Research Article

Plant Arrangement Effect on the Sunflower Yield and Yield Traits in Spring Season Crop

Murad Ali Khan* and Mohammad Akmal

Department of Agronomy, Faculty of Crop Production Sciences, The University of Agriculture, Peshawar, Khyber Pakhtunkhwa Pakistan.

Abstract | This study was conducted to evaluate the effect of plant arrangements i.e. planting geometry on yield and yield contributing traits of sunflower (*Helianthus annuus* L.) hybrid Hysun-33 at the Agronomy Research Farm, The University of Agriculture Peshawar, Pakistan during spring 2011 and repeated in spring 2012. The planting geometries were (a) 70 x 20 cm with rows spaced at 70 cm and plants spaced within the rows at 20 cm and (b) 90 x 15.5 cm with rows spaced at 90 cm and plants spaced within rows at 15.5 cm. It is important to mention here that 70 cm is the recommended row spacing used for sunflower crop in the region. Experiments were conducted in randomized complete block design, replicated four times. Results showed no significant changes in yield traits i.e. plant density (m^{-2}), number of grains per head and 1000 grains weight (g). However, biomass yield (kg ha^{-1}), grain yield (kg ha^{-1}) and oil content (g kg^{-1}) were found significantly ($p<0.05$) higher for planting geometry 90 x 15.5 cm as compared to 70 x 20 cm on mean values in both years. It is obvious from the data that yield traits are not significantly affected but still differences in its yield and seed oil content exists. So, it is possible to improve yield and yield components through proper planting geometry that may enhance crop canopy light interception and assimilates distribution within the plant parts to yield the best healthy grains.

Received | February 24, 2016; **Accepted** | May 30, 2016; **Published** | August 18, 2016
***Correspondence** | Murad Ali Khan, Department of Agronomy, Faculty of Crop Production Sciences, The University of Agriculture, Peshawar, Pakistan; **Email:** murad145@yahoo.com
Citation | Khan, M.A., and M. Akmal. 2016. Plant arrangement effect on the sunflower yield and yield traits in spring season crop. *Sarhad Journal of Agriculture,* 32(3): 151-155.
DOI | http://dx.doi.org/10.17582/journal.sja/2016.32.3.151.155
Keywords | Sunflower, Planting geometry, Grains yield, Yield traits, Oil content

Introduction

Pakistan is much deficient in edible oil production. The situation is getting worse day by day with terrifyingly growth of population. Currently, the local edible oil production meets around 23% demand (PODB Report, 2013). The import bill is approximately 2.84 million tons worth US $2.611 billion (Rs. 261 billion). Canola (*Brassica napus* L.) and cotton (*Gossypium hirsutum* L.) has contributed in local edible oil till 1960. Sunflower (*Helianthus annuus* L.) and soybean (*Glycine max* L.) came in cultivation in 1960 and 1980, respectively but could not get expected space in the existing cropping system due to many reasons including low per acre yield (Khan and Akmal, 2014). Currently, sunflower contributes 22.36% of total domestic edible oil need, which is mainly due to local oil extraction facility and its cultivation in both spring and summer season. The enormous population expansion of future will demand for more edible oil which has to be substituted from local resources. Opportunity of local oil seed production has to be explored for the cropping patterns climate is changing in Pakistan with heavy rain in winter and mild in summer in Khyber Pakhtunkhwa (Hanif, 2014). Sunflower is one of the potential crops that could be accommodated in the cropping system and also could be grown twice in a year with satisfactory economic production (Khan et al., 2014).

It is an established fact that crop yield is product of genotype and environment. A crop may respond differently because of its adaptation to new environment and climate (Phillip et al., 2009). Crop growth is mainly associated with crop canopy architecture and leaf surface area which is not only intercepts the solar radiation for the crop growth but also play a significant role in assimilates partitioning within the plant parts (Bannayan et al., 2010). Optimum plant density is a major concern and cause low yield in majority of crops (Akmal et al., 2014). The optimum plant density and its proper geometry is also a major constraint for low production of sunflower crop in the country which may lead to a significant difference in grain yield. Proper arrangement of plants is important to get advantage of the free available solar radiation in crop production (Barros et al., 2004). In another research, Legha and Giri (1999) has reported the maximum production of sunflower when planted in broader spacing (e.g. 75 x 30 cm). A decline in seed weight and production was observed when sunflower plant density increased per unit area (Nel et al, .2000). Increase in yield by reducing row spacing has also been reported by Zarea et al. (2005). More grain yield was achieved when intra-plant spacing of 20 cm was maintained that significantly declined yield with further increase or decrease (Pal et al., 1997).

Keeping in view the significance of plant geometry for optimum light interception by the canopy, this study was conducted with the objective to investigate proper planting pattern on grain yield and seed oil content of sunflower crop under climatic condition of Peshawar during spring season.

Materials and Methods

Experimental Site

Field experiments were conducted at Agronomy Research Farm, The University of Agriculture Peshawar during spring 2011 and repeated in spring 2012. Field was located at 34.01°N latitude and 71.35°E longitude at an altitude of 359 m above sea level. Environmental conditions at research farm were warm to hot, semi-arid subtropical with a mean annual rainfall of 360 mm. Soil was deep silt clay loam, alkaline (pH 7.5) and deficient in total N (< 0.5 g kg^{-1}). According to soil survey of Pakistan classification, the soil of the experimental site belongs to Tarnab series. The Meteorological data collected regarding the crop growth period for the year 2011 and 2012 are presented in Table 1. Experiment was conducted in a randomized complete block design, replicated four times. Field was prepared with cultivator run twice and subsequently refined with a rotavator. To study the effect of planting geometry on sunflower (Hysun-33) as spring crop, two different planting geometries were used and compared yield and yield traits having uniform planting density (7.14 m^{-2}). The sub plot size for planting geometry (a) was 70x20 cm with row to row distance as 70 cm and plants spaced within the rows at 20 cm which is also recommended planting geometry for sunflower in the area. The planting geometry (b) was maintained at 90x15.5 cm with space between the rows were 90 cm and plants spaced at 15.5 cm within rows. To keep uniform plant population and number of rows (06), plots size for Treatment (a) was 3.0 m long & 4.2 m wide while the plot size for Treatment (b) maintained at 3.10 m long & 5.4 m wide. Recommended fertilizers rate (N 90 and P 60 kg ha^{-1}) was applied from urea and SSP sources. Half of the nitrogen and full dose of phosphorus was applied at sowing time and the remaining N was used after 30 days of sowing with the first irrigation. The crop was sown with single row hand drill on March 10, 2011 & 2012 on well prepared soil using seed of 7 kg ha^{-1}. Other management and agronomic practices were kept same for both the planting geometries. Crop was irrigated when there was a demand for the irrigation about 4 times in each season.

Table 1: *Meteorological data of mean monthly temperature (°C) and rainfall (mm) from March to June of two years experimental duration (2011 and 2012)*

Month	Year					
	(2011)			2012		
	Avg. Temp. (°C)		Total Rainfall (mm)	Avg. Temp. (°C)		Total Rainfall (mm)
	Min	Max		Min	Max	
March	16.16	25.73	19.53	16.83	27.11	8.37
April	22.92	30.10	26.40	20.05	30.68	42.30
May	26.29	36.26	17.98	24.20	39.17	31.62
June	25.65	40.78	2.70	26.56	40.34	7.50

Data Recording Procedure

Data were recorded on randomly selected plant samples minimum 10 from each experimental unit for yield contributing components in each season and by harvesting two central rows in an experimental unit.

Yield Traits

Data on plant population per unit area (m^{-2}) were recorded by counting plants in a meter square area at two locations within a sub plot a week before the harvesting and converted into m^{-2} accordingly by dividing the population on harvested area. Head diameter of sunflower crop was measured on plants from border rows in a subplot and the final value was calculated by averaging all readings for a treatment. Grain number $head^{-1}$ was recorded by selecting randomly ten heads from subplot. Grains were shelled from heads already counted at harvest. All grains were divided on total number of heads for a mean value. Thousand grains weight (g) was obtained from clean grains in a subplot from randomly selected plants and weighed the grains on a precise digital balance.

Biomass Yield (kg ha^{-1})

Two central rows in an experimental unit were harvested; sun dried in field for two weeks and weighed the total biomass as biological yield of the treatment. Data were converted into kg ha^{-1} by dividing sample weight on harvested area and multiplied with ten thousand.

Grain Yield (kg ha^{-1})

Two central rows in an experimental unit were harvested; sun dried in field for two weeks, threshed manually and weighed to record grain weight. Grain yield was converted into kg ha^{-1} by dividing sample weight on harvested area and multiplied with ten thousand.

Grain Oil Content (g kg^{-1})

The finding of oil content (%) in sunflower seed was carried out using Near Infrared reflectance Spectroscopy (NIRS) at Nuclear Institute for Food and Agriculture (NIFA) Peshawar (Khan et al., 2014). The oil content (%) was converted into g kg^{-1} by dividing the oil content (%) with 10.

Data for yield and yield contributing traits were subjected to analysis of variance (ANOVA) according to the methods described by Steel et al. (1997). Treatment means, where significant, were separated using least significant difference (LSD) at ($p \leq 0.05$).

Results and Discussion

Data regarding mean minimum and maximum temperature with monthly total rainfall of the crop growth period (i.e. starting from March to June) for the year 2011 and 2012 are shown in Table 1. As the spring converted to summer, the mean temperatures of the crop growth period gradually increased that promote crop growth and development. However, the mean data showed almost the same values for both years (2011 & 2012). Yield is the production of genotypes x environment (Paolo, 2002) and we have used the same genotype of sunflower in both the years, therefore the climate was almost the same and it was expected an almost similar production in both the growing seasons. The data showed a slight increase in rainfall during the second year and the crop was irrigated as per crop water demand in the season. Data of yield and yield traits were statistically analysed and combined for means comparison. The mean sum of squares with coefficient of variations for yield and yield traits are shown in Table 2.

Sunflower planted in two planting geometries i.e. 70x20 cm and 90x15.5 cm having similar agronomic practices during the crop growth period starting from sowing to the harvest and recorded data for yield and yield components are shown in Table 3. The data noted

Table 2: *Combined ANOVA for yield and yield traits of sunflower (Helianthus annuss L.) planted with different planting geometry as spring crop in 2011 and 2012*

SoV	**d.f.**	**Mean sum of squares**						
		Plant Density (m^{-2})	**Head Diameter (cm)**	**Grain $head^{-1}$**	**1000 grain weight (g^{-1})**	**Biological Yield (kg ha^{-1})**	**Grain yield (kg ha^{-1})**	**Grain oil content (g kg^{-1})**
Year	1	0.000	0.047	2540.66	0.018	58322.25*	5094.75*	0.237
Year(Rep.)	6	0.000	1.860	2160.11	5.278	7060.29	4195.94	0.564
Planting geometry	1	0.000	2.916	1183.70	5.629	708122.25*	5095.68*	1.207*
Error	7	0.000	0.884	1760.42	5.223	5522.96	8636.02	0.197
Model	8	0.000	1.765	2085.63	4.664	101100.78	10153.76	0.604
Total	**15**	-	-	-	-	-	-	-
CV		0.000	5.061	4.208	4.390	2.360	3.368	0.336

Table 3: *Yield and yield components of sunflower (Helianthus annuss L.) affected by planting geometry as spring crop in 2011 and 2012*

Planting Geometry Row x Plant distance	Plant Density (m^2)	Head diameter (cm)	Grain head^{-1}	1000 grain weight (g^{-1})	Biological Yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Grain oil content(g kg^{-1})
(a) 70 x 20 cm	7.14	18.15	988.42	51.46	10840.88b	2702.32 b	4.26 b
(b) 90 x 15.5 cm	7.14	19.01	1005.62	52.65	10961.63a	2815.20 a	4.44 a
LSD	0.000	1.112	49.61	2.70	87.87	109.87	0.166
2011	7.14	18.52	984.42	52.02	10690.88 b	2740.92	4.32
2012	7.14	18.63	1009.62	52.09	11111.63 a	2776.60	4.39
LSD	0.000	1.112	49.61	2.70	87.87	109.87	0.166

Means in same column followed by a different letter are significantly different from one another at 5% level of probability

on plant density (m^2), head diameter (cm), number of grains head^{-1} and thousand grains weight (g) did not show any significant effect in single years of the study and on two years averages. It was expected an almost non-significant effect of yield contributing components of sunflower as the same hybrid was planted and there was no significant difference observed in environmental conditions for both the years including mean minimum and maximum temperatures. Unexpectedly, the planting geometries significantly ($p<0.05$) affected the biomass yield (kg ha^{-1}), grain yield per unit area and oil content (%) on two years averages and recorded higher for planting geometry of 90x15.5 cm as compared to planting geometry 70x20 cm. Nonetheless, individual season of the crop did not show any significant effect on yield and oil content. No doubt that yield is mainly contributed by yield contributing parameters i.e. plant population per unit area, grains head^{-1} and thousand grain weight which did not show any significant effect but slightly increased, though they were alone non-significant, might have contributed in total grains weight and hence resulted a significant grain yield on two years averages. It might be due to the difference in weather conditions between the two years as the temperature and rainfall recorded more for 2012 compared 2011. Biomass production per unit area is product of the solar radiation intercepted by the crop canopy produced the assimilates and its partitioning in the plant parts (Christian, 2013). Planting geometry showed a significant difference in biomass yield (kg ha^{-1}) and recorded maximum value for 90x15.5 cm as compared to 70x20 cm and also observed significantly high mean value for 2012 as compared 2011. It may also be due to the difference in weather condition between the two years. Similar results were recorded by Yasin et al. (2013) who reported maximum biomass yield (kg ha^{-1}) for planting geometry 75 x 20 cm as compared to 60 x 25 cm. Planting geometry is one of the most important factors to be taken in consideration for the crops to yield the highest net return (Freeman et al., 2014). In case of sunflower, its grain and the grain oil content are the prime parameters to be focused, either variety, fertilizers and the most important is to arrange plants per unit area in a way so that the exposed leaves could get maximum benefits from the available solar radiation for the biomass production and its effective utilization for economic production e.g. grains and grain oil content. During growth and development of a crop, leaf size and its existence on stem is a significant factor for the production of assimilates and its distribution in economic and non-economic parts of the plant (Daniel et al., 1998). The average irradiance decreases exponentially when plant advance in growth towards maturity, however, leaf arrangements and their size might change its final productivity (Monsi and Saeki, 2005). Optimum plants per unit area and its arrangement within rows and between rows is, therefore, more important for crops to be studied for its maximum net return as grains and grain oil content.

Conclusion

This study shows significance of plants arrangement, which is important to be taken in consideration for optimum production of a crop to get maximum advantage of the free natural resources (i.e. solar radiation and assimilates partitioning). Actual yield on two years average shows a significant difference but reasons still needs to be investigated for further improvement in harvestable yield of sunflower crop in the area.

Acknowledgment

Authors are highly thankful to the Higher Education

Commission (HEC) Islamabad, Pakistan for awarding financial support during PhD degree program for research and study as scholarship.

Authors' Contribution

Murad Ali Khan carried out the research, verified and analysed data, prepared the draft of the manuscript and replied to comments of the referees while M. Akmal designed the research, helped in manuscript preparation and editing.

References

Akmal, M., M. Asim and M. Gilbert. 2014. Influence of seasonal variation on radiation use efficiency and crop growth of maize planted at various densities and N-rates. Pak. J. Agric. Sci. 51:835-846.

Bannayan, M., S. Sanjani and A. Alizadeh. 2010. Association between climate indices, aridity index, and rainfed crop yield in Northeast of Iran. Field Crops Res. 118(2):105-114. http://dx.doi.org/10.1016/j.fcr.2010.04.011

Barros, J.F.C., M.D. Carvalho and G. Basch. 2004. Response of sunflower (*Helianthus annuss* L.) to sowing date and plant density under Mediterranean conditions. European J. Agron. 21(3):347-356. http://dx.doi.org/10.1016/j.eja.2003.10.005

Christian, K. 2013. Plant-environment interaction. Institute of Botany University of Basel, Basel Switzerland. p. 1065-1066.

Daniel R., M.M. Zubillaga, E.L. Ploschuk, W.G. Keltjens, J. Oudriaan and R.S. Lavado. 1998. Leaf area expansion and assimilate production in sunflower (*Helianthus annuss* L.) growing under low phosphorus conditions. Plant Soil. 202(1):133-147. http://dx.doi.org/10.1023/A:1004348702697

Freeman, A.M., A.H. Joseph and C.L. Kling. 2014. The Measurement of Environmental and Resource Values Theory and Methods. 3rd ed. p. 237-255.

Hanif, M. 2014. Weather prediction past, present and future in KP and Punjab. Report presented to IC Peshawar. National Weather Forecasting Center (PMD), Islamabad.

Khan, M. A., and M. Akmal. 2014. Sole and intercropping Sunflower-Mungbean for spring cultivation in Peshawar. Pure Appl. Biol. 3(4):121-131.

Legha, P.K., and G. Giri. 1999. Effect of date of sowing and planting geometry on spring sunflower (*Helianthus annuss* L.). Indian J. Agron. 44(2):404-407.

Monsi, M., and T. Saeki. 2005. On the factor light in plant communities and its importance for matter production. Annal. Bot. (AOB). 95:549–567. http://dx.doi.org/10.1093/aob/mci052

Nel, A.A., H.L. Loubser and P.S. Hammes. 2000. The effect of plant population on the quality of sunflower seed for processing. S. Afr. J. Plant Soil. 17(1):6-9. http://dx.doi.org/10.1080/02571862.2000.10634858

PODB. 2013. Pakistan Oil Seed Development Board Annual Reports. Pp. 233-235.

Pal, M.S., A. Kumar and R.P. Singh. 1997. Response of spring grown sunflower (*Helianthus annuss* L.) cultivars to different planting geometry in foothills of Utar Pradesh. Indian J. Agron. 42(1):502-505.

Paolo, A. 2002. Genotype x environment interaction, Challenges and opportunities for plant breeders and cultivar recommendation. Food and Agriculture Organization of the United Nations, Rome Italy. FAO Plant Production and Protection Paper 174. p. 23.

Philip K.T., P.G. Jones, G. Alagarswamy and J. Andresen. 2009. Spatial variation of crop yield response to climate change in East Africa. Global Environ. Change. 19:54–65. http://dx.doi.org/10.1016/j.gloenvcha.2008.08.005

Steel, R.G.D., J.H. Torrie and D.A. Dickey. 1997. Principles and procedures of statistics: A biometrical approach. 3rd ed. Megraw Hill book Co. Inc. New York USA.

Yasin M., A. Mahmood, A. Ali, M. Aziz, M.M. Javaid, Z. Iqbal and A. Tanveer. 2013. Impact of varying plantings patterns and fertilizer application strategies on autumn planted sunflower hybrid. Agron. Res. Maldivia. 2(154):39-51. http://dx.doi.org/10.2478/v10298-012-0082-x

Zarea, M.J., A. Ghalavand and J. Daneshian. 2005. Effect of planting patterns of sunflower on yield and extension coefficient. Agron. Sustain. Dev. 25(4):513-518. http://dx.doi.org/10.1051/agro:2005052