



## Effect of different planting geometry and sulphur fertilization on growth and yield, quality, nutrient uptake and post harvest soil nutrient status of sunflower in sunflower + greengram intercropping system

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### Abstract

A field experiment was carried out during Mar-May, 2019 at the Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai nagar, to study the effect of different planting geometry and sulphur levels in sunflower + greengram intercropping system on the growth and yield attributes, yield, quality, nutrient uptake and post harvest nutrient status of sunflower. The experiment consisted of twenty treatments and were laid out in factorial randomized block design with two replications. The treatment consisted of Factor A (different plant geometry levels): M<sub>1</sub> - sole sunflower (60 x 30 cm), M<sub>2</sub> - sunflower (60 x 30 cm) + 1 row of greengram, M<sub>3</sub> - sunflower (90 x 30 cm) + 2 rows of greengram, M<sub>4</sub> - sunflower (120 x 30 cm) + 3 rows of greengram, M<sub>5</sub> - sole greengram and Factor B (sulphur levels): S<sub>0</sub> - 0 kg S ha<sup>-1</sup>, S<sub>1</sub> - 20 kg S ha<sup>-1</sup>, S<sub>2</sub> - 40 kg S ha<sup>-1</sup> and S<sub>3</sub> - 60 kg S ha<sup>-1</sup>. The results revealed that growth and yield attributes, yield, quality and nutrient uptake of sunflower were significantly influenced by different plant geometry and various sulphur levels. Among the different planting geometry levels tried, sole sunflower (60 x 30 cm) (M<sub>1</sub>) significantly recorded maximum growth and yield attributes, yield, quality, nutrient uptake and post harvest soil nutrient status of sunflower. With regard to various sulphur levels tried, Application of sulphur at 40 kg ha<sup>-1</sup> (S<sub>2</sub>) significantly recorded maximum growth and yield attributes, yield, quality and nutrient uptake of sunflower. Interaction between planting geometry and sulphur levels were significant. Among the treatment combinations tried, sole cropping of sunflower (60 x 30 cm) along with application of S at 40 kg ha<sup>-1</sup> (M<sub>1</sub>S<sub>2</sub>) had a spectacular effect on growth and yield attributes, quality and nutrient uptake ultimately leading to maximum seed yield (2152 kg ha<sup>-1</sup>). The minimum growth and yield attributes, yield, quality and nutrient uptake were recorded in sunflower (120 x 30 cm) intercropped with three rows of greengram along with application of S at 0 kg ha<sup>-1</sup> (M<sub>4</sub>S<sub>0</sub>). With regard to post harvest soil nutrient status, the treatment combination of sunflower (120 x 30 cm) intercropped with three rows of greengram along with application of S at 60 kg ha<sup>-1</sup> (M<sub>4</sub>S<sub>3</sub>) significantly recorded higher post harvest soil nutrient status.

**Keywords:** sunflower, planting geometry, intercropping, sulphur, yield and quality

### Introduction

Oilseed plays a vital role in Indian agriculture as food for human and concentrate for animals. Oil industry is an important determinant of agricultural economy in India. Oilseed crops occupied 14 per cent of the gross cropped area and is the second largest agricultural commodity after cereals (Kumar *et al.*, 2016) [8]. Among the oilseed crops, sunflower (*Helianthus annuus* L.) is an all-season crop. Sunflower has gained popularity in the recent past because of its excellent quality oil due to richness with high degree poly unsaturated fatty acids, anti-cholesterol properties, short duration, wide adaptability to soil and climatic conditions, photo and thermo-insensitiveness, drought tolerance and higher oil yield per unit area (Thimmegowda *et al.*, 2007) [19]. Sunflower seed is highly nutritious containing 14-19 per cent protein and 40-45 per cent oil associated with very high calorific value and 30-35 per cent carbohydrates. Plant geometry determines the distribution pattern of plants in a field. It affects evaporation, water use efficiency of the crop and weed intensity competition. Proper spacing of plants in a particular area makes plant canopy more effective in intercepting the radiant energy and shading effect on weeds resulted higher growth and yield (Saleem *et al.*, 2008) [15]. In modern agriculture, intercropping is considered to be an effective and most potential way of increasing crop production per unit area.

Khan and Akmal (2014) [7] documented that intercropping of pulses is the one way of increase overall productivity and also claimed that intercropping of sunflower is more beneficial than sole cropping of sunflower. Balance supply of macro and micro nutrients enhanced the oilseed production, among them sulphur plays a multiple role in providing nutrition to oilseed crops. Sulphur is the fourth most important nutrient and it is best known for its role in the synthesis of proteins, oils, vitamins and flavoured compounds in plants. Sulphur is also involved in the formation of chlorophyll, glucosides and glucosinolates (mustard oils), activation of enzymes and sulphhydryl linkages that are the source of pungency in onion, oils, etc. (Jamal *et al.*, 2010) [6]. Thus, adequate sulphur is so crucial for oil seed crops. Sulphur deficiency in sunflower is detrimental to seed yield and quality. Oil yield is a function of oil content and grain yield, both the attributes increased with increasing the levels of sulphur resulting in a significant increase in oil yield (Kumar *et al.*, 2011) [9].

### Materials and Methods

The field investigation was carried out during March-May, 2019 at Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar. The soil of experimental field was clay loam in texture. The soil was low in available nitrogen, medium in

available phosphorous, high in available potassium and low in available sulphur. The sunflower cultivar TNAU sunflower hybrid CO 2 was chosen for the study. The intercrop greengram (ADT-3) was chosen for the study. The experiment consisted of twenty treatments and were laid out in factorial randomized block design with two replications. The treatment consisted of Factor A (different plant geometry levels): M<sub>1</sub> - sole sunflower (60 x 30 cm), M<sub>2</sub> - sunflower (60 x 30 cm) + 1 row of greengram, M<sub>3</sub> - sunflower (90 x 30 cm) + 2 rows of greengram, M<sub>4</sub> - sunflower (120 x 30 cm) + 3 rows of greengram, M<sub>5</sub> - sole greengram and Factor B (sulphur levels): S<sub>0</sub> - 0 kg S ha<sup>-1</sup>, S<sub>1</sub> - 20 kg S ha<sup>-1</sup>, S<sub>2</sub> - 40 kg S ha<sup>-1</sup> and S<sub>3</sub> - 60 kg S ha<sup>-1</sup> through gypsum. Recommended dose of 60:90:60 kg of N, P and K ha<sup>-1</sup> was applied in the form of urea, DAP and MOP respectively. Half the dose of N and entire dose of P and K were applied basally. The remaining quantity of N was applied at 30 DAS. The biometric observations were recorded at critical stages and at harvest. The estimated data were analysed as per the procedure outlined by Gomez and Gomez (1994) [4]. The critical difference was worked out at five per cent probability level for significant result.

## Results and Discussion

### Growth attributes (Table 1)

Different planting geometry levels significantly influenced the growth attributes of sunflower. The sole sunflower which is grown with a spacing of 60 x 30 cm (M<sub>1</sub>) recorded maximum values for plant height, LAI, DMP, CGR, RGR, chlorophyll content and early days to fifty per cent flowering. This might be due to an uninterrupted availability of various resources viz., sunlight, soil moisture and nutrients for sole sunflower have helped the crop to utilize the resources to a greater extent resulting in enhanced values of all growth parameters. Leaf area index (LAI) had crucial significance in increasing the crop yield. More number of plants m<sup>-2</sup> and higher leaf numbers plants<sup>-1</sup> might be the possible reason for maximum leaf area index (Iqbal *et al.*, 2007) [5]. Similar findings were noticed by Baradan (2007) [3]. Application of different levels of sulphur was found to influence the growth attributes of sunflower viz., plant height, LAI, DMP, CGR, RGR, chlorophyll content and early days to fifty percent flowering. The growth attributes were significantly enhanced by application of sulphur at 40 kg ha<sup>-1</sup> (S<sub>2</sub>) this response was due to deficiency of sulphur in experimental soil. Addition of sulphur nutrition enhanced the cell division, cell elongation and expansion and chlorophyll synthesis. It was also important in the activity of meristematic tissues and development of shoots (Ravi *et al.*, 2010) [13]. Thus, adequate supply of sulphur will be expected that plants grow taller with a greater number of leaves having bigger size and higher chlorophyll content. Since sulphur is constituent of succinyl CO A, which is precursor of biosynthesis of chlorophyll. These results were in agreement with the findings of Vaiyapuri *et al.* (2004) [21]. The interaction effect between plant geometry and sulphur levels were found to be significant on growth attributes at all stages of crop growth. The higher growth attributes viz., plant height, LAI, DMP, CGR, RGR, chlorophyll content and early fifty per cent flowering under the treatment combination of sole sunflower with application of 40 kg S ha<sup>-1</sup> (M<sub>1</sub>S<sub>2</sub>), which produced higher growth attributes due to increased utilization of carbohydrate for synthesis of protein and more availability of photosynthesizing area and

physiological capacity to translocate them to the organ of vegetative growth. Similar results were earlier reported by Anas *et al.* (2017) [2].

### Yield attributes and yield (Table 2)

Among the different planting geometry levels, the sole sunflower grown with a spacing of 60 x 30 cm (M<sub>1</sub>) significantly registered maximum yield attributes viz., head diameter, total number of seeds head<sup>-1</sup>, number of filled seeds head<sup>-1</sup>, percentage of filled seeds and maximum seed yield and stalk yield. However, the test weight is not influenced significantly due to plant geometry levels. The improvement of growth attributes leads to higher yield attributes and also absence of competition from intercrop resulting in higher nutrient uptake, higher photosynthetic assimilates production and effective portioning from source to sink (Saleem *et al.*, 2008) [15]. The results were in agreement with the findings of Sarma *et al.* (2016) [16]. Application of sulphur at 40 kg ha<sup>-1</sup> (S<sub>2</sub>) significantly increased yield attributing characters viz., head diameter, total number of seeds head<sup>-1</sup>, number of filled seeds head<sup>-1</sup>, percentage of filled seeds, test weight, seed yield and stalk yield over other levels of sulphur. This significant and positive influence of sulphur on head diameter and number of filled seeds per head was due to improved growth through increased nutrient assimilation which in turn accelerated the crop to put forth larger heads and filled seed. Significant increase in total number of seeds head<sup>-1</sup> and number of filled seeds head<sup>-1</sup> due to sulphur through gypsum could be attributed to improve the availability of most of the nutrients and created more favourable soil environment which helped the plant to uptake large quantity of nutrients resulted in increased seed and stalk yield (Thorat *et al.*, 2007) [20]. This is also due to more accumulation of amino acids and amide substances and their translocation to the reproductive organs which influenced growth and yield due to application of sulphur. Similar findings were earlier reported by Kumar *et al.* (2011) [9]. The interaction effect between plant geometry and sulphur levels were found to be significant on yield attributes and yield of sunflower. The higher values on yield characteristics viz., head diameter, total number of seeds head<sup>-1</sup>, number of filled seeds head<sup>-1</sup>, percentage of filled seeds, test weight and also higher seed yield and stalk yield were observed under the treatment combination of sole sunflower (60 x 30 cm) with application of 40 kg S ha<sup>-1</sup> (M<sub>1</sub>S<sub>2</sub>) due to higher yield characteristics and non-competition effects in using the available resource and optimum supply of sulphur. The minimum values for yield attributes, seed yield and stalk yield were recorded under the treatment combination of sunflower (120 x 30 cm) intercropped with three rows of greengram along with application of S at 0 kg ha<sup>-1</sup> (M<sub>4</sub>S<sub>0</sub>) which could be due to inadequate availability of nutrients (Anas *et al.*, 2017) [2]. The similar trend of result was noticed by Singh *et al.* (2013) [18].

### Quality characters (Table 3)

The different planting geometry levels did not influence the quality characters significantly viz., oil content and protein content of sunflower. Oil content and protein content was unaffected with spacing due to the genetic nature of the variety. These results were in accordance with the findings of Prasannakumara *et al.* (2014) [11].

The quality determining attributes such as oil content and protein content were significantly influenced by levels of sulphur. Higher oil and protein content were recorded under application of sulphur at 40 kg ha<sup>-1</sup> (S<sub>2</sub>). Increase in oil content by sulphur application due to the role of sulphur in synthesis of oil. Patra *et al.* (2013) reported that sulphur nutrition involved in the formation of glucosides and glucosinolates and sulphhydryl-linkage and activation of enzymes which aid in biochemical reaction within the plant and increased the oil content in sunflower seeds.

With regard to interaction, the higher quality characters of sunflower were observed under the treatment combination of sole sunflower (60 x 30 cm) with application of 40 kg S ha<sup>-1</sup> (M<sub>1</sub>S<sub>2</sub>) due to proper plant population, optimum supply of sulphur which contains the acetic thiolinase, a sulphur-based enzyme converts acetyl Co A to melonyl Co A rapidly resulting in higher oil content of sunflower with sulphur application which plays important role in increasing seed yield result in higher quality characteristics. These results were in agreement with the findings of Ali *et al.* (2007) [1].

### Nutrient uptake (Table 3)

Among the different planting geometry levels tried, the sole sunflower grown with a spacing of 60 x 30 cm (M<sub>1</sub>) significantly recorded the higher nutrient uptake of N, P, K and S. This might be due to optimum spacing, absence of competition from intercrops resulting in utilization of the resources to a maximum extent and consequent by enhanced the uptake of nutrient by sole crop sunflower. The results were in agreement with the findings of Kumar (2011) [9].

Application of sulphur in various levels significantly influence the nutrient uptake of N, P, K and S of sunflower. Application of sulphur at 40 kg ha<sup>-1</sup> (S<sub>2</sub>) recorded maximum nutrient uptake. Sulphur application improved the nutritional environment in the soil which caused more nutrient uptake by the crop and increased the dry matter production, this might be due to direct involvement in cell

division, cell elongation and cell enlargement. Similar finding was reported by Rasool *et al.* (2013) [12].

The interaction effect between different planting geometry and various levels of sulphur application were found to be significant on nutrient uptake of sunflower. Among the interactions, the treatment combination of sole sunflower with application of 40 kg S ha<sup>-1</sup> (M<sub>1</sub>S<sub>2</sub>) recorded higher nutrient uptake. This could be due to higher availability of essential nutrients to the crop, non-competition effects to utilize the available resources to a maximum extent which produced dry matter yield and enhanced the nutrient uptake of sunflower. Similar findings were earlier reported by Sheoran *et al.* (2013) [17].

### Post harvest soil nutrient status (Table 3)

With regard to different planting geometry of sunflower, the sunflower grown with a spacing of 120 x 30 cm intercropped with three rows of greengram (M<sub>4</sub>) registered the higher post harvest available nutrient status in soil. This might be due to presence of legume intercrop which accumulated higher quantum of nitrogen by its enhanced nodulation behaviour.

Among various levels of sulphur, application of 60 kg S ha<sup>-1</sup> (S<sub>3</sub>) registered the higher post harvest available nutrient in soil. This increase might be due to amelioration and synergistic effect of sulphur with other nutrients which improved the physico-chemical properties of soil. The results were in agreement with the findings of Sahoo *et al.* (2018).

The interaction effect between different planting geometry and sulphur levels were found to be significant. The maximum amount of post harvest soil available nutrients available were recorded in combination of sunflower (120 x 30 cm) intercropped with three rows of greengram along with application of S at 60 kg ha<sup>-1</sup> (M<sub>4</sub>S<sub>3</sub>). This might be due to less utilization of essential nutrients by both sunflower and greengram. The similar trend of results was noticed by Baradhan (2007) [3].

**Table 1:** Effect of different planting geometry and sulphur fertilization on growth attributes of sunflower

Treatments	Plant height (cm) at harvest	LAI at flowering stage	DMP (kg ha <sup>-1</sup> ) (at harvest)	CGR at flowering stage (g m <sup>-2</sup> day <sup>-1</sup> )	RGR at flowering stage (g m <sup>-2</sup> day <sup>-1</sup> )	Chlorophyll content (mg g <sup>-1</sup> )	Days to 50 % flowering
Plant Geometry							
M <sub>1</sub>	152.0	4.53	4878	5.22	0.073	26.03	51.75
M <sub>2</sub>	148.4	4.45	4667	5.06	0.068	25.27	52.78
M <sub>3</sub>	144.41	4.33	4433	3.16	0.063	24.08	53.97
M <sub>4</sub>	139.9	4.16	4158	2.25	0.057	23.00	54.99
S.Ed	1.59	0.04	18.85	0.06	0.002	0.15	0.29
CD(P=0.05)	3.26	0.07	38.06	0.11	0.004	0.28	0.59
Sulphur							
S <sub>0</sub>	134.9	3.96	4110	3.54	0.059	20.93	56.05
S <sub>1</sub>	144.3	4.19	4422	3.92	0.063	24.39	53.86
S <sub>2</sub>	155.6	4.72	4895	4.18	0.072	27.60	51.30
S <sub>3</sub>	150.0	4.61	4709	4.05	0.067	25.47	52.28
S.Ed	1.63	0.04	18.70	0.06	0.003	0.14	0.29
CD(P=0.05)	3.34	0.08	38.16	0.11	0.006	0.30	0.59

**Table 2:** Effect of different planting geometry and sulphur fertilization on yield attributes and yield of sunflower

Treatments	Head diameter (cm)	Number of seeds head <sup>-1</sup>	Number of filled seeds head <sup>-1</sup>	Seed filling percent	100 seed weight (g)	Seed yield (kg ha <sup>-1</sup> )	Stalk yield (kg ha <sup>-1</sup> )
Plant Geometry							
M <sub>1</sub>	17.73	860	711	82.67	5.68	2018	4038
M <sub>2</sub>	16.81	814	659	80.95	5.61	1912	3945
M <sub>3</sub>	15.74	775	611	78.83	5.54	1785	3834
M <sub>4</sub>	14.42	726	557	76.72	5.47	1646	3696

S.Ed	0.11	8.23	6.56	0.14	0.03	26.62	16.51
CD(P=0.05)	0.24	16.56	13.19	0.30	NS	53.52	33.20
Sulphur							
S <sub>0</sub>	14.26	694	522	75.21	5.37	1648	3642
S <sub>1</sub>	15.65	762	600	78.74	5.54	1789	3838
S <sub>2</sub>	17.90	876	729	83.21	5.75	2016	4055
S <sub>3</sub>	16.88	843	687	81.49	5.64	1908	3978
S.Ed	0.12	8.09	6.57	0.15	0.04	26.94	16.54
CD(P=0.05)	0.26	16.27	13.21	0.32	0.08	54.16	33.25

**Table 3:** Effect of different planting geometry and sulphur fertilization on quality characters, nutrient uptake and post harvest soil nutrient status of sunflower

Treatments	Oil content (%)	Protein content (%)	Nutrient Uptake (kg ha <sup>-1</sup> )				Post harvest soil nutrient status (kg ha <sup>-1</sup> )			
			N	P	K	S	N	P	K	S
Plant Geometry										
M <sub>1</sub>	38.30	17.74	78.70	21.24	71.68	13.54	207.6	16.13	313.3	15.88
M <sub>2</sub>	37.75	17.67	77.10	20.23	70.34	12.81	211.3	17.23	316.0	17.16
M <sub>3</sub>	37.11	17.52	75.46	19.03	68.76	11.95	214.9	18.33	318.7	18.68
M <sub>4</sub>	36.41	17.36	73.58	18.08	67.43	10.73	218.5	19.42	321.7	19.77
S.Ed	0.14	0.14	0.32	0.16	0.27	0.11	0.70	0.23	0.43	0.20
CD(P=0.05)	NS	NS	0.65	0.34	0.55	0.24	1.41	0.48	0.87	0.42
Sulphur										
S <sub>0</sub>	36.24	16.71	73.43	17.31	66.66	10.52	196.6	14.45	301.1	16.80
S <sub>1</sub>	37.03	17.41	75.45	19.28	69.15	11.81	218.7	18.61	323.0	17.65
S <sub>2</sub>	38.51	18.15	78.82	21.41	71.89	13.76	210.6	16.50	310.6	17.10
S <sub>3</sub>	37.79	17.96	77.14	20.37	70.51	12.94	226.5	21.55	334.9	19.95
S.Ed	0.14	0.13	0.33	0.15	0.29	0.13	0.73	0.21	0.44	0.21
CD(P=0.05)	0.34	0.28	0.67	0.31	0.60	0.28	1.47	0.44	0.90	0.44

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