Management of *Orobanche* in Mustard

ABSTRACT

An experiment was conducted during *rabi* season in 2017-18, 2019-20 and 2021-22 (three years) at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat, India having loamy sand soil to study the management of *Orobanche* in mustard. The experiment was laid out in a randomized block design and four replications with nine treatments. On three years pooled results rewarded that for securing higher yield and net return keeping mustard crop weed-free (removal of all weeds including *Orobanche*) but under laborer scarce situation, advised to carry out a directed spray of glyphosate 25 g active ingredient/ha at 25-30 DAS and 50 g a.i./ha at 50-55 DAS on *Orobanche***.** Further, weed-free (Removal of all weeds including *Orobanche*) also significantly increased seed yield (1809 kg/ha) while maximum net realization and benifit: cost ratio (BCR) was registered with the application of glyphosate @ 25 g a.i./ha at 25-30 DAS and 50 g/ha @ 50-55 DAS followed by treatment weed free (Removal of all weeds including *Orobanche*) in pooled results.

Keywords: *Orobanche*, mustard, glyphosate, weed free

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I. INTRODUCTION

Among the major agricultural crop losses, weeds alone caused severe yield losses ranging from 10% to 95%. Yield losses caused by weeds could vary from crop to crop and region to region. Parasite weeds attack other plants through linkages and draw partially or completely their nutrition from the host. They attach themselves either to the roots or the shoots. They produce a large number of long-lived seeds. *Orobanche* or Broomrape (*Orobanche* spp.), locally known as Margoja, Rukhri, Khumbhi or Gulli, is a phanerogamic, obligate, troublesome holo root parasite that lacks chlorophyll and obtains carbon, nutrients, and water through haustoria which connect the parasite with the host vascular system. It germinates only in response to specific chemicals released by the host plant. After germination, the seedling-attached parasite functions as a strong metabolic sink, often named “super sink”, strongly competing with the host plant for water, minerals and assimilates. 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). Additionally, a single broomrape plant can produce more than 5 lakh seeds. Keeping this view, the present experiment was planned to study the effectiveness of

neem and castor cakes, seed treatment with herbicides and post-emergence application of glyphosate at low doses against *Orobanche* in mustard crops.

II. MATERIAL and METHODS

An experiment was conducted during the *rabi* season of the years 2017-18, 2019-20 and 2021-22 (three years) at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar having loamy sand soil to study the management of *Orobanche* in mustard. The experiment was laid out in randomized block design and four replications with nine treatments *viz*., T_1: Glyphosate @ 25 g a.i./ha at 25-30 DAS and 50 g/ha @ 50-55 DAS, T_2 : Glyphosate @ 0.25% PE to *Orobanche* at 42-45 DAS, T_3: Pendimethalin 1.0 kg a.i./ha PE to *Orobanche* at 30-35 DAS as herbigation, T_4 : Seed treatment with sulfosulfuron @ 1.0 ppm, T_5: Seed treatment with sulfosulfuron @ 1.0 ppm *fb* pendimethalin 1.0 kg a.i./ha PE to *Orobanche* at 30-35 DAS as herbigation, T_6: Neem cake @ 500 kg/ha, T_7: Castor cake @ 500 kg/ha, T_8: Weed free (Removal of all weeds including *Orobanche*) and T_9: Control. A mustard variety GDM-4 was used as a test crop. The soil texture of the experimental field was loamy sand. Mustard seeds (3.75 kg/ha) were sown at a row distance of 45 cm and 10 cm plant-to-plant distance. Various growth and yield-attributing characteristics of the crop were measured and studied during investigations. Other management practices were followed as recommended. In addition, recommended dose of fertilizer 50: 50: 00 kg N-P_2O_5-K_2O/ha was applied commonly in all the treatments. Statistical analysis of the data of various characters studied in a present investigation was carried out with the help of the computer as per appropriate procedure suggested by Panse and Sukhatme (1985) for the design of the experiment.

III. RESULTS and DISCUSSION

Effect on plant population, growth and yield attributes (Pooled)

Pooled data over three years on plant population at 30 DAS and harvest are presented in Table 1. The data revealed that plant population at 30 DAS and harvest was not significantly affected by the different weed management practices.

The data presented in Table 2 on plant height (cm) of mustard at 30 DAS, 60 DAS, and at harvest were significantly affected by different weed management treatments in pooled results. Significantly taller plant height at 30 DAS was observed under treatment T8 (weed free: removal of all weeds including Orobanche), but it did not differ significantly from treatments T1 (glyphosate @ 25 g a.i./ha at 25-30 DAS and 50 g a.i./ha @ 50-55 DAS), T5 (seed treatment with sulfosulfuron @ 1.0 ppm followed by pendimethalin 1.0 kg a.i./ha PE to Orobanche at 30-35 DAS as herbigation), T6 (neem cake @ 500 kg/ha), and T7 (castor cake @ 500 kg/ha). Significantly taller plants were observed at 60 DAS and at harvest

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under the weed-free treatment (removal of all weeds including Orobanche), which remained at par with treatment T1 (glyphosate @ 25 g a.i./ha at 25-30 DAS and 50 g a.i./ha @ 50-55 DAS) at harvest.

The pooled data on number of silique per plant are presented in Table 3 revealed that weed free (removal of all weeds including *Orobanche*) treatment T_8 had registered significantly higher number of silique per plant and it was at par withtreatment T_1 (glyphosate @ 25 g a.i./ha at 25-30 DAS and 50 g a.i./ha @ 50-55 DAS). Significantly higher number of seeds per siliqua was recorded under treatment T_8weed free (Removal of all weeds including *Orobanche*), but it was at par with treatments T_1 and T_2.

The pooled data on the number of siliques per plant, presented in Table 3, reveal that the weed-free treatment (removal of all weeds including Orobanche), designated as T8, registered a significantly higher number of siliques per plant. This treatment was on par with treatment T1 (glyphosate @ 25 g a.i./ha at 25-30 DAS and 50 g a.i./ha @ 50-55 DAS).

Additionally, a significantly higher number of seeds per silique was recorded under the weed-free treatment T8, although it was comparable to treatments T1 and T2. Furthermore, the weed-free treatment T8 also registered the highest 1000-seed weight, significantly surpassing the rest of the treatments.

The data on seed and stover yield of mustard are presented in Table 4 indicated that different weed control treatments exerted significant effect on seed and stover yield. Treatment T_8 (Weed free: removal of all weeds including *Orobanche*) produced significantly the highest seed yield of 1809 kg/ha, followed by treatment T_1 (1604 kg/ha). Similarly, weed free (Removal of all weeds including *Orobanche*) treatment (T_8) registered significantly the highest stover yield (4143 kg/ha).

Bio-assay study

Plant stand of succeeding bajra crop was found non-significant. It indicated that no residual effect of herbicide was observed on succeeding crop bajra. Phytotoxic effect due to any of the herbicidal treatments on succeeding bajra was not observed in mean data of three years. (Table 10).

Effect on *Orobanche*

Maintaining weed free condition (removal of all weeds including *Orobanche*) had recorded significantly the lowest *Orobanche* count per meter row length at 55, 65, 75 DAS and at harvest, over rest of the treatments tested in present study during individual years and in pooled data. Among different herbicidal treatments, application of glyphosate @ 25 g a.i./ha at 25-30 DAS and 50 g a.i./ha @ 50-55 DAS significantly lowered the population of *Orobanche* count per meter row length at 55, 65, 75 DAS and at harvest (Table 6 and 7). Significantly the lowest dry weight of *Orobanche* at harvest was obtained under weed free treatment (removal of all weeds including *Orobanche*). When comparison done among different herbicidial treatments, application of glyphosate @ 25 g a.i./ha at 25-30 DAS and 50 g a.i./ha @ 50-55 DAS registered minimum dry weight of *Orobanche* plants over other treatments.

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Economics

Maximum net realization was obtained under treatment T_8 weed free (Removal of all weeds including *Orobanche*) followed by glyphosate @ 25 g a.i./ha at 25-30 DAS and 50 g a.i./ha @ 50-55 DAS (Table 5). Higher benefit cost ratio was observed with application of glyphosate @ 25 g a.i./ha at 25-30 DAS and 50 g a.i./ha @ 50-55 DAS followed by removal of all weeds including *Orobanche.*

Conclusion

On three years pooled results rewarded that for securing higher yield and net return keep mustard crop weed free (removal of all weeds including *Orobanche*) but under labourer scarce situation, advised to carry out directed spray of glyphosate 25 g a.i./ha at 25-30 DAS and 50 g a.i./ha at 50-55 DAS on *Orobanche***.** Further, weed free (Removal of all weeds including *Orobanche*) also significantly increased seed yield (1809 kg/ha) while maximum net realization and benifit : cost ratio (BCR) was registered with application of glyphosate @ 25 g a.i./ha at 25-30 DAS and 50 g/ha @ 50-55 DAS followed by treatment weed free (Removal of all weeds including *Orobanche*) in pooled results.

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Table 1: Effect of different treatments on plant population of mustard

Treatments	Plant population per metre row length							
	25 DAS				At harvest			
	2017-18	2019-20	2021-22	Pooled	2017-18	2019-20	2021-22	Pooled
T_1: Glyphosate @ 25 g a.i./ha at 25-30 DAS and 50 g/ha @ 50-55 DAS	6.57	6.55	6.51	6.54	6.37	6.22	6.33	6.30
T_2: Glyphosate @ 0.25% PE to *Orobanche* at 42-45 DAS	6.52	6.54	6.56	6.54	6.35	6.19	6.30	6.28
T_3: Pendimethalin 1.0 kg a.i./ha PE to *Orobanche* at 30-35 DAS as herbigation	6.45	6.49	6.52	6.49	6.31	6.17	6.26	6.25
T_4: Seed treatment with sulfosulfuron @ 1.0 ppm	6.47	6.42	6.50	6.46	6.32	6.18	6.24	6.24
T_5: Seed treatment with sulfosulfuron @ 1.0 ppm *fb* pendimethalin 1.0 kg a.i./ha PE to *Orobanche* at 30-35 DAS as herbigation	6.51	6.45	6.48	6.48	6.26	6.14	6.29	6.22
T_6: Neem cake @ 500 kg/ha	6.54	6.41	6.47	6.47	6.24	6.11	6.20	6.18
T_7: Castor cake @ 500 kg/ha	6.49	6.45	6.57	6.50	6.27	6.08	6.28	6.21
T_8: Weed free (Removal of all weeds including *Orobanche*)	6.55	6.59	6.60	6.58	6.40	6.27	6.39	6.35
T_9: Control	6.60	6.47	6.54	6.54	6.03	6.00	6.09	6.03
S.Em ±	0.23	0.24	0.22	0.12	0.22	0.22	0.25	0.13
CD (P= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Y * T				NS				NS
CV (%)	7.14	7.48	6.72	7.12	7.08	7.04	7.90	7.36

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Table 2: Effect of different treatments on plant height of mustard

Treatments	Plant height (cm)											
	30 DAS				60 DAS				At harvest			
	2017-18	2019-20	2021-22	Pooled	2017-18	2019-20	2021-22	Pooled	2017-18	2019-20	2021-22	Pooled
T_1: Glyphosate @ 25 g a.i./ha at 25-30 DAS and 50 g/ha @ 50-55 DAS	32.3	38.1	35.3	35.2	123.2	126.7	125.2	125.1	156.9	156.0	160.8	157.9
T_2: Glyphosate @ 0.25% PE to *Orobanche* at 42-45 DAS	31.6	36.7	34.5	34.3	119.0	123.9	120.7	121.2	150.3	148.6	156.3	151.7
T_3: Pendimethalin 1.0 kg a.i./ha PE to *Orobanche* at 30-35 DAS as herbigation	31.0	37.6	33.3	34.0	107.2	111.2	113.4	110.6	140.7	141.8	145.5	142.7
T_4:Seed treatment with sulfosulfuron @ 1.0 ppm	30.7	36.5	33.8	33.6	106.2	109.1	110.8	108.7	135.5	136.8	138.5	137.0
T_5:Seed treatment with sulfosulfuron @ 1.0 ppm *fb* pendimethalin 1.0 kg a.i./ha PE to *Orobanche* at 30-35 DAS as herbigation	31.9	38.1	34.3	34.8	115.8	118.6	119.9	118.1	145.1	143.7	154.6	147.8
T_6: Neem cake @ 500 kg/ha	33.6	37.8	34.0	35.1	111.5	117.6	117.6	115.6	132.4	129.6	142.8	134.9
T_7: Castor cake @ 500 kg/ha	33.8	38.9	36.0	36.2	117.2	120.4	122.0	119.9	139.3	133.6	150.4	141.1
T_8:Weed free (Removal of all weeds including *Orobanche*)	33.0	41.5	35.7	36.8	134.3	136.5	137.6	136.1	168.0	165.5	170.3	167.9
T_9: Control	29.1	37.1	31.3	32.5	100.4	102.2	105.4	102.7	127.3	121.1	129.8	126.1
S.Em ±	1.2	1.6	1.4	0.8	5.6	5.5	5.9	3.0	7.2	6.6	7.2	3.7
CD (P= 0.05)	NS	NS	NS	2.2	16.4	15.9	17.2	8.3	21.1	19.2	20.9	10.33
Y * T				NS				NS				NS
CV (%)	7.41	8.31	7.92	7.96	9.76	9.20	9.90	9.62	10.06	9.25	9.54	9.53

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Table 3: Effect of different treatments on number of silique/plant, number of seeds/siliqua and test weight of mustard

Treatments	Number of silique/plant				Number of seeds/siliqua				Test weight (g)			
	2017-18	2019-20	2021-22	Pooled	2017-18	2019-20	2021-22	Pooled	2017-18	2019-20	2021-22	Pooled
T_1: Glyphosate @ 25 g a.i./ha at 25-30 DAS and 50 g/ha @ 50-55 DAS	281.4	283.8	291.4	285.5	13.0	12.4	12.3	12.6	4.72	4.83	4.90	4.81
T_2: Glyphosate @ 0.25% PE to *Orobanche* at 42-45 DAS	276.3	267.7	287.2	277.0	12.9	12.2	12.0	12.3	4.56	4.71	4.68	4.65
T_3: Pendimethalin 1.0 kg a.i./ha PE to *Orobanche* at 30-35 DAS as herbigation	251.2	253.5	269.4	258.0	12.3	11.4	11.5	11.7	4.39	4.55	4.40	4.45
T_4:Seed treatment with sulfosulfuron @ 1.0 ppm	244.3	240.2	249.6	244.7	12.0	11.2	11.0	11.4	4.26	4.37	4.32	4.32
T_5: Seed treatment with sulfosulfuron @ 1.0 ppm *fb*pendimethalin 1.0 kg a.i./ha PE to *Orobanche* at 30-35 DAS as herbigation	267.0	262.7	279.2	269.6	12.6	11.6	11.8	12.0	4.49	4.63	4.65	4.59
T_6: Neem cake @ 500 kg/ha	241.2	225.5	240.9	235.9	11.8	11.1	10.8	11.2	4.15	4.03	4.18	4.12
T_7: Castor cake @ 500 kg/ha	260.0	236.2	273.3	256.5	12.5	11.2	11.2	11.6	4.51	4.11	4.47	4.36
T_8: Weed free (Removal of all weeds including *Orobanche*)	297.0	301.7	299.4	299.4	13.3	12.5	12.7	12.8	5.20	5.17	5.25	5.20
T_9: Control	197.5	184.8	207.4	196.6	11.9	10.2	10.3	10.5	3.61	3.52	3.73	3.62
S.Em ±	12.9	13.1	14.3	7.2	0.5	0.5	0.5	0.3	0.16	0.18	0.16	0.090
CD (P= 0.05)	37.8	38.2	41.7	20.23	NS	NS	NS	0.7	0.45	0.52	0.47	0.25
Y * T				NS				NS				NS
CV (%)	10.06	10.44	10.73	10.42	7.79	8.65	8.78	8.39	7.03	8.01	7.08	7.38

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Table 4: Effect of different treatments on seed and stover yields of mustard

Treatments	Seed yield (kg/ha)				Stover yield (kg/ha)			
	2017-18	**2019-20**	**2021-22**	**Pooled**	**2017-18**	**2019-20**	**2021-22**	**Pooled**
T_1: Glyphosate @ 25 g a.i./ha at 25-30 DAS and 50 g/ha @ 50-55 DAS	1631^{b}	1517^{b}	1654^{a}	1604^{b}	3693^{b}	3466^{b}	3806^{b}	3653^{b}
T_2: Glyphosate @ 0.25% PE to *Orobanche* at 42-45 DAS	1445^{bc}	1328^{c}	1424^{b}	1399^{c}	3240^{c}	2962^{c}	3108^{c}	3103^{c}
T_3: Pendimethalin 1.0 kg a.i./ha PE to *Orobanche* at 30-35 DAS as herbigation	997^{e}	1176^{cd}	1103^{cd}	1092^{de}	2134^{f}	2544^{e}	2362^{f}	2347^{de}
T_4: Seed treatment with sulfosulfuron @ 1.0 ppm	957^{e}	1020^{de}	1086^{cd}	1021^{e}	2011^{h}	2171^{f}	2345^{g}	2176^{e}
T_5:Seed treatment with sulfosulfuron @ 1.0 ppm *fb* pendimethalin 1.0 kg a.i./ha PE to *Orobanche* at 30-35 DAS as herbigation	1205^{d}	1272^{c}	1307^{bc}	1261^{cd}	2602^{e}	2771^{d}	2898^{d}	2758^{cd}
T_6: Neem cake @ 500 kg/ha	936^{e}	820^{f}	972^{d}	908^{e}	2087^{g}	1883^{h}	2206^{h}	2058^{e}
T_7: Castor cake @ 500 kg/ha	1280^{cd}	848^{ef}	1155^{cd}	1094^{de}	2781^{d}	1984^{g}	2578^{e}	2448^{de}
T_8:Weed free (Removal of all weeds including *Orobanche*)	1870^{a}	1718^{a}	1835^{a}	1809^{a}	4295^{a}	4010^{a}	4133^{a}	4143^{a}
T_9: Control	618^{f}	531^{g}	645^{e}	598^{f}	1297^{i}	1125^{i}	1389^{i}	1270^{f}
S.Em ±	70.5	62.0	74.2	42.14	137.0	157	145	87
CD (P= 0.05)	205.9	180.8	216.6	118.4	400.1	460	425	245
Y * T				NS				NS
CV (%)	11.59	10.90	11.95	11.53	10.22	11.48	10.57	10.71

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Table 5: Effect of different treatments on economics of mustard

Treatments	Seed yield (kg/ha)	Stover yield (kg/ha)	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	BCR
T_1: Glyphosate @ 25 g a.i./ha at 25-30 DAS and 50 g/ha @ 50-55 DAS	1604	3653	37531	98067	60535	2.61
T_2: Glyphosate @ 0.25% PE to *Orobanche* at 42-45 DAS	1399	3103	38741	85492	46750	2.21
T_3: Pendimethalin 1.0 kg a.i./ha PE to *Orobanche* at 30-35 DAS as herbigation	1092	2347	37989	66694	28704	1.76
T_4:Seed treatmentwith sulfosulfuron @ 1.0 ppm	1021	2176	36221	62348	26127	1.72
T_5: Seed treatment with sulfosulfuron @ 1.0 ppm *fb* pendimethalin 1.0 kg a.i./ha PE to *Orobanche* at 30-35 DAS as herbigation	1261	2758	38159	77039	38880	2.02
T_6: Neem cake @ 500 kg/ha	908	2058	47231	55509	8278	1.18
T_7: Castor cake @ 500 kg/ha	1094	2448	42131	66864	24733	1.59
T_8: Weed free (Removal of all weeds including *Orobanche*)	1809	4143	45571	1,10,611	65040	2.43
T_9: Control	598	1270	32201	36515	4314	1.13

Selling price: Mustard Seed :₹ 60/kg
Stover :₹0.50/kg

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Table 6: Effect of different treatments on *Orobanche* population at 55 and 65 DAS

Treatments	No. of *Orobanche*/m row length							
	55 DAS				65 DAS			
	2017-18	2019-20	2021-22	Pooled	2017-18	2019-20	2021-22	Pooled
T_1: Glyphosate @ 25 g a.i./ha at 25-30 DAS and 50 g/ha @ 50-55 DAS	1.72^{e} (2.50)	1.71^{e} (2.44)	1.69^{e} (2.37)	1.71^{e} (2.42)	1.68^{e} (2.35)	1.62^{f} (2.12)	1.61^{e} (2.10)	1.64^{e} (2.19)
T_2: Glyphosate @ 0.25% PE to *Orobanche* at 42-45 DAS	1.98^{d} (3.43)	2.01^{d} (3.55)	1.86^{d} (2.96)	1.95^{d} (3.31)	1.99^{d} (3.46)	2.04^{e} (3.66)	1.91^{d} (3.15)	1.98^{d} (3.42)
T_3: Pendimethalin 1.0 kg a.i./ha PE to *Orobanche* at 30-35 DAS as herbigation	2.31^{c} (4.84)	2.33^{c} (4.92)	2.09^{c} (3.89)	2.24^{c} (4.53)	2.37^{c} (5.13)	2.37^{d} (5.16)	2.17^{c} (4.22)	2.30^{c} (4.80)
T_4: Seed treatment with sulfosulfuron @ 1.0 ppm	2.36^{c} (5.09)	2.38^{c} (5.18)	0.12^{c} (4.02)	2.29^{c} (4.73)	2.47^{c} (5.54)	2.50^{cd} (5.73)	2.21^{c} (4.41)	2.39^{c} (5.20)
T_5: Seed treatment with sulfosulfuron @ 1.0 ppm *fb* pendimethalin 1.0 kg a.i./ha PE to *Orobanche* at 30-35 DAS as herbigation	2.02^{d} (3.59)	2.04^{d} (3.69)	1.93^{d} (3.21)	1.99^{d} (3.48)	2.05^{d} (3.71)	2.09^{e} (3.85)	2.00^{d} (3.51)	2.04^{d} (3.68)
T_6: Neem cake @ 500 kg/ha	2.65^{b} (6.53)	2.56^{b} (6.05)	2.37^{b} (5.10)	2.52^{b} (5.87)	2.72^{b} (6.92)	2.66^{bc} (6.59)	2.39^{b} (5.26)	2.59^{b} (6.23)
T_7: Castor cake @ 500 kg/ha	2.33^{c} (4.92)	2.68^{b} (6.68)	2.09^{c} (3.92)	2.36^{c} (5.09)	2.38^{c} (5.17)	2.73^{b} (6.96)	2.19^{c} (4.30)	2.43^{bc} (5.42)
T_8:Weed free (Removal of all weeds including *Orobanche*)	0.71^{f} (0.00)	0.71^{f} (0.00)	0.71^{f} (0.00)	0.71^{f} (0.00)	0.71^{f} (0.00)	0.71^{g} (0.00)	0.71^{f} (0.00)	0.71^{f} (0.00)
T_9: Control	3.03^{a} (8.69)	3.16^{a} (9.49)	3.07^{a} (8.96)	3.09^{a} (9.04)	3.20^{a} (9.74)	3.22^{a} (9.92)	3.15^{a} (9.42)	3.18^{a} (9.63)
S.Em ±	0.053	0.054	0.049	0.058	0.056	0.068	0.055	0.056
CD (P= 0.05)	0.154	0.157	0.142	0.170	0.162	0.198	0.161	0.17
Y x T				0.145				0.17
CV (%)	4.96	4.95	4.87	4.94	5.12	6.15	5.41	5.59

*Figures in the parenthesis are original values. All Figures are square root ($\sqrt{x + 0.5}$) transformed values

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Table 7: Effect of different treatments on *Orobanche* population at 75 DAS and at harvest

Treatments	No. of *Orobanche* count/m row length							
	75 DAS				At harvest			
	2017-18	2019-20	2021-22	Pooled	2017-18	2019-20	2021-22	Pooled
T_1: Glyphosate @ 25 g a.i./ha at 25-30 DAS and 50 g/ha @ 50-55 DAS	1.74^{e} (2.52)	1.73^{e} (2.50)	1.74^{d} (2.52)	1.76^{e} (2.51)	2.11^{f} (3.96)	1.87^{e} (2.99)	1.96^{e} (3.33)	1.98^{f} (3.41)
T_2: Glyphosate @ 0.25% PE to *Orobanche* at 42-45 DAS	2.05^{d} (3.72)	2.12^{d} (4.03)	1.96^{c} (3.37)	2.05^{d} (2.39)	2.35^{e} (5.03)	2.31^{d} (4.85)	2.19^{d} (4.31)	2.28^{e} (4.71)
T_3: Pendimethalin 1.0 kg a.i./ha PE to *Orobanche* at 30-35 DAS as herbigation	2.47^{c} (5.62)	2.40^{c} (5.27)	2.33^{b} (4.93)	2.40^{c} (5.26)	2.62^{cd} (6.40)	2.49^{cd} (5.70)	2.45^{c} (5.51)	2.52^{cd} (5.85)
T_4: Seed treatment with sulfosulfuron @ 1.0 ppm	2.50^{c} (5.78)	2.53^{c} (5.91)	2.38^{b} (5.19)	2.47^{bc} (5.60)	2.69^{c} (6.72)	2.57^{c} (6.10)	2.48^{c} (5.64)	2.58^{c} (6.14)
T_5: Seed treatment with sulfosulfuron @ 1.0 ppm *fb* pendimethalin 1.0 kg a.i./ha PE to *Orobanche* at 30-35 DAS as herbigation	2.11^{d} (3.98)	2.16^{d} (4.19)	2.12^{c} (4.00)	2.13^{d} (4.04)	2.48^{de} (5.62)	2.36^{d} (5.07)	2.25^{d} (4.59)	2.36^{de} (5.06)
T_6: Neem cake @ 500 kg/ha	2.74^{b} (7.02)	2.76^{b} (7.11)	2.41^{b} (5.32)	2.63^{b} (6.44)	2.89^{b} (7.86)	2.77^{b} (7.20)	2.66^{b} (6.57)	2.77^{b} (7.19)
T_7: Castor cake @ 500 kg/ha	2.48^{c} (5.65)	2.78^{b} (2.25)	2.37^{b} (5.13)	2.54^{bc} (5.97)	2.67^{cd} (6.65)	2.87^{b} (7.76)	2.47^{c} (5.61)	2.67^{bc} (6.63)
T_8: Weed free (Removal of all weeds including *Orobanche*)	0.71^{f} (0.00)	0.71^{f} (0.00)	0.71^{e} (0.00)	0.71^{f} (0.00)	0.71^{g} (0.00)	0.71^{f} (0.00)	0.71^{f} (0.00)	0.71^{g} (0.00)
T_9: Control	3.25^{a} (10.05)	3.27^{a} (10.25)	3.16^{a} (9.51)	3.23^{a} (9.92)	3.48^{a} (11.61)	3.54^{a} (12.09)	3.40^{a} (11.06)	3.47^{a} (11.55)
S.Em ±	0.071	0.061	0.062	0.375	0.066	0.063	0.055	0.048
CD (P= 0.05)	0.208	0.179	0.182	0.105	0.193	0.184	0.160	0.14
Y * T				NS				0.17
CV (%)	6.36	5.37	5.86	5.87	5.43	5.28	4.79	5.19

*Figures in the parenthesis are original values. All figures are square root ($\sqrt{x + 0.5}$) transformed values

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Table 8: Effect of different treatments on dry weight and reduction of *Orobanche*

Treatments	Dry weight (kg/net plot)				*Orobanche* reduction over control (%)			
	2017-18	2019-20	2021-22	Pooled	2017-18	2019-20	2021-22	Pooled
T_1: Glyphosate @ 25 g a.i./ha at 25-30 DAS and 50 g/ha @ 50-55 DAS	0.83^{d} (0.18)	0.86^{d} (0.23)	0.84^{f} (0.21)	0.84^{f} (0.21)	79.52	78.22	75.97	78.03
T_2: Glyphosate @ 0.25% PE to *Orobanche* at 42-45 DAS	0.89^{c} (0.31)	0.94^{c} (0.38)	0.92^{e} (0.35)	0.92^{e} (0.35)	64.84	64.79	60.39	63.07
T_3: Pendimethalin 1.0 kg a.i./ha PE to *Orobanche* at 30-35 DAS as herbigation	0.99^{b} (0.48)	0.96^{c} (0.42)	0.97^{cd} (0.44)	0.97^{cd} (0.44)	45.74	60.99	50.56	53.20
T_4: Seed treatment with sulfosulfuron @ 1.0 ppm	0.99^{b} (0.48)	0.98^{c} (0.47)	0.99^{bc} (0.50)	0.99^{bc} (0.48)	44.97	56.38	43.67	48.87
T_5: Seed treatment with sulfosulfuron @ 1.0 ppm *fb* pendimethalin 1.0 kg a.i./ha PE to *Orobanche* at 30-35 DAS as herbigation	0.92^{c} (0.34)	0.95^{c} (0.40)	0.94^{de} (0.39)	0.93^{de} (0.37)	61.52	62.95	55.66	60.61
T_6: Neem cake @ 500 kg/ha	1.01^{b} (0.56)	1.03 (0.56)	1.03^{b} (0.56)	1.02^{b} (0.54)	42.53	47.52	36.15	42.46
T_7: Castor cake @ 500 kg/ha	0.98^{b} (0.45)	1.05^{b} (0.60)	0.98^{cd} (0.46)	1.00^{bc} (0.51	48.56	43.30	48.09	46.22
T_8: Weed free (Removal of all weeds including *Orobanche*)	0.71^{e} (0.00)	0.71^{e} (0.00)	0.71^{g} (0.00)	0.71^{g} (0.00)	100	100	100	100
T_9: Control	1.17^{a} (0.88)	1.25^{a} (1.07)	1.18^{a} (0.88)	1.20^{a} (0.94)	0	0	0	0
S.Em ±	0.012	0.016	0.015	0.008	-	-	-	-
CD (P= 0.05)	0.034	0.045	0.043	0.04	-	-	-	-
Y * T				0.04	-	-	-	-
CV (%)	2.42	3.26	3.15	2.98	-	-	-	-

*Figures in the parenthesis are original values. All figures are square root ($\sqrt{x + 0.5}$) transformed values

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Table 9: Effect of different treatments on weed index of mustard

Treatments	Weed index (%)			
	2017-18	2019-20	2021-22	Pooled
T_1: Glyphosate @ 25 g a.i./ha at 25-30 DAS and 50 g/ha @ 50-55 DAS	12.48	11.61	9.89	11.33
T_2: Glyphosate @ 0.25% PE of *orobanche* at 42-45 DAS	22.80	22.70	22.40	22.66
T_3: Pendimethalin 1.0 kg a.i./ha PE of *orobanche* at 30-35 DAS as herbigation	46.69	31.55	39.89	39.64
T_4: Seed treatment with sulfosulfuron @ 1.0 ppm	48.89	40.61	40.81	43.56
T_5: Seed treatment with sulfosulfuron @ 1.0 ppm *fb* pendimethalin 1.0 kg a.i./ha PE of *Orobanche* at 30-35 DAS as herbigation	35.66	25.98	28.80	30.29
T_6: Neem cake @ 500 kg/ha	50.09	52.27	47.04	49.81
T_7: Castor cake @ 500 kg/ha	31.74	50.63	37.05	39.52
T_8: Weed free (Removal of all weeds including *Orobanche*	0.00	0.00	0.00	0.00
T_9: Control	67.01	69.11	64.85	66.94

Table 10: Bio-assay study and phyto toxicity rating on succeeding bajra (Mean data)

Treatments	Plant stand at 15 DAS per meter row length	phototoxicity rating (0 to 10 scale)
T_1: Glyphosate @ 25 g a.i./ha at 25-30 DAS and 50 g/ha @ 50-55 DAS	9.3	0.0
T_2: Glyphosate @ 0.25% PE to *Orobanche* at 42-45 DAS	9.6	0.0
T_3: Pendimethalin 1.0 kg a.i./ha PE to *Orobanche* at 30-35 DAS as herbigation	9.3	0.0
T_4: Seedtreatmentwithsulfosulfuron @ 1.0 ppm	9.3	0.0
T_5: Seedtreatmentwithsulfosulfuron @ 1.0 ppm *fb*pendimethalin 1.0 kg a.i./ha PE to *Orobanche* at 30-35 DAS as herbigation	9.3	0.0
T_6: Neem cake @ 500 kg/ha	9.6	0.0
T_7: Castor cake @ 500 kg/ha	9.6	0.0
T_8: Weed free (Removal of all weeds including *Orobanche*)	9.3	0.0
T_9: Control	9.6	0.0

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Fig. 1 T_1: Glyphosate @ 25 ga.i./ha at 25-30 DAS and 50 g/ha @ 50-55 DAS

Fig.2 T_8: Weed free (Removal of allweeds including*orobanche*)

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