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OIL YIELD, FATTY ACID PROFILE, ACHENE YIELD AND YIELD ATTRIBUTES OF SUNFLOWER (*HELIANTHUS ANNUUS* L.) AS INFLUENCED BY AUTUMN PLANTING CONDITIONS IN ISLAMABAD

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Abstract

Field experiment was conducted at National Agricultural Research Center, Islamabad during autumn, 2009, to explore the role of temperature on oil contents, fatty acids composition and heat units accumulation of local sunflower hybrids. Fourteen sunflower hybrids (Hysun-33, SMH-9902, SMH-9903, SMH-9904, SMH-9905, SMH-9906, SMH-9908, SMH-9909, SMH-9910, SMH-9911, SMH-9912, SMH-9913, SMH-9914, and SMH-9915 were sown in randomized complete block design with 4 replications under field conditions. Significant variation ($p<0.05\%$) was found among the sunflower hybrids for oil contents, oil compositions, heat units accumulation, yield and yield components. Significantly highest oil contents and oil quality (highest linoleic acid %) were recorded by sunflower hybrid SMH-9914. On average Hysun-33, SMH-9910, SMH-9902 and SMH-9912 performed best for plant height, head diameter and achene yield Kg ha^{-1}. It was concluded from the above study that the hybrids which accumulated higher heat units were late maturing, but hybrids with lesser heat units were early maturing. It was also inferred that the temperature positively influence the oil quality of sunflower hybrids under autumn planting conditions.

Introduction

Among environmental attributes temperature regulates plant growth and development processes variably (Ritche & Ne Smith, 1991; Killi & Altunbay, 2005; Kaleem *et al.,* 2009; Hamayun *et al*., 2010, 2010a). Thermal time provides a measurement of physiological time as it is related to many poikilothermic species of plants (Trudgill *et al.,* 2005). Sunflower (*Helianthus annuus* L.) is one of the most important oilseed crops containing high quality edible oil (Bakht *et al.,* 2010). In Pakistan, the crop is grown with imported seed of hybrids. The cost of imported seed is very high and has also adaptability problems locally. Potential yield of sunflower in Pakistan is about 4000 Kg ha^{-1} (Raheela *et al.,* 2012). It is a temperate zone crop and can thrive well under various climatic and soil conditions. It can resist early frost in autumn season that usually kills maize and soybean. The climatic adaptation of sunflower under various temperature regimes have been reported by various researchers in their research investigations (Khalifa *et al.,* 2000; Hassan *et al.,* 2005; Qadir *et al.,* 2006). It can be grown successfully in two growth season (spring and autumn), due to a wide adaptation in Pakistan (Rana *et al.,* 1991). In autumn season sunflower crop is sown at high temperature and high humidity of July-August. Its germination and early vegetative growth undergoes high to medium temperature of August and September before entering into reproductive stage. The reproductive phase of autumn crop takes off at medium temperature of October. It matures and is harvested under low temperatures of November and December (Khalifa *et al*., 2000).

Cumulative effects of environmental variables not only modify plant phenology, but also cause many physiological as well as qualitative changes. Variations in environmental conditions affect crop growth, development, yield, oil and fatty acid accumulation through agronomic, physiological and qualitative functions of the crop plant (Kaleem *et al.,* 2010a). Sunflower yields and oil quality is influenced by a number of plant's developmental and physiomorphic adaptations to the environment (Hassan *et al.,* 2005). Crop exhibits environmental disparity due to its wider adoptability (Kaleem *et al.,* 2010b). Crop sown during autumn season accumulates lesser heat units and influence the physio-morphic traits from germination to physiological maturity (Qadir *et al.,* 2007). Being a C_4 plant it is sensitive to cold temperatures conditions prevailing in autumn season and declared as warm season plant when compared with C_3 plants (Brouder *et al.,* 2008). Keeping in view the importance of temperature in growth, physiology and biochemical attributes a research study was undertaken to analyze the affect of temperature on growth, yield, oil contents, oil composition and heat units accumulation of sunflower hybrids under autumn planting conditions.

Materials and Methods

Field experiment was conducted in autumn, 2009 at National Agricultural Research Center (NARC) Islamabad. The experimental area lies at 33°38'N and 73° 08'E and altitude of 518 m above sea level in Islamabad. Climate of the area is sub humid to humid type and form a part of Pothwar land. The soil of the area is alkaline (pH, 7.1 to 8.0), non-saline (EC, 0.08 to 0.73 ds m^{-2}) and slightly to moderately calcareous. Organic matter ranges between 0.31 to 2.50% in the surface soils and 0.15 to 2.5% in sub surface. Extractable P and K ranged from 1.4 to 36.4 mg kg^{-1} and 23.9 to 190 mg kg^{-1} respectively. Fourteen sunflower hybrids (Hysun-33, SMH-9902, SMH-9903, SMH-9904, SMH-9905, SMH-9906, SMH-9908, SMH-9909, SMH-9910, SMH-9911, SMH-9912, SMH-9913, SMH-9914, and SMH-9915) were sown in the autumn season. The Hysun-33 was used as check hybrid. The experiment was laid out in a randomized complete block design replicated four times. A uniform dose of fertilizer @ 120 kg N and 60 kg P_2O_5 ha^{-1} was applied in the form of urea and DAP. The inter and intra row space was maintained at 75cm and 25cm in net plot

size of 5m × 3m. The seeds were sown with the help of dibbler putting three seeds hill^{-1}. After emergence one plant hill^{-1} was maintained by manual thinning. Weeds were controlled by hand weeding throughout crop life cycle. The cumulative heat units for different growth stages were calculated by the equation of Dwyer & Stewart (1986).

$$CHU = \sum_{t_1}^{t_2} [(T_{max} + T_{min})/2\text{-}8]$$

where $[(T_{max}+T_{min})/2\text{-}8] \geq 0$, T_{max} and T_{min} were daily maximum and minimum air temperatures in degree centigrade and t_1 and t_2 were the time intervals. Base temperature for sunflower development is 8°C (Sadras & Hali, 1988). At physiological maturity central two rows were harvested at physiological maturity. The crop was harvested manually. The plants were left for seven days for sun drying. Heads were thrashed manually and grains cleaned with small blower. Seed oil contents were determined by following the NMR (Nuclear Magnetic Resonance apparatus) Model Oxford-4000 (Granlund & Zimmerman, 1975), while fatty acids (palmitic, stearic, oleic and linoleic acids) composition was determined by shimadzo gas liquid chromatograph (GLC). The data thus recorded during study were subjected to Fisher's analysis of variance technique. Treatment means were compared for significance using Duncan's Multiple Range Test at $p<0.05\%$ level of probability (Steel & Torrie, 1980). The temperature and rainfall data recorded from August-2009 to November-2009 is presented in the Fig. 1.

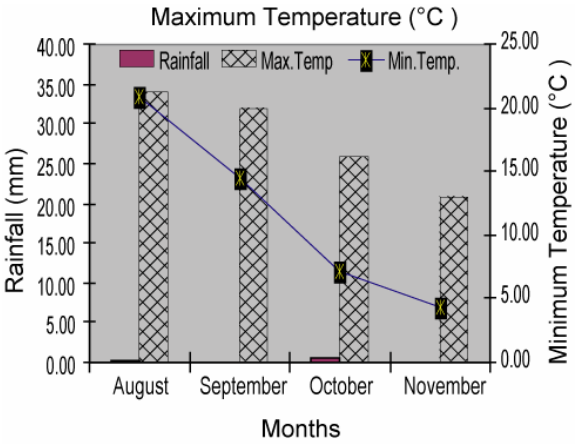

Fig. 1. Mean minimum and maximum temperature and rainfall recorded during autumn-2009.

Results and Discussion

Oil contents: The data pertaining to oil contents of sunflower hybrids is presented in the Table 1. The perusal of the data revealed that sunflower hybrid differed significantly for oil contents. The highest oil contents (38.39%) were recorded in SMH-9904. It was remained at par with Hysun-33, SMH-9915, SMH-9913, SMH-9904, SMH-9912, SMH-9903, SMH-9908 and SMH-9909. The lowest oil content (32.77%) was recorded in SMH-9911. Sunflower productivity mainly depends on the prevailing environmental conditions during life cycle of the crop. Environmental factor, especially temperature during the period of seed development and maturation might have affected oil contents in maturing cultivated sunflower seeds (Seiler, 1986; Baydar & Erbas, 2005). The effect of temperature on oil content, however, has been variable. Harris *et al.,* (1978) reported that oil content decreased as temperature increased. In early maturing hybrids high temperature probably increased the oil contents. The hybrid SMH-9914 accumulated the lowest (1390) heat units, which declared it early maturing when temperature was high. The high temperature might have favored higher oil accumulation in this hybrid. Higher oil content at higher temperature has also been reported by Unger & Thompson (1982).

Oil composition

Palmitic acid: The perusal of the data revealed significant ($p<0.05\%$) differences among sunflower hybrid for palmitic acid percentage (Table 1). The highest percentage (6.97%) of palmitic acid was observed in SMH-9913. It was at par with all other hybrids except SMH-9912, SMH-9902 and Hysun-33. The lowest (5.27%) palmitic acid was recorded in Hysun-33. The probable reason for low and high palmitic acid concentration in oil of different sunflower hybrids might be due to the affect of temperature during the physiological maturity. Hysun-33 took maximum heat units up to physiological maturity and matured late under low temperature. This low temperature might have favored less palmitic acid accumulation. These results are in consonant with findings of Gupta & Wagle (1986) who observed similar results for palmitic acid accumulation in sunflower hybrids.

Oleic acid: The highest (17%) oleic acid was recorded in SMH-9911 (Table 1). The hybrid SMH-9915 produced lowest (12.46%) oleic acid. The increase or decrease of oleic acid in seeds of different sunflower hybrids might be due to the affect of temperature from flowering to physiological maturity. Radiation and day length could have been also other factors contributing for variation in oleic acid concentration as reported by Filipescu & Stoenescu (1978) at a wide range of latitude, although they considered temperature as a major factor. The results of the current study are in agreement with findings of Tremolieres (1984) who investigated that oleic acid was favored by warm temperature in sunflower. Similar results regarding oleic acid contents were observed by Aslam *et al.,* (2010) in sunflower genotypes planted in the field under high temperature conditions.

Linoleic acid: The highest linoleic acid (76.78%) was observed in SMH-9914 (Table 1). It was at par with all other hybrids except SMH-9909. The lowest (73.19%) linoleic acid was recorded in SMH-9909. These findings confirmed the results of Tremolieres & Jacques (1984) who reported that linoleic acid accumulated preferentially at low temperature and oleic acid at high temperature. In this study all the hybrids accumulated almost the same concentration of linoleic acid. However, hybrids SMH-9914 and SMH-9915 have special edge over others. These hybrids accumulated lowest heat units from sowing to physiological maturity. It also gave the clue that lower heat units probably favored better oil quality.

Table 1. Oil contents, Oil composition, Heat units, Head diameter and Achene yield Kg ha^{-1} of field grown sunflower hybrids.

S.NO	Oil contents (%)	Palmitic acid (%)	Oleic acid (%)	Linoleic acid (%)	HUFI	HUFC	HUPM	Head Diameter(cm)	Achene yield Kg ha^{-1}
Hysun-33	38.14 a	5.27 d	14.94 abcde	75.79 ab	1128.0 a	1190.0 a	1522.0 a	17.83 a	3495.0 b
SMH-9902	32.87 b	5.69 cd	16.19 abc	74.24 ab	982.2 bcde	1079.0 bcd	1404.0 cde	15.63 bc	3584.0 a
SMH-9903	35.27ab	5.96 abcd	14.18 bcde	76.1 ab	960.1 de	1016.0	1382.0 f	14.50 c	3397.7 c
SMH-9904	36.23 ab	6.321 abc	14.02 bcde	75.81 ab	974.7 cde	1069.0 bcde	1395.0 ef	14.80 c	2865.0 h
SMH-9905	33.02 b	6.24 abcd	15.83 abcd	74.34 ab	986.0 bcde	1077.0 bcd	1401.0 de	16.00 abc	2981.0 e
SMH-9906	33.06 b	6.39 abc	14.88 abcde	75.03 ab	989.5 bcde	1068.0 bcde	1399.0 de	16.25 abc	2948.0 f
SMH-9908	34.82 ab	6.34 abc	15.32 abcd	74.63 ab	996.5 bcd	1091.0 bc	1415.0 bc	15.43 bc	2931.7 g
SMH-9909	34.24 ab	6.35 abc	16.81 ab	73.19 b	989.7 bcde	1089.0 bc	1426.0 bc	15.60 bc	3397.7 c
SMH-9910	33.79 b	6.15 abcd	14.04 bcde	76.34 ab	1012.0 b	1096.0 b	1412.0 cd	17.38 ab	2981.0 e
SMH-9911	32.77 b	6.80 ab	17.00 a	73.49 ab	1001.0 bc	1079.0 bcd	1401.0 de	14.55 c	2850.7 i
SMH-9912	35.74 ab	5.84 bcd	14.63 abcde	76.28 ab	963.5 de	1054.0 cdef	1394.0 ef	16.18 abc	3248.3 d
SMH-9913	36.67 ab	6.97 a	13.06 de	75.64 ab	971.1 cde	1041.0 def	1397.0 e	15.40 bc	2948.0 f
SMH-9914	38.39 a	6.06 abcd	13.65 cde	76.78 a	963.7 de	1030.0 ef	1395.0 ef	15.00 c	2682.3 j
SMH-9915	36.87 ab	6.86 ab	12.46 e	76.70 ab	956.1 e	1048.0 def	1390.0 ef	15.27 bc	2682.0 j
LSD(0.05)	3.598	0.883	2.38	2.962	31.97	34.90	12.12	1.842	2.987

Means sharing a common letter within a column do not differ significantly at 5 % probability level. HUFI; Heat units for flower initiation, HUFC; heat units for flower completion, HUPM; Heat units for physiological maturity.

Heat units for flower initiation: The perusal of data exhibited significant variation ($p<0.05$) among sunflower hybrids for heat units for flower initiation (Table 1). The highest (1128.0) heat units for flower initiation were recorded in Hysun-33. Heat units for flower initiation among rest of the hybrids were in the range of 950-990. Lowest heat units were recorded in SMH-9915. The highest heat units accumulation by Hysun-33 declares that it was due to its long vegetative growth period and its origin from low temperature area. These results are in agreement with those of Salera & Baldini (1998 II) who reported similar findings among sunflower hybrids in Italy.

Heat units for flower completion: The data revealed non-significant (Table 1) variation among sunflower hybrids for heat units for flower completion. Hybrids were divided in to three groups based on heat units accumulation. The hybrids with higher (1080-1100) heat units, hybrid with intermediate (1040-1080) and hybrids with lower (1000-1040) heat units. The results of the current research study are in line with those of Toit & Human (1982).

Heat units for physiological maturity: Data revealed significant ($p<0.05$) variation in heat units accumulation among sunflower hybrids (Table 1). The highest (1522.0) heat units were recorded in Hysun-33 at physiological maturity sage. The lowest heat units (1382.0) were recorded in SMH-9903. The maximum heat units accumulation by Hysun-33 declares it as late maturing. The main reason for this might be due to its long vegetative period and origin from low temperature area. The findings of current research investigation are similar with those of Salera & Baldini (1998 II) who reported similar results among different sunflower hybrids for heat heats accumulation till physiological maturity.

Plant height: The data showed (Table 1) that tallest (148.0 cm) plants were observed in SMH-9910. Plant height of a crop is the function of the combined effects of genetic makeup and the environment. The other hybrids such as Hysun-33, SMH-9912, SMH-9909, SMH-9904, SMH-9915, SMH-9902 and SMH-9908 were at par with SMH-9910 for plant height. The shortest (128.3 cm) plant height was recorded in SMH-9914. The variation in plant height of various sunflower hybrids in the current research study might be due to their different genetic makeup. These results are in agreement with those of Zambrana & Menchaca (1978) who observed variation in plant height of different sunflower cultivars planted in the field.

Head diameter: Data regarding head diameter of various sunflower hybrids revealed significant differences among them (Table 1). The largest head (17.83 cm) was recorded in Hysun-33 which was at par with SMH-9910, SMH-9906, SMH-9912 and SMH-9905. The shortest head (14.5 cm) was recorded in SMH-9903. The difference in head diameter of different sunflower hybrids may probably be due to their different genetic potential. Similar results have been reported by Khan *et al.,* (1989).

Achene yield per hectare: Final achene yield is the result of additive effect of all the yield components under the effect of a set of specific environmental conditions. Data pertaining to achene yield of sunflower hybrids showed significant ($p<0.05$) differences among them (Table 1). The highest achene yield (3584 kg ha^{-1}) was recorded in SMH-9902. The Hysun-33 ranked 2nd for achene yield (3495.0 kg ha^{-1}). The lowest achene yield (2466.7 kg ha^{-1}) was recorded in SMH-9906. SMH-9902 exhibited 31.25% increase in achene yield over SMH-9906. The main reason for variation in achene yield among the various sunflower hybrids might be due to their different genetic

make up and effect of environment. The results of the present study are in conformity of those of Khan *et al.*, (1989) who reported significant variation in achene yield among different sunflower hybrids.

Conclusion

Hybrids maturing early in the autumn season at high temperature accumulated less heat units but higher oil contents. Hysun-33, SMH-9910, SMH-9912 and SMH-9902 showed best performance for head diameter. However higher linoleic acid and oil contents were recorded by SMH-9914. This hybrid was declared as hybrid with superior quality oil.

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