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EFFECT OF ROW RATIO AND LEVELS OF SULPHUR ON QUALITY PARAMETERS OF GROUNDNUT AND SESAME IN GROUNDNUT (*Arachis hypogaea* L.) + SESAME (*Sesamum indicum* L.) INTERCROPPING SYSTEM

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ABSTRACT

An experiment was carried out to evaluate the “effect of row ratio and levels of sulphur on quality parameters of groundnut and sesame in groundnut (*Arachis hypogaea* L.) + sesame (*Sesamum indicum* L.) intercropping system during kharif seasons of 2022 and 2023 in loamy soil. The experiment was laid out with three replications in Split plot design in which six cropping system practices allotted in the main plot viz, sole groundnut, sole sesame, and row ratio of groundnut + sesame (1:1), groundnut + sesame (2:1), groundnut + sesame (2:2) and groundnut + sesame (3:1) intercropping system assigned to main plots and four treatments of sulphur levels viz., 0, 20, 40 and 60 kg S/ha were allotted in sub plots. Among different cropping systems, groundnut + sesame (2:2) intercropping system was found superior over other intercropping treatment with respect to nitrogen, phosphorus and sulphur content in groundnut kernel and sesame seeds. Sulphur application at 40 kg/ha significantly increased protein and oil content and nitrogen, phosphorus and sulphur content in groundnut kernel and sesame seeds. Further, increase in sulphur level to 60 kg/ha remained at par with 40 kg S/ha.

Key words: Nitrogen, phosphorus and sulphur content, Protein content, Oil content

Introduction

In Indian agricultural sector, oilseeds are the second most important crops after food grains in terms of acreage and production. India stands second in world's human population after china and it is continually rising which further leads to increase in pressure on agriculture production system. Right now India imported a total of 16.5 million tonnes of edible oil which is approximately 60% of total domestic demand (Anonymous, 2025). It maximizes negative trade balance in the country and more extremely negative impact on country's economy. Further, rapid increase in urbanization and industrialization accelerate demands of edible oils. At the same time, land becoming limiting factor due to rapid reduction of arable land which leads to increasing pressure on production under per unit land. However, this shortage of production

can be achieved through increasing the productivity by acquisition modern, sustainable and environment friendly agronomic practices. Intercropping system can be a foremost way to enhanced productivity of the system within same area (Chaudhari *et al.*, 2017). Legume - oilseed based intercropping system may provide an alternative to the more traditional cereal - legume system and contribute to sustainable food and edible oil supply. Moreover, it is well known fact that fertilizers contribute nearly 35-45% per cent in crop production and for oilseeds sulphur is an essential element for increase in oil and protein content. Therefore, considering the importance of groundnut and sesame intercropping in the system productivity, nutritional security, soil health, need for self-dependence in edible oil present field investigation is need of the hour.

Table 1: Effect of row ratio and levels of sulphur on nutrient content in groundnut kernel in groundnut + sesame intercropping system.

Treatments	Nitrogen content (%)			Phosphorus content (%)			Sulphur content (%)		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
Intercropping system									
I ₁ - Sole Groundnut	3.25	3.34	3.30	0.792	0.799	0.796	0.165	0.185	0.175
I ₂ - Sole Sesame	-	-	-	-	-	-	-	-	-
I ₃ - Groundnut+Sesame (1:1)	3.50	3.57	3.57	0.836	0.845	0.841	0.173	0.192	0.182
I ₄ - Groundnut + Sesame (2:1)	3.43	3.48	3.48	0.809	0.820	0.815	0.170	0.189	0.179
I ₅ - Groundnut+Sesame (2:2)	3.55	3.60	3.60	0.847	0.853	0.850	0.176	0.195	0.185
I ₆ - Groundnut+Sesame (3:1)	3.31	3.42	3.42	0.801	0.807	0.804	0.167	0.187	0.177
SE_{em}±	0.09	0.08	0.06	0.018	0.022	0.014	0.005	0.004	0.003
CD (P = 0.05)	NS	NS	0.18	NS	NS	NS	NS	NS	NS
CV (%)	9.62	7.70	-	7.50	9.36	-	9.27	7.50	-
Levels of Sulphur									
S ₀ - Control	3.01	3.06	3.03	0.782	0.788	0.785	0.162	0.180	0.171
S ₁ - 20 kg/ha	3.44	3.52	3.48	0.813	0.821	0.817	0.168	0.188	0.178
S ₂ - 40 kg/ha	3.56	3.64	3.60	0.833	0.841	0.837	0.172	0.194	0.183
S ₃ - 60 kg/ha	3.65	3.72	3.68	0.842	0.850	0.846	0.179	0.196	0.187
SE_{em}±	0.07	0.05	0.05	0.012	0.017	0.011	0.004	0.003	0.002
CD (P = 0.05)	0.21	0.15	0.13	0.035	NS	0.030	0.010	0.008	0.006
CV (%)	8.38	6.01	-	5.80	8.16	-	8.11	5.84	-

Materials and Methods

The field experiment was conducted in *Kharif* season 2022 and 2023 under at S.K.N. Agriculture University, Jobner, Jaipur, Rajasthan, India. The experimental site is located in Jaipur district of Rajasthan, 45 km from Jaipur on the western side at 26° 05' North latitude, 75° 28' East longitude and at an altitude of 427 meters above mean sea level. The region falls under Agro-climatic zone III–A (Semi-Arid Eastern Plain Zone) of Rajasthan. Soil samples were analyzed in the laboratory for their chemical properties as per their standard protocol and the soil was loamy sand in texture, slightly alkaline in reaction, poor in organic carbon, low in available N, and available S while medium in available P and high in available K. The experiment was laid out with three replication in Split plot design in which six cropping system practices allotted in the main plot viz, sole groundnut, sole sesame, and row ratio of groundnut + sesame (1:1), groundnut + sesame (2:1), groundnut + sesame (2:2) and groundnut + sesame (3:1) intercropping system assigned to main plots and four treatments of sulphur levels viz., 0, 20, 40 and 60 kg S/ha were allotted in sub plots. Source of sulphur was gypsum (agriculture grade 12% sulphur) applied as basal dose before sowing. The experimental crop varieties for groundnut and sesame was RG-510 and RT-351 respectively. The crop received 546.0 mm and 521.4 mm rainfall during the *kharif*, 2022 and 2023, respectively. For N content representative samples of both groundnut and sesame crops were oven dried, ground in Willey mill and analyzed for their nitrogen content. Nitrogen was estimated by digesting plant samples with 2 ml concentrated sulphuric acid using hydrogen peroxide for

removing black colour in kjeldhal flask. Completely digested samples were cooled and diluted in 100 ml volumetric flasks. The distilled ammonia was quantitatively absorbed in 4% boric acid solution containing bromocresol green and methyl red indicator in a conical flask and titrated against standard acid. Estimation of nitrogen was done by colorimetric method using Nessler's reagent to develop colour (Snell and Snell, 1949). Nitrogen content was calculated and expressed in percentage. Phosphorus content in both the crops was determined by "Vanado molybdo phosphate" Yellow colour method. Digestion of samples was done by triacid mixture. Ammonium molybdate-ammonium vandate solution was used to develop colour and resultant intensity of colour was measured by spectrophotometer at 420 nm wavelength and expressed as per cent phosphorus content on dry weight basis (Jackson, 1973). Sulphur was estimate by turbi-dimetric method (Tabatabai and Bremmer, 1970). The plant samples (groundnut kernel and sesame seeds) were digested in diacid mixture and barium chloride solution was used for development of turbidity. The resultant was measured on UV spectrophotometer (LABINDIA UV 3200) at 420 nm wavelength. All the chemicals used for determining S content were of AR grade. The sulphur content was calculated and represented in percentage. Crude protein content was calculated from the per cent nitrogen in kernel multiplied by the factor 5.76 (Jones 1941) in groundnut while for sesame seeds, it multiplied by the factor 6.25 (A.O.A.C., 1960) and expressed as per cent protein content. Oil content in groundnut kernels and sesame seeds was determined by Soxhlet apparatus using

Table 2: Effect of row ratio and levels of sulphur on nutrient content in sesame seed in groundnut + sesame intercropping system.

Treatments	Nitrogen content (%)			Phosphorus content (%)			Sulphur content (%)		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
Intercropping system									
I ₁ - Sole Groundnut	-	-	-	-	-	-	-	-	-
I ₂ - Sole Sesame	2.98	3.07	3.03	0.657	0.697	0.677	0.183	0.201	0.192
I ₃ - Groundnut+Sesame (1:1)	3.16	3.26	3.21	0.686	0.732	0.709	0.189	0.207	0.198
I ₄ - Groundnut + Sesame (2:1)	3.11	3.19	3.15	0.674	0.711	0.693	0.187	0.204	0.196
I ₅ - Groundnut+Sesame (2:2)	3.20	3.29	3.25	0.696	0.744	0.720	0.192	0.210	0.201
I ₆ - Groundnut+Sesame (3:1)	3.08	3.13	3.05	0.667	0.706	0.687	0.186	0.203	0.195
SEm±	0.08	0.07	0.05	0.018	0.016	0.012	0.005	0.004	0.003
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	9.42	7.58	-	9.34	7.52	-	9.32	7.49	-
Levels of Sulphur									
S ₀ - Control	2.85	2.92	2.88	0.644	0.680	0.662	0.179	0.195	0.187
S ₁ - 20 kg/ha	3.10	3.18	3.14	0.670	0.711	0.690	0.186	0.204	0.195
S ₂ - 40 kg/ha	3.20	3.29	3.25	0.691	0.736	0.713	0.192	0.211	0.201
S ₃ - 60 kg/ha	3.28	3.36	3.32	0.701	0.746	0.724	0.193	0.212	0.203
SEm±	0.07	0.05	0.04	0.014	0.011	0.009	0.004	0.003	0.003
CD (P = 0.05)	0.19	0.14	0.12	0.041	0.031	0.025	NS	0.009	0.007
CV (%)	8.27	5.86	-	8.19	5.86	-	8.11	5.84	-

petroleum ether (60-80°C) Extraction Method (A.O.A.C., 1960). The solvent is heated in a boiler; the pure vapor rises up through a by-pass and into the top part of the Soxhlet container where the sample to extract is contained. In the condenser, the vapors are condensed and drip into the sample-containing thimble. When the level of liquid reaches the same level as the top of the siphon, the liquid containing the extracted material is siphoned back into the boiler. Soxhlet extraction is not a continuous procedure, but a batch system with repeated extractions. Extraction was continued until the solvent in the siphon tube became colourless, indicating complete extraction of oil.

Results

Nutrient content in groundnut kernel and sesame seeds

Intercropping system: A critical examination of the data (Table 1 and Table 2) indicated that that different row ratios of intercropping system did bring any significant effect on nitrogen, phosphorus and sulphur content in groundnut kernel and sesame seed in both the years as well as in pooled analysis except pooled analysis of nitrogen content in groundnut kernel where data revealed that all the intercropping treatments except row ratio of 3:1 recorded significantly higher content of N in kernel over sole planting (3.30%). The maximum average N content was observed under groundnut + sesame intercropping system with 2:2 row ratio (3.60%) that was closely accompanied by groundnut + sesame intercropping system with 1:1 row ratio (3.57%) and 2:1 row ratio (3.48%). These four intercropping systems

enhanced the N content by 9.1, 8.2 and 5.5 percent in kernel over control, respectively.

Sulphur levels: Data pertaining to the effect of sulphur fertilization on nitrogen and sulphur content in groundnut kernel and sesame seeds presented in Table 1 and Table 2 showed that nitrogen and sulphur content was influenced significantly during both the years and in pooled data. Result revealed that sulphur application at 40 kg S/ha, being at par with 20 and 60 kg S/ha, recorded significantly higher content of nitrogen and sulphur in groundnut kernel and sesame seeds as compared to control. The nitrogen content in kernel was increased by 18.8 and 21.5 percent, respectively due to 40 and 60 kg S/ha over control while application of sulphur at 20, 40 and 60 kg/ha in groundnut increased the sulphur content in kernel by 4.1, 7.0 and 9.4 percent over control, respectively. In case of sesame seeds the content of N was increased by 12.8 percent due to 40 kg S/ha and 15.3 percent due to 60 kg S/ha over control. Sulphur application at 20, 40 and 60 kg/ha in sesame increased the sulphur content in sesame seed by 4.3, 7.4 and 8.5 percent over control, respectively. Results further revealed that P content in groundnut kernel was significantly improved due to sulphur fertilization during 2022 and in pooled data but remained unaffected during 2023 while in case of sesame pooled results showed that application of 40 and 60 kg S/ha enhanced the P content by 7.7 and 9.4 per cent in sesame seed.

Crude protein and oil content in groundnut kernel and sesame seeds

Intercropping system: Result showed that crude

Table 3: Effect of row ratio and levels of sulphur on Crude protein and oil content in groundnut kernel and sesame seeds in groundnut + sesame intercropping system.

Treatments	Groundnut						Sesame					
	Crude protein (%)			Oil content (%)			Crude protein (%)			Oil content (%)		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
Intercropping system												
I ₁ - Sole Groundnut	17.59	18.09	17.84	37.12	37.47	37.30	-	-	-	-	-	-
I ₂ - Sole Sesame	-	-	-	-	-	-	18.39	18.95	18.67	47.56	48.60	48.08
I ₃ - Groundnut+Sesame (1:1)	18.96	19.34	19.15	39.45	39.77	39.61	19.52	20.14	19.83	49.26	50.53	49.89
I ₄ - Groundnut + Sesame (2:1)	18.58	18.85	18.71	38.56	38.86	38.71	19.20	19.70	19.45	48.79	50.06	49.42
I ₅ - Groundnut+Sesame (2:2)	19.23	19.51	19.37	40.04	40.35	40.20	19.77	20.33	20.05	50.11	51.18	50.64
I ₆ - Groundnut+Sesame (3:1)	17.92	18.52	18.22	38.27	38.50	38.39	19.02	19.33	19.17	48.32	49.67	48.99
SEm±	0.52	0.42	0.35	1.13	0.92	0.73	0.53	0.44	0.34	1.34	1.09	0.86
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	9.70	7.77	-	10.14	8.18	-	9.53	7.67	-	9.53	7.54	-
Levels of Sulphur												
S ₀ - Control	15.70	16.05	15.87	35.83	36.09	35.96	16.87	17.32	17.09	45.62	46.78	46.20
S ₁ - 20 kg/ha	18.80	19.20	19.00	38.36	38.66	38.51	19.35	19.86	19.60	48.49	49.41	48.95
S ₂ - 40 kg/ha	19.43	19.86	19.64	39.89	40.22	40.05	20.01	20.56	20.29	50.05	51.53	50.79
S ₃ - 60 kg/ha	19.90	20.34	20.12	40.68	41.00	40.84	20.48	21.03	20.76	51.07	52.30	51.68
SEm±	0.40	0.29	0.25	0.89	0.64	0.55	0.41	0.30	0.26	1.06	0.76	0.65
CD (P = 0.05)	1.16	0.84	0.70	2.57	1.84	1.55	1.20	0.87	0.72	3.06	2.19	1.84
CV (%)	8.45	6.00	-	8.91	6.32	-	8.37	5.93	-	8.39	5.86	-

protein and oil content in groundnut kernel as well as in sesame seed remained uninfluenced due to different treatments of intercropping of groundnut + sesame including sole groundnut during both the years of investigation as well as in pooled analysis (Table 3).

Sulphur levels: Groundnut crop responded favorably to increasing levels of sulphur fertilization in terms of crude protein and oil content in groundnut kernel and sesame seed up to 40 kg/ha (Table 3). In groundnut this level of sulphur recorded the mean crude protein content of 19.64 per cent in pooled analysis thereby increasing it to the extent of 3.4 and 23.8 percent over 20 kg/ha and control, respectively. Likewise, application of 40 kg S/ha recorded the oil content of 40.05 percent which was 11.4 percent more than obtained under control. However, it showed statistical resemblance with 60 kg S/ha in mean crude protein content (20.12%) and oil content (40.05 %) that were 26.8 and 11.4 percent more than recorded under control, respectively. In sesame application of sulphur at 40 kg/ha improved the crude protein in seed by 3.5 and 18.7 percent as compared to 20 kg/ha and control, respectively whereas, the oil content increased by 3.7 and 9.9 percent than 20 kg/ha and control, respectively. Further increase in level of sulphur to 60 kg/ha was observed to exhibit the highest crude protein (20.41%) and oil content (51.68%) in sesame seed, but the difference between these two levels was not of statistical significance in both the years as well as pooled analysis.

Discussion

A critical examination of data indicated that different row ratios of intercropping system did not brought any significant difference on N, P and S content in groundnut kernel and sesame seeds in both the years as well as in pooled analysis except N where pooled results revealed that all the intercropping treatments recorded significantly higher content of N in kernel over sole groundnut (Table 1 and Table 2). This might be due to the extraction of soil moisture and nutrients from the same soil layers in sole groundnut so they compete for the same physical space where *Rhizobium* bacteria colonize while in intercrop sesame in between groundnut reduced the competition and enhanced the availability of nitrogen to plant. The findings of the present investigation are in close conformity with the results of Panda *et al.*, (2022) in groundnut + sesame intercropping system. Shivran and Yadav (2016) also reported that nitrogen content in seed increased in intercropping as compared to sole sesame. Sulphur application at 40 kg S/ha being at par with 60 kg S/ha, boosted N, P and S content in groundnut kernel and sesame seeds as compared to control (Table 1 and Table 2). This might be due to application of sulphur fertilizer increase nitrate reductase activity which is an important enzyme in plant to helps in conversion of nitrates into amino acids and subsequently in proteins this process helps in reduces risk of accumulation of unused soluble nitrogen to toxic levels and maintained metabolic balance in plant thus it increase in nitrogen content in groundnut and sesame. Sulphur application also stimulates root

growth and increase phosphorus absorption capacity of the plant which leads to higher phosphorus content in groundnut. The significant variation in sulphur content in plant can be also ascribed due to disulfide bond which maintained structural and functional integrity of roots for longer duration. Another reason for improvement might be due to the positive effect of sulphur application leading to greater availability and subsequently accumulation of macro and micro nutrients especially N, P and S in plant parts possibly with better metabolism led to translocation of these nutrients to economic parts *i.e* kernels of groundnut and seeds of the sesame crop which appears to be the most probable reason of higher N, P and S content. (Finalayson *et al.*, 1970).

The crude protein and oil content in groundnut kernels and sesame seeds were not significantly influenced due to different treatments during both the years of investigation as well as in pooled analysis (Table 3). This might be due to crops have strong genetic ceilings for how much oil and protein they can accumulate in their seeds. Agronomic practices like intercropping can change total yield which leads to significantly influence the mean oil yield, but they rarely alter the biochemical composition determined by the plant's genetics. The findings of the present study are in close conformity with the results of Chavan *et al.*, (2019) on groundnut based intercropping and Jagadeesh *et al.*, (2025). Being at par with 60 kg S/ha, application of 40 kg S/ha also improved the crude protein and oil content in groundnut kernel and sesame seed as compared to 20 kg/ha and control, (Table 3) This improvement might be due to the nitrogen and sulphur is the components of protein and application of sulphur increases their availability and increase the utilization of nitrogen for the synthesis of protein (Finalayson *et al.*, 1970). Sulphur is also responsible for synthesis of three sulphur containing amino acid namely; cysteine, cysteine and methionine and these triggers protein synthesis. Moreover, oilseeds crops like groundnut require higher dose of sulphur compared to pulses and cereals for biochemical reactions that helps in maintained disulphide bond and increases oil content in oilseeds crops. Since sulphur is also an important constituent of co-enzyme A, which form acetyl-CoA by combination with acetic acid and it is a core precursor molecule for fatty acid and lipid biosynthesis. Moreover, sulphur also helps in development in oil glands by expanding oil storage organs and it might be reason of higher crude protein and oil content in kernel and seeds. These results are in cognizance with the findings of Seema *et al.*, (2025).

Conclusion

Among different cropping systems, groundnut + sesame (2:2) intercropping system was found superior

over other intercropping treatment with respect to nitrogen content in groundnut kernel. Sulphur application at 40 kg/ha significantly increased protein and oil content, nitrogen, phosphorus and sulphur content in groundnut kernel and sesame seeds. Further, increase in sulphur level to 60 kg/ha remained at par with 40 kg S/ha.

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