99 (120.57)	10.24 (104.53)	9.24 (85.05)	8.80 (77.04)	8.37 (69.60)	7.90 (62.06)
Clodinafop propargyl @ 40 g ha^{-1} as post-emergence	12.72 (161.83)	12.12 (146.51)	11.35 (128.38)	10.80 (116.42)	9.72 (94.33)	9.31 (86.32)	8.88 (78.48)	8.44 (70.91)
Clodinafop propargyl @ 60 g ha^{-1} as post-emergence	13.19 (174.01)	12.61 (158.76)	11.18 (124.66)	10.54 (110.67)	9.46 (89.19)	9.03 (81.18)	8.58 (73.34)	8.15 (66.07)
Clodinafop propargyl @ 80 g ha^{-1} as post-emergence	13.45 (180.82)	12.87 (165.57)	10.55 (111.09)	10.07 (101.05)	9.04 (81.36)	8.58 (73.35)	8.15 (66.01)	7.68 (58.57)
Pendimethalin @ 1000 g ha^{-1} as pre-emergence	8.69 (75.16)	8.06 (64.61)	7.77 (60.04)	7.44 (55.01)	6.38 (40.38)	6.18 (37.80)	5.95 (34.94)	5.77 (32.89)
Oxyfluorfen @ 200 g ha^{-1} as pre-emergence	9.08 (82.14)	8.64 (74.37)	9.71 (94.09)	9.15 (83.46)	8.42 (70.60)	7.87 (61.59)	8.11 (65.46)	7.49 (55.73)
Imazethapyr + Imazamox @ 80 g ha^{-1} as post-emergence	12.91 (166.56)	12.26 (150.31)	7.53 (56.38)	7.19 (51.33)	6.15 (37.37)	5.93 (34.80)	5.78 (32.95)	5.53 (30.09)
Imazethapyr+ Pendimethalin (RM) @1000 g ha^{-1} as pre-emergence	8.38 (69.88)	7.82 (60.81)	7.19 (51.32)	6.85 (46.59)	5.84 (33.65)	5.63 (31.24)	5.49 (29.68)	5.25 (27.11)
Imazethapyr @ 60 g ha^{-1} as post-emergence	12.49 (155.66)	11.85 (140.41)	7.97 (63.25)	7.77 (60.04)	6.63 (43.59)	6.40 (40.54)	6.16 (37.53)	5.98 (35.34)
Weed free	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
Weedy check	13.09 (171.10)	12.34 (151.85)	15.77 (248.35)	15.32 (234.91)	15.32 (234.81)	15.02 (225.80)	14.45 (208.81)	14.01 (196.24)
SEm±	0.39	0.39	0.34	0.35	0.32	0.29	0.29	0.29
CD (P=0.05)	1.14	1.13	0.99	0.98	0.94	0.83	0.85	0.84

Values are square root $\sqrt{(X + 0.5)}$ transformed and the original mean value are given in parenthesis

Table 2: Total weed dry matter (g m^{-2}) as affected by different treatments at various stages of crop growth.

Treatments	30 DAP		60 DAP		90 DAP		120 DAP	
	2015	2017	2015	2017	2015	2017	2015	2017
Propaquizafop-p-ethyl @ 40 g ha^{-1} as post-emergence	7.38 (53.99)	7.09 (49.88)	10.80 (116.48)	10.30 (105.84)	17.91 (321.13)	17.53 (307.60)	13.84 (191.63)	13.34 (178.06)
Propaquizafop-p-ethyl @ 60 g ha^{-1} as post-emergence	6.87 (46.87)	6.57 (42.67)	10.42 (108.30)	9.89 (97.66)	17.68 (312.93)	17.30 (299.40)	13.55 (183.43)	13.04 (169.86)
Propaquizafop-p-ethyl @ 80 g ha^{-1} as post-emergence	6.61 (42.23)	6.29 (39.12)	9.76 (95.04)	9.20 (84.40)	17.27 (298.74)	16.88 (285.21)	13.01 (169.24)	12.48 (155.67)
Propaquizafop-p-ethyl @ 100 g ha^{-1} as post-emergence	6.82 (46.03)	6.50 (41.92)	8.98 (80.30)	8.37 (69.66)	16.59 (275.19)	16.18 (261.66)	12.08 (145.69)	11.50 (132.12)
Clodinafoppropargyl @ 40 g ha^{-1} as post-emergence	6.80 (45.92)	6.50 (41.81)	9.51 (90.06)	8.93 (79.91)	17.07 (291.89)	16.69 (278.36)	12.76 (162.39)	12.21 (148.82)
Clodinafoppropargyl @ 60 g ha^{-1} as post-emergence	6.72 (44.72)	6.41 (40.61)	9.17 (83.66)	8.57 (73.02)	16.82 (282.60)	16.40 (269.07)	12.38 (153.10)	11.82 (139.53)
Clodinafoppropargyl @ 80 g ha^{-1} as post-emergence	6.81 (45.99)	6.50 (41.68)	8.63 (74.24)	8.00 (63.60)	16.22 (262.96)	15.79 (249.43)	11.65 (135.46)	11.05 (121.89)
Pendimethalin @ 1000 g ha^{-1} as pre-emergence	4.49 (19.70)	4.22 (17.32)	5.86 (33.96)	5.30 (27.72)	7.47 (55.53)	6.87 (46.80)	6.09 (63.73)	5.92 (34.55)
Oxyfluorfen @ 200 g ha^{-1} as pre-emergence	4.80 (22.59)	4.50 (19.79))	7.81 (60.70)	7.23 (51.96)	12.39 (153.30)	11.84 (139.97)	9.54 (90.80)	9.11 (82.83)
Imazethapyr + Imazamox @ 80 g ha^{-1} as post-emergence	6.31 (39.38)	6.07 (36.39)	5.61 (31.02)	5.03 (24.78)	7.01 (48.81)	6.40 (40.63)	5.75 (32.96)	5.58 (30.70)
Imazethapyr+ Pendimethalin (RM) @1000 g ha^{-1} as pre-emergence	4.26 (17.66)	4.03 (15.79)	5.32 (27.87)	4.72 (21.83)	6.51 (42.04)	5.93 (34.71)	5.43 (29.07)	5.25 (27.08)
Imazethapyr @ 60 g ha^{-1} as post-emergence	6.50 (41.76)	6.13 (37.21)	6.09 (36.72)	5.45 (29.30)	7.88 (61.79)	7.22 (51.65)	6.34 (39.75)	6.14 (37.26)
Weed free	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
Weedy check	7.49 (55.73)	7.22 (51.62)	12.45 (194.63)	12.00 (143.99)	24.08 (581.05)	23.80 (567.52)	22.53 (508.55)	22.23 (494.98)
SEm±	0.20	0.20	0.28	0.28	0.52	0.47	0.41	0.41
CD (P=0.05)	0.59	0.58	0.82	0.81	1.51	1.37	1.19	1.18

Values are square root $\sqrt{(X + 0.5)}$ transformed and the original mean value are given in parenthesis

Table 3: Nitrogen removal at harvest, weed control efficiency (90 days after planting) and weed index (at harvest) as influenced by weed management practices

Treatments	Nitrogen removal (kg ha^{-1})		Weed control efficiency (%)		Weed index (%)	
	2015	2017	2015	2017	2015	2017
Propaquizafop-p-ethyl @ 40 g ha^{-1} as post-emergence	53.63	51.06	44.73	45.80	28.51	27.98
Propaquizafop-p-ethyl @ 60 g ha^{-1} as post-emergence	52.26	50.00	46.14	47.24	27.83	26.86
Propaquizafop-p-ethyl @ 80 g ha^{-1} as post-emergence	50.19	47.63	48.59	49.74	25.64	24.69
Propaquizafop-p-ethyl @ 100 g ha^{-1} as post-emergence	46.51	43.96	52.64	53.89	20.26	19.52
Clodinafoppropargyl @ 40 g ha^{-1} as post-emergence	49.33	46.21	49.77	50.95	23.81	22.91
Clodinafoppropargyl @ 60 g ha^{-1} as post-emergence	47.48	44.93	51.36	52.59	23.03	22.23
Clodinafoppropargyl @ 80 g ha^{-1} as post-emergence	44.18	41.65	54.74	56.05	19.10	19.20
Pendimethalin @ 1000 g ha^{-1} as pre-emergence	9.38	7.91	90.44	91.75	10.27	9.00
Oxyfluorfen @ 200 g ha^{-1} as pre-emergence	25.91	23.51	73.62	75.34	15.38	14.44
Imazethapyr + Imazamox @ 80 g ha^{-1} as post-emergence	8.35	6.91	91.60	92.84	8.82	8.68
Imazethapyr+ Pendimethalin (RM) @1000 g ha^{-1} as pre-emergence	7.19	5.90	92.76	93.88	6.87	5.99
Imazethapyr @ 60 g ha^{-1} as post-emergence	10.44	8.68	89.37	90.90	11.04	10.03
Weed free	0.00	0.00	100.00	100.00	0.00	0.00
Weedy check	97.04	94.78	0.00	0.00	70.65	70.13
SEm±	1.62	1.31	2.64	2.94	0.80	1.05
CD (P=0.05)	4.70	3.81	7.68	8.55	2.31	3.06

References

1. Anonymous, 2016 www.mcxindia.com:products/menthaoil
2. Chaudhari DD, Patel BD, Patel HK, Patel VJ, Mishra A. Weed management through new generation herbicides in Kharif greengrm. In: Biennial Conference of the Indian Society of Weed Science on "Doubling Farmers' Income by 2022: The Role of Weed Science", MPUA&T, Udaipur, 2017, 80.
3. Dev J. Herbicide use studies in Japanese mint (*Mentha arvensis* L.). Thesis submitted to the G. B. Pant Univ. of Agric. And Technol. Pantnagar for fulfillment of the requirement for the degree of Doctor of Philosophy, 1988.
4. Gulati BC, Bhan VM. Chemical weed control in Japanese mint (*Mentha arvensis* L.). Indian pref. 1971; 16:19-25.
5. Jakhar P, Yadav SS, Choudhary R. Response of weed management practices on the Productivity of urdbean (*Vigna mungo* L. Hepper). Journal of Applied and Natural Science. 2015; 7(1):348-352.
6. Kavita D, Rajput AS, Kamble, Sonawane RK, Bhale M. Influence of herbicides and cultural practices on uptake of nutrients by weeds and black gram. In: Extended Summary

of Biennial Conference of Indian Society of Weed Science, Feb. 15-17, DSWR, Jabalpur (M.P.): 2014b, 212.
7. Patil MR, Chaudhari PM, Bodake PS, Patil SB, Girase PP, Chaudhari PM et al. Effect of post-emergence herbicides on weed management and seed yield of soybean in vertisols. In: Proceeding Biennial Conference of Indian Society of Weed Science on "Emerging Challenges in Weed Management". February 15-17, Directorate of Weed Science Research, Jabalpur, Madhya Pradesh, India. 2014, 152.
8. Skrubis B. Effects of weed control on the yield of herb, the yield and oil composition of *Mentha piperita* (L.) Flavour Ind. 1971; 2:367-69.
9. Shaikh AR, Lokhande OG, Bhosale RH, Giri AN, Shinde GG. Weed management in black gram (*Phaseolus mungo*). Indian Journal Agronomy. 2002; 47(2):231-233.
10. Singh R, Singh JN, Singh G. Effects of crop-weed competition on yield and quality of essential in Japanese mint. (*Mentha arvensis* L.) Indian perfumer. 1993a; 37:161-166.
11. Tilgam M, Yadav KS, Sharma J, Prajapati BL. Effect of weed management practices on yield and economics of blackgram. In: 25th Asian Pacific Weed Science Society Conference on "Weed Science for Sustainable Agriculture, Environment and Biodiversity", Hyderabad, 2015, 247.
12. Upadhyay RK, Patra DD, Tewari SK, Baksh H. Effect of Farm yard manure, vermicompost, chemical fertilizer and integrated Weed management on yield, yield contributing characters and quality of mint (Mentha arvensis L.). Crop Research (Hisar); 2012; 44(3):34434
13. Walia US, Sandhu KS, Saini SS, Samra JS. Studies on chemical weed control in Japanese mint (*Mentha arvensis* L.). Indian J Weed Sci. 1980; 12:181-85.
14. Yadav SL, Kaushik MK, Mundra SL. Effect of weed control practices on weed dry weight, nutrient uptake and yield of clusterbean (*Cyamopsistetragonoloba* L.) under rainfed condition. Indian Journal of Weed Science. 2013; 43:81-84.
15. Yadav RS, Singh SP, Sharma V, Bairwa RC. Herbicidal weed control in green gram in arid zone of Rajasthan. In: Extended Summary of Biennial Conference of Indian Society of Weed Science, Feb. 15-17, DSWR, Jabalpur (M.P.): 2014, 97.
16. Yadav RS, Singh SP, Sharma V, Bairwa RC. Evaluation of post emergence herbicides in greengram. In: 25th Asian-Pacific Weed Science Society Conference on "Weed Science for Sustainable Agriculture, Environment and Biodiversity" Hyderabad, 2015, 242