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Research Article

EFFECT OF SULPHUR AND ZINC ON GROWTH, YIELD, ECONOMICS OF HYBRID SUNFLOWER (*HELIANTHUS ANNUUS* L.) AND SOIL FERTILITY IN ALFISOL OF TAMIRAPARANI TRACT

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Abstract: Field experiment was conducted at Agricultural College and Research Institute, Killikulam during Rabi season (November- February) of 2016-2017 to study the response of sulphur and zinc on yield and quality of hybrid sunflower variety CO_2 in an Alfisol of Tamiraparani tract. The experiment was laid out in randomized block design (RBD) replicated thrice with eight treatments. Application of recommended dose of fertilizer (RDF) as 60:90:60 kg of NPK ha^{-1}+ S @ 25 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1}(T_2) produced significantly tallest plant (170.6 cm), days to 50 % flowering (51), largest size of capitulam (20.1 cm), highest number of seed capitulam^{-1} (1013), maximum weight of capitulam (73.1 g), hundred seeds weight (5.7 g), seed yield (2101 kg ha^{-1}) and stover yield (6523 kg ha^{-1}), net return (82,159 ha^{-1}) and B:C ratio (3.39). However, the RDF as 60:90:60 kg of NPK ha^{-1}+ $ZnSO_4$ @ 37.5 kg ha^{-1} + S @ 0.2 % foliar spray (T_8) registered taller plant, days to 50 % flowering, larger size of capitulam, higher number of seed capitulam^{-1}, weight of capitulam, hundred seeds weight, seed yield and stover yield and B:C ratio. Significant built up of organic carbon (0.65%), available N (241kg ha^{-1}), available P (17.9 kg ha^{-1}) and available K (265.7kg ha^{-1}) were also registered with the application of RDF as 60:90:60 kg of NPK ha^{-1}+ S @ 25 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1}.

Keywords: Alfisol, Hybrid Sunflower, Seed yield, Available nutrients and Economics

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Introduction

Sunflower (*Helianthus annuus* L.) is the second most important oil seed crop after groundnut in India. In India, sunflower is cultivated in the area of 4.87 lakh ha and the production of 2.96 lakhtons with the productivity of 1325 kg ha^{-1} [1]. In Tamil Nadu the production is 11,554 tonnes from the area of 8720 hectares with the productivity of 1325 kg ha^{-1} [2]. Hybrid sunflower respond well to application of N, P and K fertilizers under irrigated condition in terms of both quantitative and qualitative yield. Combined use of S and Zn with NPK improve the productivity and soil fertility. Sulphur and zinc are essential to synthesize the sulphur containing amino acids and proteins, activity of proteolytic enzyme and increases yield attributes such as capitulam size, seeds per capitulam and seed weight [3]. Even though the sunflower crop has the yield potential of around 2.3 to 2.5 tonnes ha^{-1} under favourable conditions but average productivity level in India is only 0.6 tonnes ha^{-1} due to imbalanced fertilization. Inadequate and imbalanced nutrient supply is the reason for low productivity of sunflower. Absence of sulphur and zinc, the crop shows nutritional disorders which eventually lead to low yield with poor quality of seed and oil in sunflower [4]. The recently released high yielding hybrid varieties remove more nutrients from the soil, so proper management of nutrient is essential for sustainable production. Though there are several studies on sulphur and zinc nutrition on sunflower in different parts of Tamil Nadu. Studies on the effect of sulphur and zinc on sunflower have not been attempted in Tamiraparani tract. Hence, the present investigation was under taken to study the effect of sulphur and zinc with recommended dose of NPK on growth, yield, quality and economics of hybrid sunflower (*Helianthus annuus* L.) in Alfisols of Tamiraparani tract.

Materials and Methods

A field experiment was conducted at orchard of Agricultural College and Research Institute, Killikulam, Thoothukudi during Rabi season November, 2016-February, 2017. The soil of experimental field was sandy clay loam in texture, nearly neutral in reaction (pH 6.7), low in organic carbon (0.48 %), low in available nitrogen (234 kg ha^{-1}), medium in available phosphorus (18.0 kg ha^{-1}) and high in available potassium (258 kg ha^{-1}). The available sulphur and zinc were low with the values of 7.56 and 1.03 mg kg^{-1}. The cation exchange capacity of the soil was 22 c mol (p+) / kg. The bulk density of the soil was (1.36 Mg/m^3). The soil was taxonomically grouped as Rhodustalfs [5]. The experiment consisted of eight treatments *viz*. T_1- Control, T_2- 60:90:60 kg of NPK ha^{-1} + S @ 25 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1}, T3- 60:90:60 kg of NPK ha^{-1}+ S @ 12.5 kg ha^{-1} + $ZnSO_4$@ 0.5 % foliar spray, T_4- 60:90:60 kg of NPK ha^{-1} + S @ 25 kg ha^{-1} + $ZnSO_4$@ 0.5 % foliar spray, T_5- 60:90:60 kg of NPK ha^{-1}+ S @ 37.5 kg ha^{-1} + $ZnSO_4$@ 0.5 % foliar spray, T_6 - 60:90:60 kg of NPK ha^{-1}+ $ZnSO_4$@ 12.5 kg ha^{-1} + S @ 0.2 % foliar spray, T_7- 60:90:60 kg of NPK ha^{-1}+ $ZnSO_4$ @ 25 kg ha^{-1} + S @ 0.2 % foliar spray and T_8 - 60:90:60 kg of NPK ha^{-1}+ $ZnSO_4$ @ 37.5 kg ha^{-1} + S @ 0.2 % foliar spray was carried out in randomized block design (RBD) with three replication. The hybrid sunflower var. CO_2 was taken as test crop. Sowing of sunflower was done during first week of November with the spacing of 60 cm × 30 cm. The cultivation practices were followed as per the guidance of crop production guide of Tamil Nadu Agricultural University [6]. The fertilizer sources used were urea for N (46 % N), single super phosphate for P (16 % water soluble P_2O_5), muriate of potash for K (60 % of K_2O), gypsum (19% of SO_4), and Zinc sulphate (21% of Zn). Growth and yield attributes were recorded as per standard procedures. Five representative samples of each plot were collected and observations of biometric and yield attributes such as plant height, days to 50 % flowering, capitulam size, number of filled seeds per capitulam, percent of filled seeds, seed yield, hundred seeds weight and dry matter production were statistically analysed. The nutrient content and uptake by plant were analysed through laboratory procedures.

Table-1 Effect of sulphur and zinc on growth, yield attributes, yield and economics of hybrid sunflower

Treatment	Plant height (cm)	Days to 50% flowering	Size of capitulam (Diameter in cm)	No. of seeds capitulam^{-1}	Weight of capitulam (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C ratio
T_1- Control	145.4	57	11.3	629.3	48.5	975	3923	29,982	28,978	1.96
T_2- RDF + S @ 25 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1}	170.6	51	20.1	1013	73.1	2101	6523	34,347	82,159	3.39
T_3-RDF + S @ 12.5 kg ha^{-1} + $ZnSO_4$@ 0.5 % foliar spray	148.7	56	15.1	872	60.7	1712	5102	31,024	66,734	3.15
T_4-RDF + S @ 25 kg ha^{-1} + $ZnSO_4$@ 0.5 % foliar spray	159.1	54	16.2	945	65.4	1801	5531	31,197	70,367	3.25
T_5- RDF + S @ 37.5 kg ha^{-1} + $ZnSO_4$@ 0.5 % foliar spray	162.8	53	17.6	976.3	68.0	1892	5601	32,520	73,713	3.26
T_6-RDF + $ZnSO_4$ @ 12.5 kg ha^{-1} + S @ 0.2 % foliar spray	150.5	55	15.8	913.3	63.0	1757	5385	32,385	68,637	3.11
T_7-RDF + $ZnSO_4$ @ 25 kg ha^{-1} + S @ 0.2 % foliar spray	161.1	54	16.8	934.7	66.6	1813	5588	34,005	70,856	3.08
T_8- RDF + $ZnSO_4$ @ 37.5 kg ha^{-1} + S @ 0.2 % foliar spray	165.2	52	18.5	982.3	70.2	1980	5813	33,679	77,093	3.28
SEd	2.98	1.10	0.29	19.70	1.24	43.16	125.61	-	-	-
CD (P=0.05)	6.39	2.36	0.64	42.27	2.66	92.58	269.44	-	-	-

RDF: Recommended dose of fertilizer for hybrid sunflower (60:90:60 kg of NPK ha^{-1})

Table-2 Effect of sulphur and zinc on soil fertility

Treatment	Available nutrients					
	Organic carbon (%)	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	S (mg kg^{-1})	Zn (mg kg^{-1})
T_1- Control	0.31	202	10.7	196.7	18.68	0.98
T_2- RDF + S @ 25 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1}	0.65	241	17.9	265.7`	26.54	2.25
T_3-RDF + S @ 12.5 kg ha^{-1} + $ZnSO_4$@ 0.5 % foliar spray	0.48	220	13.3	222.7	21.44	2.08
T_4-RDF + S @ 25 kg ha^{-1} + $ZnSO_4$@ 0.5 % foliar spray	0.50	226	14.6	240.3	27.11	2.06
T_5- RDF + S @ 37.5 kg ha^{-1} + $ZnSO_4$@ 0.5 % foliar spray	0.55	235	15.2	246.2	28.20	2.02
T_6-RDF + $ZnSO_4$ @ 12.5 kg ha^{-1} + S @ 0.2 % foliar spray	0.45	222	13.4	233.1	19.0	2.17
T_7-RDF + $ZnSO_4$ @ 25 kg ha^{-1} + S @ 0.2 % foliar spray	0.52	228	14.1	242.6	19.54	2.28
T_8- RDF + $ZnSO_4$ @ 37.5 kg ha^{-1} + S @ 0.2 % foliar spray	0.59	237	16.7	252.7	20.52	2.30
SEd	0.012	4.52	0.34	5.68	0.54	0.032
CD (P=0.05)	0.027	9.69	0.73	12.18	1.16	0.069

RDF: Recommended dose of fertilizer for hybrid sunflower (60:90:60 kg of NPK ha^{-1})

The post harvest soil samples were collected from 0-30 cm depth for analysing for physical and chemical parameters available nutrient status. Soil samples were analysed for alkaline permanganate oxidizable N, 0.5 M $NaHCO_3$-extractable P, 1 N NH_4OAC-exchangeable K, Turbidimetry for S and DTPA extractant using AAS for Zn. Two-way analysis of variance (ANOVA) was performed for trait for seasons and the combined (Pooled) over seasons after testing error variance homogeneity was carried out according to the procedure outlined by [7] statistical package. Significance difference between the treatments were compared with the critical difference at (± 5%) probability by LSD.

Result and Discussion

Growth and yield attributes

The plant height was measured and recorded at harvest (table 1). The height of the plant significantly differed for various treatments. The ranges of the plant height was 145.4 to 170.6 cm at final harvest. At harvest, the tallest plants (170.6 cm) was recorded in the treatment (T_2) with RDF + S @ 25 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} followed by treatment (T_8) with RDF + $ZnSO_4$ @ 37.5 kg ha^{-1} + S @ 0.2 % foliar spray had recorded next tallest plant (165.2 cm). The increase in plant height was significant due to recommended NPK along with optimum S and Zn. This could be due to supplying N, P, K, S and Zn nutrients in proper proportion through soil application. These results are in conformity with those of [8] and [9]. The shortest plant (145.4 cm) was recorded in absolute control (T_1). The number of days required for 50% flowering of the crop were assessed in all the treatments and presented in table 1. Among the treatments T_2 with RDF + S @ 25 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} had achieved the 50 %flowering at the earliest (51 days) followed by the treatment (T_8) with RDF + $ZnSO_4$ @ 37.5 kg ha^{-1} + S @ 0.2 % foliar spray, which reached the 50 % flowering earlier (52 days). Both the treatments were on par to each other. The 50 % flowering was late (57 days) in the control (T_1). This might be due to proper growth of sunflower, which enhanced the earliest flowering as 50%. This corroborates the earlier findings of [10]. The yield attribute parameters like size of capitulam, number of seeds capitulam^{-1} and weight of capitulam were significantly influenced for various treatments. Among all the treatments, the largest size of capitulam (20.1 diameter in cm), maximum number of seed capitulam^{-1} (1013) as in table 1, was recorded in the treatment applied with RDF + S @ 25 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} (T_2) followed by the application of RDF + $ZnSO_4$ @ 37.5 kg ha^{-1} + S @ 0.2 % foliar spray (T_8) recorded the larger size of capitulam (18.5 diameter in cm) and higher number of seeds capituam^{-1} (982.3). These treatments were on par with each other. The smallest size of capitulam (11.1diameter in cm) and minimum number of seeds capitulam^{-1} (629.3) was registered from absolute control (T_1). The maximum weight of the capitulam (73.1 g) was recorded in the treatment (T_2) with RDF + S @ 25 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} followed by the treatment (T_8) with the application of RDF + $ZnSO_4$ @ 37.5 kg ha^{-1} + S @ 0.2 % foliar spray recorded the next maximum weight of fruit (70.2 g). Both these treatments (T_2) and (T_8) were on par to each other. The minimum weight of the capitulam (48.5 g) was noted in the absolute control (T_1). Adequate supply of NPKS and Zn nutrients enhanced the availability at critical growth stages resulted in enhanced yield characters *viz*., capitulam size, number of seeds capitulam^{-1} and 100 seeds weight. These results are in agreement with [11] and [12].

Yield

Application of sulphur and zinc at different levels and methods with the recommended dose of NPK in hybrid sunflower significantly enhanced the seed and stover yield of hybrid sunflower compared to control. The application of RDF + S @ 25 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} produced the maximum seed and stover yield (2101 and 6523 kg ha^{-1}, respectively) which was significantly higher to the tune of 115 and 66 % over control. The second best treatment was RDF + $ZnSO_4$ @ 37.5 kg ha^{-1} + S @ 0.2 % foliar spray which also recorded the seed and stover yield (1980 and 5813 kg ha^{-1}, respectively), whereas lowest yield of seed and stover (975 and 3923 kg ha^{-1}, respectively) was noticed with no application of fertilizer (control). The increase in seed and stover yields might be due to increased growth and yield attributes. This might be due to adequate and steadily supply of all nutrients to plants at all stages of crop growth. This corroborates the earlier report of [13] and [14].

Soil fertility

Perusal of data presented in table 2 revealed that the available nutrient status at post harvest soil were influenced for various treatments. The highest values of organic carbon and nitrogen (0.65 % and 241 kg ha^{-1}) were recorded with the treatment with RDF + S @ 25 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1}. Combined application of sulphur and zinc with recommended dose of NPK might slow down the urease activity and reduce the loss of added nitrogen through regulation of

nitrogen release at a relatively slow rate would have increased available nitrogen. The availability of N increased in the soil might be due to the application of S and Zn along with RDF. These findings are in conformity with the earlier work of [15] and [16]. The available phosphorus also was highest (17.9 kg ha^{-1}) for the same treatment. The increase might be due to the combination of sulphur and zinc added to soil might dissolve the phosphorus fixed by soils in the form of in the form of insoluble phosphates such as tricalcium phosphates and flourapatite, thus phosphorus making them slow contributing phosphorus fertilizers. The highest available potassium (265.7 kg ha^{-1}) was also recorded with the treatment (T_2) with RDF + S @ 25 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1}. [17] reported that the potassium rich minerals in the soils might have been destroyed and potassium being major constituent of all soil forming minerals would have been released and brought into soil solution. The highest available sulphur (28.2 mg kg^{-1}) was recorded for the treatment (T_5) applied with RDF + S @ 37.5 kg ha^{-1} + $ZnSO_4$ @ S @ 0.5 % foliar spray. The treatment (T_8) with RDF + ZnSO4 @ 37.5 kg ha^{-1} + S @ 0.2 % foliar spray registered the maximum available zinc (2.30 mg kg^{-1}). The addition of S and Zn through soil and foliar resulted in increased S and Zn availability. These results are in agreement with [18]. The lowest values of available N, P and K nutrients (0.31 %, 202, 10.7 and 196.7 kg ha^{-1}, respectively) and the sulphur and zinc (18.68 and 0.98 mg kg^{-1}) were recorded for control.

Economics

The application of RDF + S @ 25 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} fetched significantly higher net returns (82,159 ha^{-1}) and benefit : cost ratio (3.39) over the rest of treatments (Table 1). The additional net return was to the tune of 53,181 ha^{-1} due to application of RDF + S @ 25 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} over control. The second best treatment was RDF + $ZnSO_4$ @ 37.5 kg ha^{-1} + S @ 0.2 % foliar spray which fetched a net returns of 77,093 ha^{-1} and benefit : cost ratio of 3.28. This might be due to achieved higher productivity as well as lower cost of cultivation owing to increased economic returns in hybrid sunflower. These results are in close conformity with the findings of [19].

Conclusion

It was concluded that soil application of RDF + S @ 25 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} not only improves the hybrid sunflower productivity and net profit but soil fertility status was also improved due to the combined application of sulphur and zinc.

Application of research: Sulphur and zinc application both in soil and foliar spray not only proves most beneficial but economic for hybrid sunflower productivity in Alfisols of Tamil Nadu.

Research Category: Soil Science

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