PERFORMANCE OF AUTUMN PLANTED SUNFLOWER (*Hlianthus annuus* L.) HYBRIDS UNDER DIFFERENT PLANTING PATTERNS

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Studies were undertaken to evaluate the response of autumn planted sunflower (*Helianthus annuus* L.) hybrids to different planting patterns at the Agronomic Research Farm, University of Agriculture, Faisalabad during, 2004 and 2005. Treatments comprised of two hybrids (FH-314 and FH-245) grown under six different planting patterns viz., 60 x 15 cm, 60 x 22.5 cm, 60 x 30 cm, 75 x 15 cm, 75 x 22.5 cm, & 75 x 30 cm. Data collected on achene yield and yield components were subjected to standard statistical analysis. The average data showed that hybrid FH-314 produced significantly higher achene yield (2487.24 kg ha^{-1}) than that of FH-245. The highest achene yield (2821.89 kg ha^{-1}) was obtained when the crop was sown with the planting pattern of 60 cm x 22.5 cm.
Kywords: *Helianthus annuus*, hybrids, planting patterns, yield, Pakistan

INTRODUCTION

Pakistan population is increasing rapidly hence, the demand for edible oil is increasing. Pakistan is facing a serious shortage of edible oil because the domestic production is too low to meet our total demand. Thus country is constrained to import edible oil in large quantities involving huge expenditure in terms of foreign exchange. A developing country like ours cannot afford to pay such a huge amount indeed. So it is crucial to enhance the domestic production to meet the increasing demand of edible oils.

After mineral oil, edible oil is the second largest import item in Pakistan. Total domestic requirement of edible oil for 2005-06 was 2.110 million tons, of which 26.5% (0.560 m. t) came from local production and remaining 73.5 % (1.550 m .t) was imported from abroad (GOP, 2006a)

Oil contribution from cotton seed is 62.50% in the total national edible oil production in the country (PODB, 2006). But cotton is primarily grown for its fiber with edible oil as a by-product. It is not bred for oil because its seed oil content is negatively correlated with fiber. Therefore, breeding cotton for increasing oil content is counter economic (PODB, 1997).

Rapeseed and mustard are the major winter oilseed crops and constitute about 10.15% of the domestic edible oil production (GOP, 2006b). Unfortunately, rapeseed and mustard oil is not regular cooking oil due to the presence of higher erucic acid and glucosinolates and therefore, cannot be used more than 5% in oil blending for ghee manufacturing (PODB, 1995).

Therefore, we must search for non-conventional oilseed crops. For this the most promising crops are sunflower, soybean and safflower. Although, soybean enjoys a lot of production benefits but due to processing at conventional expeller plants soybean and safflower contribute a little (less than 1%), towards meeting the oil deficiency.

Thus, Sunflower remains the best choice because it can be grown twice a year and its seed has excellent quality oil with ideal combination of saturated and poly-unsaturated fatty acids, which are important for the reduction of high serum cholesterol levels, and its oil cake contains higher amount of protein (40-44%) and balanced amino acids (Balasubramaniyan & Palaniappan, 2001). But average yield recovery is very low against the possessed potential of cultivars in the field. Kraevskii *et al*. (1991) planted sunflower hybrids at 30,000, 40,000 to 50,000 plants ha^{-1} and concluded that capitulum diameter, stem girth, seed number per head and 1000-seed weight were decreased as plant density increased from 30,000 to 50,000 plants ha^{-1}. Hussain (1994) concluded that various quantitative and qualitative characters of sunflower such as leaf area plant^{-1}, stem girth, disc diameter, number of seeds head^{-1}, seed weight head^{-1} and protein percentage increased progressively with the decrease in population. Killi F. (2004) performed an experiment to determine the response of oilseed (P-6482) and confection (Inegol) sunflower cultivars to plant density and N levels. The experiment comprised of three plant populations (23800 (P1), 35710 (P2) and 71420 (P3) plant ha^{-1}) and N levels [0 (N_0), 60 (N_{60}) and 120 (N_{120}) kg ha^{-1}]. N60 treatment gave highest seed (4.3 t ha^{-1}) and oil yield (1.7 t ha^{-1}).

Ekin *et al*. (2005) conducted an experiment on six sunflower varieties (NSH-01, NSH-712, NSH-43, NSH-111, TR-6149 and 64 A52) in Van, Turkey with a stand density of 55000 plants ha^{-1}. It was concluded that TR-6149, NSH-43 and NSH-111 were considered the best cultivars, having high oil and seed yields under irrigated conditions.

Keeping this in vision, the present study was undertaken to determine an appropriate planting pattern to achieve the maximum yield of sunflower hybrids.

MATERIALS AND METHODS

The present studies were conducted to determine a suitable planting pattern for harvesting the maximum yield of sunflower (*Helianthus annuus* L.) hybrids FH-314 & FH-245 at the Agronomic Research Farm, University of Agriculture, Faisalabad during, 2004 and 2005. The experiment was laid out in randomized complete block design (RCBD) with split plot arrangement and replicated three times. Net plot size was 3.0 m x 4.5 m. Hybrids were kept in main plots and planting patterns in sub-plots. The experiment consisted of six planting patterns viz., 60 x 15 cm, 60 x 22.5 cm, 60 x 30 cm, 75 x 15 cm, 75 x 22.5 cm, & 75 x 30 cm, respectively.

Seedbed was prepared by cultivating the soil for 3-4 times with tractor mounted cultivator each followed by planking. Sowing was done with the help of dibbler using seed rate of 8 kg ha^{-1} in the last week of August. Fertilizer dose was 120:60 NP kg ha^{-1}, where half of N plus full phosphorus were applied at sowing, while remaining N was applied with first irrigation after 20 days of sowing. Appropriate plant protection measures were adopted to keep the crop free of weeds, insect pests and diseases. Observations on various agronomic characters were recorded by using standard procedures.

The data collected were statistically analyzed using the Fisher's Analysis of variance technique and LSD test at 5% probability was used to compare the differences among treatments means (Steel *et* al., 1997).

Table 1. Effect of planting patterns on number of plants at harvest, days taken to 50% flowering and days to maturity of sunflower hybrids

Hybrid	Number of plants at harvest (m^{-2})			Days taken to 50% flowering			Days to maturity		
	2004	2005	Mean	2004	2005	Mean	2004	2005	Mean
FH-314	7.20 ^{NS}	7.20 ^{NS}	7.20 ^{NS}	67.00 a	65.00 a	66.00 a	97.00 a	95.00 a	96.00 a
FH-245	7.19	7.19	7.19	61.00 b	59.00 b	60.00 b	91.11 b	89.11 b	90.11 b
LSD 5%	0.04	0.06	0.02	1.09	1.09	0.49	2.66	2.66	1.21
PLANTING PATTERNS (P)									
S_1= 60 x 15 cm	11.09 a	11.09 a	11.09 a	62.00 b	60.00 b	61.00 b	92.00 b	90.00 b	91.00 b
S_2= 60 x 22.5 cm	7.38 c	7.37 c	7.38 c	64.00 ab	62.00 ab	63.00 ab	94.00 ab	92.00 ab	93.00 ab
S_3= 60 x 30 cm	5.52 e	5.53 e	5.53 e	66.00 a	64.00 a	65.00 a	96.33 a	94.00 a	95.33 a
S_4= 75x 15 cm	8.84 b	8.84 b	8.84 b	62.00 b	60.00 b	61.00 b	92.00 b	90.00 b	91.00 b
S_5= 75x 22.5 cm	5.90 d	5.90 d	5.90 d	64.00 ab	62.00 ab	63.00 ab	94.00 ab	92.00 ab	93.00 ab
S_6= 75x 30cm	4.42 f	4.42 f	4.42 f	66.00 a	64.00 a	65.00 a	96.00 a	94.00 a	95.00 a
LSD 5%	0.03	0.03	0.03	2.61	2.61	2.53	3.00	3.00	2.90

Mean in the same column having different letters differ significantly (P = 0.05)
NS = Non-significant

RESULTS AND DISCUSSION

Number of plants at harvest (m^{-2})

One of the major constraints in growing sunflower in many regions is the difficulty in establishing a good crop stand. Optimum plant population per unit area ensures good crop stand, which ultimately leads to higher crop yield. There was non-significant difference between plant population m^{-2} of the two sunflower hybrids (Table-1) during 2004, 2005 and two years mean as well.

As regards planting patterns, all treatments differed significantly from each other with respect to number of plants m^{-2}. During 2004 treatment S_1 (60cm x 15cm) produced maximum (11.09) number of plants m^{-2}, while minimum (4.42) number of plants m^{-2} were recorded in case of S_6 (75cm x 30cm) treatment. Almost similar trend was noted during 2005 and in two years mean values. In the present studies the significant differences in plant population were attributed to the varying plant spacing.

Days taken to 50% flowering

Data presented in table Table-1 show a significant difference in days to flowering of sunflower hybrids in both the years. In 2004, FH-314 took more time (67 days) to flower than by FH-245, which took 61 days to flower. Similar trend was observed in 2005 and the average of two years data.

Planting patterns significantly influenced days to 50% flowering during both the years, as well as in two years mean data. During 2004, treatment S_3 (60cm x 30cm) and S_6 (75cm x 30cm) took maximum (66) number of days to 50% flower, while minimum (62) number of days to 50% flowering was noted in case of S_1 (60cm x 15cm) and S_4 (75cm x 15cm) treatment. Almost similar trend was noted during 2005 and in two years mean values. The possible reason of taking more number of days to 50% flower in S_3 and S_6 could be wider plant spacing with less plant competition, which delayed 50% flowering. Ogunremi (1983) also endorsed significant effect of plant spacing on days to 50% flowering of sunflower crop.

Days to maturity

In 2004, FH-314 took relatively more time (97 days) to mature than by FH-245, which took 91.11 days to reach maturity. Similar trend was observed in 2005 and the average of two years data.

Planting patterns significantly influenced days to maturity during both the years, as well as in two years mean data (Table-1). During 2004, treatment S_3 (60cm x 30cm) took maximum (96.33) number of days to mature, while minimum (92) number of days to mature were recorded in case of S_1 (60cm x 15cm) and S_4 (75cm x 15cm) treatments. Almost similar trend was noted during 2005 and in two years mean values. The possible reason of taking less number of days to mature in S_1 could be narrow plant spacing with more plant competition, which enhanced early maturity. Ogunremi (1983) also reported significant effect of plant spacing on days to maturity of sunflower crop.

Plant height at maturity

Plant height is a function of both genetic constitution of a plant and the environmental conditions under which it is grown. Data presented in table-2 show a significant difference in plant height of sunflower hybrids in both the years. In 2004, significantly taller plants (126.16cm) were produced by FH-314 than by FH-245, which produced 116.11 cm tall plants. Similar trend was observed in 2005 and the average of two years data. The reason being that FH-314 was a variety of standard height while FH-245 was a semi dwarf cultivar.

Planting patterns significantly influenced plant height during both the years. In 2004 significantly taller plants (127.66cm) were produced by S_1 (60cm x 15cm) and shortest plants (115.16 cm) were recorded in the S_6 (75cm x 30cm) treatment. Almost similar trend was observed during 2005 and in two years mean values. These results suggest that plant height increases with decrease in row spacing and decreases with increase in row spacing among sunflower plants. This may be attributed to better utilization of light, moisture and more competition within plants into crop canopy in case of narrow spaced plants as compared to wider spaced plants. Similar effect of high light intensity on plant height of narrow spaced plants has been reported by Nawaz *et al*. (2001).

Head diameter

Size of head contributes substantially to achene yield of sunflower because it influences both number of achenes head^{-1} and achene size. Table-2 exhibits that the two hybrids differed significantly in head diameter in 2004, where FH-314 produced larger head (14.71 cm) than FH-245 (13.70 cm). During 2005 and in average of two years data also, head diameter was greater in FH-314 than in FH-245.

Planting patterns significantly affected the head diameter of sunflower (Table-2). In 2004 largest head diameter (17.08 cm) was produced by S_2 (60cm x 22.5cm) and minimum head diameter (11.20 cm) was observed in the S_1 (60cm x 15cm) treatment. Almost similar trend was observed during 2005 and in two years mean values. The possible reason could be better plant growth due to proper utilization of light, moisture, nutrients and less planting competition in S_2 as compared to S_1. These results are in agreement with that of Killi F. (2004), who reported significant effect of planting patterns on head diameter of sunflower.

Number of achenes head^{-1}

It is an important yield component of sunflower. Hybrids differed significantly in producing number of achenes head^{-1} during both the years (Table-2). FH-314 produced about 14.87% more achenes head^{-1} than FH-245 during 2004. Similarly during 2005 and in average of two years data FH-314 significantly out-numbered the FH-245.

Planting patterns had a significant effect on number of achenes head^{-1}. During 2004, treatment S_2 (60cm x 22.5cm) produced maximum (654.33) number of achenes head^{-1}, and remained statistically at par with S_4 & S_5, while minimum (554.83) number of achenes head^{-1} were recorded in case of S_6 (75cm x 30cm) treatment. Almost similar trend was noted during 2005 and in two years mean values. This might be due to larger head diameter and more number of plants per unit area in S_2 as compared to S_6, which produced more number of achenes head^{-1}. These results are also endorsed by Killi F. (2004) who found significant effect of planting patterns on number of achenes head^{-1} of sunflower.

Table 2. Effect of planting patterns on plant height, head diameter and number of achenes head^{-1} of sunflower hybrids

Hybrid	Plant height (cm)			Head diameter (cm)			No. of achenes head^{-1}		
	2004	2005	Mean	2004	2005	Mean	2004	2005	Mean
FH-314	126.16 a	124.16 a	125.16 a	14.71 a	13.63 a	14.17 a	652.55 a	632.00 a	642.27 a
FH-245	116.11 b	114.11 b	115.11 b	13.70 b	12.58 b	13.14 b	555.50 b	535.00 b	545.25 b
LSD 5%	2.75	2.75	1.25	0.99	0.94	0.44	32.71	1.09	10.55
PLANTING PATTERNS (P)									
S_1= 60 x 15 cm	127.66 a	125.66 a	126.66 a	11.20 d	10.10 d	10.65 e	575.33 cd	554.33 cd	564.83 cd
S_2= 60 x 22.5 cm	121.83 ab	119.83 ab	120.83 ab	17.08 a	15.98 a	16.53 a	654.33 a	634.00 a	644.16 a
S_3= 60 x 30 cm	117.83 bc	115.83 bc	116.83 bc	12.53 cd	11.45 cd	11.99 de	594.16 bcd	573.83bcd	584.00bcd
S_4= 75x 15 cm	125.33 a	123.33 a	124.33 a	14.80 b	13.71 b	14.25 bc	612.66 abc	592.33abc	602.50 abc
S_5= 75x 22.5 cm	119.00 bc	117.00 bc	118.00 bc	15.63 ab	14.55 ab	15.09 ab	632.83 ab	612.16 ab	622.50 ab
S_6= 75x 30cm	115.16 c	113.16 c	114.16 c	14.01 bc	12.86 bc	13.44 cd	554.83 d	534.33 d	544.58 d
LSD 5%	6.31	6.31	6.11	1.65	1.70	1.62	51.16	49.72	48.88

Mean in the same column having different letters differ significantly (P = 0.05)
NS = Non-significant

1000-achene weight

1000-achene weight plays a leading role in determining the yield potential of a crop as it expresses the enormity of grain development. Data in table-3 show that the hybrids differed significantly in 1000-achene weight in 2004, where FH-314 produced significantly higher 1000-achene weight (51.29g) than FH-245 (47.25g). Similar trend was maintained during 2005 and in the mean of two years data.

Table-3 further exhibits that planting patterns, affected significantly 1000-achene weight. During 2004, maximum weight (54.79g) per 1000 achenes was recorded in S_2 (60cm x 22.5cm), while the minimum weight (43.74g) per 1000 achenes was noted in S_1 (60cm x 15cm) treatment. Almost similar trend was noted during 2005 and in two years mean values. These results are in contradiction with that of Ahmad *et al*. (1997) who reported significant effect of wider plant spacing on 1000-achene weight of sunflower.

Biological Yield

It is overall expression of biological forces embodied in a production system, which are affected by the treatments applied. A scrutiny of table-3 shows that significantly different biological yield was recorded in two hybrids during both the years. In 2004, higher biological yield (15709.01 kg ha^{-1}) was recorded in FH-314 while significantly less biological yield (13846.20 kg ha^{-1}) was observed in FH-245. Similar trend was noted in 2005 and in two years mean data.

Table 3. Effect of planting patterns on 1000-achene weight, biological yield and achene yield of sunflower hybrids

Hybrid	1000-achene weight (g)			Biological Yield (kg^{-ha})			Achene Yield (kg^{-ha})		
	2004	2005	Mean	2004	2005	Mean	2004	2005	Mean
FH-314	51.29 a	49.28 a	50.29 a	15709.01 a	14779.87 a	15244.44 a	2581.44 a	2393.04 a	2487.24 a
FH-245	47.25 b	43.25 b	45.25 b	13846.20 b	13001.58 b	13423.89 b	2385.30 b	2199.11 b	2292.20 b
LSD 5%	2.83	0.20	0.91	531.04	813.66	313.41	133.92	122.16	58.47
PLANTING PATTERNS (P)									
S_1= 60 x 15 cm	43.74 d	40.73 d	42.24 d	13613.42 d	12694.63 d	13154.02 d	2193.67 e	2015.62 e	2104.64 e
S_2= 60 x 22.5 cm	54.79 a	51.78 a	53.28 a	16195.40 a	15497.75 a	15846.58 a	2923.80 a	2719.98 a	2821.89 a
S_3= 60 x 30 cm	48.40 bc	45.39 bc	46.89 bc	14624.53 c	13698.96 c	14161.75 c	2402.31 d	2217.48 d	2309.90 d
S_4= 75x 15 cm	50.23 bc	47.25 bc	48.74 bc	15071.64bc	14147.42 bc	14609.53 bc	2540.78 c	2357.30 c	2449.04 c
S_5= 75x 22.5 cm	52.24 ab	49.23 ab	50.74 ab	15754.85ab	14816.00 ab	15285.43 ab	2730.16 b	2532.05 b	2631.11 b
S_6= 75x 30cm	46.22 cd	43.21 cd	44.72 cd	13405.78d	12489.59 d	12947.68 d	2109.49 e	1934.04 e	2021.77 e
LSD 5%	4.46	4.33	4.26	829.80	758.00	770.00	116.30	111.10	110.20

Mean in the same column having different letters differ significantly (P = 0.05)
NS = Non-significant

Planting patterns also significantly affected biological yield in both the years. It was observed that a similar pattern of biological yield was exhibited during 2004, 2005 and also in two years mean. Highest biological yield was recorded in S_2 (60cm x 22.5cm), whereas the minimum biological yield was observed in S_6 (75cm x 30cm) treatment. More biological yield in S_2 treatment was due to more dry matter accumulation and higher achene yield. The possible reason might be that plant spacing of S_2 treatment would be ideal for the plants to be utilized and had contributed towards the promotion of biological yield with a significant difference. These results are in line with findings of Steer *et al*. (1986) who reported significant effect of higher plant population (narrow row spacing) on biological yield of sunflower crop.

Achene Yield

Final achene yield is the function of cumulative effect of all the yield components under the influence of a particular set of environmental conditions. Significantly different achene yield was recorded in two hybrids during both the years (table-3). In 2004 higher achene yield (2581.44 kg ha^{-1}) was recorded in FH-314 while less achene yield (2385.30 kg ha^{-1}) was observed in FH-245. Similar trend was noted in 2005 and two years mean data. Higher achene yield in FH-314 was due to more number of achenes $head^{-1}$ than FH-245.

It was observed that a similar pattern of achene yield was exhibited during 2004, 2005 and also in two years mean. Highest achene yield (2923.80 kg ha^{-1}) was recorded in S_2 (60cm x 22.5cm), whereas, the minimum achene yield (2109.49 kg ha^{-1}) was observed in S_6 (75cm x 30cm) treatment. The reason of more achene yield in S_2 treatment might be due to more achenes $head^{-1}$, higher 1000-achene weight, larger head diameter and more number of plants per unit area. These results are supported by Zarea et al. (2005) who reported that when row spacing was reduced, grain yield increased.

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