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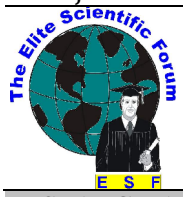

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RESEARCH ARTICLE

Impact of Planting Time and Silicon Levels on Yield and Yield Components of Sunflower (*Helianthus annuus* L.)

Muhammad Tahir[1]*, Sajjad Ahmad[1], Muhammad Ayub[1], Muhammad Naeem[2], Haseeb-ur-Rehman[1] and Muhammad Aqeel Sarwar[1]
[1]Department of Agronomy, University of Agriculture, Faisalabad, Pakistan
[2]University College of Agriculture and Environmental Sciences, Islamia University, Bahawalpur, Pakistan

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***Corresponding Author:**
drtahirfsd@hotmail.com

ABSTRACT
A field study was carried out to evaluate the interactive impact of planting times of sunflower hybrid with different silicon levels on yield and yield contributing components. Sunflower hybrid Hysun-33 was selected as a test crop. The experiment was laid out in Randomized Complete Block Design with split plot arrangement. Sowing times (10 and 15 February) were placed in main plots and silicon levels (0, 23, 26, 69 kg ha^{-1}) were assigned to sub plots. The crop was grown upto harvesting and data were recorded according to the standard procedures. The results showed that significantly maximum economic yield (2.60 ton ha^{-1}) was observed in 10 February sown sunflower where silicon was applied @ 23 kg ha^{-1}. Silicon application significantly enhanced the plant height (223.92 cm), head diameter (23.83 cm), 1000-achene weight (62.27 g), biological yield (10.82 t ha^{-1}) harvest index (28.53), protein content (21.97) and oil contents (44.05%). Planting time had no positive effect on achene protein and oil percentage. The interaction of early and late sown sunflower with silicon application was found non-significant.

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is the member of composite family and was introduced during 1960 in Pakistan. Vegetable oil is very important in a nation's economy. The production of oilseed crops in the country is not sufficient to meet the requirements of the country, thus its imports take a very toll of foreign exchange (GOP, 2011). Ahmad et al. (2002) emphasized an increase in area under oil seed to boost up the domestic production of oil seed crops by adopting advanced production technology of oil seed crops. Presently, domestic proportion of 30% of edible oil has been stimated from totalbeing imported. Cotton, Canola and Sunflower contributes 67%, 19.6% and13.4% respectively to the domestic oil production (Shah et al., 2005).To reduce the burden of exports of edible oil, per acre yield of sunflower should be increased to enhance the domestic production of oil accomplished with institutional and financial support to farmers (Ashiq, 2001). Sunflower being important oilseed crop is preferred by many people in Pakistan for cooking purposes. Sunflower,being grown twice a year as spring and autumn crop, high yielding with great economic return to the farmers but no planned efforts has been carried out to enhance its domestic production (GOP, 2011; Bakht et al., 2010).The sunflower being high yielding crop can easily meet the future demands of oil of the Pakistan (Bakht et al., 2010). The average yield of sunflower is 1450.83 kg ha^{-1} (GOP, 2011) which is very low as compared to other sunflower producing countries like Argentina, Ukraine and Russia. The main reasons of less production are unavailability of quality seed, improper and low use of inputs particularly micronutrients and lack of sound price incentives for sunflower growers.

Silicon is the second most abundant element in soil and it is 3-17 percent in the soil in the form of solution while about 31% by weight (Epstein, 1999). It is found in the soil in the form of Silicic acid (Chen et al., 2000) and all plant species take it in the form of Silicic acid (Ma et al., 2001). Different studies indicated positive effect of silicon application on the plant growth and development including enhanced pollination, increase dry biomass, final yield (Korndorfer and Lepsch, 2001) and resistance against various diseases (Gillman et al.,

2003). The growth of oat, barely, cucumber, tomato, rye and sugarcane has been positively influenced by the application of silicon (Goto et al., 2003). Tahir et al. (2006) reported a positive trend in wheat yield due to silicon application, however, different sunflower genotypes are positively influenced with silicon application via changes in plant phenology in dry spells (Gunes et al., 2008). Surapornpiboon et al. (2008) documented that silicon application in rice enhanced the dry matter production possibly due to maintenance of activity of photo synthates.

Sowing time of sunflower is dependent upon pattern of wind and rainfall, availability of water and attack of insect pest (Yousaf et al., 2007). The importance of sowing has been realized in many studies and it was reported that early sown crops produced tall plants. (Uzun et al., 2009; Anjum et al., 2004).

Leaf area, net assimilation rate and crop growth duration are key determinants in sunflower production. Spring sown sunflower has advantage of increased net assimilation rate due to more leaf area and longer crop duration resulting in better yields as compared to kharif sown sunflower crop (Reddy et al., 2003). In subtropical and temperate environments the delayed sowing results in decrease of yield contributing parameter which results in less yields (Ahmad et al., 2005). Delayed sowing of sunflower exposes the crop to high episodes of temperature at early vegetative stages thus increasing the vegetative growth and shortening the growth cycle of crop (Barros et al., 2004). Sunflower crop sown in February yields more (Yousaf et al., 2007).

Keeping in view the above facts, this study was conducted with the objectives to assess the proper planting time, to estimate the optimum dose of silicon for sunflower crop, to evaluate the interactive effect of different sowing times and silicon levels on yield and yield components of spring sown under the climatic conditions of Faisalabad.

MATERIALS AND METHODS

This study was conducted at the Agronomic Research Area, University of Agriculture, Faisalabad to evaluate the interactive effect of planting times and different silicon levels on yield and yield contributing components of sunflower hybrid. Crop was sown during spring 2011. The experiment was laid out under randomized complete block design (RCBD) using split plot arrangements with four replications, randomizing the sowing dates in main plots and keeping the silicon levels in sub plots using the sunflower hybrid Hysun-33 as test specie. The seed of Hysun-33 were collected from Ayub Agriculture Research Institute (ARRI), Faisalabad. The net plot size of 8 m × 3.75 m was maintained for each replication. There were two sowing dates (10th February and 25th February) and four silicon levels (Control 0kg Silicon, 23kg, 46kg and 69kg Silicon per hectare).Levels of silicon 0kg, 23kg, 46kg and 69kg were comprises of sodium silicate 0kg, 100, 200 and 300 kg ha^{-1} respectively. Soaking Irrigation (rouni) was applied earlier than seed bed preparation for the planting purpose. Land was set for sowing by using cultivator (2-3 cultivation followed by planking).The crop was sown with the help of hand drill in 75 cm spaced rowsusing seed rate of 5 kg ha^{-1}.After 20 days of sowing crop was thinned out by maintaining plant to plant distance of 25 cm. Fertilizer was applied @ 150-100 kg NP ha^{-1}. DAP and Urea was applied as a source of phosphorus and nitrogen. All recommended phosphorus (100 kg ha^{-1}) was applied at sowing time as a basal dose while the nitrogen was applied in three splits 1st at sowing time, 2nd with first irrigation and 3rd with second irrigation. A silicon source, sodium silicate, was applied with 1st irrigation by fertigation method et al. in each treatment. The field was set aside free of unwanted vegetation and weeds by physical hoeing. At maturity, data on crop yield and yield components such as head diameter (cm), number of achene per head, 1000 achene weight (g) economic yield (kg ha^{-1}), biological yield (kgha^{-1}) and Harvest index (%) was recorded according to the standard procedures. The collected data was analyzed statistically by using the Fisher analysis of variance technique and treatment means were compared by using Least Significance Difference (LSD) test at 5% probability level (Steel et al., 1997).

RESULTS AND DISCUSSION

Yield parameters

The data on yield parameters are presented in table 1. Results showed that the crop which was planted on 10th of February gave maximum head diameter (20.97 cm) while minimum head diameter (19.32) was noticed where crop was sown on 25th of February. Regarding silicon levels significantly maximum head diameter was measured where silicon was applied @ 46 kg ha^{-1}. Crop where silicon was not applied produced minimum head diameter. These results are in line with Shengyi et al. (1999) who reported the similar results. Maximum numbers of achenes (1398.5) per head were observed where crop was sown on February 15 and lowest achenes number was noticed in late planted crop. Maximum achenes (1483.5) per head was produced where silicon was applied @ 46 kg ha^{-1} and minimum achenes per head were observed where silicon was applied @ 69 kg ha^{-1} which was statistically at par with control treatment @ 0 kg ha^{-1}. This increase in number of achenes per head may be due to improved root and shoot growth and better grain filling rate. These results are supported by Filho et al. (2005) who reported the similar results.

Table: 1: Effect of different sowing dates and silicon levels on yield components of sunflower (*Helianthus annuus* L.) (Individual comparison of treatment means)

Treatments	Head diameter (cm)	Achene per head	1000 achene weight (g)	Economic yield (ton ha^{-1})	Biological yield (ton ha^{-1})	Harvest index (%)
Sowing dates						
10 Feb.	20.97a	1398.5a	53.84a	2.60a	9.71	27.06
25 Feb.	19.32b	1127.7b	49.16b	2.45b	9.77	25.48
LSD value	1.256	85.17	2.21	0.075	NS	NS
Silicon levels						
0 kg/ha	17.53c	1125.8c	46.57c	2.50b	8.83c	28.53a
23 kg/ha	21.65b	1350.9b	50.74b	2.60a	9.93b	26.13b
46 kg/ ha	23.83a	1483.5a	62.27a	2.64a	10.82a	24.54b
69 kg/ha	17.59c	1092.3c	46.42b	2.38c	9.39bc	25.38b
LSD value	0.954	57.40	4.14	0.058	0.814	2.32
Interaction Sowing dates x Silicon	NS	NS	NS	NS	NS	NS

Means not sharing the same letters differ significantly at 5% probability level

Table 2: Effect of different sowing dates and silicon levels on quality components of sunflower (*Helianthus annuus* L.) (Individual comparison of treatment means)

Treatments	Oil content (%)	Protein content (%)
Sowing date		
10 Feb.	43.29 a	21.13 a
25 Feb.	42.96 a	20.94 a
LSD value	NS	NS
Silicon level (Sodium silicate)		
0 kg/ha	41.10 c	20.38 c
23 kg/ha	44.08 a	21.70 b
46 k/ ha	44.08 a	21.97 a
69 kg/ha	43.25b	20.08 d
LSD value	0.343	0.213
Interaction	NS	0.331

Means not sharing the same letters differ significantly at 5% probability level.

achenes per head were observed where silicon was applied @ 69 kg ha^{-1} which was statistically at par with control treatment @ 0 kg ha^{-1}. This increase in number of achenes per head may be due to improved root and shoot growth and better grain filling rate. These results are supported by Filho et al. (2005) who reported the similar results.

Maximum achene yield (2.60 t ha^{-1}) was recorded in the plots where sowing was done on 10th of February and minimum achene yield (2.45 t ha^{-1}) was observed in 25th February planted plots. Appropriate sowing time significantly enhanced the achene yield. These results are supported by Yousaf et al. (2007) who stated that sowing of sunflower early in the month of February increased the final achene yield due to longer crop growth cycle and regular light interception. Regarding silicon levels, the maximum achenes yield (2.64 t ha^{-1}) was observed where silicon was applied @ 46 kg ha^{-1} which was statistically at par where silicon was used @ 23 kg ha^{-1}and minimum achene yield (2.38 t ha^{-1}) was recorded in the plots which were treated with silicon 69 kg ha^{-1} (S_3). These results are supported by Kumbhar and Saavant (1999) who stated that application of silicon increased the seed yield as compared to control treatment.

Highest achene weight (53.84g) was observed in early planted crop while late sown crop produced (49.16 g) per 1000 achene weight. Maximum 1000-achenes weight (62.27 g) was observed where silicon was applied at @ 46 kg ha^{-1} and minimum 1000-achene weight (46.42 g) was recorded where 69 kg ha^{-1} silicon was applied. This increase in 1000 achene weight might be due to the results of the fact that silicon enhanced the grain filling rate. These results are in line with findings of Singh et al. (2007) who stated that the application of silicon increased the grain filling rate which leads towards maximum 1000-seed weight which is the sign of good grain yield. The other yield parameters like biological yield and harvest index were statistically non-significant between two sowing dates. Yousaf et al. (2007) also reported higher yields in February sown sunflower. Among silicon treatments maximum biological yield (10.82 t ha^{-1}) was noticed in the plots where silicon was applied @ 46 kg ha^{-1} and minimum biological yield (8.82 t ha^{-1}) was produced in silicon non-treated plots. Maximum harvest index (28.53) was observed where silicon was not applied. Positives effects of silicon application on yield and biomass of sunflower as noticed in our study has also been reported by Gunes et al. (2008). The interaction between the sowing date and silicon levels for yield and yield components was non-significant in all treatments.

Quality parameters

Data regarding quality characteristics presented in table 2 show that among different sowing times oil contents and protein contents were non-significant. Among the levels of silicon maximum oil contents (48.08 %) were

found in the plots where silicon was applied @ 46 kg ha^{-1} which was statistically at par with 23 kg ha^{-1} silicon treated plots while minimum oil contents (41.10%) were recorded in the plots where silicon was no applied. In case of protein contents in silicon treated plots maximum protein (21.97%) was found in those plots where silicon was applied @ 46 kg ha^{-1} and minimum achene protein contents (20.08%) were found in the plots where silicon was applied at the rate of 69 kg ha^{-1}. Interactive effect of silicon levels and different planting times (S x D) on achene protein was observed statistically highly significant. Maximum protein contents (22.60 %) were observed in the 10th February sown plots where silicon was applied @ of 46 kg ha^{-1} and minimum achene protein (20.05 %) was observed in 25th February (D_2) sown plots where silicon was applied @ 69 kg ha^{-1} and difference was significant.

Conclusions

This study concludes that silicon application at rate of 23 kg ha^{-1} and sowing of spring sunflower crop in the second week of February should be followed to attain maximum yield and benefits under the climatic conditions of Faisalabad.

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