Plant Archives
Journal home page: www.plantarchives.org
DOI Url: https://doi.org/10.51470/PLANTARCHIVES.2021.v21.no1.132

EFFECT OF DIFFERENT PLANTING GEOMETRY AND SULPHUR FERTILIZATION ON YIELD, QUALITY, NUTRIENT UPTAKE AND POST HARVEST SOIL NUTRIENT STATUS OF SUNFLOWER IN SUNFLOWER + GREENGRAM INTERCROPPING SYSTEM

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(Date of Receiving-17-12-2020; Date of Acceptance30-03-2021)

ABSTRACT

The field experiment was carried out during Mar-May 2019 at the Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai nagar-608002, to study the effect of different planting geometry and sulphur levels in sunflower + greengram intercropping system on the yield, quality, nutrient uptake and post harvest nutrient statusof 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_1 - sole sunflower (60 x 30 cm), M_2 -sunflower (60 x 30 cm) + 1 row of greengram, M_3 -sunflower (90 x 30 cm) + 2 rows of greengram, M_4- sunflower (120 x 30 cm) + 3 rows of greengram, M_5 - sole greengram and Factor B (sulphur levels): S_0- 0 kg S ha^{-1}, S_1 - 20kg S ha^{-1}, S_2- 40kg S ha^{-1} and S_3- 60kg S ha^{-1}.The results revealedthat yield, quality, nutrient uptake and post harvest nutrient status 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_1) significantly recorded maximum yield, quality, and nutrient uptake of sunflower. With regard to various sulphur levels tried, application of sulphur at 40 kg ha^{-1}(S_2) significantly recorded maximum 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^{-1} (M_1S_2)had a spectacular effect on yield, qualityand nutrient uptake of sunflower.The minimum yield, quality and nutrient uptake of sunflower were recorded in sunflower (120 x 30 cm) intercropped with three rows of greengram along with application of S at 0 kg ha^{-1} (M_4S_0). 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^{-1}(M_4S_3) significantly recorded higher post harvest soil nutrient status.

Keywords: nutrient uptake, planting geometry, post-harvest, quality, sunflower, sulphur, yield.

INTRODUCTION

Oilseed plays a vital role in Indian agriculture as food for human and concentrates 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).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). 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). 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) documentedthatintercropping of pulsesis 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, vitaminsand flavoured compounds in plants. Sulphur is also involved in the formation of chlorophyll, glucosides and glucosinolates (mustard oils), activation of enzymes and sulphydryl linkages that are the source of pungency in onion, oils, etc. (Jamal *et al*., 2010). 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

Table 1: Effect of different planting geometry and sulphur fertilization on yield and quality characters of sunflower

Treatments	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Oil content (%)	Protein content (%)
Plant Geometry				
M_1	2018	4038	38.30	17.74
M_2	1912	3945	37.75	17.67
M_3	1785	3834	37.11	17.52
M_4	1646	3696	36.41	17.36
S.Ed	26.62	16.51	0.14	0.14
CD(P=0.05)	53.52	33.20	NS	NS
Sulphur				
S_0	1648	3642	36.24	16.71
S_1	1789	3838	37.03	17.41
S_2	2016	4055	38.51	18.15
S_3	1908	3978	37.79	17.96
S.Ed	26.94	16.54	0.14	0.13
CD(P=0.05)	54.16	33.25	0.34	0.28

yield (Kumar *et al*., 2011).

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 inavailable 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_1 - sole sunflower (60 x 30 cm),M_2 -sunflower (60 x 30 cm) + 1 row of greengram, M_3 - sunflower (90 x 30 cm) + 2 rows of greengram, M_4 -sunflower (120 x 30 cm) + 3 rows of greengram, M_5 -sole greengram and Factor B (sulphur levels): S_0 - 0 kg S ha^{-1}, S_1- 20kg S ha^{-1}, S_2 - 40kg S ha^{-1} and S_3- 60kg S ha^{-1}through gypsum. Recommended dose of 60:90:60 kg of N,P and K ha^{-1} was applied in the form of urea, DAPand MOP respectively. Half the dose of N and entiredose of P and K were applied basally. The remainingquantity 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). The critical difference was worked at five per cent probability level for significant result.

RESULTS AND DISCUSSION

Yield (Table 1)

Among different planting geometry tried, the sole sunflower grown with a spacing of 60 x 30 cm (M_1) significantly registered maximum values forseed yield and stalk yield.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. The results were in agreement with the findings of Sarma *et al*., (2016).

Sulphur levels significantly influenced the seed yield and stalk yield of sunflower. Application of sulphur at 40 kg ha^{-1}(S_2) significantly increased higher seed yield and stalk yield over other levels of sulphur. This due to improved growth through increased nutrient assimilation which in turn accelerated the crop to put forth larger heads and filled seedand 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. 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).

The interaction effects between plant geometry and sulphur levels was found to be significant on yield of sunflower. The higher seed yield and stalk yieldwere observed under the treatment combination of sole sunflower (60 x 30 cm) with application of 40 kg S ha^{-1} (M_1S_2) due to higher yield characteristics and non-competition effects in using the available resource and optimum supply of sulphur. The increase in seed and stalk yield might be due to stimulatory effect of applied sulphur on the synthesis of protein, which in turn might have accelerated photosynthesis and improved most of the yield contributing characters which resulted in significantly higher seed and stalk yield.

Table 2: Effect of different planting geometry and sulphur fertilization on nutrient uptake and post harvest soil nutrient status of sunflower

Treatments	Nutrient Uptake (kg ha^{-1})				Post harvest soil nutrient status (kg ha^{-1})			
	N	P	K	S	N	P	K	S
Plant Geometry								
M_1	78.70	21.24	71.68	13.54	207.6	16.13	313.3	15.88
M_2	77.10	20.23	70.34	12.81	211.3	17.23	316.0	17.16
M_3	75.46	19.03	68.76	11.95	214.9	18.33	318.7	18.68
M_4	73.58	18.08	67.43	10.73	218.5	19.42	321.7	19.77
S.Ed	0.32	0.16	0.27	0.11	0.70	0.23	0.43	0.20
CD(P=0.05)	0.65	0.34	0.55	0.24	1.41	0.48	0.87	0.42
Sulphur								
S_0	73.43	17.31	66.66	10.52	196.6	14.45	301.1	16.80
S_1	75.45	19.28	69.15	11.81	218.7	18.61	323.0	17.65
S_2	78.82	21.41	71.89	13.76	210.6	16.50	310.6	17.10
S_3	77.14	20.37	70.51	12.94	226.5	21.55	334.9	19.95
S.Ed	0.33	0.15	0.29	0.13	0.73	0.21	0.44	0.21
CD(P=0.05)	0.67	0.31	0.60	0.28	1.47	0.44	0.90	0.44

The minimum values forseed yield and stalk yield were recorded under the treatment combination of sunflower (120 x 30cm) intercropped with three rows of greengram along with application of S at 0 kg ha^{-1} (M_4S_0)which could be due to inadequate availabilityof nutrients.The similar trend of result was noticed bySingh *et al*., (2013).

Quality characters (Table 1)

The different planting geometry levels did not influence the quality characters significantly *viz.,* oil content and protein contentof 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).

The quality determining attributes such as oil contentand protein content were significantly influenced by levels of sulphur. Higher oil and protein contentwere recorded under application of sulphur at 40 kg ha^{-1}(S_2). 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 sulphydril-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 kgS ha^{-1} (M_1S_2) 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 inincreasing seed yield result in higher quality characteristics. These results were in agreement with the findings of Ali *et al.,* (2007).

Nutrient uptake (Table 2)

Among the different planting geometry levels tried, the sole sunflower grown with a spacing of60 x 30 cm (M_1) significantly recorded the highernutrient 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).

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^{-1}(S_2) 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).

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^{-1}(M_1S_2) 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).

Post harvest soil nutrient status (Table 2)

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_4) 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^{-1} (S_3) 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 ofSahoo *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^{-1}(M_4S_3). 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).

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