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PLANTING DENSITY AND NITROGEN RATES OPTIMIZATION FOR GROWTH AND YIELD OF SUNFLOWER (*HELIANTHUS ANNUUS* L.) HYBRIDS

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ABSTRACT

Planting densities and nitrogen application rates are the major production factors contributing to the final yield of crops especially for sunflower being a non branched plant. Experiments were conducted to assess the effects of planting densities & nitrogen rates and their interaction on growth and yield of two sunflower hybrids during spring season, 2010 and 2011. In treatments, there were two hybrids (Hysun-33 and S-278), two planting densities, 8.33 and 5.55 plants m-^{2} (20 and 30 cm plant spacing) with three levels of nitrogen (100, 125 and 150 kg N ha^{-1}). The Split split plot design was used for layout of trial. The results showed significant difference for both of the hybrids in all the studied parameters except, number of plants m^{-2} in both years of experiments. In comparison of hybrids, S-278 was highest for yield and yield components while less in plant height. Averaged overall of both the years of trial, Maximum achene's yield (3.39 t ha^{-1}, 2.80 t ha^{-1}) was recorded for S-278 and Hysun-33 hybrid, respectively. Increasing plant density increased the final achene, s yield whereas, head diameter, 1000- achene's weight and seed yield per plant decreased. The Nitrogen application markedly enhanced growth and yield by affecting plant height, head diameter and thousand achene's weight. The interaction between hybrids x planting densities, and hybrids x nitrogen was significant for plant height, head diameter and achene's yield ha^{-1} but non- significant for 1000- achene's weight and plant population m^{-2}. Among hybrids the overall yield response of S-278 was highest at plant spacing 20 cm (8.33 plants m^{-2}), with125 kg ha^{-1} nitrogen application levels in both years.

Key words: achene, growth, nitrogen, planting densities, yield.

INTRODUCTION

Sunflower (*Helianthus Annuus* L.) is an important crop among oil seeds and as a source of edible oil in the world ranks the fourth next to soybean, palm oil and canola as an oil seed crop (FAS.USDA, 2008). Pakistan is facing an acute shortage of edible oil while, demand is increasing with increase in population. Millions of dollars are being spent on the import of chief food items, which is a major drain in shrinking foreign reserves of the country. The area under sunflower crop during 2010-11 was 1,108 (000 acres) with seed and oil production of 643 and 244 (000 tons), respectively (GOP, 2011).

Plant spacing is one of the most important production factors that is often manipulated in order to ensure optimum plant populations and to reduce the yield losses due to overcrowdings affecting sunflower yield and achene's oil percentage (Basha, 2000, Allam *et al.,* 2003). Mojiri and Arzani, (2003) described that increasing plant population had an incremental effect on plant height and negatively affects stem girth and head diameter. Plant population of 85000 plants ha^{-1} was recorded as suitable planting density, whereas higher than that plant population had a negative effect on achene's yield. Killiand Ozdemir (2001) used three plant populations (23800, 35710 and 71420 plant ha^{-1}) and three different nitrogen rates (0, 60 & 120 kg ha^{-1}) and noted highest head diameter, total number of seeds head^{-1}, seed yield head^{-1} and 1000 seed weight in planting density of 23800 plants ha^{-1}. Xiao *et al*. (2006) observed that the mean plant height increased and then decreased with increasing population density (1, 4, 16, and 64 plants m^{-2}). Higher plant populations produce less weight seeds, low stem girth, taller plants and higher yield than low plant population (Beg *et al*., 2007). Various planting densities treatments caused significant differences in most of the studied traits i.e. vegetative growth, seed yield per plant and 1000- seed weight (Abdel-Ghany *et al.,* 2008). Yield is positively correlated with the number of plants per unit area, increasing plant population up to 95000 plants ha^{-1} increased yield (Fazel and Lack, 2011).

Nitrogen is an essential major mineral nutrient for plant growth and development. Higher level of nitrogen application results more rapid leaf area development, prolongs life of leaves, improves leaf area duration, overall crop assimilation, thus resulting to increase in seed yield (Khaliq *et al.,* 2008, Khaliq *et al.,* 2009, Nasim *et al.,* 2011). Sunflower yield could be increased by fertilizer application, particularly nitrogen. All the metabolic routes which are based on protein, leads to increase in vegetative, reproductive growth and yield of the crop (Martinez *et al*., 2010) are dependent upon the

amount of nitrogen fertilization (Veerana and Steer, 2003; Peng *et al*., 2010). There are several problems as regard to sunflower production in Pakistan, particularly unavailability and high prices of inputs, old traditional methods of sowing, low plant population in the field, Improper uses of fertilizers, use of old and less potential varieties, unawareness of the farmers about site specific production technology. The objectives of this study therefore, were, to study the effect of planting densities and different rates of nitrogen on growth and yield of sunflower hybrid for obtaining higher yield.

MATERIALS AND METHODS

The Experiments were conducted at Research Area of University College of Agriculture, Sargodha (32^0. 04' N, 72^0.08' E) over a period of two spring seasons (2010 & 2011). The soil was silty loam and composite sample to a depth of 30 cm was obtained from experimental area and was analysed (Nitrogen = 0.05 %, available Phosphorus = 5.41ppm and potassium 225 ppm). The experiment were laid out in split split plot design having three replications, keeping net plot size 3.6 x 6 m. Sunflower hybrids (Hysun-33, S-278) was kept in main plots, planting densities (83,333 plants ha^{-1} and 55,555 plants ha^{-1}) by maintaining plant to plant distance 20 and 30 cm, respectively randomized in sub plots and nitrogen rates (100, 125 (standard), 150 kg ha^{-1}) in sub sub plots.

Crop was sown in the month of March, with the help of a dibbler on 60 cm spaced ridges keeping plant to plant distance of 20 and 30 cm. Phosphorus and potassium was applied at the rate of 60-30 kg ha^{-1}, respectively. Nitrogen, phosphorus and potassium were given in the form of Urea, DAP and SOP (K_2SO_4). $1/3^{rd}$ dose of nitrogen and all of P and K fertilizer was applied at the time of sowing and remaining $2/3^{rd}$ of N was applied in two splits, at first irrigation and flowering stage. All other cultural practices were kept normal for the crop, Dual gold pre-emergence herbicide was applied @ 1.5 liter ha^{-1}. Half plot area of 2.40x6m from each plot was harvested in mid June for threshing and a sub sample of 10 plants was taken for the determination of different yield components. All plants was threshed for the estimation of plot yield and converted into t ha^{-1}.The data were collected for number of plants m^{-2}, Plant height at maturity, Head diameter, 1000-achene weight and Achene's yield.

The data collected on various growth and yield parameters were statistically analyzed by employing the Fisher's analysis of variance technique and treatments means were compared least significant difference (LSD) test at 0.05 level of probability (Steel *et al*., 1997).

RESULTS AND DISCUSSION

Number of plants m^{-2}: Plant population was maintained in per unit area according to treatments in both the years of experimentation. Highest plant population (8.33 m^{-2}) was recorded from the plant spacing of 20cm while significantly minimum number of plants (5.55 m^{-2}) was recorded at plant spacing of 30cm which was maintained at the sowing and later on during thinning. The interaction among factors under study was also found to be non significant. These results are in accordance with Barros *et al.,* (2004) but contrary to present findings of Bakht *et al.,* (2006) who reported significant differences among sunflower hybrids.

Plant height at maturity (cm): The data regarding the plant height at harvest as affected by different levels of nitrogen and planting densities is given in table-1. Averaged overall during both the years of experimentation 2010 & 2011, nitrogen levels of 150 kg ha^{-1} produced significantly higher plant height (198.91 cm) than125 kg ha^{-1} and 100 kg ha^{-1} (192.14cm), (182.47 cm), respectively. Increase in plant height with nitrogen application has also been reported by Abdel-motagally and Osman (2010). There was also significant difference between sunflower hybrids for plant height. The sunflower hybrid Hysun-33 averaged overall of both years obtained maximum plant height (206.85cm) as compared to Hybrid S-278(177.07cm). These results are also in accordance with Abdel- motagally and Osman (2010), they reported that sunflower cultivars significantly differed in plant height and this difference might be due to varietal behavior. Similarly, planting densities showed significant effect on plant height (195.61cm) in case of 20cm plant spacing as compared to 30cm plant spacing (179.72 cm). These results are in line with Esechie *et al,* (1996 Beg *et al*., 2007), who reported that plant height increased with increasing plant population in the field but partially accordance to the findings of Xiao *et al*., (2006) who observed that the mean plant height increased and then decreased with increasing population density.

The interactive effects of planting densities and sunflower hybrids on plant height were found to be significant in 2010. Maximum plant height (214.56) was recorded in hybrid Hysun-33 was grown at 20 cm plant spacing (H_1D1) and was followed by the same hybrid at plant spacing of 30 cm (H_1D_2). This might be due to more competition among plants in higher plant population area, and secondly genetic characteristics of hybrids of taller height. In the interactive effect of hybrids and nitrogen, Hysun-33 obtained maximum plant height (212.89 cm) where nitrogen was given at the rate of 150 kg ha^{-1} and minimum plant height (167.22cm) was observed in S-278 in plots where nitrogen was applied at the rate of 100 kg ha^{-1}, while the interaction between planting density and

nitrogen, sunflower crop achieved maximum plant height (206.50 cm) at 20 cm plant spacing and 150 kg ha^{-1} of N application (D_1N_3) and minimum plant height (170.67 cm) was at 30 cm plant spacing and 100 N kg ha^{-1}(D_2N_1). In 2011, the interaction between hybrids & planting densities, and, hybrids & nitrogen was found to be non significant while significant effect was noted in planting densities and nitrogen.

Head diameter (cm): Data in table-1 showed that nitrogen have significant effect on head diameter, In 2010, the maximum head diameter (20.13cm) was recorded in case of those plots which were fertilized at the rate of 150 kg ha^{-1}, which was followed by the treatment 125 kg ha^{-1}(18.19cm), while the minimum head diameter (16.18 cm) was recorded in case of plots which were fertilized with lowest rates of nitrogen (100 kg ha^{-1}). Similar trend was also found in 2011. Sunflower hybrids showed significant difference in case of head diameter. Averaged overall of both the years of data of experiments, the sunflower hybrid S-278 produced significantly higher head diameter (20.45cm) as compared to Hysun-33 (16.46cm). Effect of plant spacing was highly significant and 30cm plant spacing resulted in significantly larger head diameter (20.83 cm), while 20 cm plant spacing resulted in significantly smaller head diameter (15.87cm) in 2010. There was a linear increase in head diameter with increase in plant spacing. Same trend of plant population effects on head diameter was observed in the following year of study. These results are supported with the findings of Al-thabet (2006), Killi, (2001), and Salehi & Bahrani (2000), who concluded that head diameter was significantly increased as the space between plants was increased.

As regard to interaction between hybrids and plant spacing in 2010, head diameter reached its maxima (22.24 cm) of hybrid-278 sowing on 30 cm plant spacing (H_2D_2) and was followed by hybrid Hysun-33 at same plant spacing, and S-278 at 20 cm plant spacing, while minimum head diameter of 14.04 cm was obtained by hybrid Hysun-33 at 20 cm plant spacing. But in year 2011, the interaction between hybrids and planting densities was found to be non-significant. In interaction effect of hybrids and nitrogen, maximum head diameter (22.46 cm), was obtained in H_2N_3 which was followed by H_2N_2 treatment having 20.31cm head diameter. Larger head diameter (22.61cm) was obtained in D_2N_3 treatment which was followed by D_2N_2 treatment and the lowest head diameter (14.37 cm) was in case of D_1N_1 treatment in both the year of studies.

1000 - Achene's weight (g): The data presented in table-2 showed that 1000-achene's weight was affected significantly by different levels of nitrogen fertilizer. Averaged overall, of the results of 2010 and 2011, the plots receiving nitrogen levels of 150 kg ha^{-1} produced statistically higher 1000- achene's weight (65.63g) than those plots receiving 125 kg N ha^{-1} (62.50g) and 100 kg N ha^{-1}(53.94g).These findings are supported by the observation of Ali *et al.,* (2006) who reported increase in achene's weight with increasing fertilizer dose. Thousand achene's weight of hybrid S-278 (64.92g) was statistically higher than Hysun-33, (56.36g) in 2010. Effect of plant spacing was highly significant and 30cm plant spacing resulted in significantly more 1000 achene's weight (63.83g)) than 20 cm plant spacing (58.62g) in 2010. Similar trend was noted in 2011 for thousand achene weight for hybrids at different plant spacing. The findings are in conformity with the recommendation of (Diepenbrock *et al.,* 2001), they demonstrated that 1000 achene weight decreased with increasing plant density. These results are in agreement with the findings of Al-thabet (2006), who also observed similar types of results.

The interaction of hybrids x plant spacing and, hybrids x nitrogen was non-significant, while plant spacing and nitrogen interaction for 1000- achene's weight was observed significant in 2010 and 2011. Sunflower crop sown at 30 cm plant spacing and nitrogen application at the rate of 150 kg ha^{-1} obtained highest 1000-achene's weight during both the years.

Achene's yield (t ha^{-1}): It is clear from the data given in table -2 that achene's yield kg ha^{-1} was affected significantly by all of the factors under study. Averaged overall of both the years of experimentation, nitrogen levels of 125 kg ha^{-1} produced maximum achene's yield (3.32t ha^{-1}) but was statistically similar with those plots receiving 150 kg N ha^{-1} (3.31 t ha^{-1}). Lowest achene's yield (2.65 t ha^{-1}) was recorded in case of those plots which were fertilized at the rate of 100 kg ha^{-1}. These results are in confirmatory with those of Abdel-Motagally and Osman (2006), Ali *et al.,* 2006 and Al- Thabet (2006). Effect of sunflower hybrids on achene's yield was found significant. The maximum achene's yield of (3.34 t ha^{-1}) was recorded from hybrid S-278 as compared to hybrid Hysun-33 which produced (2.73 t ha^{-1}) achene's yield during the year 2010. Same trend was observed between hybrids for achene yield in 2011. The effect of plant spacing on achene's yield was also found to be significant. Averaged overall of both the years, 2010 and 2011, The highest seed yield (3.47 t ha^{-1}) was produced when sunflower crop was planted at 20 cm plant spacing and significantly less yield of 2.69 t ha^{-1} was obtained at plant spacing of 30 cm. The positive effect of closer plant spacing as obtained in the present study agreed well to the findings of Islam *et al*., (2000), and Jahangir *et al*., (2006).

The interactive effect of hybrids with planting densities, and hybrids with nitrogen was significant in 2010 but non-significant in 2011, while the interaction of plant densities and nitrogen was significant during both the years. The highest achene's yield (3.75 t ha^{-}) was

produced with sowing sunflower hybrid S-278 on 20 cm plant spacing (H_2D_1), which was followed by Hybrid Hysun-33 sowing on same plant spacing (H_1D_1), while the lowest yield for achene's yield (2.46 t ha^{-1}) was obtained for H_1D_2 treatment. However, in interactive effect of hybrids and nitrogen, highest achene, s yield (3.57 t ha^{-1}) was noted in H_2N_2 treatment which was statistically at par with H_2N_3 treatment obtaining 3.54 t ha^{-1}. In the interaction between plant spacing and nitrogen the highest achene's yield (3.72 t ha^{-}) was noted in D_1N_3 in 2010 and 3.55 t ha^{-1} in treatment D_1N_2 in 2011, D_1N_2 and D_1N_3 treatments were statistically similar during both years of study. Fazel and Lack, (2011) also supported these results who concluded that that yield is positively co-related with the number of plants per unit area. Similar results were also reported by Hedge and Havanagi (1987) and Sharma *et al.,* (1992) who obtained higher seed yield with closer plant spacing with increasing rate of nitrogen- phosphorus application in sunflower crop.

Table 1: Effects of planting densities and nitrogen rates on plant height and head diameter of sunflower hybrids

Treatments	Plant height (cm)			Head diameter (cm)		
	2010	2011	Mean	2010	2011	Mean
A= Hybrids						
Hysun-33	205.78 a	206.85 a	206.31	16.18 b	16.75 b	16.46
S-278	175.00 b	177.07 b	176.03	20.16 a	20.75 a	20.45
LSD value	3.864	7.026		0.542	0.951	
B=Planting densities						
D_1(20cm)	194.72 a	196.51 a	195.61	15.87 b	16.43 b	16.15
D_2(30cm)	178.83 b	180.61 b	179.72	20.83 a	20.87 a	20.57
LSD value	4.896	4.429		0.606	0.595	
C= Nitrogen						
N_1	182.17 c	182.78 c	182.47	16.19 c	16.34 c	16.26
N_2	191.28 b	193.00 b	192.14	18.19 b	18.98 b	18.58
N_3	197.72 a	200.11 a	198.91	20.13 a	20.94 a	20.53
LSD value	1.393	1.713		0.267	0.364	
Interaction (H x D)						
H_1D_1	214.56 a	NS		14.04 c	NS	
H_1D_2	193.78 b	NS		18.32 b	NS	
H_2D_1	180.67 c	NS		17.70 b	NS	
H_2D_2	163.89 d	NS		22.24 a	NS	
LSD value	6.638			0.855		
Interaction (H x N)						
H_1N_1	197.11 c	NS		14.67 e	16.64 b	
H_1N_2	207.33 b	NS		16.08 d	16.78 b	
H_1N_3	212.89 a	NS		17.80 c	16.85 b	
H_2N_1	167.22 f	NS		17.71 c	20.59 a	
H_2N_2	175.22 e	NS		20.31 b	20.83 a	
H_2N_3	182.56 d	NS		22.46 a	20.84 a	
LSD value	3.972			0.585	0.514	
Interaction (D x N)						
D_1N_1	188.17 c	196.00 a		14.37 e	16.31 b	
D_1N_2	198.17 b	197.17 a		15.76 d	16.61 b	
D_1N_3	206.50 a	196.33 a		17.48 c	16.38 b	
D_2N_1	170.67 e	182.00 b		17.79 c	20.72 a	
D_2N_2	179.50 d	180.67 b		20.45 b	21.02 a	
D_2N_3	186.33 c	179.17 b		22.62 a	20.87 a	
LSD value	5.274	2.967		0.713	0.63	

Means followed by similar letters in each column are not significantly differ at the 5 % level of probability.
NS = non significant.

Table 2: Effects of planting densities and nitrogen rates 1000- achene's weight and achene's yield of sunflower hybrids

Treatments	1000- achene's weight (g)			Achene,s yield (t ha^{-1})		
	2010	2011	Mean	2010	2011	Mean
A= Hybrids						
Hysun-33	56.36 b	56.40 b	56.38	2.73 b	2.87 b	2.8
S-278	64.92 a	65.11 a	65.01	3.34 a	3.44 a	3.39
LSD value	7.709	6.392		0.23	0.372	
B=Planting densities						
D_1(20cm)	58.55 b	58.70 b	58.62	3.42 a	3.53 a	3.47
D_2(30cm)	63.84 a	63.82 a	63.83	2.64 b	2.75 b	2.69
LSD value	1.553	1.496		0.184	0.77	
C= Nitrogen						
N_1	54.04 c	53.87 c	53.94	2.61 b	2.70 b	2.65
N_2	62.44 b	62.56 b	62.5	3.23 a	3.38 a	3.32
N_3	65.43 a	65.84 a	65.63	3.27 a	3.40 a	3.31
LSD value	0.93	0.948		0.089	0.074	
Interaction (H x D)						
H_1D_1	NS	NS		3.10 a	NS	
H_1D_2	NS	NS		2.46 d	NS	
H_2D_1	NS	NS		3.75 b	NS	
H_2D_2	NS	NS		2.82 c	NS	
LSD value						
Interaction (H x N)						
H_1N_1	NS	NS		2.31 c	NS	
H_1N_2	NS	NS		2.97 b	NS	
H_1N_3	NS	NS		2.92 b	NS	
H_2N_1	NS	NS		2.91 b	NS	
H_2N_2	NS	NS		3.57 a	NS	
H_2N_3	NS	NS		3.54 a	NS	
LSD value				0.239		
Interaction (D x N)						
D_1N_1	50.89 d	58.78 d		2.86 b	2.53 b	
D_1N_2	60.75 c	60.63 c		3.68 a	3.55 a	
D_1N_3	63.99 b	62.27 b		3.72 a	3.50 a	
D_2N_1	59.69 c	61.34 c		2.38 d	2.80 b	
D_2N_2	65.79 a	63.19 a		2.86 b	2.79 b	
D_2N_3	66.05 a	64.83 a		2.68 c	2.81 b	
LSD value	2.032	1.662		0.222	0.128	

Means followed by similar letters in each column are not significantly differ at the 5 % level of probability.
NS = non significant.

Conclusion. The results of this study have shown that sunflower hybrids responded favorably to increase in population density. S-278 hybrid performed better than Hysun-33 during both the years. Considering the superiority of Sunflower hybrid S-278, application of125 kg N ha^{-1} and larger plant density (83,333 plants ha^{-1}) at 20 cm plant spacing is recommended for producing desirable yield.

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