WALIA journal 31(S2): 111-116, 2015
Available online at www.Waliaj.com
ISSN 1026-3861

Competitive interaction of canola (*Brassica napus*) against wild mustard (*Sinapis arvensis*) using replacement series method

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Abstract: A greenhouse experiment was conducted to evaluate the competitive effects of different densities of wild mustard as against rapeseed. The experiment was performed in a randomized complete block design with four replications using replacement series in which wild mustard and rapeseed were respectively planted in different ratios of 8:0, 6:2, 4:4, 2:6 and 0:8 plants per pot. Results indicated that the maximum dry weight, height, number of branches, number pod per plant, and number of grains per pod in rapeseed vs. the same traits in wild mustard were obtained in their monoculture states. Overall evaluation of relative yield showed that both species were exploiting the resources in same ways or mutual antagonism. Relative competition coefficient of rapeseed as against wild mustard just in the 6:2 treatment was greater than that in the other plant ratio treatments. Competition indices revealed that wild mustard benefited from a more competitive ability than rapeseed.

Key words: *Competition; Rapeseed; Replacement series; Wild mustard*

1. Introduction

Increasing costs of herbicide inputs in intensive crop production systems and the incidence of herbicide resistance in weeds have renewed interest in exploiting crop competitiveness to reduced herbicide use (Lemerle *et al.,* 2001). Two factors contribute to crop competitiveness against weeds: ability to withstand competition (AWC), or the ability to maintain high yields in the presence of weeds, and weed suppressive ability (WSA), the ability of the crop to reduce weed biomass and seed production (Jannink *et al.,* 2000). In order to measure the competition and other kinds of interference some growth quantitative measures such as yield are used (Wright, 1981). Yield can be considered as the seed yield or the biologic yield, while using yield for each species is considered the best measuring method of competition and rivalry. There are several different methods and schemes for studying the species relationships of plants. Among these methods additive plans, replacement plans and systematic ones can be mentioned (Javanshir *et al.,* 2000). Replacement series experiment is a method of studying crop-weed competition (Radosevich et al., 1997). It includes pure stands as well as mixtures in which the proportion of two species studied is varied. The total plant density is kept constant over all treatments in such experiments. Rapeseed, from Brassicaceae, provides a convenient alternative for cereal-based agricultural systems, as it is broad leaved and can be grown as a break crop in a continuous run of cereals (Khachatourians *et al.,* 2001). It is increasingly becoming a popular oilseed crop in Iran. Wild mustard is a dominant weed in rapeseed fields of Iran bringing about major yield losses. A strongly persistent seedbank, competitive growth habit, and high fecundity all contribute to its weedy nature ensuring that it will be a continuing problem (Warwick *et al.,* 2000). Wild mustard densities of 10 plants m^{-2} can reduce rapeseed seed yield by 20%, whereas 20 plants m^{-2} can reduce rapeseed yield by more than 36 % (Warwick *et al.,* 2000). In addition to yield losses in rapeseed, wild mustard can reduce crop quality even at its low densities (Rose and Bell, 1982). Rapeseed seeds contaminated with wild mustard seeds had caused an increase in linolenic and erucic acid levels in the extracted oil and glucosinolate content in the meal (McMullan *et al.,* 1994).The main objective of the current paper is to investigate the competitive ability of the canola against wild mustard, and evaluating of empirical yield loss model in predicting the effect of different densities of wild mustard on canola yield.

2. Materials and methods

The experiment was performed in a completely blocks randomized design with four replications using replacement series in which wild mustard and rapeseed were planted in different ratios of 8:0, 6:2, 4:4, 2:6 and 0:8 plants per pot in 2014. Mature seeds of wild mustard were collected from Dezfoul Experimental Station farm, located in 48˚24' eastern longitude and 32˚22' northern latitude. Wild mustard and rapeseed seeds were planted 1 and 2

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cm deep, respectively, in 35 cm diameter plastic pots filled with a sandy clay loam soil. Plants were harvested from the soil surface at maturity and were oven dried at 75^{0}C for 48h, while total shoot biomass for each species being determined. Measurements included shoot and root dry weight, plant height, number of branches per plant, number of pod per plant, number grain per pod and plant grain yield in rapeseed. Relative Yield (RY), Relative Yield Total (RYT) and Relative Crowding Coefficient (RCC) were calculated. Relative yield (RY) is a measure of the relative competitive ability of the two species. Large RY values indicate a high degree of competitiveness of one species relative to the other. Values of approximately one indicate that interspecific and intraspecific competition is equal. Values greater than one indicate that intraspecific competition is more than interspecific competition. Values less than one indicate that intraspecific competition is less than interspecific competition. RY was calculated using the equation (Ghadiri, 2005):

$RY = \frac{Ymix}{Ymon}$ Where $Ymix$ and $Ymon$ are yields in mixture and monoculture.

Relative Yield Total (RYT) describes how the species pair utilizes resources. Values of approximately one indicate that two species are competing for the same limiting resources. Values greater than one suggests that species are making demands on different resources, avoiding competition, or maintaining a symbiotic relationship. Values less than one imply mutual antagonism. When the RYT of a pair of species is approximately one, the combined yield of species in a mixture is predictable from species monocultures (Ghadiri, 2005). RYT was calculated using the equation: RYT= $\sum_{i=1}^{n} RY$

Relative Crowding Coefficient (RCC) is a measure of competitiveness between the two species. Large RCC values indicate a high degree of competitiveness of one species relative to the other. The RCC was calculated using the equation (Ghadiri, 2005):

$$\text{RCC}= \frac{YAmix}{YBmix} \Big/ \frac{YAmon}{YBmon}$$

Where Y_{Amix} and Y_{Bmix} are average yield per plant of A and of B grown in mixture, respectively, Y_{Amon} and Y_{Bmon} are average yield per plant of A and B grown in monoculture, respectively (Ghadiri, 2005). Means were compared using Duncans, Multiple Range Test ($P_{0.05}$) (SAS, 2002).

3. Results and discussion

3.1. Relative yield (RY) and relative yield total (RYT)

RY values indicate the relative competitive ability of the two species. In the replacement series experiment in order to determine the competitive response of rival species we use the relative yield measure of each species as well as total relative yield or relative productivity of land (Bauman, 2002; Iftikhar *et al*, 2006; Weiget and Jolliffe, 2003). Hence, the higher value of the relative yields of each species tends to higher its competitive strength. Gaudet and Keddy (1988) studied the competitive capability of 88 grass species in vase experiments and concluded that the biologic yield is a proper characteristic for indicating the competitive strength of a plant. The results showed that the relative yield of rapeseed decreased in the density ratio of 25 and 50 percent compared to the same density of wild mustard (Table1). In comparison, rapeseed in a lower or even equal density was more sensitive to competition than wild mustard and hence it faced to sharp yield decrease. However, in the higher planting densities of 75 percent the relative yield of rapeseed increased and the value reached to 0.497 (Table1). Regarding the higher values of wild mustard compared to rapeseed's relative yield in higher density ratios of 50 and 75 percent it can be concluded that wild mustard possesses a higher competitive strength, as a consequence, was able to better use nutrition resources. Fleming *et al.* (1988) in a study on competitive relationship among winter wheat, jointed goat grass (*Aegiolps cylindrica)* and downy brome (*Bromus tectorum*) found that the competitive ability of jointed goat grass and winter wheat was similar, but both species exhibited a more competitive ability than downy brome. RYT was lower than 1 in all mixture ratios (Table 1).

Table.1: The relative yields of rapeseed and wild mustard in different ratios of rapeseed-wild mustard plantation density

Canola: mustard ratio	RY of rapeseed	RY of mustard	TRY
75:25	0.497	0.169	0.666
50:50	0.173	0.361	0.534
25:75	0.04	0.654	0.694

This showed that rapeseed and wild mustard were exploiting the resources in same ways or mutual antagonism. Wall (1997) indicated that dog mustard (*Erucastrum gallicum*) and flax (*Linum usitatissimum* L.) were making exploitation of the same resources.

3.2. Relative competition coefficient

Relative competition coefficient of rapeseed in density ratios of 25 and 50 percent was lower than that was observed in wild mustard (Table 2) which means that wild mustard possesses a higher competitive strength compared to rapeseed even in equal density ratios. The capability of the plant for taking up nutritious factors such as water, different elements and light has a significant role in increasing its competitive ability (Fernandez *et al*, 2002). Among these light is the most important factor for creating rivalry in farming ecosystems because it is an instantaneous resource which cannot be stored

(Najafi, 2002). So, rapid growth can be an important factor in increasing the competitive capability of a plant. In contrast, wild mustard possess a higher altitude (data not shown) which in turn increases its capability to absorb light that cause to rapid growth and expanding its canopy in the higher density ratios.

Table 2: Relative competition coefficient for rapeseed and wild mustard in different ratios of rapeseed and wild mustard

Canola: mustard ratio	RCC of canola	RCC of mustard	Total RCC
75:25	0.986	0.203	0.2
50:50	0.209	0.565	0.118
25:75	0.04	1.89	0.076

3.3. The dry weight, branch number and plant height of rapeseed

The shoot dry weight of rapeseed was significantly affected by the density (Table 3) as by increasing the density of wild mustard the biomass of rapeseed was decreased. The dry weight reduction of rapeseed in ratio of 25:75 was more than 69% compared to the pure culture (100:0). The decrease in shoot dry weight of rapeseed in competition with wild mustard return to the rivalry in taking up nutrition elements, light and humidity (Rahimian and Shariati, 1999; Tingle *et al*., 2003; Ross and von Acker, 2005; Soleimani *et al*., 2010). In the study of Safahani et al. (2007) the biological yield of rapeseed, hayola 401, in the mixed cultivation with weeds decreased up to 61%. In the experiment carried out by Jafari Zadeh and Modhj (2011) by increasing the density of malva weed the biological yield of wheat was significantly reduced. Mirshekari et al. (2008) stated that season-long interference of weeds cause to 40% reduction in biological yield of rapeseed. A very similar changing pattern similar to that observed in shoot dry weight found in root dry weight, plant height and number branches plant1^{-1}, too (Table4). Ghadiri (2005), using a similar replacement series experiment, reported that pinto beans (*Phaseolus vulgaris* L.) shoot and root dry matter decreased as the number of field bindweed (*Convolvulus arvensis* L.) plants per pot increased.

4. Yield and Yield Components of Rapeseed

4.1. The Number of Pods per plant

Results (Table3) showed that the effect of density ratios on pods plant^{-1}was significant (P<0.01). Wild mustard density influenced maximum number pods plant^{-1}. The highest and lowest number of pods plant^{-1} was related to 100:0 (110 pod) and 25:75 (38 pod) ratios. Decrease in rapeseed density significantly decreased the number of pods plant^{-1}(Table4). This might have been the result of decline in light interception by plant canopy. Therefore, initiation of constituent buds on secondary branches declined. The decrease in the number of secondary branches is the main cause of decline in pods plant^{-1}. Furthermore, the diminishing carbohydrate supply with exceeding competition among the plants at the flowering time is another reason (Eilkaee and Emam, 2003). This result was consistent with those of (Majnon Hosseini *et al*., 2006; Ozer, 2003). In order to maintain the equilibrium between generated materials of the source and amount of consumed materials in the reservoir, some of the flowers shed (Safahani Langerodi *et al*., 2008) and decreasing number of flowers ultimately led to a decline in the number of pods in lower density of rapeseed. Black Shaw et al. (2002) reported the decrease of the pod number of rapeseed in competition with charlock.

Table.3: Analysis of variance for the effects of Different Ratios of Rapeseed-Wild mustard Plantation on studied traits for rapeseed

S.O.V	df	Shoot dry weight	Root dry weight	Plant height	Branch no plant^{-1}	Pod no plant^{-1}	Grain no pod^{-1}	1000-grain weight	Grain yield
Block	3	24.15^{ns}	0.846^{ns}	8.89^{ns}	0.571^{ns}	14.36^{ns}	0.268^{ns}	0.022^{ns}	0.353^{ns}
Treatment	3	369.28$^{\times\times}$	8.38$^{\times\times}$	2120.9$^{\times\times}$	63.54$^{\times\times}$	3864.6$^{\times\times}$	60.72$^{\times\times}$	8.54$^{\times\times}$	46.23$^{\times\times}$
Error	9	15.03	0.799	37.35	0.585	32.22	1.34	0.144	0.636
Total	15								
CV%		6.8	8.8	6.65	7.51	7.35	7.18	13.74	9.26

$^{ns,\ \times\times}$ non-significant and significant at 1% probability level, respectively

4.2. The Number of grains per pod

Results (Table3) revealed that the effect of density ratios on grains pods^{-1}was significant (P<0.01). The highest and lowest number of grains pods^{-1}were concerned to the ratios of 100:0 (15.4) and 25:75 (6.7). Increased wild mustard density significantly decreased the number of rapeseed grains pods^{-1} (Table4). This phenomenon due to the plant competition for absorbing environmental resources that resulting in reduction of photosynthetic materials and its transfer to rapeseed grains (Rahman *et al*., 2009; Ozoni Davaji, 2006).

Table.4: Means comparison of rapeseed studied traits in different ratios of rapeseed-wild mustard plantation

% Presence of rapeseed	Shoot dry weight (g)	Root dry weight (g)	Plant height (cm)	Branch no plant^{-1}	Pod no plant^{-1}	Grain no pod^{-1}	1000-grain weight (g)	Grain yield plant^{-1} (g)
25	10.1^{c}	1.1^{b}	64^{d}	5.2^{d}	38^{d}	6.7^{d}	1.1^{d}	0.3^{d}
50	16.2^{bc}	3.3^{a}	88^{c}	8.7^{c}	66^{c}	9.8^{c}	2.1^{c}	1.4^{c}
75	22.3^{b}	3.9^{a}	98^{b}	12.7^{b}	92^{b}	12.1^{b}	3.2^{b}	3.8^{b}
100	33.4^{a}	4.1^{a}	115^{a}	13.8^{a}	110^{a}	15.4^{a}	4.4^{a}	8.1^{a}

The means with same letter do not have statistically significant difference at 5% probability level.

4.3. The Weight of 1000 grains

Results of the current experiment (Table3) indicated that the effect of density ratios on 1000-grain weight were significant (P<0.01). The highest and lowest 1000-grains weight was related to the ratios of 100:0 (4.4g) and 25:75 (1.1g). Increased wild mustard density significantly reduced the 1000-grains weight of rapeseed (Table4), which indicated the intensity of competition and significant shortage of resources. Reduction of rapeseed grain weight in lower density can be attributed to the formation of smaller grains because of more limited access to environmental resources particularly light due to higher competition, declining production of photosynthetic materials and finally, transfer of less photosynthetic materials to the grains at grain filling period (Salehi, 2004; Abdolrahmani, 2003).

4.4. Grain yield

Grain yield (Table4) influenced markedly by density ratios (P<0.01). Comparing the averages showed that the maximum and minimum yields of individual plant were at the density ratios of 100 and 25 by 8.1g and 0.3 g, respectively. Increase in wild mustard ratios significantly decreased plant grain yield in manner that in ratio of 75:25 the reduction exceed by 62% in compare to 0:100 ratio (Table4). The reason can be attributed to the reduction of yield components including; the number of pods plant^{-1}, number of grains pod^{-1} and 1000-grain weight. Rapeseed lower density decreased the yield of individual plant via reduction of pods number as well as the 1000-grain weight due to exceeded competition among plants for utilizing environmental resources. Van Acker and Oree (1999) showed that increasing the density of the charlock weed to 200 plants m^{-2} decreases the yield of rapeseed up to 75%. Amini et al. (2006) showed that the interference of the rye causes a decrease in the cumulative dry matter of wheat which in turn reduces the grain yield. In other researches the decrease in the grain yield of rapeseed in competition against weeds is reported (Harker *et al*., 2001; Safahani *et al*., 2007; Mac Mullan 1994).

5. Conclusion

The results of the present study were based on competition indices indicated that rapeseed was of a less competitive ability than wild mustard. Also, there was a significant negative correlation observed between wild mustard density and rapeseed yield components which implies that a high density of wild mustard can cause serious yield reduction in rapeseed.

References

Abdolrahmani B.; 2003. Effects of plant density on yield and agronomic traits of sunflower cv. Armavirsky under dryland condition in Maragheh. Iranian J. Crop Sci., 5, pp. 216-224.

Amini A., Sharifzadeh F., Baghestani M.A., Mazaheri D. and Atri A.; 2006. Competitive effect of rye (*Secale cereal* L.) on the growth of winter wheat. Special Iranian Journal of Agricultural Sciences Resources, Tehran University. Agri. Agrono. Plant Breeding Biotech., 37(2), pp. 273-285.

Bauman D.T., Bastians L. and Kropff M.J.; 2002. Inter cropping system optimization for yield, quality and weed suppression combining mechanistic and descriptive models. Agron. J., 94, pp. 734-742.

Black Shaw R.E., Molnar L.J., Muendel H.H., Saind G. and Li X.J.; 2002. Integration of cropping practices and herbicides improves weed management in dry bean. Weed Tech., 14, pp. 327- 336.

Eilkaee M.N. and Emam Y.; 2003. Effect of plant density on yield and yield components in two winter oilseed rape (*Brassica napus* L.) cultivars. Iranian J. Agri. Sci., 34, pp. 509-515.

Fernandez O.N., Vignolio O.R. and Requesens E.C.; 2002. Competition between corn (*Zea mays*) and Bermuda grass (*Cynodon dactylon*) in relation to the crop plant arrangement. Agron. J., 22, pp. 293-305.

Fleming G.F., Young F.L., and Ogg A.G.; 1988. Competitive relationships among winter wheat (*Triticum aestivum*), jointed goatgrass (*Aegilops cylindrica*) and downy brome (*Bromus tectorum*). Weed Sci., 36, pp. 479-489.

Gaudet C.L. and Keddy P.A.; 1988. A comparative approach to predicting competitive ability from plant traits. Nature., 334, pp. 242-243.

Ghadiri H.; 2005. Effect of field bindweed (*Convolvulus arvensis*) and pinto bean (*Phaseolus vulgaris*) densities on growth and yield of pinto beans in greenhouse. Proc. 13th European Weed Research Society Symposium. Bari. Italy.

Harker K.N., Clayton G.W., Odonovan J.T. and Blackshaw R.E.; 2001. Canola Variety and seeding rate effects on weed management and yield. Weed Sci. Soc. Amer., 41, pp. 25-32.

Iftekhar H.B., Riaz A., Abdul J., Nazir M.S. and Mahmood T.; 2006. Competitive behavior of component crops in different Sesame-Legume intercropping systems. J. Agri. Bio., 2, pp. 165-167.

Jafari Zadeh S.H. and Modhj A.; 2011. Evaluation of weed competition Pnyrk (*Malva* spp) at different levels of nitrogen on yield. Iranian Crop Sci., 42(4), pp. 777-767.

Jannink J.L., Orf J.H., Jordan N.R. and Shaw R.G.; 2000. Index selection for weed suppressive ability in soybean. Crop Sci., 40, pp. 1087–1094.

Javanshir A., Dabbagh Mohammadi Nasab A., Hamidi A. and Golipor M.; 2000. Inter cropping ecology. Ferdosi university press. (In Persian).

Khachatourians G., Summer A.K. and Philips P.; 2001. An introduction to the history of canola and the scientific basis for innovation. CABI. London. 360 pp.

Lemerle D., Verbeek B. and Orchard B.; 2001. Ranking the ability of wheat varieties to compete with Lolium rigidum. Weed Res., 41, pp. 197–209.

Mac Mullan P.M., Daun J.K. and DeCercq D.R.; 1994. Effect of weed mustard (*Brassica kaber*) competition on yield and quality of triazin-tolerance and triazin-susceptible canola (*Brassica napus* and *Brassica rapa*). Can. J. Plant Sci., 74, pp. 369-374.

Majnon Hosseini N., Alizade H. M. and Malek Ahmadi H.; 2006. Effects of plant density and nitrogen rates on the competitive ability of canola (*Brassica napus* L.) against weeds. J. Agri. Sci. Tech., 8, pp. 281-291.

McMullan P.M., Daun J.K. and Declercq D.R.; 1994. Effect of wild mustard (*Brassica kaber*) competition on yield and quality of triazine-tolerant and triazinesusceptible canola (*Brassica napus* and *Brassica rapa*). Can. J. Plant Sci., 74, pp. 369-374

Mirshekari B. and Javanshir A.S.; 2008. Reaction of morphological traits, yield and harvest index of rape seed cultivars time weeds weed control. New findings Agri., 4, pp. 411-400.

Najafi H., Loui-Hassanzadeh M., Rashed Mohasel M.H., Zand A. and, Baghestani M.A.; 2006. Ecological management of grass weeds. Plant Pests Diseases Res. Ins., 599 p.

Ozer H.; 2003. The effect of plant population densities on growth, yield and yield components of two spring rapeseed cultivars. Plant Soil Environ., 49, pp. 422-426.

Ozoni Davaji A.; 2006. Effects of plant density and planting pattern on yield, yield components and growth indices of apetalous flowers and petalled rapeseed (*Brassica napus* L.). M.Sc. Thesis. Faculty of Agriculture College, Guilan University. Iran. 133 p.

Radosevich S.R., Holt J. and Ghersa C.; 1997. Weed Ecology: Implications for management. John Wiley. 589 p.

Rahimian H. and Shariati S.H.; 1998. Grass weeds and crop modeling competition, publishing, education agriculture, 294 p.

Rahman I., Ahmad H., Serajuddin I., Ahmad I., Abbasi F., Islam M. and Ghafoor S.; 2009. Evaluation of rapeseed genotypes for yield and oil quality under rainfed conditions of district Mansehra. Afr. J. Biot., 8, pp. 6844-6849.

Rose S.P. and Bell J.M.; 1982. Reproduction of mice fed low erucic acid rapeseed oil contaminated with weed seed oils. Can. J. Animal Sci., 62, pp. 617-624.

Ross D.M. and Van Acker R.C.; 2005. Effect of nitrogen fertilizer and landscape position on wild oat (*Avena fatua*) interference in spring wheat. Weed Sci., 53, pp. 869-876.

Safahani Langerodi A., Kamkar B., Zand E., Bagherani N. and Bagheri M.; 2008. Reaction of grain yield and its components of canola (*Brassica napus* L.) cultivars in competition with wild mustard (*Sinapis arvensis* L.) in Gorgan. Iranian J. Crop Sci., 9, pp. 356-370.

Safahany Langroodi A.R., Kamkar B., Zand A., Baqrany N. and Bagheri M.; 2007. The reaction yield in competition with weeds in oilseed rape and wild mustard (*Sinapis arvensis* L.) in Iran. Iranian Crop Sci., 6(4), pp. 370-356.

Salehi B.; 2004. Effect of row spacing and plant density on grain yield and yield components in maize (cv. Sc 704) in Miyaneh. Iranian J. Crop Sci., 6, pp. 383-394.

Soleimani F., Ahmadvand G. and Sadatyan B.; 2010. Indices of growth and yield of rapeseed (*Brassica napus* L.) in competition with wild mustard (*Sinapis arvensis* L.) affected by different nitrogen levels. J Agri. Eco., 2(4), pp. 547-537.

Tingle C.H., Steele G.L. and Chandler J.M.; 2003. Competition and control of smell melon (*Cucumis melo var. dudaim Naud*.) in cotton. Weed Sci., 51, pp. 589-591.

Van Acker R.C. and Dree R.; 1999. Wild oat (*Avena Fatua* L.) and wild mustard (*Brassica kaber*) wheller interference in canola (*Brassica napus*). Weed Sci. Soc. Amer. 119 p.

Wall D.A.; 1997. Dog mustard (*Erucastrum gallicum*) response to crop competition. Weed Sci., 45, pp. 397-403.

Warwick S.I., Bechie H.J., Thomas A.G. and Mcdonald T.; 2000. The biology of Canadian weeds. 8. *Sinapis arvensis* L. Can. J. Plant Sci., 71, pp. 473-480.

Wright A.J.; 1981. The analysis of yield-density relationship in binary mixture using inverse polynomials. J. Agri. Sci., 96, pp. 564-567.