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Effects of Combined and Separate Herbicide Application on Rapeseed and its Weeds in Southern Iran

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ABSTRACT

A farm experiment was conducted to examine the separate and combined effects of Alachlor, Treflan, Butisan Star, Galant Super and Lontrel on rapeseed and associated weeds during 2007. Grain yield in Galant Super+Lontrel treated plots were similar to weed-free check. The numbers of broad leaved and grass weed significantly reduced in treatments containing Galant Super, Butisan Star and Lontrel. Dominant weed species were effectively controlled by Butisan Star, Galant Super and Lontrel. Post emergence application of Galant Super+Lontrel and Butisan Star were found to be the good weed management treatments that can be recommended for rapeseed production in Bousheher province and other regions with similar agroclimate conditions.

Key Word: Rapeseed; Weed control; Chemical herbicides; Grain yield

INTRODUCTION

Rapeseed (*Brassica napus* L.) belongs to family *Brassicaceae* and is an important oil-seed crop throughout world and in Iran (Miri, 2007). Although rapeseed is a smother crop because of its large leaves, rapid growth and early canopy closing, still weed competition is very critical during the early stand establishment (Joel *et al*., 1995), especially in winter grown crop. Besides lowering production, weeds also decrease oil quality (Bagherani & Shimi, 2001). Several methods have been used for weed control in rapeseed, like hand weeding, cultivation in row cropping and use of chemicals. Chemical weed control, being independent of weather, cheap and saving labor is given preference. Pre-emergence herbicides are more effective than post-emergence or manual control methods (Khan *et al.,* 1995; Rapparini, 1996).

Limited herbicides for weed control in rapeseed are available. For example, Treflan (trifluralin) is the only herbicide registered for use in rapeseed in Iran; whereas, in Egypt, alachlor, metolachlor, pendimethalin, diphenamid, CGA 10832 and EPTC showed satisfactorily good annual grass weed control up to harvest time (Ibrahim *et al*., 1987). Effectiveness of these herbicides have been reported earlier, e.g., that of Butisan Top (a mixture of metazachlor & quinmerac), which was comparable to Treflan (Hossaini & Shimi, 2004; Pourazar & Shimi, 2004), haloxyfop-R methyl (Galant Super), holoxyfop-etoxy ethyl (Galant), sycloxydim (Focus) and sethoxydim (Nabu-S) (Bagherani & Shimi, 2001; Mousavi & Shimi, 2004).

Treflan is the only pre-planting herbicide recommended for weed control in rapeseed fields in Iran. This herbicide can control some weeds such as, *Stellaria sp*., *Galium sp*., *Fumaria sp*., *Setaria sp*., *Avena fatua*, *Lolium sp*., but had little effects on some broad leaved weeds and grasses. Keeping in view the importance of the different herbicides for controlling weeds in rapeseed, the experiment was conducted to figure out the most effective, economical and suitable herbicide for the area concerned.

MATERIALS AND METHODS

The experiment was conducted at a research farm in Boushehr province (29° 44´ latitude, 52° 48´ altitudes & elevation of 70 m from see level) during 2006. Meteorological data of experimental site are shown in Table I. Soil of experimental farm was sandy loam with pH of 7.1 and 1.5% organic matter. The trial was laid out in randomized complete blocks design (RCBD) using 15 treatment and four replications with a plot size of 5 m x 3.5 m. Each plot consisted of 7 planting rows with 5 m length and 0.45 m row spacing and final density of 20 plant m^{-2}. Rapeseed, Hayolla 401 variety, was hand seeded on 29 November 2006. Before planting P and K fertilizers were incorporated with soil at 100 kg ha^{-1}. Nitrogen fertilizer (150 kg ha^{-1}) was applied at two stages (early after planting & during stem elongation). In order to have a uniform weed stand in plots, weed seeds (common rapeseed weed species, which prepared from local seed cleaning center) were planted at time of rapeseed planting. Pre-planting herbicides (Treflan, Alachlor, Treflan+Alachlor, Treflan+Butisan Star, Alachlor+Butisan Star, Alachlor+Treflan+Butisan Star &

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Butisan Star) were applied before planting and incorporated with 5-10 cm soil depth with the help of hand harrow. All other cultural practices were kept normal and uniform for all the experimental units.

The experiment comprised of 13 herbicide treatments and two weed-free (hand weeding) and weedy (without control) checks. Herbicide treatments along with applied dosage are shown in Table II. Early post emergence treatment (Butisan Star) was applied on 19 December (20 days after planting). Post emergence herbicides (Galant Super & Lontrel) were applied in 04 February (67 days after planting). The herbicides were sprayed in moist condition. In weed-free check, weeds were removed weekly during entire growing season.

Above-ground weed biomass was harvested in all experimental units at 20, 40, 60 and 90 days after planting using 0.5 m^{-2} quadrat. Weeds were separated by species and counted. To measure rapeseed grain yield, yield components (number of pods per plant, number of seeds per pod & seed weight) and biological yield, plants were hand harvested from 2 m^2 of experimental units. Harvested parts were air dried and then weighed to determine biological yield. The numbers of pods per plant counted in all harvested plants and seeds per pod were counted from 40 randomly selected pods after hand threshing. The weight of 500 seeds was taken to determine the seed 1000 weight. Harvest index was determined as the ratio of grain yield to total dry matter. Data were subjected to analysis of variance (ANOVA) using SAS software. Means were compared using the Duncan Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Grain yield and its components. Grain yield of rapeseed was significantly affected by various herbicidal treatments (Table III). The highest grain yield (2560 kg ha^{-1}) was observed in weed-free check, which was, however, statistically similar to the Galant Super+Lontrel (treatment 9; 2440 kg ha^{-1}). The lowest (1270 kg ha^{-1}) grain yield was obtained in weedy check plots. However, separate application of Galant Super (12) and treatments containing Alachlor (3, 4, 5 & 6) produced relatively low grain yield. Although Alachlor gives good suppression of weeds but this herbicide exhibits phytotoxicity on rapeseed plants (Ibrahim *et al.,* 1987). The performance of Galant Super+Lontrel can be attributed to the best control of weeds thereby reducing the competition thus enabling increased flow of nutrients towards the seeds and ultimately the grain yield in rapeseed was significantly increased. Khan *et al.* (2003) stated that good weed control using pre-emergence herbicides had significantly increased the seed yield of rapeseed crop. Similar results were reported by Singh *et al.* (2000), Yadav *et al.* (1995) and Khan *et al.* (1995).

Different herbicide treatments significantly affected the pods per plant (Table III). The highest number of pods per plant was recorded in weed-free check and Galant Super+Lontrel treated plots, while application of Butisan

Table I. Meteorological data of experimental site during rapeseed growing season in 2006

Month	Precipitation	Temperature (ºC)		Relative humidity (%)	
		Minimum	Maximum	Minimum	Maximum
December	94.5	8.0	19.9	56	79
January	52.5	4.9	11.4	55	71
February	65.0	9.0	17.6	58	79
March	0	11.2	26.4	49	75
April	38.0	19.3	34.8	41	61

Star (12) and combination of Butisan Star+Treflan (8) resulted in low pods per plant. There was no significant difference between numbers of seed per pod in different herbicides treatment (Table III). This was to some extent due to compensatory relation between yield components, so that treatments with higher pods per plant produce relatively low seeds per pod (for example 11 & 14), while more seeds per pod were observed in treatments with low pods per plant (for example 8 & 10). Herbicides can modify the relationship between yield components. Thomas (1998) showed that herbicides efficiently enhanced the yield components and Khan *et al.* (1995) reported that application of some herbicides increases the number of pod per plant in rapeseed. Highest 1000-seed weight (4.53 g) was obtained in the Trefalan+Lontrel+Galant Super treated plots (2) followed by Galant Super+Lontrer (9) (Table III). The increased grain weight is attributed to the availability of resources to the rapeseed crop. This showed that in these treatments little competition exist during in grain filling period. Galant Super and Lontrel applied in 67 days after planting and weed control in this stage resulted in low competition of weed with crop and increasing seed weight. Sohail (1993; cited by Khan *et al.,* 2004) also stated that grain weight increases with application of some herbicides. Lowest 1000 seed weight (3.14 g) was recorded in the weedy check plots (10) (Table III).

Different herbicide treatments showed inconsistent influence on harvest index (Table III). Weed-free check (14) showed the highest HI however, this was not significantly different from treatment 4, 5, 6, 7, 9, 10, 11, 12, 13 and 15. The lowest HI was observed in Treflan+Lontrel+Galant Super and combination of Butisan Star+Trfelan.

Leaf area index. Herbicide treatments had significant effects on rapeseed leaf area index (LAI) at flowering (Table III). Highest LAI (5.0) was observed in weed-free check (14) and it was statistically similar to Butisan Star (11) and Galant Super+Lonter (9) treated plots. Weedy check (10) and combination of Alachlor+Treflan (6) showed the lowest LAI (2.9 & 2.8, respectively). Treatments containing Alachlor and Treflan (1, 2, 3, 4 & 5) also had relatively low LAI. Lack of weed competition and increased weed free duration can result in increasing crop LAI. Miri and Ghadiri (2006) showed that in safflower plants weed-free plots reached its maximum LAI earlier and maintained a maximum LAI for a longer period compared to weedy check. Weed interference decreased LAI by increasing the

Table II. Detail of treatments of the experiment†

No.	Herbicide treatment	Application time	Rate (kg a.i. ha^{-1})
1	Trefelan	PPI	2
2	Trefelan+Lontrel+Galant Super	PPI + Post-em. +Post-em	2+0.7+1
3	Alachlor	PPI	5
4	Alachlor+Lontrel+Galant Super	PPI + Post-em. +Post-em	5+0.7+1
5	Alachlor+Butisan Star (combined)	PPI	5+3
6	Alachlor+Trefelan (combined)	PPI	5+2
7	Butisan Star + Alachlor + Trafelan (combined)	PPI	3+5+2
8	Butisan Star+Trafelan (combined)	PPI	3+2
9	Galant Super+Lontrel	Post-em. +Post-em.	1+0.7
10	Weedy check		
11	Butisan Star	Post-em.	3
12	Galant Super	Post-em.	1
13	Lontrel	Post-em.	0.7
14	Weed-free check (hand weeding)		
15	Butisan Star	PPI	3

PPI: Pre-planting incorporated with soil, Post-em.: Post-emergence; †This order of experimental treatments is also used in following tables

Table III. Rapeseed yield and yield components†

Treatment	Grain yield (kg ha^{-1})	Pods per plant	Seeds per pod	1000 seed weight (g)	HI (%)	LAI
1	1830 d-g‡	105.0 cd	21.7 a	3.16 de	27.3 bc	3.5 c
2	1870 de	110.0 cd	21.6 a	4.53 a	26.0 c	3.5 c
3	1670 gh	95.3 ef	21.3 ab	3.58 cde	27.3 bc	3.3 cd
4	1860 def	100.9 de	21.3 a	3.74 b-e	27.8 abc	3.5 c
5	1680 fgh	94.7 ef	20.9 ab	3.60 cde	28.8 abc	3.2 cd
6	1670 gh	92.5 ef	21.2 a	3.44 cde	28.0 abc	2.8 d
7	1920 d	110.9 c	21.4 a	3.90 bc	30.8 abc	3.7 c
8	1730 e-h	93.8 ef	22.1 a	3.56 cde	26.5 c	3.4 cd
9	2440 ab	137.5 a	21.3 ab	4.23 ab	33.3 ab	4.7 ab
10	1127 i	64.1 g	21.1 ab	3.14 e	27.5 abc	2.9 d
11	2300 bc	125.6 b	20.4 b	3.67 b-e	28.5 abc	4.5 ab
12	1590 h	88.8 f	21.6 a	3.47 cde	28.5 abc	3.2 cd
13	2170 c	119.7 b	20.3 b	3.79 bcd	28.5 abc	4.4 b
14	2560 a	142.5 a	20.9 ab	3.63 b-e	34.0 a	5.0 a
15	1940 d	106.9 cd	20.7 ab	3.98 abc	29.5 abc	3.6 c

†For treatment details see Table II; ‡Means followed by the same letter in a column do not differ significantly at 5 % level with Duncan Multiple Range Test

Table IV. Broad leaved and grass weeds density m^{-2} at 20, 40, 60 and 90 days after planting in different herbicides treatment†

Treatment	Grass weed				Broad leaved weed			
	20	40	60	90	20	40	60	90
1	60 bc	18 d	15 cd	16 c	52 efg	49 d	66 c	22 c
2	28 c	20 d	15 cd	0 d	58 efg	58 cde	69 c	23 c
3	36 c	76 cd	43 b	37 b	73 def	84 cd	75 b	18 cd
4	50 bc	46 d	43 b	0 d	90 cde	93 cd	78 b	17 cd
5	10 c	2 d	6 cd	7 cd	54 efg	11 e	30 e	10 ef
6	54 bc	36 d	23 c	16 c	47 efg	88 cd	47 d	19 c
7	6 c	10 d	9 cd	6 cd	39 efg	36 d	16 f	8 f
8	12 c	4 d	10 cd	12 cd	48 efg	51 d	35 e	7 f
9	218 a	192 ab	194 a	0 d	116 bcd	196 a	177 a	37 a
10	218 a	192 ab	203 a	39 b	166 ab	175 ab	182 a	31 b
11	224 a	87 cd	12 cd	9 cd	170 ab	127 bc	18 f	14 de
12	154 ab	158 bc	189 a	169 a	143 abc	174 ab	173 a	28 b
13	214 a	276 a	189 a	0 d	192 a	173 ab	178 a	33 ab
14	0 c	0 d	0 d	0 d	0 g	0 e	0 g	0 g
15	24 c	6 d	13 cd	0 d	33 fg	28 d	17 f	7 f

†For treatment details see Table II; ‡ Means followed by the same letter in a column do not differ significantly at 5 % level with Duncan Multiple Range Test

number of senesced leaves and decreasing both the number of expanded leaves and leaf expansion rate (Hall *et al.*, 1992).

Weed density m^{-2}. Weed flora of experimental site comprised of white clover (relative abundance 52%), bullwort (18%), wildmustard (8.6%), common lambsquarters (13.7%), wood surrel (4.9%) and sea beat (2.8%). Maximum grass and broad-leaved weeds m^{-2} (Table IV) were recorded in the weedy check (10). At 20 days after planting (DAP) treatments 1, 2, 3, 4, 5, 6, 7, 8 and 15 reduced weed numbers by 72, 87, 83, 77, 95, 75, 97, 94 and 88% in comparison to weed-free check, respectively. Other herbicide treatments were not applied in this time. At this stages combined application of Alachlor+Butisan Star (5) Btisan Star+Alachlor+Treflan (7) and Butisan Star+Treflan (8) showed good control of grass weeds.

After application of treatments 11 and 15 (40 DAP) number of grass weeds reduced in this treatment. At 90 DAP treatments of Treflan+Lontrel+Galan Super (2), Alachlor+Lontrel+Galan Super (4), Galant Super+Lontrel (9), Lontrel (13) and Butisan Star (15) showed the minimum grass weeds m^{-2}. This shows the efficiency of Galant Super in controlling grass weeds. Mousavi and Shimi (2004) also showed that the Galant Super and Galant had a good control against grass weed in rapeseed and the highest grain yield was observed in these herbicide treatments.

Number of broad-leaved weeds differed significantly in herbicide treatments (Table IV). In treatments contains pre-planting herbicides (1, 2, 3, 4, 5, 6, 7, 8 & 15) broad-leaved weeds were reduced significantly at 20 days after planting. However, some herbicides as Butisan Star (15) and combination of Butisan Star+Alachlor+Treflan (7) showed better control against broad leaved weeds at this time. At 90 days after planting maximum broad leaved weeds were observed in weedy check (10) and Lontrel (13) treatments, while in other treatments number of broad-leaved weeds was reduced significantly. Minimum broad-leaved weeds were observed in Alachlor+Butisan Star combination (5), Butisan Star+Alachlor+Treflan combination (7), Butisan Star+Treflan combination (8) and Butisan Star (15) demonstrating the efficacy of Butisan Star in controlling broad-leaved weeds.

The variability in weed populations in different treatments can be attributed to the selectivity of these herbicides for weed control. Similar results have been reported by Marwat *et al.* (2005) and Khan *et al.* (2003) and Lolas (1997).

Weed species. The effects of different herbicide treatments on number of dominant weeds are showed in Table V. White clover (*Trefolium repense*) was efficiently controlled with Treflan+Lontrel+Galant Super (2), Alachlor+Lontrel+Galant Super (4), Galant Super+Lontrel (9) and Galant Super (12) application. All of these treatments contained Galant Super and this showed the efficiency of this herbicide in controlling white clover. Other herbicides had little or no effect on white clover in comparison to weedy check.

Table V. Number of dominant weeds per m^{-2} at 90 days after planting in different herbicides treatment†

Treatment	*Trifolium repense*	*Ammi majus*	*Sinapis arvensis*	*Chenopodium album*	*Rumex acetosella*	*Beta maritima*
1	21.5 c	18.3 b	10.0 a	0.5 d	0.3 d	0.5 d
2	0.5 g	0.5 d	7.8 bc	1.0 d	0.0 d	0.8 d
3	29.8 b	7.3 c	6.0 c	12.8 bc	2.5 c	2.0 c
4	0.8 g	0.3 d	8.0 abc	11.5 c	0.0 d	2.3 bc
5	22.5 c	2.5 d	1.8 d	1.3 d	0.0 d	0.0 d
6	24.3 c	6.3 c	6.5 c	0.8 d	0.0 d	0.5 d
7	11.8 de	0.5 d	1.3 d	0.8 d	0.0 d	0.0 d
8	15.5 d	0.8 d	1.5 d	0.5 d	0.0 d	0.0 d
9	0.5 g	0.5 d	9.0 ab	13.0 bc	0.0 d	2.8 abc
10	56.0 a	19.3 b	9.3 ab	14.8 ab	5.3 a	3.0 ab
11	10.0 ef	1.0 d	2.0 d	0.8 d	0.3 d	0.8 d
12	0.3 g	0.3 d	9.3 ab	14.5 ab	0.0 d	3.3 a
13	54.3 a	30.3 a	10.0 a	15.8 a	3.8 b	3.3 a
14	0.0 g	0.0 d	0.0 d	0.0 d	0.0 d	0.0 d
15	6.8 f	0.0 d	2.0 d	1.0 d	0.0 d	0.3 d

†For treatment details see Table II; ‡ Means followed by the same letter in a column do not differ significantly at 5 % level with Duncan Multiple Range Test

All herbicide treatments except Treflan (1) and Lontrel (13) significantly reduced number of bullwort (*Ammi majus*) in comparison to weedy check (Table V). In all treatments containing Galant Super and Butisan Star (4, 5, 7, 8, 9, 11, 12 & 15) bullwort density was statistically similar to hand weeding check. The best control of wildmustard (*Sinapis arvensis*) was observed in herbicide treatments contain Butisan Star (5, 7, 8, 11 & 15). Separate and combined (with Alaclor & Treflan) application of Butisan Star significantly reduced density of wildmustard (Table V). Pourazar and Shimi (2004) showed that Treflan and Butisan Top were unable to control wildmustard, while sea beat (*Beta maritima*) was controlled with these herbicides.

The density of common lambsquarters (*Chenopodium album*) was significantly reduced with the application of Treflan (1), Treflan+Lontrel+Galant Super (2), Alachlor+Butisan Star (5), Alachlor+Treflan (6), Butisan Star+Treflan+Alachlor (7), Butisan Star+Treflan (8), Butisan Star as post-emergence (11) and Butisan Star as PPI (15) (Table V). Separate application of Alachlor (3), Galant Super (12) and Lontrel (13) showed low efficiency in relation to control for suppressing common lambsquarters.

All herbicide treatments significantly reduced the number of wood surrel (*Rumex asetosella*) in comparison to weedy check (Table V), however, separate application of Lontrel (13) and Alachlor (3) to lower extent reduced the number of this weed. All herbicide treatments except those containing Galant Super and Lontrel (4, 9, 12 & 13) significantly reduced the number of sea beat (*Beta maritim*a).

In conclusion, results of this experiment showed that all herbicide treatments significantly increased rapeseed grain yield in comparison with weedy check. The highest rapeseed grain yield after weed-free check was observed in Galant Super+Lontrel and Butisan Star application. However, separate application of Galant Super and Lontrel did not show this yield advantage. The number of broad leaved and grass weed significantly reduced in treatment containing Galant Super, Butisan Star and Lontrel. By considering these results, post emergence application of Galant Super+Lontrel and Butisan Star are the good weed management treatments that can be recommended for rapeseed production in Bousheher province and other regions with similar agroclimate conditions.

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