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Herbicides' efficacy on Egyptian broomrape *(Orobanche aegyptiaca Pers.)* in tomato and brinjal in South-West Haryana, India

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ABSTRACT

Egyptian broomrape (*Orobanche aegyptiaca* Pers.) is the most troublesome root holoparasitic weed which causes severe damage to tomato and brinjal crops grown in Mewat and Bhiwani areas of Haryana. A study was conducted to test the efficacy and selectivity of two sulfonylurea herbicides, *viz*. sulfosulfuron and ethoxysulfuron, and neem cake; pendimethalin in combination with metalaxyl along with sulfonylurea herbicides for managing *O. aegyptiaca* in tomato and brinjal in field conditions. The post-emergence application (PoE) of sulfosulfuron and ethoxysulfuron at 50 g/ha 30, 60, 90 DAP (days after planting) were more selective to tomato and to control the parasite, *O. aegyptiaca*, more effectively with average yield increase of 51.7% over untreated check. Neem cake or metalaxyl were not effective to inhibit the growth of *O. aegyptiaca* in brinjal. It is inferred from this study that ethoxysulfuron at 25 g/ha PoE at 30 DAP and at 50 g/ha or sulfosulfuron at 50 g/ha PoE at 30 and 60 DAP, provided 85-90% control of *O. aegyptiaca* in tomato. Both the herbicides caused phytotoxicity to brinjal. The results of eight adaptive on-farm trials conducted in tomato during 2016-17 also revealed 92.3% control of *O. aegyptiaca* with a yield increase of 30.8% over untreated control.

INTRODUCTION

Egyptian broomrape (*Orobanche aegyptiaca* Pers.) locally known as margoja/rukhri/khumbhi/gulli is an achlorophyllous, phanerogamic troublesome root parasite which depends completely on host to complete its life cycle. This parasitic plant causes economic damage in field crops and vegetable production worldwide (Parker and Riches 1993, Eizenberg *et al*. 2004). Tomato (*Lycopersicon esculentum* Mill.) is highly vulnerable to three broomrape species, *viz*. *O. aegyptiaca*, *O. ramosa* L. and *O. cernua* Loefl. that are known to cause damage and reduce tomato yields (Joel *et al*. 2007). *Orobanche aegyptiaca* is the major limiting factor in tomato production in Israel, Egypt, Sudan, Syria, Tunisia, Turkey and Lebanon.

Survey of weed flora in tomato and brinjal (*Solanum melongena* L.) fields in Haryana during 2013-2014 revealed that both tomato and brinjal were found badly infested with *Orobanche aegyptiaca* threatening their cultivation in Nuh, Ferozepur Jhirka, Nagina, Taoru areas of Mewat, Charkhi Dadri and Loharu areas of Bhiwani of Haryana state in India. Farmers reported 40-75% yield loss due to its infestation in tomato depending on the intensity of infestation (Punia *et al*. 2016). A continuous increase in *O. aegyptiaca* infestation in these areas has forced farmers to abandon tomato and brinjal cultivation and switch over to other less-profitable alternative crops.

Orobanche aegyptiaca exerts the greatest damage prior to emergence of flowering shoot. Therefore, most of the field losses would occur before diagnosis of infection. In such situations, chemical control measures and host resistance appear to be the most appropriate measures whenever available and affordable. Potential herbicides must be selective for the host plant but phytotoxic to the parasite. Most promising soil fumigant methyl-bromide is phased out. The conventional methods of weed control are time consuming, expensive and laborious, more over ineffective due to continuous germination of *O. aegyptiaca* throughout the crop growth period.

The herbicides to be used must be selective for the host plant but phytotoxic to the parasite. The effectiveness and selectivity of sulfosulfuron and other ALS inhibiting herbicides to control *O. aegyptiaca* in tomato *(Solanum lycopersicum)* was demonstrated earlier in Israel (Hershenhorn *et al.* 2009) and India (Punia *et al.* 2016). Hence, herbicides use can be an effective measure for *O. aegyptiaca* management. The herbicide should persist up to certain period so that it may provide adequate weed control for a certain period and later it should degrade.

The studies conducted between 2012-2016 by Punia *et al.* (2016) demonstrated efficacy of ethoxysulfuron and sulfosulfuron in tomato but the results, over the years, were inconsistent with respect to time of application and dose of herbicides. Optimal crop stage for herbicide application is critical for the herbicide to cause mortality of preconditioned seeds or young attachments of *O. aegyptiaca.* Hence, to validate results of the previous studies under field conditions and assess their efficacy under Indian context, the present study was undertaken to quantify the efficacy of sulfonylurea herbicides on *O. aegyptiaca* in tomato and brinjal under Indian conditions with the objectives: 1. To assess the efficacy of sulfonyl urea herbicides against *O. aegyptiaca* and their effect on growth and yield of brinjal and tomato; 2. To study efficacy of neem cake and metalyxyl in combination with pendimethalin in managing *O. aegyptiaca* in brinjal; and 3. To quantify the phytotoxic effects of tested herbicides on tomato and brinjal.

MATERIALS AND METHODS

Tomato hybrid *'2853'* was planted for two consecutive years on November 18, 2016 and November, 11, 2017 at the farm of Abaas of village Rehna (Nuh) Mewat and November 19, 2016 at the farm of Arsad of village Bivan, Tehsil Nuh of Mewat district (Haryana). The experimental plot size was 25 x 6 m^2. A randomized block design was used with three replications. Tomato was grown as per the recommended package of practices of CCS Haryana Agricultural University (CCSHAU), except for the tested weed management treatments *i.e* ethoxysulfuron 25 g/ha pre-emergence application (PE); oxyfluorfen 120 g/ha PE; ethoxysulfuron 50 g/ha post-emergence application (PoE) at 60 and 90 days after transplanting (DAP); sulfosulfuron PoE 25 g/ha at 60 DAP followed by (*fb*) 50 g/ha 90 DAP, sulfosulfuron 50 g/ha PoE at 60 and 90 DAP and farmers practice of hand pulling. In the first year of the study, all the pre-emergence application of herbicides was done by using a knap sack sprayer fitted with flat fan nozzle using 750 litres of water/ha. The ethoxysulfuron PE and oxyfluorfen PE have caused toxicity to crop during 2016 and hence these treatments were deleted during experimentation of 2017. The post-emergence application of herbicides was done using 375 litres/ha of water. The observations on number of *O. aegyptiaca* spikes/m^2 and *O. aegyptiaca* visual control (0-100 scale) as affected by different treatments was recorded at 60, 90, 120 days after planting (DAP) and at harvest. Data on tomato plant height and number of fruits/plant was recorded at 120 DAP. The number of tomato fruits/plant was recorded from five tagged plants at 120 DAT and the values were averaged to compute the number of tomato fruits/plant. The tomato fruits were picked in four flushes, weighed and tomato total yield/plot was computed. Crop phyto-toxicity due to different treatments was assessed at 120 DAP and harvest on a scale of 0-100, where 0 means no injury and 100 = complete mortality of tomato plant. Foliar necrosis, yellowing, stunting, necrosis and wilting were the main symptoms considered while making visual estimate of visual injury on tomato plants. Keeping in view the excellent efficacy of sulfonylurea herbicides even in 2015, eight field trials at farmers' fields were conducted in tomato during 2016-17.

The experiment on brinjal was conducted using the brinjal hybrid '*707*' at farmers' field in V. Bivan tehsil Nuh, Distt. Mewat (Haryana) during (rainy season) *Kharif* 2017 in randomized block design with 4 replications Each plot size was 15x 10 m2. The brinjal crop was grown as per CCSHAU recommended package of practices, except the herbicide treatment, *viz.* neem cake 200 kg/ha at sowing *fb* pendimethalin 1.0 kg/ha at 3 DAP *fb* soil drenching of metalaxyl MZ 0.2 % at 20 DAP, ethoxysulfuron 20 g/ha PE *fb* PoE at 45 DAP, ethoxysulfuron 20 g/ha PE *fb* PoE at 45 DAP, sulfosulfuron 25 g/ha PoE at 25 and 45 DAP and sulfosulfuron 25 g/ha PE at sowing *fb* PoE 45 DAP. The post-emergence herbicides were applied using 375 litres/ha of water. The observations on number of *O. aegyptiaca* spikes/m^2 as affected by different treatments were recorded on 60, 90, 120 DAP and at harvest. The *O. aegyptiaca* control was assessed visually using 0-100 scale and was recorded at 120 DAP and harvest. The data on plant height, length of *O. aegyptiaca* spike were recorded at 120 DAP. The number of brinjal fruits/plant was recorded from five tagged plants and were averaged to compute number

of brinjal fruits/plant. The crop phyto-toxicity due to different treatments was assessed at 30, 60 and 120 DAP on a scale of 0-100, where 0 means no injury and 100 = complete mortality of brinjal plant

The recorded observations were subjected to ANOVA and means were compared with appropriate Fisher's protected LSD test at 5% level of probability. The crop injury data were arc sin transformed prior to ANOVA but data was also presented in their original form for clarity.

Phytotoxicity/injury data in both commodities were arcsin transformed prior to ANOVA. All other data were also subjected to ANOVA and means were compared with appropriate Fisher's protected LSD test at 5% level of probability.

RESULTS AND DISCUSSION

Evaluation of herbicides efficacy on *Orobanche aegyptiaca* in tomato

The *Orobanche aegyptiaca* panicles didn't appear in any of the treatment up to 60 DAP during 2017-18 at field of Arsad but during 2016-17 at the field of Abaas of Nuh, some panicles appeared even at 60 DAP. During 2016-17, although, the pre-emergence application of ethoxysulfuron at 25 g/ha and oxyfluorfen at 120 g/ha proved very effective against *O. aegyptiaca* but they caused toxicity to tomato plants. The percentage toxicity was more due to oxyfluorfen as compared to ethoxysulfuron. At 30 days after planting (DAP), 100% mortality of tomato plants was recorded. Plants which survived after treatment of ethoxysulfuron (PRE) were also very weak and wrinkled with stunted growth. Excellent control of *O. aegyptiaca* was achieved with post-emergence spray of sulfosulfuron and ethoxysulfuron compared to untreated control. During 2016-17, at the field of Arsad, ethoxysulfuron and sulfosulfuron treated plots showed infestation of 2.0-7.7 *O. aegyptiaca* spikes/m^2 at 120 DAP with no injury to tomato crop but at the field of Abaas, number of *O. aegyptiaca* panicles in the plots treated with sulfosulfuron and ethoxysulfuron (PoE) were 0.7-2.7/m^2 and 1.3-1.7/m^2 during 2016-17 and 2017-18, respectively as against 14.7-40.0 panicle/m^2 in untreated check (**Table 1**). During 2017-18, plots treated with ethoxysulfuron remained free from *O. aegyptiaca* even up to 120 DAP and exhibited 85 to 100% control of *O. aegyptiaca* up to harvest without any crop suppression. The *O. aegyptiaca* spikes which emerged 120 DAP or at harvest in ethoxysulfuron and sulfosulfuron treatments were very weak and small sized. Sulfosulfuron is registered for *O. aegyptiaca* control in Israel in tomato, so obviously it was well expected no any damage in tomato. These results corroborate the earlier findings of Eizenberg *et al*. (2004) and Punia *et al*. (2016) who reported effective control of *O. aegyptiaca* in tomato with post emergence use of sulfosulfuron at 25, 50 and 75.0 g/ha. Ethoxysulfuron 25 g/ha (PRE)

Table 1. Effect of different weed control treatments on *Orobanche aegyptiaca* population, visually assessed control and spike length of broom rape, tomato plant height, crop toxicity and tomato fruit yield and B:C (2016-17) (farmer Arsad field)

Treatment	No. of broom rape spikes/m^2			Broom rape control (%)			Broom rape spike length (cms)	Tomato plant height (cms)	Tomato crop phytotoxicity (%) 30 DAT	No. of tomato fruits/ plant	Tomato fruit yield (t/ha)	B:C
	90 DAP	120 DAP	Harvest	90 DAP	120 DAP	Harvest						
Ethoxysulfuron 25 g/ha PE	1.24 (0.7)	1.33 (1.0)	2.35 (5.0)	79.5 (95.0)	71.9 (90.0)	69.3 (90.0)	1.2	14.3	70.0 (88.3)	3.3	0.2	0.06
Oxyfluorfen 120 g/ha PE	1 (0)	1.24 (0.7)	1.24 (0.7)	77 (95.0)	66.8 (85.0)	71.5 (90.0)	0.9	16.0	79.5 (95)	2.7	0	0
Ethoxysulfuron 50 g/ha PoE at 60 and 90 DAP	1.58 (1.6)	1.79 (2.3)	3.15 (9.0)	71.6 (92.0)	63.5 (65.0)	60.1 (76.0)	16.9	44.9	0 (0)	26.7	18.3	5.78
Sulfosulfuron PoE 25 g/ha at 60 DAP *fb* 50 g/ha 90 DAP	1 (0)	2.89 (7.7)	2.06 (3.3)	71.9 (90.0)	65 (80.0)	56.9 (70.0)	15.7	44.0	0 (0)	24	17.9	5.27
Sulfosulfuron 50 g/ha PoE at 60 and 90 DAP	1 (0)	1.67 (2.0)	2.81 (7.0)	90 (100.0)	79 (95.0)	67.2 (82.0)	18.5	45.0	0 (0)	29	20.5	5.88
Farmers practice of hand pulling	1 (0)	2.21 (4.0)	3.45 (11.0)	50.8 (60.0)	45 (45.0)	36.2 (35.0)	12.6	45.0	0 (0)	20	14.6	3.22
Weedy check	3.49 (11.3)	6.40 (40.0)	6.03 (35.6)	0 (0)	0 (0)	0 (0)	19.3	39.7	0 (0)	14	10.5	3.44
LSD (p=0.05)	0.6	0.96	0.99	8.8	9.4	5.8	0.45	2.4	6.92	1.58	0.75	-

*Original figures in parentheses related to *broom rape* density were subjected to square root transformation $(\sqrt{x+1})$ before statistical analysis. Values on broom rape control were subjected to arc $\sin^{-1}$ transformation before statistical analysis. Broom rape did not emerge above ground up to 60 DAP so no data is generated. PE: Pre-emergence application; PoE: Post-emergence application; DAP: Days after planting

was more phytotoxic than its PoE application and tomato exhibited severe growth reduction. At the field of Abaas, during 2016-17 and 2017-18, minor developmental delay in tomato was observed with ethoxysulfuron applied PE or 30 DAP at 25 g/ha with 10% phytotoxicity recorded at 10 DAT which further reduced to only 3.3% at harvest. No damage was observed to tomato plants with the use of post-emergence application of either sulfosulfuron or ethoxysulfuron during 2016-17 at the field of Arsad and Abaas during 2016-17 and 2017-18 as well (**Table 2**). During 2016-17, maximum fruit yield (20.5 and 26.9 t/ha) was recorded in the plots treated with sulfosulfuron 50 g/ha at 60 and 90 DAP at both the locations but during 2017-18 (Abaas's farm), sulfosulfuron 25 g/ha at 60 DAP and 50 g/ha at 90 DAP resulted the maximum fruit yield (35.7 t/ha) which was 42.8% higher than untreated check, and it was at par with ethoxysulfuron 50 g/ha at 60 and 90 DAP, and sulfosulfuron 50 g/ha at 60 and 90 DAP (**Table 3**). During 2016-17, maximum B:C (5.88 and 8.0) was obtained with post-emergence use of sulfosulfuron 50 g/ha at 60 and 90 DAP but during 2017-18, the maximum B:C of 5.0 was obtained with use of sulfosulfuron at 25 g/ha at 60 DAP and 50 g/ha at 90 DAP. These findings were in accordance with those of Dinesha *et al.* (2012) and Hershenhorn *et al.* 2009 who reported excellent efficacy of sulfosulfuron 75 g/ha at 30 DAP in preventing the development of *O. aegyptiaca* and reducing the seed inoculums potential in the soil by registering significantly lowest *O. aegyptiaca* number, spike

Table 2. Effect of different weed control treatments on *Orobanche aegyptiaca* population, visually assessed control, plant height, crop toxicity and fruit yield of tomato (farmer Abaas field) 2016-17

Treatment	No. of broom rape spikes/m^2				Broom rape control (%)			Visual phytotoxicity (%) on crop			Plant height (cms) 120 DAP	No. of fruits/ plant	Fruit yield (t/ha)	B:C
	60 DAP	90 DAP	120 DAP	Harvest	90 DAP	120 DAP	Harvest	10 DAP	30 DAP	120 DAP				
Ethoxysulfuron 25 g/ha PE)	1.0 (0)	1.0 (0)	1.24 (0.7)	1.49 (1.3)	90 (100.0)	90 (100.0)	72.3 (86.7)	58. (73.3)	55.8 (68.3)	49.9 (58.3)	17.0	3.7	0.27	0.1
Oxyfluorfen 120 g/ha (PE)	1.0 (0)	1.0 (0)	1 (0)	1 (0)	90 (100.0)	90 (100.0)	90 (100)	60. (75.0)	90 (100)	90 (100)	0.0	0.0	0.00	0.0
Ethoxysulfuron 50 g/ha at 60 and 90 DAP	1.4 (1)	1.75 (2.33)	1.91 (2.7)	1.85 (3.0)	79.5 (95.0)	67.8 (80.0)	62.5 (78.3)	18 (10.0)	19.3 (11.7)	8.6 (3.3)	47.0	32.0	23.50	7.6
Sulfosulfuron 25 g/ha at 60 DAT *fb* 50 g/ha 90 DAP	1.4 (1)	1.47 (1.33)	1.58 (1.7)	1.66 (2.0)	78.1 (93.3)	72.8 (86.7)	73.5 (88.3)	1 (0)	1 (0)	1 (0)	47.0	35.0	25.30	7.7
Sulfosulfuron 50 g/ha at 60 and 90 DAP	1.0 (0)	1.24 (0.67)	1.24 (0.7)	1.48 (1.7)	90 (100.0)	82.4 (95.0)	82.4 (95.0)	8.6 (3.3)	4.3 (1.7)	1 (0)	47.0	37.0	26.90	8.0
Hand pulling (FP)	1.7 (2)	2.57 (5.67)	2.95 (8.0)	3.08 (8.7)	62.3 (78.3)	33.2 (31.7)	27.1 (21.7)	1 (0)	1 (0)	1 (0)	44.7	28.3	16.57	3.7
Weedy check	1.7 (2)	3.31 (10.0)	3.65 (12.3)	4.07 (15.7)	72.4 (86.7)	1 (0)	1 (0)	1 (0)	1 (0)	1 (0)	43.7	26.7	14.37	4.9
LSD (p=0.05)	0.3	0.66	0.72	1.13	13.9	19.8	18.9	6.7	68.3	6.4	3.2	4.6	1.13	

*Original figures in parentheses related to broom rape density were subjected to square root transformation $(\sqrt{x+1})$ and visual toxicity to arc/sin transformation before statistical analysis

Table 3. Effect of different weed control treatments on *Orobanche aegyptiaca* population, visually assessed control, plant height, crop toxicity and fruit yield of tomato (2017-18) (farmer Abaas field)

Treatment	No. of *O. aegyptiaca* spikes/m^2				Visual phytotoxicity (%) on crop	Visual broom rape control (%)		Plant height (cms) 120 DAP	No. of fruits/ plant	Fruit yield (t/ha)	B:C
	60 DAP	90 DAP	120 DAP	Harvest	10 DAT	120 DAP	Harvest				
Ethoxysulfuron 50 g/ha PoE at 60 and 90 DAP	0	1.14 (0.40)	1.49 (1.33)	1.99 (3.00)	14.0 (6)	73.5 (88)	62.9 (79)	52.0	35.0	25.4	4.9
Sulfosulfuron 25 g/ha PoE at 60 DAT *fb* 50 g/ha 90 DAP	0	1.24 (0.60)	1.58 (1.67)	1.73 (2.33)	0 (0)	71.1 (85)	72.4 (87)	51.7	35.7	24.9	5.0
Sulfosulfuron 50 g/ha PoE at 60 and 90 DAP	0	1(0)	1.63 (1.67)	1.72 (2.00)	15.2 (7)	90 (100)	67.4 (85)	51.7	34.3	24.4	4.6
Farmers practice - hand pulling	0	2.76 (6.20)	2.70 (6.33)	2.52 (5.67)	0 (0)	37.2 (37)	33.1 (30)	46.3	27.3	16.7	2.7
Weedy check	0	3.21 (9.40)	3.93 (14.67)	4.50 (19.33)	0 (0)	0.0 (0)	0.0 (0)	43.3	25.0	13.0	3.0
LSD(P=0.05)		0.52	0.74	1.05	2.59	20.0	14.9	5.6	2.6	1.4	-

*Original figures in parentheses related to broom rape density were subjected to square root transformation $(\sqrt{x+1})$ and visual toxicity to arc/sin transformation before statistical analysis; PoE= post-emergence application; DAP= days after planting

height, spike dry weight with higher *O. aegyptiaca* control efficiency, which also accounted for higher tomato plant height, number of branches, leaf area/ plant at harvest, higher fruit weight/ plant and fruit yield of tomato in Karnataka state of India.

Adaptive on-farm trials on the use of herbicides to manage *Orobanche aegyptiaca* in tomato

To demonstrate the efficacy of sulfosulfuron and ethoxysulfuron against parasitic weed *O. aegyptiaca*, adaptive on-farm trials were conducted at 8 locations in the village Rehna of Nuh tehsil of Mewat district. The application of ethoxysulfuron provided 85-90% control of *O. aegyptiaca with* 3.5-3.7 panicle of *O. aegyptiaca* at harvest and tomato yield of 27.0-27.6 t/ha as against 16.8-19.5 t/ha in untreated check (**Table 4**). Per cent control with the use of sulfosulfuron was higher as compared to ethoxysulfuron which ranged from 90-100% yielding 23.8-26.5 t/ha. On an average, the use of herbicides provided 92.4% control of *O. aegyptiaca* resulting 43% increase in tomato yield,

Evaluation of herbicides against *Orobanche aegyptiaca* in brinjal

The *O. aegyptiaca* panicles didn't appear in any of the treatment up to 60 DAP. Application of neem cake at sowing in combination with pendimethalin followed by soil drenching of metalaxyl (MZ 0.2%) at 20 DAP didn't cause any inhibition in *O. aegyptiaca* emergence as evident from its density at 120 DAP (**Tables 5 and 6**). Although an excellent control of *O. aegyptiaca* was obtained with PoE or PE plus PoE treatments of sulfosulfuron and ethoxysulfuron when compared with untreated controls but these herbicides proved phytotoxic to brinjal crop. *O. aegyptiaca* stalks to the tune of 1.7-3.0 panicles/m^2 appeared in various herbicide treatments which was

Table 4. Efficacy of demonstrated herbicides at the on-farm multi-locational demonstrations conducted on *Orobanche aegyptiaca* control in tomato during 2016-17

Name & address of farmer	Hybrid	Herbicide used	*O. aegyptiaca* panicles/m^2 Treated			*O. aegyptiaca* control (%)	Tomato yield (t/ha)	
			120 DAP	Harvest	Untreated		Treated	Untreated
Arsad, V.Bivan (Nuh)	2853	Sulfosulfuron 25 g/ha PoE at 60 DAT *fb* 50 g/ha 90 DAP	0.2	1.5	16	90	23.8	18.5
Abaas, V. Rehna (Mewat)	Namdhari	Sulfosulfuron 25 g/ha PoE at 60 DAT *fb* 50 g/ha 90 DAP	0	0.4	58	95	24.7	14.0
Abaas, v. Rehna (Mewat)	2853	Ethoxysulfuron 50 g/ha PoE at 60 and 90 DAP	0.3	3.5	48	90	27.0	16.8
Jaid V. Rehna (Nuh)	Himsikhar	Sulfosulfuron 25 g/ha PoE at 60 DAT *fb* 50 g/ha 90 DAP	0	2.4	24	95	24.1	18.9
Jaid, V. Rehna (Nuh)	2853	Sulfosulfuron 25 g/ha PoE at 60 DAT *fb* 50 g/ha 90 DAP	0	1.5	14	94	22.0	17.2
Vaseem,V. Rehna (Nuh)	2853	Sulfosulfuron 25 g/ha PoE at 60 DAT *fb* 50 g/ha 90 DAP	0	4	78	100	24.3	17.0
Lykat,V.Rehna (Nuh)	Satyam	Sulfosulfuron 25 g/ha PoE at 60 DAT *fb* 50 g/ha 90 DAP	0.2	2.4	56	90	26.5	18.0
Lykat,V.Rehna (Nuh)	2853	Ethoxysulfuron 50 g/ha PoE at 60 and 90 DAP	0.4	3.7	50	85	27.6	19.5
Mean	-	-*	0.13	2.42	43	92.37	25.0	17.5

PE: Pre-emergence application; PoE: Post-emergence application; DAP: Days after planting

Table 5. Effect of different weed control treatments on *Orobanche aegyptiaca* population visually assessed control, crop toxicity and fruit yield of brinjal during 2016-2017

Treatment	Number of *O. aegyptiaca* spikes/m^2 (120 DAP)	Visual control (%) (120 DAP)	Visual phytotoxicity (%) on crop 120 DAP	Fruit yield (t/ha)
Neem cake 200 kg/ha at sowing *fb* pendimethalin 1.0 kg/ha at 3 DAP *fb* soil drenching of metalaxyl MZ 0.2% at 20 DAP	5.22(26.2)	0(0)	0(0)	22.5
Ethoxysulfuron 20 g/ha PE *fb* PoE at 45 DAP	1.0(0)	59.3(74)	56.7(70)	11.2
Sulfosulfuron 25 g/ha PoE at 25 and 45 DAP	1.95(3)	63.5(80)	29.9(25)	22.7
Sulfosulfuron 25 g/ha PE at sowing *fb* PoE 45 DAP	1.64(1.7)	64.9(82)	42.1(45)	14.8
Weedy check	4.93(23.5)	0(0)	0(0)	23.4
LSD (p=0.05)	0.50	3.01	2.18	2.4

*Original figures in parenthesis related to *broom rape* density were subjected to square root transformation ($\sqrt{x+1}$) and t on *broom rape* control were subjected to arc $\sin^{-1}$ transformation before statistical analysis; PE= pre-emergence application; PoE= post-emergence application; DAT = days after transplanting

Table 6. Effect of different weed control measures on *Orobanche aegyptiaca* population visual control, crop toxicity and fruit yield of brinjal during 2017- 2018

Treatment	Number of *O. aegyptiaca* spikes/m^2 (120 DAS)	Visual control (%) (120 DAS)	Visual phytotoxicity (%) on brinjal crop 120 DAP	Brinjal fruit yield (t/ha)
Neem cake 200 kg/ha at sowing *fb* pendimethalin 1.0 kg/ha at 3 DAP *fb* soil drenching of metalaxyl MZ 0.2 % at 20 DAT	5.13(25.4)	0(0)	0(0)	21.2
Ethoxysulfuron 20 g/ha (PRE) and at 45 DAT	1.41(1.0)	63.5(80)	56.7(70)	12.4
Sulfosulfuron 25 g/ha at 25 and 45 DAT	2.0(3)	56.7(70)	33.1(30.0)	20.8
Sulfosulfuron 25 g/ha at sowing and 45 DAT	1.41(1.0)	73.5(88.3)	36.5(35.0)	15.6
Weedy check	5.29(27.0)	0(0)	0(0)	21.8
LSD (p=0.05)	0.46	3.01	2.18	2.6

*Original figures in parentheses related to broom rape density were subjected to square root transformation $(\sqrt{x+1})$ and t on broom rape control were subjected to arc/sin transformation before statistical analysis

significantly less than untreated control. The *O. aegyptiaca* spikes which emerged in ethoxysulfuron and sulfosulfuron treatments were very weak and small sized. Ethoxysulfuron 20 g/ha was more phytotoxic than sulfosulfuron as 70% brinjal growth reduction occurred with this treatment. Only 25 - 30% suppression on brinjal plant was recorded with sulfosulfuron at 25 g/ha PoE at 25 and 45 DAP (**Tables 5** and **6**) resulting in 80 and 88% control of *O. aegyptiaca* during 2017 and 2018, respectively. The crop suppression with the use of sulfosulfuron 25 g/ha had also an adverse effect on plant height, number of fruits/plant and total fruit yield of brinjal. The herbicide treatment in brinjal resulted into malformed and splitted brinjal fruits along with yield penalty was earlier reported by Anonymous (2018 and 2019) in sandy loam soils of Haryana. Malformation and splitting of brinjal fruits were also reported with use of rimsulfuron (Vouzounis and Americanos 1998).

Maximum fruit yield of 23.4 and 21.8 t/ha was recorded from untreated check during 2016-17 and 2017-18, respectively which was at par with sulfosulfuron 25 g/ha at 25 and 45 DAP (22.7 and 20.8 t/ha) and also neem cake *fb* pendimethalin and metalyxyl, but significantly higher than ethoxysulfuron and sulfosulfuron PE (**Table 5**). Sulfosulfuron at 20 g/ha at 45 and 90 DAP in brinjal provided effective control of *O. aegyptiaca* but with 5-10% crop suppression (Singh *et.al.* 2017).

Conclusions

Based on the present investigation, it was concluded that post-emergence application of (30, 60/ 90 DAP) ethoxysulfuron/sulfosulfuron 25 g/ha at 30 DAP followed by its use at 50 g/ha or sulfosulfuron at 50 g/ha at 30 and 60 DAP could effectively manage *O. aegyptiaca* in the tomato. The neem cake and metalaxyl could not inhibit the growth of *O. aegyptiaca* in brinjal and also none of tested herbicide was selective to the brinjal crop.

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