International Journal of Agriculture and Crop Sciences.
Available online at www.ijagcs.com
IJACS/2015/8-2/187-193
ISSN 2227-670X ©2015 IJACS Journal

IJACS

The Effect of Chilling at the End of the Growth Period on Yield and Morphological Traits of Sunflower Hybrids

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ABSTRACT: In order to study grain yield and some of the morphological traits of sunflower hybrids, a factorial experiment was conducted based on complete randomized block design with three replications in research farm of Agricultural jihad Ministry of Ardel town during the 2012. This experiment comprised of three implantation dates, including: May 13th (which is considered to be the current date of implantation in that region), June 5th and June 28th and had three hybrids of Azargol (control), Farokh and Aline59* R-864. The results of the research indicated that number of leaves and leaf surface during the harvest, petiole length, the third petiole length under the tray, stem length, bush height, stem diameter, chlorophyll concentration (a) and (b), dry matter in maturity stage and grain yield have been all affected by the implantation date. On the other hand the traits of the angle of leaf- lamina to horizon, angle of leaf to stem and bending of tray did not become significant affected by implantation date. There was a significant difference between the hybrids according to: leaf surface during the harvest stage, petiole length, the third petiole length under the tray, bush length, bush height, stem diameter, chlorophyll concentration (a) and dry matter during the maturity stage. Also grain yield, number of leaves during the harvest stage, the angle of leaf- lamina to horizon, angle of leaf to stem, bending of the stem and chlorophyll concentration (b) did not become significant affected by hybrid difference. The maximum grain yield, leaf surface during the harvest stage, petiole length, the third petiole length under the tray, stem length, bush height, stem diameter and dry matter during the Maturity stage, were observed during the implantation date of May 13th x Azargol hybrid. And also the maximum amount in trait number of leaves during the maturity stage was observed in implantation date of May 13th in Aline59*R-864 hybrid. The maximum amount of chlorophyll concentration (a) and chlorophyll (b) was related to Azargol hybrid during the implantation date of June 28th.

Key words: sunflower, Chilling at the end of the Growth period, implantation date, hybrid, morphological traits

INTRODUCTION

Sunflower yield like other crops is influenced by different factors including type, date of planting, density, moisture and soil fertility, temperature and radiation. Sunflower reacts to date of planting and plant density in different environments of production. These two factors play an important role in yield and oil percentage of this plant (Khajepur, 1991; Allard and Garner, 1990; Izquierdo et al., 2006). Hasan et al. (2005) who were considering the effect of seasonal factors on growth of sunflower reported that bush height and stem diameter of sunflowers which were planted during spring, was much more than those planted during winter. They attributed creation of sunflowers with high stem in spring to desirable conditions of growth during the growth phase. The amount of light that the plant uses depends on intensity and quality of light, distance between leaf and the source, pigments existing in the leaf as well as the duration of light and leaf age, leaf structure, and its chlorophyll amount (Kafi et al., 2000). Among factors influencing the amount of chlorophyll we can refer to radiation difference, plant density, type and status of nutrients, particularly Nitrogen, which causes color change in leaves (Tod et al., 2005). Different angles of leaves have been defined and illustrated by Doyt

(1965). These ideal patterns vary between near horizontal state (less than 35 degrees from horizontal state) to inclined state to near vertical state (more than 60 degrees from horizontal state). Throneboss and Angus (1975) conducted a study in which they observed that leaves of different species of plants have various angles. Leaves' angles influence radiation reception and its distribution in plant community. Many of the plant communities that were studied regarding leaves' angles have horizontal leaves (Throneboss and Angus 1975). This may be due to natural selection of these plants in order to compete with weeds in plant community. The growth of many of the weeds is stopped because of shade-making of plants. Therefore, by the existence of maximum shade-making on weeds during the growth season, crops weaken weeds regarding absorption of nutrients, radiation and water. Leaves' angles may vary between different layers of plant community. Plant communities whose upper leaves are vertical and they become more horizontal as we move towards the earth, are considered as the most ideal vegetation (Throneboss and Angus 1975).

MATERIALS AND METHODS

This study was conducted in 2012 in research farm of Agriculture Jihad of Ardal town in Chaharmahal va Bakhtiary province with 32 degrees, 00 minute and 16.4 seconds longitude, and 50 degrees, 39 minutes and 31.9 seconds latitude, with 1850 meter altitude, and in 75 kilometers to Shahre Kord. Based on Copen classification, this region is classified as a region with cool temperate climate with hot and dry summers. This experiment was conducted as factorial in the form of base design of randomized block with three replications. Two factors considered include date of planting on May 13th (T_1, control and common planting date of the region), June 5th (T_2) and June 28th (T_3) and three hybrids of Azargol (C_1), Farokh (C_2) and Aline 59*R-864 (C_3) were conducted based on the above model. Distance of cultivation rows were 60 centimeters and the distance of two bushes in one row was 25 centimeters in zigzag pattern. Each plot included 8 rows of cultivation with 8 meters long. Measurements include number of leaves in harvest phase, leaf area in harvest phase, dry matter in maturity stage, size of the third petiole under the head, stem length, bush height, stem diameter, angle of the leaf lamina to horizon, angle of the leaf to stem, percentage of stem bending, chlorophyll a, chlorophyll b, and grain yield. In order to calculate leaf area after trimming it, three bushes were removed from each plot and the length and width of its leaves were measured using a ruler. After determining the area of all leaves in different experimental treatments, leaf area was measured using the following equation (Sobhani, 2000).

$$S = 0.655(L \times W) - 0.00011(L \times W)^2$$

where S is leaf area, L and W are maximum length and width of the green leaf of sunflower (ESmaeelnezhad 2007 and 2008). In order to calculate concentration of chlorophyll a and b, spectrophotometry device and the following equations were used (Esmaeelnezhad 2007 and 2008) (quoted by Arnon 1975).

Milligram of chlorophyll a per leaf gram = $$[12.7(D663) - 2.59(D645)] \times \frac{V}{1000 \times W}$$

Milligram of chlorophyll a per leaf gram = $$[22.9(D645) - 4.69(D663)] \times \frac{V}{1000 \times W}$$

where D is optical density of chlorophyll extract in a given wavelength, V is the final volume of chlorophyll extract in 80% acetone, W is fresh weight of the sample leaf in gram. The angle of petiole was determined using the following equation (Baldy 1972).

$tg = \frac{AC\,edge}{AB\,edge}$ and $tg = \frac{AB\,edge}{BC\,edge}$

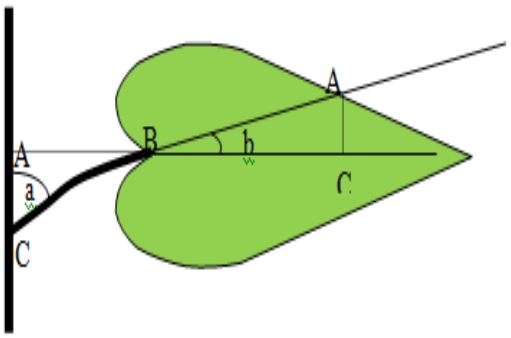

Figure 1. angle of leaf to stem and angle of leaf lamina to horizon

Percentage of the bush bending was calculated as “distance of head to the highest point of the stem” divided by “bush height” (Nabipour et al., 2005).

(8.3)

$$percentage\ of\ the\ bush\ bending = \frac{distance\ of\ the\ head\ to\ the\ highest\ point\ of\ the\ stem}{bush\ height} \times 100$$

Variance analysis was conducted using MSTAT-C software, and traits mean was conducted using test of mean comparison LSD.

RESULTS AND DISCUSSION

Number of green leaves at harvest

The results (Table.1) showed that the effect of sowing date on number of leaves at harvest were significant at the 1% probability level. Table (1-2) showed that the Farokh hybrid and Aline59 * R-864 hybrid were not significantly different and the date of the first sowing has the highest number of leaves at harvest (28/10 numbers) compared to the rest of the varieties. This probably reflects the greater number of leaves affected by genetic factors more than environmental factors. Hybrids were not significantly different in the number of leaves (Table.1). Sowing date × hybrid interaction on leaf number was significant at the 1% probability level (Table.1). As table (1-2) shows, the highest number of leaves (13.6) belonged to the Aline59 * R-864 hybrid, and the smallest number in the third sowing date (5.26) also belonged to the Aline59 * R-864 hybrid. By delaying the sowing date and facing of the plant vegetative stages to cold, plant goes to the reproductive stage earlier to complete its development stages and does not complete its development in the vegetative stage. For this reason, it probably produces less leaves. On the other hand, because the harvesting stage faces low temperatures due to the sowing date of May 15 and May 7 and due to the decrease in light intensity, some of the leaves near the surface become dry and waste, and that is itself a cause of reduction in the number of leaves in different sowing dates and hybrids. The research results were consistent with the results of Ebrahim Kafuri (1379).

Green leaf area at harvest

The effects of sowing date and hybrid on the green leaf area were significant at the 1% probability level (Table.1). Hybrids planted on the first, second and third sowing dates were significantly different from each other. The first sowing date with an average leaf area of 95.09 cm^2 led to the highest leaf area; and the third sowing date, with an average leaf area of 36.77 cm^2 was the lowest among all the sowing dates. The results of Table (2) show that the Azargol hybrid with an average leaf area of 114.09 cm^2 had the highest green leaf area and the Aline59 * R-864 hybrid with an average leaf area of 47.34 cm^2 was accounted for the least green leaf area. Here is the interaction result in table (2): the highest green leaf area (163.21 cm^2) belonged to the Azargol hybrid at the first sowing date and the smallest leaf area (16.09 cm^2) belonged to the Aline59 * R-864 hybrid at the third sowing date. Delaying the sowing date leads to a gradual decrease in green leaf area and this probably occurs due to bad weather conditions and especially heat stress and facing the various development stages to these bad conditions. Green leaf area has a great impact on the level of plant photosynthesis and thus can also affect plant yield. The research results were consistent with the results of Ebrahim Kafuri (1379).

Petiole length

Petiole length is one of the attributes that is considered in researches related to plant density for measuring the optic competition. In this research this attribute was studied for hybrid comparison. The effect of sowing date and hybrid on average size of the petioles were significant at the 1% probability level (Table.1). The results of Table (2) shows that the Azargol hybrid with an average petiole size of 7.69 cm has the largest petiole size and the Aline59 * R-864 hybrid, with an average petiole size of 4.1 cm has the minimum petiole size. The maximum petiole size (7.69 cm) belonged to the Azargol hybrid at the first sowing date and the minimum size (2.64 cm) belonged to the Aline59 * R-864 hybrid in the third sowing date. In their experiments on sunflower sowing densities, Shell et al (1975) found that with increasing density, the lamina and leaf petiole angle decreases towards the horizon. Also, by keeping the sunflower plant in closed chamber, it will have less leaf angular variation and leaf spin in contrast to the outdoor environment sunflower plant. The results of this study were consistent with Shell et al, 1975.

Shoot length

The Table results (1) shows that the effect of sowing date on plant average length was significant at the 1% probability level. The Table results (2) shows that with delaying the sowing date from May 23 to June 7, the plant reduced the average length, so that the first sowing date had the highest plant length. On the third sowing, the plant length was approximately 35 cm less than the plant with the first sowing date; but the first and

second sowing dates showed no significant difference in these characteristics. Reducing plant length in the second and third sowing dates is due to the shorter vegetative period of plant, given that the average temperature was higher during the vegetative period with summer sowing date. Plants have progressed more rapidly toward reproductive period and did not have much time for shoot elongation. Usually in the weeding plants like sunflower, reducing plant length also reduces the number of leaves per plant and possibly reduces the production of photosynthetic products and shrinks the head, and this ultimately reduces the yield. Allahyari (1376) also reported that the delay in sowing date decreases the plant length; he also inferred that as a result of the thermal pressure due to delay in sowing dates, the growing season duration falls to reach the upper length. The Azargol hybrid with the average shoot length of 107.48 cm had the largest shoot length and the Aline59 * R-864 hybrid had the lowest shoot length of 95.75 cm. the interaction of sowing date × cultivar on shoot length was not significant (Table.1) as it can be seen in the table (2), the highest shoot length (129.27 cm) belonged to the Azargol hybrid with the first sowing date and the lowest (72.66 cm) belonged to the Aline59 * R-864 hybrid with the third sowing date. The results of this study were consistent with Ebrahim Kafuri results (1379).

Plant height

The effect of sowing date and hybrid difference on plant height was significant at the 1% probability level (Table.1). As in new varieties and hybrids, the plant is suffered from hogging due to genetic changes, heavy heads and reducing the bird damage, so the plant height is defined as the size according to the length of the highest point of stem bending vertical to the surface. Regarding the results (Table.2), the first sowing date, with average 89.07 cm has the highest length and the third sowing date, with an average 65.29 cm, has the lowest length ranked among the sowing dates. The results of the table 2 shows that the Azargol hybrid with the average length of 85.33 cm, has the largest size and the Aline59 * R-864 hybrid with the average length of 72.33 cm has the minimum size. The interaction sowing date × cultivar was not significant on plant height (Table.1). As the Table (2) shows, the highest plant height (101.44 cm) belonged to Azargol in the first sowing date and the smallest plant height (62.33 cm) belonged to the Aline59 * R-864 hybrid in the third sowing date. The plant height is affected by plant length, shoot diameter, head weight. The more the plant has higher length and head weight, the greater is the bending.

Shoot diameter

The effect of sowing date and cultivar on shoot diameter was significant at the 1% probability level (Table.1), but by checking out the shoot diameter it was observed that the date of the first sowing, has the maximum shoot diameter with the average of 15.33 mm, and the reason is probably that the thermal conditions were suitable planted with the sowing date of April 23, and therefore the diameter was more than that of the other sowing dates. Also in the third sowing date, due to lower temperature, plant spends more energy dealing with this type of stress. Hybrid differences were not significant in terms of shoot diameter (Table.1). The interaction of sowing date × cultivar on shoot diameter was significant at 1% probability level (Table.1). Shoot diameter is one of the attributes that relate directly to the vegetative situation and transportation of the photosynthetic products to the head and thus affects the grain yield (Dedieu, 1986).

Leaf angle to the horizon

The effect of sowing date and interaction of sowing date × hybrid on the lamina angle to the horizon was not significant (Table.1). Leaf angle to the horizon is one of the attributes that considered in density-related investigation for optical competition of the plant. The purpose of this attribute investigation was the comparison of the hybrids. Taghavi et al (1385) reported that with increasing density, the optical loss coefficient and petiole angle were reduced and thus less energy was received from the sun by the leaves and they expressed this mechanism as a resistance against the thermal and moisture stress.

Leaf to shoot angle

The effect of sowing date and hybrids and the interaction of sowing date × hybrid on the leaf to shoot angle were not significant (Table.1). The leaf to shoot angle is one of the attributes that are examined in researches related to plant density and light competition. The purpose of this attribute investigation was the comparison of the hybrids. Spatial arrangement of the aerial parts is one of the factors affecting the absorption of incoming radiation in vegetation at different stages of the life cycle of a plant (Benunovoty, 1987).The results of this study were consistent with Taghavi et al (1385).

The percentage of shoot bending

The effect of sowing date and hybrid and the interaction of sowing date × hybrid on the percentage of the bending was not significant (Table.1). The larger plant heads are belonged to the taller and stronger plants and there is a direct relationship between the size and the bending of the head towards the ground. Shoot

bending has also contributed in reducing bird damage. Nabipour et al (1384) showed no significant effect of block on shoot bending.

Chlorophyll a

The results of table 1 showed that the effect of sowing date on chlorophyll b was significant at the 1% probability level. The hybrids with the third sowing date, with the average of 0.84 mg chlorophyll a per gram of leaf were accounted for the highest concentration of chlorophyll. The Table results (2) show that Azargol hybrid with the average concentration of 42/0 mg chlorophyll a per gram of leaves had the greatest amount. The interaction of sowing date × hybrid on chlorophyll a concentrations were significant at the 1% probability level (Table.1). According to table 2-1, it is observed that the highest concentrations of chlorophyll a (1.026 mg chlorophyll a per gram of leaf) belonged to the Azargol hybrid with the third sowing date and the smallest (0.03 mg chlorophyll a per gram of leaves) belonged to the Aline59 * R-864 hybrid with the first sowing date. Among the factors affecting chlorophyll content are the difference of radiation, plant density, cultivar and nutrients status, especially nitrogen that leads to changing the color (Todd et al, 2005).Cold resistance is due to a set of different factors such as the accumulation of chlorophyll concentrations, chloroplast integrity photosynthetic capacity and Asmolyte accumulation, and this gene expression is inductive and cause resistance to cold (Jahanbakhsh Gadeh Kahriz et al. 2006). In this study also the third sewing date and faced to low temperature, and the plants increase resistance to low temperature by concentrating their chlorophyll a.

Chlorophyll b

The results of table 1 showed that the effect of sowing date on chlorophyll b was significant at the 1% probability level. Hybrid with the third sowing date with an average of 0.218 mg chlorophyll b per gram of leaves with the first sowing date with average of 0.008 mg chlorophyll b per gram of leaves was accounted for the highest and lowest chlorophyll content, respectively. The interaction of sowing date × hybrid on the chlorophyll b concentration was not significant (Table.1). According to Table (2) it is observed that the highest concentrations of chlorophyll b (0.264 milligrams of chlorophyll b per gram of leaf) belongs to Azargol with the third sowing date and the lowest (0.007 milligrams of chlorophyll b per gram of leaf) belongs to Azargol with the first sowing date. During cold, adaptation occurs by biochemical and physiological changes, including increased probability levels of sugars, soluble proteins, antioxidant enzymes, proline, chlorophyll fluorescence, chlorophyll content, the appearance of new protein isoforms and membrane lipid composition changes (Karimzadeh et al. 2006).

Grain yield

Grain yield was affected by sowing date and it was significant at the 1% probability level (Table.1). Average yields obtained showed that the sowing date of 23 May and 15 June and 7 July, had significant superiority over one another statistically (Table.2). Accordingly, it can be inferred that the plants obtained from these three planting dates resulted in higher yields due to having different stages of development and maximum use of ambient conditions during the growing season. The absolute maximum yield was achieved from the first planting date of May 23, and the lowest yield was achieved from the third planting date of May 7. Stresses such as temperature increase and light intensity during the vegetative stage can have negative effects on vegetative growth, reproductive growth, or both (Ehdaei & Nourmohammadi, 1363; Arshi, 1368; Mayrana et al, 1990; Owen, 1983; Silva and Songi, 1985). There were no significant differences between hybrids for grain yield (Table.1). In the experiment, Ahmad et al (2005) reported that the grain yield of sunflower is damaged from the early and late sowing dates. The interaction of sowing date × hybrid on grain yield was significant at the 1% probability level (Table.1). As the Table (2) shows, the highest yield (3674.83 kg per hectare) belonged to the Azargol with the first sowing date and the lowest (523.94 kg per hectare) belonged to the Aline59 * R-864 with the third sowing. Azargol, due to the superiority of most of the traits measured on the date of the first sowing, was able to account for the highest yield on this date. This Hybrid with the first sowing date possessed the highest grain weight, head diameter, dry weight and leaf area compared to the other hybrids. Aline59 * R-864 with the third sowing date obtained the lowest yield due to the weakness in most traits measured compared to the other hybrids.

CONCLUSIONS

based on the results of this study, for obtaining maximum yield and maximum morphological traits like leaf area, petiole length, shoot length, plant height, shoot diameter and dry matter, the sowing date of May 23 and the Azargol hybrid seem to be the best options compared to the other sowing dates and the other hybrid, respectively.

Table 1. of variance analysis of studied traits

Mean Square (MS) Grain yield	Chlorophyll b concentration	Chlorophyll a concentration	Tray bending	Angle of leaf to stem	Angle of leaf lamina to horizon	Stem diameter	Bush height	Stem length	Petiole length	Leaf area in harvest phase	Number of leaves in harvest phase	Freedom degree	Changes sources
188007.9ns	0.001ns	0.002ns	7.07ns	1.93ns	9.82ns	0.055ns	66.45ns	139.63ns	0.025ns	4.502ns	0.078ns	2	Repetition
12540919.5**	0.12**	1.68**	40.74ns	1.81ns	0.084ns	152.48**	1291.91**	2979.4**	6.14**	8025.83**	8.766**	2	Planting date
202650.41ns	0.002ns	0.032**	28.51ns	40.07ns	73.6ns	18.51**	397.36**	345.35*	17.43**	13339.6**	0.286ns	2	Hybrid
877356.84*	0.002ns	0.022**	18.05ns	30.75ns	3.47ns	1.75ns	62.06ns	116.79ns	2.37ns	1982.88**	23.701**	4	Planting date × Hybrid
264090.184	0.001	0.003	25.741	14.197	23.085	2.858	55.195	67.351	0.518	19.652	0.596	16	Error
22.80	27.94	16.53	20.09	10.28	13.48	15.49	9.52	8.17	13.73	6.37	8.42	-	Changes coefficient (percent)

*, **, ns: significant at probability level of 5 and 1 percent and no significant difference, respectively
Means were independently compared using LSD test at probability level of 1 and 5 Perce

Table 2. of comparison of means of studied traits

Grain yield (kilogram per hectare)	Chlorophyll a concentration (milligram per leaf gram)	Chlorophyll a concentration (milligram per leaf gram)	Tray bending (percent)	Angle of leaf to stem (degree)	Angle of leaf lamina to horizon (degree)	Stem diameter (millimeter)	Bush height (cm)	Bush length (cm)	Petiole length (cm)	Green leaf area in harvest phase (square cm)	Green leaf at harvest phase (number)	treatments
Planting date												
3435.78	0.008	0.033	22.94	36.14	35.59	15.33	89.07	116.31	5.86	95.1	10.3	13th May (control)
2250.63	0.031	0.185	25.68	36.99	35.75	10.23	79.74	104.51	5.57	77.06	8.8	5th June
1074.91	0.218	0.844	27.13	36.82	35.58	7.18	65.29	80.6	4.3	36.7	8.42	28th June
%1- 972.65	%1- 0.06	%1- 0.1	Ns- 8.82	Ns- 6.56	Ns- 8.35	%1- 3.2	%1- 14.06	%1- 15.53	%1- 3.49	%1- 8.39	%1- 1.46	LSD
Hybrid												
2272.11	0.102	0.42	23.44	38.9	32.9	12.56	85.33	107.5	6.79	114.1	9.00	Azargol (control)
2393.81	0.072	0.32	25.32	36.18	35.42	9.97	76.44	98.2	4.83	71.49	9.16	Farokh
2095.39	0.084	0.319	26.9	34.81	38.6	10.2	72.33	95.8	4.10	47.34	9.36	Aline59*R-864
Ns- 892.95	Ns- 0.05	%1- 0.1	Ns- 8.82	Ns- 6.56	Ns- 8.35	%1- 3.2	%1- 14.06	%5- 14.26	%1- 5.94	%1- 8.39	Ns- 1.34	LSD
Planting date × Hybrid												
3674.8	0.007	0.036	20.73	39.61	32.51	17.87	101.44	129.27	7.69	163.2	8.73	13th May × Azargol (control)
3225.9	0.003	0.032	23.57	32.00	34.99	13.61	86.44	110.93	4.32	45.42	8.53	13th May × Farokh
3406.5	0.013	0.030	24.53	36.82	39.26	14.50	79.33	108.73	5.56	76.66	13.6	13th May×Aline
1618.6	0.034	0.207	23.28	39.10	33.64	11.53	86.89	104.53	7.00	123.79	8.33	5th June × Azargol
2777.5	0.025	0.179	28.17	36.69	36.33	9.40	76.99	103.13	5.58	58.11	8.87	5th June × Farokh
1255.6	0.035	0.168	25.59	35.18	37.29	9.75	75.33	105.87	4.11	49.28	9.2	5th June× Aline
1522.8	0.264	1.026	26.31	38.16	32.54	8.29	67.66	88.67	5.69	55.29	9.93	28th June × Azargol
1177.9	0.187	0.749	24.20	39.87	34.94	6.90	65.89	80.47	4.59	38.93	10.07	28th June × Farokh
523.9	0.204	0.758	30.89	32.44	39.27	6.35	62.33	72.67	2.64	16.09	5.27	28th June×Aline
%5- 1546.63	Ns- 0.09	%1- 0.18	Ns- 15.27	Ns- 11.34	Ns-14.46	Ns- 5.09	Ns- 22.36	Ns- 24.7	Ns- 6.95	%1- 14.53	%1- 2.53	LSD

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