Research Article

Effect of Sulphur Application on Growth, Oil Content and Yield of Sunflower

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Abstract | Sunflower is important oil seed crop for human being diet and sulphur plays major role in increasing the achen yield and oil content. A field study was conducted to observe the effects of sulphur on sunflower growth, oil content and yield. The sulphur rates were 0, 5, 10, 15, and 20 kg ha^{-1}. The recomended rates of nitrogen, phosphorus and potasium were given to all plots of different treatments. The economical important plant growth parameters ; height of plant (cm), stem girth, diameter of flower disk (cm), quantity of achenes ($head^{-1}$), weight of 1000 achenes, oil (%) in achene, yield (ha^{-1}), and sulphur content (%) in plant straw were evaluated. The values among the treatments for higher plant height (161.80 cm), wide stem girth (4.80 cm), flower head diameter (15.40 cm), maximum number of achene $head^{-1}$ (787), weight of 1000 achenes (50.29 g), higher grain yield ha^{-1} (650.33 kg), oil content % (42.20), achene yield $plant^{-1}$ (39.57 g) and sulphur content % of plant straw (0.225) were recorded when sulpher rate at 20 kg ha^{-1} were applied to crop. These values were significantly higher compared to other S levels of 5,10 and 15 kg ha^{-1}. The outcome of experiment had revealed that with the increasing level of S, the sunflower plant growth and yield attributes were significantly improved. The application of sulphur at 20 kg ha^{-1} was superior in enhancing overall growth, achene yield and oil content % of sunflower.

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Introduction

Sunflower (*Helianthus annuus* L.) is an essential oilseed cash crop due to its excellent nutritional qualities with high concentration of linoleic acid, fine quality edible oil with adequate unsaturated fatty acids, anticholesterol properties, higher oil yield per unit area, early maturity, short duration , compliance to different climate and soil conditions, photothermo insensitiveness, less water requirement and responsiveness to better production management practices (Kaya and Kolsarici, 2011; Burton et al., 2008; Tamak et al., 2007). Sunflower is a potential oilseed crop with promise of increased area under its cultivation for enhancing oilseed production (Cheema and Singh, 2008).

Although cooking oil is very imperative commodity of daily use but Pakistan is undersupplied in its production. Seventy percent domestic edible oil supplies are met through imports as it requires around 3 million tones cooking oil for domestic consumption and out of this 0.646 m ton produced in country and remaing 2.32 m ton of worth Rs. 207 billion imported (PARC, 2014). There are huge gaps between possible yield and nationwide yield of major oilseed crops.

According to one estimating 69% of the prospective yield of sunflower was not achieved (PARC, 2014).

The sunflower is a crop with high potentials to successfully meet cooking oil needs of the country but its average yield is low incompare to world average yield. So, it is necessary to identify the key problems for yield improvements and support measures that will make doable future planning for their sustainable production (Ravikumar et al., 2016).

The imbalanced use of nutrients is one of the major reasons for low yields. Plants require essential nutrients for better growth and yield. Sulphur is a major nutrient for healthy crop growth. It is the fourth major nutrient after NPK (Naser et al., 2012; Najar et al., 2011). Sulphur is the constituent of the cystin, amino acids, methionine and chlorophyll (Wani et al., 2001). Oilseed crops require higher amounts of S for their growth and oil yield because it is critical in the oil synthesis and formation of bold grains for oil production in the oilseeds crops (Brady and Weil, 2002). Sulphur plays a principal job in improving the achene value of sunflower and also the effectiveness of nitrogen and phosphorus (Najar et al., 2011). Sulphur had much importance for oil seed plant, its achene yield, oil and protein production, better quality, role in enzymatic processes and in the chemical composition of seeds (Naser et al., 2012). The significant increase in plant height, dry matter and weight of seeds, head diameter, the percentage of oil and biological yields of sunflower were recorded when sulphur was applied (Babu and Hegde, 2010).

There are some studies which have shown that soils of Pakistan are deficient in available S and the per acre yield of sunflower and other oilseed crops were affected due to S deficiency (Khalid et al., 2011). Due to the significance of sulphur for oil seed crops a field study was planned to observe its effects on yield and oil content % of sunflower crop.

Materials and Methods

An experiment was conducted at the experimental field of Agriculture Research Institute Tandojam in 2016 with plot size of 7×4 m (28 m^2) with three replications and RCBD design. The soil was clay loam texture, non saline with EC of 0.86 dS m^{-1}, pH 8.1 alkaline soil reactions, low in organic matter (%) 0.75, Lime ($CaCO_3$) 11.7 %, low in N 0.03 %, deficient in P 4.6 mg kg^{-1}, sufficient in K 161 mg kg^{-1} and medium in S 55.3 mg kg^{-1}. The applied source of sulpher was elemental sulphur and levels were T_1= 0 kg S ha^{-1}(Control), T_2= 5 kg S ha^{-1}, T_3= 10 kg S ha^{-1}, T_4= 15 kg S ha^{-1} and T_5= 20 kg S ha^{-1}. The recommended fertilizer levels of NPK (120-60-60 kg ha^{-1}) were applied in all treatments. The fertilizers urea and DAP were used as source of N, and P whereas muriate of potash as source of K.

The sunflower variety tested in the experiment was HO-1. The dibbler was used for planting by placing 3-4 seeds $hill^{-1}$ at 3-5 cm depth in the soil. The crop spacing between plant to plant was 25×25 cm. The plants were thinned at 4-5 leaf stage, stem elongation and flowering to retain a homogeneous plant population. The crop irrigated regularly according to plant requirement to prevent the crop from water stress and harvested at maturity stage. The agronomic observations were acquired by randomly choosing five plants from an individual plot. At the time of harvesting the growth characters observed were: height of plant, stem girth, diameter of flower disk, number of achenes $head^{-1}$, 1000 achenes weight, seed yield ($plant^{-1}$), achene yield (ha^{-1}), oil content (%), sulphur content in plant straws. The heads were sun dried for ten days after harvest before threshing manually to calculate achene yield per hectare. The diameter of head was calculated by average of indiscriminately select five plants from each plot. Thousand achene weights (g) were calculated on the base of average by randomly choosing three samples of 1000 seeds from every treatment. The oil % of achene was determined by commercial nuclear magnetic resonance spectrometer (NMRS) method.

The soil was sampled before crop sowing and after harvest. Available S in soil was extracted by using 0.001 M $CaCl_2$ (1:5) ratio. The clear extract was quantified for sulphur by Turbidimetric method (Tandon, 1991). Total sulphur in sunflower leaves was determined by first digesting the leaf tissue material in an acid mixture followed by sulphur analysis on spectrophotometer by turbidimetric method (Tandon, 1991). Soil texture, pH, EC, organic matter %, $CaCO_3$, N, P and K in soil was determined by laboratory methods as defined by Ryan et al. (2001). The statistical programme MSTAT-C was used to analyse collected plant and soil data. To compare the superiority of different treatments, LSD test was used (Snedecor and Chocran, 2000).

Results and Disscusion

Sulphur applications had positive effects on sunflower, whereby growth, yield, oil content and sulphur content in straw were significantly improved. The sunflower plant height (cm) was significantly increased by different sulphur levels (Table 1). The heighest plant height (161.81 cm) was noted in plants where 20 kg S was applied while the crop with applied sulphur levels of 15, 10 and 5 kg ha^{-1} resulted in plant height of 160.40, 159.10 and 157.39 cm, respectively. The lowest plant height 156.37 cm was recorded from plots (0 kg ha^{-1}). This higher plant height under various sulphur levels were mainly due to the use of these soil applied nutrients which were desirable for healthy crop growth and development. The results of our experiment matched the findings of prevous studies by Poonia (2000) and Sing et al. (2000) where they found that plant height significantly increased with the increasing level of sulphur in comparison to plants which were not applied with S fertilizer. The stem girth of sunflower plants was positively affected by S application and the thickest (4.80 cm) girth was witnessed at S level 20 kg ha^{-1} followed by 15, 10 and 5 kg S ha^{-1} with stem girth of 4.51, 4.30 and 4.10 cm, respectively. The broadest flower head diameter (15.40 cm) among the different S levels was observed in plots whereas S levels at 20 kg ha^{-1} was applied in comparison to other S levels of 15, 10 and 5 kg ha^{-1} which resulted in flower head diameter of 15.20, 14.90 and 14.60 cm, respectively. Hassan et al. (2007) reported that sunflower head diameters increased with increasing sulphur fertilization. Hussain et al. (2011) reported that application S recorded highest plant height and dry matter at harvest of sunflower in two year experiment.

The number of grains has close relationship with final yield. The maximum number of achene $head^{-1}$ of 787 was produced at 20 kg S ha^{-1} whereas the crop getting S rates of 15, 10 and 5 kg ha^{-1} were with 762, 731 and 708 achene $head^{-1}$ respectively.

The findings of our experiment are consistent with previous results of Rana et al. (2015), Pati et al. (2011) and Hassan et al. (2007). They found that application of S along with nitrogen application increased achene yiled and at 20 kg S ha^{-1} the number of achene $head^{-1}$ were high from other treatments. The weight of 1000 achenes increased with the application of sulphur level at 20 kg ha^{-1} which produced higher 1000 achene weight of 50.29 g at the same time as the crop receiving S levels of 15, 10 and 5 kg ha^{-1} resulted in 1000 achene weight of 49.50, 48.60 and 47.80 grams, respectively (Table 2). The lowest mean value of the weight of 1000 achene was 47.00 g from control plots. Our results share a number of similarities with Ravikumar et al. (2016) and Rasool et al. (2013) where they reported that S application increased the 1000 seed weight in their studies. Similar findings have also been reported by Wani et al. (2001) reported that with the increasing levels of sulpher application on sunflower significantly enhanced achene yield and crop protein content. The maximum oil content (42.20%) was acquired at the level of 20 kg S ha^{-1} while the sulphur levels of 15, 10 and 5 kg ha^{-1} resulted in mean oil content percentage of 41.60, 40.87 and 40.30, respectively and the lowest oil content 39.30 % was calculated in plots with no any application of sulphur. The comparable findings were reported by Vala et al. (2014) and Rasool et al. (2013) they revealed that oil content (%) was significantly increased when increasing levels of sulphur application. The laboratory analysis of plant straw had shown that S content in plant was increased with the application of S fertilizer. At 20 kg S ha^{-1} plant straw S content was 0.22 % followed by 0.18, 0.18 and 0.17% at sulphur level 15, 10 and 5 kg ha^{-1} in leaf, respectively. Dhage and Patil (2008) observed the higher nutrient uptake of NPK and S over the control in sunflower with the treatments of NPK and S.

The improvement in sunflower growth parameters and yield were due to positive role of sulphur in plant growth as Scherer in 2001 informed that sulphur is required in higher quantity for oilseed crops in compare to cereal crops because they contain more sulphur compounds for biosynthesis of oil. The improvement of growth attributes were may be owed to production of amino acids, enhancement in the photosynthetic activity and enhancement of cell division which resulted in higher plant height, stem girth and flower head diameter (Raja et al., 2007; Intodia and Tomar, 1997). Sulphur application significantly improved plant growth parameters so due to this yield potential of the crop enhanced and as a result achene yield ha^{-1} increased. The maximum yield (650.33 kg ha^{-1}) among the treatments was obtained at 20 kg S ha^{-1} level while the plots receiving 15, 10 and 5 kg S ha^{-1} resulted in mean ha^{-1} grain yield of 630.0, 610.0 and 588.50 kg respectively and the lowest grain yield (570 kg) was from control (0 kg ha^{-1}).

Table 1: *Plant height, stem girth, flower head diameter and number of achene head^{-1} of sunflower as influenced by various sulphur levels.*

Sulphur Rates (kg S ha^{-1})	Plant height (cm)	Stem girth (cm)	Flower head diameter (cm)	No. of achene head^{-1}
Control	156.37 D	3.90 E	14.30 E	679 E
5	157.39 d	4.10 D	14.60 D	708 D
10	159.10 c	4.30 C	14.90 C	731 C
15	160.40 b	4.51 B	15.20 B	762 B
20	161.80 a	4.80 A	15.40 A	787 A

The values with same letter within columns are not significantly different at P=0.05 each values is a mean of 03 replicates.

Table 2: *1000 achene weight, oil content %, S % in plant straw and achene yield ha^{-1} of sunflower as influenced by varied sulphur levels.*

Sulphur Rates (kg S ha^{-1})	1000 seeds weight (g)	Oil content (%)	Achene yield (kg ha^{-1})	S % in plant straw
Control	47.00 E	39.30 E	570 E	0.172 b
5	47.80 D	40.30 D	588.50 D	0.175 b
10	48.60 C	40.87 C	610.00 C	0.182 b
15	49.50 B	41.60 B	630.00 B	0.185 b
20	50.29 A	42.20 A	650.33 A	0.225 a

The values with same letter within columns are not significantly different at P=0.05 each values is a mean of 03 replicates.

The S requisite varies between different crops and their growth stages. The oil seed crops need more S than from cereal crops as they require more S containing compounds for oil biosynthesis, around 16 kg S is needed to bring into being achene yield of one tone with 91% dry matter (Scherer, 2001; MacGrath and Zhao, 1996).

The positive effects of S application on overall sunflower plant growth was due to the role of sulphur in conversion of carbohydrates into oil, S also helps in the fatty acid synthesis in which an enzyme thiokinase is implicated which depends on sulphur (Sreemannarayana et al., 1998). Bonari et al. (2013) found that when the level of sulphur application increased the grain yield also increased. Barbara et al. (2008) stated that better yield of grain was impacted by higher level of sulphur application.

Conclusions and Recommendations

The results of this study had shown that application of sulphur at 20 kg S ha^{-1} along with recommended nitrogen, phosphorus and potasium (120-60-60 kg ha^{-1}) was found to be appropriate combination for increasing yield and oil of sunflower. However future studies should be conducted on more than one varieties of sunflower for longer period of time 2 or 3 seasons to reach on more definite conclusion.

Novelty Statement

Sunflower is important oil seed crop in Pakistan. The current research highlights that sunflower yield and oil content can be successfully improved by inclusion of sulpher (20 kg ha^{-1}) in sunflower nutrition.

Author's Contribution

Muhammad Saleem, conducted research and writeup. Ehsan Ellahi, conducted research. Allah Wadayo Gandahi, helped in laboratory analysis. Saleem Maseh Bhatti, helped in laboratory analysis and writeup. Hajra Ibrahim, helped in laboratory analysis. Muhammad Ali, helped in writeup.

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