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Effect of Organic Nutrient Sources and Chemical Fertilizers on Crop Growth and Yield of Sesame (*Sesamum indicum* L.) in Coastal Saline Zone of West Bengal

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***Abstract*:** Sesame has great potential in decreasing current gap between production and consumption of vegetable oil with lower levels of agricultural inputs. Combined application of various organic and inorganic nutrient sources is addressed by many researchers for obtaining higher yield of many oilseed crops. However, fewer findings are available on this to enhance growth and yield of oilseeds in Indian sub-continent. Field experiment was formulated to study the effect of different organic nutrient sources in combination with various doses of nitrogenous fertilizer for enhancing seed and oil yield of sesame in *pre-kharif* season of 2023 and 2024 comprising nine treatments combining different percentage of nitrogenous fertilizer, vermicompost, FYM, sulphur and *Azospirillum* that can significantly improve growth and yield of sesame. Application of 75% RDN + 25% vermicompost + *Azospirillum* recorded highest seed yield (1083 kg/ha) and oil yield (479.7 kg/ha) among all the treatments, although 75% RDN + 25% vermicompost + sulphur @20 kg/ha significantly increased oil content (44.7%) of sesame. Combined effect of vermicompost and microbial inoculation reflected better vegetative and reproductive growth that ultimately triggered seed and oil yield of sesame while improved oil content was obtained due to additional sulphur fertilization.

***Keywords*:** Sesame, Seed yield, Vermicompost, Microbial inoculation, Sulphur fertilization

Oilseed crops are thought to be the second most significant economic factor after cereals influencing India's agricultural economy. India has now become self-sufficient in cereal crop production while it is lagging behind in oilseed production. India is currently the world's biggest importer of vegetable oils despite being the fifth- largest nation in oilseed production. Therefore, it is crucial to maintain and increase the productivity of oilseed crops in order to sustain food and nutritional security (DRMR 2015, Meena et al., 2015, Lal 2016, Singh and Singh 2017 and Singh et al., 2017). In India, per capita vegetable oil consumption is 14.1 kg, which is substantially less than the global average of 23.6 kg (GOI 2015). Again, the current population growth is driving up per capita demand at a rate that domestic oilseed supply could not keep up with. Thus, there is an immediate need for augmentation of vegetable oil production in India.

Sesame (*Sesamum indicum* L.) is considered as an important edible oil source in terms of nutritional benefits as well as high quality oil in the world. It has great potential in decreasing the current gap between the production and consumption of the vegetable oil with lower levels of agricultural inputs. Sesame oil contains about 17-20% of good quality protein along with 40-50% of vegetable oil (Gholamhoseini 2020). However, majority of the cultivated area is occupied by small and marginal landholders with limited agronomic management. In contrast, the crop can be grown under limited water supply and fairly high temperature due to its relatively high drought tolerance with shortened vegetative growth.

Varieties with high yield potentiality, application of adequate amount of nutrients, weed control and good irrigation water management practices are the key to enhanced production of any crop. Similarly, productivity of sesame can also be enhanced following several agronomic measures including nutrient management practices. Application of various organic nutrient sources (manures, bio-fertilizers etc.) combined with chemical fertilizers is frequently addressed by many researchers for obtaining higher crop yield and improving soil biological, physical and chemical properties. The current tendency is to investigate the possibilities of using organic manures, which are more economical and environmentally benign, in addition to chemical fertilizers (Das and Goswami 2017). Application of bio-fertilizer can also significantly improve the growth and yield parameters of sesame. However, fewer findings are available on using various organic nutrient sources in combination with chemical fertilizers under field conditions to enhance the growth and yield of sesame in coastal soils of the Indian sub-continent. Therefore, this experiment was formulated to replace a part of nitrogenous fertilizers by organic nutrient sources for augmenting the crop yield, enhancement of economic benefits and improving the health of these poorly fertile coastal soils.

MATERIAL AND METHODS

Experimental site: The field experiment was carried out at The Neotia University, Diamond Harbour, South 24 Parganas, West Bengal in the *pre-kharif* season of 2023 and 2024. The farm is geographically located at 22°26' N latitude and 88°19' E longitude with an average altitude of 8 m above the mean sea level . The soil of the experimental field was fine textured and clayey type, having 213.6 kg/ha available N, 22.5 kg/ha available P_2O_5, 312.26 kg/ha available K_2O and 0.46% organic carbon. The climate of the area is sub-tropical and humid. The experimental period was hot and received moderate rainfall (Table 1).

Layout and treatment details: The experiment was carried out in a randomized complete block design (RCBD) comprising nine treatments each replicated thrice with plot size of 4 m × 3 m. Width of irrigation channels was 1 m and bund width of each plot was kept 0.5 m. Treatment details with different nutrient combinations are given in Table 2. FYM and vermicompost were collected from the Instructional Farm (dairy and vermicompost unit), School of Agriculture and Allied Sciences, The Neotia University and *Azospirillum* was brought from the Vivekananda Institute of Biotechnology, Nimpith Ashrama, South 24 Parganas, West Bengal.

Observation: Crop was raised as per recommended practices (Ranganatha et al., 2013). Agronomic observations were recorded from each plot by selecting ten plants randomly on plant height, branches per plant, dry matter accumulation and yield components *viz.* number of capsule per plant, capsule length, seeds per capsule, thousand seed weight, seed and stover yield and harvest index (HI) were taken. Approximately, 2 g of well dried sesame seeds were used from each treatment to estimate the oil content by Soxhlet apparatus using petroleum ether (AOAC 1960) and thereafter oil yield was calculated by multiplying the estimated oil percentage with the seed yield. Post-harvest soil samples were collected from each of the treatment plot from 0-30 cm soil depth. The samples were air-dried, crushed, sieved and stored in container for subsequent chemical analysis. The analysis involved all the standard procedures to determine available nitrogen, available phosphorus, and available potassium content as described by Jackson (1973). Soil nutrient index was also calculated (Parker et al., 1951) .

$$\text{Soil Nutrient Index (SNI)} = \frac{N_1 \times 1 + N_2 \times 2 + N_3 \times 3}{N_T}$$

Where,

N_1 = Number of samples falling in low class of nutrient status;

N_2 = Number of samples falling in medium class of nutrient status;

N_3 = Number of samples falling in high class of nutrient status and

N_T = Total number of samples.

Statistical analysis: Statistical data analysis was carried out using OPSTAT software and Fisher's least significant test was used to compare the mean values at a probability level of 0.05.

Table 2. Details of the experimental treatments

Treatment	Details
T_1	Control (RDF)
T_2	75% RDN + 25% Vermicompost
T_3	75% RDN + 25% Vermicompost + *Azospirillum*
T_4	75% RDN + 25% Vermicompost + Sulphur
T_5	50% RDN + 50% Vermicompost + *Azospirillum* + Sulphur
T_6	75% RDN + 25% FYM
T_7	75% RDN + 25% FYM + *Azospirillum*
T_8	75% RDN + 25% FYM + Sulphur
T_9	50% RDN + 50% FYM + *Azospirillum* + Sulphur

Table 1. Meteorological data during the period of field experimentation (pooled data)

Months	Temperature (^{0}C)		Rainfall (mm)	Relative humidity (%)		Bright sunshine (hrs)
	Maximum	Minimum		Maximum	Minimum	
February	29.72	18.42	6.8	92.46	63.37	6.83
March	33.61	21.35	32.2	93.85	65.42	7.12
April	36.45	24.81	15.4	94.75	66.13	6.75
May	39.42	25.87	18.7	94.21	61.43	6.63
June	36.12	24.78	51.2	95.16	58.19	6.23

Source: Department of Soil Science & Agricultural Chemistry, SAAS, TNU

RESULTS AND DISCUSSION

Crop growth parameters: Supplementation of inorganic fertilizer by organic nutrient sources in diverse combinations induced distinct variation in growth parameters of sesame to a great extent. Crop growth in terms of plant height increased as the crop grew older and moved towards maturity, irrespective of the difference in nutrient combinations (Table 3). Every aspect of nutrient variations positively impacted growth parameters. Amongst all the treatment combinations, the maximum height (99.2 cm) was in T_3 (*i.e.*75% RDN + 25% vermicompost + *Azospirillum*) followed by T_4 and T_2. Integrating chemical fertilizer, organic manure, and biofertilizer provided superior results in terms of nutrient availability and uptake as compared to the use of any of the three sources individually. Ahirwar et al., (2017) also reported that the trend of increase in plant height might be due to nutrient allocation from varied sources which aided in continuous availability of nutrients to the growing plants for a longer period. The significant reduction of plant height was when inorganic nitrogen was reduced to half of the recommended doses irrespective of biofertilizer and sulphur fertilization. The treatment of 75% RDN + 25% vermicompost along with additional application of either biofertilizer viz. *Azospirillum* or sulphur exhibited maximum primary branches production in both the seasons, whereas the treatment, half of the recommended doses of inorganic nitrogen together with any of the two different type of organic manure incorporation and supplementary sulphur and microbial inoculation i.e., T_5 and T_9 exhibited lowest number of primary branches per plant which might be due to lack of inorganic nitrogen that could enhance the rate of branch production. The incorporation of nutrients through organic sources especially via vermicompost and *Azospirillum* inoculation, along with 75% RDN and full P, K applications improved the dry biomass production per plant. At harvest, maximum amount of dry matter was produced from treatment T_3 (245.6 g/m^2) which was statistically at par with T_4, T_2 and T_1. Sahu et al., (2017) revealed that potential of free-living nitrogen-fixing bacteria to improve plant growth through nitrogen fixation as well as the impact of their metabolites secretion on the crop may be ascribed for the same when combined with potential biofertilizer or organic nutrient sources.

Yield attributes: The seed inoculation of sesame with *Azospirillium* in conjunction with 25% vermicompost + 75% RDN incorporation (T_3) significantly increased the capsule production in individual plant than remaining treatments (Table 3). Followed by the result of two consecutive years, the average variation of capsule numbers was to the tune of 20.48% from lowest (41.5) to highest (50.0) treatment. Integrated nutrient management through chemical fertilizer, microbial biofertilizer and vermicompost triggered better dry matter allocation to reproductive parts of plants. Veeral and Nayakanti (2019) also reported that balanced application of nutrients from different sources helped in greater photosynthetic activity and efficient translocation of photosynthates from source to sink, which might be attributed to greater number of capsule formations. Length of each capsule did not vary significantly due to variations of sources and doses of nutrients in respective seasons. The higher number of seeds per capsule was maximum (45.2) in T_3 followed by T_4, T_2 and T_1 which distinctly indicated that full recommended doses or partial (25%) replacement of chemical fertilizer + vermicompost in addition with *Azospirillium* or sulphur fertilization proved to be superior regarding seed production per capsule than FYM application along with the similar combinations. Diversified nutrient applications did not exhibit significant variations in 1000 seed weight of sesame plants.

Seed yield and oil yield: Seed yield revealed positive

Table 3. Effect of organic nutrient sources and chemical fertilizers on growth and yield attributes (pooled data)

Treatment	Plant height (cm)	No. of primary branches plant^{-1}	DMA (g m^{-2})	Number of capsule plant^{-1}	Capsule length (cm)	Number of seeds capsule^{-1}	1000 seed weight (g)
T_1	95.4	3.2	233.7	45.2	2.25	42.8	2.46
T_2	97.1	3.3	235.2	47.3	2.28	43.1	2.47
T_3	99.2	3.4	245.6	50.0	2.30	45.2	2.50
T_4	98.7	3.4	240.1	47.7	2.28	43.9	2.48
T_5	93.2	3.0	225.1	41.5	2.29	41.7	2.43
T_6	93.4	3.1	222.8	42.0	2.26	41.9	2.42
T_7	94.0	3.2	227.3	42.9	2.30	41.5	2.44
T_8	94.4	3.2	229.3	43.3	2.27	41.7	2.45
T_9	93.7	3.0	220.4	42.3	2.28	41.4	2.42
CD (p=0.05)	3.62	0.16	12.53	1.70	NS	1.63	NS

See Table 2 for treatment details

response due to nutrient supply from vermicompost, with supplemental application of *Azospirillum* inoculum or sulphur fertilization in combination with 75% recommended dose of nitrogen and 100% of phosphorous and potassium. Highest seed yield (1083 kg/ha) was from T_3 which was statistically at par with T_4 (Table 4). The combined effect of vermicompost and microbial inoculation reflected better vegetative and reproductive growth that ultimately helped in enhancing the seed yield. The increased seed yield of sesame under T_3 might be attributed to higher nutrient availability particularly N to the plants (Das et al., 2021). Simultaneous application of vermicompost and growth-promoting bacteria can also enhance the yield of sesame through a synergistic connection (Akhgar and Sotodeh 2021). Pooled over data of two consecutive seasons revealed that seasons T_3 recorded highest stover yield (3060 kg/ha) as compared to all other treatments. On the contrary, skip of half the recommended doses of inorganic nitrogen along with 25% FYM application with sulphur fertilization and microbial inoculation disclosed poor performance in respect to all the major parameters. No significant difference has been found for harvest index of sesame due to nutrient versatility. Highest oil content (44.7%) was recorded from T_4 treatment where sulphur fertilization was done additionally along with other inorganic and organic nutrient sources while T_3 treatment exhibited maximum oil yield (479.7 kg/ha) due to highest seed production. There was strong correlation of sesame seed yield with other growth and yield attributes during the study period (Fig. 1).

Available soil nutrients: Post harvest soil available N, P and K of sesame varied significantly within the treatments (Table 5). Treatments with full amount of N from urea solely or with vermicompost in combination with either microbial inoculation or sulphur fertilization recorded significantly higher soil available N over the treatments obtained nutrition from integrated application of inorganic fertilizers and FYM as organic nutrient sources. Significantly maximum available soil nitrogen (329.14 kg/ha) after harvest of the crop was in T_3 while lowest (271 kg/ha) was in T_9 treatment. Significantly higher available phosphorus (43.20 kg/ha) was in 100 % chemical fertilizer applied treatments. The maximum available potassium (353.16 kg/ha) content was registered from T_1 followed by T_3 and T_2. This could be because adding organic sources to the soil from vermicompost along with inorganic fertilizers generated an environment that was favourable for microbial multiplication and biochemical activity, enhanced water holding capacity and CEC of the soil led to a proliferating root system that added organic matter to the soil and released complex organic substances during organic matter decomposition, which in turn formed more stable available nutrients.

Nutrient index and soil fertility: Effect of multiple nutrient sources with versatile doses influenced the availability of soil nutrients significantly which in turn showed a distinct

Table 5. Effect of organic nutrient sources and chemical fertilizers on soil available nutrients (pooled data)

Treatment	Available nitrogen (kg/ha)	Available phosphorous (kg/ha)	Available potassium (kg/ha)
T_1	316.50	43.20	353.16
T_2	327.45	35.42	341.25
T_3	329.14	38.63	348.53
T_4	318.40	36.08	337.60
T_5	273.24	31.97	330.11
T_6	296.15	33.69	336.47
T_7	309.60	35.24	337.25
T_8	291.36	33.19	331.57
T_9	271.00	30.49	326.48
CD (p=0.05)	16.02	1.34	13.03

See Table 2 for treatment details

Table 4. Effect of organic nutrient sources and chemical fertilizers on yield and oil content (pooled data)

Treatment	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)	Oil content (%)	Oil yield (kg/ha)
T_1	952	2841	25.1	44.2	421.2
T_2	1029	3056	25.3	43.3	445.7
T_3	1083	3060	26.1	44.3	479.7
T_4	1056	3043	25.8	44.7	472.0
T_5	899	2748	24.7	43.5	392.2
T_6	963	2891	25.1	42.5	409.6
T_7	977	2863	25.5	41.6	407.2
T_8	981	2887	25.4	43.6	427.7
T_9	878	2646	24.9	41.3	362.6
CD (p=0.05)	46.09	163.51	NS	2.19	16.29

See Table 2 for treatment details

variation in nutrient indexing regarding all three macronutrients with special emphasis on nitrogen level (Table 6). SNI for available N, P and K was 1.78, 3 and 3 respectively, against the standard nutrient index value <1.67 for low, 1.67 to 2.33 for medium and >2.33 for high fertility status of the sesame harvested soil. Followed by the nutrient index analysis, soil fertility status is medium with respect to nitrogen content and status is high for both phosphorous and potassium content.

Production economics Application of 30 kg N (75% RDN) + 30 kg P_2O_5 (100% RDP) + 20 kg K_2O (100% RDK) through chemical fertilizers along with vermicompost and *Azospirillum* (T_3) inoculation as organic nutrient sources recorded maximum gross return (Rs. 89022 /ha), net return (Rs. 55837 /ha) and B:C ratio (1.68) (Table 7). The lowest

Table 6. Effect of organic nutrient sources and chemical fertilizers on soil nutrient index and fertility status (pooled data)

Available nutrients (kg/ha)	Nutrient index	Fertility status
Nitrogen	1.78	Medium
Phosphorous	3	High
Potassium	3	High

Table 7. Effect of organic nutrient sources and chemical fertilizers on production economics (pooled data)

Treatment	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	B:C Ratio
T_1	29293	77398	48102	1.64
T_2	33125	84584	51462	1.55
T_3	33185	89022	55837	1.68
T_4	33790	86803	53013	1.57
T_5	33850	73088	39244	1.15
T_6	31117	79158	48046	1.54
T_7	31177	80309	49134	1.57
T_8	31782	80638	48859	1.53
T_9	31842	71381	39538	1.24

See Table 2 for treatment details

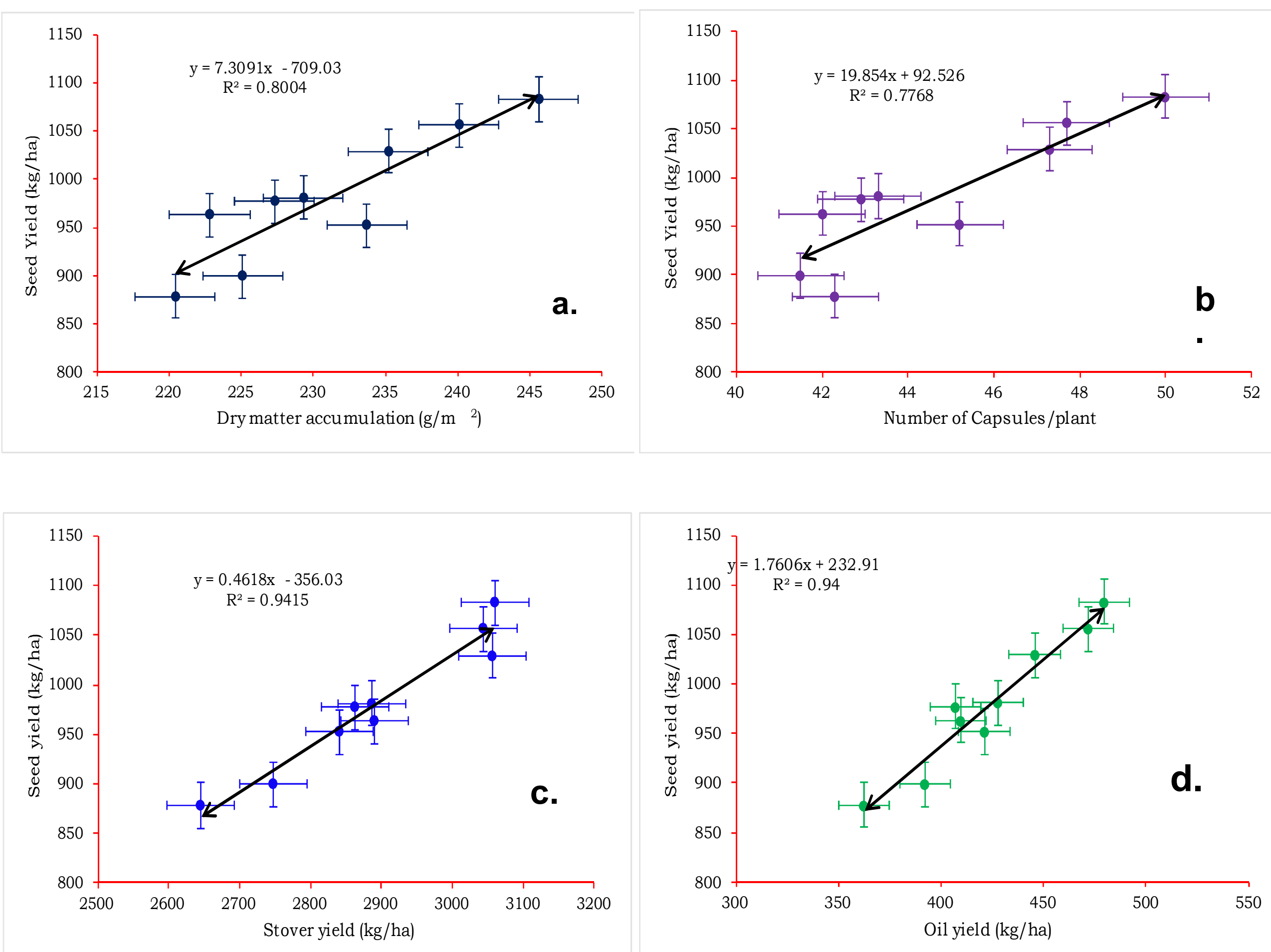

Fig. 1. Regression analysis of seed yield of sesame with a. dry matter accumulation, b. number of capsules plant^{-1}, c. stover yield and d. oil yield

monetary return in terms of net return and B:C ratio was obtained from T_5 where half amount of inorganic nitrogen was replaced by vermicompost incorporation followed by additional sulphur fertilization + microbial inoculation that might be attributed to high production cost.

CONCLUSIONS

The combined use of organic and inorganic sources of nutrients improved all the growth and yield attributes of sesame. Vermicompost and *Azospirillum* integration along with partial (25%) replacement of inorganic nitrogen fertilizer revealed highest seed and oil yield of sesame. Application of 75% RDN + 25% vermicompost + *Azospirillum* was identified as the best conjunction which exhibited higher content of available nitrogen in the soil and maximum economic benefit. Partial substitution of inorganic fertilizers with different organic nutrient sources not only offer better crop productivity but also strengthen soil health, thus maintaining the sustainability of eco-system to a great extent.

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