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Morphological Features in Sunflower as Influenced by Varying Nutritional Area

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Abstract: Agronomic traits ultimately contribute to final achene yield. Any improvement in agronomic traits means increase in achene yield. For this purpose, a field trial was conducted at experimental area of Agronomy Department, PMAS Arid Agriculture University, Rawalpindi during two consecutive years 2008 and 2009 to evaluate the performance of two sunflower hybrids i.e S-278 and Hysun-33 under different levels of nutritional area i.e, 60 x 20, 60 x 30, 60 x 40, 60 x 50, 60 x 60 (with 1 plant/hill) and 60 x 60 cm^{-2} (with 2 plants hill). The experiment was laid out in randomized complete block design with three replications in split plot arrangement keeping nutritional areas levels in main plot and sunflower hybrids in sub plot effects. It was observed that among sunflower hybrids, S-278 produced significantly taller plants, heavier 1000-achene weight, higher achene and stalk yield, but lesser harvest index than these in Hysun-33. Both hybrids were, however, similar for head diameter and number of achene/head. Sunflower hybrid Hysun-33 planted at nutritional area of 60 x 20 cm^2 produced the highest achene yield (2.89 t/ha), which was also statistically at par with other treatments; whereas sunflower hybrid S-278 planted at nutritional area of 60 x 40 cm^2 produced the lowest achene yield (2.45 t/ha). Likewise, sunflower hybrid Hysun-33 planted at nutritional area of 60 x 40 cm^2 computed the highest harvest index (37.75%), which was also statistically at par with other treatments; whereas sunflower hybrid S-278 planted at nutritional area of 60 x 20 cm^2 computed the lowest harvest index (31.00%). It is therefore suggested that sunflower hybrid S-278 should be cultivated at level of nutritional area of 60 x 20 cm^2 to get maximum achene and stalk yield.

Key words: Sunflower, hybrids, nutritional area, agronomic traits

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is an important non conventional oilseed crop in Pakistan and belongs to family Asteraceae (Compositae). Sunflowers originated in North America and were domesticated by western native tribes about 1000 BC. Sunflower oil is made from sunflower seeds. The seeds contain about 39-49% oil. Sunflower oil is low in saturated fats and trans fats. Sunflower oil is more stable than other vegetable oils and suffers from a lesser degree of partial hydrogenation when kept in storage for long periods of time. This also translates into an excellent shelf life (Anonymous, 2008-09).

Pakistan is an agricultural country but chronically deficient in edible oil spending huge amount of foreign exchange on its import. It is Pakistan's largest single food import with consumer demand steadily increasing from 0.30 million to 2.79 million tons during the last two decades (GOP, 2010). In Pakistan sunflower can be grown twice in a year during spring and winter. Sunflower grown in spring is usually slower in growth than during autumn (Kaleem *et al*., 2010) but the response for the agronomic parameters remains significant. Plant height (Ahmad *et al*., 2001), number of achene/head (Ahmed and Hasasn, 2000) and achene yield (Kaleem *et al*., 2010) in sunflower are significantly influenced by season mainly by the temperature, growth durations which are particular characteristics of seasonal changes (Killi and Altunbay, 2005; Qadir *et al*., 2007). According to Kaleem *et al*. (2009) and Jose *et al*. (2004), longer reproductive phase and high temperature at the time of seed development for spring sown sunflower are favorable for achene and stalk yield than during season with high temperature and low relative humidity at the time of pollination in autumn season that affects pollen vigor, causing poor pollination, produces less weight and infertile achene consequently leading to head infertility and low achene yield (Weiss, 2000; Miralles *et al*., 1997).

It is usually assumed that an equal amount of fertilizer applied was absorbed uniformly to every plant, but the availability of the nutritional area to every plant

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determines the extent of availability of the nutrients to plants (Bukhsh *et al*., 2011). Difference in nutritional area varies availability of nutrients; even they are equally and uniformly applied. Similarly, it is assumed that more nutritional area gives more nutrition to plants, but the extent where maximum uptake of nutrients occurs again creates the question to be quenched (Allam *et al*., 2003). Sunflower hybrids planted in Pakistani showed diversity in their response to nutritional area which due to difference in their root system and penetration capacity, vary in their response to achene yield (Bukhsh *et al*., 2011) as well as stalk yield (Ahmed and Hasasn, 2000; Richards, 2006). Sunflower hybrids available in Pakistani markets exhibited diversity in their response to K application (Martre *et al*., 2009). The hybrids which remained for longer duration in the field produced higher yield and yield contributing components including head diameter (Martre *et al*., 2009), plant height (Kaleem *et al*., 2009; Khan *et al*., 1999), number of achenes/head (Saeidi, 2007), 1000-achene weight (Razi and Assad, 1999) and achene yield (Weiss, 2000). Better physio-morphic expressions help to materialize better achene yield in terms of sunflower cooking oil which is extensively used by heart patients because of very low cholesterol concentration and high fatty acid concentration (Ahmed and Hasasn, 2000; Chaudhary and Mushtaq, 1999).

Unfortunately, very little information is available in this regard so a study was conducted to evaluate the performance of two sunflower hybrids under varying levels of nutritional areas under the agro-ecological conditions of district Rawalpindi, Pakistan.

MATERIALS AND METHODS

The study to evaluate the performance of two sunflower hybrids i.e, S-278 and Hysun-33 under different levels of nutritional area was conducted at the experimental area, Department of Agronomy, PMAS Arid Agriculture University, Rawalpindi during spring 2008 and 2009. Soil samples were collected to a depth of 30 cm from the experimental area before sowing the crop and analyzed for physico-chemical properties (Table 1).

The experiment was carried out at an irrigated sandy clay loam soil in tri-replicate. The experiment was laid out in split plot design keeping different nutritional levels i.e 60 x 20, 60 x 30, 60 x 40, 60 x 50, 60 x 60 (with 1 plant/hill) and 60 x 60 cm^{-2} (with 2 plants/hill) in main plots and sunflower hybrids in subplots. Net plot size was 3.60 m x 7.20 m. Crop was planted by dibbler using recommended seed rate of 7.5 kg/ha on a well prepared bed. Both hybrids Hysun-33 and S-278 were sown on February 4 and 7 during 2008 and 2009, respectively. Fertilizer was applied @ 100 kg N+100 kg P_2O_5/ha in the form of urea and DAP. All the P and half dose of the N were applied at the time of sowing, while rest of the urea was applied with first irrigation (4 weeks after sowing). Subsequent irrigations were given when needed to the crop during spring 2008 and 2009.

Table 1: Pre-sowing physico-chemical analysis of soil

		Value	
Determination	Unit	2008	2009
Physical analysis			
Sand	%	67.00	64.00
Silt	%	15.00	15.00
Clay	%	18.00	21.00
Textural class		Sandy clay loam	
Chemical analysis			
Saturation	%	35.00	34.00
pH		7.80	7.40
EC_e	dS m^{-1}	2.20	2.18
Organic matter	%	0.80	0.83
Total nitrogen	%	0.041	0.040
Available phosphorus	ppm	7.10	7.00
Available K	ppm	169.00	165.00

Thinning was done at 4-5 leaf stage to keep plant to plant distance of 20 cm. Plant population was constant in all treatments. Crop was kept weeds free by providing interculture and hand weeding to avoid competition between weeds and sunflower crop. Crop was harvested manually on June 6 and 10 during 2008 and 2009, respectively. Achene yield was recorded at 15% moisture content. Plant height was measured (in centimeters) at the completion of flowering. Ten plants were selected at random from each sub plot and their heights were measured from the soil surface up to top of flower. Ten heads were taken from randomly selected plants before harvesting from each sub plot. Diameter of each head was measured with the help of a measuring tape. Five sunflower heads from each sub plot/treatment were selected at random and threshed separately. Number of achenes/head was calculated by the following formula:

No. of achenes/head = 1000 x achene weight/1000-achene weight

Two samples of 1000-achenes were taken random from each sub-plot and weighed on automatic electric balance. Seed yield was recorded on sub plot basis and then converted in to t/ha. For stalk weight, weight of air dried stalks (along with leaves) per sub plot was recorded after threshing the seed and then converted into t/ha. Harvest index was calculated by using the following formula as described by Hunt (1978).

Harvest index = Seed yield x 100/biological yield

Data obtained were statistically analyzed by Fisher's analysis of variance techniques using least significant difference test at 5% level of probability to compare the differences among treatment means (Steel *et al*., 1997). Weather data for both years were obtained from Meteorological Center, Rawalpindi situated in the University premises (Table 2).

Table 2: Meteorological data recorded during 2008 and 2009 in Rawalpindi district

	Max. Temp. (°C)	Min. Temp. (°C)	RH (%)	Rainfall (mm)
February, 2008	26.70	10.60	55.00	45.00
March, 2008	29.90	12.92	60.00	81.00
April, 2008	34.00	15.90	44.00	18.00
May, 2008	37.30	19.80	42.00	80.60
June, 2008	37.60	23.00	51.00	22.30
February, 2009	27.80	10.40	50.00	30.00
March, 2009	30.05	12.02	51.57	15.00
April, 2009	29.70	15.77	59.33	92.90
May, 2009	37.16	20.76	40.00	10.10
June, 2009	35.57	22.29	62.43	225.0

Temp. = Temperature; RH = Relative Humidity

RESULTS AND DISCUSSION

Plant height: There was statistically significant effect of different levels of nutritional area on plant height (Table 3). It was observed that with the increase in nutritional area, the plant height decreased gradually and then it again began to increase when sunflower crop was provided nutritional area of 60 x 60 cm^2 (2 plants/hill). Maximum plant height was recorded when crop was provided nutritional area of 60 x 20 cm^2, where as minimum plant height was recorded when crop was provided nutritional area of 60 x 60 cm^2 (1 plant/hill). Similar trends were reported by Chaudhary and Mushtaq (1999) and Jose *et al*. (2004) those found that with the increase in nutritional area, the plant height decreased. There was statistically significant difference among the sunflower hybrids regarding plant height. S-278 (164.63 cm) had significantly higher plant height than that of Hysun-33 (111.29 cm). The difference might be due to difference of genetic makeup (Ahmad, 1993; Bukhsh *et al*., 2010). Interactive effects of nutritional area and sunflower hybrids on plant height were statistically significant. Sunflower hybrid S-278 planted at nutritional area of 60 x 60 cm^2 (2 plants/hill) produced maximum plant height (176.00 cm), where as sunflower Hysun-33 planted at nutritional area of 60 x 40 cm^2 produced minimum plant height (105.75 cm).

Head diameter: There was statistically significant effect of different levels of nutritional area on head diameter (Table 3). It was observed that with the increase in nutritional area, the plant height increased gradually and then it again decreased when sunflower crop was provided nutritional area of 60 x 60 cm^2 (2 plants/hill). Maximum head diameter was recorded when crop was provided nutritional area of 60 x 20 cm^2 (1 plant/hill), where as minimum plant height was recorded when crop was provided nutritional area of 60 x 20 cm^2. Similar trends were reported by Nazir *et al*. (1986) and Ahmad *et al*. (2001).

There was statistically significant difference among the sunflower hybrids regarding head diameter. Hysun-33 (17.93 cm) produced significantly larger head diameter than that of S-278 (17.34 cm). The difference might be due to difference of genetic makeup (Matri *et al*., 2009; Miralles *et al*., 1997). Interactive effects of nutritional area and sunflower hybrids on head diameter were also statistically significant. Sunflower hybrid Hysun-33 planted at nutritional area of 60 x 60 cm^2 (1 plants/hill) produced the largest head diameter (20.77 cm), which was also statistically at par with so many treatments; whereas sunflower hybrid S-278 planted at nutritional area of 60 x 20 cm^2 produced the smallest head diameter (13.80 cm).

No. of achenes/head: There was statistically significant effect of different levels of nutritional area on number of achenes/head (Table 3). It was found that with the increase in nutritional area, the number of achenes/head increased gradually and then it again decreased when sunflower crop was provided nutritional area of 60 x 60 cm^2 (2 plants/hill). Maximum number of achenes/head (1673) was recorded when crop was provided nutritional area of 60 x 20 cm^2 (1 plant/hill), where as minimum number of achenes/head (1259) was recorded when crop was provided nutritional area of 60 x 20 cm^2. Similar trends were reported by Qadir *et al*. (2007) and Ahmad *et al*. (2001) that increase in nutritional area, the number of achenes/head increased. There was statistically significant difference among the sunflower hybrids regarding number of achenes/head. Hysun-33 (1484) had significantly higher number of achenes/head than that of S-278 (1336). The difference might be due to difference of genetic makeup (Bukhsh, 2010; Nazir *et al*., 1986). Interactive effects of nutritional area and sunflower hybrids on number of achenes/head were significant. Sunflower hybrid Hysun-33 planted at nutritional area of 60 x 60 cm^2 (1 plants/hill) produced the highest number of achenes/head (1798), which was also statistically at par with so many treatments; whereas sunflower S-278 planted at nutritional area of 60 x 20 cm^2 produced the lowest number of achenes/head (1050).

1000-achenes weight: There was no statistically significant effect of different levels of nutritional area on achene yield (Table 3). However, significant difference was observed among sunflower hybrids for 1000-achene weight. Sunflower hybrid S-278 significantly produced higher 1000-grain weight (39.98 g) than that of Hysun-33 (36.58 g). The difference might be due to difference of genetic makeup (Ahmad *et al*., 2001; Saeidi, 2007).

Interactive effects of nutritional area and sunflower hybrids on 1000-achene weight were also statistically significant. Sunflower hybrid S-278 planted at nutritional area of 60 x 60 cm^2 (1 plant/hill) produced the heaviest 1000-achene weight (40.80 g), which was also statistically at par with so many treatments; whereas sunflower Hysun-33 planted at nutritional area of 60 x 60 cm^2 (2 plants/hill) produced the lightest 1000-achene weight (35.80 g).

Table 3: Morphological features in sunflower as influenced by varying nutritional area

Treatments	Plant height (cm)	Head diameter (cm)	No. of achenes head^{-1}	1000-achene weight (g)	Achene yield (t ha^{-1})	Stalk yield (t ha^{-1})	Harvest index (%)
A- Nutritional area (N) (cm^2)							
P_1 = 60 x 20	152.25a	13.90e	1099f	37.36	2.88a	5.53a	33.16b
P_2 = 60 x 30	144.38b	16.02d	1309d	38.38	2.72ab	5.14b	34.36ab
P_3 = 60 x 40	133.75c	17.92c	1443c	38.00	2.64ab	4.53c	35.90a
P_4 = 60 x 50	124.63d	19.56b	1578b	38.38	2.63ab	5.24b	33.36ab
P_5 = 60 x 60 (1 plant hill^{-1})	119.63e	20.46a	1673a	39.02	2.62b	4.71c	35.75a
P_6 = 60 x 60 (2 plants hill^{-1})	152.20a	16.85d	1259de	37.63	2.68ab	5.23ab	34.95a
LSD (a)	4.609*	0.86*	62.22*	N.S	0.249*	0.372*	2.98*
B- Sunflower Hybrids (H)							
H_1 = Hysun-33	111.29b	17.93a	1484a	36.58b	2.78a	4.86b	36.52a
H_2 = S-278	164.63a	17.34b	1336b	39.98a	2.60b	5.26a	32.30b
LSD (b)	4.384*	0.57*	69.35*	1.44*	0.115*	0.231*	1.23*
C- Interaction (H x N)							
P_1 x H_1	127.25e	14.00d	1148fg	36.33cde	2.89a	5.42ab	34.77abcd
P_1 x H_2	177.25a	13.80d	1050h	39.72abc	2.88a	5.63a	31.00de
P_2 x H_1	120.75e	15.82c	1336def	36.53bcde	2.89a	4.79c	36.47abc
P_2 x H_2	168.00ab	16.23c	1282efg	40.23a	2.55bc	5.42ab	32.54bc
P_3 x H_1	105.75f	17.90b	1490cd	36.03de	2.74ab	4.53c	37.75a
P_3 x H_2	161.75bc	17.95b	1389cde	39.97ab	2.45c	4.53c	34.04bcd
P_4 x H_1	95.50gf	19.52a	1697ab	36.58bcde	2.69ab	4.70c	36.05ab
P_4 x H_2	153.75cd	19.60a	1460cd	40.19a	2.56bc	5.79a	30.23e
P_5 x H_1	90.00g	20.77a	1798a	37.28cde	2.80ab	4.71c	37.48a
P_5 x H_2	149.25d	20.15a	1548bc	40.80e	2.57bc	4.71c	34.03bcd
P_6 x H_1	128.50e	17.08bc	1330def	35.80e	2.78abc	5.04bc	36.45abc
P_6 x H_2	176.00a	16.63bc	1189fgh	39.47abcd	2.65bc	5.42ab	33.44cd
LSD (c)	10.739*	1.41*	169.86*	3.52*	0.281*	0.57*	3.02*

Means followed by different letters in columns are significantly different at p = 0.05

Achene yield: There was statistically significant effect of different levels of nutritional area on achene yield (Table 3). It was observed that with the increase in nutritional area, the achene yield decreased gradually and then it again began to increase when sunflower crop was provided nutritional area of 60 x 60 cm^2 (2 plants/hill). Maximum achene yield (2.88 t/ha) was recorded when crop was provided nutritional area of 60 x 20 cm^2, where as minimum achene yield (2.62 t/ha) was recorded when crop was provided nutritional area of 60 x 20 cm^2. Similar trends were reported by Richards (2006) and Bukhsh *et al*. (2009).

There was statistically significant difference among the sunflower hybrids regarding achene yield. Hysun-33 had significantly higher (2.78 t/ha) achene yield than that of S-278 (2.60 t/ha). The difference might be due to difference of genetic makeup (Miralles *et al*., 1997; Razi and Assad, 1999). Interactive effects of nutritional area and sunflower hybrids on achene yield were significant. Sunflower hybrid Hysun-33 planted at nutritional area of 60 x 20 cm^2 produced the highest achene yield (2.89 t/ha), which was also statistically at par with so many treatments; whereas sunflower S-278 planted at nutritional area of 60 x 40 cm^2 produced the lowest achene yield (2.45 t/ha).

Stalk yield: There was statistically significant effect of different levels of nutritional area on stalk yield (Table 3). It was observed that with the increase in nutritional area, the stalk yield decreased gradually and then it again began to increase when sunflower crop was provided nutritional area of 60 x 60 cm^2 (2 plants/hill). Maximum stalk yield (5.53 t/ha) was recorded when crop was provided nutritional area of 60 x 20 cm^2, where as minimum stalk yield (4.71 t/ha) was recorded when crop was provided nutritional area of 60 x 60 cm^2 (1 plant/hill) Similar trends were reported by Chaudhary and Mushtaq (1999).

There was statistically significant difference among the sunflower hybrids regarding stalk yield. S-278 had significantly higher (5.26 t/ha) stalk yield than that of Hysun-33 (4.86 t/ha). The difference might be due to difference of genetic makeup (Kaleem *et al*., 2010). Interactive effects of nutritional area and sunflower hybrids on stalk yield were significant. Sunflower hybrid S-278 planted at nutritional area of 60 x 20 cm^2 produced the highest stalk yield (5.63 t/ha), which was also statistically at par with so many treatments; whereas sunflower hybrid Hysun-33 and S-278 planted at nutritional area of 60 x 40 cm^2 produced the lowest achene yield (4.53 and 4.53 t/ha, respectively).

Harvest index: There was statistically significant effect of different levels of nutritional area on harvest index (Table 3). It increased gradually and reached to it maximum value then it gradually decreased. Maximum harvest index was noted when crop was planted at the nutritional area level of 60 x 40 cm^2, where as minimum harvest index was recorded when crop was planted at the nutritional area level of 60 x 20 cm^2. Similar trends

were reported by Bukhsh *et al*. (2010) that harvest index gradually increased with the increase in nutritional area. There was statistically significant difference among the sunflower hybrids regarding harvest index. Hysun-33 had significantly higher (36.52%) harvest index than that of S-278 (32.30%). The difference might be due to difference of genetic makeup (Bukhsh, 2010). Interactive effects of nutritional area and sunflower hybrids on harvest index were significant. Sunflower hybrid Hysun-33 planted at nutritional area of 60 x 40 cm^2 computed the highest harvest index (37.75%), which was also statistically at par with so many treatments; whereas sunflower hybrid S-278 planted at nutritional area of 60 x 20 cm^2 computed the lowest harvest index (31.00%).

Conclusion: On the basis of these experimentations, it is concluded that sunflower hybrid S-278 should be cultivated at level of nutritional area of 60 x 20 cm^2 to get maximum achene and stalk yield.

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