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EVALUATION AND OPTIMIZATION OF SULPHUR SOURCES THROUGH GROWTH ENHANCEMENT AND YIELD MAXIMIZATION OF SUNFLOWER (*HELIANTHUS ANNUUS*.L.) IN CLAY LOAM SOIL

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Abstract

The area under sunflower cultivation in India quite increasing nowadays, but the yield of the oil seeds remained low, resulting in a long yield gap. The study was to assess the yield gap and increasing the yield through the application of sulphur with different sources and levels in sunflower, especially in the clay loam soil. The experiments were conducted in a randomized block design with ten treatments viz., RDF (60.90.60 kg ha^{-1}), RDF+ SSP, Elemental sulphur and Gypsum @ 15, 30 and 45 kg ha^{-1} respectively. Among the practices, Elemental sulphur @ 45 kg ha^{-1} with RDF found to be promising yield increase 33.12 and 38.08 per cent over RDF alone and other levels of sulphur in two seasons of experimental study.

Keywords **:** Elemental sulphur, Gypsum, Nutrient management, Sunflower, Yield maximization.

Introduction

Sunflower (*Helianthus annuus* L.) is one of the most important oilseed crops containing high-quality edible oil. It is easy to cultivate and grown in different conditions and soils (Kaya and Kolsarici, 2011). In India, oilseed crops constitute the second-largest agricultural produce, next only to food grains and these are the important sources of our economy contributing 5% to GNP. India's contribution to the world productivity of oilseeds is very low (9.54%) owing to the low productivity of different oilseed crops. Nowadays, intensive farming is one of the predominant tools to increase food production as well as feed the entire growing population in our country. However, the practice of intensive cropping with high yielding varieties is a great scope to boost production on one hand whereas, it caused a marked depletion of inherent nutrient resources in soil on the other in India. Apart from the major nutrients, the 'S' deficiency was observed in different states of India. Sulphur is increasingly being recognized as the fourth major plant nutrient after nitrogen, phosphorus and potassium (Tandon and Messick, 2002). Sulphur plays a predominant role in improving the grain quality of sunflower crop and also the use efficiency of nitrogen and phosphorus. Eighty-eight out of four hundred-odd districts were identified as sulphur deficient with varying degrees (Tandon, 1986). Sulphur deficiency has been reported 70 countries worldwide, of which India is one, Tamilnadu is one of the agriculturally important states with very little data on soil sulphur status. It has been found that 80 per cent of the samples obtained from 15 bench mark clay soil in Cuddalore district were reported to be 'S' deficient (Balasubramanian *et al.,* 1990). Accordingly, the yield of oilseed crops, especially sunflower, is severely affected due to S deficiency. Besides, the disproportionately greater use of nitrogen (N) and P in comparison to S has widened the N–S and P–S ratios (Manickam and Vijayachandran, 1985). Hence the present investigation was carried out to evaluate the appropriate source of sulphur and its response and optimize levels of S for sunflower production.

Materials and Methods

To study the response of different sources of sulphur at varying levels on the quantitative and qualitative characters of sunflower, the experiment was conducted at Annamalainagar, experimental farm, Tamilnadu, India during Feb to Apr and June to September on 2016. The experimental site of the study is geographically located at 11^0 24'N latitude, 79^0 44'E longitude and an altitude of +5.79 m of above mean sea level. Soil was analysed for their physical and chemical properties. A composite soil sample was collected at a depth of 0-30 cm. It was air-dried, crushed, and tested for physical and chemical properties. The soil was clay loam in texture with soil reaction of (pH 7.9), electrical conductivity 0.49 dS m^{-1}, organic matter (0.59%), low available nitrogen (242.5 kg.ha^{-1}), available phosphorus (19.4 Kg ha^{-1}), and low available sulphur (16.9 kg.ha^{-1}). The experimental design was carried out in a randomized block design with an arrangement of treatments in three replications. Experimental plots consist of three sulphur sources (SSP, Elemental sulphur and Gypsum), levels (15, 30, 45 kg.ha^{-1}) and control i.e., recommended N, P and K (60:90:60 kg. ha^{-1}) alone. The plots were prepared with the dimension of 5 m × 4 m and seeds of variety KBSH1 were sown with a spacing of 60×30 cm. At 4 - 5 leaf stage plants were thinned to appropriate density. Irrigation was given uniformly and regularly to all plots as per the requirement to prevent the crop from water stress at any stage. The crop biometric observations such as seed yield, stalk yield and biological yield were recorded.

Statistical analysis

The experimental data were statistically analysed as suggested by Gomez and Gomez (1976). For significant results, the critical difference was worked out at 5 per cent level.

Results and Discussion

Growth attributes

Statistically analyzed results proved that the effect of different sources and levels of the sulphur application had a

positive influence on all growth attributes. Among the different levels of sulphur, the highest plant height (161.8 cm and 166.9 cm) were noticed with the application of elemental sulphur @ 45 kg ha^{-1} along with RDF (60:90:60 kg ha^{-1}) at harvest which was significantly followed by gypsum and SSP with consistent pace in two seasons over 0 kg S ha^{-1}. Application of sulphur significantly increased the plant height in sunflower (Legha and Gajendra Giri 1999). Similar results have been reported by Intodia and Tomar, 1997. The similar trend was noticed in LAI (7.6 and 7.7) at flowering stage, DMP (5769.4.00 and 5964.2 kg ha^{-1}) at harvest stage in both the seasons. This was evidenced through the studies of Dubey and Khan (1993). This might be due to more synthesis of amino acids, increase in chlorophyll content in a growing region and improving the photosynthetic activity, ultimately enhancing cell division resulted in an increment in plant height, higher LAI and DMP. This was evidenced through the studies of Raja *et al*. (2007)

Yield Attributes and yield

Sulphur levels and sources significantly influenced the yield components and yield in both the season. Among the different sources and levels of sulphur, the plot supplemented through elemental sulphur @ 45 kg ha^{-1} along with RDF (60:90:60 kg ha^{-1}) registered maximum head diameter (17.6 cm and 17.9 cm), seed yield (2213.3 and 2479.2 kg ha^{-1}), stalk yield (3006.4 and 3289.0 kg ha^{-1}) followed by gypsum and SSP in both seasons. The yield increase in elemental sulphur @ 45 kg ha^{-1} received plots over control are 33.12 and 38.08 per cent in first and second crop, respectively. The sulphur application resulted in a significance increase in all growth attributes.

Table 1 : Effect of different sources and levels of Sulphur on growth attributes of sunflower

Treatments	First Season			Second Season		
	Plant heighti n cm	LAI @ Flow	DMP @ HarvestKg ha^{-1}	Plant height in cm	LAI @ Flow.	DMP @ Harvest Kg ha^{-1}
T_1 - RDF	137.6	5.8	4153.6	140.6	5.9	4197.0
T_2 - RDF + 15 kg Sulphur ha^{-1} through Single Superphosphate	138.4	6.0	4228.3	142.2	5.9	4297.3
T_3 - RDF + 30 kg Sulphur ha^{-1} through Single Superphosphate	145.2	6.5	4811.5	149.7	6.4	4909.0
T_4 - RDF + 45 kg Sulphur ha^{-1} through Single Superphosphate	152.4	7.2	5278.1	157.1	7.3	5452.7
T_5 - RDF + 15 kg Sulphur ha^{-1} through Elemental Sulphur	142.2	6.3	4510.0	146.5	6.4	4640.2
T_6 - RDF + 30 kg Sulphur ha^{-1} through Elemental Sullphur	149.1	7.0	5123.9	153.7	7.0	5294.5
T_7 - RDF + 45 kg Sulphur ha^{-1} through Elemental Sulphur	161.8	7.6	5769.4	166..9	7.7	5964.2
T_8 - RDF + 15 kg Sulphur ha^{-1} through Gypsum	141.5	6.1	4307.8	145.0	6.0	4402.6
T_9 - RDF + 30 kg Sulphur ha^{-1} through Gypsum	147.8	6.7	4952.2	152.4	6.8	5110.9
T_{10} - RDF + 45 kg Sulphur ha^{-1} through Gypsum	156.7	7.4	5421.3	161.7	7.4	5605.1
$S.E_{(m)}$	**1.12**	**0.04**	**52.3**	**1.23**	**0.06**	**56.9**
C.D (P = 0.05)	**2.40**	**0.09**	**111.9**	**2.63**	**0.13**	**121.8**

Eventually increased the yield potential of the crop as reciprocated by the higher seed yield. Such a response to increasing levels of 'S' might be ascribed to an adequate supply of nutrients resulted in high production of photosynthates and their translocation to sink (Zeiny *et al.,* 1998 and Kapila Shekawat and Shivay, 2008). Further, the properties of elemental sulphur reveal that when it is applied to the soil, absorbs moisture and disintegrates into fine and coarse particles. The finer particles oxidise rapidly and coarser particles slowly which might have supplied sufficient sulphur to the soil pool throughout the growth period of sunflower (Ravikumar *et al*., 2016) and resulted in higher seed yield than other sources like gypsum and SSP respectively during both the seasons.

Table 2 : Effect of different sources and levels of Sulphur on yield attributes and yield of sunflower

Treatments	First Season			Second Season		
	Head Diameter in cm	Seed yield Kg ha^{-1}	Stalk yield Kg ha^{-1}	Head Diameter in cm	Seed yield Kg ha^{-1}	Stalk yield Kg ha^{-1}
T_1 - RDF	12.2	1185.4	2257.9	12.4	1220.3	2381.9
T_2 - RDF + 15 kg Sulphur ha^{-1} through Single Superphosphate	12.4	1210.2	2312.4	12.7	1275.6	2486.0
T_3 - RDF + 30 kg Sulphur ha^{-1} through Single Superphosphate	14.1	1526.7	2527.0	14.3	1611.4	2737.2
T_4 - RDF + 45 kg Sulphur ha^{-1} through Single Superphosphate	16.1	1989.7	2756.0	16.9	2098.0	2998.8
T_5 - RDF + 15 kg Sulphur ha^{-1} through Elemental Sulphur	14.1	1425.9	2453.5	14.4	1552.0	2631.0
T_6 - RDF + 30 kg Sulphur ha^{-1} through Elemental Sullphur	15.4	1801.8	2691.8	15.8	1893.5	2912.4
T_7 - RDF + 45 kg Sulphur ha^{-1} through Elemental Sulphur	17.6	2213.3	3006.4	17.9	2479.2	3289.0
T_8 - RDF + 15 kg Sulphur ha^{-1} through Gypsum	13.2	1392.0	2387.8	13.5	1482.8	2572.0
T_9 - RDF + 30 kg Sulphur ha^{-1} through Gypsum	14.7	1692.5	2598.1	15.1	1780.0	2826.0
T_{10} - RDF + 45 kg Sulphur ha^{-1} through Gypsum	16.8	2056.4	2921.5	17.2	2152.8	3172.5
$S.E_{(m)}$	**0.27**	**24.76**	**21.45**	**0.29**	**25.68**	**22.9**
C.D (P = 0.05)	**0.58**	**52.9**	**45.9**	**0.62**	**54.9**	**49.0**

Conclusion

From the above study, it may be concluded that application of sulphur particularly through Elemental sulphur @ 45 kg.ha^{-1}combined with RDF (60:90:60 kg ha^{-1}) is an appropriate practice for augmenting sunflower yields in clay loam regions of Cuddalore district sunflower growers.

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