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# A study on the effect of weeds interference periods and plant density of on some traits of sesame (*Sesamum indicum*) and weeds in Birjand, Iran

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**ABSTRACT: The effect of plant density and weeds interference duration was studied on some traits of sesame and weeds in the competition with each other in Birjand, Iran in a factorial experiment based on a Randomized Complete Block Design with three replications in 2013. The studied factors included weeds interference at five levels (weeds control or full control of weeds until the end of growing season, interference of weeds from 20, 40 and 60 days after emergence, and no weeds control in whole growing season) and sesame density at three levels (7, 14 and 28 plants $m^{-2}$). Analysis of variance revealed that weeds interference period and sesame plant density significantly influenced sesame foliage and seed yield as well as narrow-leaf and broadleaf weeds population and dry weight, so that the commencement of weeds interference from 20, 40 and 60 days after sesame emergence and weeds interference in whole growing season decreased sesame foliage dry yield by 42.76, 27.58, 2.42 and 95.48% as compared to full control of weeds in whole growing season, respectively. Also, the increase in sesame density from 7 to 14 and 28 plants m-2 enhanced foliage dry weight by 71.91 and 43.92%, respectively. In addition, the increase in interference period significantly increased the population and dry weight of narrow-leaf and broadleaf weeds. But the increase in density from 7 to 28 plants m-2 significantly reduced narrow-leaf and broadleaf weeds population by 10.84 and 9.32% and significantly reduced their dry weight by 44.91 and 47.37% respectively.**

**Keywords:** sesame, yield, interference, plant density, weed.

## INTRODUCTION

Oilseeds are one of the rich sources of energy and protein that form the second most important food resource of the world after grains. They are grown for the oil of their seeds. However, they are important for their invaluable protein whose residue is used for this protein after extracting their oil (Rashed Mohasel, 1992). The plants should be supplied with optimal amounts of factors affecting their growth and development - including water, nutrients, radiation and $CO_2$ - for realizing their maximum yields (Carpenter, 1999). On the other hand, the adverse consequences of excessive application of herbicides have made the researchers look for alternative methods for suppressing weeds with reduced rates of herbicides (Serkar, 2000).

Plant density is known as a management variable that can be exploited for adapting plants' requirements with the availability of resources and environmental conditions (Smith and Hemel, 1998). Plant density is effectively involved in radiation interception by leaves and photosynthesis regulation (Anwar et al., 1993). Cousens et al. (1991) stated that higher density resulted in higher competition for radiation and lower interception of photosynthetically active radiation caused by the crop-weeds intervention. Studies on sunflower cultivars at the densities of 10 000-110 000 plants ha-1 revealed significant differences between cultivars and densities (Veed and Ferman, 1988). In a study on the effect of within-plant spacing of 15, 18, 21 and 24 cm at inter-row spacing of 60 cm in sunflower cultivars, Rafi'i al-Hosseini and Salehi (2004) showed that seed yield increased with the decrease in within-plant spacing and the increase in plant density. The increase in density from 20 000 to 67 000 plants $ha^{-1}$ resulted in higher seed yield (Khan *et al.*, 1974).

Studies show sigmoid relationship between yield and weeds density, so that yield is lost slightly at lower densities of weeds but the increase in weeds densities severely reduced the yield. However, the yield was frozen or even increased slightly at very high densities of weeds (Hagod *et al.*, 2006).

The selection of suitable plant density on the basis of the regional conditions and cultivar properties is an important factor for maximum crop yield and successful competition with weeds. Researchers have recently concluded that high potential yield achieved by adequate moisture, high soil fertility and/or genetic capacities of the crop is made possible only by regulating the density through in-creasing plant number per unit area (Amini *et al.,* 2006). As the plant density per unit area is in-creased, the individual plants' yield is usually lost due to higher shading and lower available light for individual plants. Nonetheless, higher number of plants per unit area (up to optimum level) can compensate the loss of individual plants' yield resulting in higher yield per unit area (Seiter *et al.,* 2004). Although the more the plant density is increased at initial growth stages, the more the crop yield is due to higher photosynthesizing area and the absorption of 95% of light, when crop covers the field totally, two conditions are arose: first as the density is increased, the crop yield increases up to a certain level and then, starts to decrease which is true for seed yield, and second as the den-sity is increased, the crop yield increases up to a certain level and then it freezes which is mostly true for dry matter (Pumphrey *et al.,* 2004).

In a study on the impact of weeds interference on their dry weight in aerobic rice farm, it was re-vealed that the increase in interference period to over six weeks after sowing increased the densities and dry weights of the weeds and then, they started to decrease (Anwar *et al.,* 2012). Brigz *et al.* (1992) reported that when the interference of Euphorbia heterophyla lasted for over two weeks after the emergence of groundnuts, the yield was significantly lost. Kirkland (1993) indicated that the removal of wild oat at the density of 64 plants $m^{-2}$ before 7-leaf stage and at the density of 119 plants $m^{-2}$ before 5-leaf stage of wheat did not improve wheat yield.

As a low-demanding and low-input oilseed, sesame not only plays an important economical role in subsistence farming in arid and semiarid regions but also is agronomically important. This crop is highly adapted to the climatic conditions of Iran and is highly tolerated to drought. Despite the long history of sesame cultivation in Iran as compared to other corps, the influence of the competition of weeds on sesame and their management is under-researched.

Therefore, the objective of the present study was to investigate the effect of weeds interference periods and sesame plant density on some traits of sesame and weeds in Birjand, Iran.

## MATERIALS AND METHODS

The present study was carried out in research farm of Islamic Azad University of Birjand (Long. 59°13' E., Lat. 32°52' N., Alt. 1491 m.) in 2013. The 15-year mean precipitation of the region is 176 mm and the mean minimum and maximum temperatures are 4.6 and 27.5°C, respectively.

The study was a factorial experiment based on a Randomized Complete Block Design with three replications in which one factor was devoted to weeds interference at five levels (weeds control or full control of weeds until the end of growing season, the commencement of weeds interference from 20, 40 and 60 days after emergence, and no weeds control in whole growing season) and the other factor was devoted to sesame density at three levels (7, 14 and 28 plants $m^{-2}$). The length of the experimental plots was 4 meters composed of 4 planting rows with within-row spacing of 50 cm, within-plot spacing of 1 m and within-replication spacing of 1.5 m.

The field was prepared through plowing, disking and leveling in April-May 2013. The sesame seeds were disinfected with Benamol 2:1000 and then, they were sown at the depth of 2-3 cm on the both sides of the ridges on June 2, 2013. The seeds were covered with fine soil. Post-emergence irrigation was carried out at 8-day intervals. The thinning to obtain the desired densities was carried out at 3-4-leaf stage. The densities included 7, 14 and 28 plants m-2 acquired by adjusting on-row within-plant spacing to 5, 10 and 20 cm, respectively. The plants were harvested at full maturity of capsules on October 31, 2013. To calculate the yield, the plants of an area of 2 m2 from the middle of the plots were cut and the seed yield was determined after removing the capsules and winnowing.

To study the traits of weeds, they were cut from an area of 2 $m^2$ in the middle of the plots at the end of interference period and were transferred to laboratory. Then, the weeds were counted in terms of species including narrow-leaf and broadleaf weeds. Afterwards, they were oven-dried for 72 hours to find out their dry weight with a 0.01-precision scale. The weeds were mostly cockspur, ivy, camelthorns and lamb's quarter.

Finally, the data were analyzed with SPSS and MSTAT-C Statistical Software Packages and the means were compared with Duncan Multiple Range Test at the 5% probability level.

## RESULTS AND DISCUSSION

*A. Sesame foliage dry yield*

Analysis of variance revealed that sesame foliage dry yield was significantly affected by weeds interference and plant density at the 1% probability level and by the interaction between weeds inter-ference and sesame plant density at the 5% probability level (Table 1).

Sesame foliage dry yield was reduced by 42.76, 27.58, 2.42 and 95.48% under the beginning of weeds interference from 20, 40 and 60 days after sesame emergence and the interference in whole growing season as compared to no-weeds interference treatment, respectively (Table 2). Shorter periods of weeds interference allowed sesame plants to better use (light, water and nutrients) re-sources. Therefore, they produced more foliage at different densities under lower competition with weeds which was reflected in significantly higher foliage dry yield per unit area at shorter weeds interference period. In a study on pea, Mohammadi *et al.* (2004) concluded that shoot dry weight was decreased with the increase in interference period.

**Table 1: Mean of squares for the effect of weeds interference and plant density on sesame and weeds traits.**

| SOV | df | Foliage dry weight | Seed yield | Weeds density of narrow-leaf | Weeds density of broadleaf | Dry weight of narrow-leaf | Dry weight of broadleaf |
|---|---|---|---|---|---|---|---|
| Replication | 2 | 187253.756 $^{ns}$ | 325279.061 $^{ns}$ | 242.9 $^{ns}$ | 849.2 $^{ns}$ | 1430.46 $^{ns}$ | 124.95 $^{ns}$ |
| Weeds interference (A) | 4 | 1341171.59** | 12146878.70** | 1283.0** | 12021.6** | 58712.35** | 629.67* |
| Plant density (B) | 2 | 97938.42* | 10421971.30** | 126.1 | 245.0 | 3970.86 | 236.39 |
| A*B | 8 | 15998.8$^{ns}$ | 1163466.55* | 262.8 | 113.6 | 1772.42 | 237.68 |
| Error | 28 | 21819.71 | 506528.6 | 134.7 | 563.3 | 1356.91 | 181.39 |

$^{ns}$ Non Significant and *, ** Significant at 0.05 and 0.01 probability level, respectively

**Table 2: The means comparison of sesame and weeds traits in weeds interference levels.**

| Interference (days after sowing) | Foliage dry weight (kg ha$^{-1}$) | Seed yield (kg ha$^{-1}$) | Weeds Density of narrow-leaf | Weeds Density of broadleaf | Dry weight of narrow-leaf (g m$^{-2}$) | Dry weight of broadleaf (g m$^{-2}$) |
|---|---|---|---|---|---|---|
| Control (weed free) | 2987.08a | 962.2a | 0c | 0d | 0c | 0d |
| 20 | 1709.98b | 303.3c | 14.8b | 34.4b | 37.3b | 288b |
| 40 | 2163.41ab | 669.4b | 12.8b | 18.1c | 29.3b | 89c |
| 60 | 2914.88a | 868.8a | 0.4c | 0.5d | 0.7c | 1.8d |
| No weed control | 135.04c | 48.5d | 28.8a | 88.5a | 193.5a | 723.4a |

Means followed by the same letters in each column are not significant according to Duncan's multiple range test (P<0.05)

As sesame density was increased from 7 to 14 and 28 plants m$^{-2}$, foliage dry weight was increased by 71.91 and 43.92%, respectively (Table 3). Clearly, the photosynthesis and dry matter accumulation in foliage was significantly increased with the increase in density from 7 to 28 plants m$^{-2}$ be-cause of the loss of competitiveness of the weeds on the one hand and the increased leaf area and more ability of sesames to intercept radiation on the other hand. In a study on soybeans, Gan *et al.* (2002) found that higher plant density resulted in higher stem and leaf dry yield of soybeans. It was found that the treatment of weeds interference from 60 days after emergence at sesame density of 28 plants m$^{-2}$ produced the highest foliage dry yield (4739.56 kg ha$^{-1}$, on average) and sesame density of 7 plants m$^{-2}$ with no weeds control produced the lowest foliage dry yield (31.29 kg ha-1, on average) (Table 4). As is evident in Table 4, although foliage dry yield was increased at higher plant densities at all weeds interference levels, the rate of its increase was not uniform so the interaction between weeds interference period and plant density was significant for it. It can be seen that as the density was increased from 7 to 28 plants m m$^{-2}$, foliage dry yield was multiplied by the order of 2.62, 1.53, 2.52, 8.75 and 2.40 under the treatments of weeds interference from 20, 40 and 60 days after emergence, weeds interference in whole growing season, and no weeds interference, respectively (Table 4).

*B. Sesame seed yield*

It was found that seed yield was significantly influenced by plant density, weeds interference and their interaction at the 1% probability level (Table 1).

The highest seed yield of 962.2 kg $ha^{-1}$ was obtained under the treatment of no weeds in whole growing season and was reduced by 68.4, 30.41, 9.67 and 94.95% under the treatments of weeds interference from 20, 40 and 60 days after emergence and weeds interference in whole growing sea-son, respectively (Table 2). In a study on weeds interference, Imer *et al.* (2008) obtained the highest yield of sesame (916 kg $ha^{-1}$) in the treatment of weeds interference until 10 days after emergence and the increase in interference period up to 70 days after emergence reduced seed yield to as low as 174 kg ha $m^{-1}$. Mishel *et al.* (2006) reported that the higher seed yield was caused by the shorter period of competition with weeds. They stated that the presence of weeds after the critical period of the crop had no negative impact on crop efficiency. In a study on the effect of weeds interference on the yield of two rain-fed cultivars of pea, Allahdadi *et al.* (2006) found that grain yield of both cultivars was influenced by the competition of weeds so that the presence of weeds resulted in the loss of grain yield.

Means comparison showed that sesame seed yield was significantly increased by 24.7% as the den-sity was increased from 7 to 28 plants $m^{-2}$ (Table 3). Koocheki *et al.* (2006) stated that higher plant density per unit area resulted in significantly higher seed yield of fennel. Ahmadizadeh and Rezavani Moghadam (2005) reported the ascending trend of seed yield of fennel flower with the increase in density. In a study on density of dill, Randhawa *et al.* (2003) reported that seed yield was increased with the decrease in row spacing. In a study on soybeans, Gan *et al.* (2002) found that higher plant density produced higher yield. On the contrary, Rahimzadeh and Najafimirak (2009) studied the agronomic traits of rain-fed sunflowers and found no significant influence of density on grain yield.

Means comparison of the interaction between sesame plant density and weeds interference revealed that the highest seed yield of 1120 kg $ha^{-1}$ was produced at the density of 28 plants $m^{-2}$ without ex-posing to the weeds. The lowest seed yield of 15 kg $ha^{-1}$ was produced at the density of 7 plants $m^{-2}$ exposed to weeds in whole growing season. It should be noted that the increase in sesame plant density under weeds interference in whole growing season did not significantly increase seed yield and all densities were ranked in the same statistical group under weeds interference treatment (Table 4).

**Table 3. The means comparison of sesame and weeds traits in plant density levels.**

| Density ( plant. $m^{-2}$) | Foliage dry weight (kg $ha^{-1}$) | Seed yield (kg $ha^{-1}$) | Weeds density of narrow-leaf | Weeds density of broadleaf | Dry weight of narrow-leaf (g $m^{-2}$) | Dry weight of broadleaf ( g $m^{-2}$) |
|---|---|---|---|---|---|---|
| 7 | 1274.022 b | 491.1 b | 14.7a | 32.6a | 68.6a | 304a |
| 14 | 1771.501 b | 567.6a b | 9.3b | 27.6ab | 51.8b | 189.9b |
| 28 | 2900.724 a | 652.6 a | 10.2b | 24.6b | 36.1c | 167.4b |

Means followed by the same letters in each column are not significant according to Duncan's multiple range test (P<0.05)

*C. Narrow-leaf and broadleaf weeds density*

According to analysis of variance, the effect of weeds interference period and sesame plant density and their interaction was significant on the densities of narrow-leaf and broadleaf weeds (Table 1). Means comparison showed that the increase in interference period significantly increased the population of narrow-leaf and broadleaf weeds so that the interference of weeds in whole growing sea-son and the interference commencement from 20 and 40 days after emergence increased the population of narrow-leaf weeds by 54.43, 98.99 and 97.23% and the population of broadleaf weeds by 98.61, 97.29 and 96.87% as compared to no weeds interference and the interference from 60 days after emergence, respectively (Table 2). In a study on rice, Ahmadi *et al.* (2008) found that the in-crease in weeds interference period after rice transplanting increased the number and dry weight of weeds. Also, they reported that the rate of the increase in weeds density was higher during early-season than during late-season period because weeds use water and nutrients without competition at their early-growth stages, but over the time as the density of crops and weeds increases, inter-species and intra-species competition results in self-thinning of weeds causing the loss of their den-sities. Chaab *et al.* (2006) stated that prolonged interference of weeds with corn at early-season phase resulted in lower population and dry weight of weeds due to self-thinning. Also, higher plant density will result in lower density of weeds because of the establishment of more plant and lower share of weeds in resources.

Means comparison of the simple effect of sesame plant density on the density of narrow-leaf and broadleaf weeds showed that the increase in sesame density from 7 to 28 plants m$^{-2}$ significantly reduced them by 10.84 and 9.32%, respectively (Table 3). It implies that the increase in sesame density successfully reduced the competitiveness and density of weeds. It seems that as the plant density is increased, the spatial availability of light, water and nutrients to weeds is reduced resulting in more severe inter-species and intra-species competition and the decrease in the number of weeds per unit area (Radosevich, 1987). Some studies like Chaichi *et al.* (1989) on soybeans and Mahmoudi *et al.* (2007) on cotton have reported the effect of crop canopy on the decrease in weeds biomass. In a study on rice, Dastan *et al.* (2011) found that the population of weeds was significantly influenced by rice density at the 1% probability level. As the rice density was increased, the availability of light, water and nutrients was increased to weeds. Then, there was lower competition over these resources resulting in higher population of weeds.

According to means comparison, the highest number of broadleaf and narrow-leaf weeds (44.66 and 99 plants m$^{-2}$, respectively) was observed at sesame density of 7 plants m$^{-2}$exposed to weeds in whole growing season (Table 4).

**Table 4: The means comparison of sesame and weeds traits as affected by weed interference and weed density.**

| Density ( plant. m$^{-2}$) | Interference (days after sowing) | Foliage dry weight (kg ha$^{-1}$) | Seed yield (kg ha$^{-1}$) | Weeds density of narrow-leaf | Weeds density of broadleaf | Dry weight of narrow-leaf ( g m$^{-2}$) | Dry weight of broadleaf ( g m$^{-2}$) |
|---|---|---|---|---|---|---|---|
| 7 | Control (weed free) | 1739.11de | 791.6bcd | 0 d | 0 b | 0 c | 0 d |
| | 20 | 1039.57efg | 188.3g | 15.6bcd | 36.6b | 46.6c | 381.6bc |
| | 40 | 1680.49de | 638.3de | 13.3bcd | 26.6b | 49.6c | 154.3cd |
| | 60 | 1879.63cde | 821.6bc | 0d | 1b | 0c | 3.3d |
| | No weed control | 31.29g | 15.6g | 44.6a | 99a | 247a | 980.6a |
| 14 | Control (weed free) | 3044.43 bc | 975ab | 0 d | 0 b | 0 c | 0 d |
| | 20 | 1364.51 ef | 255fg | 24b | 28.6b | 50.6c | 284bcd |
| | 40 | 2223.35 cde | 708.3cde | 2cd | 20.3b | 12c | 77cd |
| | 60 | 2125.45 cde | 850bcd | 0.6cd | 0.6b | 1.3c | 2.3d |
| | No weed control | 99.74 g | 50g | 20bc | 88.6a | 195ab | 586.3b |
| 28 | Control (weed free) | 4177.69 ab | 1120 a | 0 d | 0b | 0c | 0d |
| | 20 | 2725.87 cd | 466.6 ef | 5bcd | 38b | 14.6c | 198.3cd |
| | 40 | 2586.39 cd | 661.6 de | 23.3b | 7.3v | 26.3c | 35.6d |
| | 60 | 4739.56 a | 935 abc | 0.6cd | 0b | 1c | 0d |
| | No weed control | 274.09f g | 80 g | 22b | 78a | 138.6b | 603.3b |

Means followed by the same letters in each column are not significant according to Duncan's multiple range test (P<0.05)

*D. Dry matter accumulation in broadleaf and narrow-leaf weeds*

As analysis of variance showed, narrow-leaf and broadleaf weeds dry weight was significantly affected by the duration of weeds interference, sesame plant density and their interaction (Table 1). Means comparison indicated that as the interference period was extended, weeds weight was in-creased so that when the interference was started 20 days after emergence, narrow-leaf weeds biomass was increased by 72.88 and 99.29% as compared to the commencement of the interference from 40 and 60 days after the emergence of sesame, respectively. This increase was 76.31 and 97.37% for broadleaf weeds, respectively. However, it should be noted that the highest dry weight of narrow-leaf and broadleaf weeds was 723.4 and 193.5 g m$^{-2}$ obtained under weeds interference in whole growing season, respectively. (Table 2) implying that the control of weeds just in the first 20 days after weeds emergence can significantly reduce the competitiveness of the weeds.

Furthermore, it should be noted that the dry matter of narrow-leaf weeds is higher than that of broadleaf weeds implying higher competitiveness of the former than that of the latter. However, it is likely that the seed reserve of the study farm contained more number of the seeds of narrow-leaf weeds seeds resulting in their higher density and dry weight as compared to broadleaf weeds. Ab-baspour (2008) reported that prolonged interference of weeds increased their dry weight. Mobin *et al.* (2009) related the increase in weeds in fennel farm to the increase in the duration of weeds interference and competition. Also, Mohammadi *et al.* (2005) found that shorter duration of weeds con-trol in pea farm reduced weeds dry weight. In a study on rice.

Dastan *et al.* (2012) found that weeds dry weight was significantly influenced by rice plant density so that lower rice density increased weeds biomass. According to means comparison of the simple effect of plant density, as sesame density was in-creased from 7 to 28 plants $m^{-2}$, narrow-leaf and broadleaf weeds dry weight was significantly de-creased by 44.91 and 47.37%, respectively (Table 3). It can be related to the decrease in the density of weeds at higher densities of sesame per unit area. It seems that under the conditions of the present study, higher density of sesame reduced the availability of resources to weeds for their bio-mass production by conquering the canopy and increasing the competitiveness of the crop. Hosseini *et al*. (2009) stated that higher plant density reduced the density and dry weight of weeds in fennel flower farm because of the inter-species competition with weeds in addition to intra-species competitions. In addition, Makarian *et al.* (2004) concluded that the increase in corn density from 7.1 to 9.5 plants $m^{-2}$ reduced the biomass of weeds.

As means comparison revealed, the highest dry weight of broadleaf and narrow-leaf weeds (247 and 980.6 g $m^{-2}$, respectively) was observed at sesame density of 7 plants $m^{-2}$ exposed to weeds in whole growing season (Table 4).

## CONCLUSION

It was found that the duration of weeds interference and sesame plant density were both important factors for the yield and competitiveness of weeds with sesame, that the lowest yield was obtained under the longest period of weeds interference and the lowest plant density, and that the most optimum yield was obtained at the highest density of sesame by controlling weeds and suppressing their interference and competition.

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