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Effect of sulphur and bio fertilizers on sesame (*Sesamum indicum* L.) yield and quality in red and lateritic soils of West Bengal, India

Anamika Das* • Pabitra Kumar Biswas

Palli Siksha Bhavana, Visva-Bharati University, Shantiniketan, 731235

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ABSTRACT

A field experiment was conducted on sesame during pre-kharif season to study the effect of combined application of sulphur and biofertilizers on yield attributes of sesame (*Sesamum indicum* L) and its quality. The experiment was laid out in randomized block design with three replicants and thirteen treatments. Result of the study showed highest grain yield (8.13 q ha-1), stover yield (19.57 q ha-1), bilogical yield (27.55 q ha-1) and harvesting index (29.41) of sesame was registered where higher dose of sulphur along with combined application of PSB and Azotobacter *viz.* S @ 45 kg ha-1 + PSB + Azotobacter. The highest crude protein content and protein yield in seed of sesame (kg q-1) was recorded due to higher application of sulphur along with combined application of PSB and Azotobacter *viz.* S @ 45 kg ha-1 + PSB + Azotobacter. The study conclude higher yield and better quality of yield in sesame resulted from application of sulphur @ 45 kg ha-1 + PSB + Azotobacter which leads to overall profit to the farmers. Thus study recommended for integrated use of biofertilizers and chemical fertilizers in sesame cultivation in red and lateritic belt of West Bengal and other part of country where ever the soil of this kind is available.

1. Introduction

The sesame (*Sesamum indicum* L.) is a member of the padaliaceae plant family, it is one of the world most important and oldest known edible oil seed crops (Abou Gharbia *et al.,* 1997). The sesame is not only an important edible oilseed crop but also helps in export earnings and widely grown in different parts of the world. Asian and African countries are the major producers of this crop. The annual acreage of the world is near to 16 to 17 lakhs hectare. This crop took 9th position among the top 13 oil seed crops which make up 90 per cent of the world production of edible oil (Adeola *et al.,* 2010). In 2013, world production of sesame seeds were 4.2 million tones led by India and mainland China (FAO, 2008). India ranks first in both acreage and production in the world and also one of the leading and the largest organic exporters of sesame seed and it ranks third in terms of total culturable area and fourth in terms of total oilseed production.

It is grown mostly for the oil extraction which is edible and use for industrial and pharmaceutical purposes. The seed of sesame contains all essential amino acids and fatty acids (Malik *et al.,* 2003) and has been shown to contain about 35 to 60 per cent of oil (El. Khier *et al.,* 2010; Jimoh *et al.,* 2011; Borchani *et al.,* 2010; Alyemeni *et al.,* 2001; Mohammad and Hamza, 2008), 20 per cent of protein and 14-20 per cent of carbohydrate (BARI, 2004). The seeds of this crop are used as food, source of edible oil and bio-medicine and its oil has excellent nutritional and medicinal value, also has cosmetic and cooking qualities for which it is known as 'the queen of oils'. However, this crop is mainly cultivated in summer, kharif and post-kharif season in West Bengal with an area of about 0.182 millon ha (Anonymous, 2012b). The area, production and productivity of sesame are higher in summer season than those of post-kharif and kharif seasons (Anonymous, 2006). But the productivity of sesame in general is much lower than its potential yield. Lower productivity may be due to the fact of sub-optimal rate of fertilizer, poor management and deficiency of macronutrients

*Corresponding author: anudasag@gmail.com

such as nitrogen, phosphorus, potassium in cultivated area like in marginal and sub-marginal lands. This indicates the vast scope and need to increase the productivity of sesame. Against this background, a concerted effort is needed on the part of all concerned especially to the soil science researcher to study the yield attributes of sesame, effects of Sulphur and bio fertilizers in yield and its' quality. Whether the application of Sulphur and bio fertlizers increases or decreases the yield of sesame and enhance quality of sesame yield are the matter of concern. With considering those research interest based on previous studies, this study is aimed to study the effect of sulphur and bio fertilizers on sesame yield and its quality in red and lateritic soils of West Bengal.

2. Materials and Methods

A field experiment was carried out to study the effect of sulphur and bio fertilizers on sesame yield and its quality in red and lateritic soils of West Bengal was conducted during pre-kharif season of 2016**.** The initial soil analysis revealed that the soil of the experimental plot was sandy-loam in texture which contains high percentage of sand and low percentage of clay. The soil was slightly acidic (pH 5.10), low in soil organic carbon (0.40%), very low in available nitrogen (115.52 kg/ha), medium in available phosphorus (50.40 kg/ha), low in available potassium content (32.48 kg/ha) and available sulphur (12.6 kg/ha). The field experiment was carried out in Randomized Block design with three replications and total thirteen treatments. As per the treatments specification, fertilizers were applied in the form of urea, diammonium phosphate (DAP), murate of potash (MOP) for the source of nitrogen, phosphorus and potassium respectively. Magnesium sulphate (26.63% S) was used for the source of sulphur. A general recommended dose of N: P_2O_5: K_2O for sesame was applied for each plot at the rate of 60:40:40 kg ha^{-1} as urea, DAP and MOP. As per treatment sulphur was applied @ 0, 30, 45 and 60 kg ha^{-1} from zinc sulphate (15 % S). Phosphorus, potassium and sulphur was applied as basal dose and nitrogen as split doses. The fertilizer was weighted separately as per need of the treatment for individual plots. Required quantity of fertilizer as per treatment was applied uniformly in the plots through broadcast method of application. Seed were soaked in clean water for better germination. The soaked seeds were treated with bio fertilizers like PSB and *Azotobacter* as per treatment and dried in the shade before sowing. The bio fertilizers were treated with seed @ 60 kg ha^{-1}. Sesame was sown on 17th Feb, 2016 at 30 cm apart row spacing by making shallow furrows with the help of tines in 5 cm soil depth. The seed rate was 4 kg ha^{-1}. After sowing, seeds were covered with loose soil for compaction of soil and better germination.

The observation for the yield attributes of sesame and its quality were taken at various stages of experiment. The yield attributes and its quality parameters were analyzed following standard procedures (Sahu *et al.,* 2017).

Table 1. Effect of treatments on crop yield attributes

Treatments	Yield attributes	
	No of branches plant^{-1}	No of capsule plant^{-1}
Control	3	50
S @ 0 kg ha^{-1} + PSB	4	54
S @ 0 kg ha^{-1} + *Azotobacter*	5	68
S @ 0 kg ha^{-1} + PSB + *Azotobacter*	5	71
S @ 15 kg ha^{-1} + PSB	4	76
S @ 15 kg ha^{-1} + *Azotobacter*	4	72
S @ 15 kg ha^{-1} + PSB + *Azotobacter*	5	78
S @ 30 kg ha^{-1} + PSB	4	78
S @ 30 kg ha^{-1} + *Azotobacter*	5	89
S @ 30 kg ha^{-1} + PSB + *Azotobacter*	5	80
S @ 45 kg ha^{-1} + PSB	5	82
S @ 45 kg ha^{-1} + *Azotobacter*	5	90
S @ 45 kg ha^{-1} + PSB + *Azotobacter*	6	111
Sem (±)	0.39	5.68
CD 5%	1.16	16.58
CV %	14.56	12.82
RBD(0.05)	NS	S

3. Result and Discussion

Effect of sulphur and biofertilizer on crop yield and its attributes

Number of branches plant-1

Data pertaining to the number of branches plant-1 recorded after harvest of the crop are presented in table 1. Presented data revealed that application of different levels of sulphur has no variation on number of branches plant-1. It was observed that the number of branches plant-1 ranged revising 3 to 6 at harvest. Application of bio fertilizers along with different levels of sulphur was not found to be statistically significant on the number of branches plant-1. The maximum number of branches plant-1 was obtained with the application of higher dose of sulphur *i.e.* 45 kg ha-1 along with bio fertilizers PSB and Azotobacter and the minimum number of branches plant-1 was recorded in control.

Number of capsules plant^{-1}

Data pertaining on number of capsules plant^{-1} are presented in table 1. Application of different levels of sulphur influenced the number of capsules plant^{-1} and significantly little variation were noted. Receiving sulphur @ 45 kg ha^{-1} recorded significantly higher number of capsules plant^{-1} as compared to other treatments. The maximum value of number of capsules plant^{-1} was obtained from treatment receiving sulphur 45 kg ha^{-1} (111) and the lowest value of number of capsules plant^{-1} was recorded in control (50). Higher number of capsules plant^{-1} with application of sulphur may be attributed to increase in photosynthetic activity of the plants and increased plant growth which ultimately resulted in higher yield. These results were corroborating with the findings of Yadav *et al.* (2009) and Dhingra *et al*. (1988). Seed inoculation of *Azotobacter* + PSB @ 60 g kg^{-1} seed recorded maximum number of capsuless plant^{-1} as compared to control. The maximum number of capsules plant^{-1} was at per with the application of sulphur @ 45 kg ha^{-1} with single inoculation of *Azotobacter* (90) and sulphur @ 30 kg ha^{-1} with single inoculation of *Azotobacter* (89). The beneficial effect of seed inoculation of biofertilizers could be attributed to the production of IAA and GA like substance (Sarkar and Saha 2005) and also increase supply of the essential nutrient and water to the plant, thereby enhancing grain weight plant^{-1} is in agreement with the observation made by Shinde *et al.* (2011) and Yadav *et al.* (1996). This result is conformity with the findings of Mukherjee and Rai (2000).

Seed yield (q ha^{-1})

Data regarding on grain yield (q ha^{-1}) of sesame after harvest represented in table 2. The findings indicating a promising yield with the different level of sulphur application along with other single and dual inoculations of seed. The results revealed a statistically significant difference in grain yield of sesame with the various treatments. (2.03 to 8.51 q ha^{-1}). Irrespective of strains, co-inoculation with PSB + *Azotobacter* and fertilizers as basal always recorded more yield in comparison to the uninoculated control. The application of sulphur @ 45 kg ha^{-1} along with combined seed inoculation of *Azotobacter* and PSB gave the highest crop yield (8.51q ha^{-1}) as compared to uninoculated control (2.03 q ha^{-1}). The result showed in table 2, compared with uninoculated control, all the treatments increased the mean yield of crop by 2.48 to more than 4 fold. The highest yield of crop in q ha-1 was recorded in treatment of integrated application of sulphur @ 45 kg ha-1 and co-inocultion of PSB + Azotobacter (8.51q ha-1) followed by sulphur @ 30 kg ha-1 and co-inocultion of PSB + Azotobacter (8.21 q ha-1), sulphur @ 45 kg ha-1 + single inoculation of Azotobacter (7.48 q ha-1) and then sulphur @ 45 kg ha-1 + single inoculation of Azotobacter (7.13q ha-1) after harvest. The treatment with sulphur @ 30 kg ha-1 and co-inocultion of PSB + Azotobacter and sulphur @ 45 kg ha-1 and co-inocultion of PSB + Azotobacter increased yield by the range of 17.3 to 304.4 per cent and 16.1 to 300.5 per cent as compared to uninoculated control, single inoculation of PSB & Azotobacter, dual inoculation of PSB + Azotobacter and sulphur @ 15 kg ha-1 with single and combined inoculation of PSB & Azotobacter, respectively. The treatment sulphur @ 30 kg ha-1 along with dual inoculation of PSB and Azotobacter increased yield of crop in q ha-1 by 304.4, 59.4, 63.2, 52, 17.3, 22 and 18.5 per cent over uninoculated control (2.03 q ha-1), only PSB inoculation (5.15 q ha-1), only Azotobacter inoculation (5.03 q ha-1), dual inoculation of PSB + Azotobacter (5.4 q ha-1), sulphur @ 15 kg ha-1 along with single inoculation of PSB (7 q ha-1), sulphur @ 15 kg ha-1 along with single inoculation of Azotobacter (6.73 q ha-1) and sulphur @ 15 kg ha-1 along with duel inoculation of PSB + Azotobacter (6.93 q ha-1), respectively. The lowest grain yield was found in control (2.03 q ha-1) may be due to the absence of external supply of fertilizers. This results conformity with the findings of Chatterjee *et al.* (1985) where they concluded that increased seed yield with sulphur application might be due to the effect of sulphur in utilizing larger quantities of nutrients through their well-developed root system which might have resulted in better plant development and ultimate yield.

It may be concluded that single or dual inoculation of PSB and *Azotobacter*, gave lower yield, however, combined seed inoculation with *Azotobacter* + PSB @ 60 g kg^{-1} seed with sulphur fertilizer application recorded higher seed yield comparison to the others. This result is line with the findings of Mukherjee and Rai (2000) and Bera (2008). Saren *et al*. (2004); Ceccotti (1996) and Panda *et al.* (1991) found that the grain yield of sesame increased due to increasing levels of sulphur. The increase in grain yield is largely a function of improvement in the yield attributes. These results are in agreement with the findings of Sarkar and Shah *et al.* (2013).

Stalk yield (q ha^{-1})

Data regarding on stover yield (q ha^{-1}) of sesame after harvest indicating a increasing yield with the different level of sulphur application along with single and dual seed inoculations of PSB and *Azotobacter* (table 2).

The results revealed a statistically significant difference in stover yield of sesame with the various treatments (4.70 to 19.57 q ha^{-1}). Irrespective of strains, co-inoculation with each other and fertilizers as basal always recorded more yield in comparison to the uninoculated control. The basal application of sulphur @ 45 kg ha^{-1} along with combined seed inoculation of *Azotobacter* and PSB gave the highest stover yield (19.57 q ha^{-1}) after harvest as compared to uninoculated control (4.7 q ha^{-1}). The result showed in table 2, compared with uninoculated control, all the treatments increased the mean yield of stover by 2.41 to 4.16 fold. The highest yield of stover in q ha^{-1} was recorded in treatment of integrated application of sulphur @ 30 kg ha^{-1} and co-inocultion of PSB + *Azotobacter* (19.57 q ha^{-1}) followed by sulphur @ 45kg ha^{-1} with single inocultion of PSB (18.6 q ha^{-1}), sulphur @ 15 kg ha^{-1} along with dual inoculation of PSB + *Azotobacter* (17.63 q ha^{-1}) and then sulphur @ 45 kg ha^{-1} + single inoculation of *Azotobacter* (17.22 q ha^{-1}) after harvest. The treatment with sulphur @ 45 kg ha^{-1} and co-inocultion of PSB + *Azotobacter* and sulphur @ 45 kg ha^{-1} and single inocultion of PSB increased stover yield by the range of 27.9 to 316.4 per cent and 21.6 to 295.7 per cent as compared to uninoculated control, single inoculation of PSB & *Azotobacter*, dual inoculation of PSB + *Azotobacter* and sulphur @ 15 kg ha^{-1} with single inoculation of PSB & *Azotobacter*, respectively. The treatment sulphur @ 45 kg ha^{-1} along with dual inoculation of PSB and *Azotobacter* increased yield of stover in q ha^{-1} by 316.4, 72.4, 69.0, 55.1, 48.6 and 27.9 per cent over uninoculated control (4.7 q ha^{-1}), only PSB inoculation (11.35 q ha^{-1}), only Azotobacter inoculation (11.58 q ha^{-1}), dual inoculation of PSB + *Azotobacter* (12.62 q ha^{-1}), sulphur @ 15 kg ha^{-1} along with single inoculation of PSB (13.17 q ha^{-1}) and sulphur @ 15kg ha^{-1} along with single inoculation of *Azotobacter* (15.3 ha^{-1}), respectively. It may be concluded that single or dual inoculation *Azotobacter* and PSB gave lower yield *i.e.* 11.35, 11.58 and 12.62 q $ha^{-1,}$ respectively. However, combined seed inoculation with sulphur application recorded higher stover yield comparison to the others. The positive influence of S and B in improving yield and yield attributes of sesame was reported earlier by Shilpi *et al.* (2012). They concluded that sulphur improves cell division and cell elongation and has a favorable influence on chlorophyll synthesis. This might have contributed to the increased stover yield.

Biological yield (q ha^{-1})

Depending upon stalk yield and seed yield the biological yield was summed up and results were presented in table 2. Results highlights that the biological yield (q ha^{-1}) of the crop was lowest in control as comparison to other treatments. Data revealed a significant difference in biological yield of sesame with the various treatments. (6.73 to 27.55 q ha^{-1}). Irrespective of strains, co-inoculation with each other and fertilizers as basal always recorded more yield in comparison to the uninoculated control. The basal application of sulphur @ 45 kg ha^{-1} along with combined seed inoculation of *Azotobacter* and PSB gave the highest biological yield (27.55 q ha^{-1}) after harvest as compared to uninoculated control (6.73 q ha^{-1}).

The result showed in table 2, compared with uninoculated control, all the treatments increased the mean biological yield by 2.27 to 4.09 fold. Compared to single inoculation of PSB, *Azotobacter* and co-inoculation of PSB + *Azotobacter*, all the treatments except control increased the mean biological yield by 1.14 to 1.67; 1.23 to 1.80 and 0.96 to 1.40 fold, respectively. The highest biological yield in q ha^{-1} was recorded in treatment of integrated application of sulphur @ 45 kg ha^{-1} and co-inocultion of PSB + *Azotobacter* (27.55 q ha^{-1}) followed by sulphur @ 15 kg ha^{-1} and co-inocultion of PSB + *Azotobacter* (24.57 q ha^{-1}), sulphur @ 45kg ha^{-1} and single inocultion of PSB (24.43 qha^{-1}), sulphur @ 45 kg ha^{-1} + single inoculation of *Azotobacter* (24.22 q ha^{-1}) after harvest. The treatment with sulphur @ 45 kg ha^{-1} and co-inocultion of PSB + *Azotobacter* and sulphur @ 45 kg ha^{-1} and single inocultion of PSB increased yield by the range of 14.5 to 309.4 per cent and 10.9 to 263.0 per cent as compared to uninoculated control, single inoculation of PSB & *Azotobacter*, dual inoculation of PSB + *Azotobacter* and sulphur @ 15 kg ha^{-1} with single inoculation of PSB & *Azotobacter*, respectively. The treatment sulphur @ 45 kg ha^{-1} along with dual inoculation of PSB and *Azotobacter* increased biological yield in q ha^{-1} by 309.4, 67, 80.3, 40.4, 46 and 14.5 per cent over uninoculated control (6.73 qha^{-1}), only PSB inoculation (16.5 q ha^{-1}), only Azotobacter inoculation (15.28 q ha^{-1}), dual inoculation of PSB + *Azotobacter* (19.62 q ha^{-1}), sulphur @ 15 kg ha^{-1} along with single inoculation of PSB (18.87 q ha^{-1}) and sulphur @ 15 kg ha^{-1} along with single inoculation of *Azotobacter* (22.03 q ha^{-1}) respectively. It may be concluded that biological yield promisingly increase with the sulphur level and with single or combined seed inoculation of PSB and *Azotobacter* by 12.1 to 309.4 per cent. The study of Shah *et al.* (2013); Panda *et al.* (1991) also concluded that increasing level of sulphur lead to higher bilogical index.

Harvest Index (%)

Harvest index was also calculated depending upon the seed yield and biological yield and presented in table 2. The ranges of harvest index lies between 28.71 to 35.59 per cent for the crop but there was no significant difference between treatments.

Table 2. Effect of treatments on crop yield

Treatment	Seed Yield	Stover Yield	Biological Yield	Harvest Index (%)
	q ha^{-1}			
Control	2.03	4.70	6.73	28.71
S @ 0 kg ha^{-1} + PSB	5.15	11.35	16.50	33.86
S @ 0 kg ha^{-1} + *Azotobacter*	5.03	11.58	15.28	33.55
S @ 0 kg ha^{-1} +PSB+ *Azotobacter*	5.40	12.62	19.62	35.37
S @ 15 kg ha^{-1} +PSB	7.00	13.17	18.87	31.63
S @ 15 kg ha^{-1} + *Azotobacter*	6.73	15.30	22.03	30.83
S @ 15 kg ha^{-1} + PSB + *Azotobacter*	6.93	17.63	24.57	32.44
S @ 30 kg ha^{-1} + PSB	6.06	14.63	20.69	32.21
S @ 30 kg ha^{-1} + *Azotobacter*	7.48	14.87	22.35	33.65
S @ 30 kg ha^{-1} + PSB + *Azotobacter*	8.21	15.03	23.25	35.59
S @ 45 kg ha^{-1} + PSB	5.83	18.60	20.43	29.24
S @ 45 kg ha^{-1} + *Azotobacter*	7.13	17.22	24.22	29.98
S @ 45 kg ha^{-1} + PSB + *Azotobacter*	8.51	19.57	28.42	30.08
Sem (±)	0.48	1.185	1.38	2.81
CD 5%	1.40	3.457	4.05	8.19
CV %	13.25	14.32	11.75	14.84
RBD(0.05)	S	S	S	NS

Highest harvest index was obtained from treatment sulphur @30 kg ha^{-1} + PSB + *Azotobacter* (35.59%) and lowest was obtained from uninoculated control (28.71%).

Estimation of oil content and crude protein content of sesame seed

Oil content of sesame (%)

Analysis of oil content of sesame was carried out and presented in table 3. Perusal of table indicates that the oil content of sesame ranges between 41.8 to 52.33%. Irrespective of strains, co-inoculation with each other and fertilizers as basal always recorded more oil content in comparison to the uninoculated control. The basal application of sulphur @ 45 kg ha^{-1} along with combined seed inoculation of *Azotobacter* and PSB increased the oil content of sesame (52.33%) as compared to uninoculated control (41.80%). The maximum oil content was recorded for treatment sulphur @ 45 kg ha^{-1} along with combined seed inoculation of PSB + *Azotobacter* (52.33%) followed by sulphur @ 45 kg ha^{-1} along with single seed inoculation of *Azotobacter* (51.77%) and sulphur @ 45 kg ha^{-1} along with single seed inoculation of PSB (50.57%). The minimum oil content of 41.8 per cent was noticed in untreated control. The highest oil content with sulphur @ 45 kg ha^{-1} along with combined seed inoculation of PSB + *Azotobacter* registered an increase of 25.1 per cent over control. Almost similar increasing trend of oil content were noticed due to nitrogen and bio fertilizer application with different level of sulphur. The increase in oil content may be due to fact of positive influence of sulphur on bio synthesis of oil. Increased oil content due to application of nitrogen and sulphur was also reported by Das and Das (1995) and Imayavaramban *et al.* (2002). The acetic thiolinase, a sulphur based enzyme in the presence of S convert acetyl Co-A to melonyl Co-A, rapidly resulting in higher oil content in seed crops (Krishnamurthy and Mathan, 1996). However, this study corroborates the study of previous study that increase in oil content due to higher level of sulphur application (Singh *et al.,* 2006; Patel and Shelke 1995 and Jaggi and Sharma 1999).

Protein content of sesame (%)

The observed result of protein content of sesame presented in table 3 indicated that the trend in protein content was similar to that of nitrogen uptake by sesame. Study indicates that the protein content increased significantly over control and varied from 19.27 per cent to 25.79 per cent. The maximum protein content of 25.79 per cent was recorded in treatment with application of sulphur @ 45 kg ha^{-1} + PSB + *Azotobacter* with an increase of 0.33 per cent over control. Almost similar increasing trend of protein content were noticed due to the application of nitrogen and bio fertilizer with different level of sulphur. The minimum protein content of 19.27 per cent was noticed in untreated control. Patel and Shelke (1995) observed that not only the total quantity of protein was improved by sulphur addition but at the same time the quality of protein was also improved. They observed that relative proportion of all sulphur containing amino acids, *viz.* methionine, cysteine and cysteine increased significantly. This indicates that synthesis of these amino acids is impeded without supply of a prime element *i.e.* sulphur and stimulated rapid metabolism at a faster rate with successive higher levels applied (Das and Das 1995).

The study showed integrtated use of biofertilizers and chemical fertilizers in sesame helps in higher yield. The application of sulphur @ 45 kg ha-1 along with combined seed inoculation of Azotobacter and PSB gave the highest crop yield as compared to uninoculated control along with maximum oil and protein content of sesame in treatment with application of sulphur @ 45 kg ha-1 along with combined inoculation of PSB and Azotobacter. The finding of integrated use of sulphur and co-inoculation of biofertilizers mainly with PSB+Azotobacter resulting into higher yield and better quality of sessame seed when the rate of the nutrient application is below the normal rate. Thus higher yield and its quality leads to overall profit to the farmers. Thus, it may be recommended that application of sulphur @ 45 kg ha-1 along with combined seed inoculation of Azotobacter and PSB will gave the maximum profit for the farmers of red and lateritic belt of West Bengal and other part of country where ever the soil of this kind is available.

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Table 3. Oil and protein content of sesame seed

Treatment	Oil content (%)	Oil Yield (Kg/ha)	Crude Protein %	Protein (kg/ha)
Control	41.80	0.85	19.27	39.12
S @ 0 kg ha^{-1} + PSB	42.27	2.18	24.34	125.20
S @ 0 kg ha^{-1} + *Azotobacter*	42.50	1.57	24.83	91.77
S @ 0 kg ha^{-1} + PSB + *Azotobacter*	42.40	2.97	25.09	175.25
S @ 15 kg ha^{-1} + PSB	44.87	2.56	24.46	138.88
S @ 15 kg ha^{-1} + *Azotobacter*	45.27	3.04	25.26	170.22
S @ 15 kg ha^{-1} + PSB + *Azotobacter*	45.53	3.16	24.96	173.38
S @ 30 kg ha^{-1} + PSB	47.50	2.88	24.73	149.88
S @ 30 kg ha^{-1} + *Azotobacter*	48.17	3.60	23.68	177.11
S @ 30 kg ha^{-1} + PSB + *Azotobacter*	48.73	4.00	25.31	207.76
S @ 45 kg ha^{-1} + PSB	50.57	2.95	26.65	155.59
S @ 45 kg ha^{-1} + *Azotobacter*	51.77	3.62	24.58	172.03
S @ 45 kg ha^{-1} + PSB + *Azotobacter*	52.33	4.46	25.79	219.66
Sem (±)	0.28	0.29	0.33	16.86
CD 5%	0.82	0.87	0.95	49.21
CV %	1.05	11.78	2.31	13.30
RBD(0.05)	S	S	S	S