bBIO-ECONOMICS OF AUTUMN PLANTED SUNFLOWER (*Helianthus annuus* L.) HYBRIDS UNDER DIFFERENT NPK APPLICATIONS

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Studies were undertaken to evaluate the response of autumn planted sunflower (*Helianthus annuus* L.) to different levels of N, P and K fertilizers at the Agronomic Research Farm, University of Agriculture, Faisalabad during, 2004 and 2005. Treatments comprised five N levels (0, 60, 90, 120 and 150 kg ha^{-1}), five P levels (0, 30, 60, 90 and 120 kg ha^{-1}), four K levels (0, 60, 90 and 120 kg ha^{-1}) in different combinations and two hybrids viz. FH-314 (standard height) and FH-245 (semi dwarf). Hybrid FH-314 produced significantly higher achene yield (2725.41 kg ha^{-1}) than that of FH-245. There was a progressive increase in achene yield and yield components with increasing levels of N, P and K. The highest achene yield (3023 kg ha^{-1}) and highest net benefit (Rs.19743) was obtained when the crop was fertilized @ 120:90:60 kg NPK $ha^{-1.}$
Keywords: *Helianthus annuus* , hybrids, NPK combinations, achene yield, economics.

INTRODUCTION

Due to increasing population, the demand for edible oil is increasing. Pakistan is facing a serious shortage of edible oil because the domestic production is too low 26.5 % (0.560 m. t) to meet our total demand 2.110 million tons. Thus country is constrained to import edible oil 73.5 % (1.550 m .t) in large quantities involving huge expenditure in foreign exchange (GOP, 2006). A developing country like ours cannot afford to such a huge amount indeed. So it is imperative to enhance the domestic production to meet the increasing demand of edible oils.

Sunflower 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 and Palaniappan, 2001). But average yield recovery is very low against the possessed potential of cultivars in the field. Growth, seed yield and seed oil content increased with increasing rates of nitrogen (Akhtar 2004). Gu and Gao (1998) reported that deficiency of N, P, and K decreased seed yield of hybrid sunflower by 19.4, 15.3 and 22.7%, respectively.

Keeping this in view, the present study was undertaken to determine a suitable level of N, P and K for harvesting the maximum economic returns of sunflower hybrids.

MATERIALS AND METHODS

The present studies were conducted to determine an appropriate level of N, P and K for harvesting the maximum economic returns 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 NPK levels in sub-plots. The experiment consisted of eight fertilizer treatments viz. 0-0-0, 60-0-0, 60-30-0, 90-30-30, 90-60-60, 120-90-60, 120-90-90, 150-120-90 kg ha^{-1} NPK, 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} maintaining a line-to-line distance of 75 cm and plant to plant 22.5 cm in the last week of August. Fertilizer dose of NPK in this experiment was applied as per treatment. In each case, half of N plus full phosphorus and potash were applied at sowing, while remaining N was applied with first irrigation after 20 days of sowing. Thinning was done when the crop was at 3-4 leaf stage to maintain plant to plant distance. 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.

Oil contents in seeds were determined by Soxhlet Fat Extraction method (AOAC, 1990). Gas liquid chromatography was done for determining relative composition of different fatty acids in oil (Xu et al. 1999), while nitrogen in seeds was determined according to kjeldahl method (Bremner, 1964) and converted into protein by multiplying with factor 6.25.

Economic analysis was worked out on the basis of cost of production using prevailing markets prices. 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).

RESULTS AND DISCUSSION

Leaf area index

Individual year data as well as two years average showed that effect of hybrids (except 2005) and NPK levels was significant on LAI recorded at 75 days after sowing (Table 1). In 2004 significantly higher LAI (5.96) was recorded in FH-314. Data recorded during 2005 was non-significant, whereas two years average data showed similar trend as noted in 2004. These results are supported by Ali *et al*. (2000) who while comparing sunflower hybrids reported that higher leaf area in Hysun-33 might be due to its genetic characteristic.

In 2004 maximum (6.30) LAI was recorded in T_6 (120:90:60 NPK kg ha^{-1}), while the minimum (5.02) LAI was observed in T_1 (control).Same trend was noted in 2005 and two year mean values. Ali et al. (2000) also observed significant effects of Nitrogen and phosphorus on LAI of sunflower.

Crop growth rate

Average seasonal CGR (30 DAS to 75 DAS) presented in table 1 reveals that FH-314 had significantly higher seasonal CGR (48.04 and 47.13 g m^{-2} day^{-1}) in 2004 and 2005, respectively than FH-245 (44.03 and 43.09 g m^{-2} day^{-1} in 2004 and 2005, respectively). Reddy *et al*. (2002) also observed different dry matter accumulation and CGR values in various sunflower hybrids and reported that it was the genetic potential that compelled the hybrids to grow differently even under similar conditions.

Data on seasonal CGR (Table 1) exhibit significant differences at various NPK levels, in 2004 where highest seasonal CGR (50.84 g m^{-2} day^{-1}) was found in T_6 (120:90:60 NPK kg ha^{-1}) which differed significantly from all other NPK levels with minimum CGR value in the T_1 (control) treatment. The same trend was found in two years mean values. Crop growth rate was non-significantly affected by various NPK levels in 2005. Mandal *et al*. (2002) reported that NPK did not increase dry matter accumulation but Reddy *et al*. (2002) observed significant effect of NPK on the parameter under discussion.

Plant height

Data presented in table 1 show a significant difference in plant height of sunflower hybrids in both the years. In 2004, significantly taller plants (128.91 cm) were produced by FH-314. 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 semidwarf cultivar. Similar results were reported by Tunio *et al*. (1999).

NPK levels did not significantly influence plant height during both the years, whereas two years mean data was significantly affected by these levels. In two years mean data significantly taller plants (128.33 cm) were produced by T_6 (120:90:60 NPK kg/ha^{-1}) and shortest plants (117.83 cm) were recorded in the T_1 (control) treatment. Increase in plant height with increased phosphorus level was also observed by Fagbayide *et al*. (1998).

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 (15.20 cm) than FH-245 (14.33 cm). During 2005 and in average of two year data also, head diameter was greater in FH-314 than in FH-245.

NPK levels also significantly affected the head diameter of sunflower (Table 2). In 2004, largest head diameter (18.61 cm) was produced by T6 (120:90:60 NPK kg ha^{-1}) and shortest head size (12.00 cm) was observed in the T1 (control) treatment. Almost similar trend was observed during 2005 and in two years mean values. Malik *et al*. (2004) also reported that head diameter of sunflower was increased by increasing level of N, P and K.

Number of achenes $head^{-1}$

Hybrids differed significantly in producing number of achenes $head^{-1}$ during both the years (Table 2). FH-314 produced about 16.08 % 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.

As regards NPK levels, during 2004 Treatment T_6 (120:90:60 NPK kg ha^{-1}) out numbered all other treatments, while minimum achene number $head^{-1}$ was recorded in case of T_1 (control) treatment where no NPK was applied. Almost similar trend was noted during 2005 and in two year mean values. Sadiq *et al* (2000) reported that by increasing NPK levels, number of achenes $head^{-1}$was also increased.

1000-achene weight

Table 2 shows that the two hybrids differed significantly in 1000-achene weight in 2004 where FH-314 produced significantly higher 1000-achene weight (53.83g) than FH-245 (48.68g). Similar trend was maintained in 2005 and the mean of two years data.

Table 1. Effect of NPK levels on leaf area index, crop growth rate and plant height of sunflower hybrids

Hybrids	Leaf area index 75 DAS			Crop growth rate 75 DAS ($g\ m^{-2}\ day^{-1}$)			Plant height (cm)		
	2004	2005	Mean	2004	2005	Mean	2004	2005	Mean
FH-314	5.96 a	5.59 NS	5.77 a	48.04 a	47.13 a	47.59 a	128.91 a	126.91 a	127.91 a
FH-245	5.36 b	5.01	5.18 b	44.03 b	43.09 b	43.56 b	118.91 b	116.91 b	117.91 b
LSD 5%	0.54	0.70	0.22	2.44	2.30	1.08	6.11	6.11	2.79
NPK levels (kg/ha)									
T_1(0-0-0)	5.02 e	4.68 e	4.85 f	42.39 e	41.46 NS	41.93 b	118.83 NS	116.83 NS	117.83 c
T_2 (60-0-0)	5.19 de	4.85 de	5.02 ef	43.30 de	42.26	42.78 b	120.00	118.00	119.00 bc
T_3 (60-30-0)	5.38 cde	5.03 cde	5.20 def	44.27 cde	43.26	43.76 ab	121.33	119.33	120.33 abc
T_4 (90-30-30)	5.56 bcde	5.20 bcde	5.38 cde	45.51 bcde	44.62	45.06 ab	123.16	121.16	122.16 abc
T_5 (90-60-60)	5.76 abcd	5.40 abcd	5.58 bcd	46.21 bcd	45.31	45.76 ab	124.66	122.66	123.66 abc
T_6(120-90-60)	6.30 a	5.93 a	6.12 a	50.84 a	49.77	50.30 a	129.33	127.33	128.33 a
$T_7$120-90-90)	6.12 ab	5.74 ab	5.93 ab	48.38 ab	47.74	48.06 ab	128.00	126.00	127.00 ab
T_8(150-120-90)	5.94 abc	5.57 abc	5.75 abc	47.42 bc	46.46	46.94 ab	126.00	124.00	125.00 abc
LSD 5%	0.60	0.62	0.43	3.41	10.01	7.31	9.05	9.05	8.86

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

Table 2. Effect of NPK levels on head diameter, number of achenes $head^{-1}$ and 1000-achene weight of sunflower hybrids

Hybrids	Head diameter (cm)			No. of achenes $head^{-1}$			1000-achene weight (g)		
	2004	2005	Mean	2004	2005	Mean	2004	2005	Mean
FH-314	15.20 a	14.11 a	14.65 a	679.83 a	659.66 a	669.75 a	53.83 a	51.85 a	52.84 a
FH-245	14.33 b	13.29 b	13.86 b	570.45 b	545.45 b	557.95 b	48.68 b	44.66 b	46.67 b
LSD 5%	0.71	0.75	0.33	2.03	2.41	1.01	4.04	4.05	1.84
NPK levels (kg/ha)									
T_1(0-0-0)	12.00 f	10.93 f	11.46 f	562.00 f	540.00 f	551.00 f	45.93 e	42.94 d	44.44 d
T_2 (60-0-0)	12.85 ef	11.73 ef	12.29 ef	575.33 ef	552.66 ef	564.00 ef	47.39 de	44.38 cd	45.89 cd
T_3 (60-30-0)	13.60 de	12.43 def	13.01 de	593.83def	571.00 def	582.41 def	48.82 cde	45.79 bcd	47.30 bcd
T_4 (90-30-30)	14.26 cde	13.16 cde	13.71 cde	616.66 cde	594.00 cde	605.33 cde	52.05 bcd	49.18 abc	50.61 abc
T_5 (90-60-60)	14.88 cd	13.81 cd	14.35 cd	635.33bcd	612.66 bcd	624.00 bcd	50.23 cde	47.20 bcd	48.72 bcd
T_6(120-90-60)	18.61 a	17.41 a	18.01 a	689.33 a	666.83 a	678.08 a	56.86 a	53.83 a	55.34 a
$T_7$120-90-90)	16.63 b	15.50 b	16.06 b	671.66 ab	649.16 ab	660.41 ab	53.39 abc	50.34 ab	51.87 ab
T_8(150-120-90)	15.68 bc	14.61 bc	15.15 bc	657.00 abc	634.16 abc	645.58 abc	55.38 ab	52.37 a	53.87 a
LSD 5%	1.52	1.54	1.50	52.92	52.93	51.76	4.80	4.91	4.75

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

Table further exhibits that NPK affected significantly 1000-achene weight during 2004. The highest weight (56.86g) per 1000 achenes was recorded in T_6 (120:90:60 NPK kg ha^{-1}), while the minimum weight (45.93g) per 1000 achenes was recorded in T_1 (control) treatment, where no NPK was applied. Almost similar trend was noted during 2005 and in two years mean values. Arif *et al*. (2003) reported that by increasing NP levels, 1000-achene weight was increased. Who concluded that 160 kg N ha^{-1} and 90 kg P ha^{-1} was proper dose of N and P to get maximum 1000-achene weight.

Achene Yield

Significantly different achene yield was recorded in two hybrids during both the years (Table 3). In 2004 higher achene yield (2823 kg ha^{-1}) was recorded in FH-314 while less achene yield (2582 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.

NPK levels also affected significantly achene yield in both the years. It was observed that a similar pattern of achene yield was exhibited during 2004, 2005 and also

Table 3. Effect of NPK levels on Achene yield, Achene oil contents and Achene protein content of sunflower hybrids

Hybrids	Achene yield (kg/ha)			Achene oil contents (%)			Achene protein content (%)		
	2004	2005	Mean	2004	2005	Mean	2004	2005	Mean
FH-314	2822.99 a	2627.83 a	2725.41 a	42.64 a	41.57 a	42.10 a	21.55 NS	22.61 a	22.08 a
FH-245	2581.90 b	2395.18 b	2488.54 b	39.77 b	38.74 b	39.25 b	20.72	21.75 b	21.24 b
LSD 5%	173.61	163.11	76.84	0.57	1.40	0.48	1.57	0.55	0.42
NPK levels (kg/ha)									
T_1(0-0-0)	2234.69 f	2055.52 e	2145.10 g	40.14 NS	39.11 NS	39.62 NS	17.73 e	18.76 d	18.24 d
T_2 (60-0-0)	2449.03 e	2269.42 d	2359.22 f	40.45	39.26	39.85	19.02 de	20.04 cd	19.53 cd
T_3 (60-30-0)	2501.94 de	2319.43 d	2410.69 ef	40.64	39.61	40.13	20.30 cde	21.32 bc	20.81 bc
T_4 (90-30-30)	2629.61 cd	2438.84 cd	2534.22 de	40.93	39.90	40.41	20.70 bcd	21.32 bc	21.21 bc
T_5 (90-60-60)	2793.56 bc	2599.57 bc	2696.57 cd	41.36	40.33	40.84	21.66 abc	22.69 ab	22.17 ab
T_6(120-90-60)	3126.12 a	2921.24 a	3023.68 a	42.46	41.44	41.95	23.11 ab	24.30 a	23.71 a
$T_7$120-90-90)	2971.05 ab	2773.48 ab	2872.27 ab	42.03	41.00	41.51	23.25 ab	24.27 a	23.76 a
T_8(150-120-90)	2913.58 b	2714.53 b	2814.06 bc	41.61	40.58	41.09	23.32 a	24.34 a	23.83 a
LSD 5%	178.90	174.70	172.90	4.57	4.01	4.20	2.57	2.27	2.37

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

Table 4. Economic analysis of sunflower

	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	Remarks
Seed yield	2145.10	2359.22	2410.69	2534.22	2696.57	3023.28	2872.27	2814.06	Kg ha-1
Gross income	34579.01	38030.62	38860.32	40851.62	43468.70	48735.27	46300.99	45362.64	@ Rs.645/ 40 kg
Fertilizer cost	0	1535	2701	4977	7703	9587	11147	13032	Urea, SSP, SOP @ Rs.550, 350 & 1300 per bag respectively
All other operation charges	19405	19405	19405	19405	19405	19405	19405	19405	
Total cost	19405	20940	22106	24382	27108	28992	30552	32437	
Net benefit	15174.01	17090.62	16754.32	16469.62	16360.70	19743.27	15748.99	12925.64	

in two years mean. Highest achene yield was recorded in T6 (120:90:60 NPK kg ha^{-1}), whereas the minimum achene yield was observed in T1 (control) treatment where no NPK was applied. More achene yield in T6 and T7 treatments was due to more achenes $head^{-1}$ and higher 1000-achene weight. The reason might be that these two NPK levels would be ideal for the plants to be utilized and had contributed towards the promotion of yield components with a significant difference. Increase in achene yield from T1 (control) to T2 (60:00:00 NPK kg ha^{-1}) treatment was only 8.75 – 9.42% because a minimum nutrient proportion is a requisite to ensure the desirable physiological conditions necessary for successful plant production. Nawaz *et al*. (2003) reported that nitrogen alone or in combination with phosphorous and potash significantly increased the achene yield against control.

Achene oil contents

Hybrids differed significantly in achene oil percentage during both the years (Table 3). Achene oil contents were 42.64 % in FH-314 and 39.77 % in FH-245 in 2004. Equivalent values in 2005 were 41.57% and 38.74%. Average over two years gave 42.10% and 39.25% achene oil in FH-314 and FH-245, respectively. Solangi *et al.* (1999) found significantly different achene oil content in two sunflower hybrids.

NPK levels showed non-significant effect on achene oil contents in both the years and two years mean values (Table 3). Overall, achene oil contents varied between 39.11% and 42.46%. These results are contradictory to those of Hussain *et al*.(1998) who reported significant increase in oil content and also to Kadar *et al*. (2001) who reported decline in oil contents of seeds from 50% to 45% with increasing P level.

Achene protein contents

Table 3 exhibits that achene protein contents was higher in FH-314 than FH-245 during 2004, 2005 as well as two year mean data. These differences were non-significant in 2004 but significant in 2005 and two years mean data

Table 3 also shows that NPK levels significantly affected achene protein contents during both years. In 2004, highest achene protein contents (23.32%) were found in case of treatment T8 where NPK was applied @ 150:120:90 kg ha-1. While lowest protein contents (17.73%) were recorded in T1 (control) treatment, where no NPK was applied. Similar trend was observed during 2005 and over two year data. Saleem and Malik (2004) also found significant effect of phosphorus on achene protein contents.

Economic Analysis

Table-4 reflects that highest net benefit (Rs.19743.27 ha^{-1}) was obtained from T6 (120-90-60 kg NPK ha^{-1}) while T8 (150-120-90 kg NPK ha^{-1}) resulted in least net benefit (Rs.12925.64 ha^{-1}) and control gave benefit of Rs.15174.01 ha^{-1}. So it can safely be concluded that a fertilizer dose of 120-90-60 kg NPK ha^{-1} was the most appropriate and economical level for harvesting a good sunflower crop. Malik *et al* (2004) also reported similar trend of net benefit in economic analysis of sunflower as a result of NPK fertilization.

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