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Effect of Leaf Removal and Different Levels of Density on Yield and Yield Components of Sunflower Seeds

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Abstract: *A factorial experiment was conducted in the Ahwaz, in the form of a randomized complete block design with three replications on sunflower plant, in 2016 crop year. The experiment factors included the plant density per area (60000, 110000, and 160000 plants per a hectare) and leaf removal (without leaf removal, with ¼ leaf removal, with 2/4 leaf removal, and with ¾ leaf removal). The attributes studied were the weight of each seed, the seed yield, total biomass, the grain and oil harvest index, percentage, and oil yield. The effects of density were significant on most of the attributes except for the 1000-seed weight and oil percentage, however, the leaf removal treatment effects were only significant on the total biomass and the grain harvest index. The seed yield was significantly increased with the increase in density, as the lowest and the highest seed yield were observed in 60000 and 160000 plants per hectare density. Generally, it can be said that with the increase in the lower leaves of the plant, which are the biggest consumers, it can be cultivated in large densities and obtain a good yield, both in terms of quality and quantity.*

Keywords: *Oil-Bearing Crop, Oil Percentage, Grain Harvest Index, Qasim Hybrid*

INTRODUCTION

Sunflower is among the most important oil-bearing crops in the world, cultivated for supplying the edible oil (Arshi, 1994). In a report by Ahmadi et al., (2016), the sunflower cultivation area have been expressed to be 8246 hectares from which, 8776 tons of seed have been harvested. The sunflower seed has 15-20% protein (Khajepuor, 2004). The sunflower protein is comparable to other oily seeds protein in terms of nutrition quality, consisting of 50 to 60% of Globulin, 17 to 23% of albumin, 11 to 17% of glutamine, and 1 to 4% of proline (Aliari, 2000).

The accurate recognition of the climatic requirements, conditions, and industrial plants production method, especially the sunflower, for increasing their yield per area, is of great importance (Khajepour, 1996). The selection of the proper density is one of the important factors in crops management, based on the plant form and environmental conditions. The increase in yield due to the density increase in sunflower plant, is affected by temperature, Soil Fertility, Climate, Planting Method, the cultivar, and variety (Dippen Burk et al, 2001). Holt and Campbell (1984) also conducted an experiment on 4 varieties of sunflower under 40000, 55000, 70000, and 85000 plants density per hectare. They reported that plant density has a significant effect on all attributes except the seed yield. Majid and Schteiter (1988) studied the 32000, 49000, 66000, and 84000 plant densities per hectare for four hybrids of sunflower and reported that the highest seed yield was obtained for 83000 density. They asserted that by the increase in plant density from 55000 to 83000 plants per hectare, the seed yield per area was increased in all cultivars while in 111000 plants density per hectare, the seed yield per area was decreased. Emami et al., (2004) studying the oily sunflower plant cultivar densities of 50000, 75000, and 140000 per hectare, reported the significance of the effects of this density on oil percentage at the significance level of 1%. They concluded that with the increase in plant density, the seed's oil level is decreased.

In the sunflower plant, leaves are the first source of photosynthetic material needed to fill seeds, and any reduction or inefficiency of them, due to factors such as pests, diseases, mechanical damage, and hail, would lead to reduction of photosynthetic materials transfer to seeds and reduction of yield. So, identification yield reduction due to leaf loss plays an important role in yield prediction (Morro et al, 2001).

Studying the leaves removal and its effects on the yield, paying attention to the recognition and reactions to plant population, is required for applied objectives, since the plant density, as the largest usable managerial variable, is greatly dependent on provision of the environmental sources in adaptation of the plant requirements, as in low densities, the available sources are not properly utilized and it leads to significant reduction in seed and biological yield (Smith, 2005). Abbaspour et al. (2005) concluded that leaf removal at the initial stages of pollination has the greatest effects on attributes such as head diameter, percentage of hollow seeds, 1000-seed weight, and harvest index, followed by grain and oil yields. The results of Abdi et al.'s (2007) experiment showed that leaf removal at the end of vegetative growth and the onset of reproductive growth has the highest effects on the stem height. In the Morro et al.'s experiment (2001), the highest decrease in yield was obtained by 100% removal of the leaves in reproductive growth to the physiological ripeness. They reported the reason behind this phenomenon to be the reduction in two components of yield, i.e., 1000-seed weight and the number of the seeds per head. In Roshdi et al.'s experiment (2006), the application of different levels of leaf removal led to the decrease in head diameter, however it did not significantly affect it. Johnson (2003) also reported that the 1000-seed weight reduction in 100% leaf removal treatment at the onset of reproductive stage, was high. In this regard, this experiment was conducted aiming to study the possibility of increasing the plant density per area through lower leaves removal.

Method and Material:

The current study was conducted in 2016 crop year in Research farm of Khuzestan University of Agricultural Sciences and Natural Resources, in 2016 crop year, in Molasani, located 36 Kilometers northeast of Ahwaz City. The field of the experiment site which was left fallow, was irrigated one month before the start of the experiment to provide conditions for combating weeds. This study was a factorial experiment conducted in the form of a randomized complete block design with three replications on sunflower plant. The experiment factors included the plant density per area in the three levels of 60000, 110000, and 160000 plants per a hectare and leaf removal at four levels of lower leaves removal at the flowering stage (without leaf removal, with ¼ leaf removal, with 2/4 leaf removal, and with ¾ leaf removal). Based on the previous studies, the distance between the planting lines was 75cm and the distances on the planting rows were 9, 13, and 24cm, based on the density treatment. Each sub-terrace included 5 stacks and the length of each stack was 3.5 m. The cultivar used for the purpose of this study was Qasim hybrid. Since the sunflower is an oil-bearing plant and needs phosphate and potassium fertilizers, before formation of the stack, the amount of 300 kg/ha Triple Superphosphate and 200 kg/ha of potassium sulfate, and 50% nitrogen required (150 kg/ha) was spread by hand on the ground, which was placed in the depth of the soil by the formation of clay and stacks. The planting depth was considered to be 3cm. The first irrigation was carried out exactly at the time of planting on 12/03/2017. In the 4- and 6-leaf stage of plant, after thinning, the remaining 50% of nitrogen was poured into the groove at the foot of the bushes. During the experiment, weed control was carried out on several occasions though weeding by hand. In order to prevent the damage by the birds, the plant heads, after pollination, were placed in nylon bags with lots of holes that were made for this purpose. For determination of the quantitative attributes of the plant in one square meter, the sampling was done based on the plant density and after omission of the margins. Then, the biological yield was measured in each terrace. The seeds and the heads of the harvested plants were separated and weighed, and afterwards, were revised by 9% humidity, to be reported as the seed yield. The harvest index was calculated trough the following equation:

$$100 \times (\text{total plant weight}/\text{total seed weight}) = \text{HI (percent)}$$

For calculation of 1000-seed weight, the weights of two 500-seed samples which were randomly chosen, were calculated, providing that there was not a 6% difference between the two samples. For calculation of the oil percentage, the Soxhlet Extraction Device was used (Eivaz Zade, 2010) and the oil yield was obtained through the following equation:

$$\text{Oil yield} = \text{oil percentage} \times \text{seed yield}$$

The statistical analysis of the data including the variance analysis and comparison between the means were carried out by SAS Software. Also, the data means comparison was carried out by LSD Test, and the graphs were drawn by the Excel Software.

1000-seed Weight:

The results of the variance analysis (table 1) showed a significant difference at the 5% significance level in terms of the mutual effects and leaf removal. However, the effects of other factors were not significant. The mean comparison of the mutual effects of density treatment × leaf removal showed that in the control group treatment without leaf removal, with the increase in plant density from 60000 to 160000 plants per hectare, the 1000-seed weight took a decreasing trend. Also, in ¼ leaf removal, the 1000-seed weight was decreasing. With 2/4 leaf removal, and increase in density, the increase in 1000-seed weight can be observed, which is justifiable regarding the fact that before reproductive growth of the plant, the accumulation and storage of sap occurs in the stems, as well as the transfer of materials to the grains takes place in the nearest place to the reservoir. In ¾ leaf removal, with the increase in density, the 1000-seed weight is approximately fixed whose reason can be the low number of the leaves (because the leaf removal occurs in at flowering stage, which would neutralize the effect of increasing the density) (table 4). Gobles and Dediu (1990) studying the 30000, 45000, and 600000 plant density per hectare on the two hybrids as Sun M20 and CW894, observed that with the increase in density, the 1000-seed weight was decreased from 61.2 to 47.8 grams.

Seed Yield:

The seed yield variance analysis showed that this attribute was placed in 1% error level under the influence of density per area (table 1). However, the leaf removal treatment and their mutual effects were not significant. Regarding the density treatments mean comparison table, the lowest yield was obtained in 60000 density (2870.83Kg/ha) and the highest yield was obtained in 160000 density (4126.50Kg/ha) (table 2). The evaluation of this table reveals that with the increase in density, the seed yield has taken an increasing trend in general, whose main reason is the increase in number plants per area from 60000 plants to 160000 plants per hectare. It can be further elaborated that probably, through the increase in density, the number of plants heads per area would be increased, however, it reduces the diameter of the heads and consequently, the number of the seeds on the head, which ultimately lead to the decrease in hollow seeds percentage and an improvement in overall yield. The reason behind the insignificance of the leaf removal effect on seed yield can be the lack of removal of ¼ of the upper leaves in all removal treatments. It should be noted that the upper ¼ leaves of the plant play the most important role in seed yield. Abbaspour et al. (2005) and Morro et al. (2001) reported similar results on reduction of seeds on head together with leaf removal.

Total Biomass:

In data variance analysis (table 1), it was revealed that in 1% error level, the mutual effects of density and leaf removal and the main effects of density and leaf removal were significant. Studying the effect of plant density on total dry matter, which was measured at the growth stage, it was observed that the density of 16 plants per square meter led to a significant increase in dry matter (table 2). The increase in the biomass in 60000 plant density led to the change in total biomass from 9985.8Kg to 17185Kg in 160000 plant density. In biomass mean comparison (table 3), it was observed that ¼ and 2/4 leaf removal, as well as control group treatment, led to the increase in dry matter from 11737.8Kg to 16191.1Kg per hectare, however, with the ¾ leaf removal, the dry matter was reduced to 14537.8Kg/ha, whose reason can be the fact that the stems remain thin, as well as the excessive leaf drop in the high densities. The mean comparison of the mutual effects of density and leaf removal revealed that with the increase in density from 60000 plants per hectare to 160000 plants, the plant biomass in 2/4 and ¾ leaf removal treatments was increased (20047Kg/ha and 21110Kg/ha, respectively), and the lowest plant biomass was obtained in 60000 plant density with ¼ leaf removal (8680Kg/ha). Jafari et al. (2006) stated that the increase in plant density led to increase in plant biomass, though it reduced the head diameter and mean seed weight.

Grain Harvest Index:

The data variance analysis (table 1) showed the significance of effects of all experimental factors at the 1% significance level, on this attribute. The highest grain harvest index was obtained in 60000 plant density per hectare (29.08%) and the lowest index was obtained in 110000 plant density per hectare (21.80%). However, the 160000 plant density again led to the increase in grain harvest index (26.55%). Elaborating this phenomenon, it can be said that in 60000 plant density, due to presence of environmental conditions and more space for plant growth, and also provision of enough food and lack of leaves overlap, greater seed yield could be obtained, while in 110000 plant density, due to the competition and the increase in plant hollow percentage, the yield was not good, that led to decrease in harvest index. In 160000 plant density, the decrease in head diameter, the increase in hollow percentage, and the competitions could be compensated by the increase in number of plants per area and consequent increase in number of heads, which led to the increase in harvest index. Investigating the mean comparison of leaf removal treatments (table 3), the control treatment (28.46%) and the ¼ leaf removal (28.94) had the highest harvest index. Table 5 shows that with the increase in density and leaf removal, the decrease in grain harvest index from 110000 plant density to 60000 plant density was obtained, however for 160000 plant density, again the grain harvest index was increased. Likely, in 110000 plant density, the toleration of density increase is still possible, but the sources limitations leads to the failure in transference of sufficient matter to destination. However, in 160000 plant density, self-revision takes place, i.e., the decrease in stem diameter is formed, that leads to the increase in harvest index. In an experiment, due to the plant density and data of cultivation, it was reported that by the increase in plant density, the leaf area index of each plant was decreased due to the internal competition, however, in general, the leaf area index was increased due to the increase in number of plants, and subsequently, the absorption of solar radiation increased and seed yield per area was increased (Jamshidi, 2007).

Oil Percentage:

The results of variance analysis (table 1) showed that mutual effect of density treatment with leaf removal was significant at the 1% significance level, however, the effects of other factors were not significant. In mean comparison of oil percentage under influence of density (table 2), with the increase in plant density from 60000 plants to 110000 plants, there were no significant difference as its amount was decreased from 30.74% to 28.86% for 60000 and 110000 plants density, however, with the increase in density to 160000 plants, it was slightly increased, reaching up to 30.05%. As it is shown in table 3, in mean comparison of mutual effect of density treatment, and increase in density and ¾ leaf removal, the oil percentage is reduced, however the difference between the treatments is low. Likely, the reason behind the decrease in oil percentage in ¾ leaf removal and high density, is the increase in seed yield and the negative relationship between the seed yield and oil percentage. According to the table of mean comparison, with the increase in density and leaf removal, the oil percentage was increased as the mean of the 60000 plant density was calculated as 25.75%, that of 110000 density was calculated as 28.87%, and that of 160000 density was calculated as 30.25%.

Oil Yield:

The results of variance analysis was under influence of density at the 1% significance level (table 1), however, it was significant on the leaf removal treatment and their mutual effects. In table 2, in the oil yield comparison in the density treatment, with the increase in plant density from 60000 plants to 160000 plants, the oil yield was increased from 878.32 to 1252.89Kg/ha, since it has a significant correlation with seed yield (Arnoks, 1978. By the increase in density, besides the oil percentage increase, the seed yield is also increased.

Oil harvest index:

The oil harvest index is obtained by dividing the oil yield on the biological yield of the plant multiplied by 100. The results of variance analysis showed the error probability in the main treatment of density and mutual effect at 1% level. In table 2, the mutual effect of mean comparison, by the increase in density in control treatment, the oil harvest index was increased from 24% to 35%. However, in all treatments of leaf removal, by the increase in density, the harvest index was reduced. The highest index percentage was obtained for 60000 plant density and ¼ leaf removal (34%) and the lowest index percentage was obtained for 2/4 leaf removal (20%) (Table 3).

Conclusion:

In the conducted study, the sunflower, in the climatic conditions of Khuzestan Province, and with the proper density, can have an acceptable yield. The results of the current study showed that in the high densities, the seed yield was also increased and through self-adjustment, it managed to use the environmental conditions, nutrition, and proper light. The oil and seed harvest indices were increased with the increase in density. The oil percentage, under the influence of density, did not show a significant difference with the increase in plant density from 60000 to 110000 plants, as its amount was decreased from 30.74% for 60000 plant density to 28.86% for 110000 plant density. However, with the increase in density to 160000 plants, it was slightly increased and reached up to 30.05%. In general, it can be stated that through the decrease in lower leaves of the plant, which are the biggest consumer of sources, plants with high density can be cultivated and a proper yield can be reached in terms of quality and quantity.

References

1. Abbaspour, Fatemeh, Mohammad. Reza. Shakiba, Hooshang. Aliyari and Mostafa Valizadeh 2005. Effects of leaf removal at the beginning of pollination stage on oil yield and its components in two sunflower cultivars. Journal of Agricultural Science, Vol. 15, No. 1: 7-1.
2. Abdi Sakineh And Amir, Fayyaz Bakhshi and Morteza, Ghadimzade. 2007. Effect of different levels of leaf removal in plant production stages on seed yield and oil percentage of two hybrids of sunflower. Journal of Science and Technology of Agriculture and Natural Resources. Volume 11. Number 40. Page 255-245.
3. Ahmadi, Karim., Gholizadeh, Heshmatollah. Abazadeh, Hamid Reza. Hatami, Farshad. Fazli Estabraq, Hosseinpour, Robabeh. Kazimian, Arezoo, And Wafiyi, Maryam. (2016). Agricultural Statistics of the Crop Years 2014. Ministry of Agricultural Jihad, Deputy Director of Planning and Economic, ICT Center. Tehran. P. 89.
4. Aliari, H., & Shekari, F., (2000), “Oil-bearing seeds (Agriculture and Physiology)”, Tabriz University Press. P.182.
5. Arnox M. 1978. Morphological and Physiological bases for the breeding of sunflower. Helia. 1:15-53.
6. Arshi, Yousef. 1996. Science and technology of sunflower. Iran Cotton and Oil Seeds Department.
7. Diepenbork, W. Long M. and Fell B.(2001). Yield and quality of sunflower as affected by row spacing and plant density. Australian Journal of Agricultural Research Vol 52 pp:29-36
8. Emami, B. Shiranirad, H., Naderi, M. and A. Banitaba.2004. Effects of palnting Arrangement on yield and yield compoment of three variety of sunflower in Esfahan. The Proceeding of Iranian Crop Science Congress. Gilan University, 3-5 September, 342 PP.
9. Eyvazzadeh, O., Seyyedain. Ardebili, M., Chamani, M., and Darvish, F., 2010.Evaluation of fatty acid composition and stability of sose hip oil. Food Technology and Nutrient. 7: 66_74.
10. Gubbels; G. H. and W. Dedio. 1990. Response of sunflower hybrids to row spacing . Can. Journal. Plant Science. 68:1125-1127.
11. Holt; N. W. and Campbell ; S. J. 1984. effect of plant density on the agronomic derformance of sunflower on dry land Journal plant science. 64:596-605.
12. Jafari, F, H. Amir Hallaji, M. Yarnia, H, and M. Valizadeh, 2006. Effect of Planting Density on Yield, Morphological and Phenological Characteristics of Sunflower Azargol Hybrid. Abstract of the articles of the 9th Iranian Congress of Agriculture and Plant Breeding. University of Tehran. Pardis Abourihan. Page 59.
13. Jamshidi , E.(2007). Determination of the suitable plant density and planting date for new hybrid(CMS-26*R103) of sunflower (Helliantus Annuus L.) MSc Thesis. Terbia Mo dares University. Tehran Iran.
14. Johnson. B. L,. 2003. Dwarf sunflower response to row spacing stand reduction, and defoliation at different growth stages. Canadian gournal of plant Science 83: 319_329.
15. Khajepour, M.R., 2004. Industrial plants. Isfahan University of Technology.
16. Khajepour, Mohammad Reza. 1996. Production of industrial plants. Jihad Publishing, Isfahan University of Technology.
17. Majid, H. R. and A. A. Schneiter. 1988. Semidwardwarf and conventional height sunflower performance at five plant populations. Agronomy Journal 80: 821-824.
18. Muro, J., I. Irigoyen. A. F. Milition and C. Lamsfus. 2001. Defoliation effects on sunflower yield reduction. Agron. J. 93: 634_637.

19. Roshdi, Mohsen, Sasan. Rezaodost and Jawad. Khalili Mahale. (2006) Investigating the Effect of Density and Leaves on Developmental Steps on Yield and Yield Components of Nut Sunflowers. Abstract of the articles of the 9th Congress of Agronomy and Plant Breeding Sciences of Iran, Tehran University, Aboureyhan pardis, p. 95.
20. Smith, D. L. and C. Hamel. (2005). (Emam, Y. and Seghateleslami, M. J.)Crop Yield Physiology and Processes. Shiraz University Press 376 PP.

Table 1: the variance analysis of 1000-seed weight, seed yield, total biomass, seed harvest index, oil percentage, oil yield, oil harvest index

Source of change	Degree of freedom	Mean square						
		1000-seed weight	Seed yield	Total biomass	Seed harvest index	Oil percentage	Oil yield	Oil harvest index
Block	2	ns61/29	ns563611/11	ns9829411/1	ns3/41	ns9/57	ns12445/12	ns1/59
Density	2	ns6/17	5939652/78**	158439536/1**	**163/69	ns10/78	**575721/91	**19/56
Leaf removal	3	ns12/56	ns328888/89	**33301358/2	**106/72	ns11/632	ns72838/94	ns6/30
density × leaf removal	6	77/28*	ns221875/00	**39605547/3	127/75**	60/10**	ns41161/41	15/95**
Error	22	21/54	306338/38	2314832/3	21/08	12/61	33988/71	2/57
Coefficient of changes (percent)	-	9/87	16/49	13/12	17/78	11/88	18/43	20/72

* and ** are significant at 5% and 1% error levels and ns stands for not significant

Table 2: the mean comparison of seed yield, total biomass, and harvest index under the density treatment

Density (plant per hectare)	Seed yield (kilogram per hectare)	Total biomass (KG/ha)	Seed harvest index (percent)
60000	b2870/83	c9985/8	a29/08
110000	b3033/33	b14445	b21/80
160000	a4162/50	a17185	a26/55
LSD	468/61	1541/5	3/88

The similar letters in each column are indicative of lack of significant difference at 5% error level in LSD test

Table 3: mean comparison of seed yield, total biomass, and sunflower yield index under leaf removal treatment

Treatment (leaf removal)	Seed yield (kilogram per hectare)	Total biomass (KG/ha)	Seed harvest index (percent)	Seed yield (kilogram per hectare)
Control	a3111/1	c11737/8		a28/46
¼ leaf removal	a3555/6	bc13021/1		a28/94
2/4 leaf removal	a3444/4	a16191/1		b21/90
¾ leaf removal	a3311/1	ab14537/8		b23/94
LSD	541/1	1779/9		4/48

The similar letters in each column are indicative of lack of significant difference at 5% error level in LSD test

Table 4: mean comparison of mutual effect of density and leaf removal on 1000-seed weight, total biomass, seed and oil harvest index, and oil percentage

Treatment combination	1000-seed weight	Total biomass (KG/ha)	Harvest index	Oil percentage (percent)	Oil harvest index (percent)
D1L0	bcd46	cd10200	cd26	cd26	de7
D1L1	ab50	d8680	ab36	bc30	ab11
D1L2	d41	cd10360	cd26	a38	abc10
D1L3	bcd47	cd10710	bc29	bcd29	bcd8
D2L0	abc49	b15520	d20	bcd30	de6
D2L1	bcd45	c12300	cd26	bcd28/5	cd7
D2L2	abcd48	ab18200	d19	d24	e5
D2L3	bcd47	c12000	cd23	ab33	cd8
D3L0	cd41	cd9500	a40	bcd29	a12
D3L1	bcd45	ab18100	cd25	ab33	bcd8

D3L2	a56	a20050	d21	bc30	de6
D3L3	bcd48	a21110	d20	bcd29	de6

The similar letters in each column are indicative of lack of significant difference at 5% error level in LSD test

D1L0, D1L1, D1L2, and D1L3 stand for lack of leaf removal, ¼ leaf removal, 2/4 leaf removal, and ¾ leaf removal in 60000 plant density per hectare, respectively،

D2L0, D2L1, D2L2, and D2L3 stand for lack of leaf removal, ¼ leaf removal, 2/4 leaf removal, and ¾ leaf removal in 110000 plant density per hectare, respectively،

D3L0, D3L1, D3L2, and D3L3 stand for lack of leaf removal, ¼ leaf removal, 2/4 leaf removal, and ¾ leaf removal in 160000 plant density per hectare, respectively،

Table 5: mean comparison of sunflower oil yield under density treatment

Density (plant per hectare)	Oil yield (percent)	Oil yield (Kg/ha)	Oil harvest index
60000	[a]30/74	[b]878/32	[a]8/91
110000	[a]28/86	[b]868/88	[b]6/37
160000	[a]30/05	[a]1252/89	[a]7/93
LSD	3	150/09	1/35

The similar letters in each column are indicative of lack of significant difference at 5% error level in LSD test