Indian Journal of Weed Science **51**(3): 266–269, 2019

Print ISSN 0253-8040 Online ISSN 0974-8164

Biology and large scale demonstration for management of *Orobanche aegyptiaca* in mustard

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Article information

DOI: 10.5958/0974-8164.2019.00056.X

Type of article: Research article

Received : 4 June 2019
Revised : 27 August 2019
Accepted : 29 August 2019

Key words
Glyphosate
Indian mustard
Orobanche
Neem cake
Trichoderma viridae
Pendimethalin

ABSTRACT

Field experiments to study the efficacy of neem cake, soil drenching of metalaxyl, post-emergence application of glyphosate at very low concentrations alone and in combination with 1% solution of ammonium sulphate and 125% of recommended fertility, were conducted at village Ganghala (Bhiwani) during *Rabi* seasons of 2014-15 and village Bidhwan (Bhiwani) during 2015-16. Feasibility of adoption of results of studies conducted earlier on use of glyphosate 25 g/ha at 30 DAS and 50 g/ha at 55 DAS is being demonstrated by multi location field trials through farmers participatory approach in different parts of state during 2010-2016. Neem cake 400 kg/ha *fb* pendimethalin (PPI) at 0.75 kg/ha *fb* HW at 60 DAS did not prove effective in minimizing density of *Orobanche*. Post-emergence application of glyphosate at 25 and 50 g/ha at 25 and 55 DAS, respectively showed promising results with 75-95% control of this weed in experimental field and 76.5% on large scale demonstrations at farmers' fields. Biotype from Ganghala (Bhiwani) was found to be most robust biotype with 5840 seeds per capsule.

INTRODUCTION

Parasitization of *Orobanche* in broad-leaf crops especially that belonging to brassicaceae and solanaceae family is a serious problem globally. *Orobanche* is a serious weed of mustard, tomato, brinjal, tobacco, potato and other commercial crops in some regions throughout the country. It is a phanerogamic, obligate, troublesome holo root parasite that lack chlorophyll (Baccarini and Melandri 1967, Saghir *et al*. 1973) and obtain carbon, nutrients, and water through haustoria which connect the parasite with the host vascular system. (Dorr and Kollmann 1976, Press *et al*. 1986). The diversion of these substances to the parasitic weed causes moisture and assimilate starvation, host plant stress and growth inhibition leading to extensive reduction in crop yield and quality in infested fields. Depending upon the extent of infestation, environmental factors, soil fertility, and the crops' response, damage from *Orobanche* can range from zero to complete crop failure (Dhanapal *et al*. 1996). This parasitic weed has the tendency to proliferate well in coarse textured soils with high pH, low nitrogen status and poor water holding capacity. In Haryana state, infestation of obnoxious weed *Orobanche aegyptiaca* has been observed in mustard fields in 0.25 mha area in south-western part of the state. However, the increasing infestation of *Orobanche* over the years have seriously impacted mustard cultivation and threatened the livelihood security of farmers of the region

Intensive research was undertaken under the All India Coordinated Research Programme on Weed Management at Hisar centre for more than a decade using farmers' participatory approaches. Herbicide screening trials were undertaken using chemicals at different rates, time and method of application. Pre-emergence, Pre- plant incorporation (PPI) or herbigation of trifluralin along with hoeing proved ineffective in minimizing the density of this weed. Post-emergence application of glyphosate at normal doses, kerosene oil and paraquat caused toxicity to mustard crop. Change in the genotype or sources of nutrient supply did not prove effective in minimizing density of this weed. After some initial positive response on tolerance of mustard plants and significant reduction in *Orobanche* shoots with application of glyphosate, research work was straightened to standardize the dose, timing and number of sprays and also associated agronomic practices. It was realized that a slight suppression in mustard growth occurs with glyphosate application at some places. This difference in selectivity can be

genetically inherited. Keeping in view, studies were undertaken to study the biology of *Orobanche* of seeds collected from different locations and effectiveness of different treatments in conjunction with glyphosate.

MATERIALS AND METHODS

The experiment on biology was undertaken in screen house of CCS HAU Hisar. Seeds of *Orobanche* collected from Bidhwan (Bhiwani), Obera (Bhiwani), Budhera (Bhiwnai) and Hasan (Bhiwani) during 2012-13 and Gangala (Bhiwani), Juglan (Hisar) Gignau (Bhiwani) and dry land area of HAU, Hisar during *Rabi* 2013-14 were sown in earthen pots of 1x1 ft diameter filled with loamy sand soil and FYM. After 15 days of germination, 10 plants per pot were maintained and observations on days to appearance of *Orobanche*, fresh and dry weight/panicle, number of shoots/panicle flower initiation (days after emergence) number of capsules/shoot, capsule weight/panicle and number of seeds/capsule were recorded.

In field experiment, studies were conducted to observe the effectiveness of neem cake alone or in conjunction with pendimethalin at 200 and 400 kg/ha, glyphosate at 25 and 50 g/ha at 30 and 55 DAS respectively, alone and in combination with 1% solution of ammonium sulphate [$(NH_4)_2So_4$], *Trichoderma viride* at 5.0 kg/ha before sowing, glyphosate alone at 50 g/ha at 40 DAS were compared with three hand weedings at 30, 60 and 90 DAS and untreated check. Present experiment was conducted at the farm of Sh. Rai Singh of village Bidhwan Distt. Bhiwani situated at latitude of N 28 ° 45' 772" and E 075 ° 36' 526 ''. Variety '*RH-0749*' was planted on 22th November 2013 in randomized block design in a plot size of 25 x 6 m^2 with three replications. Field selected was heavily infested with *Orobanche aegyptiaca* during previous years. Various treatments were imposed as per schedule as given in **Table 2** and **3**. Data on number of *Orobanche* panicles/m^2, per cent visual control of *Orobanche* was recorded at 120 days after sowing on 0-100 scale. The technology on use of glyphosate was validated through a large number of multi-locational trials in different districts of Hisar, Bhiwani and Mahendergarh between 2010 and 2017. A total of 758 demonstrations were conducted in mustard growing areas of Haryana state covering 1781 ha area.

RESULTS AND DISCUSSION

Biology of *Orobanche*: During 2012, *Orobanche* panicles appeared above soil on an average 55-60 days after sowing of mustard. Fresh weight of shoot was in the range of 30.9-40.2 g/plant as against 3.56-4.60 g/plant dry shoot weight. Violet cream colored flowers started to appear 10-12 days after panicle emergence of *Orobanche*. The capsule number per shoot varied from 40-46 while capsule weight was observed to be in the range of 0.084-00.132 g. The number of seeds per capsule varied from 3690-5625. Among all the biotypes, it was observed that biotypes of Bidhwan were stronger as compared to others. During 2013-14, *Orobanche* panicles appeared above soil on an average 45-54 days after sowing of mustard. Fresh weight of shoot was in the range of 34.9-42.5 g/plant as against 4.2-5.20 g/plant dry weight of shoot. Violet cream colored flowers started to appear 11-13 days after panicle emergence of *Orobanche*. The capsule number per shoot varied from 38-45 while capsule weight was observed to be in the range of 0.094-0.124 g. The number of seeds per capsule varied 3870-5840. Biotype from Gangala was stronger as compared to others. This collaborates the finding of Punia *et al.* (2018).

Effect of different weed control measures on *Orobanche* population and seed yield of mustard

During both the years, pendimethalin alone or in combination with neem cake did not prove useful in minimizing population of *Orobanche aegyptiaca*. Use of *Trichoderma viridae* at 5 kg/ha and neem cake at 200 and 400 kg/ha did not cause any inhibition of *Orobanche* emergence. Glyphosate application at 25 g/ha at 30 DAS and 50 g/ha at 55 DAS alone or with 1% with $(NH_4)_2So_4$ provided good (80-95%) and (75-80%) control of *Orobanche* up to 120 days after sowing during 2012-13 and 2013-14, respectively (**Table 2** and **3**). Although use of glyphosate alone at 50 g/ha at 40 DAS provided 60-80% control of *Orobanche* but 10% crop suppression in terms of chlorosis and necrosis was observed resulting in poor yield. Maximum seed yield of mustard (1.82 t/ha during 2012-13 and 1.81 t/ha during 2013-14) was observed with use of glyphosate 25 g/ha at 30 DAS and 50 g/ha at 55 DAS which was at par with all glyphosate treatments. Presence of *Orobanche* throughout crop season caused 29.4 and 20.4% reduction in seed yield of mustard during 2012-13 and 2013-14, respectively as compared to use of glyphosate 25 g/ha at 25 DAS and 50 g/ha at 55 DAS (RP).

Similar findings on the control of *Orobanche* in mustard through glyphosate application were also reported by the scientists at Gwalior and Bikaner (DWSR 2009, Punia *et al.* 2012 and Punia *et.al.* 2016).

Table 1. Various phenological parameters of *Orobanche* in mustard (2012-13 and 2013-14)

Characteristic	2012-13				2013-14			
	Bidhwan	Obera	Budhera	Hasan	Gangala	Juglan	Gignau	Hisar
Days to appearance of panicle	55	52	60	58	50	48	45	54
Fresh wt./plant (g)	40.2	36.6	35.8	30.9	42.5	40.6	38.2	34.9
Dry wt./plant (g)	4.60	3.86	3.60	3.56	5.20	4.98	4.02	4.2
No of shoots/plant	4.5	2.6	3.5	2.5	5.5	4.4	3.9	2.7
Flower initiation (days after emergence)	12	10	11	12	12	11	11	13
Capsules (no./shoot)	46	40	45	42	45	42	38	40
Capsule wt./plant(g)	0.132	0.084	0.098	0.013	0.124	0.110	0.094	0.095
No. of seeds/capsule	5625	4580	3690	3944	5840	4472	3870	4150

Table 2. Effect of different weed control measures on *Orobanche* population and seed yield of mustard (2012-13)

Treatment	*Orobanche* panicles /m^2		Visual control (%)	Seed yield (t/ha)	Remarks
	70 DAS	120 DAS			
Pendimethalin 1.0 kg/ha *fb* HW at 60 DAS	4	17	0	1.42	10% poor germination
Neem cake 200 kg/ha in furrow *fb* HW at 60 DAS	2	14	0	1.38	
Neem cake 200 kg/ha in furrow and pendimethalin 0.5 kg/ha *fb* HW at 60 DAS	3	19	0	1.46	
Neem cake 400 kg/ha in furrow *fb* HW at 60 DAS	4	11	0	1.48	
Neem cake 400 kg/ha in furrow *fb* pendimethalin 0.5 kg/ha *fb* HW at 60 DAS	0	17	0	1.52	
Glyphosate 25 and 50 g/ha at 30 and 55 DAS	0	0.66	95	1.82	
Glyphosate 25 and 50 g/ha at 30 and 55 DAS with 1% $(NH_4)_2So_4$	0	1	90	1.74	
Glyphosate 25 and 50 g/ha at 30 and 55 DAS(RP)	0	0	100	1.76	
Glyphosate 25 g/ha at 30 DAS and 50 g/ha at 40 DAS	0	2	90	1.76	15 % crop suppression
Glyphosate 50 g/ha at 40 DAS	0	4	80	1.74	10 % crop suppression
HW at 30,60 and 90 DAS	4	22	0	1.60	
Trichoderma viride at 5 kg/ha before sowing	2	17	0	1.65	
Weedy check	4	21	-	1.44	
LSD (p=0.05)		2.4	-	0.01	

Table 3. Effect of different weed control measures on *Orobanche* population and seed yield of mustard (2013-14)

Treatment	*Orobanche* panicles/m^2			Visual control (%)	Seed yield	Remarks
	60 DAS	90 DAS	120 DAS	120 DAS	(t/ha)	
Neem cake 200 kg/ha in furrow and pendimethalin 0.5 kg/ha *fb* HW at 60 DAS	1.73(2)	1.73(2.0)	4.79(22)	0	1.48	
Neem cake 400 kg/ha in furrow *fb* HW at 60 DAS	2.65(6)	2.45(5)	4(15)	0	1.44	
Neem cake 200 kg/ha in furrow *fb* HW at 60 DAS	1.96(3)	2.0(3)	4.2(16)	0	1.45	
Pendimethalin 1.0 kg/ha *fb* HW at 60 DAS	2.52(5.3)	2.65(6)	4.97(24)	0	1.22	10% poor germination
Neem cake 400 kg/ha in furrow *fb* pendimethalin 0.5 kg/ha *fb* HW at 60 DAS	1.96(3)	2.76(6)	4.47(19)	0	1.38	
Glyphosate 25 and 50 g/ha at 30 and 55 DAS	1(0)	1(0)	1.73(2)	75	1.81	
Glyphosate 25 and 50 g/ha at 30 and 55 DAS with 1% $(NH_4)_2So_4$	1(0)	1(0)	1.41(1)	80	1.76	15% toxicity
Glyphosate 25 and 50 g/ha at 30 and 55 DAS(RP)	1(0)	1(0)	1.73(2)	75	1.78	
Glyphosate 25 g/ha at 30 DAS and 50 g/ha at 40 DAS	1(0)	1(0)	1.73(2)	75	1.80	5% crop suppression
Glyphosate 50 g/ha at 40 DAS	1(0)	1(0)	2.24(4)	60	1.70	10% crop suppression
HW at 30, 60 and 90 DAS	1.9(3)	3.51(11.3)	4.73(21)	0	1.58	
Trichoderma viride at 5 kg/ha before sowing	2.24(4)	3.42(10.7)	4.2(17)	0	1.60	
Weedy check	2.63(6)	3.51(11.3)	4.83(22)	-	1.40	
LSD (p=0.05)	0.20	0.18	0.22	-	0.035	

The results obtained earlier on efficacy of glyphosate were validated in large scale multi-locational trials conducted at different locations through farmers' participatory approach in Haryana State during the *Rabi* seasons of 2010-11 to 2016-17. A total of 758 demonstrations were conducted in mustard growing areas of Haryana state covering 1831 ha area and it was observed that overall 76.5% (range 40-95%) reduction in *Orobanche* weed infestation with 21.4% (range 13.9-38.7%) yield superiority was noticed with glyphosate treated plots (25 g/ha at 30 DAS followed by 50 g/ha at 55-60 DAS) when compared with the farmers' practice of one hoeing at 25-30 DAS (**Table 4**). This technology

Table 4. Comparative performance of glyphosate application *vis-à-vis* farmers' practice for *Orobanche* management and its subsequent effect on seed yield of mustard in large scale multi-locational trials

Year	No. of trials	Area covered (ha)	*Orobanche* Control (%)	Seed yield (t/ha)		Percent reduction in yield in farmer's practice
				Treated*	Farmer's practice*	
2010-11	12	5	82 (70-95)	1.72 (1.40-2.10)	1.49 (1.20-1.95)	15.5
2011-12	24	20	79 (65-90)	1.59 (1.20-2.20)	1.37 (0.90-1.80)	16.3
2012-13	86	156	72 (55-90)	1.75 (1.25-2.25)	1.54 (1.00-1.95)	13.9
2013-14	35	82	63 (40-90)	1.65 (1.25-2.40)	1.44 (1.10-2.10)	14.6
2014-15	119	486	80 (48-90)	1.85 (1.42-2.50)	1.50 (1.18-1.84)	23.4
2015-16	232	597	80 (79-87)	1.75 (1.13-2.22	1.26 (0.71-1.66)	38.7
2016-17	250	485	79 (75-84)	1.83 (1.48-2.28)	1.40 (1.25-1.55)	30.1
Mean	758	1831	76.5	1.73	1.43	21.4

*25 g/ha at 30 DAS and 50 g/ha at 55-60 DAS-2 sprays; **one hoeing at 25-30 DAS; figures in parenthesis indicate range of the treatment effect on *Orobanche* control and mustard seed yield.

has now spread to the most *Orobanche*-infested mustard-growing areas of Haryana and the farmers are fully convinced of the benefits of this low-cost technology.

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