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Evaluating the Effects of competition among different densities of mallov (*Malva parviflora*) using replacement series method on the yield and yield components of canola (*Brassica napus L.*)

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Key words: Competition, relative yield, replacement series, relative competition coefficient.

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Abstract

In order to evaluate the competitive capability of rapeseed and malva towards different densities, experimental planting under vase conditions using replacement series and in perfectly random blocks was carried out in Dezfool City in 2012. Experimental treatments included rapeseed and malva plantings with different ratios (0:100, 25:75, 50:50, 75:25, and 100:0) with the density of eight bushes in each vase. The results showed that the biomass of the farm plant of rapeseed decreased due to an increase in the density of malva weed in the mixed plantations. The highest decrease in the dry mass of one bush of rapeseed comparing to its pure plantation was in the 25 percent density with 68 percent decrease. Moreover the biomass of malva experienced a significant decrease due to raising the share of rapeseed in the combination. Also by increasing the density of malva bushes the seed yields, the number of pods in a bush, the number of seeds in pods and the weight of 1000 seeds were decreased. The relative yielding of rapeseed in density ratios of 50 and 75 percent show the higher competitive capability of this crop plant, while in the lower density of rapeseed (25 percent) the relative yielding of malva was better. Relative competition coefficients of these two species also confirm that in higher densities rapeseed possesses a higher competitive strength.

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Introduction

Weeds have long been the most important rivals of crop plants and the major factor in reducing their yield. Hence human beings have always been trying to control them (Parsa and Bagheri, 1999). Despite the stiff control of weeds, relatively 10 percent of the decrease in the crop yields all around the world in most of the agricultural systems can be considered the result of the rivalry from weeds (Zimdal, 2004). The weed rivalry was one of the most important barriers in the production of crop products and a research area for increasing the production of foods. Hence perfect understanding of the growth process and the competition methods of weeds against the crop plants provides us with better methods to manage them. The amount of decrease in the yield of crop plants is significantly dependent upon the number and weight of the rival weeds (Booth *et al*, 2003). Some of the scholars state that the presence and rivalry of weeds causes yield depreciation, and controlling these species significantly increases the production and accumulation of dry matter in the crop plants (Black shaw *et al*, 2000). Interference or rivalry as one of the most important relationships among plant species is defined as a process in which two plants or plant species have a negative mutual impact on each other. Rivalry is a situation in which each of the plants competes regarding some factors such as critical resources (Dabagh *et al*, 2004). A competitive strength is the impact of one unit of biomass or other characteristics of a species on another's (Habibi Savadkoohi *et al*, 2008). 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. For each one of these treatments three factors, namely density, space arrangement and species ratios are considered with different degrees. Among these methods additive plans, replacement plans and systematic ones can be mentioned (Javanshir *et al*, 2000). In the replacement experiment or replacement series (Pantone, 1995) the ratio of A and B species are changed in the mix and it increases to the extent of pure plantation of each one. The total density (A+B) in this method is a constant. The share of each species in the total yield indicates the relative capability of that species in conquering the resources and turning them into biomass. Rapeseed (*Brassica napus* L.) is an annual plant from the Brassicaceae family whose production rate has increased significantly during the last two decades due to its high oil and protein percentage which is used as human and livestock food as well as its high nutrition value comparing to other species (Shahidi and Forouzan, 2000). Autumn weeds are among the most important growth inhibitors of rapeseed and controlling them around the world make up a significant portion of production costs. Among these kinds of weeds is malva. Malva possesses deep straight roots and it rapidly increases its biomass, with a high competition capability for taking up soil's nutrition elements particularly nitrogen (Makowski, 2005). However there is a lack of information and researches regarding the interference impacts of malva in rapeseed fields as well as the competition capability of this species against rapeseed. The main objective of the current paper is to investigate the competitive impacts of different densities of malva on the yield and yield factors of rapeseed.

Materials and methods

This study was carried out in Dezfool City (48˚24' eastern longitude and 32˚22' northern latitude, 140 m sea level altitude, average fall of 400 mm, and average annual temperature of 27˚C) in the farming year of 2012-2013. The experiment was carried out using completely random blocks with replacement series with 4 repetitions and 5 treatments under vase conditions. Experimental treatments included the mix plantings of rapeseed and malva with the ratios of (100:0, 25:75, 50:50, 75:25, and 0:100) with the total bush density of 8 bushes in each vase. Sampling was done in 4 phases with the time distance of 1 month. In each phase of sampling 20 vases were broken hence the number of vases was 80. In order to

create similar conditions to farm's the boxes were put adjacent to each other and they were put in the normal conditions of the region regarding light, temperature and humidity.

The planting environment was a wooden box (25×25×50 cm) and the soil was a combination of garden soil, pit and sand with the ratio of 2:2:1 and completely void of weed seeds. In order to create proper drainage 1 cm of gravel was spread on the bottom of each box. Both plants were cultivated simultaneously in December with a 5 cm distance from each other and with a square formation. Potash, and phosphorous fertilizers and a portion of nitrogen were added as a basic component and the remaining fertilizers were added to the boxes in two steps in rosette and shooting phases of rapeseed. It is worth mentioning that before the plantation process the malva seeds were awakened by sandpaper incision treatment and throughout the treatment the humidity was kept at optimum. Characteristics such as the dry weight of aerial organs (by putting them in a 75˚C oven for 48 hours), seed yield, the number of pods in a bush, the number of seeds in each pod, and the weight of 1000 rapeseed seeds were measured at the end. Analyzing the data and statistical calculations were carried out using SAS software application and the graphs were drawn in Excel environment. In order to compare the averages we used Duncan's multiple-stage test in 5 percent level. In the current study relative competition coefficient (RCC) and total relative yield (RYT) were used in order to determine the relative competition of these two species. Moreover cumulative congestion coefficient as a measure of the relative competition coefficient of the weed against the rival crop plant and vice versa was used (Spiters *et al*, 1989). The congestion coefficient of species A with respect to species B is calculated by**:**

1) $RCCa = \frac{\mathrm{RYa}}{1-\mathrm{RYa}}$

2) 2) $RCCb = \frac{\mathrm{RYb}}{1-\mathrm{RYb}}$

3) 3)$RCCab = (\frac{RYa}{1-RYa} \times \frac{RYb}{1-RYb})$

If RCC is high the competition is also high or the competitive strength of a species against the other one is significantly higher. Total relative yield (RYT) is calculated from the sum of the relative yield of the two species using the following relation (Panton and Baker, 1991):

4)RYT =$\mathrm{RY_1}$ + $\mathrm{RY_2}$

5)$RY1$ =$\mathrm{Y_{12}/Y_{11}}$

6)$RY2$ =$\mathrm{Y_{21}/Y_{22}}$

Results and discussion

Evaluating Competition Measures

Relative Yield

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 (Baumann, 2002; Iftikar *et al*, 2006; Weiget and Jolliffe, 2003). Hence, the higher the value of the relative yields of each species the 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 (the dry weight of the bush) is a proper characteristic for indicating the competitive strength of a plant. The results showed that in the density ratio of 25 percent rapeseed compared to the same density of malva, the relative yield decreased (Table 1). In reality the rapeseed in a lower density was more sensitive to competition than malva and hence it faced a stiffer yield decrease. But in the higher planting densities of 50 and 75 percent the relative yield of rapeseed (respectively, 0.667 and 0.809) were higher than the relative yields of malva (respectively, 0.488 and 0.34).

Table 1. The Relative Yields of Rapeseed and Malva in Different Ratios of Rapeseed-Malva Plantation Density.

% Presence in the Mix (Malva: Rapeseed)	Relative Yield of Rapeseed	Relative Yield of Malva	Total Relative Yield
75:25	0.315	0.768	1.083
50:50	0.667	0.488	1.154
25:75	0.809	0.340	1.149

The total relative yield was higher in 50 percent density compared to other density ratios of rapeseed and malva. In reality in this density ratio rapeseed and malva were able to better use nutrition resources and yield more dry matter due to less competition with each other. However the individual rapeseed bushes were able to produce more dry matter and they had a more significant role in increasing total relative yield. In the study carried out by Pour Amir *et al* (2010) the highest extent of total relative yield was witnessed in the 50 percent density ratio of sesame and peas. Regarding the higher values of rapeseed's relative yield compared to malva weed's in higher density ratios of 50 and 75 percent it can be said that rapeseed possesses a higher competitive strength. In replacement series experiments in order to evaluate the rivalry among the two species, besides the relative yields of the species, the status of variation curve of the relative yields of the species is also an also an indication of the competitive situation with the dominated species having a concave curve and the dominant species having a convex curve (Zimdal *et al*, 2005). Hence, the variation trend of the relative yields showed that on the whole rapeseed has a competitive advantage compared to malva weed (Figure 1).

Table 2. Relative Competition Coefficient for Rapeseed and Malva in Different Density Ratios of Rapeseed and Malva.

% Presence in the Mix (Malva: Rapeseed)	Relative Competition Coefficient For Rapeseed	Relative Competition Coefficient For Malva	Total Relative Competition Coefficient
75:25	0.461	0.516	1.52
50:50	1.99	0.952	1.90
25:75	4.23	3.31	2.18

Table 3. The Results of the Variance Analysis (Average Squares) for Yield and Yield Components of Rapeseed under Different Density Ratios to Malva.

Variation Source	Degree of Freedom	Shoot Dry Weight	Seed Yield	Number of Pods in Bush	Number of Seeds in Pod	The Weight of 1000 seeds
Block	3	8/39 ^{ns}	0/293 ^{ns}	38/17*	1/27 ^{ns}	0/155^{ns}
Treatment	3	148/16**	20/62**	3010/17**	19/96**	3/17**
Error	9	7.05	0.184	32.11	0.691	0.098
Total	15					
Variation Coefficient (%)		18.08	16.93	6.91	7.87	12.93

Relative Competition Coefficient

Relative competition coefficient of rapeseed in density ratios of 50 and 75 percent was higher than the relative competition coefficient of malva (Table 2) which means that rapeseed possesses a higher competitive strength compared to malva in these two density ratios. Atri and Zand (2005) by investigating six species of rapeseed against wild oat showed that on the whole rapeseed is more competitive than wild oat.

The capability of the crop plant for taking up nutritious factors such as water, different elements and light has a significant role in increasing its competitive ability and reducing the negative impact of weeds on crop products (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). On the other hand the premature and rapid growth can be a factor in increasing the competitive capability of a plant (Baghestani, 2003). Because rapeseed possesses a higher altitude which in turn increases its capability to take up light and on the other hand because it is a rapid plant regarding growth and expanding its canopy in the higher density ratios it has to ability to achieve a higher relative competition coefficient compared to malva.

In this study by increasing the ratio of rapeseed in the mix the relative competition coefficient was increased and it reached its highest value (2.18) in the 75 percent density ratio of rapeseed.

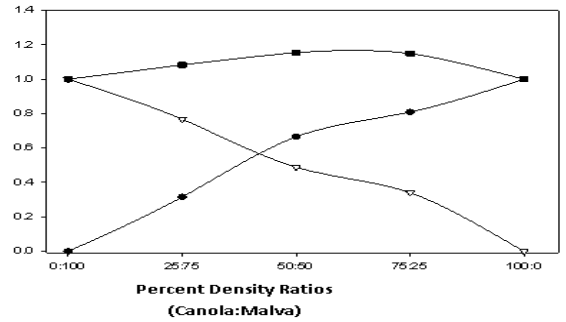

Fig. 1. Variation Trend of Relative Yield for Rapeseed ( ), Malva (Δ), and Total Relative Yield (■) in Different Plantation Density Ratios .

The Dry Weight of the Aerial Organs (Biomass)

The biomasses of the aerial organs of rapeseed and malva were significantly affected by the density of malva (Table 3) such that by increasing the density of malva the biomass of rapeseed was decreased (Figure 2). This indicates the negative and significant impact of the competition on the part of malva weed on the dry weight of rapeseed. The higher dry weight of rapeseed in the pure cultivation (100 percent density) compared to the mixed cultivation with malva weed (75, 50 and 25 percent densities) can be an indication of the lack of rivalry or insignificant competition on the part of the rapeseed species. The dry weight of rapeseed in 25 percent treatment experienced a decrease of more than 68 percent compared to the 100 percent treatment. Water, nutrition elements and light are considered the three main factors in creating rivalry (Soleimani *et al*, 2010). The decrease in the dry weight of the aerial organs of rapeseed in competition with malva is probably because of the rivalry in taking up nutrition elements, light and humidity (Rahimian and Shariati, 1999; Tingle *et al*, 2003; Ross and von Acker, 2005). In the study of Safahani *et al* (2007) the biologic yield of rapeseed hayola 401, in the mixed cultivation with weeds decreased up to 61 percent. In the experiment carried out by Jafari Zadeh and Madhaj (2011) by increasing the density of malva weed the biologic yield of wheat was significantly reduced. In another study increasing the density of the rye caused the linear reduction of the biologic yield of wheat (Baghestani *et al*, 2003). Mirshekari *et al* (2008) stated that season-long interference of weeds with rapeseed caused a 40 percent decrease in the biologic yield of this crop product.

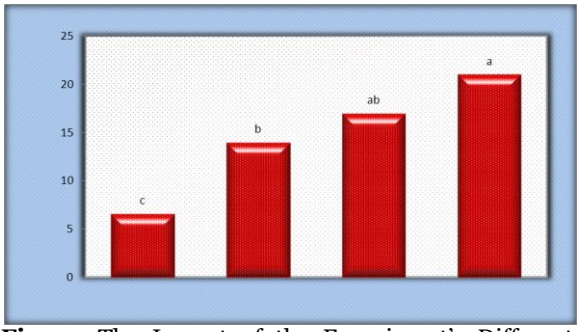

Fig. 2. The Impact of the Experiment's Different Treatments on the Shoot Dry Weight of Canola in Competition with Malva.

Yield and Yield Components of Rapeseed

The Seed Yield

The results of the variance analysis showed that by increasing the density of malva the seed yield of rapeseed was decreased (Table 3). Comparing the averages showed that the maximum and minimum yields of individual rapeseed bushes were at the density ratios of 100 and 25 with 5.8 and 0.73 grams, respectively. There was no significant difference between the density ratios of 25 and 50 percent. The yields of individual bushes in 75 and 50 percent treatments were 2.4 and 1.2 grams, respectively (Figure 3). The seed yield is an important cultivating characteristic which is affected by the competition from the weeds. The study carried out by Van Acker and Oree (1999) showed that increasing the density of the charlock weed to 200 bushes in each square meters decreases the yield of rapeseed up to 75 percent. Amini *et al* (2006) in investigating the effects of the competition of the rye on the growth measures of winter wheat showed that the interference of the rye causes a decrease in the cumulative dry matter of wheat which in turn reduces the seed yield. In other researches the decrease in the seed yield of rapeseed in competition against weeds is reported (Harker *et al*, 2001; Safahani *et al*, 2007; Mac Mullan 1994 et al).

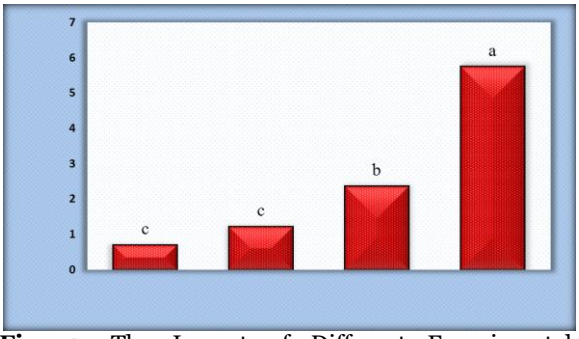

Fig. 3. The Impact of Different Experimental Treatments on Seed Yields.

The Number of Pods in Each Bush

The results showed that the impact of experimental treatments on the number of pods in the rapeseed's bush was significant in the 1 percent probability level (Table 3). In the 100 percent density, in which no competition between the two species was present, the number of obtained pods from each bush was 118 which had a significant difference with other treatments. In the 75 percent and 50 percent treatments there were 85.75 and 71 pods, respectively, in each bush. In the 25 percent density in which the highest competition among the two species was present, the lowest number of pods (53.25) was obtained (Figure 4). In the study carried out by Safahani *et al* (2007) the number of pods in the hayola 401 in the pure cultivation treatment was 153 while this value decreased to 64 in the mixed cultivation treatment. Black Shaw *et al* (2002) reported the decrease of the pod number of rapeseed in competition with charlock. Sadati (2001) reports similar results. The decrease in the number of pods in the bush under competitive conditions can be due to the limitation of resources. Plants compete for different resources and the stiffness of the competition varies based on the species of the weed, the crop's phonology and the weed's phonology (Najafi *et al*, 2006).

The Number of Seeds in Each Pod

The impact of different density ratios of rapeseed on the number of the seeds in each pod was highly significant (Table 3). The highest number of the seeds in a pod was obtained in the pure cultivation of rapeseed which added up to 13.65 instances. The number of seeds in each pod for the 75, 50 and 25 percent treatments was 10.6, 9.48, and 8.5, respectively. There was no significant difference between 75 and 50 percent treatments as well as 50 and 25 percent treatments (Figure 5). In the study of Safahani *et al* (2007) the numbers of seeds in the rapeseed's pods under no competition as well as under the competitive conditions were respectively 14 and 10. Sadati (2001) also reported a decrease in the number of rapeseed's seeds in competition with weeds. The reason behind the decreasing number of seeds in the pod of rapeseed in competition with weeds can be attributed to the decreasing photosynthesis efficiency in rapeseed due to the shadowing effect and in turn the decreased competitive capability for taking up light, nutrition elements and allocating assimilates to the reproductive organs. In order to maintain the balance between the rate of produced materials at the source and the rate of consuming the materials some of the flowers are withered or due to the lack of photosynthesis material the insemination is not complete (Abasdokht, 2003).

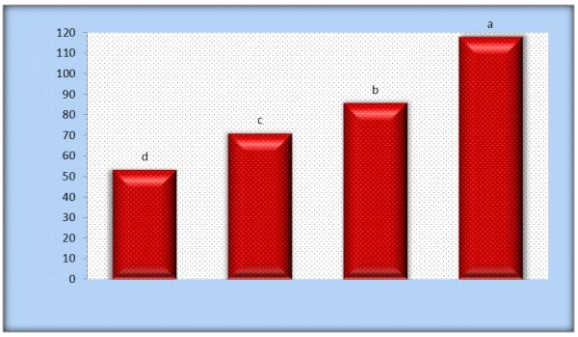

Fig. 4. The Impact of Different Experimental Treatments on the Number of Pods in Each Bush.

The Weight of 1000 Seeds

The impact of experimental treatments on the weight of a thousand seeds of rapeseed was significant at the probability level of one percent (Table 3). The highest weight of 1000 seeds equal to 3.6 grams was obtained in 100 percent density. There was no significant statistical difference between the 50 percent treatment with 1.85 grams and the 25 percent treatment with 1.63 grams (Figure 6). In the study carried out by Safahani *et al* (2007) the weight of

1000 seeds of rapeseed decreased in the competition with weeds so that their weights in the pure and mixed cultivations were 4.9 and 3.6 grams, respectively. Zamani *et al* (2005) by investigating the impact of the density of wild oat on the yield and yield components of wheat reported that the weight of 1000 seeds of wheat was decreased under the competitive conditions. Increasing the weed bushes causes increasing rivalry between the species, and closing the shadow range of the plants as well as disorder in the distribution of sunlight on the plant community and the shortage of available nutritious elements (Gill and Anderson, 1994).

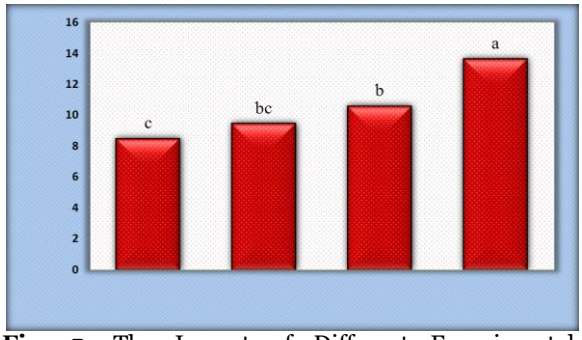

Fig. 5. The Impact of Different Experimental Treatments on the Number of Seeds in Each Pod.

These reactions lead to the weakness of the plant and a decrease in the production of processed material for filling up the seeds which in turn causes the reduced number of pods and the weight of 1000 seeds (Clark and Simpson, 1978).

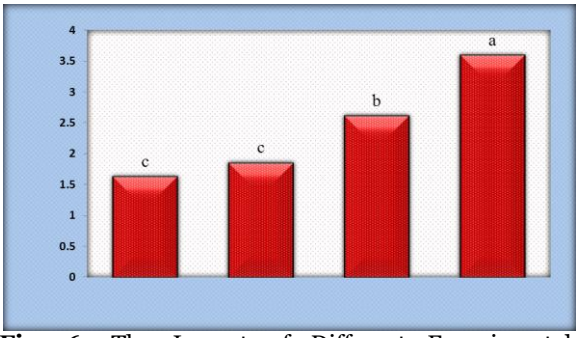

Fig. 6. The Impact of Different Experimental Treatments on the Weight of 1000 Seeds.

In the current paper by increasing the presence ratio of malva weed in the mixture with rapeseed the weight of 1000 seeds of this crop product decreased which indicated the intensity of competition and significant shortage of resources.

Conclusion

In a nutshell it can be said that the malva weed is not considered a serious rival for rapeseed when the density of this crop products is high but in the lower densities of this crop the yield significantly decreases due to the competition with malva.

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