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EFFECT OF PLANTING PATTERN ON RADIATION USE EFFICIENCY, YIELD AND YIELD COMPONENTS OF SUNFLOWER

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Abstract
In order to determinate suitable planting pattern of sunflower, a field experiment was done in research field of university of Mohaghegh Ardabili in 2009. Factorial experiment was done based on randomized completely block design with three replication and two factor includes cultivars with three levels (Armavirusky, Azargol and Progress) and planting pattern with three levels (75*16.5, 60*20.5 and 45*27.5) with constant density (8 plant.m^{-2}). Results of study showed that planting pattern effect was significant on head diameter and radiation use efficiency but have no significantly effect on yield and yield components. Cultivar effect was significant on yield and yield components but has no significantly on head diameter and radiation use efficiency. Among the cultivars studied, the highest grain yield (3616 kg.ha^{-1}) belonging to Azargol cultivar and lowest grain yield (3131 kg.ha^{-1}) belong to Progress cultivar. Therefore, it is better that according to exist facilities and machinery suitable planting pattern shall be selected and in the study area Azargol cultivar being planted.

Key Words: planting pattern, sunflower, yield, radiation use efficiency.

Introduction
Sunflower (*Hellianthus annus* L.) is annual crop from compositeae family which grows firm. During its growth depending on cultivar and environmental factors and between 90 to 150 days is variable [1].

Uniform plant distribution increased productivity of plants to environmental factors and it can be increased branch's productivity and yield [7, 8, 9 and 10]. Planting in rows thinner in comparison with larger row distance in optimal conditions, yield is increased [11, 12, 13 and 14]. Arashi and Jaafari [2] reported the most suitable planting pattern for mechanized cultivation in Mehr cultivar is 60×15. Abdolrahmani [3] in an experiment concluded that 80 thousand plant densities per hectar is recommended for Record cultivar in Isfahan plain. Khalifeh [4] reported that the number of seeds with increasing distance between rows increased. Chogan [5] in an experiment on different planting pattern on rainfed sunflower in Gorgan concluded that planting pattern 75×30 is suitable. Taee [6] also reported that the planting pattern 75×40 cm for dryland in Urmia for Armavirusky cultivar with mean yield 893 kg.h^{-1} is the best density.

Leaf area index is one of the most important effective factors on grain yield. If the leaf area index in short time to reach desired level. The maximum yield is obtained. Slowly increased leaf cause weak crop cover and therefore less radiation is absorbed. Finally reduced plant growth rate will be followed [14]. Appropriate planting pattern can compensate for lower leaf area index.

Materials and Methods
This experiment was done in research field of university of Mohaghegh Ardabili in 2008. Factorial experiment was done based on randomized completely block design with three replication and two factor includes cultivars with three levels (Armavirusky, Azargol and Progress) and planting pattern with three levels (75×16.5, 60×20.5 and 45×27.5) with constant density (8 plant.m^{-2}). Each plot experiment includes 5 rows of 4 m in length. After preparing the land value of 150 kg of phosphate and potassium fertilizer to the land was given as base fertilizer. 150 kg of N fertilizer two time was given the land. First 100 kg with base fertilizer and second time the rate of 50 kg was used at the time of flowering. Inside each hole at planting time three seeds were placed. Plants were thinned when the plants had 3 to 4 leaves. Irrigation during the growth was done based on plant need.

Intercepted radiation plant community was measured by using of Sunscan. Data collection was done at 12 pm. The radiation below canopy one in between rows and once on the rows were measured and their mean as the radiation passing was calculated. Accumulated radiation during the growth period was calculated by using of meteorological data.

For measuring yield and yield components when the behind of receptacle was brown, 8 plants of each plot were harvested with considering margins. Analyzing data, calculating correlation coefficient and drawing graphs was done by using of Mstat- c, SPSS and Excel respectively.

Results and Discussion

Results of analysis of variance of traits were summarized in table 1. Radiation use efficiency in different planting pattern and also interaction of cultivar×planting pattern in the 5 percent level was significant. The highest radiation use efficiency was achieved from the planting pattern 16.5×75 cm however, that planting pattern with planting pattern 20.5×60 cm was not significantly different. Among cultivars of light use efficiency was no significantly different. Also radiation use efficiency with none of the traits showed significant correlation (table 3). Atlasipak et al [15] reported significant differences in radiation use efficiency in different planting pattern in canola.

Table 1. Results of analysis of variance of studied traits.

		MS											
SV	DF	RUE	number of whole seeds	Weight of seeds	Weight of full seeds	Weight of empty seeds	Percentage empty	1000 seed weight	HI	biomass	Seed yield	Height of plant	Head Diameter
R	2	0.159^{ns}	7366.93**	64.151*	53.526*	0.876*	35.162*	53.18^{ns}	15.47*	6074.2^{ns}	409997.3*	322.465^{ns}	4.157*
V	2	0.052^{ns}	58119.15*	107.69**	130.816*	1.124**	57.921**	732.4**	240.42**	72688.2*	689695.03**	1848.927*	1.06^{ns}
P	2	0.598 *	2167.82^{ns}	7.662^{ns}	5.249^{ns}	0.39*	19.082^{ns}	30.52^{ns}	5.03^{ns}	7418.4^{ns}	50482.38^{ns}	35.19^{ns}	6.735**
V×P	4	0.061 *	3802.87^{ns}	14.927*	15.515*	0.036^{ns}	2.574^{ns}	7.36*	9.32^{ns}	5888.5^{ns}	95381.172*	871.86*	0.955*
E	16	0.137	10384.43	13.089	12.509	0.149	7.75	33.65	5.695	18496.7	83818.66	396.47	0.86
CV%		18.35	12.30	8.78	8.86	29.73	19.4	11.37	7.75	12.53	8.78	14.28	5.59

Table 2. Results of means comparisons between studied traits.

Treatment	RUE ($g.Mj^{-1}$)	Number of whole seeds	Weight of seeds (g)	Weight of full seeds (g)	Weight of empty seeds (g)	Percentage empty	1000 seed weight (g)	Harvest index (%)	Biomass ($g.m^{-2}$)	Seed yield ($kg.ha^{-1}$)	Height of plant (cm)	Head Diameter (cm)
Armavirskey	2.097^{a}	889.1^{a}	39.28^{b}	37.78^{b}	1.497^{a}	15.75^{a}	44.53^{b}	27.16^{b}	1165^{a}	3142^{b}	145.5^{a}	16.99^{a}
Azargol	1.947^{a}	737.1^{b}	45.20^{a}	44.31^{a}	0.8903^{b}	11.42^{b}	61.31^{a}	36.72^{a}	987.8^{b}	3616^{a}	123.1^{b}	16.39^{a}
prograss	2.00^{a}	858.3^{a}	39.13^{b}	37.63^{b}	1.508^{a}	15.87^{a}	47.19^{b}	28.54^{b}	1103^{ab}	3131^{b}	149.7^{a}	16.41^{a}
45×27.5	1.724^{b}	878.4^{a}	42.28^{a}	40.77^{a}	1.510^{a}	15.81^{a}	49.23^{a}	30.75^{a}	1114^{a}	3382^{a}	137.6^{a}	17.6^{a}
60×20.5	2.107^{a}	824.4^{a}	40.62^{a}	39.33^{a}	1.290^{ab}	14.35^{a}	50.39^{a}	30.10^{a}	1085^{a}	3249^{a}	141.5^{a}	16.10^{b}
75×16.5	2.214^{a}	781.7^{a}	40.71^{a}	39.62^{a}	1.094^{b}	12.89^{a}	52.91^{a}	31.59^{a}	1056^{a}	3256^{a}	139.1^{a}	16.10^{b}

Table 3. Results of means comparison between combinations treatments.

Variety	Planting Pattern	RUE ($g.Mj^{-1}$)	Weight of whole seeds (g)	Weight of full seeds (g)	1000 seed weig (g)
	45×27.5	1.910^{ab}	38.61^{ab}	36.81^{b}	41.18^{b}
Armavirskey	60×20.5	2.171^{ab}	38.07^{ab}	36.64^{b}	45.05^{ab}
	75×16.5	2.210^{ab}	41.16^{ab}	39.90^{ab}	47.36^{ab}
	45×27.5	1.501^{b}	48.53^{a}	47.52^{a}	60.78^{a}
Azargol	60×20.5	2.173^{ab}	43.86^{ab}	43.01^{ab}	61.59^{a}
	75×16.5	2.166^{ab}	43.19^{ab}	42.39^{ab}	61.57^{a}
	45×27.5	1.760^{ab}	39.70^{ab}	37.99^{ab}	45.73^{ab}
Prograss	60×20.5	1.976^{ab}	39.92^{ab}	38.33^{ab}	46.04^{ab}
	75×16.5	2.265^{a}	37.78^{b}	36.56^{b}	49.80^{ab}

Table 4. Simple correlation coefficients between traits

Radiation use efficiency (1)	1											
Height plant (2)	0.129	1										
1000 seed weight (3)	0.123	-0.344	1									
Number of whole seeds (4)	-0.334	0.174	-0.789**	1								
Percent empty (5)	-0.207	0.362	-0.828**	0.837	1							
Weight of whole seeds (6)	-0.289	-0.258	0.471*	0.156	-0.134	1						
Weight of full seeds (7)	-0.258	-0.286	0.556*	0.054	-0.235	0.994**	1					
Weight of empty seeds (8)	-0.270	0.292	-0.849**	0.938**	0.965**	-0.041	-0.147	1				
Biomass (9)	-0.017	0.293	-0.449*	0.593**	0.559**	0.146	0.082	0.585**	1			
Seed yield (10)	-0.289	-0.258	0.471*	0.156	-0.33	1.00**	0.994**	-0.041	0.146	1		
Head diameter (11)	-0.298	0.252	-0.234	0.234	0.406*	-0.012	-0.046	0.32	0.289	-0.012	1	
Harvest index (12)	-0.197	-0.45**	0.708**	-0.389*	-.56**	0.580**	0.63**	-0.518**	-0.712**	0.58**	-0.236	1

Effect of planting pattern other than the radiation use efficiency on the head diameter was significant (Table 1). Greatest head diameter was obtained from the planting pattern 27.5×45 cm (Table 2) which can be due to plant distance row on more and more uniform distribution of plants and is creating an atmosphere for growth [16]. Agele et al. [17] reported that between rows narrower head diameter is decreased.

Some researchers announced that the planting pattern had no significant effect on yield and yield components [10] but other researchers reported that the planting pattern had significant effect on yield and yield components [16, 17]. Cultivar effect on seed number in receptacle was significant (Table 1) and Armavirusky showed superiority over other varieties, although that Progress cultivar was not significantly

different (Table 2). This can be due to the larger receptacle and smaller seeds.

Cultivar effect on the total grain weight, filled and unfilled seed weight and unfilled percentage were significant (Table 1). Effect of cultivar on total seed weight, filled and unfilled seed weight and unfilled seed percentage was significant (Table 1). Maximum total seeds weight (45.2 gr) and filled seeds weight of receptacle belong to Azargol and however Armavirusky and Progress had more seed number but its seeds had less weight. Minimum unfilled seed weight and unfilled seed percentage belong to Azargol and were significant with two other cultivar (Table 2) but maximum unfilled seed weight belong to Progress cultivar and has no significant with Armavirusky cultivar.

Taghdiri et al [18] reported that lowest unfilled seed number belongs to Azargol cultivar in a study. Differences between cultivars in yield are related to genetic characteristics, percentage fertility flowers and insect pollinator activity. Therefore Azoegol with having large flowers percentage of empty seed is less. Cutivar effect on seed thousand weight and harvest index was significant (Table 1). Maximum seed thousand weight (61.31 gr) belongs to Armavirusky cultivar that was not significant with Progress cultivar (47.19 gr). Taghdiri et al [18] reported that among cultivars studied the highest seed hundred weight (5.61 gr) belonging to Azargol. Harvest index of Azargol (36.72%) was superior of the two other cultivars. Harvest index with traits such as seed thousand weight (r=0.71**), total grain weight (r=0.58**) and seed yield (r=0.58**) showed a significant positive correlation and with traits such as plant height (r=-0.45*), unfilled seed percentage (r=-0.56**), unfilled seed weight (r=-0.58**) and shoot dry weight (r=-0.71**) significant negative correlation (table 3).

Cultivar effect on shoot dry weight was significant (Table 1). Maximum dry weight (1165 $g.m^{-2}$) belongs to Armavirusky cultivar. Seed yield was affected by cultivar and maximum and minimum seed yield belong to Azorgol and Progress cultivars respectively (table 2).

Azorgol cultivar had less dry weight and seed number in comparison with other two cultivars can be concluded that the superiority in grain yield is related to more seed thousand weight, harvest index and less unfilled seed.

Conclusion

The results of this study showed that Azorgol cultivar with producing less foliage and higher seed yield than other cultivars studied is significant superior. Because between studied planting patterns was no significant differences in seed yield, then the planting pattern 16.5×75 is superior to other planting pattern, because of the availability of machinery for this type of row spacing. Therefore Azorgol cultivar with planting pattern 16.5×75 is recommended for this area.

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