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Effectiveness of different methods for controlling *Orobanche* in mustard

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ABSTRACT

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 $(NH_4)_2SO_4$ and 125% of recommended fertility, field experiments were conducted at the villages Ganghala and Bidhwan in Bhiwani district of Haryana during *Rabi* seasons of 2014-15 and 2015-16, respectively. 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 at sowing *fb* soil drenching of metalaxyl MZ 0.2% at 25 DAS *fb* glyphosate at 40 g/ha at 45 DAS or neem cake 400 kg/ha *fb* pendimethalin (PPI) at 0.75 kg/ha *fb* metalaxyl 0.2% at 25 DAS did not prove effective in minimizing density of *Orobanche*.

Post-emergence application of glyphosate at 25 and 50 g/ha with 1% solution of $(NH_4)_2SO_4$ at 30 and 55 DAS showed promise with 85- 91% control of this weed not only in experimental fields but in large scale demonstrations on farmers' fields.

INTRODUCTION

Broomrape locally known as *margoja, rukhri, khumbhi, gulli or bhuiphod* is an obligate root parasitic angiosperm. Being devoid of chlorophyll (Baccarini and Melandri 1967, Saghir *et al.* 1973) it obtains nourishment through specialized feeding structures called haustoria, which penetrate the host tissues until they reach the vascular system for uptake of water, nutrients and assimilates. The attached parasite strongly competes with the host plant for obtaining water, mineral nutrients and assimilates, thus acting as a strong metabolic sink, often named as "super-sink". The extent of damage due to *Orobanche* ranges from zero to total crop failure based on nature of infestation, environmental factors, soil fertility and crop response. In Indian mustard (*Brassica juncea* L.), infestation of *Orobanche* causes yield reduction up to the extent of 13.9-16.3 % (Sheoran *et al.* 2014) which may be up to 58 % (Prusty *et al.* 1996). This weed exhibits the tendency of mushrooming well under coarse textured soils with high pH and low in nitrogen status. The mustard fields in sand dunal areas of south-west Haryana are more prone to the infestation with this obnoxious weed. Pre-plant incorporation (PPI) and pre-emergence (PE) application of dinitroaniline herbicides along with hoeing earlier proved ineffective in minimizing the population of this weed. Post-emergence (PoE) application of glyphosate, paraquat and kerosene oil caused toxicity to mustard crop. Keeping this in view, the present investigation was planned to find out suitable option for the control of broomrape in Indian mustard.

MATERIALS AND METHODS

The experiment was conducted to study the bioefficacy of different weed management treatments for the control of broomrape in Indian mustard (var. '*RH-749*') at village Ganghala and Bidhwan in the district of Bhiwani (Haryana) during *Rabi* 2014-15 and 2015-16, respectively. Seven treatments were assigned in a randomized complete block design with three replicates in a individual plot size of 25 x 6 m^2. The mustard fields having previous history of heavy infestation with broomrape were selected for the study. Mustard crop variety '*RH-749*' was planted on 18-10-2014 and 21-10-2015 by using 5 kg/ha. The treatments in the study were glyphosate at 25 and 50 g/ha at 30 DAS and 55 DAS (recommended practice), recommended fertility (N&P) + glyphosate

with 1% solution of $(NH_4)_2SO_4$ at 25 and 50 g/ha at 30 DAS and 55 DAS, 125% of recommended fertility (N&P) + glyphosate with 1% solution of $(NH_4)_2SO_4$ at 25 and 50 g/ha at 30 DAS and 55 DAS, neem cake 400 kg/ha at sowing *fb* soil drenching of metalaxyl MZ 0.2% at 25 DAS *fb* glyphosate at 40 g/ha at 45 DAS, neem cake 400 kg/ha *fb* pendimethalin (PPI) at 0.75 kg/ha *fb* metalaxyl 0.2% at 25 DAS, neem cake 400 kg/ha *fb* soil drenching of metalaxyl MZ at 0.2% at 25 DAS and weedy check (farmer's practice). Data on number of broomrape (*Orobanche*) panicles/ m^2, per cent visual control of broomrape was obtained at 60, 90 and 120 days after sowing (DAS). During 2015-16, broomrape panicles did not appear in field up to 60 DAS, so no data on density of broomrape at 60 DAS was reported. Visual control of broomrape was also evaluated at 60, 90 and 120 DAS using 0-100 scale. Economics of various weed control treatments were also calculated by using benefit cost ratio of each treatment, separately.

RESULTS AND DISCUSSION

Neem cake in combination with either soil drenching with metalaxyl and glyphosate or pendimethalin and metalaxyl did not prove effective in minimizing the population of broomrape during both the years in comparison to two rounds of glyphosate application. Maximum number of broomrape panicles/m^2 at 90 and 120 DAS were recorded in weedy check which was followed by application of neem cake + pendimethalin (PPI) + metalaxyl (25 DAS), neem cake + soil drenching of metalaxyl MZ (25 DAS) and neem cake + soil drenching of metalaxyl MZ (25 DAS) + glyphosate (45 DAS), while it was lowered down at all the stages under 125% of recommended fertility (N&P) + glyphosate with 1% solution of $(NH_4)_2SO_4$ (30 and 55 DAS), and 100% recommended fertility (N&P) + glyphosate with 1% solution of $(NH_4)_2SO_4$ (30 and 55 DAS). Recommended fertility + glyphosate with 1% solution of $(NH_4)_2SO_4$ registered the highest weed control efficiency (91.7%) up to 120 DAS, and was followed by 125% of recommended fertility + glyphosate with 1% solution of $(NH_4)_2SO_4$ (90%) with the appearance of slight phyto-toxicity on mustard crop to the extent of 5% at 20 DAS, which was mitigated completely up to 30 DAS without any yield penalty (**Table 1**). The treatments involving the use of neem cake did not show any phyto-toxic symptoms on mustard crop.

Broomrape panicles emerge above soil at 40-120 DAS depending upon the temperature and causes losses to mustard crop remaining below the soil. So, broomrape attachments are to be killed before emergence to avoid losses. Broomrape seeds start to germinate 7 days after sowing of mustard in response to hormones secreted by roots of mustard. At 25-30 DAS, nut like structures of broomrape are found to attach with mustard roots which remains below the soil. So, systemic herbicide glyphosate is applied directly on leaves at 30 DAS which moves through phloem to the mustard roots killing broomrape nuts due to inhibition of amino acids in roots. Similarly, herbicide applied on leaves at 55 DAS moves symplastically to the roots resulting in death of broomrape. As, broomrape panicles which emerge above soil does not contain chlorophyll, so no post-emergence herbicide acts on these panicle.

Table 1. Effect of weed control treatments on broomrape population and seed yield of mustard at the village *Ganghala* (*Rabi*, 2014-15)

Treatment	*Orobanche* panicles /m^2			Crop phytotoxicity (%)			*Orobanche* control (%)			Seed yield (t/ha)	*B:C*
	60 DAS	90 DAS	120 DAS	10 DAT	20 DAT	30 DAT	60 DAS	90 DAS	120 DAS		
Glyphosate at 25 and 50 g/ha at 30 DAS and 55 DAS (recommended practice)	1.7 (2)	2.6 (5.7)	1.8 (2.7)	0	0	0	70.1 (88.3)	65.9 (83.3)	64.2 (81)	1.94	2.17
Recommended fertility (N&P) + glyphosate with 1% solution of $(NH_4)_2SO_4$ at 25 and 50 g/ha at 30 DAS and 55 DAS	1 (0)	1.6 (1.7)	1.7 (2)	5	5	0	85.7 (98.3)	76.2 (91.7)	76.2 (91.7)	1.96	2.15
125% of recommended fertility (N&P) + glyphosate with 1% solution of $(NH_4)_2SO_4$ at 25 and 50 g/ha at 30 DAS and 55 DAS	1 (0)	1 (0)	2.2 (4)	5	5	0	81.4 (96.7)	79.5 (95)	71.6 (90)	1.97	2.06
Neem cake 400 kg/ha at sowing *fb* soil drenching of metalaxyl MZ 0.2% at 25 DAS *fb* glyphosate at 40 g/ha at 45 DAS	2.7 (6.3)	6.4 (40.3)	6.1 (36)	0	0	0	55.7 (68.3)	63.5 (80)	53.7 (65)	1.66	1.53
Neem cake 400 kg/ha *fb* pendimethalin (PPI) at 0.75 kg/ha *fb* metalaxyl 0.2% at 25 DAS	4.17 (15.7)	10.3 (104.7)	10.6 (112)	0	0	0	18.4 (10)	14.8 (6.7)	10.4 (5)	1.50	1.27
Neem cake 400 kg/ha *fb* soil drenching of metalaxyl MZ at 0.2% at 25 DAS	4.6 (20)	9.9 (98)	9.1 (82)	0	0	0	1(0)	16.6 (8.3)	18 (10)	1.43	1.32
Weedy check (farmer's-practices)	4.3 (17.3)	11.5 (132.3)	11.1 (123)	0	0	0	1(0)	1(0)	1(0)	1.41	1.27
LSD (p=0.05)	0.6	0.6	0.5	-	-	-	6.6	11.2	11.2	0.04	-

DAT - Days after treatment; Original figures are given in parentheses

Maximum seed yield of mustard (1.97 and 2.14 t/ha) was observed with the use of 125% of recommended fertility (N&P) + glyphosate with 1% solution of $(NH_4)_2SO_4$ at 25 and 50 g/ha at 30 and 55 DAS which was at par with 100% recommended fertility (N&P) + glyphosate with 1% solution of $(NH_4)_2SO_4$ at 25 and 50 g/ha at 30 and 55 DAS (1.96 and 2.06 t/ha) and glyphosate at 25 and 50 g/ha at 30 and 55 DAS (1.94and 1.95 t/ha). Lowest seed yield of mustard was obtained under weedy check (1.41 and 1.32 t/ha) which was 28.4 and 38.4 % less in comparison to the best treatment of 125% of recommended fertility (N&P) + glyphosate with 1% solution of $(NH_4)_2SO_4$ at 25 and 50 g/ha at 30 and 55 DAS during 2014-15 and 2015-16, respectively. The highest B: C (2.17) was obtained with the use of glyphosate at 25 and 50 g/ha at 30 DAS and 55 DAS (glyphosate at 25 and 50 g/ha at 30 and 55 DAS: recommended practice) during 2014-15 while during 2015-16 the highest B: C (2.26) was obtained with recommended fertility (N&P) + glyphosate with 1% solution of $(NH_4)_2SO_4$ at 25 and 50 g/ha at 30 and 55 DAS. The lowest B: C (1.27 and 1.19) was recorded under weedy check and application of neem cake 400 kg/ha *fb* pendimethalin (PPI) at 0.75 kg/ha *fb* metalaxyl 0.2% at 25 DAS during both the years (**Table 2**).

Similar findings on the control of broomrape in mustard through glyphosate application were also reported (DWSR 2009, Punia *et al.* 2012, Punia *et.al.* 2016). Based on two-year study, it can be inferred that recommended fertility (N&P) + glyphosate with 1% solution of $(NH_4)_2SO_4$ at 25 and 50 g/ha at 30 and 55 DAS is the most effective treatment for the *Orobanche* control in mustard.

Efficacy of glyphosate was validated in large scale under multi-locational trials through farmers' participatory approach in Haryana state during the *Rabi* seasons of 2010-11 to 2016-17. A total of 758

Table 2. Effect of weed control treatments on broomrape population and seed yield of mustard at the village *Bidhwan* (*Rabi*, 2015-16)

Treatment	*Orobanche* panicles /m^2		Crop phytotoxicity (%)			*Orobanche* control (%)		Seed yield (t/ha)	*B:C*
	90 DAS	120 DAS	10 DAT	20 DAT	30 DAT	90 DAS	120 DAS		
Glyphosate at 25 and 50 g/ha at 30 DAS & 55 DAS (recommended practice)	2.81 (7.0)	1.82 (2.7)	0	0	0	64.88 (81.7)	70.99 (88.7)	1.95	2.18
Recommended fertility (N&P) + glyphosate with 1% solution of $(NH_4)_2SO_4$ at 25 and 50 g/ha at 30 DAS & 55 DAS	1.47 (1.3)	2.27 (4.3)	5	5	0	71.49 (89.0)	67.94 (85.7)	2.06	2.26
125% of recommended fertility (N&P) + glyphosate with 1% solution of $(NH_4)_2SO_4$ at 25 and 50 g/ha at 30 DAS & 55 DAS	1.00 (0)	2.79 (7.0)	5	5	0	72.64 (90.3)	68.37 (86.0)	2.14	2.24
Neem cake 400 kg/ha at sowing *fb* soil drenching of metalaxyl MZ 0.2% at 25 DAS *fb* glyphosate at 40 g/ha at 45 DAS	6.99 (48.0)	6.44 (40.7)	0	0	0	55.01 (67.0)	50.79 (60.0)	1.56	1.44
Neem cake 400 kg/ha *fb* pendimethalin (PPI) at 0.75 kg/ha *fb* metalaxyl 0.2% at 25 DAS	10.10 (101.0)	10.48 (109.0)	0	0	0	12.91 (5.3)	12.74 (5.0)	1.40	1.19
Neem cake 400 kg/ha *fb* soil drenching of metalaxyl MZ at 0.2% at 25 DAS	9.62 (91.7)	8.88 (78.0)	0	0	0	12.13 (4.7)	13.87 (6.0)	1.37	1.26
Weedy check (farmer's-practices)	11.74 (137.0)	10.88 (117.3)	0	0	0	0.00 (0)	0.00 (0.0)	1.32	1.19
LSD (p=0.05)	0.71	0.75	-	-	-	9.88	8.52	0.21	-

DAT - Days after treatment

Table 3. Comparative performance of glyphosate application *vis-à-vis* farmers' practice for broomrape 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)		Yield reduction (%) in FP plots
				Treated*	FP*	
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	80.5 (79-87)	1.75 (1.13-2.22)	1.26 (0.71-1.66)	38.7
2016-17	250	485	79.3 (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

*Glyphosate 25 g/ha at 30 DAS and 50 g/ha at 55-60 DAS-2 sprays; **FP: Farmers' practice (one hoeing at 25-30 DAS); Figures in parentheses indicate range of the treatment effect on *Orobanche* control and mustard seed yield.

demonstrations were conducted in an area coverage of 1831 ha under mustard. 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 3**). This technology 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.

Based on two years finding, it can be concluded that post-emergence application of glyphosate at 25 and 50 g/ha with 1% solution of $(NH_4)_2SO_4$ at 30 and 55 DAS provides better control of this weed, not only in experimental fields but in large scale at farmers' fields. Also, by increasing the recommended dose up to 125%, setback caused to the crop can be nullified with some little enhancement of grain yield.

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