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Interrelationships between oilseed rape yield and weeds population under herbicides application

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Abstract

In order to investigate the effect of herbicides on oilseed rape yield and population and biomass of weeds a field experiment was conducted during the 2004 and 2005 at the Darab Agricultural College, east of Shiraz, Iran. Herbicide treatments included combination of trifluralin with pronamide, haloxyfop-p methyl, propaquizafop, and isoxaben. Results showed that with increasing number and biomass of wild mustard (*Sinapis arvensis* L.), fumitory (*Fumaria sp*.) and wild oat (*Avena fatua* L.), per square meter, oilseed rape yield decreased significantly, in both 2004 and 2005. There were highly negative significant correlations between oilseed rape and wild mustard (r=-0.73, p<0.01), fumitory (r=-0.86, p<0.01) and wild oat (r=-0.88, p<0.01) biomass at 8 weeks after planting (WAP). There were significant path coefficient, direct effect, between wild mustard number at 8 WAP (p=0.58, p<0.01), fumitory number at 8 WAP (p=-0.11, p<0.05), fumitory biomass at 8 WAP (p=-0.19, p<0.01), wild oat biomass at 8 WAP (p=-0.12, p<0.01), wild oat number at 16 WAP (p=-0.11, p<0.05) with oilseed rape yield. The lowest oilseed rape yield observed at trifluralin at 1200 g ha^{-1} (2615 and 2609 kg ha^{-1}) and at 1400 g ha^{-1} (2565 and 2612 kg ha^{-1}) in 2004 and 2005, respectively. Decreasing oilseed rape yield may be due to highest weed biomass in these treatments Generally, the results of the present study indicated that the combination of trifluralin plus haloxyfop-p methyl plus isoxaben were suitable option for broadleaved and grass weed control in oilseed rape.

Keywords: *Brassica napus* L., weed population, herbicides, path analysis, wild mustard

Abbreviations*:* DAP_Days after planting; PPI_Pre plant incorporated; WAP_Weeks after planting

Introduction

Recently, Oil crops especially oilseed rape become important in Iran due to its high oil and rapid growth (Ghadiri and Naderi, 2008). The most noxious weeds in oilseed rape include wild mustard (*Sinapis arvensis* L.), wild oat (*Avena fatua* L.), and green foxtail (*Setaria viridis* L.) (Ghadiri et al., 2008; Blackshaw and Harker, 1992). These weeds are early competitors of the crop during establishment period, and may decrease Oilseed rape growth (Ghadiri and Naderi, 2008; Bagherani and Shimi, 2001). Weed control is necessary to achieve higher yields as weeds compete for water and nutrients with crops, causing significant yield reduction (Bijanzadeh and Ghadiri, 2006; Abdolahi and Ghadiri, 2004). In one study in Iran, Oilseed rape yield decreased 23 to 64% due to weed infestation (Bagherani and Shimi, 2001).

Herbicides are major input costs in canola in Iran (Bagherani and Shimi, 2001; Miri and Rahimi, 2009). Trifluralin, soil applied and preplant soil incorporated, is the most widely used in Iran. Trifluralin is 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 and grass weeds (Miri and Rahimi, 2009). Recently, several post emergence herbicides including pronamide, haloxyfoppmethyl, propaquizafop, and isoxaben have been applied to control weed. Pronamide are applied as a post emergence herbicide for control of annual grass and broadleaved weeds in oilseed rape (El-Bastawesy et al., 2000). Haloxyfoppmethyl, and propaquizafop control emerged weedy grasses or volunteer grains when applied in the three leaved to early tillering stages (Harker et al., 1995). Isoxaben applied as a post emergence herbicide to control annual broadleaved weeds in oilseed rape (Schneegurt et al., 1994).

The effectiveness of new herbicides and their combinations on weed and oilseed rape yield has not yet been fully investigated in Iran. Considering the above facts, the objectives of the present study was to determine effects of trifluralin, pronamide, haloxyfop-p methyl, propaquizafop, and isoxaben on number and biomass of weeds and oilseed rape yield and to investigate relationships between number, and biomass of weeds with oilseed rape yield.

Table 1. Simple correlation coefficients among the weeds number, biomass and oilseed rape yield

	GY*	WMN 8	WMB 8	WMN 16	WMB 16	FN8	FB8	FN 16	FB 16	WON 8	WOB 8	WON 16	WOB 16
GY	1												
WMN 8	-0.74	1											
WMB 8	-0.73	0.96	1										
WMN16	-0.88	0.87	0.85	1									
WMB16	-0.88	0.88	0.84	0.98	1								
FN 8	-0.87	0.71	0.76	0.83	0.81	1							
FB 8	-0.86	0.70	0.76	0.81	0.77	0.98	1						
FN 16	-0.89	0.68	0.71	0.82	0.80	0.84	0.81	1					
FB 16	-0.90	0.70	0.73	0.80	0.79	0.83	0.81	0.95	1				
WON 8	-0.77	0.57	0.56	0.78	0.74	0.72	0.71	0.78	0.71	1			
WOB 8	-0.88	0.64	0.66	0.82	0.79	0.81	0.81	0.85	0.88	0.91	1		
WON 16	-0.87	0.68	0.66	0.81	0.79	0.79	0.76	0.82	0.87	0.84	0.82	1	
WOB 16	-0.82	0.66	0.66	0.77	0.74	0.77	0.74	0.79	0.86	0.80	0.91	0.98	1

*: GY: Grain yield, WMN 8: Wild mustard number at 8 weeks, WMN 16: Wild mustard number at 16 weeks, WMB 8: Wild mustard biomass at 8 weeks, WMB 16: Wild mustard biomass at 16 weeks, FN 8: Fumitory number at 8 weeks, FN 16: Fumitory number at 16 weeks, FB 8: Fumitory biomass at 8 weeks, FB 16: Fumitory biomass at 16 weeks, WON 8: Wild oat number at 8 weeks, WON 16: Wild oat number at 16 weeks, WMB 8: Wild mustard biomass at 8 weeks, WMB 16: Wild mustard biomass at 16 weeks

Materials and methods

In order to investigate the effect of herbicide application on oilseed rape yield and number and biomass of broad leaved and grass weeds, a two-year field experiment was conducted during 2004 and 2005 cropping seasons at the Darab Agricultural College, east of Shiraz (28°29´ N, 54°55´ E), Iran,. Mean temperatures in the months of experiments were 20.4 and 21.1 °C in November, 18.5 and 19.4 °C in December, 12.6 and 14.1 °C in January, 10.2 and 11.4 °C in February, 15.6 and 17.7 °C in March, 19.1 and 22.4 °C in April, 25.4 and 26.8 °C in May, and 26.8 and 29.1 °C in June, in 2004 and 2005, respectively. The pervious crop was wheat (*Triticum aestivum* L.) and barley (*Hordeum vulgar*e L.) during 2004 and 2005, respectively.

The soil was a loam (fine, loamy, carbonatic, hyperthermic, typic Torriorthents) with pH of 8.1 and 0.75 organic matter. According to soil test recommend-dations, 65 kg P ha^{-1} and 100 kg N ha^{-1} were applied. Commercial oilseed rape (CV. Hyola 308) were planted 2 cm deep on 19 November 2004 and 21 November, 2005. Each plot was 4 m wide consisting of 9 rows of oilseed rape with 40 cm between-row and 5 cm within row spacing by 6 m long. One row was kept blank to prevent herbicide drift. Experimental design was a randomized complete block with three replicates.

Herbicide treatments consisted of trifluralin at 1200 and 1400 g ha^{-1}, trifluralin plus propaquizafop plus pronamide at 1200+100+2000 and 1200+200+1500 g ha^{-1}, trifluralin plus propaquizafop plus isoxaben at 1200+100+500 and 1200+200+250 g ha^{-1}, trifluralin plus haloxyfop-p methyl plus pronamide at 1200+100+2000 and 1200+200+1500 g ha^{-1}, and trifluralin plus haloxyfop-p methyl plus isoxaben at 1200+100+500 and 1200+200+250 g ha^{-1}, respectively. Herbicides were applied separately in each treatment. Control treatments consisted of weedy and hand weeded checks. Trifluralin, propaquizafop, and haloxyfop-p methyl formulations were emulsions, whereas pronamide formulation was a wettable powder, and isoxaben formulation was dry flowable. Trifluralin at 1200 and 1400 g ai ha^{-1} applied PPI and other herbicides were applied post emergence 5 to 6 WAP. Herbicides were applied as a broadcast application in 300 L ha^{-1} of water using a 20L knapsack sprayer equipped with one flat-fan nozzle 8002 at a pressure of 271 kPa.

Weeds were harvested from a one square meter area in each plot at 8 and 16 WAP. Weeds were separated by species, counted, and oven dried at 72 °C for 48 hours. At physiological maturity, the three middle rows of each plot of oilseed rape were harvested to determine yield. Seed oil content was determined using Agrawal and Daldani's method (1987). The collected data were subjected to analysis of variance (ANOVA) and the means were separated using LSD test (p<0.01) using SAS software (SAS 2000). Correlation and path analyses were done using Minitab14.

Results and discussion

Number and biomass of Weeds

At 16 WAP, with increasing wild mustard number form 0 to 22 weed m^{-2} in 2004, and form 0 to 18 weed m^{-2} in 2005 and wild mustard biomass form 0 to 171 g m^{-2} in 2004, and form 0 to 146 g m^{-2} in 2005, oilseed rape yield decreased significantly in 2004 from 3284 to 815 kg ha^{-1} and in 2005 from 3347 to 903 kg ha^{-1} [Fig. 1(a), 1(b), 2(a), and 2(b)]. In the Studying competition between wild mustard and oilseed rape, Ghadiri and Naderi (2008) reported that increasing wild mustard density from 0 to 40 weeds m^{-2} and biomass from 0 to 800 g m^{-2} caused a significant reduction in oilseed rape yield. Wall (1993) in a study on navy bean (*Phaseolus vulgaris* L.) and wild mustard reported that the greatest navy bean yield loss occurred at 20 wild mustard numbers per square meter. Oilseed rape yield sharply decreased as fumitory (*Fumaria officinalis* L.) number increased from 0 to 11 weed m^{-2} in 2004, and from 0 to 12 weed m^{-2} in 2005 and fumitory biomass form 0 to 29 g m^{-2} in 2004, and form 0 to 36 g m^{-2} in 2005 at 16 WAP [Fig. 1(c), 1(d), 2(c), and 2(d)]. In addition, at 16 WAP, There was a negative significant relationship among wild oat number (R^2=0.94 and R^2=0.96) and wild oat biomass with oilseed rape yield, in 2004 and 2005, respectively [Fig. 1(e), 1(f), 2(e), and 2(f)]. It may be due to high competition of wild oat during growing season. This finding was in agreement with the results of Ghadiri et al., (2008) who reported that there was a negative significant relationship between wild oat biomass and wheat yield (R^2=0.78).

Correlation analysis

The correlations between oilseed rape yield and weeds number and biomass at 8 and 16 WAP are presented in the Table 1. There were highly negative significant correlations between oilseed rape yield and wild mustard biomass at 8 WAP (r=-0.73, p<0.01), wild mustard biomass at 16 WAP (r=-0.88, p<0.01), wild mustard number at 8 WAP (r=-0.74, p<0.01), wild mustard number at 16 WAP (r=-0.88, p<0.01), fumitory biomass at 8 WAP (r=-0.86, p<0.01) fumitory biomass at 16 WAP (r=-0.90, p<0.01), fumitory number at 8 WAP (r=-0.87, p<0.01), fumitory number at 16 WAP (r=-0.89, p<0.01), wild oat biomass at 8 WAP (r=-0.88, p<0.01) wild oat biomass at 16 WAP (r=-0.82, p<0.01), wild oat number at 8 WAP (r=-0.77, p<0.01), wild oat number at 16 WAP (r=-0.87, p<0.01) (Table 1). The negative correlation between weed biomass and crops yield have been reported by many researchers. For example, Ghadiri and Naderi (2007) reported that there was a negative significant correlation between oilseed rape yield and wild mustard biomass (r=-0.96, p<0.01). Farris and Murray (2006) in a study on influence of crownbeard (*Verbesina encelioides*) densities on peanut (*Arachis hypogaea*) yield declared that there was a significant correlation between dry weed biomass and peanut yield. Singh (2005) also, reported that There was a significant negative correlation (r = –0.82) between weed biomass and wheat yield.

Path analysis

The relationship between oilseed rape and the measured traits is determined using path analysis and shown in figure 3. There were significant path coefficient, direct effect, between wild mustard number at 8 WAP (p=0.58, p<0.01), fumitory number at 8 WAP (p=-0.11, p<0.05), fumitory biomass at 8 WAP (p=-0.19, p<0.01), fumitory biomass at 16 WAP (p=0.16 p<0.01), wild oat biomass at 8 WAP (p=-0.12, p<0.01), wild oat number at 16 WAP (p=-0.11, p<0.05) with oilseed rape yield. In a study on competition between Canada thistle (*Circium arvens* L.) and winter wheat using path analysis, Mamolos and Calburtji (2001) reported that the weed number and biomass were the second and third factor, which reduced

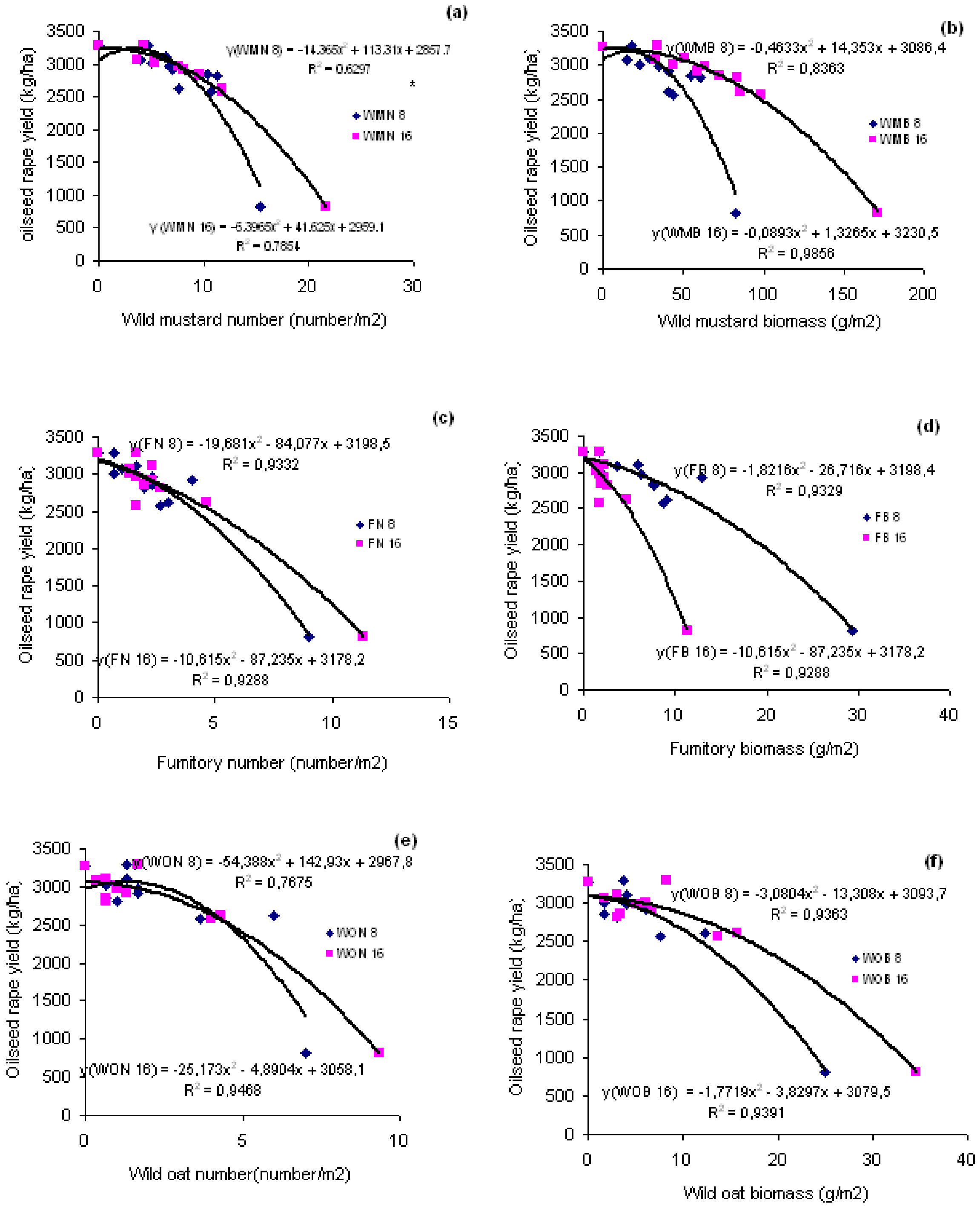

Fig 1. Relationship between wild mustard, fumitory and wild oat number and biomass with oilseed rape yield response to the various herbicides application in 2004*: WMN 8 : Wild mustard number at 8 weeks, WMN 16: Wild mustard number at 16 weeks, WMB 8: Wild mustard biomass at 8 weeks, WMB 16 : Wild mustard biomass at 16 weeks, FN 8 : Fumitory number at 8 weeks, FN 16: Fumitory number at 16 weeks, FB 8 : Fumitory biomass at 8 weeks, FB 16 : Fumitory biomass at 16 weeks, WON 8 : Wild oat number at 8 weeks, WON 16 : Wild oat number at 16 weeks, WMB 8 : Wild mustard biomass at 8 weeks, WMB 16 : Wild mustard biomass at 16 weeks

Table 2. Total weed biomass, grain yield, percentage of oil, and oil yield of oilseed rape as affected by various herbicides at Darab, Iran, during the 2004 and 2005 growing seasons

Treatments	Rate (g/ha)	2004					2005				
		Weed biomass[a]		Grain yield ($kg\ ha^{-1}$)	Percentage of oil	Oil yield ($kg\ ha^{-1}$)	Weed biomass		Grain yield ($kg\ ha^{-1}$)	Percentage of oil	Oil yield ($kg\ ha^{-1}$)
		8WAP[b]	16WAP				8WAP	16WAP			
Weedy check	-	137.2	252.3	815	45.71	372	141.3	202.3	903	45.47	410
Hand weeded	-	0	0	3276	45.84	1501	0	0	3428	45.41	1556
Trifluralin	1200	61.6	114.7	2615	45.42	1187	60.2	88.6	2609	45.65	1191
Trifluralin	1400	59.7	118.5	2565	45.23	1160	67.6	87.1	2612	45.53	1189
Trifluralin+propaquizafop+ pronamide	1200+100+2000	60.2	74.2	2920	45.71	1334	35.4	53.2	2916	45.90	1338
Trifluralin+propaquizafop+ pronamide	1200+200+1500	63.7	84.1	2849	45.63	1300	62.1	56.8	2862	45.88	1313
Trifluralin+ propaquizafop+isoxaben	1200+100+500	26.2	54.5	3010	45.82	1379	31.2	35.3	3119	45.67	1424
Trifluralin+ propaquizafop+isoxaben	1200+200+250	20.4	39.2	2987	45.43	1356	31.8	34.4	3113	45.82	1426
Trifluralin+haloxyfop-p methyl+ pronamide	1200+100+2000	44.8	75.4	2973	44.96	1336	51.6	51.8	3005	45.61	1370
Trifluralin+haloxyfop-p methyl+ pronamide	1200+200+1500	71.3	95.3	2814	45.82	1289	62.8	52.2	2996	45.55	1364
Trifluralin+haloxyfop-p methyl+isoxaben	1200+100+500	23.2	48.6	3284	45.62	1498	15.4	36.7	3347	45.83	1533
Trifluralin+haloxyfop-p methyl+isoxaben	1200+200+250	38.8	62.2	3105	45.90	1425	27.2	33.5	3183	45.43	1446
LSD (0.05)		17.9	14.3	107	NS	57	15.6	11.2	122	NS	72

[a]Weed biomass, the predominant weeds were wild mustard, fumitory and wild oat.
[b]WAP, weeks after planting

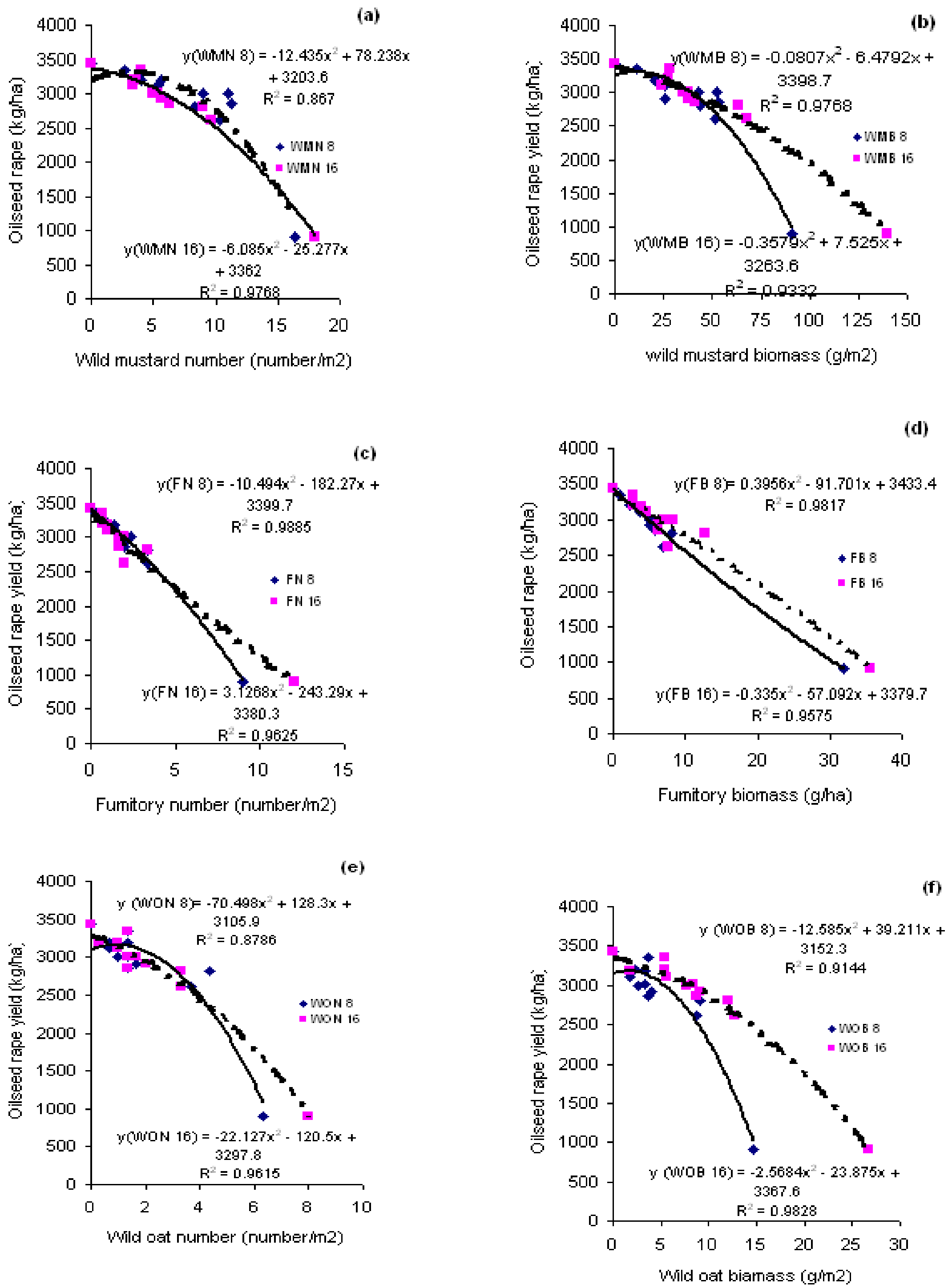

Fig 2. Relationship between wild mustard, fumitory and wild oat number and biomass with oilseed rape yield response to the various herbicides application in 2005*: WMN 8: Wild mustard number at 8 weeks, WMN 16: Wild mustard number at 16 weeks, WMB 8: Wild mustard biomass at 8 weeks, WMB 16: Wild mustard biomass at 16 weeks, FN 8: Fumitory number at 8 weeks, FN 16: Fumitory number at 16 weeks, FB 8: Fumitory biomass at 8 weeks, FB 16: Fumitory biomass at 16 weeks, WON 8: Wild oat number at 8 weeks, WON 16: Wild oat number at 16 weeks, WMB 8: Wild mustard biomass at 8 weeks, WMB 16: Wild mustard biomass at 16 weeks

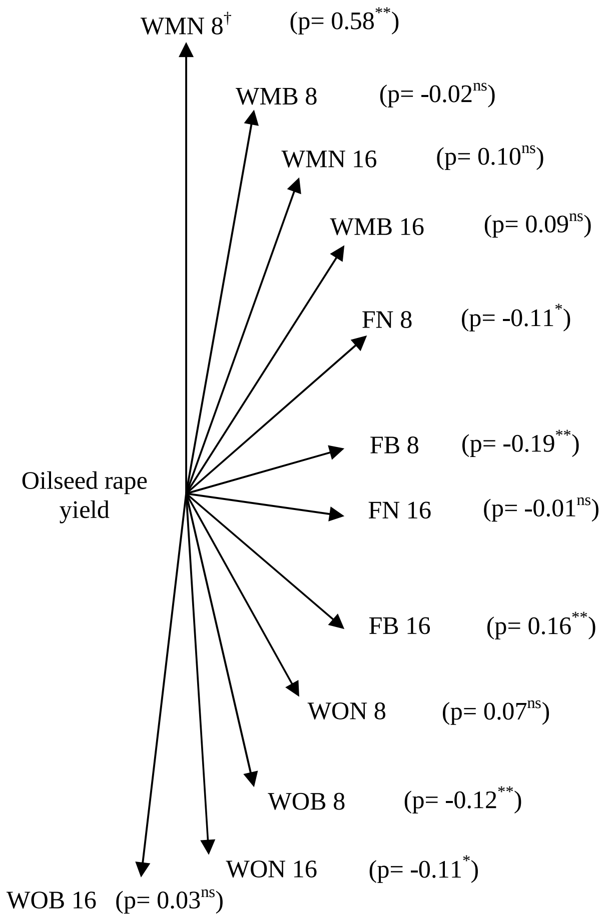

Fig 3. Path coefficient diagram showing the direct effects of weeds biomass and number at 8 and 16 WAP and oilseed rape yield under herbicides application. ns: not significant,*: significant at 5 % level. **: significant at 1 % level.†: WMN 8: Wild mustard number at 8 weeks, WMN 16: Wild mustard number at 16 weeks, WMB 8: Wild mustard biomass at 8 weeks, WMB 16: Wild mustard biomass at 16 weeks, FN 8: Fumitory number at 8 weeks, FN 16: Fumitory number at 16 weeks, FB 8: Fumitory biomass at 8 weeks, FB 16: Fumitory biomass at 16 weeks, WON 8: Wild oat number at 8 weeks, WON 16: Wild oat number at 16 weeks, WMB 8: Wild mustard biomass at 8 weeks, WMB 16: Wild mustard biomass at 16 weeks

wheat yield. In rice, weed biomass had negative direct effect, path coefficient, (p=-0.87, $p<0.01$) in wet season (Ni et al., 2000)

Oilseed rape grain and oil yield

The results showed that the highest oilseed rape yield was obtained at trifluralin plus haloxyfop-p methyl plus isoxaben at 1200+100+500 g ha^{-1} (3284 and 3347 kg ha^{-1}), hand weeded check (3276 and 3428 kg ha^{-1}), and trifluralin plus haloxyfop-p methyl plus isoxaben at 1200+200+250 g ha^{-1} (3105 and 3183 kg ha^{-1}) in 2004 and 2005, respectively (Table 2). There were no significant differences among these treatments. Ghosh and Bera (1996) showed that propaquizafop plus isoxaben at 100+500 g ha^{-1} gave good weed control in oil seed rape and resulted in seed yields of 1930 kg ha^{-1} compared with 1340 kg ha^{-1} for one hand weeding at 30 days after sowing and 610 kg ha^{-1} without weed control.

The lowest oilseed rape yield observed at trifluralin at 1200 g ha^{-1} (2615 and 2609 kg ha^{-1}) and at 1400 g ha^{-1} (2565 and 2612 kg ha^{-1}) in 2004 and 2005, respectively (Table 2). Decreasing oilseed rape yield may be due to highest weed biomass in these treatments (Table 2). It means that trifluralin alone could not control broadleaved and grass weeds effectively. This finding was in agreement with the results of Miri and Rahimi (2009) who reported that trifluralin alone had maximum broad leaved and grass weed at 90 DAP and minimum oilseed rape yield. In addition, our results similar to Chow (1996), who found that trifluralin at 1400 g ai ha^{-1} provided the lowest rapeseed yield (710 kg ha^{-1}) relative to other herbicides. Maximum oil yield was obtained at trifluralin plus haloxyfop-p methyl plus isoxaben at

1200+100+500 g ha^{-1} in 2004 (1498 kg ha^{-1}) and 2005 (1533 kg ha^{-1}) and trifluralin at 1200 and 1400 kg ha^{-1} had the lowest oil yield in both years (Table 2). Our result showed that weed competition affected oil yield via decreasing the oilseed rape yield. However, Herbicide treatments had no significant effect on oil percent in both years. Blackshaw et al., (2002) also indicated that competition of wild radish (*Raphanus raphanistrum* L.) in oilseed rape did not reduce percentage of oil seed. In addition, Bagherani and Shimi (2001) reported that oil yield and percentage of oil were not affected at trifluralin application at 1200 and 1400 kg ha^{-1}.

In conclusion, the results of the present study indicated that with increasing number and biomass of wild mustard, fumitory and wild oat, per square meter, oilseed rape yield decreased significantly, in 2004 and 2005. In addition, there were highly negative significant correlations between oilseed rape yield and weeds number and biomass. Fumitory numbers and biomass at 8 weeks after planting had negative significant direct effect on oilseed rape using path analysis. Also, the combination trifluralin plus haloxyfop-p methyl plus isoxaben at 1200+100+500 and 1200+200+250 g ha^{-1} was suitable option for decreasing of number and biomass of broadleaved and grass weeds oilseed rape in Both years. On the other hand, application of trifluralin at 1200 g ha^{-1} and at 1400 g ha^{-1} could not control weeds and the lowest oilseed rape yield was obtained in these treatments.

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