Sun flower oil production under different sowing dates and hybrids

Usman Sultan[*], Asim Muhammad[*], Faiza Aman[**], Habib Ullah[***], Roohul Amin[****]
[*] Department of Agronomy, The University of Agriculture Peshawar, Khyber Pukhthunkhwa, 2513, Pakistan
[**] Department of Horticulture, The University of Agriculture Peshawar, Khyber Pukhthunkhwa, 2513, Pakistan
[***]Department of Agriculture Chemistry and Biochemistry, The University of Agriculture Peshawar, Khyber Pukhthunkhwa, 2513, Pakistan
[****]Department of Agriculture, Bacha Khan University, Charsadda, Khyber Pukhthunkhwa, 24420,, Pakistan

Abstract- Field experiment was conducted at Palatoo Research Farm, Amir Muhammad Khan Campus Mardan, The University of Agriculture Peshawar-Pakistan, during spring 2018. The experimental design was randomized complete block with split plot arrangement having three replications. The treatments were comprised of five sowing dates (March 3rd, 10th, 17th, 24th and 31st) allotted to main plot and four different hybrids sunflower cv. (Hysun-33, Agsun-8251, S-278 and 5551-Agricol) allotted to sub-plot. Effects showed that sowing dates significantly affected yield and yield components of sunflower hybrids except days to emergence and physiological maturity. Among different sowing timings, March3rdenhanced plant height (240.40 cm),early maturity (103), head diameter (18 cm), biological yield (8380 kg ha^{-1}), seed weight $head^{-1}$ (55.70 g), number of $seedshead^{-1}$(1087), 1000-seed weight (52.23 g), seed yield (2318 kg ha^{-1}), oil content (36 %) and oil yield (848kg ha^{-1}). However, delay in sowing timing(March 31st)reduced the plant height (231cm), head diameter (16.45 cm),biological yield (7781 kg ha^{-1}),seed weight $head^{-1}$ (50 g), number of seeds $head^{-1}$ (992), 1000-seed weight (48 g), seed yield (2062 kg ha^{-1}), oil content (26.25 %) and oil yield (542 kg ha^{-1}). Among different hybrids Hysun-33 produced tallest plants (238 cm),larger head diameter (18cm), higher biological yield (8256 kg ha^{-1}), heavier achene's weight $head^{-1}$ (54.70 g), $moreseedshead^{-1}$ (1102), maximum seed yield (2289 kg ha^{-1}), oil content (33.80 %) and oil yield (779 kg ha^{-1}). Interaction between sowing dates and sunflower hybrids was found significant for seed weight $head^{-1}$ and thousand seed weight (g).It was concluded from the study that sunflower hybrid Hyson-33seeded on March 3rdshowed maximum yield and yield components, therefore recommended under the agro-ecological condition of Mardan region.

Keywords: Sowing timing, Sunflower hybrids, Sunflower yield,

I. INTRODUCTION

Sunflower (*Helianthus annuus* L.) is an important protein rich edible oil seed crop belongs to Astaraceae family. Sunflower is of great importance because its seed has high oil contents ranging from 40-50% (Iqbal et al., 2010). Only 30% of edible oil requirements of Pakistan are met through local production, and the other 70% of the country's requirements are met through importation. The imported edible oils are mainly palm and soybean oil. However, the shortage of edible oil still persists. The situation of oil production in Pakistan is better than before, but due to increasing demand by the ever-increasing human population, continuous improvement in its productivity is highly desirable (Iqbal et al., 2010). It contains higher amount of linoleic acid. Sunflower is the capacity to receive to extensive variety of various agro-climatic conditions and diverse soil types. The lack of edible oils has turned into a significant issue in Pakistan with expanding its request of utilization (Heather et al., 2012). Area of sunflower during 2016-17 (Spring) was 216 (Acres) having oil production of 41000 tons. It was cultivated on an area of 152693 hectares with the production of 193122 tons with an average seed yield of 1265 kg ha^{-1}. Sunflower contributes to 41 thousand tons of edible oil and 22 % of the local oil production (MNFSR, 2016-17). Average yield at farmer's fields is 1520 kg ha^{-1}, while potential yield at progressive farmer's field is 3800 kg ha^{-1}, potential yield at research station is greater than 3500 kg ha^{-1} (Shah et al., 2013). Sunflower was introduced during early sixties as oilseed crop, but now it is the second important source of vegetable oil after cotton seed. Sunflower seeds are a major source of vegetable oil worldwide. Accordingly, the growth of large populations of sunflower plants as an oilseed crop, which begins in Russia around 1860, has developed into an international agricultural production. Currently, the extracted oil accounts for approximately four fifths of the value of these crop plants (Kutschera and Winslow, 2016).

Change in sowing time under various climatic conditions has fundamentally influenced the yield and oil substance (Ahmed et al., 2015). To build yield and its security, it is important to plan to decide the ideal sowing date for accomplishing complex yield of sunflower. Sowing date impacts vegetative characteristics, together with seed yield and its parameters (Allam et al., 2003). The seed yield, head diameter, the proportion of seed weight $head^{-1}$, 1000 seed weight, oil substance of seed is decidedly influenced by early sowing of sunflower (Abdou et al., 2011 and Ahmed et al., 2015). Results from past investigations additionally showed that the seed yield can be reduced by delaying the sowing date (Baghdadi et al., 2014). The late planting is effective in delaying of emergence, flowering and maturity in cultivars of sunflower. However, in some studies that were conducted at in different ecology and climatic conditions, the sowing date is delayed, growth, seed yield, and quality (oil content) generally tend to decrease (Baghdadi et al., 2014 and Ahmed et al., 2015). It is expressed that the yield and agronomical characteristics of the sunflower were especially higher in the early sown crops whereas the late sown crops showed lower yield and growth (Ali et al., 2004).

In Pakistan cultivation of exotic sunflower hybrids are not good for better yield because these are not well adapted to our agro climatic conditions (Skoric, 2012 and Seiler et al., 2017). Therefore, introduction of such hybrids which are early maturating, having high oil contents and producing high seed yield (Bakht et al., 2006). While choosing hybrids, we must to exactly consider seed yield potential, oil content and oil production. Maximum seed and oil percentage obtained from S-278 hybrid (Ali et al., 2012). The highest percentages of seed oil

recorded in Hysun-33, SMH-0917 and SMH-0907. Overall Hysun-33, SMH-0917 and SMH-0907 hybrids showed maximum plant height, head diameters, seed numbers head^{-1} and seed yield kg ha^{-1} (Iqrasan et al., 2017). Selection of hybrids with characteristics which are best suited to agro-ecological conditions of Pakistan needs emergent attention. Now a day's numbers of hybrids in sunflower are available and practiced by farmers. As well as the climate change and shifting of season noticed due to global warming and it is paramount importance to re-designate the optimum sowing time for spring sunflower.

Therefore, sunflower hybrids have to be tested for their performance with different sowing timings under irrigated condition of spring season.

II. MATERIALS AND METHODS

Experimental site and treatments

The current study on the effect of sowing timings for best hybrids selection of sunflower for spring crop was carried out at Palatoo Research Farm, Amir Muhammad Khan Campus Mardan, The University of Agriculture Peshawar-Pakistan during spring 2018. The experimental design was randomized complete block with split plot arrangement having three replications. The treatments were comprised of five sowing dates (March 3rd, 10th, 17th, 24th and March 31st) as the main plot treatments and four different sunflower hybrids (Hysun-33, Agsun-8251, S-278 and 5551-Agricol) as sub-plot treatments. The land was prepared and ploughed thoroughly using cultivator and rotavator and first irrigation was done after five days of sowing. A standard agronomic practice like irrigation was done after five days of sowing. A standard agronomic practice like irrigation was provided uniformly for each and every date. Two times weeding were done throughout the experiment.

Hybrids detail

The different hybrid including Hyson-33 was developed by ICI and has been in the field in Pakistan since 1992. It is tallest hybrid with potential up to 5000 kg ha^{-1} yield. It takes 110 days to mature. It has resistance against major sunflower diseases. The hybrid Agsun-8251 was imported by Seethi seeds, Pakistan from South Africa. High yielding crop variety between 800 Kg acre^{-1}and was included in the NUYT on sunflower by NARC/PARC in spring, 2012 and Autumn-2012. Maturity period between 90-95 Days. The hybridS-278 hybrid was introduced in Pakistan by Syngenta seeds in 2002. It is medium hybrid with yield potential between 4000 to 5000kg ha^{-1}. It mature early in 90-100 days but diseases susceptibility is reported recently. The hybrid5551-Agricol was developed by South Africa. Yield potential up to 2133 kg ha^{-1}. Resistance to pest and disease including leaf rust, leaf spot and anthrank nose (Source: National Agriculture Research Council (NARC), Islamabad).

Climatic condition of experimental area

The experimental site is located at latitudes of 33^{o} N, longitudes of 72^{o} East and altitude of 285 m. During crop growing season, maximum and minimum temperatures were gradually increased from March to June (Fig. 1). The maximum quantity of whole rainfall was noted in July (97.6 mm), while lowest rainfall (22.4 mm) was occurred in June (Fig. 2). The maximum relative humidity (43%) was noted in July and smallest in June (24%) (Fig. 3).

Parameter such as the head diameter was noted by randomly selecting five heads in every plot at harvesting stage. The data was recorded with the help of measuring tape and then averaged. Three central rows are collected from every sub plot, the material was sun dried, weighed and then converted into biological yield (kg ha^{-1}) by using succeeding formula.

Biological yield (kg ha^{-1})

$$= \frac{\text{biological yield in three central rows}}{\text{row to row dist.} \times \text{ no. of rows} \times \text{ row length}} \times 10000$$

The randomly selected achene's from five different heads of each plot were dried, shelled from sunflower head^{-1}, counted, weight and averaged for seed weight head^{-1}. Numbers of seeds head^{-1} were calculated in randomly selected five heads from every experimental unit and then recorded data were averaged. 1000-seeds weights were calculated for each plot. The randomly selected three samples of 1000-seeds for every plot was taken, weighted and averaged. Three central rows already collected for biological yield in an experimental unit after sun drying in field were consequently threshed by hand and weight to record the seed yield. Data were converted into kg ha^{-1} through via the formula mansion below.

$$\text{Seed yield kg ha}^{-1} = \frac{\text{Seed yield in three central rows}}{\text{R}-\text{R distance} \times \text{R length} \times \text{No.of Rows}} \times 10000$$

Harvest index was calculated by dividing the total grain yield by biological yield multiplied with 100.

$$\text{Harvest index} = \frac{\text{Economical yeild}}{\text{Biological yeild}} \times 100$$

Oil content (%) was calculated by the following formula

$$\text{Oil content (\%)} = \frac{\text{oil weight}}{\text{Sample weight}} \times 100$$

Oil content determination

A five (5) gram sample obtained from each treatment plots were analyzed by Near Infra-red Reflectance Spectroscopy System, (TR-3657-C Model 6500) as described by Ahmad et al., (2015) at Oilseed Quality Laboratory, Crop Breeding Division, Nuclear Institute for Food and Agriculture Peshawar, Pakistan. Oil yield determined by multiplying percent oil content with seed yield of sunflower.

Oil yield (kg ha^{-1}) = Percent oil content ×seed yield

Statistical analysis

Analysis of variance was carried out by using procedure related for RCBD with split plot arrangements. Its means was compared by using LSD test at 0.05level of probability, when the F-values are significant (Steel and Torrie, 1984).

III. RESULTS AND DISCUSSION

Days to emergence

Days to emergence were not significantly influence by different planting dates and different sunflower hybrids (Table.1). The crop sown on March 3rd showed early emergence when compared to the late sown crop. This due to the high temperature during the late sowing dates which delayed the emergence; as high temperature retards the activities of the seed (Fig.1).The effects are in agreement with the outcomes of Shafiullah et al. (1991) who stated that sunflower seeds took 13 to 14 days to emergence when planted on March 1st. Same results were observed by Bakhat et al. (2006).

Number of plant m^{-2}

Number of plant m^{-2} was significantly affected by planting times and sunflower hybrids (Table.2). The crop sown earlier produced more plants m^{-2}. This might due to lower temperature and shorter

photoperiod during the early sowing timing which significant vegetative growth period of the crop. The crop sown on March 3rd showed prevalence of higher air temperature and ageing of leaves, as the crop was more near to maturity because of relatively shorter crop duration. Delay in sowing timing decreased the plant m^{-2}. Maximum number of plant m^{-2} was recorded in those plots which were sown in the March 3rd. This might be due to the favorable climatic condition in the first week of March that resulted in maximum number of plant m^{-2}. Same findings were observed by Shafiullah et al. (1991) who stated that early seeding increased number of plant m^{-2}. While by different sunflower hybrids Sunbred-278 was produced highestnumber of plant m^{-2} as related to Hysun-33. These outcomes are in agreement of Zambrana and Menchaca (1978) who observed correlated types of variance in many sunflower cultivars.

Plant height (cm)

Plant height (cm) was significantly influence by planting dates and sunflower hybrids (Table.1). The crop sown earlier produced highest plant height. Delay in sowing timing decreased the plant height. Maximum plant heights (cm) were noted in those plots which were seeded in the March 3rd. This might be due to the favorable climatic condition in the first week of March that resulted in maximum plant height (cm). It incomes that at better level of houseplant height, the achene yield was similarly better marginally. These outcomes are in line with those of stated by Mazher (2005), Razzaq (2006), Akhtar (1985) and Osman (2010) and Abdel-Motagally, who reported that these variances due to varietal performance. This was actually related with the chiller weather environments normal during the initial growing period and flowering, mostly at the first two planting dates. In difference the late planting produced stable decrease in plant height. While by different sunflower crossbreeds Hysun-33 was made supreme plant stature and 5551-Agricol was produced minimum plant height. Our effects are in contract by the results of Sarwar et al.(2013) who stated that hybrid Hysun-33 improved plant stature. He also stated that Hysun-33 provided the supreme plant height. Bakhat et al. (2006) also observed important variances between sunflower crosses for plant height. These outcomes designate that variance in plant height due to heritable makeup. These effects are more over by the results of Iqbal et al. (2008) who observed that hybrid 5551-Agricol attained less height as related to Hysun-33.

Days to physiological maturity

Days to physiological maturity of sunflower crossbreeds were not significantly influence by various sowing dates (Table.1&2). The delay planted crop acquired extra days to maturity as related to the earlier sown crop. It might be the influence of high temperature through the late growing which delayed physiological maturity. The physiological maturities were also not significantly influenced by hybrids. Different result was reported by Khalid et al. (2013) also initiate non-significant variance for physiological maturity.

Days to flowering

Days to flowering decreased significantly with delay in seeding (Table.1&2). The crop seeded on March 3rd took significantly extra days to flowering than the crop planted later than March 3rd. It might due to the lower temperature of soil and surrounding air which encouraged vegetative growth and increased the duration taken by the crop of flowering (Fig.1). Results discovered that late seeded crop flowered before than those of initial sown crop which might be due to the statement that greater temperature reduced asexual growth and greater flowering (Summer et al.,1985 and Nihal 2010). The different scientist reported that delay in sowing decreased the duration between seedling emergence and flowering formation (Angadiet al.,2000; Shafiullahet al., 1991; Dhillon and Sharma 2017). It is proposes that if flowering arises early then achene yield will be greater. These outcomes are also maintained by Arshad et al. (2013) who observed important changes for days to flower opening between different mixtures. While by different sunflower crosses Hysun-33 was produced maximum head diameter and 5551-Agricol have produced minimum head diameter.

Head diameter (cm)

Head diameter (cm) was significantly influence by various planting dates and sunflower hybrids (Table.1). It was clear from the data larger heads was recorded in first week of March. The early sown crop in March probably favored more vegetative growth due to favorable temperature (Fig.1). In the late sown crop, the growth period was reduced and the normal development of the crop was impaired, which might have resulted into the reduced head diameter in the late sown plots. Astiz and Hernandez (2013) reported that, the higher temperature might be responsible for lower pollen viability and reduced pollen load under late-sown conditions, leading to lower yield. Maximum head diameter in the first week of March might be due to the favorable climatic situations available for the normal growing and development of the sunflower. These results were complete by the results of Shafiullah et al. (1991) who identified that reduction in head diameter by delay in sowing dates. While by different sunflower hybrids Hysun-33 was produced bigger heads diameter and 5551-Agricol was produced smaller heads diameter of sunflower. Our outcomes are in contract through Sarwar et al. (2013) who stated that head diameter of hysun-33 was bigger than the other mixtures. Large size head produced by Hysun-33 due to genetic character of crossbreed. Contrasting effect was stated by Iqbal et al. (2008) who stated that Hysun-33 created bigger head diameter.

Biological yield (kg ha^{-1})

Biological yield (kg ha^{-1}) was significantly influence in various planting times (Table.1). More biological yield was calculated in those plots which were seeded in March 3rd while smallest biological yield was designed in those plots which were sown in March 31st. Maximum biological yield in the March 3rd sown plots might due to the favorable climatic environments available for the crop to complete its regular growing. The effect on biological yield was similarly significant with higher values in spring than in autumn period. Our results are in line with inference of Smiderle (2001) who evaluated the sunflower farming in changing seasons, and reported that spring sowing was more appropriate than autumn sowing in increase of maximum biological yield possible. The hybrid Hysun-33 noted uppermost biological yield (8256 kg ha^{-1}), which was significantly more over Sunbread-278 hybrid. The lowermost biological yield (kg ha^{-1}) was noted by crossbreed 5551-Agricol (7958 kg ha^{-1}). The sunflower crossbreed Hysun-33 showed the greater biological yield however, S-278 produced a smaller amount of biological yield because S-278 was semi dwarf stature and shape smaller amount biomass. Our effect with the findings

of Ahmad et al. (2005) that Hysun-33 produced highest biological yield.

Maximum achene weight head^{-1}

Maximum achene weight head^{-1} was noted in those plots which were seeded in March 3rd, followed by March 10th while lowest achene weight head^{-1} was observed in March 31st (Table.1). The reduced seed weight in the delayed sown plots might due to higher temperature, moisture stress and shorter growing period of the crop (Fig.1). Seed weight normally reduced with late seeding which might be recognized to the reduction in yield mechanisms (Siddique et al., 2002). Generative growth of various crop types may similarly be injured by warmness stroke impressive plants create no flowers or established a smaller amount of number of achene's with reduced size. These outcomes are set by the result of shafiullahet al. (1991) and Dhillon and Sharma (2017) who revealed that delay in sowing produced less number of achene's with reduced achene weigh. The influence of hybrids in respect of achene weight head^{-1} was significant (Table.2). The hybrid Hysun-33 recorded highest achene weight head^{-1} (54 g) as compared to Agsun-8251 and 5551-Agricol.

Number of achene's head^{-1}

Sowing dates showed significant influence on number of achene's head^{-1} (Table.1). Crop sown on March 3rd recorded more achene's head^{-1} when correlated to the crop sown later than March 3rd. This might due to the favorable climatic condition available in first week of March that resulted in maximum photosynthates formation and transfer of these assimilates to the grain at a higher rate. These effects were comparable to the results of Dhillon and Sharma (2017).It is initiated that the highest achene's head^{-1} was counted in Hysun-33 (1102) as related to rest of hybrids (Table.2). Our outcomes are similar with the results of Ali et al. (2013) who stated that outcomes for seeds per head. Great harvestable yield is the eventual determination for developing crops, and crop development and yield traits are influenced by several spring reasons. Extreme number of seed head^{-1}was noticed when Spring sown Hysun-33 (Jose et al., 2004).

Thousand seed weight (g)

A heaviest seeds was noted in those plots which were seeded in March 3rd while plot sown later than March 3rd resulted in reduced weight (Table.10). The reduced seeds weight in the delayed sown plots might be due to higher temperature, moisture stress and shorter growing period of the crop (Fig.1). These factors affected the flow of moisture and nutrients towards the grain and ultimately lighter grains were produced. Kakani et al. (2002) reported that, high temperature at flowering period prevents pollen growth and pollen viability, consequently resulting in lower seed set and yield. Our outcomes are confirmed by the finding of Shafiullah et al. (1991) and Chajjro et al. (2013) who revealed that reduced was seed weight in late sowing. The spring season increased seeds weight as related to summer season. Present results were in line with findings of Agele (2003) who'sstated that spring season is best for environment. The hybrid Hysun-33 recorded highest seeds weight (51 g) as compared to Agsun-8251 and S-278. The result are in conformism with conclusions of Pirani and Gupta (1995) and Bakhatet al.(2006) whoinformed significant change for achene weight and former agronomic types.

Seed yield (kg ha^{-1})

Sowing dates had a significant influence on seed yield (kg ha^{-1}) (Table.1). Late sown plots caused in lower achene yield. However, extreme achene yields kg ha^{-1}was noted in the March 3rd sown plots. The minor seed yield in the March 31stsown plots might be due to the higher temperature through the later emergent season which reduced the number of days to maturity and similarly other growth parameters. Achene yield commonly reduced with late seeding which might be ascribed to the reduction in yield mechanisms (Siddique et al., 2002). Reproductive growth of various crop types may also be broken by temperature stroke imposing plants set less number of achene with cheap size. Maximum seed yield in Hysun-33 was greater head diameter (18 cm) than 5551-Agricol and S-278, which might be due to its better flexibility. These outcomes are in line with those of Khaliq and Cheema (2005).The outcomes of the current study are in conformism of Khan et al. (1989) who told important difference in achene yield among many sunflower crossbreeds.

Harvest index

Sowing dates had a non-significant influence on harvest index (%) (Table.1&2). Late sown plots recorded lower harvest index..The effect of hybrids on harvest index was also initiated non-significant.

Oil content (%)

Oil content (%) of the sunflower crossbreeds was affected significantly by the seeding time (Table.1). Oil content reduced through delay in seeding dates. These finding are in line with those reported by Lopez and Del (1978) and Pal and Nazri (1981) who observed that oil percentage of the seeds decreased with delay in seeding times. Maximum oil yield was produced in plots sown in March 3rd but plots sown late resulted in a lower oil yield. The achene oil content revealed greater oil content in spring than in summer. The oil content was significantly influenced in hybrids. The upper most oil content was recorded by Hysun-33 (33%) which was significantly superior over other hybrid S-278 (33%) and Agsun-8251 (30%). Harris et al. (1978) stated that oil content reduced as temperature greater.

Oil yield kg ha^{-1}

Similarly oil yield kg ha^{-1} was significantly influenced by hybrids (Table.2). The highest oil yield was recorded by Hysun-33 (779 kg ha^{-1}) which is significantly superior over other hybrids. The lowest oil yield recorded in 5551-Agricol (579) than other hybrids. These outcomes are confirmed by the result of Jocic et al. (2015) who stated that hybrid Hysun-33 produced highest oil yield in sunflower.

IV. CONCLUSION

On the basis of results it can be concluded that hybrids sown on March 3rd resulted in higher plant height, thousand seeds weight, head diameter, seeds head^{-1}, seed weight head^{-1}, seed yield, biological yield, oil content and oil yield than rest of the sowing dates. Hysun-33 produced higher seed yield and yield components as compared to rest of the hybrids, respectively, hence recommended under the agro-ecological condition of Mardan region.

Table 1.Days to emergence, number of plants m^{-2}, plant height (cm), physiological maturity, days to flowering, head diameter (cm), biological yield (kg ha^{-1}), seed weight $head^{-1}$ (g), number of seeds $head^{-1}$, thousand seed weight (g), seed yield (kg ha^{-1}), o*il content (%),*oil yield (kg ha^{-1}) of sunflower as affected by different sowing dates.

Sowing dates	DE	NP	PH	PM	DF	HD	BY	SWD	NSH	TSW	SY	HI	OC	OY
3rd March	13	5.82 a	240.40 a	103	74 a	18.07 a	8380 a	55.70 a	1087.08 a	52.23 a	2318 a	27.66	36 a	848.04 a
10th March	14	5.69 ab	238.72 a	109	73 ab	17.97 ab	8348 ab	55.03ab	1074.17 a	51.67 a	2298 ab	27.55	33 a	776.29ab
17th March	15	5.44 b	235.39 b	113	69 b	17.33 b	8145 b	52.18bc	1041.42ab	50.63ab	2219 bc	27.26	32 ab	723.46 bc
24th March	16	5.49 b	234.49bc	116	67 bc	16.88 c	7920 c	51.83bc	1010.08 b	49.40bc	2184 c	27.63	29 bc	638.62 cd
31st March	16	5.32 bc	231.97 c	117	67 bc	16.45 cd	7781 cd	50.16 c	992.42 bc	48.81 c	2062 d	26.55	26 c	542.97 d
LSD at 0.5	ns	0.1	3.0	ns	3.0	0.43	168.1	3.2	51.1	1.6	93.7	ns	4.4	157.08

DE=Days to emergence, NP=number of plants m-2, PH=Plant height, DF=Days to flowering, BY=Biological yield, SWH=Seed weight head-1, TSW=Thousand seed weight, SY=Seed yield, HI=Harvest index, OC=Oil Content, OY=Oil yield

Table 2. Days to emergence, number of plants m^{-2}, plant height (cm), physiological maturity, days to flowering, head diameter (cm), biological yield (kg ha^{-1}), seed weight $head^{-1}$ (g), number of seeds $head^{-1}$, thousand seed weight (g), seed yield (kg ha^{-1}), harvest index (%), o*il content (%),*oil yield (kg ha^{-1}) of sunflower as affected by different hybrids.

Sowing dates	DE	NP	PH	PM	DF	HD	BY	SWD	NSH	TSW	SY	HI	OC	OY
Hysun-33	15	5.38 b	238.31 a	107	72 a	18.02 a	8256 ab	54.70 a	1102.87 a	51.40 ab	2289 a	27.72	33 a	779.43 a
Agsun-8251	15	5.51ab	236.98 a	112	71ab	17.23 b	8082 b	52.63 b	1036.53 ab	51.55 a	2200 b	27.30	30 ab	677.61b
S-278	15	5.68 a	235.67ab	113	68 b	17.19 bc	8163 a	51.81 bc	1027.27 b	50.49 b	2288 a	28.03	33 a	68.51a
5551-Agricol	15	5.64 a	233.80 b	114	68 b	16.90 c	7958 bc	52.78 ab	997.47 bc	48.75 bc	2088 c	26.27	28 b	597.95 b
LSD at 0.5	ns	0.1	2.7	ns	2.4	0.39	188.5	1.8	52.9	1.3	82.0	ns	3.5	154.11

DE=Days to emergence, NP=number of plants m-2, PH=Plant height, DF=Days to flowering, BY=Biological yield, SWH=Seed weight head-1, TSW=Thousand seed weight, SY=Seed yield, HI=Harvest index, OC=Oil Content, OY=Oil yield

Mean of the same category followed by different letter (s) are significantly different at 5% level of probability using least significant difference (LSD) test.

Table 3. Days to emergence, Number of plants m^{-2}, Plant height (cm), Physiological maturity, Days to flowering, Head diameter (cm), Biological yield (kg ha^{-1}), Seed weight $head^{-1}$ (g), Number of seeds $head^{-1}$, Thousand seed weight (g), Seed yield (kg ha^{-1}), Harvest index (%), *Oil content (%),*Oil yield (kg ha^{-1}) of sunflower hybrid as affected by different sowing dates.

SOV	DF	DE	NP	PH	PM	DF	HD	BY	SWD	NSH	TSW	SY	HI	OC	OY
Rep	2	1.71	0.14	11.29	15.8	5.6	0.01	7284.2	0.62	2385.26	1.58	22533.65	3.04	52.71	29880.49
SD	4	18.01	0.47	136.47	379.6	129.05	5.78	825585.9	64.57	19620.15	25.20	125098.9	2.60	190.60	169617.4
Error I	8	0.46	0.04	10.81	6.52	10.18	0.21	31886.85	11.66	2955.72	3.18	9917.46	1.88	22.32	13297.72
Hybrids	3	0.46	0.27	55.67	145.13	45.9	3.44	240363.8	22.39	29655.93	24.84	135431	8.78	89.13	108901.6
SD x H	16	0.63	0.10	4.63	2.92	29.26	0.29	118219.5	24.07	6045.76	9.33	6733.35	2.11	6.88	3854.68
Error II	26	2.62	0.07	15.53	5.95	12.41	0.33	73780.57	7.33	5824.03	3.59	13965.6	3.17	26.07	14643.26
Total	59.0	CV1: 4.41	CV1: 3.72	CV1: 1.39	CV1: 2.2	CV1: 4.53	CV1: 2.67	CV1: 2.20	CV1: 6.44	CV1: 5.22	CV1: 3.53	CV1: 4.49	CV1: 5.02	CV1: 14.93	CV1: 16.33
		CV2: 10.45	CV2: 4.86	CV2: 1.66	CV2: 2.1	CV2: 5.00	CV2: 3.31	CV2: 3.34	CV2: 5.11	CV2: 7.33	CV2: 3.75	CV2: 55.33	CV2: 6.51	CV2: 16.14	CV2: 17.14

DE=Days to emergence, NP=number of plants m-2, PH=Plant height, DF=Days to flowering, BY=Biological yield, SWH=Seed weight head-1, TSW=Thousand seed weight, SY=Seed yield, HI=Harvest index, OC=Oil Content, OY=Oil yield

Mean of the same category followed by different letter (s) are significantly different at 5% level of probability using least significant difference (LSD) test.

REFERENCES

[1] Abdel-Motogally, F.M.F., and E.A. Osman. 2010. Effect of nitrogen and potassium fertilization combinations on productivity of two sunflower cultivars under east of Elewinate condition. Eurasian J. Agric. environ. Sci. (4): 397.

[2] Abdou, S.M.M., K.M. Abdel-Latif, R.M.F. Farrag, and K.M.R. Yousef. 2011. The response of sunflower yield and water. Adv. in Appl. Sci. Res. 2(3):141-150.

[3] Agele, S.O. 2003. Sunflower responses to weather variations in rainy and dry cropping seasons in a tropical rain forest zone. Int. J. Bio. 32: 17-33.

[4] Ahmad, S., F. U. Hassan, H. Ali and U. Robab. 2005. Response of sunflower to dibbling time for yield and yield components. J. Res. Sci. 16(1):19-26.

[5] Ahmed, B., M. Sultana, J. Zaman, S.K. Paul, M.M. Rahman, M.R. Islam and F. Majumdar. 2015. Effect of sowing dates on the yield of sunflower. Ban. Agron.J. 18(1):1-5.

[6] Akhtar, M.R. 1985. Studies on growth and yield of five sunflower cultivars planted on two different geometrical patterns. M. Sc. (Hons.) Dep. Agron. Univ. Agric. Faisalabad, Pak.

[7] Ali Shah, Nisr and Aujla, Khalid and Ishaq, Muhammad and Farooq, Arshad. 2013. Trends in sunflower production and its potential in increasing domestic edible oil production in Punjab, Pak. 29: 7-13.

[8] Ali, A., A. Ahmad, T. Khaliq, M. Afzal and Z. Iqbal. 2012. Achene yield and quality response of sunflower hybrids to nitrogen at varying planting densities. Int. Conf. on Agriculture, Chemical and Environ. Sci. (ICACES 2012) Oct.6-7, Dubai (UAE) pp.7377.

[9] Ali, H., S.A. Randhawa, and M. Yousaf. 2004. Quantitative and qualitative traits of sunflower (*Helianthus annuus* L.) as influenced by planting dates and nitrogen application. Int. J. Agriculture and Bio. 6(2): 410-412.

[10] Allam, A.Y., G.R. El-NagSar, and A.H. Galal. 2003. The response of two sunflower hybrids to planting dates and densities. ActaAgron. Hung. 51(1): 25-35.

[11] Angadi, S. V., H. W. Cutforth, P. R. Miller, B. G. McConkey, Entz M. H. S. A. Brandt and K.M. Volkmar. 2000. Response of three brassica species to high temperature stress during reproductive growth. Canadian J. Plant Sci. 693-701.

[12] Arshad, M., M.A. Khan, I. Ullah and M. Amjad. 2013. Development of short duration and high yielding indigenous sunflower (*Helianthus annuus* L.) hybrids. Sci. Tech. Dev. 32(3): 205-214.

[13] Astiz, V. and Hernandez, L.F. 2013. Pollen production in sunflower (*Helianthus annuus*L.) is affected by air temperature a relative humidity during early reproductive growth. Intern. J. Exp. Bot.82: 297–302.

[14] Baghdadi, A., A.H. Ridzwan, A. Nasiri, I. Ahmad, and F. Aslani. 2014. Influence of plantspacing and sowing time on yield of sunflower (*Helianthus annuus*L.). J. Food, Agri. Environ.(2): 688-691.

[15] Bakht, J., S. Ahmad, M. Tariq, H. Akbar and M. Shafi. 2006. Performance of various hybrids of sunflower in Peshawar valley. J. Agri. Sci. 3: 25-29.

[16] Chajjro, M. A., Zia-ul-hassan, I. Rajpar, A. N. Shah and K. A. Kubar. 2013. Sunflower hybrids differentially accumulate potassium for Growth and achene yield. Pak. J. Agri., Agri. Eng. Vet. Sci. 29(1): 31-43.

[17] Dhillon, B. S. and P.K. Sharma. 2017.Physiology, growth and productivity of staggered sown spring sunflower (*Helianthus annuus* L.) in response to varying intra-row spacing and applied nitrogen in the Indo-Gangetic plains. Indian J. Agron. 62(4): 496–504.

[18] Heather, D., H. Harwood, E. Cummings, R. Madden and S. Monahan. 2012. Sunflower planting dates trial. University of Vermont crops and soils technicians. 802: 524-544.

[19] Iqbal, A., H. A. Sadaqat, A.S. Khan and M. Amjad. 2010. Identification of sunflower (*Helianthus annuus*L.) hybrids using simple-sequence repeat markers, Genet. Mol. Res. 10(1): 102-106.

[20] Iqbal, J., B. Hussain, M. F. Saleem, M. A. Munir and M. Aslam. 2008. Bioeconomics of autumn planted sunflower (*Helianthus annuus* L.) hybrids under different NPK applications. Pak. J. Agric. Sci. 45(3):19-24.

[21] Iqrasan, A. Qayyum,S.U. khan,S.A. khan, A. Mehmood, Y. Bibi, A. Sher, H. Khan, and M.A. Jenks. 2017. Sunflower (*Helianthus annuus* L) hybrids evaluation for oil quality and yield attributes under spring planting conditions of Haripur, Pak. 1806-9681.

[22] Jose F.C.B., M.D.Carralho, andG. Basch. 2004. Response of sunflower (*Helianthus annuus* L.) to sowing date and plant density under mediterranean conditions. Eur. J. Agron. 21: 347-56.

[23] Jocic, S., D. Miladinovic, and Y. Kaya. 2015. Breeding and genetics of sunflower. In sunflower: chemistry, production, processing, and utilization; Martínez-Force,E., Dunford, N.T., Salas, J.J., Eds.; AOCS Press: Urbana, IL, USA pp. 1–26. ISBN978-1-893997-94-3.

[24] Kakani, V. G., P.V.V. Prasad,P.Q.Craufurd, andT.R.Wheeler.2002.Response of in vitro pollen germination and pollen tube growth of groundnut (*Arachis hypogae* L.) genotypes totemperature. Plant Cell Environ. (12): 1,651-1,661.

[25] Khalid, M. E., A. H. Abdalla, and M. K. Sabahelkhier. 2013. Evaluation of sunflower (*Helianthus annuus* L.) hybrid grown under rainfed area. Sudan, J. Sci, and Tech. 3(1): 6-11.

[26] Khaliq, A. and Z. A. Cheema. 2005. Effect of irrigation regimes on some agronomic traits and yield of different sunflower (*Helianthus annuus* L.) hybrids. Int. J. Agric. Biol. 7(6): 920-24.

[27] Khan, M. I. 1989. Correlation study in sunflower (*Helianthus annuus* L.). J. Agric. Res. 27: 275-295.

[28] Kutschera, U. Briggsand Winslow. 2016. How do sunflowers follow the Sun- And to what end. Sci. 353: 541-542.

[29] Lopez, M. DE. L. 1978. Effect of date of seeding of sunflower in irrigated plots on seed yield and oil content. Inproceeding of the 6th International Sunflower Conference Bucharest. International Sunflower Ass. 55-563.

[30] Mazhar, M. 2005. Evaluation of comparative growth and yield performance on sunflower hybrids planted in autumn season. Msc (Hons) thesis, Deptt. of agron, Univ. of Agric. Faisalabad.

[31] MNFS&R, 2016-17. Ministry of Finance, Economic Advisors Wing, Islamabad.

[32] Pal, M.S.and S.N.Nazari. 1981. Agronomic evaluation of composite and hybrid sunflower cultivars. Ann. Agric. Res. 18(3): 377-379.

[33] Pirani, V., and A. Gatto. 1995. Characteristics of some sunflower hybrids in the course of being entered on the national register of varieties. SementiElette. 41: 27-30.

[34] Razzaq, A.H. 2006. Determination of growth, yield and quality performance of different spring planted sunflower hybrid. Msc (Hons) thesis, Deptt. Of Agron. Univ. of Agri. Faisalabad.

[35] Sarwar, M.A., M.N.K. Rehman, H.M.R. Javed, W. Ahmad, M. A. Shehzad, S. Iqbal and H.T. Abbas. 2013. Comparative performance of various sunflower hybrids for yield and its related attributes CercetăriAgronomiceîn Moldova. 46(4): 57-64.

[36] Seiler, G. J., and L. F. Marek. 2017. Utilization of sunflower crop wild relatives for cultivated sunflower improvement. *Crop Sci.* 57: 1083–1101.

[37] Shah, A., Nisr and Aujla, Khalid and Ishaq, Muhammad and Farooq, and Arshad. 2013. Trends in sunflower production and its potential in increasing domestic edible oil production in Punjab Pak. 29. 7-13.

[38] Siddique, A.B., D. Wright and S.M.M. Ali. 2002. Effect of sowing dateson the phenology, seed yield and yield components of peas. Online Biol. Sci. 2(5): 300- 303.

[39] Skoric, D. 2012. Sunflower breeding in *sunflower genetics and breeding* ed. Kovacevic Z. editor. Novi Sad: Serbian Academy of Sci. 165: 350–354.

[40] Smiderle, O.J. 2001. Potential of sunflower production in two sowing dates in the savana ecosystem of Roraima. Revista-Cientifica-Rural. 6: 51-55.

[41] Steel, R. G. D. and J.H. Torrie. 1984. Principles and procedure of statistics. 2nd ed Mc, Graw Hill, New York.

[42] Summer, F., R. J., E.H. Roberts, W. Erskine and R. H. Killis. 1985. Effects of temperature and photoperiod and flowering in lentils (*Lens culinaris Medic.*). Ann. Bot. 56(5): 659-671.

[43] Zambrana, T., and M.Menchaca. 1987. Evaluation of sunflower (*Helianthus annuus* L.) cultivars for seed production. CienTecniaAgricPastosForrajes. 10: 51-63.

[44] Harris, H.C.,J. R. Mcwilliam, and W. K. Mason. 1978. Influence of temperature on oil contents and composition of sunflower seed. Austr. J. Agric. Res. 29:1203-12.

[45] Shafiullah, K., M. Baitullah, M. Rana, B. Khan, Cansu and Ozair. 2001. Effect of desiccant application and time of harvest on yield and oil quality of sunflower. (*Helianthus annuus* L.).

[46] Nihal, K. 2010. Response of lentil (*Lens culinarisMedik*.) to sowing date and timing of nitrogen application. J. Food. Agric. Environ. 8(2): 422-426.

AUTHORS

First Author – Ussman Sultan, M.Sc (Hons), Department of Agronomy, The University of Agriculture Peshawar, Khyber Pakhtunkhwa, Pakistan and email: kamransorani@gmail.com.

Second Author – Asim Muhammad, Ph.D, Department of Agronomy, The University of Agriculture Peshawar, Khyber Pakhtunkhwa, Pakistan and email: asimmuh@aup.edu.pk

Third Author – Faiza Aman, Ph.D, Department of Horticulture, The University of Agriculture Peshawar, Khyber Pakhtunkhwa, Pakistan and email: faizaaman@aup.edu.pk

Fourth Author – Habib Ullah Ph.D, Department of Agronomy, The University of Agriculture Peshawar, Khyber Pakhtunkhwa, Pakistan and email: habib_297@aup.edu.pk

Fifth Author –Department of Agriculture, Bacha Khan University, Charsadda, Khyber Pukhthunkhwa, Pakistan and email: drroohulamin@bkuc.edu.pk

Correspondence Author – Asim Muhammad, asimmuh@aup.edu.pk,asimmir96@gmail.com, contact: 0092-3339883051.