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Effect of sulphur on availability of N, P, K and S in sunflower

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Abstract
Experimental trials were conducted during two consecutive seasons on 2015-16 at Experimental Farm, Annamalai University, Annamalai Nagar, Tamil Nadu, India to evaluate the response of different sources and levels of sulphur on hybrid sunflower (*Helianthus annuus* L.). The experiment comprised ten treatments includes RDF, RDF combines with three sources and levels of sulphur Viz., elemental sulphur, gypsum and pyrite with each applied at three levels such as 15, 30 and 45 kg S ha^{-1}. The experiments were laid out in randomized block design and replicated thrice. Among the treatment combinations, pyrite @ 45 kg ha^{-1} with RDF (T_{10}) found to be promising with increased available nutrients of N, P, K and S over RDF alone during both the period of experimental study. Application of RDF + Sulphur @ 45 kg ha^{-1} through elemental sulphur enhanced the availability of nutrients and eventually increased the nutrient uptake of N, S, P and K and thereby decreased the availability pool of N, P, K and S in hybrid sunflower.

Keywords: elemental sulphur, gypsum, nutrient uptake, pyrite and sunflower

Introduction
Sunflower (*Helianthus annuus* L.) is one of the most important oilseed crops grown worldwide by its high-quality edible oil. Its high synthetic capacity and harvest index allows this crop to be productive in a broad range of environments (Agele, 2003) [1]. Besides, it has tolerance to drought and high poly unsaturated fatty acid contents are added advantages. Nowadays, intensive cropping is unavoidable circumstances with regards to food production in order to meet out the national goal. For that adoption of high yielding varieties and intensive cropping systems require more attention with regard to nutrient management to increase crop yield and quality. Scientific reports indicate that the soils of north cauvery delataic region are low in N and S but moderate in P, K. Nitrogen is the major nutrient that enhances the metabolic processes that lead to increase in vegetative, reproductive and yield of crops. Sulphur is increasingly being recognized as the fourth major plant nutrient after nitrogen, phosphorus and potassium (Tandon and messick, 2002) [11]. Sulphur plays a predominant role in improving the grain quality of sunflower crop and also the use efficiency of nitrogen and phosphorus. This study is the moment of an effort to understand the effect of N and S fertilization on nutrient uptake especially the availability of nutrients to the soil pool during the crop period of sunflower which enhanced the growth and yield of sunflower in the northern part of Cauvery deltaic region.

Materials and Methods
Study area
To study the effect of different sources and levels of sulphur on the yield and nutrient (N, P, K and S) uptake and the availability of nutrients to the soil pool of sunflower, the experiment was conducted at Annamalainagar, experimental farm, Cuddalore district, Tamilnadu, India during June to September of 2015 and Feb to Apr on 2016. The experimental site of the study details furnished in Table.1 Soil was analysed for their 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 (242.5kg.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 arrangement of treatments in three replications. Experimental plots consist of three sulphur sources (Elemental sulphur, Gypsum and pyrite), levels (15, 30, 45 kg ha^{-1}) and control i.e., recommended N, P and K (60:90:60 kg. ha^{-1}) alone.

Table 1: Characteristics of the study area

Site characteristics	
District	Cuddalore (Annamalai Nagar)
Latitude and Longitude	11^0 24'N and 79^0 44'E
Agro climatic zone	Northern Cauvery deltaic zone
Mean Sea Level	+5.79mts
South East Monsoon	400 mm
North East Monsoon	1000 mm
Summer rain	100 mm
Major soils	Red soil, moderately clay loam and Sandy loam

Post-harvest soil analysis for available N, P, K and S nutrients
Post-harvest soil samples were taken from each treatment plot during the experiment for estimation of available N through (Subbiah and Asija, 1956) [8] method. For determination of P by (Olsen, 1954) [6], available K by (Stanford and English, 1949) [7], and available S by (Chesiin and Yein, 1951) [2]. The experimental data were statistically analysed as suggested by Gomez and Gomez (1976) [4]. For significant results the critical difference was worked out at 5 per cent level.

Results and Discussion

Effect of different sources and levels of sulphur on available N, P, K and S nutrient

The lowest soil available N, P and K was recorded with of Elemental sulphur as a sulphur source @ 45 kg.ha^{-1} with RDF (60:90:60 kg ha^{-1}). This might be due to better uptake by the crop in elemental sulphur treated plots as is evident from the Table 2. Higher values were recorded in RDF alone treated plots due to positive interaction between the N and P with S which paves betterment of nutrient availability during the crop growth period. Similar results were also obtained by Kalaiarsan (2000). Post-harvest soil available sulphur was significantly influenced by the addition of sulphur. Sulphur application is known to have a considerable residual sulphur in soil (Tanddon, 1991). The highest available sulphur was recorded with application of pyrite @ 45 kg ha^{-1} followed by gypsum and elemental sulphur. The higher availability of sulphur noticed under pyrite treatment indicates that this source has more potential in supply sulphur to the soil pool as residual sulphur than the other sources. However, pyrite has more potential in sulphur supply to the soil available pool as residual sulphur than other sources; the availability during the crop period is less due to its poor oxidation potential compared to other sources viz. gypsum and elemental sulphur. In case of elemental sulphur (T_4), the available sulphur was lower than iron pyrite, could be due to the maximum utilization by the crop, which is confirmed by the highest seed yield obtained under this treatment. These results were corroborated with the findings of Surendra Singh *et al*., (2000) [9], Tomar *et al*., (2000) [12] and Ganie *et al*., (2014) [3]

Conclusion

From the above detailed experiment, it may be concluded that application of Elemental sulphur as a sulphur source @ 45 kg.ha^{-1} with RDF (60:90:60 kg ha^{-1}) is an appropriate practice for augmenting sunflower yields through enhanced the crop growth thereby leads to better uptake of nutrients in northern regions of Cauvery deltaic areas sunflower growers. Furthermore, this could be proved by lower availability of N, P, K and S nutrients in the soil pool.

Table 2: Effect of different sources and levels of sulphur on N, P, K and S available nutrient

Treatments	Available Nutrients Kg ha^{-1}							
	First Season				Second Season			
	N	P	K	S	N	P	K	S
T_1 – RDF	240.0	22.4	210.2	8.7	236.0	22.6	207.6	8.4
T_2 - RDF + 15 kg Sulphur ha^{-1} through Elemental Sulphur	230.8	20.9	196.1	19.2	225.8	21.1	193.0	18.9
T_3 - RDF + 30 kg Sulphur ha^{-1} through Elemental Sulphur	220.0	19.2	184.2	17.3	216.0	19.4	181.1	17.0
T_4 - RDF + 45 kg Sulphur ha^{-1} through Elemental Sulphur	213.2	17.0	171.6	15.2	210.0	17.3	167.2	14.9
T_5 - RDF + 15 kg Sulphur ha^{-1} through Gypsum	234.6	21.6	199.4	17.9	230.6	21.9	195.0	17.6
T_6 - RDF + 30 kg Sulphur ha^{-1} through Gypsum	222.2	19.7	189.1	19.4	218.2	19.9	185.2	19.1
T_7 - RDF + 45 kg Sulphur ha^{-1} through Gypsum	219.6	18.2	175.2	16.1	215.6	18.5	171.0	15.8
T_8 - RDF + 15 kg Sulphur ha^{-1} through pyrite	239.0	22.0	204.8	19.9	235.0	22.3	200.1	19.6
T_9 - RDF + 30 kg Sulphur ha^{-1} through pyrite	230.1	20.4	192.6	18.6	226.1	20.7	188.0	18.3
T_{10}- RDF + 45 kg Sulphur ha^{-1} through pyrite	224.0	18.8	181.0	16.8	220.0	21.1	176.4	16.5
$S.E_{(m)}$	1.03	0.10	1.13	0.05	1.08	0.09	1.22	0.48
C.D (P = 0.05)	2.20	0.21	2.27	0.11	2.31	0.18	2.44	0.57

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