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Responses of Morphological Characteristics, Yield and Yield Components of Rapeseed (*Brassica napus* L.) as the Second Crop After Rice to Plant Density and Weed Interference Duration

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ABSTRACT- In order to determine the responses of morphological characteristics, yield and yield components of rapeseed (*Brassica napus* L.) to plant density and weed interference duration, a factorial experiment was conducted using a randomized complete block design with 3 replications at the Rice Research Institute of Iran (RRII) in Rasht, in the 2008 growing season. The factors comprised plant density at 2 levels (80 and 57 plants m^2) and weed interference duration at 7 levels (including weed competition with canola until the end of crop emergence, 2, 4, 8 leaf stages, and formation of flower buds). After the above mentioned growth stages, weeds of each treatment were removed manually until harvest. Two check treatments including weedy and weed free were also selected as control. The traits evaluated in this research were plant height, number of secondary branches plant^1, height of the lowest pod bearing branch, pod length, pod number plant^1, grain number pod^1, 1000 grain weight and grain yield. The results indicated that plant density, weed interference duration and their interaction had significant effects on all traits except pod length. In addition, the 1000 seed weight showed significant response to separate effect of each factor, but was not influenced by their interaction. The highest value of grain yield was related to a density of 80 plants m^2 on total weed free check (full season weed free) and the lowest value of this trait was obtained from a density of 57 plants m^2 on weedy check (fullseason weed infested) treatment.

Keywords: Canola, Full Season Weed Free, Grain Yield, Plant Density, Weed Interference

INTRODUCTION

Rapeseed (*Brassica napus* L.) is now the second most important source of vegetable oil in the world and canola oil is considered healthy for human nutrition due to its lowest content of saturated fatty acids among vegetable oils and moderate content of poly-unsaturated fatty acids (28). Thus, great portions are needed to supply the food requirements of the growing population (34).

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The cultivation of canola after rice in a rotation system causes decreased soil erosion during winter and improves absorption of the additional nitrate in the soil. It also decreases leaching during winter heavy rains. The penetration of canola roots in paddy fields causes the depletion of organic acids in the soil and changes soil phosphorous to the solution form. Canola cultivation in paddy fields also decreases the possibility of infection with sclerotinia stem rot disease by breaking the life cycle of the fungi (22).

Weeds are considered as one of the most important limitation factors in rapeseed fields. They compete with crop plants for light, water, nutrients and space. Weed interference on crops is not the same in various growth and development stages. Therefore, weed-crop competition capability is different during their life cycle (30). Rapeseed is a slowly growing crop and thereby exposed to severe competition by weeds. However, at the early stage of growth, the canopy of rapeseed leaves grows up over the rows and covers the field, hence; shading might suppress weed growth beneath. In addition, weeds with branched, vigorous root systems inhibit the development of rapeseed plants through severe nutrient depression; hence the growth, yield and its quality will be reduced (21). The duration of weed interference is one of the effective factors on weed-crop competition and eventually, the crop yield (36). Yaghoobi and Siyami (32) reported that periodical weed interference had no influence on seed weight and the seed number on pods of lateral branches but caused a significant reduction on pod number of main and lateral branches and seed number in pods of the main shoot with increasing weed interference duration. In addition, seed yield was significantly decreased by weed interference duration exceeding. Hamzei et al (9) also found that the grain yield of rapeseed was decreased by increasing the weed interference duration.

The crop depends largely on temperature, solar radiation, moisture and soil fertility for its growth and nutritional requirements. Plant density may affect the maximum availability and utilization of these factors (5). Therefore, adjusting plant density is an important tool to optimize crop growth and the time required for canopy closure, and to achieve maximum biomass and grain yield (4, 8, 29, 31). Salehian et al (25) showed that plant density significantly affected the number of pods, secondary branches and seeds per plant. Al-Barzinji et al (3) investigated the effects of different plant densities ranging from 20 to 130 plants m^{-2} in rapeseed. They concluded that pods per plant, seeds weight and dry matter per plant decreased as plant density increased. Leach et al (12) reported that plants grown at high density had fewer pod- bearing branches per plant but produced more branches, and with an increase in density, the 1000-seed weight increased. Majnon Hosseini et al (14) also concluded that an increase in plant density significantly decreased the pod bearing stem length and total pod numbers per plant, but increased plant height and seed yield.

The objective of this study was to determine the responses of morphological characteristics, yield and yield components of rapeseed (*Brassica napus* L.) to plant density and weed interference duration.

MATERIALS AND METHODS

The experiment was conducted during the 2008-2009 growing season in paddy fields of the Rice Research Institute of Iran, approximately 5 km from Rasht (51^{o} 3$'$ E longitude , 37^{o} 16$'$ N latitude and an altitude of -7 m below sea level). The total annual precipitation of the research site during growing season was 1039.44 mm and soil texture was silty clay loam with a pH of about 6.7 and organic matter content of about 1.63%. This experiment was conducted as a factorial randomized complete block design with 3 replications. The experimental factors included plant density at 2 levels (80 and 57 plants m^{-2}) and weed interference duration at 7 levels (including weed interference until the end of crop emergence (V_C), 2 (V_2), 4 (V_4), 8 (V_8) leaf stages and formation of flower buds (FB)). After these stages, weeds were manually removed until harvest. Two treatments including weedy and weed free checks were also considered. The experimental field area was about 1300 square meters. In mid September, plowing was carried out with moldboard plow and with plowing, based on the recommendations of the soil and water sector of the Rice Research Institute, basic fertilizers including 100 kg ha^{-1} urea, 150 kg ha^{-1} ammonium phosphate and 150 kg ha^{-1} potassium sulphate were added to the soil. The field was then flattened by rotary. Experimental units were created in 2.5×3.5 m dimensions and 0.5 m away from the adjacent experimental units. The blocks were also 2 meters apart from each other. Considering the weather conditions of Rasht and likely flooding of the field, some drainage channels were devised between the blocks and experimental units. Plant density and weed interference treatments were randomly determined and allocated to each block. Row spacing for densities of 80 and 57 plants m^{-2} was 25 and 35 centimeters and the number of planting rows were 7 and 10 rows for desired plant densities, respectively. Distance between plants within the rows was also 5 cm. Seeds were planted in mid-November 2008 in rows with approximately 1-2 cm in depth. The selected canola cultivar was Hyola 401. Topdress urea fertilizer was used as much as 100 kg ha^{-1} during two stages, exiting from the rosette stage (before stem elongation) and squaring stage (before flowering), respectively. Metaldehyde was also used particularly in the early stages of rapeseed growth to control the snails in the farm. Irrigation was not required due to the adequacy of atmospheric precipitations during canola growth stages. Treatments were hand-harvested when 30-40% of the seeds changed their color from green to brown (Late May in 80 and Early June in 57 plants m^{-2}). Seed moisture was about 25% at harvest. To eliminate the marginal effect, a row from the beginning and the end and 0.5 m from both sides of experimental units was removed and harvest was done from the remaining area. Following the harvest, plants were left on the field for 2 days dry under sunlight. Seed moisture at this time was about 12%. Subsequently, threshing was done and straws were separated from the seeds. To determine the morphological characteristics (including plant height, number of secondary branches, height of the lowest pod bearing branch and pod length) and yield components (including pod number $plant^{-1}$ and grain number pod^{-1}), 10 plants were collected randomly from each treatment a week before harvest and these traits were measured. Grain yield was determined from 5 m^{-2} of each plot after removing the marginal effect. Seed weight was determined by a seed counter device. In this way, 1000 grains were selected from each yield sample and weighed. SAS software v.9 (PROC GLM) was used to analyze the data and comparison of means was done using Tukey 's Multiple Range Tests (at the 1 and 5% probability levels).

RESULTS AND DISCUSSION

Plant Height

Results showed that the effects of plant density, weed interference duration and their interaction on plant height were significant (P<0.01, Table 1). The maximum and minimum amounts of plant height were related to weed free treatment (full-season weed free) in a density of 80 plants m^{-2} (146.20 cm) and weedy treatment (full-season weed infested) in a density of 57 plants m^{-2} (114 cm), respectively (Fig 1).

Table 1. Analysis of variance for the effects of plant density, weed interference duration and their interaction on studied traits of rapeseed

		MS							
SOV	**DF**	**Plant height (cm)**	**Number of secondary branches**	**Height of the lowest pod bearing branch (cm)**	**Pod length (cm)**	**Pod number $plant^{-1}$**	**Grain number pod^{-1}**	**1000-grain weight (g)**	**Grain Yield (kg ha^{-1})**
R	**2**	**22.06****	**0.12****	**69.63****	**0.001^{ns}**	**117.8**	**114.79**	**0.01**	**159060****
Densit	**1**	**166.006**	**37.91****	**314.88****	**0.04^{ns}**	**4353.**	**81.93***	**0.09**	**36305412***
Weed	**6**	**556.32****	**3.73****	**540.43****	**0.05^{ns}**	**11457**	**71.45***	**1.40**	**3026465****
D×W	**6**	**10.09****	**0.09****	**4.32****	**0.017^{ns}**	**60.77***	**1.52****	**0.00**	**427933****
Error	**2**	**1.35**	**0.007**	**0.57**	**0.017**	**3.51**	**0.14**	**0.00**	**369**
C.V%	**…**	**5.90**	**10.64**	**12.47**	**2.31**	**5.36**	**7.63**	**2.30**	**13**

*** and **:Significant at 5% and 1% probability level, respectively ns: non significant**

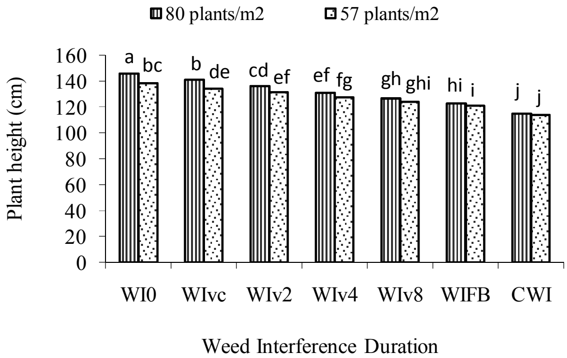

Fig. 1. Effect of weed interference duration on plant height in densities of 80 and 57 plants m^{-2}

Based on the results, increased plant density was significantly associated with increased plant height, so that this trait in a density of 80 plants m^{-2} was 3.03% higher than that of 57 plants m^{-2} (Table 2). The reason for this can be attributed to reducing light penetration in plant shading and increasing competition among plants for receiving light. Lack of light reduced the optical destruction of auxin and increased the synthesis of gibberellin in stem internodes and thus, the internodes' length and final plant height increased. In addition, in higher plant density, the amount of infrared light received by stems of plants increased and thus, the ratio of red to infrared light decreased. Responses of plants to the low ratio of red to infrared light was an increase in their height (13). The reason why plant height increased with increasing plant density can also be that increasig plant density and competition between plants, stimulated apical meristem growth and due to absorption and transmission of photosynthetic materials to apical meristem, the plant height increased. This result was consistent with those reported by Majnon Hosseini et al (14), Eilkaee and Emam (7) and Khoshnam (11).

Table 2. Comparison of means of studied traits in different treatments of plant density and weed interference duration

Treatment	Plant height cm	Number of secondary branches	Height of the lowest pod bearing branch cm	Pod length cm	Pod number plant^{-1}	Grain number pod^{-1}	1000-grain weight g	Seed yield kgha^{-1}
Plant								
80	131.32 a	4.08 b	54.21 a	5.61 a	127.79	24.46 a	3.76 b	3554.42
57	127.34 b	5.98 a	48.74 b	5.67 a	148.15	21.67 b	3.86 a	2966.40
Weed interference duration								
WI0	142.45 a	6.10 a	37.98 g	5.76 a	197.73	27.46 a	4.49 a	4240.07
WIv_c	137.70 b	5.65 b	42.85 f	5.71 ab	177.43	26.56 b	4.29 b	3899.93
WIv_2	133.97 c	5.37 c	46.98 e	5.62 ab	162.33 c	25.07 c	4.04 c	3640.54
WIv_4	129.47 d	5.13 d	52.05 d	5.63 ab	140.27	23.04 d	3.72 d	3316.92
WIv_8	125.33 e	4.60 e	55.92 c	5.71 ab	111 e	21.22 e	3.57 e	2790.53
WIFB	122 f	4.32 f	59.98 b	5.59 ab	95.97 f	19.54 f	3.41 f	2593.21
CWI	114.40 g	4.02 g	64.57 a	5.51 b	81.07	18.59 g	3.15 g	2341.65

Means with the same letter do not have statistically significant difference at 5% probability level
WI: Weed Interference

In both plant densities, plant height in competition (interference) treatments showed a downtrend with an increased duration of weed interference and reached its lowest value in weedy treatment. The highest plant height was related to weed free treatment in both plant densities (Fig 1). The average plant height in weedy treatment in comparison with weed free treatment indicated a decrease equivalent to 24.52% (Table 2). Reduction of plant height with increasing weed interference duration can be attributed to further consumption of environmental resources (water, light and nutrients) by weeds as compared to crop plants and spatial constraints for plant growth that ultimately reduced the growth of rapeseed. This result was in agreement with work undertaken by Khoshnam (11) and Memar Zahedani et al (15).

Number of Secondary Branches Plant^{-1}

The effects of plant density, weed interference duration and interaction between these factors on the number of secondary branches plant^{-1} were significant ($P<0.01$, Table 1). The maximum and minimum numbers of secondary branches were related to weed free treatment in a density of 57 plants m^{-2} (6.87 branches) and weedy treatment in a density of 80 plants m^{-2} (2.93 branches), respectively (Fig 2).

Increased plant density was significantly associated with decreasing numbers of secondary branches plant^{-1}, as such, this trait in a density of 80 plants m^{-2} was 45.20% lower than that of 57 plants m^{-2} (Table 2). The reason for this can be attributed to the reduction of light penetration in the lower part of plant shading and inactivating buds forming branches (7). In addition, rapeseed has a high compressibility power and in lower densities with more space for plant growth, secondary branches increase and try to keep its performance constant, but in higher densities due to greater competition between plants and space limitations, the plant is unable to produce more secondary branches (12). This result is in agreement with the results obtained by Abadian et al (1), Ozer (18) and Eilkaee and Emam (7).

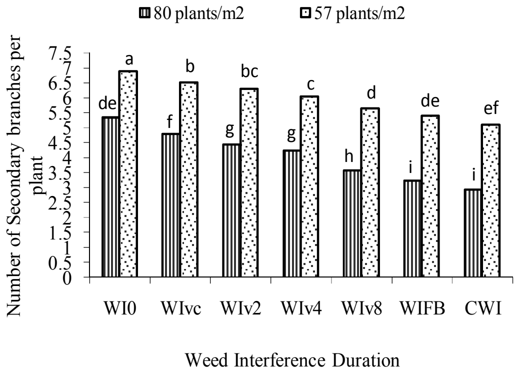

Fig. 2. Effect of weed interference duration on number of secondary branches in densities of 80 and 57 plants m^{-2}

In both plant densities, the number of secondary branches plant^{-1} in competition (interference) treatments showed a downtrend with the increased duration of weed interference and reached its lowest value in weedy treatment. The highest number of secondary branches belonged to the control treatment in both plant densities (Fig 2). The average number of secondary branches in the weedy treatment in comparison with the control treatment indicated a decrease of 51.74% (Table 2). Reduction of the number of secondary branches by increasing the duration of weed interference can be attributed to decreasing the environmental resources allocated to axillary vegetative buds due to additional consumption by weeds as compared to the crop. In addition, competition between weeds and crop led to space limitations for the plants' growth and thus, along with increasing interference duration, the space needed to produce more secondary branches by plant decreased. This result was consistent with the results of the research done by Khoshnam (11) and Eftekhari et al (6).

Height of the Lowest Pod Bearing Branch

Results showed that the effects of plant density, weed interference duration and their interaction on the height of the lowest pod bearing branch were significant ($P<0.01$). The maximum and minimum amounts of height of the lowest pod bearing branch were related to the weedy treatment in a density of 80 plants m^{-2} (66.60 cm) and the control treatment in a density of 57 plants m^{-2} (34.50 cm), respectively (Fig 3).

Based on the results, increased plant density was significantly associated with the increased height of the lowest pod bearing branch, so that this trait in a density of 80 plants m^{-2} was 10.85% higher than that of 57 plants m^{-2} (Table 2). The reason of this can be that in higher densities, plant s spend their photosynthetic materials for vegetative organs to access more radiation. On the other hand, due to overcast branches and leaves of plants, pods formed in the lower branches fell and disappeared. As a result, the height of the lowest pod bearing branch increased, which is considered a favorable trait in mechanized harvesting of rapeseed with a combine (16). In addition, considering the fact that in higher densities, because of food shortage on the one hand and lack of axillary meristem stimulation by growth hormones on the other, the number of secondary branches reduces. Therefore, the increasing height of the lowest pod bearing branch also can be attributed to the fewer number of branches (1). This result is in agreement with those reported by Khoshnam (11) and Ozoni Davaji (18).

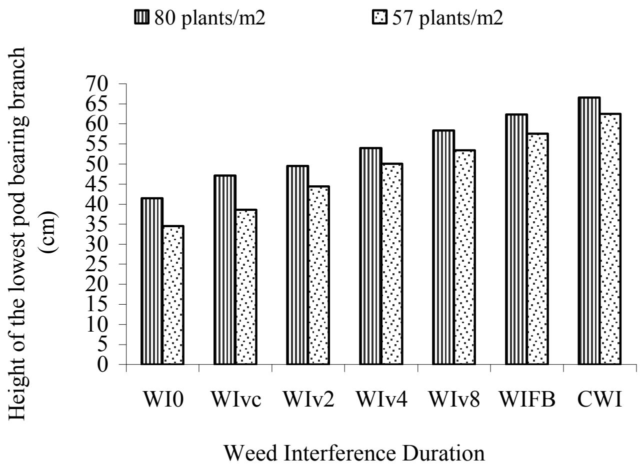

Fig. 3. Effect of weed interference duration on height of the lowest pod bearing branch in densities of 80 and 57 plants m^{-2}

In both plant densities, the height of the lowest pod bearing branch in competition (interference) treatments showed an uptrend with an increased duration of weed interference and reached its highest value in the weedy treatment. The lowest height of the lowest pod bearing branch belonged to the control treatment in both plant densities (Fig 3). The average height of the lowest pod bearing branch in the weedy treatment in comparison with the control treatment indicated a decrease of 70.01% (Table 2). The reason for height reduction of the lowest pod bearing branch with an increased weed interference duration can be attributed to further consumption of environmental resources by weeds than the crop, reducing the environmental resources allocated to axillary vegetative buds and resulting in fewer secondary branches (6, 20) which, in turn, leads to the formation of the first secondary pod bearing branch in a higher position. This result is consistent with those obtained by Khoshnam (11).

Pod Length

Pod length is a trait that indirectly affects the yield. Rapeseed cultivars with more pod length usually have higher yield (19). The reason for this can be attributed to increasing the photosynthetic producer area on the one hand and increasing the number of seeds along with increasing the pod length on the other (12).

Results (Table 1) showed that the effects of plant density, weed interference duration and their interaction on pod length were insignificant. The reason for this can be so expressed that pod length is a trait with high dependence to genetic structure and less influenced by environmental conditions (11). This result was consistent with that observed by Khoshnam (11) but contradicted the result reported by Ozoni Davaji (18). Ozoni Davaji (18) concluded that pod length significantly increased with increasing plant density up to an optimal level (60-80 plants m^{-2}) and when the density was much higher, this trait was reduced.

Based on the results, the maximum and minimum amounts of pod length were related to the control treatment and interference duration until the 8 leaf stage in a density of 57 plants m^{-2}, equally (5.84 cm) and the weedy treatment in a density of 57 plants m^{-2} (5.51 cm), respectively (Fig 4).

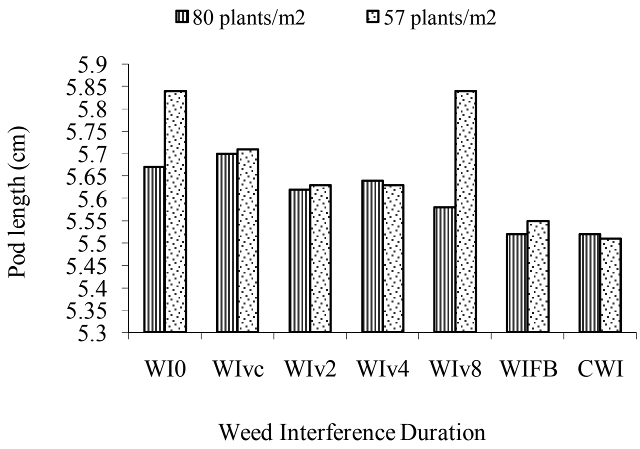

Fig. 4. Effect of weed interference duration on pod length in densities of 80 and 57 plants m^{-}

Pod Number Plant^{-1}

The results (Table 1) showed that the effects of plant density, weed interference duration and their interaction on pod number per plant were significant ($P<0.01$). The maximum and minimum amounts of pod number plant^{-1} were related to the control treatment in a density of 80 plants m-2 (212.20 pods) and the weedy treatment in a density of 57 plants m^{-2} (73 pods), respectively (Fig 5).

Based on the results, increased plant density significantly decreased the number of pods plant^{-1}, so that this trait in a density of 80 plants m^{-2} was 15.08% lower than that of 57 plants m^{-2} (Table 2). The reason for this can be so expressed that increased plant density, reduced light penetration into plants by shading which in turn reduced the emergence of buds forming secondary branches per plant (7). This result is consistent with the results obtained by Majnon Hosseini et al (14) and Ozer (17).

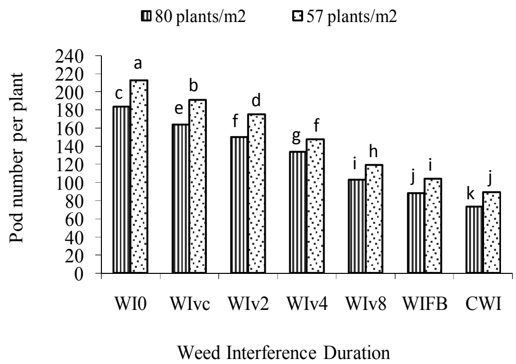

Fig. 5. Effect of weed interference duration on pod number plant^{-1} in densities of 80 and 57 plants m^{-2}

In both plant densities, the number of pods plant^{-1} in competition (interference) treatments showed a downtrend with the increased duration of weed interference and reached its lowest value in the weedy treatment. The highest number of pods plant^{-1} was related to the control treatment in both plant densities (Fig 5). The average of pods' number per plant in the weedy treatment in comparison with the control treatment indicated a decrease equivalent to 143.9% (Table 2). The reason can be expressed in terms of the competition between weeds and crop which reduced the competitive ability of rapeseed to receive light and nutrients and as a result, allocating less material to natal organs. To maintain the balance between source material productions and sink material consumption, either a number of flowers fell or, due to the lack of photosynthetic materials, fertilization was not full. The decreasing number of flowers eventually reduced the number of pods in the weedy treatment. This result is consistent with the results reported by khoshnam (11) and Keramati et al (10).

Grain Number Pod^{-1}

Results (Table 1) showed that the effects of plant density, weed interference duration and their interaction on grain number pod^{-1} were highly significant ($P<0.01$). The maximum and minimum amounts of grain number pod^{-1} were related to the control treatment in a density of 80 plants m^{-2} (29.32 seeds) and weedy treatments in a density of 57 plants m^{-2} (17.82 seeds), respectively (Fig 6).

Grain number per plant has an important contribution in determining the amount of plant sink and is one of the major components of seed yield (16).

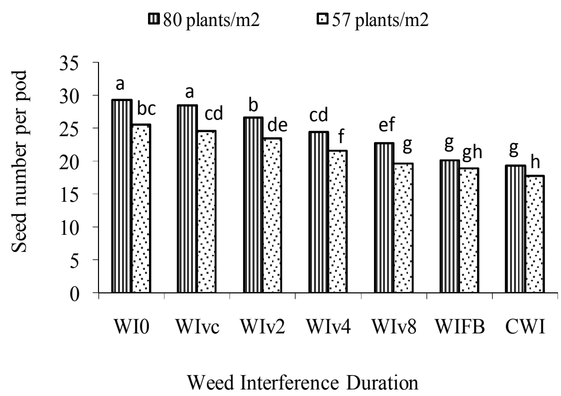

Fig. 6. Effect of weed interference duration on grain number pod^{-1} in densities of 80 and 57 plants m^{-2}

Based on the results, increased plant density significantly increased the number of grains pod^{-1}, so that this trait in a density of 80 plants m^{-2} was 12.648% higher than that of 57 plants m^{-2} (Table 2). The reason for this can be explained in terms of increased plant density, which increases competition among plants for more environmental resources and consequently reduces the amount of photosynthetic material production and transfer of these materials to grains (12, 24) causing smaller but larger numbers of grains pods^{-1}. These results were consistent with the results obtained by Rahman et al (19) and Ozoni Davaji (18) who believed that increasing plant density up to desire numbers increased the number of grains pods^{-1}. On the other hand, results obtained from this experiment contradicted those of Abadian et al

(1) and Eilkaee and Emam (7). They concluded that plant density has no a significant effect on grain number. In their opinion, high density had a higher impact through reducing the number of pods plant^{-1} and therefore, the reduction in grain numbers plant^{-1} is not significant.

In both plant densities, the number of grains pod^{-1} in competition (interference) treatments showed a downtrend with the increased duration of weed interference and reached its lowest value in the weedy treatment. The control treatment showed the highest number of grains plant^{-1} in both plant densities (Fig 6). The average grain number pod^{-1} in the weedy treatment in comparison with the control indicated a decrease equal to 47.71% (Table 2). The reason can be attributed to a decreased reception of material by the plants and thus causing the wrinkling of grains and destroying them (12). This result is consistent with the results obtained by Khoshnam (11) and Keramati et al (10).

1000-Grain Weight

Results of this experiment (Table 1) indicated that the effects of plant density and weed interference duration on the 1000-grain weight were significant ($P<0.01$). The results also showed no significant response of the 1000-grain weight to the interaction between these factors. The maximum and minimum amounts of the 1000-grain weight were related to the control treatment in a density of 57 plants m^{-2} (4.56 g) and the weedytreatment in a density of 80 plants m^{-2} (3.1 g), respectively (Fig7).

Increasing plant density significantly decreased the 1000-grain weight, so that this trait in a density of 80 plants m^{-2} was 3.67% lower than that of 57 plants m^{-2} (Table 2). Grain weight reduction at higher densities can be attributed to the formation of smaller grains due to reduced availability of photo-assimilates (2, 24). This result was consistent with those obtained by Shekari and Javanshir (27), Abdolrahmani (2) and Sedghi et al (26), but contradicted with the results of Abadian et al (1) and Eilkaee and Emam (7). They believed that different plant densities had no significant effects on the 1000-grain weight. Their reason was that grains act as powerful reservoirs and respond lessto treatments such as plant density.

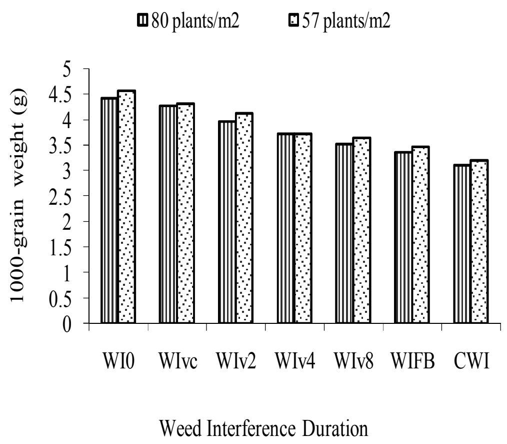

Fig. 7. Effect of weed interference duration on the 1000-grain weight in densities of 80 and 57 plants m^{-2}

In both plant densities, the 1000-grain weight in competition (interference) treatments showed a downtrend with increased duration of weed interference and reached its lowest value in the weedy treatment. The highest 1000-grain weight was also related to the control treatment in both plant densities (Fig 7). The average 1000-grain weight in the weedy treatment in comparison with the control treatment indicated a decrease equal to 43% (Table 2). The reason for this can be expressed in terms of weed competition due to the reduced availability of plants to gain access to environmental factors especially light, rate of photosynthetic materials' production so that their allocation to grains decreased and ultimately reduced grain weight (6, 23). This result was consistent with those obtained by Eftekhari et al (6) and Keramati et al (10).

Grain Yield

Results (Table 1) showed that the effects of plant density, weed interference duration and their interaction on grain yield were significant ($P<0.01$). The maximum and minimum amounts of grain yield were related to the control treatment in a density of 80 plants m^{-2} (4432.27 kg.ha^{-1}) and the weedy treatment in a density of 57 plants m^{-2} (1940.33 kg.ha^{-1}), respectively (Fig 8).

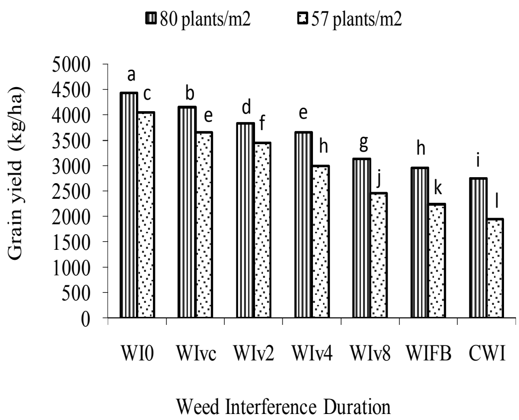

Fig. 8. Effect of weed interference duration on grain yield in densities of 80 and 57 plants m^{-2}

Based on the results, increased plant density significantly increased grain yield, so that this trait in a density of 80 plants m^{-2} was 19.29% higher than that of 57 plants m^{-2} (Table 2). This is because grain yield in rapeseed is a function of the number of pods plant^{-1}, grains pod^{-1} and the 1000-grain weight and although increasing plant density reduced grain weight of single plants by reducing the number of pods plant^{-1} and the 1000-grain weight due to competition between plants on environmental factors, increasing the number of plants compensated for the lack of performance of single plants and ultimately, increased grain yield per unit area (23). This result was consistent with those observed by Ozer (17) and Yazdifar et al (33).

In both plant densities, grain yield in competition (interference) treatments showed a downtrend with the increased duration of weed interference and reached its lowest value in the weedy treatment. The control treatment had the highest grain yield in both plant densities (Fig 8). The average grain yield in the weedy treatment in comparison with the control treatment indicated a decrease equal to 81.07% (Table 2). The reason for this reduction can be attributed to the reduction of yield components including pod number plant^{-1}, grain number pod^{-1} and 1000-grain weight due to the competition between weeds and crop which ultimately reduced grain yield (23). This result was consistent with those of Hamzei et al (9) and Yaghoobi and Siyami (32).

Since the vegetative growth period of fall rapeseed coincides with the fall and winter seasons while the reproductive growth of this crop is done in spring, the species composition of the weeds in field during the growing period of rapeseed was different and fell into two categories: spring and fall weeds. Fall weeds included rough bluegrass (*Poa trivialis* L.), curley duck (*Rumex crispus* L.), bulbous buttercup (*Ranunculus bulbosus* L.) and littleseed canarygrass (*Phalaris minor* Retz). Spring weeds were horseweed (*Erigeron Canadensis*) and purple loosestrife (*Lythr*um *salicaria* L.). In both plant densities, bluegrass (*Poa trivialis* L.) was the dominant weed in all stages of growth except for the all season weedy stage. In the all season weedy stage of 80 plants m^{-2}, spring weeds had priority and in the plant density of 57 plants m^{-2}, bluegrass (*Poa trivialis* L.) and spring weeds included the highest number of weeds equally. Dominance of bluegrass (*Poa trivialis* L.) can be attributed to its potential for high seed production.

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واکنش صفات مورفولوژیک، عملکرد و اجزای عملکرد کلزا در کشت دوم پس از برنج به تراکم بوته و طول دوره تداخل علف های هرز

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چکیده- به منظور ارزیابی واکنش صفات مورفولوژیک، عملکرد و اجزای عملکرد کلزا به تراکم بوته و طول دوره تداخل علف های هرز، آزمایشی در سال زراعی ۸۸ -۱۳۸۷ به صورت فاکتوریل در قالب طرح بلوک های کامل تصادفی در ۳ تکرار در موسسه تحقیقات برنج کشور واقع در شهرستان رشت به اجرا درآمد. فاکتورهای آزمایشی شامل تراکم بوته در ۲ سطح (۸۰ و ۵۷ بوته در متر مربع) و تداخل علف های هرز در ۷ سطح بود؛ به گونه ای که در ۵ تیمار، علف های هرز به ترتیب تا پایان مراحل فنولوژیکی سبز شدن، ۲ برگی، ٤ برگی، ۸ برگی و ظهور جوانه گل با گیاه زراعی رقابت کرده و پس از آن تا انتهای دوره رشد کلزا، به صورت دستی وجین شدند. علاوه بر این، ۲ تیمار تداخل کامل و کنترل کامل نیز به عنوان شاهد در نظر گرفته شدند. صفات مورد بررس ی در این آزمایش شامل ارتفاع بوته، تعداد شاخه فرعی در بوته، فاصله اولین شاخه فرعی خورجین دار تا طوقه، طول خورجین، تعداد خورجین در بوته، تعداد دانه در خورجین، وزن هزار دانه و عملکرد دانه بود. نتایج نشان داد که اثر تراکم بوته، طول دوره تداخل علف های هرز و همچنین اثر متقابل آن ها بر تمامی صفات مورد بررسی به جز طول خورجین معنی دار بود. علاوه بر این، وزن هزار دانه نیز به هر یک از فاکتورها به تنهایی، واکنش معنی داری نشان داده، ولی تحت تأثیر اثر متقابل آن ها قرار نگرفت. بیشترین میزان عملکرد دانه مربوط به تراکم ۸۰ بوته در متر مربع در تیمار کنترل تمام فصل (کامل) علف های هرز بوده و کمترین مقدار این صفت نیز از تراکم ۵۷ بوته در تیمار تداخل تمام فصل (کامل) علف های هرز به دست آمد.

واژه های کلیدی: تداخل علف های هرز، تراکم بوته، عملکرد دانه، کنترل تمام فصل

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