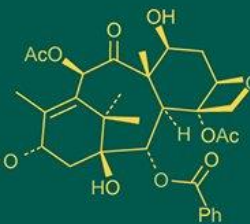
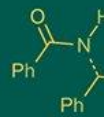


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Effect of nitrogen and sulphur levels on yield and quality parameters of safflower in a *Vertisol* of Chhattisgarh

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Abstract

The present research investigation entitled “Effect of nitrogen and sulphur levels on yield and Quality Parameters of safflower in a *Vertisol* of Chhattisgarh” was carried out during *rabi* season years 2022-23 and 2023-24 at the instructional Farm of Krishi vigyan Kendra, Balod Chhattisgarh. The experiment was laid out in split plot design with four nitrogen levels (N_0 , N_{30} , N_{60} and N_{90} kg N ha⁻¹) and three sulphur levels (S_0 , S_{20} and S_{40} kg S ha⁻¹) comprising twelve treatment combinations with three replications. The maximum seed and stover yield (17.91 & 40.46 q ha⁻¹, respectively) were recorded under N_{90} followed by N_{60} and N_{30} on mean basis of both the years. In regards to sulphur levels, treatment S_{40} observed the maximum seed and stover yield (15.33 & 39.93 q ha⁻¹, respectively). However, the minimum seed and stover yield were observed under control plot on mean basis of both the years. The number of capitula plant⁻¹, number of seed capitula⁻¹, seed yield and stover yield was at par with applied 20 kg S ha⁻¹ and the lowest was found under control. Quality parameter such as oil yield were recorded highest with applied N @ 90 kg ha⁻¹ over application of 30 kg N ha⁻¹. However, it was at par to 60 kg N ha⁻¹. The minimum oil yield was observed under control while in applied sulphur levels 40 kgs were recorded highest oil yield was at par with applied 20 kg S ha⁻¹ and the lowest was found under control.

Keywords: Capitula plant⁻¹, number of seed capitula⁻¹, seed, stover and oil yield

Introduction

Safflower (*Carthamus tinctorius* L.) is an important annual oilseed crop from the Asteraceae family, cultivated primarily for its oil and flower-based dye. Nearly all parts of the plant-stems, leaves, seeds, and flowers-have various uses. It serves as a source of vegetable and industrial oil, bird feed, forage, and traditional medicine. Its brightly colored petals are used as natural food coloring, flavoring agents, and for dyeing textiles. Safflower seeds content 32-36% oil and 22-24% protein. The oil is flavorless and colorless and is particularly rich in polyunsaturated fatty acids such as linoleic acid (73-79%), oleic acid (13-21%), palmitic acid (3-6%), and stearic acid (1-4%). These compounds are known to help reduce blood cholesterol levels, making safflower oil beneficial for heart health. The production of safflower during the cropping year 2021-22 was 45.00 (000 MT) in area of 64.00 (000ha), with a productivity of 694 kg per hectare in India (Directorate report 2021-22, IOR, Hyderabad) where as the area of safflower in the Chhattisgarh state was recorded 6.20 (000 ha), production 1.81 (000 MT) and productivity 293 kg per ha in the year 2021-22 (Director, Agriculture Raipur C.G) and in Balod district safflower area 2.5 ha and production is 1.125 MT. with a productivity 462 kg per ha in the year 2021-22 (DDA, Balod). There are ample scope to increase safflower yields and quality by adopting suitable water and fertilizers management. Major nutrients like N, P and K should be supplied in sufficient quantity and in a balanced way to enhance productivity of the crop. Since Nutrient management is major and critical input for increasing productivity of crop.

Materials and Methods

The present research investigation entitled “Effect of nitrogen and sulphur levels on yield and quality parameters of safflower in a *Vertisol* of Chhattisgarh” was carried out during *Rabi* season in the year 2022-23 and 2023-24 at the instructional farm of the krishi vigyan

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Kendra Balod (CG). The experimental site was situated in agro climatic zone of Chhattisgarh plains in village Aroud (Balod) and between 20°80' North latitude and 81°24' East longitudes with an altitude of 324 m above mean sea level. The general climate of this region is dry moist and sub humid and receives rainfall annually ranged from 1200 to 1400 mm, out of which about 88 percent is received during rainy season (June to September) and 8 percent during winter season (October to February). The rainfall pattern has great variations during rainy season from year to year. May is the hottest and December is the coolest month of the year. The temperature during the summer months reaches as high as 48 °C and drop to 10 °C during December to January. Surface soil samples (0-15 cm) were collected with the help of auger and representative samples after air dried, grounded and passed through 2 mm sieve. The experiment was laid out in split plot design with four nitrogen levels (N_0 , N_{30} , N_{60} and N_{90} kg N ha⁻¹) and three sulphur levels (S_0 , S_{20} and S_{40} kg S ha⁻¹) comprising twelve treatment combinations with three replications. The soil of the experimental site found neutral to slightly alkaline in reaction (pH 7.13), non-saline (0.22 dS m⁻¹) in nature, medium in organic carbon (5.13 g kg⁻¹), low in available nitrogen (217.12 kg N ha⁻¹), medium in phosphorus (15.30 kg P₂O₅ ha⁻¹), high in available potassium (409.12 kg K₂O ha⁻¹), medium in available sulphur (15.26 kg S ha⁻¹) and clayey in texture. The Safflower (IGKV KUSUM) was sown in distance of row to plant spacing of 45 cm X 15 cm having 5 m x 5 m (25 m²) gross plot size. The number of capitula plant⁻¹, number of seed capitula⁻¹, seed yield, Stover yield and Quality parameter were recorded. The seed and stover yield from each net plot was measured and it was later on computed as seed and Stover yield in kg ha⁻¹. Essential (volatile) oil content in safflower seed was determined by using Essential Oil Distillation Assembly (AOCS method Ba3-38 (AOCS1993). The oil yield (kg ha⁻¹) was estimated by multiplying oil content with the seed yield.

Result and discussions

Number of capitula plant⁻¹ and number of seeds capitula⁻¹

Experimental data on number of capitula plant⁻¹ and number of seeds capitula⁻¹ were analyzed statistically and found to be significantly influenced by nitrogen and sulphur levels as presented in Table 1. The number of capitula plant⁻¹ and number of seeds capitula⁻¹ of safflower differed significantly due to different levels of nitrogen over control. The higher number of capitula plant⁻¹ and number of seeds capitula⁻¹ were noted under N_{90} followed by N_{60} and N_{30} during both the years and on mean basis. The lowest capitula plant⁻¹ and number of seeds capitula⁻¹ were observed under control during both the years and on mean basis. Application of adequate nitrogen produced more capitula plant⁻¹ and number of seeds capitula⁻¹ which might be due to better availability of N containing compounds (protein, nucleic acid, chlorophyll, and functional enzymes) and sulphur compounds to the growth and yield attributes of crop. Similar observations are also collaborated with the finding of Nathan *et al.* (2017) [5] and Patel *et al.* (2022) [7]. The interaction effect of nitrogen and sulphur levels number of capitula plant⁻¹ and number of seeds capitula⁻¹ of safflower were found non-significant during both the years and on mean basis.

Seed and stover yield

The data on seed and stover yield of safflower as affected by application of different nitrogen and sulphur levels are presented in Table 2. The maximum seed and stover yield (17.91 & 40.46 q ha⁻¹, respectively) were recorded under N_{90} followed by N_{60} and N_{30} on mean basis of both the years. In regards to sulphur levels, treatment S_{40} observed the maximum seed and stover yield (15.33 & 39.93 q ha⁻¹, respectively). However, the minimum seed and stover yield were observed under control plot on mean basis of both the years. The increase in seed yield and stover yield with applied levels of nitrogen and sulphur to crop shown cumulative effect on increased yield attributing characters viz., no. of capitula plant⁻¹ and no. of seeds capitulum⁻¹ might have resulted in the production of higher seed yield. Similar findings are also confirmed by Singh and Singh (2013) [8], Nathan *et al.* (2017) [5], (Divya, 2019) [1], and Patel *et al.* (2022) [7]. The interaction between N_{90} x S_{40} was registered significantly higher seed and stover yield were as compared to others, but it was at par with interaction between N_{90} x S_{20} . The increase in yield might be due to more accumulation of amino acid and amide substances and their translocations to the reproductive organs which influenced growth and yield due to application on nitrogen and sulphur (Dongarkar, 2005) [2].

Oil content and yield

Data regarding oil content as influenced by different nitrogen and sulphur levels are presented in Table 3. Oil content significantly decreases with increase in the levels of nitrogen from 0 to 90 kg N ha⁻¹. Among different levels of nitrogen control recorded higher oil content over N_{30} and N_{60} . Lowest oil content was observed in N_{90} . Reduction in oil content in seed by higher N application, which resulted in grater accumulation of protein in plants and reduces availability of carbohydrates for polymerization in to fatty acids, which in turn lower content of oil in the seed. However, oil content of safflower influenced significantly with applied sulphur levels over control. The maximum oil content of safflower was found under S_{40} followed by S_{20} during both the years and on mean basis. The minimum oil content was recorded under control during both the years and on mean basis. The increase in oil content with increase in sulphur might be due to the involvement of sulphur in electron-transport chain. Highest oil content might be due to influence of sulphur in rapid conversion of nitrogen to crude protein and finally to oil and oil yield of safflower crop influenced significantly with applied nitrogen levels over control. Application of 90 kg N ha⁻¹ recorded significantly higher oil yield during both the years on mean basis, over application of 30 kg N ha⁻¹. However, it was at par to 60 kg N ha⁻¹. The minimum oil yield was observed under control during both the years on mean basis. Higher oil yield with increasing nitrogen levels was probably due to favorable effect of nitrogen on seed yield. Thus crop receiving adequate nitrogen recorded higher oil yield despite of lower seed oil content. However, oil yield of safflower increased steeply with increasing application rates of sulphur and attained maximum oil yield at higher doses of sulphur. The significantly maximum oil yield was recorded under S_{40} but it was at par with S_{20} during both the years and on mean basis. The minimum oil yield was noted under control during both the years on mean basis. Oil yield is a function of oil content and seed yield, both the attributes increased

with increasing levels of sulphur resulting in a significant increase in oil yield. Higher oil yield with higher dose of sulphur fertilization was due to higher seed yield. Further, application of sulphur to plant enhanced the formation of acetyl coenzyme A, a precursor compound for the synthesis of long chain fatty acid resulting in increase in oil content

which ultimately led to greater oil yield. The results are in conformity with Patel *et al.* (2002)^[7]; Rasool *et al.* (2013)^[4]. Nathan *et al.* (2017)^[5] and Legha and Giri (1999)^[3]. The interaction effect of nitrogen and sulphur levels oil content and oil yield of safflower was found non-significant during both the years and on mean basis.

Table 1: Effect of nitrogen and sulphur levels on no of capitula plant⁻¹ & no of seed capitula⁻¹ of safflower

Treatments	No of capitula plant ⁻¹				No of seed capitula ⁻¹		
	2022-23	2023-24	Mean	Capitula increase (%) over control	2022-23	2023-24	Mean
Nitrogen levels (kg ha⁻¹)							
N ₀	14.18	15.23	14.70	-	12.50	12.72	12.61
N ₃₀	16.53	17.38	16.95	15.30	17.11	17.48	17.28
N ₆₀	17.36	18.27	17.81	21.15	18.39	18.55	18.46 b
N ₉₀	18.81	19.43	19.12	30.06	20.72	21.44	21.08
SEm±	0.33	0.31	0.26		0.44	0.36	0.36
CD (P = 0.05)	1.15	1.06	0.90		1.52	1.26	1.24
Sulphur levels (kg ha⁻¹)							
S ₀	16.13	16.94	16.53	-	16.74	16.90	16.77
S ₂₀	16.71	17.59	17.15	3.75	17.25	17.60	17.48
S ₄₀	17.32	18.21	17.76	7.44	17.55	18.14	17.82
SEm±	0.22	0.22	0.22		0.19	0.21	0.28
CD (P = 0.05)	0.66	0.65	0.67		0.57	0.63	0.83

Combined effect of nitrogen and sulphur levels (Interaction N x S)						
Treatments	No of capitula plant ⁻¹			No of seed capitula ⁻¹		
	2022-23	2023-24	Mean	2022-23	2023-24	Mean
N ₀ S ₀	13.60	14.65	14.13	11.74	12.58	12.16
N ₀ S ₂₀	14.41	15.46	14.94	12.85	12.29	12.57
N ₀ S ₄₀	14.52	15.57	15.05	12.92	13.29	13.10
N ₃₀ S ₀	16.27	17.12	16.70	16.73	16.79	16.70
N ₃₀ S ₂₀	16.62	17.47	17.04	17.15	17.78	17.46
N ₃₀ S ₄₀	16.70	17.55	17.13	17.45	17.88	17.67
N ₆₀ S ₀	17.04	17.89	17.47	17.96	17.72	17.71
N ₆₀ S ₂₀	17.44	18.35	17.90	18.27	18.74	18.70
N ₆₀ S ₄₀	17.59	18.57	18.08	18.94	19.19	18.97
N ₉₀ S ₀	17.60	18.08	17.84	20.51	20.52	20.52
N ₉₀ S ₂₀	18.37	19.07	18.72	20.74	21.59	21.17
N ₉₀ S ₄₀	20.45	21.15	20.80	20.91	22.21	21.56
SEm±	0.55	0.53	0.51	0.58	0.55	0.66
CD(P = 0.05)	NS	NS	NS	NS	NS	NS

Table 2: Effect of nitrogen and sulphur levels on seed & stover Yield (q ha⁻¹) of safflower

Treatments	Seed Yield (q ha ⁻¹)				Stover Yield (q ha ⁻¹)		
	2022-23	2023-24	Mean	Yield increase (%) over control	2022-23	2023-24	Mean
Nitrogen levels (kg ha⁻¹)							
N ₀	10.89	11.26	11.07	-	29.73	31.83	30.78
N ₃₀	13.67	14.70	14.19	25.16	35.27	37.37	36.32
N ₆₀	15.47	16.14	15.80	37.47	37.25	39.34	38.05
N ₉₀	17.40	18.41	17.91	53.68	39.59	41.33	40.46
SEm±	0.54	0.65	0.50		0.56	0.57	0.55
CD (P = 0.05)	1.88	2.25	1.73		1.95	1.98	1.91
Sulphur levels (kg ha⁻¹)							
S ₀	13.56	14.31	13.94	-	34.77	36.81	35.73
S ₂₀	14.62	15.29	14.96	9.90	35.64	37.56	36.54
S ₄₀	14.89	15.78	15.33	15.45	35.97	38.02	36.93
SEm±	0.16	0.16	0.13		0.30	0.19	0.24
CD (P = 0.05)	0.47	0.47	0.38		0.89	0.57	0.71

Combined effect of nitrogen and sulphur levels (Interaction N x S)						
Treatments	Seed Yield (q ha ⁻¹)			Stover Yield (q ha ⁻¹)		
	2022-23	2023-24	Mean	2022-23	2023-24	Mean
N ₀ S ₀	10.70	10.72	10.71	20.29	31.40	30.35
N ₀ S ₂₀	10.90	11.05	10.97	29.82	31.92	30.87
N ₀ S ₄₀	11.06	12.02	11.54	30.05	32.15	37.10
N ₃₀ S ₀	12.77	14.14	13.46	34.25	36.35	35.30
N ₃₀ S ₂₀	14.01	14.97	14.49	35.60	37.70	36.65
N ₃₀ S ₄₀	14.25	14.99	14.61	35.97	38.07	37.02
N ₆₀ S ₀	14.93	15.68	15.31	36.77	38.86	37.57
N ₆₀ S ₂₀	15.71	16.18	15.95	37.16	39.25	37.95
N ₆₀ S ₄₀	15.75	16.56	16.16	37.83	39.92	38.62
N ₉₀ S ₀	15.83	16.72	16.28	38.75	40.65	39.70
N ₉₀ S ₂₀	17.87	18.97	18.42	39.99	41.39	40.69
N ₉₀ S ₄₀	18.50	19.55	19.03	40.05	41.95	40.99
SEm±	0.63	0.72	0.56	0.82	0.69	0.73
CD(P = 0.05)	2.10	2.44	1.89	NS	NS	NS

Table 3: Effect of nitrogen and sulphur levels on Oil content (%) & Oil Yield (kg ha⁻¹) of safflower

Treatments	Oil content (%) of safflower			Oil Yield (kg ha ⁻¹) of safflower			
	2022-23	2023-24	Mean	2022-23	2023-24	Mean	Oil Yield increase (%) over control
Nitrogen levels (kg ha ⁻¹)							
N ₀	28.53	29.36	28.94	315.28	331.25	323.26	-
N ₃₀	28.12	28.65	28.38	388.02	421.19	404.61	25.16
N ₆₀	27.92	28.18	28.05	433.93	454.89	444.41	37.47
N ₉₀	27.85	27.72	27.79	483.09	510.73	496.81	53.68
SEm±	0.16	0.34	0.23	17.07	13.40	11.29	
CD (P = 0.05)	0.56	1.16	0.80	59.06	46.37	39.07	
Sulphur levels (kg ha ⁻¹)							
S ₀	27.48	27.71	27.60	373.58	395.91	384.75	-
S ₂₀	28.15	28.48	28.31	412.57	433.16	422.86	9.90
S ₄₀	28.69	29.24	28.96	429.08	459.48	444.21	15.45
SEm±	0.11	0.21	0.10	4.51	5.65	4.78	
CD (P = 0.05)	0.32	0.62	0.31	13.51	16.95	14.34	

Combined effect of nitrogen and sulphur levels (Interaction N x S)						
Treatments	Oil content (%) of safflower			Oil Yield (kg ha ⁻¹) of safflower		
	2022-23	2023-24	Mean	2022-23	2023-24	Mean
N ₀ S ₀	27.61	28.07	27.84	298.00	301.32	299.66
N ₀ S ₂₀	28.84	29.69	29.27	319.24	328.24	323.74
N ₀ S ₄₀	29.14	30.30	29.72	328.59	364.18	346.39
N ₃₀ S ₀	27.52	28.20	27.86	354.89	398.57	376.73
N ₃₀ S ₂₀	28.17	28.52	28.35	397.19	426.84	412.02
N ₃₀ S ₄₀	28.67	29.22	28.95	411.99	438.17	425.08
N ₆₀ S ₀	27.43	27.58	27.51	410.70	432.39	421.55
N ₆₀ S ₂₀	28.05	28.26	28.16	442.37	457.22	449.80
N ₆₀ S ₄₀	28.27	28.69	28.48	448.71	475.05	461.88
N ₉₀ S ₀	27.37	27.00	27.18	430.75	451.35	441.05
N ₉₀ S ₂₀	27.51	27.43	27.47	491.48	520.33	505.90
N ₉₀ S ₄₀	28.67	28.74	28.71	527.04	560.52	543.49
SEm±	0.27	0.53	0.31	19.30	17.53	14.80
CD(P = 0.05)	NS	NS	NS	NS	NS	NS

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