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Economic yield potential of different hybrid varieties/cultivars of sunflower (*Helianthus annuus* L.) under semi-arid conditions

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Abstract

A two-year field trial (2014-2016) was conducted to evaluate the feasibility of cultivating sunflower hybrid cultivars/varieties under semi-arid conditions of Pakistan. Nine hybrid cultivars/varieties, i.e. LG-5658, AG-SUN-8251, FSS-60, SY-4045, SMH-0917, US-444, KSF-777, Aftab-12 and Hysun-33 were grown in field area of Regional Agricultural Research Institute, Bahawalpur for two consecutive years. The experiment was laid out in Randomized Complete Block Design with three replications with a plot size of 3×7 m. All cultivars were assessed for yield potential in terms of plant population, plant height (cm), head diameter (cm), number of achenes head^{-1}, seed index (g), 1000 grain weight (g), achene yield/ha (Kg). Statistical analysis of data showed significant differences for all parameters except plant population plot^{-1} during year 2014. Among cultivars, AG-SUN-8251 exhibited maximum plant population and plant height following KSF-777. After hysun-33, maximum number of achenes were recorded in KSF-777 following AG-SUN-8251. In case of seed index and 1000 achenes weight, LG-5658 stood best among cultivars. However, maximum yield per hectare was found in cultivar AG-SUN-8251 after Hysun-33 for both consecutive years.

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Introduction

Demand for edible oil is increasing as the population of the country is increasing. After mineral oil, edible oil is second largest import item in Pakistan. Sunflower (*Halianthus annuus* L.) is an important edible oil crop next to soybean (FAO, 2011). It is a drought tolerant and short duration crop with adaptability in wide range of environments (Khan *et al.*, 2012) hence, cultivating in arid and semi-arid regions (Wan *et al.*, 2013).

Total domestic requirement of edible oil for 2005-6 was 2.110 million tons, of which 26.5 percent was locally produced and the remaining was imported from other countries (GOP 2006). It costs 2257 million US$ to import edible oils during 2011-12 (Nasim *et al.*, 2017). For minimizing the existing gap between production and consumption of edible oil, sunflower should be grown preferably (Khan *et al.*, 2003). It is cultivated on an area of 397,306 ha (Anon, 2008-9). Average yield at farmer's field is 1520 kg/ha, while at progressive farmers field, potential yield is 3800 kg/ha (Arshad *et al*, 2010). During the year 2009-10, the production at country level was estimated at 0.680 million tons while 1.246 million tons was imported (GOP, 2010).

The sunflower cultivars and hybrids have the potential for higher yields, and expected to remain a prospective source of edible oil in the country (Badar *et al.*, 2002; Vega and Hall, 2002; Malik *et al.*, 2004; Hu *et al.*, 2008). Fick and Sweller (1972) and Beg *et al.*, (1984) reported that hybrid sunflower cultivars gave significantly higher seed yield, more uniformity in flowering, plant height and oil content than open pollinated varieties. Average achene yield of sunflower is very low in Pakistan as compared to other countries of the world, with yield of 3015kg ha^{-1} (Bilal, 2004). Inspite of having high yield potential, the production of sunflower in Pakistan is very low. One of the reasons is the cultivation of exotic hybrids, which are not well adapted to agro-climatic conditions of the country. Furthermore, climate change strongly influences the productivity of sunflower hybrids especially during reproductive stage of plants.

It is crucial to evaluate the performance of exotic and local inbred hybrids under various agroecological environments (Nasim *et al.*, 2017) since, a strong interaction exists between the sunflower hybrids and prevailing environment (Abelardo and Hall, 2002). Taking all this into consideration, the present study was conducted to assess growth and yield of various sunflower hybrids in semi-arid areas of Pakistan.

Materials and methods

Site location and description

Two-year field trial (2014-2016) was conducted in the research area of Regional Agricultural Research Institute Bahawalpur. The region experiences a semi arid type climate having. The experiment was laid out in Randomized Complete Block Design with three replications and a plot size of 3×7m. Line to line and plant to plant distance was maintained as 75cm and 22 cm respectively. Eight hybrid lines viz LG-5658, AG-sun-8251, FSS-60, SY-4045, SMH-0917, US-444, KSF-777 and Aftab-12 were tested for grain yield potential in the experiment with one control as Hysun-33. All other agronomic practices were kept uniform. Data were recorded according to standard procedures and standard method prevailing at Regional Agricultural Research Institute**.**

Data recording for parameters

Number of plants $plot^{-1}$ was recorded by simply counting the total number of plants in each replication. A sample of ten plants from each replication for each variety/ cultivar was randomly selected and their height was measured from ground level to the top edge of collar disc and then average was calculated. Heads from ten plants were selected randomly from each replication for and their diameter was measured from one edge to the other after which their average was worked out. Ten heads were selected randomly from each replication for each variety/cultivar, counted the number of achenes in each head and average was calculated. Weight of 100 seeds from each variety/cultivar was taken out on an electronic balance.1000 achenes weight was similarly calculated. Yield $plot^{-1}$ was recorded and then calculated on hectare basis.

Statistical analysis

Data recorded were analyzed statistically using Fisher's analysis of variance techniques (Steel *et al.*, 1997). Mean values were also compared using LSD (Least Significant Difference) at 5% probability level.

Results

Number of plants per plot

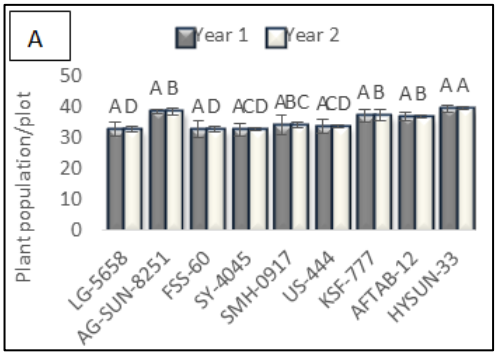
Statistical results (Fig 1A) showed maximum plant population per plot recorded in Hysun-33 followed by AG-SUN-8251 both years while the minimum was shown by LG-5658 cultivar. However, the difference was non-significant.

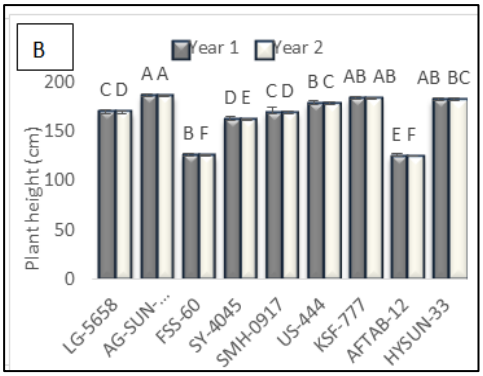
Plant height (cm)

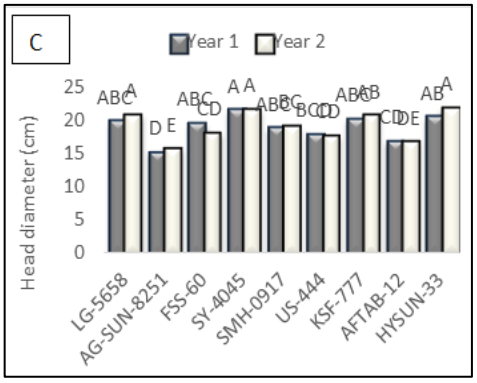
It determines vegetative growth of a crop. Analysis of the data about average plant height presented in table showed significant differences among various cultivars/varieties. Comparison of treatment means indicated that maximum plant height (185.67cm) was attained by cultivar AG-SUN-8251 followed by KSF-777 (183.3cm) which is statistically at par to Hysun-33 (182cm). The minimum plant height was recorded in case of Aftab-12 (124.63cm). Similar trend among varieties and cultivars were recorded during second crop season-2015 (Fig 1B). These significant differences among varietal means were most probably due to environmental conditions or genetic makeup of the hybrids.

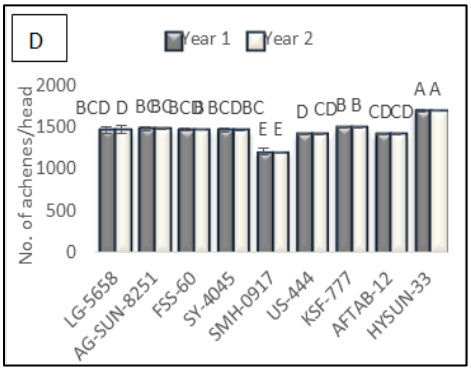
Head Diameter (cm)

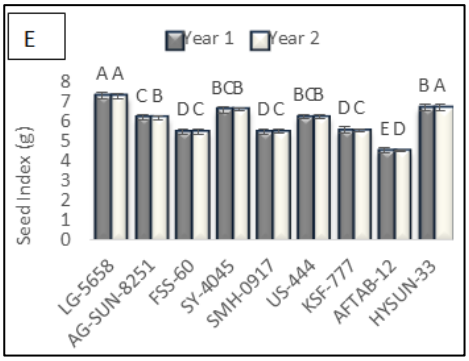
Sunflower hybrids differed significantly for head diameter. During the first growing season, largest head was produced by cultivar SY-4045 (21.667cm) followed by Hysun-33 (20.667cm). However, Hysun-33 exhibited largest head during second year. Both the years, minimum head diameter was recorded in AG-SUN-8251 as15.33cm.

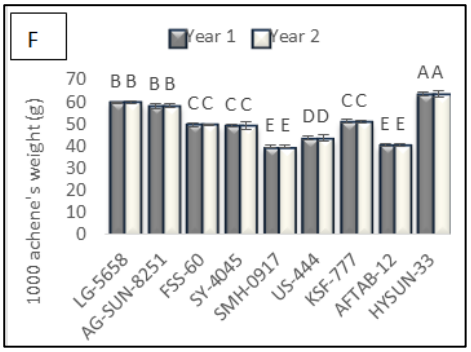












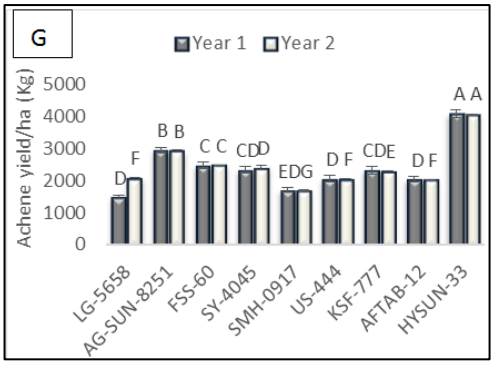


Fig. 1. Yield attributes of all cultivars/varieties for the years 2014 and 2015. A) Plant population/plot B) Plant height (cm) C) Head diameter (cm) D) No. of achenes per head E) Seed Index (g) F) 1000 achenes weight (g) G) Yield/ha (Kg).

Number of achenes head^{-1}

It is an important yield component of sunflower. Statistical analysis of data showed that sunflower varieties/cultivars had significantly different in case of number of achenes head^{-1} (Table). During cropping season of 2014, highest number of achenes were produced by Hysun-33 (1688.3) followed by KSF-777 (1491.3). The cultivar SMH-0917 produced minimum number of achenes head^{-1} recorded as 1198.3. All cultivars exhibited similar trend in number of acehenes per head during 2015.

Seed Index

Statistically analyzed data for seed index showed significant differences for varietal means among various hybrid cultivars/varieties (Table 1). The maximum seed index was recorded in cultivar LG-5658 i-e 7.3g and 7.26g in years 2014 and 2015 respectively which significantly differed from other cultivars/varieties. However, cultivars FSS-60, SMH-0917 and KSF-777 are statistically at par. Similar position was seen in cultivars SY-4045 and US-444 whose varietal means did not differ to each other significantly and are also statistically at par. In contrast to cultivar LG-5658, the minimum value for seed index was recorded in Aftab-12.

1000 Grains weight (g)

1000 grain's weight plays an important role in determining yield potential of a crop. Statistical analysis of data (Table 1) shows that the hybrid cultivars/varieties differed significantly in 1000 achene's weight, where Hysun-33 produced highest 1000 achene's weight as (63.567g and 64.53g) followed by LG-5658 (59.50g and 59.14g) and minimum (39.567g and 38.03g) was recorded in SMH-0917. Furthermore, LG-5658 and AG-SUN-8251 are statistically at par to each other. Whereas, cultivars FSS-60, SY-4045 and KSF-777 are also statistically at par to each other. Hybrid cultivars SMH-0917 and Aftab-12 had varietal means not significant to each other being also statistically at par.

Achene yield Kg ha^{-1}

Statistically analyzed data showed significant differences among varietal means for achene yield per hectare. Comparison of treatment means shown in Table, that statistically highest achene yield kg ha^{-1}during 2014 and 2015 was obtained by Hysun-33 (4086.3 and 4075.33kg ha^{-1}respectively) followed by AG-SUN-8251 (2960.7 and 2934. 67kg ha^{-1}) whereas minimum (1712.7 and 1707.33kg ha^{-1}) was recorded in cultivar SMH-0917

Discussion

Sunflower is an important crop for its edible oil production especially in developing countries. Establishing a good stand of this crop is difficulty in many regions. An optimum plant population leads towards an increment in final yield of the crop. In the experiment it indicated the homogeneity in number of plants m^{-2} as well as the uniform germination of all the varieties/cultivars included in the experiment and ultimately lead towards better crop stand and finally, the yield per hectare. It also depicted the better maintenance of the experiment by giving equal chance to grow well and giving better performance.

The results revealed that the plant population per plot showed no significant difference. The results are in line with Barros *et al.*, (2004). Contrary to the findings of Barros, during the year 2015, significant differences were found among cultivars for plant population. These significant differences among plant heights were found, most probably due to environmental conditions or genetic makeup of the hybrids.

These results are supported by Epinosa *et al.*, (1992) and Bakht *et al.*, (2006). However, contrary to these scientists, Karaaslan *et al.,* (2010) who found no significant results for plant height. Sunflower hybrids differed significantly for head diameter. The results are supported by Khan (2003), Sassikumar and Gopalan (1999), Waheed (1996) and Nouman (2009). Instead, Yousaf *et al.*, (1989), Karaaslan *et al.*, (2010) and Bakht *et al.*, (2006) reported no significant results for head diameter of sunflower cultivars.

Number of achenes head^{-1} of sunflower varieties/cultivars had significant difference in case of number of achenes head^{-1}. The results are similar to those Bakht *et al.*, (2006), Hanif *et al.*, (1996) and Razzaq (2006).

The results of seed index are in accordance with the findings of Bakht *et al.*, (2006) and Pirani and Gupta (1995) who reported that sunflower hybrids significantly affected the seed index. The hybrid cultivars/varieties differed significantly in 1000 achene's weight. These results are supported by Iqbal *et al.*, (2007) and Bakht *et al.*, (2006) who reported significant differences among varietal means for 1000 achene's weight. Results of achene yield per hectare are in accordance with those published by Iqbal *et al.*, (2007), Paradisi (1983), Beg and Aslam (1984), Ali *et al.*, (2007), Dash *et al.*, (1996) and Bakht *et al.*, (2006) who reported that achene yield was affected significantly by different head diameter, number of achenes per head and 1000 achene weight.

Thus, these results suggested that various factors like soil moisture, nutrients and environment required for the germination of seeds, subsequent growth and development were similar and all plants availed similar environments in all plots.

Head diameter is influenced by the environment in which crop is grown. Influencing both number of achenes head^{-1} and achene size, it contributes substantially to achene yield of sunflower. As a rule, large number of seeds per head is found in plants with larger head sizes (Tyagi *et al*, 2013) but in the study, Hysun-33 produced highest number of seeds while having head diameter at second position after SY-4045. Different agronomic traits ultimately lead towards final achene yield of the crop. Improvement in these traits results in improvement in final yield. Achene yield ha^{-1} is a result of cumulative effect of all yields and yield parameters in a particular set of environmental conditions, in case of this study as semi-arid conditions of Bahawalpur.

It is concluded from the results that Hysun-33 used as a control in this experiment is best adapted to the environmental conditions of Bahawalpur as it performed best for yield and most of its related traits. By economic point of view, no cultivar gave best economic yield as compared to Hysun-33 under agro ecological conditions of Bahawalpur.

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