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Main and residual influences of sulphur-augmented fertilisers on crude protein and crude lipid contents of sesame (*Sesamum indicum* L.)

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Abstract

Augmenting sources of nitrogen with Sulphur Powder (SP) could be cheaper and eco-friendlier than use of inorganic nitrogen and sulphur sources for sesame nutrition. In this study, effects of sulphur-augmented Cattle Manure (CM), Cocoa Pod Powder (CPP) and NPK applications, and their residual effects on Crude Lipid (CL) and Crude Protein (CP) contents of sesame were investigated in Ibadan and Ogbomoso, Nigeria. For two cropping seasons, E8 and NCRIBEN-01M sesame varieties were grown at Ibadan and Ogbomoso with NPK, CM, CPP at 90 kg N/ha plus SP at 30 kg S/ha alongside control in a 2×7 factorial arrangement fitted in randomised complete block design with three replicates. Data on CP and CL were analysed using ANOVA at $\alpha 0.05$. In the main cropping at Ibadan and Ogbomoso, CL ranged from 39.2±0.4 (Control) to 42.0±0.4 (NPK+SP) and 38.2±0.4 (Control) to 41.6±0.4 (NPK+SP), while CP ranged from 16.0±0.1 (Control) to 16.5±0.1 (NPK+SP) and 16.0±0.1(Control) to 16.6±0.1 (CM+SP), respectively with control significantly lower than other treatments. Variety×fertiliser (NCRIBEN-01M×control-E8×CM+SP) was significant for CL and CP. Treatments CPP+SP, CM+SP, CPP, CM significantly enhanced CL and CP more than the control but comparable to NPK and NPK+SP. In the residual at Ibadan and Ogbomoso, CL ranged from 29.8±1.5 (Control) to 41.2±1.5(CPP+SP) and 30.3±1.8 (Control) to 42.2±1.8 (CM+SP), while CP ranged from 13.0±0.5 (Control) to 16.5±0.5 (CM+SP) and 13.7±0.4 (control) to 16.6±0.4(CM+SP), respectively. Variety×fertiliser (NCRIBEN-01M×control-E8×CPP+SP) was significant on CL and CP. Augmentation of CPP and CM, each at 90 kg N/ha, with 30 kg S/ha SP was comparable to sulphur-augmented NPK in enhancing lipid and protein contents in first cropping but better in the residual cropping.

Keywords: Cattle manure, Cocoa pod powder, Crude lipid, Crude protein, Sesame varieties, Sulphur powder.

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Contents

Contribution of this paper to the literature

Augmentation of organic manures such as cattle manure and cocoa pod powder with sulphur powder at specified rates (90 kg N/ha + 30 Kg S/ha) have not been evaluated before. The rates were not arbitrarily selected but based on a preliminary experiment where varied rates of N and S were tried using the fertiliser materials to conclude on optimal combination of N and S.

1. Introduction

Sesame (*Sesamum indicum* L.), a member of the family 'Pedaliaceae'. Sesame was first domesticated in India, citing morphological and cytogenetic similarities between domesticated sesame and the south Indian native *S. malabaricum* -Nair, in addition to archaeological evidence supporting its cultivation at Harappa in the Indus Valley between 2250 and 1750 B.C [1]. According to FAOSTAT [2], the top five world sesame seed producers were Sudan (Former and South Sudan), India, China, Myanmar and Nigeria. Lal, et al. [3] noted that S is an integral part of acetyl-CoA, which helps in synthesis of fatty acids. Ceccotti [4] reported that S plays an important role in plant metabolism as component of protein, glucosinolates and other compounds, which have to do with several parameters determining the nutritive quality of plants. Sulphur is a prominent constituent of various plant proteins and plays a critical role in root growth and seed production. It is the component of several amino acids (cystine, cysteine and methionine), which are the basic structural unit of protein molecules and responsible for the development of taste and flavour in oilseed crops [5].

Sulphur application increases oil and protein contents in seeds [6]. It also enhances the availability of other nutrients such as phosphorus, potassium, zinc and subdues the uptake of sodium and chlorine, which are toxic to plant growth and development [7]. Furthermore, its application improves the fatty acid quality in seeds [8, 9] while its deficiency decreases oil content and quality of oilseeds [10]. Oilseed crops require more sulphur for their growth than cereals, as S promotes pod formation, whereas its deficiency can abort pods Girondé, et al. [11]. Murmu, et al. [12] asserted that oil content of sesame seeds was significantly influenced by S application wherein maximum oil content was recorded with single super phosphate followed by elemental sulphur, while the least oil content was recorded in control treatment. High oil content of seed crops due to sulphur application has been adduced to the effect of sulphur in conversion of nitrogen to crude protein and finally to oil by acetyl CoA carboxylase enzyme, which converts acetyl-CoA to malonyl-CoA, speedily bringing about high oil content [13].

Parmar, et al. [14] reported that sulphur applied through ammonium sulphate led to significantly high protein content (18.38 %) and protein yield (152.31 kg/ha). A similar increase in protein content due to sulphur application via ammonium sulphate was observed by Venkatesh, et al. [15]. In a study by Ustimenko-Bakumovsky [16] sesame seed was found to contain 50 – 51% oil, 17-19% protein and 16-18% carbohydrate. Dasharath, et al. [17] analysed the proximate content of sesame seeds and were found to contain 50-60% oil, 8% protein, 5.8% water, 3.2% crude fibre, 18% carbohydrate, 5.7% ash as well as appreciable amount of calcium, phosphorus and vitamin E. Sharma, et al. [18] found that seeds of sesame contained high value of protein ranging from 18 to 27.6%, water content (3.14 - 4.4%), ash (4.2 - 6.2%). They also added that sesame seeds are a good source of methionine and tryptophan. Mbaebie, et al. [19] noted in their study that sesame seed contained 5.6% moisture content, 6.6% crude fibre, 16.6% crude protein, 38.5% crude fat, 8.9% crude ash, and 2.38% carbohydrate. On the other hand, Ogbonna and Ukaan [20] reported range of proximate contents of thirteen ascensions of sesame with crude protein of 17.56 – 21.00%, crude lipid of 31.00 – 45.68%, crude fibre of 1.41 – 2.25%, crude ash of 1.14 – 2.88%, carbohydrate of 29.7 – 48.15% and moisture content of 5.12 – 7.16%.

The potential of organic fertilisers on crop production for more than one cropping season has been reported [21]. On the other hand, there is little or no tendency of mineral fertilisers to support crops for more than one cropping season owing to their fast and unconstrained release after application as well as susceptibility of excess amounts to losses via volatilization, leaching, erosion, oxidation and reduction Ojeniyi [22]. Gaskell, et al. [23] reported that the gradual release of nutrients from organic fertiliser is due to the process of converting the organic forms of nutrients into inorganic forms by soil microbes before they can be made available to crops. Therefore, there is high assurance of supply of nutrients from organic sources to support crop production for more than a cropping season without fresh application [24, 25].

2. Materials and Methods

Four (Two main and two residual) field experiments were carried out in succession at experimental field sites of Crop and Horticultural Sciences Department, University of Ibadan, Nigeria (7°22′N; 3°55′E), and Department of Crop Production and Soil Science (LAUTECH), Ogbomoso, Nigeria (8°07′N; 4°14′E) in 2020, 2021 and 2022. Two sesame varieties (E8 and NCRIBEN01-M) were grown with NPK 20-10-10, cattle manure and cocoa pod powder at 90 kg N/ha in combination with sulphur powder at 30 kg S/ha, besides the control in a 2×7 factorial arrangement fitted in a randomised complete block design with three replicates, thereby having a total of forty-two plots. Soil of the study areas was analysed for various parameters before cropping. Cattle manure (collected from the Institute of Agricultural Research and Training, Ibadan) and cocoa pod husk (collected from Cocoa Research Institute of Nigeria (CRIN), Ibadan). Air-dried powdery forms of cattle manure and cocoa pod powder were analysed for their nutrient contents according to standard procedures [26]. Harvested seeds from each plot were analysed for crude protein and crude lipid and subjected to Analysis of Variance (ANOVA) at 5% level of significance using Minitab 19 statistical software. Crude Protein (CP) content of harvested sesame seeds was determined using micro Kjeldahl method [26]. A sample of 0.2g was weighed into a Kjeldahl flask. One tablet of Kjeldahl catalyst was added to the sample in the flask with 25 ml of conc. H_2SO_4. The flask was swirled, gently clamped in an inclined position and heated electrically in a fume cupboard. The heating continued until a clear solution was obtained. The clear solution was cooled, poured into a 100 ml volumetric flask and made up to the mark with distilled water; 10 ml of the resulting mixture was measured into the distillation set-up. Five millilitres of boric acid was pipetted into a 100 ml conical flask and placed at the receiving end of the distillatory. The conical flask was placed such that the delivery tube dipped completely into the boric acid inside the flask. Forty percent sodium hydroxide (40%NaOH) was used to liberate ammonia from the digest; two drops of methyl orange were added to the digest before addition of 40% NaOH. As soon as the contents became alkaline, the red colour changed to yellow, showing NaOH to be in excess. Steam was then generated into the distillation set using a steam chest. The liberated ammonia was trapped in the boric acid solution and about 50 ml of the solution collected into a conical flask. The solution in the flask was titrated against 0.1 M HCl until the first permanent colour change was observed. A blank sample was run through the same procedures and the titre value for the blank was used to calibrate the titre for samples.

$$\%N = \frac{\text{Molarity of HCl} \times (\text{Sample titre} - \text{Blank titre}) \times 0.014 \times \text{D.F.} \times 10}{\text{Weight of sample}} \quad (1)$$

Where D. F. is the dilution factor. Percentage N was converted to % crude protein by multiplying with a factor of 6.25, i.e., %CP = %N × 6.25.

For determination of crude lipid, the Soxhlet extraction method was used. A sample of 0.5 g was weighed into a pre-weighed filter paper and folded carefully. This was placed inside a pre-weighed thimble (W_1). The thimble containing the sample (W_2) was inserted into the Soxhlet apparatus, and extraction under reflux was carried out with petroleum ether (40° C–60°C boiling range) for 6 hours. At the end of the extraction, the thimble was dried in an oven for 30 minutes at 100°C to evaporate the solvent. The thimble was then cooled in a desiccator and subsequently weighed (W_3). The fat extracted from the given quantity of sample was then calculated using the equation shown below.

$$\%CL = \frac{(W2 - W3) \times 100}{\text{Weight of sample}} \quad (2)$$

Data on crude protein and crude lipid contents were subjected to analysis of variance (ANOVA) using Minitab 19 statistical software. Means were compared using Tukey's pairwise comparison at a 5% level of significance.

3. Results and Discussion

3.1. Pre-Cropping Soil Properties

Pre-cropping soil analysis indicated that the pH of the soil of Ibadan was slightly acidic, while that of Ogbomoso location was of moderate acidity (Table 1). The available phosphorus was above critical level of 10. 0 mg/kg [27], whereas the total N values for the two locations were lower than critical values of 1.5g/kg [27, 28]. Exchangeable potassium of soil at Ibadan and Ogbomoso experimental site was above critical limit of 0.15 cmol/kg reported by Akinrinde and Obigbesan [27] and Chude, et al. [28]. Also, available sulphur of soil from Ibadan and Ogbomoso locations were quite low when compared with 10 mg/kg critical level specified by Oseni, et al. [29]. Textural components of the soil indicated sandy loam and loamy sand for Ibadan and Ogbomoso experimental locations. Response to nitrogen and sulphur application was thus obtained.

Table 1. Soil properties before cropping at Ibadan and Ogbomoso in 2020 and 2021.

Parameter	2020		2021	
	Ibadan	Ogbomoso	Ibadan	Ogbomoso
pH (H_2O)	6.1	5.7	6.3	5.8
Organic C (g/kg)	12.1	10.9	11.8	11.1
Total N (g/kg)	1.4	1.3	1.3	1.3
Available nutrients (mg/kg)				
P	12.0	13.0	12.0	14.0
S	6.1	5.6	6.2	5.8
Exchangeable cations (cmol/kg)				
Ca^{2+}	1.6	1.3	1.6	1.4
Mg^{2+}	1.3	1.2	1.5	1.2
K^+	0.2	0.3	0.2	0.2
Na^+	0.1	0.1	0.1	0.1
Exchangeable Acidity (cmol/kg)	0.1	0.3	0.2	0.2
ECEC (cmol/kg)	3.3	3.2	3.6	3.1
Extractable micronutrients (mg/kg)				
Cu	1.2	1.5	1.2	1.4
Fe	24.2	21.3	23.9	21.8
Mn	3.6	3.0	3.5	3.1
Zn	46.9	48.2	47.4	50.1
Particle size analysis (g/kg)				
Sand	651	780	679	753
Silt	150	120	125	121
Clay	199	100	196	126
Textural class	Sandy loam	Loamy sand	Sandy loam	Loamy sand

3.2. Nutrient Content of Fertilisers

The NPK fertiliser (grade 20-10-10) was higher in N, P, and K (200.0 g/kg N, 100.0 g/kg P_2O_5 and 100.0 g/kg K_2O) than cattle manure CM (5.0 g/kg N, 2 g/kg P_2O_5, 4 g/kg K_2O) and cocoa pod powder, CPP (4.0 g/kg N, 5.0 g/kg P_2O_5, 7.0 g/kg K_2O) as shown in Table 2. The CPP had higher P and K contents than CM. The sulphur (S) contents of CM and CPP were low with respective values of 3.0 and 7.0 mg/kg.

Table 2. Nutrient contents of Cattle manure, Cocoa pod powder and NPK.

Nutrient	Cattle manure	Cocoa pod powder	NPK
	g/kg		
N	5	4	200.0
P_2O_5	2	5	100.0
K_2O	4	7	100.0
Ca	1.3	1.6	0.0
Mg	6	8	0.0
	mg/kg		

Nutrient	Cattle manure	Cocoa pod powder	NPK
S	3	7	0.0
Zn	46	58	0.0
Cu	22	36	0.0
Fe	11	7	0.0
Mn	36	31	0.0

3.3. Varietal Response and Influence of Fertiliser on Crude Lipid and Crude Protein of Sesame Grown at Ibadan

Varieties E8 and NCRIBEN-01M differed in their response to fertiliser application in terms of crude lipid and crude protein with E8 having significantly higher crude lipid and crude protein in the main cropping at both locations (Table 3). The reverse was the case in the residual cropping.

Fertiliser application had significant influence, as crude protein and crude lipid of fertiliser-treated sesame had significantly higher values than control (Table 3). In main cropping, sesame plants produced seeds with similar crude protein in 2020, but in 2021, crude protein contents significantly differed from one another (Table 3). For crude lipid, a similar pattern was obtained in 2020 and 2021, as treated plants had similar values, which were significantly higher than those with no fertiliser treatments. In the residual cropping, previously applied fertilisers significantly influenced crude lipid and crude protein. Crude lipid and crude protein of plants from previously applied NPK and NPK + S fertilisers had lower values than those of cocoa pod powder (CPP) and cattle manure (CM), and their S-augmented forms (Table 3). Interaction effects of variety and fertiliser were not significant in the main cropping but manifested in residual cropping (Table 4). This result aligns with that of Gupta and Sharma [30], who reported that sulphur-augmented gypsum significantly resulted in increased crude lipid and oil compositions in a continual manner to benefit subsequent sesame grown on previously applied fertiliser treatment.

Table 3. Crude protein and crude lipid contents of sesame seeds nourished with sulphur-augmented fertilisers in main cropping and their residual influence across cropping years at Ibadan.

Treatment	2020 (Main)		2021 (Residual)		2021 (Main)		2022 (Residual)	
	CP	CL	CP	CL	CP	CL	CP	CL
Variety (V)								
E8	16.35a	41.19a	15.26b	38.54a	16.87b	41.44a	14.11b	35.69b
NCRIBEN01M	16.39a	40.70b	15.81a	37.44b	17.08a	40.52a	14.75a	37.04a
Fertiliser (F) sources								
CM	16.57a	41.66ab	16.53a	39.12c	16.88c	40.99a	14.94b	37.63b
CM + SP	16.45a	41.96a	16.50a	40.49ab	16.64c	42.26a	15.42a	39.47a
CPP	16.33ab	41.33ab	16.30b	40.14b	16.65c	42.32a	15.21ab	38.69ab
CPP + SP	16.46a	40.92bc	16.29b	41.15a	17.34b	42.46a	15.44a	40.14a
NPK	16.27a	40.45c	15.22c	37.50d	17.67a	41.89a	13.88c	35.21c
NPK + SP	16.45ab	41.11bc	14.86d	37.75d	17.73a	42.63a	14.04c	34.44c
NFT	16.05c	39.17d	13.03e	29.81e	15.93d	34.32b	12.10d	28.97d

Note: Means with similar letters along a column within a group are not significantly different according to Tukey pairwise comparison at 5% level of significance.

CP- crude protein, CL- crude lipid, CM- cattle manure at 90 kg N/ha, CPP - Cocoa pod powder at 90 kg N/ha, NPK- nitrogen phosphorus potassium fertiliser grade 20-10-10 at 90 kg N/ha, SP- sulphur powder at 30 kg S/ha, NFT-no fertiliser treatment.

Table 4. Interaction of variety and fertiliser on crude protein and crude lipid of sesame seed nourished with sulphur-augmented fertilisers in main cropping and their residual influence across cropping years at Ibadan.

Treatment variety x fertilizer	2020 (Main)		2021 (Residual)		2021(Main)		2022 (Residual)	
	CP	CL	CP	CL	CP	CL	CP	CL
E8 × CM	16.57a	42.21a	15.92d	37.73d	16.97cde	41.18ab	14.55cd	36.63bc
NCRIBEN-01M × CM	16.57a	41.11a-d	16.69a	40.50bc	16.79de	40.79ab	15.33ab	38.62ab
E8 × CM + SP	16.37ab	42.09ab	16.17cd	39.60c	16.22fg	42.58ab	15.11abc	38.47ab
NCRIBEN-01M × CM + SP	16.52a	41.83abc	16.82a	41.39ab	17.05cde	41.94ab	15.73a	40.46a
E8 × CPP	16.27ab	41.95abc	16.04cd	39.74c	16.67ef	43.10a	14.97bc	38.63ab
NCRIBEN-01M × CPP	16.38ab	40.72cd	16.54ab	40.53bc	16.63ef	41.53ab	15.44ab	38.76ab
E8 × CPP+SP	16.52a	40.85bcd	16.31bc	40.30bc	17.33bcd	42.15ab	15.16abc	39.26a
NCRIBEN-01M × CPP+SP	16.40ab	40.98a-d	16.74a	42.00a	17.34bc	42.76a	15.71a	41.02a
E8 × NPK	16.40ab	40.53d	14.99ef	36.95d	17.33bc	41.64ab	13.96de	33.87d
NCRIBEN-01M × NPK	16.49a	40.38de	14.73f	38.05d	18.00a	42.13ab	13.79e	36.54bc
E8 × NPK+SP	16.38ab	41.45a-d	15.26e	38.18d	17.69ab	42.51a	13.87de	34.09cd
NCRIBEN-01M × NPK+SP	16.16ab	40.77cd	15.17e	37.32d	17.77ab	42.76a	14.20de	34.80cd
E8 × NFT	15.92b	39.25ef	12.12h	29.59e	15.85g	36.33bc	11.17g	28.87e
NCRIBEN-01M × NFT	16.19ab	39.09f	13.94g	30.02e	16.01g	32.30c	13.02f	29.07e

Note: Means with similar letters along a column within a group are not significantly different according to Tukey pairwise comparison at 5% level of significance.

MC- moisture content, CP- crude protein, CL- crude lipid, CM- cattle manure at 90 kg N/ha, CPP - Cocoa pod powder at 90 kg N/ha, NPK- nitrogen phosphorus potassium fertiliser grade 20-10-10 at 90 kg N/ha, SP- sulphur powder at 30 kg S/ha, NFT- no fertiliser treatment.

3.4. Varietal Response and Influence of Fertiliser on Crude Lipid and Crude Protein of Sesame Grown at Ogbomoso

Varietal response was noted as NCRIBEN-01M had significantly higher crude lipid and crude protein than E8 (Table 5) in both main and subsequent(residual) cropping. Fertiliser influence was similar for treated crops in main cropping, though better than control. In subsequent croppings, sesame plants grown on plots previously nourished with S-augmented CM and CPP produced sesame seeds with significantly higher crude protein and crude lipid than those of S-augmented NPK. Variety x fertilizer interaction was significant (Table 6). Gupta and Sharma [30] have earlier reported that gypsum augmented with sulphur significantly enhanced crude lipid and oil compositions continually and had a carry-over effect on sesame produced in plots initially fertilised.

Table 5. Crude protein and crude lipid contents of sesame seeds nourished with sulphur-augmented fertilisers in main cropping and their residual influence across cropping years at Ogbomoso.

Treatment	2020 (Main)		2021 (Residual)		2021 (Main)		2022 (Residual)	
	CP	CL	CP	CL	CP	CL	CP	CL
Variety (V)								
E8	16.37b	40.79b	15.26b	38.54a	17.92b	41.87b	14.11b	35.69b
NCRIBEN01M	16.49a	41.12a	15.81a	37.44b	18.30a	43.70a	14.75a	37.04a
Fertiliser (F) sources								
CM	16.43b	41.31a	16.53a	39.12c	17.64d	42.98b	14.94b	37.63b
CM + SP	16.51ab	41.55a	16.50a	40.49ab	18.45bc	43.26ab	15.42a	39.47a
CPP	16.44ab	41.19a	16.30b	40.14b	18.04cd	43.30ab	15.21ab	38.69ab
CPP + SP	16.54a	41.43a	16.29b	41.15a	18.80ab	44.62a	15.44a	40.14a
NPK	16.48ab	41.07a	15.22c	37.50d	18.94ab	44.20ab	13.88c	35.21c
NPK + SP	16.54a	41.34a	14.86d	37.75d	19.11a	43.67ab	14.04c	34.44c
NFT	16.08c	38.79b	13.03e	29.81e	15.82e	37.50c	12.10d	28.97d

Note: Means with similar letters along a column within a group are not significantly different according to Tukey pairwise comparison at 5% level of significance.

CP- crude protein, CL- crude lipid, CM- cattle manure at 90 kg N/ha, CPP - Cocoa pod powder at 90 kg N/ha, NPK- nitrogen phosphorus potassium fertiliser grade 20-10-10 at 90 kg N/ha, SP- sulphur powder at 30 kg S/ha, NFT-no fertiliser treatment.

Table 6. Interaction of variety and fertiliser on crude protein and crude lipid of sesame seed nourished with sulphur-augmented fertilisers in main cropping and their residual influence across cropping years at Ogbomoso.

Treatment variety x fertilizer	2020 (Main)		2021 (Residual)		2021 (Main)		2022 (Residual)	
	CP	CL	CP	CL	CP	CL	CP	CL
E8 × CM	16.37bcd	41.14b-e	16.03d	41.20c	17.54d	42.56de	15.12b	39.52bcd
NCRIBEN-01M × CM	16.49abc	41.49a-d	16.30bc	39.70d	17.75cd	43.40b-e	15.31ab	38.11d
E8 × CM + SP	16.50abc	41.28b-e	16.60a	42.40ab	18.03bcd	42.94cde	15.42ab	40.55abc
NCRIBEN-01M × CM + SP	16.51abc	41.81abc	16.62a	41.73bc	18.86ab	43.59b-e	15.51ab	40.75ab
E8 × CPP	16.34cd	41.79abc	16.30bc	42.96a	18.14bcd	42.37de	15.19ab	41.58a
NCRIBEN-01M × CPP	16.55a	40.59def	16.26c	41.34c	17.93bcd	44.24a-d	15.26ab	39.11cd
E8 × CPP+SP	16.52ab	41.89abc	16.67a	42.45ab	18.77ab	43.84b-e	15.59a	40.67ab
NCRIBEN-01M × CPP+SP	16.55a	40.97c-f	16.50ab	41.18c	18.82ab	45.40ab	15.50ab	40.48abc
E8 × NPK	16.45abc	40.07f	14.30g	34.93ef	18.67abc	41.93e	13.30d	33.50e
NCRIBEN-01M × NPK	16.51ab	42.06abc	14.74f	34.59f	19.20a	46.46a	13.72cd	32.71e
E8 × NPK+SP	16.52ab	40.37ef	15.03e	35.13ef	18.79ab	42.45de	14.05c	34.14e
NCRIBEN-01M × NPK+SP	16.55a	42.31a	14.87ef	35.51e	19.43a	44.89abc	13.87c	33.83e
E8 × NFT	15.90e	38.97g	13.92h	30.86g	15.53e	37.05f	12.77e	30.06f
NCRIBEN-01M × NFT	16.26d	38.61g	13.51i	29.81h	16.10e	37.95f	12.61e	29.15f

Note: Means with similar letters along a column within a group are not significantly different according to Tukey pairwise comparison at 5% level of significance.

MC- moisture content, CP- crude protein, CL- crude lipid, CM- cattle manure at 90 kg N/ha, CPP - Cocoa pod powder at 90 kg N/ha, NPK- nitrogen phosphorus potassium fertiliser grade 20-10-10 at 90 kg N/ha, SP- sulphur powder at 30 kg S/ha, NFT- no fertiliser treatment.

4. Conclusion

Application of S-augmented fertilisers significantly enhanced crude protein and crude lipid contents of sesame seeds. The main effects were more pronounced than residual effects for sesame treated with S-augmented NPK, whereas those treated with S-augmented cattle manure and cocoa pod powder had better carry-over effects, all of which indicate that sulphur directly participates in protein and oil biosynthesis pathways. However, residual sulphur also contributed to improved quality parameters in the subsequent crop previously grown with S-augmented cattle manure and cocoa pod powder due to its slow release and residual soil availability.

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