

Orobanche weed management in mustard : Opportunities, possibilities and limitations

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Abstract

Orobanche, a ‘super sink’ to mustard plant has threatened the farming community to rethink for alternative options as this parasitic weed has become a menace to Indian mustard [*Brassica juncea* (L.) Czern & Coss.] cultivation in India. This study reports the judicious and precautionary implication of glyphosate application for its better efficacy in reducing the parasitic weed infestation while affording tolerance to the mustard crop. Foliar sprays of glyphosate twice; first 25 g/ha at 30 DAS and second 50 g/ha at 55-60 DAS is quite effective in reducing the weed infestation by inhibiting the further increase in weed seed bank in the soil and substantially increasing the crop yields.

Key words: Glyphosate application, Indian mustard, *Orobanche* weed, seed yield

Introduction

In spite of continuous and extensive research by the plant breeders, weed scientists and plant protectionists, parasitic weeds are still causing serious problems in large number of crops worldwide. Globally, root parasitism of *Orobanche* or broomrape (*Orobanche spp.*) to numerous important broadleaf crops including common vetch (*Vicia sativa* L.), crucifers such as oilseed rape (*Brassica spp.*), broad bean (*Vicia faba*) and other crops belonging to Apiaceae, Asteraceae, and Solanaceae families is well known (Goldwasser *et al.*, 1997; Hodosy, 1981; Ismael and Obeid, 1976; Sauerborn, 1991), especially in Mediterranean region, southern, northern and eastern Europe, Africa, New Zealand, Australia, north, central and south America. In India, *Orobanche* is a major biotic production constraint to Indian mustard [*Brassica juncea* (L.) Czern & Coss.] cultivation in major mustard growing regions of Haryana (Fig. 1), Punjab, northern Rajasthan, western UP, and north-east Madhya Pradesh.

Orobanche, locally known as margoja, rukhri,

khumbhi or gulli is an annual, branched, achlorophyllous, noxious, obligate root holoparasite that reproduces only by seeds (Press *et al.*, 1986; Punia *et al.*, 2012). The germinating seed (host dependent seed conditioning and stimulation) produces a germ tube or radical which elongates chemotropically and forms a haustorium that is strongly attached to the plant vascular system (Dorr and Kollmann, 1976; Parker and Riches, 1993). The attached parasite functions as a strong metabolic sink, often named “super-sink”, strongly efficiently competing with the host plant for water and mineral nutrition causing moisture and assimilates starvation, host plant stress and growth inhibition leading to significant reduction in crop yield and distressed crop quality in infested fields. Depending upon the extent of infestation, environmental factors, soil fertility, and the crop competitiveness, damage from *Orobanche* can range from zero to complete crop failure (Dhanapal *et al.*, 1996). Some of the farmers even abandoned the cultivation of mustard under the threat of this parasitic weed.

Several methods for managing *Orobanche* including hand weeding, deep ploughing, host plant

tolerance, alteration in seeding windows and N-fertilizer scheduling, application of organic manures and biofertilizers, chemical seed treatment, and kersone/soybean oil droplets spray have been attempted, but, they were often inconsistent over the years and have limited effectiveness

(Anonymous, 2010). Although, these practices may be employed in an integrated approach to mitigate the adverse effect of this parasitic weed on crop growth and development to a certain extent. Feasibility of such management practices under present cropping system has limitations and raises a question mark.

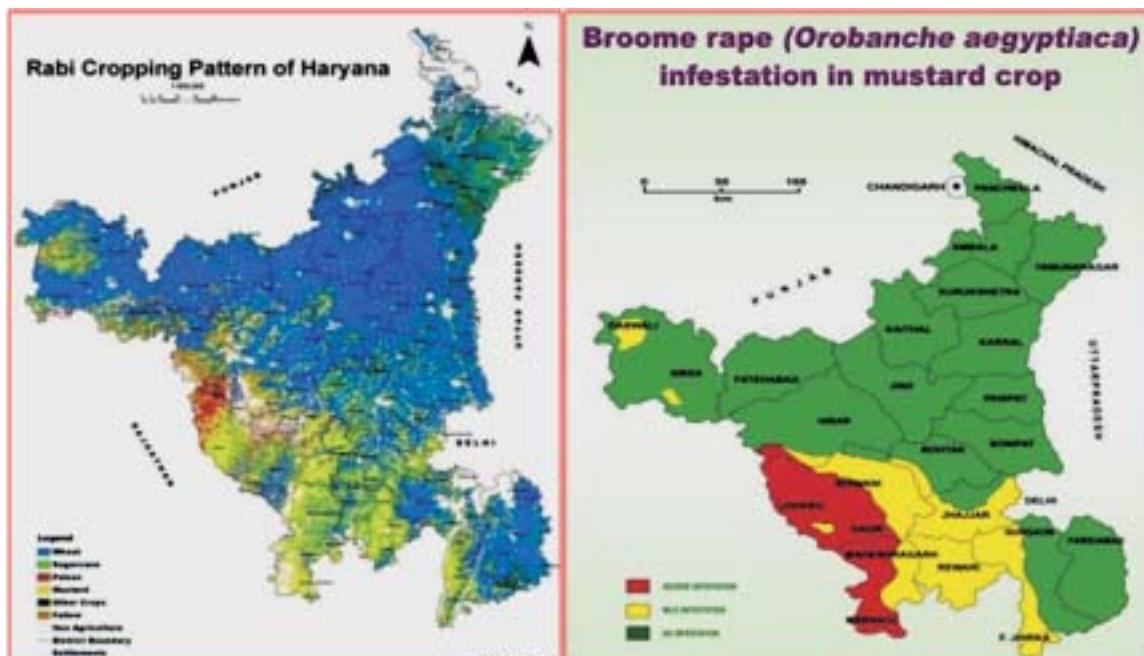


Fig. 1: Mustard area (left in yellow colour) and *Orobanche* infestation (right) in Haryana state of India

Compared with the non-parasitic weeds, the control of *Orobanche* has been proved to be exceptionally difficult due to its underground location, lack of photosynthesis, late appearance of parasitic shoots, closer association with host plant roots (Fig. 2), and complex mechanisms of seed dispersal, germination, and longevity (Cubero and Moreno, 1979; Foy *et al.*, 1989; Linke and Saxena, 1991; Puzzilli, 1983). Furthermore, when the parasite shoots become visible on and above the ground surface, most of the damage has already occurred and conventional methods of weed control would often prove futile.

To counter the problem, any residual selective herbicide that can be translocated, without being metabolized through a host plant into broomrape attached to the host roots could prove to be an effective way of controlling this weed. Parker and Riches (1993) reported the precautionary use of glyphosate on limited areas for *Orobanche* control

in broadbean, carrot and celery. Subsequently, Hershenhorn *et al.* (1998) also demonstrated the effectiveness of systemic herbicides on early development of *Orobanche* in tomato. Both reports indicate that glyphosate can be a potential herbicide for *Orobanche* management, but there is a need to conduct need based location specific research particularly under farmers' management conditions to determine the optimum period and dose of herbicide application during which the parasitic weed become most sensitive and the mustard crop remains relatively tolerant. Since glyphosate is a broad spectrum non-selective foliar-applied herbicide, its efficacy in managing *Orobanche* could prove quite useful, but the selectivity of this herbicide is limited and needs critical precautionary measures to have effective results.

Considering the vital importance of mustard crop in the present oilseeds scenario and huge financial burden of importing oilseeds on national economy



Fig. 2: Parasitic association of *Orobanche* with Indian mustard roots

and other facts mentioned above, the present study, therefore, was carried out to evaluate the efficacy and unravel the mechanism of glyphosate application against the parasitic weed *Orobanche* and to standardize the herbicide based weed management *vis-a-vis* farmers' practice with respect to weed dynamics and yield sustainability while enhancing the overall production and productivity of mustard.

Materials and Methods

Field studies were carried out for four consecutive *rabi* seasons (2007-08 to 2010-11) in mustard growing belt of Bhiwani district in Haryana state using farmers' participatory approach. The experimental site in the study domain represents coarse-textured soils with high pH, low in nitrogen, and with poor water holding capacity where the crop cultivation is either rainfed or dependent on sprinkler irrigation systems. Each year, the crop was sown in the month of October, and different locations in the respective year of study were considered as treatment replicates. An area of about 500 m² was individually demarcated for superimposing each treatment. Glyphosate 41% SL, a mean of herbicide formulation was used at different concentrations viz., (i) 50 g/ha at 30 days after sowing (DAS); one spray, (ii) 25 g/ha at 30 and 55-60 DAS; two sprays, (iii) 50 g/ha at 30 DAS followed by 25 g/ha at 55-60 DAS; two sprays, and (iv) 25 g/ha at 30 DAS followed by 50 g/ha at 55-60 DAS; two sprays, following standard application techniques using 375 liters/ha of water as a carrier. In addition, there was another treatment involving farmers' practice (one hoeing at 25-30 DAS). The

observations on weed infestation were taken twice at each location; 70-75 and 120-125 days after sowing at five different places measuring 5m x 5m area and the per cent reduction in weed intensity due to different treatments was recorded in comparison to untreated control/farmers' practice. The remaining crop management practices from sowing to harvest were followed in consultation with the selected farmers as per the package of practices for *rabi* crops of CCS Haryana Agricultural University, Hisar, India (Anonymous, 2012).

Results and Discussion

Irrespective of the dose, timings and number of sprays, significant reduction in *Orobanche* weed infestation and subsequent improvement in seed yield was noticed with glyphosate application in mustard. The data indicated that higher dose of glyphosate at early crop stages (T_4) sometimes caused localized phytotoxicity (10-20%) on mustard plants viewing marginal leaf chlorosis, slow leaf growth, interveinal leaf bleaching, and/or slight elongation of apical leaves (Fig. 4), but the crop recovered within 7-10 days after spray. Single application of herbicide (T_4) though provided effective weed control upto 70-75 DAS, but the late emergence of new shoots in the later half of crop growth (Table 1) ultimately caused reduction in seed yield due to increased weed seed bank in the soil. Supplementation of second spray of glyphosate @ 25 g/ha at 55-60 DAS (T_2) not only prolonged the effective period of weed control, but also increased 8.7% seed yield in comparison to T_4 treatment (Table 1). Glyphosate applied twice at 25 g/ha at 30 DAS followed by 50 g/ha at 55-60



Fig. 4: Phytotoxicity symptoms of glyphosate (50g/ha at 30 DAS) on Indian mustard

DAS provided more than 80% control of *Orobanche* even up to harvest (without any crop injury) with yield improvement of 19.3% over the traditional farmers' practice. The tolerance of plants to glyphosate was mainly attributed to readily degradation of this herbicide to non-toxic metabolites. It's fast absorption by the mustard plant foliage and speedy translocation to the young parasites attached to the host roots, leaves, and meristems, are probably the most likely reasons for inhibiting the synthesis of enzyme 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase that leads to the production of aromatic amino acids (phenylalanine, tyrosine and tryptophan) and protein synthesis and

growth (Amerhein *et al.*, 1980). Similar findings on the control of *Orobanche* in mustard through herbicide application were also reported by the scientists at Gwalior and Bikaner (Anonymous, 2009). These results were further 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 2012-13. A total of 120 demonstrations were conducted in mustard growing areas of Haryana state covering 181 ha area and it was observed that overall 74.4 per cent (range 72-82%) reduction in *Orobanche* weed infestation with 14.5 per cent (range 13.9-16.3%) 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 2).

Since most of the mustard cultivation in India is limited to light textured soil having inherent poor fertility status and water holding capacity, care should be taken that the crop should not suffer from any moisture stress at the time of foliar spray. Therefore, the fields should be irrigated either 2-3 days prior to herbicide application, or within 1-2 days of herbicide spray. The dose of herbicide and time of application must be strictly followed to obtain better efficacy of herbicide as repetitive/higher/lower than the recommended dose may lead to adverse

Table 1: Effect of glyphosate application on *Orobanche* management and seed yield of mustard

Treatments	Per cent reduction in <i>Orobanche</i> population over farmers' practice			Visual crop phytotoxicity (%)	Seed yield (kg/ha)
	70-75 DAS	120-125 DAS	At harvest		
Glyphosate 41% SL; 25 g/ha at 30 DAS fb 50 g/ha at 55-60 DAS-2 sprays (T ₁)	98(96-100)	94(84-96)	82(72-92)	-	1674
Glyphosate 41% SL; 50 g/ha at 30 DAS fb 25 g/ha at 55-60 DAS- 2 sprays (T ₂)	98(93-100)	90(85-95)	76(70-88)	10-20	1633
Glyphosate 41% SL; 25 g/ha at 30 and 55-60 DAS- 2 sprays (T ₃)	59(52-70)	41(30-48)	30(36-52)	-	1527
Glyphosate 41% SL; 50 g/ha at 30 DAS- 1 spray (T ₄)	92(86-98)	71(64-82)	42(38-50)	10-20	1502
Farmers' practice (one hoeing at 25-30 DAS) (T ₅)	-	-	-	-	1403
CD(P=0.05)					162

Figures in parenthesis indicate range of the treatment effect (mean of 4 years)

Table 2: 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 multilocational trials

Year	No. of trials/ locations	Area covered (ha)	<i>Orobanche</i> control (%)	Seed yield (kg/ha)		Per cent reduction in seed yield
				Glyphosate treated*	Farmers' practice**	
2010-11	12	5	82 (70-95)	1717 (1400-2100)	1487 (1200-1950)	15.5
2011-12	24	20	79 (65-90)	1589 (1200-2200)	1366 (900-1800)	16.3
2012-13	86	156	72 (55-90)	1753 (1250-2250)	1542 (1000-1950)	13.9

*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

effect on mustard crop, or may even lead to development of herbicide-tolerant weeds.

There are reports on the effectiveness of glyphosate in tomato, tobacco, fababeans, and other crops under greenhouse conditions elsewhere, but have not been yet reported from India, particularly under field conditions. Based on our findings, it can be concluded that foliar application of glyphosate twice; 25 g/ha at 30 DAS followed by 50 g/ha at 55 DAS would be very helpful in reducing the *Orobanche* infestation by reducing the further increase in weed seed bank without any crop suppression. The results of our present study very convincingly show that glyphosate, if used as recommended, may prove to be very effective in significantly reducing parasitic weed *Orobanche* infestation, and increasing yield of mustard grown in weed-infested fields.

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