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ECONOMIC FEASIBILITY ANALYSIS ON THE EFFICACY OF MICRONUTRIENT AND BIOFERTILIZER IN SESAME

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ABSTRACT

An experiment was carried out at the Assam Agricultural University-Zonal Research Station, Diphu, Karbi Anglong District, Assam during 2024-25 to examine the efficacy and economic feasibility of micronutrient and bio-fertilizer application on sesame crop. From the results it was found that recommended fertilizer application of $N_{30}P_{20}K_{20}$+ $B_{1.5}$+ $Zn_{10.5}$+FYM (3t/ha)+ Biofertilizer (Azospirillum, PSB and KSB each @ 50gm/ Kg seed as seed treatment) produced the highest number of branches and capsules per plant, a significant increase in the number of seeds per capsule and seed weight. Similar trends were observed with treatments involving fertilization with $N_{30}P_{20}K_{20}$ + $B_{1.5}$+ $Zn_{10.5}$+FYM (3t/ha) which confirmed the positive influence of organic and micro nutrient amendments on sesame growth and yield. The highest seed yield was recorded in the treatment T_9, demonstrating a 80.1% improvement in seed weight per plant over T_1. Furthermore, economic analyses revealed that treatments with organic inputs yielded substantial gross and net monetary returns, with $N_{30}P_{20}K_{20}$+ $B_{1.5}$+ $Zn_{10.5}$+FYM (3t/ha)+ Biofertilizer (Azospirillum, PSB and KSB each @ 50gm/ Kg seed)giving the highest gross monetary returns of Rs 52015 ha^{-1}, while $N_{30}P_{20}K_{20}$ + $B_{1.5}$+ $Zn_{10.5}$+FYM (T_7) produced the second highest net monetary returns of Rs 47463 ha^{-1}. The B:C ratio analysis indicated a favourable return on investment, especially in T_9, which achieved a B:C ratio of 1.90 : 1.00 which was at par with T_7. Overall, the study highlights the crucial role of organic manures, micro nutrient and bio- fertilizers in promoting a sustainable and profitable sesame production.

***Key words*:** Sesame, yield, zinc, boron, biofertilizer, fertilization.

Introduction

Sesame (*Sesamum indicum*) known as the queen of oilseeds is an important oil seed crop which is used as a spice and for seasoning food (Rebinson, 2022). It belongs to the botanical family 'Pedaliaceae' and also known by the names gingelly, benne, benniseed, simsim and sesamol (Kumar & Patel, 2023). Sesame seed is believed to have originated in East Africa or Asia and the ancient Egyptians and the Chinese are said to have used it for more than 5000 years ago. Sesame seeds were used in traditional medicines for centuries. It is rich in calcium, phosphorus and zinc, healthy unsaturated fats, natural compounds sesamin and sisamol, vitamin E, Vitamin B12 (thiamine) copper and antioxidants (Anon, 2025). The presence of such important nutrients will help in improving the human health through regulation of cholesterol, blood pressure and lower the blood sugar level. Therefore, inclusion of sesame in the daily diet will help to overcome bone disorders, cardiovascular health problems, control LDL and HDL and proper brain functioning. Since sesame is a slow digesting food it helps in energy stabilization throughout the day. It also helps in keeping the skin radiant, hair growth and keeps the hair strong and shiny.

Worldwide sesame seed consumption was USD 6559.0 million in 2018, and it is estimated that it will reach USD 7244.9 million by 2024, with a CAGR (compound

annual growth rate) of 1.7% (*). Global sesame consumption is steadily increasing mainly due to the change in consumer's consumption patterns and increase in health awareness. Myanmar is the largest producer of sesame followed by India, China, Sudan and Tanzania. The main exporter is Sudan, India, Nigeria, Burma and Tanzania, while the top importers are China, Japan, Turkey, South Korea and Iran. In India, the largest producer of sesame seed is Gujarat, followed by West Bengal, Karnataka, Rajasthan, Madhya Pradesh, Tamil Nadu, Maharashtra and Andhra Pradesh.

In Assam, Karbi Anglong District is the largest producer of sesame contributing about 26.2 percent of the total area in the State. The area under sesame in Karbi Anglong district is 3.08 thousand hectares as in 2015-16 (DES 2025) The District receives very less rainfall and the people of this district generally grow sesame either as mixed crops in traditional farming system (Jhum*)* or as mono-cropping. Among different crops, sesame is an important oilseed crop in the district and it forms an important diet for the Karbi people. In Karbi Anglong district sesame is grown during the *kharif* season and harvested in the month of October or November 1st week. The farmers do not have the habit of applying any organic manure or chemical fertilizer. Therefore, the yield of sesame is very low at 7.8qtl per hectare which is below the potential yield of 10qtl per hectare. Sesame productivity can be enhanced through the coordinated use of nutrients which can assist in achieving the potential yield while maintaining its quality. Today's production costs are on the increase because of the increased expenditure in the use of chemical fertilizers. Therefore, use of organic fertilizers in combination with inorganic fertilizers can help in reducing production costs while maintaining soil health. Coordination of nutrients in combination with organic or inorganic fertilizer treatment is crucial for improving high yield, seed quality, and oil content (Kaviya *et al*., 2024).

Nitrogen is one of the most essential plant nutrients for plant growth and crop yield. The ability to fix nitrogen is a vital physiological characteristic of Azotobacter. Azotobacter cells are not usually present on the root surface but are abundant in the rhizosphere and protect the roots from other pathogens present in the soil. Azotobacter, have the potential to meet a significant portion of the nitrogen requirements of sesame crops. These microorganisms convert atmospheric nitrogen into a form that is readily available to plants, thereby reducing the need for synthetic nitrogen inputs (Kumar *et al*., 2023). [Reddy and Sudhakarababu (1996) indicated that nitrogen fixing bacteria can be used to decrease the use of N fertilizer upto 50 per cent.

Besides, micronutrients play an important role in increasing yield of sesame. Due to continued cultivation and production of crops without applying any supplements, it leads to deficiency of macro and micro nutrients in the soil. Zinc (Zn) is one of the elements which play crucial role in sesame crop production. Nutrients depletion particularly micronutrients in the soil therefore, is increasing due to lack of nutrient management. The high demand of modern crop cultivars with higher yield potentials has also aggravated the micronutrient deficiency problems. Micronutrients such as zinc and boron play an important role in increasing yield of pulses and oilseed crops. Their impact can affect the growth and development, seed yield, stalk yield, oil content, protein content, carbohydrate content, nutrient uptake and dry matter accumulation. Symptoms of zinc deficiency mainly, include growth and yield reduction, delay in seed maturation, production of low concentration of phyto-hormones, reduced cell division and production of malformed fruit in severe deficiency condition etc. Strategies are needed for eradication of S and Zn deficiency through proper management of nutrients and this may lead to an era of sustainable sesame production and its application in future agricultural production system (Nayak and Singh2024). According to Dutta, S. (2025) boron application increased significantly seed yield, oil content and protein content of sesame. Boron application increased phosphorus content in plants marginally.

In view of the importance of micronutrient in crop production and human health this research can assist in obtaining a high yield in Hillagro climatic zone and through this paper an attempt was made to find out the economic feasibility of application of micro nutrient and bio-fertilizer in sesame crop

Materials and Methods

The experiment was carried out at the Assam Agricultural University-Zonal Research Station, Diphu, Karbi Anglong District, Assam. The experiment was conducted in complete randomized block design with three replications and nine treatments the details of which are given below.

Treatments details:

S. No.	Treatment
T_1	RDF + FYM
T_2	RDF +$B_{1.0}$+FYM
T_3	RDF +$B_{1.5}$+FYM
T_4	RDF +Zn_5+FYM
T_5	RDF +$Zn_{10.5}$+FYM
T_6	RDF + $B_{1.0}$+ Zn_5+FYM

T_7	RDF + $B_{1.5}$+ $Zn_{10.5}$+FYM
T_8	RDF + $B_{1.0}$+ Zn_5+FYM + Biofertilizer (Azospirillum, PSB and KSB each @ 50gm/ Kg seed as seed treatment)
T_9	RDF + $B_{1.5}$+ $Zn_{10.5}$+FYM+ Biofertilizer (Azospirillum, PSB and KSB each @ 50gm/ Kg seed as seed treatment)

- Recommended dose of fertilizer (RDF) = 30kgN/ ha + 20kgP_2O_5/ha + 20kgK_2O/ha.
- $B_{1.0}$ & $B_{1.5}$ – Boron @1.0kg/ha and 1.5kg/ha.
- Zn_5&$Zn_{10.5}$ – Zinc @ 5.0kg/ha and 10.5kg/ha
- Biofertilizer (Azospirillum, PSB and KSB each @ 50gm/Kg seed as seed treatment)
- FYM (Farm Yard Manure @ 3 ton/ha).
- Variety- AST 1.
- Spacing-30cm × 15cm.
- Experimental design- RBD with three replications
- The experiment was conducted for two consecutive years from 2022 to 2023 at AAU-ZRS, Diphu and multi-location trials andon farm trials were conducted at different locations of Assam in 2024.
- PSB- Phosphorus solubilizing bacteria, KSB- Potassium solubilizing bacteria

The yield and yield attributing parameters like plant height, number of branches/plant average number of capsules/branch, number of seeds/capsule and 1000 grain weights (gm) were recorded at harvest stage. Average grain yield of the two years' data was taken in to account for analysis of the results. The recorded data were analyzed using ANOVA statistical technique.

The data on input use such as seed rate, labour, fertilizer, biofertilizer, FYM, Zinc sulphateheptahydrate, Borax and grain yield were recorded and the prevailing market price was used to estimate the costs and returns of sesame under each treatment. The net return is calculated by multiplying the seed yield and their sale prices and subtracting the total cost of cultivation including treatment cost.

Gross returns (GR) = Grain yield kg × prevailing market price (Rs /kg)

Costs of production (TC) = Cost of all inputs used for production (Rs)

Net return = GR – TC

Benefit Cost Ratio (BCR) = GR/TC

Results and Discussion

Yield and yield attributing parameters:

The mean yield and yield attributing parameters of sesame recorded for two years is presented in Table 1. Among the treatments the tallest plant of sesame was recorded to be 203.55cm in T_6 but other yield parameters such as number of branches/plant (16.33), average number of capsules/branch (23), number of seeds/capsule (87.2) and 1000 grain weight (2.37gm) were recorded to be the highest in T_9. This is because of increasing levels of zinc sulphate up to 10.5 kg/ha and boron 1.5 kg/ha in combination with Azospirillum, PSB (Phosphate Solubilizing Bacteria), and KSB (Potassium Solubilizing Bacteria) which resulted insignificantly increased in the yield attributing parameters at harvest stage. The observed improvement might also be due to biosynthesis of IAA growth-hormones, cell enlargement, cell-division and multiplication. Zinc helps in plant hormone IAA biosynthesis in plant (Nayak and Singh 2024). Similar findings were also reported by Sharma and Jain (2003)

Due to plentiful availability of zinc leading to better nutritional environment in the root zone that helps in better growth and development and ultimately led to better leaf

Table 1: Yield and yield attributes of sesame (Mean of two years).

Treat-ments	Plant height (cm)	Branches / plant	Capsules / branch	Seeds /capsule	1000 grain weight(gm)	Grain yield/ha (kg)	Mean (q/ha)
T_1	156.00	8.67	19.67	72.2	1.66	527.8	5.28
T_2	160.00	11.00	20.67	73.1	1.69	632.2	6.32
T_3	172.33	10.00	21.00	73.6	1.79	665.4	6.65
T_4	186.67	9.33	19.33	74.8	1.83	619.8	6.20
T_5	197.33	12.67	20.33	75.2	1.85	710.2	7.10
T_6	205.33	13.00	19.00	75.4	2.07	779.1	7.80
T_7	182.33	12.33	20.67	76.7	2.13	911.5	9.12
T_8	180.00	13.00	21.33	79.8	2.15	819.3	8.20
T_9	188.33	16.33	23.00	87.2	2.37	954.7	9.54
CD	8.16	2.89	1.19	6.87	0.11	14.448	
CV%	6.19	5.27	4.19	7.82	2.16	6.57%	

Table 2: Economic analysis on costs and returns of sesame (Rs ha^{-1}).

T	GY	GR	CC	NR	B:C Ratio
T_1	527.8	58058	51872	6186	1.1
T_2	632.2	69542	52072	17470	1.3
T_3	665.4	73194	52172	21022	1.4
T_4	619.8	68178	52172	16006	1.3
T_5	710.2	78122	52502	25620	1.5
T_6	779.1	85701	52372	33329	1.6
T_7	911.5	100265	52802	47463	1.9
T_8	819.3	90123	52572	37551	1.7
T_9	954.7	105017	53002	52015	1.9
Farm Harvest Price of sesame = Rs 110kg^{-1} T: Treatment; GY: Grain yield (Kg/ha); GR: Gross Return (Rs); CC: Cost of cultivation (Rs); NR: Net Return(Rs)					

growth of sesame and boosted plant growth. Thus zinc plays a pivotal role in several physiological and biochemical processes which are of vital importance for the development of sesame plants. Besides, zinc is involved in the formation of S-containing amino acids, vitamins and has direct role in root growth (Yadav *et al*., 2020). So, the higher values of yield attributes, viz. capsules/plants, seed/capsules and 1000 grain weight, ultimately increased the seed yield of sesame from 5.28q/ha (T_1) to 9.54q/ha (T_9). Therefore, the yield and yield-attributing characters of sesame were significantly improved by zinc fertilization. Besides, zinc significantly boosts sesame yield by promoting essential functions like chlorophyll formation, cell division, and carbohydrate metabolism. Applying Zinc (typically as zinc sulfate) as foliar spray or soil application increased the yield of sesame increases the number of capsules per plant and seed weight, ultimately driving seed yields up by to 10-13% (Sanga D.L., 2013).

Boron application significantly increased the number of capsules per plant up to its highest level. Boron promotes the pollen-producing capacity of anthers and hence might have produced a higher number of seeds per capsule. It also has a positive effect on the photosynthetic performance of plants by influencing phosphorylation processes, reducing the quantity of assimilates consumed by respiration to obtain energy, and accelerating the removal of products of photosynthesis. Boron application increased seed yield significantly up to the highest level (Dutta, S., 2025). The effect could also be due to application of organic manures and bio-fertilizers which also contributed to significantly boosted the number of capsules per sesame plant, with FYM @ 3 $tonha^{-1}$ + Biofertilizer (Azospirillum, PSB and KSB each @ 50gmKg^{-1} seed as seed treatment) (T_9) and produced the highest yield with an increase of 80.1% as compared to the treatment (T_1).

Economic Feasibility Analysis of Sesame:

In recent years the production costs are rising due to the increased expenses of chemical fertilizers. Therefore, the use of organic fertilizers in conjunction with inorganic fertilizers can help in the reduction of production costs while also it helps in maintaining the soil health. Coordination of nutrients and organic or inorganic fertilizer treatment is crucial for high yield, seed quality, and oil content. Economic feasibility analysis is therefore essential to find out the particular technology is feasible especially for the poor, small and marginal farmers. In the present study the economic analysis on the total costs and returns were worked out and the result is given in Table 2.

Data pertaining to the effect of varying levels of fertilization on net returns of sesame showed that an increase in the level of biofertilizer as well as zinc and boron application could fetch significantly higher net

Table 3: Partial Budgeting (Rs ha^{-1}).

Treatment	Gross Return (Rs)	Cost of cultivation (Rs)	Added Return A (Rs)	Added Cost B (Rs)	Incremental Benefit (Rs)
T_1- $N_{30}P_{20}K_{20}$ + FYM	58058	51872	-	-	
T_2- $N_{30}P_{20}K_{20}$ +$B_{1.0}$+FYM	69542	52072	11484	200	11248
T_3- $N_{30}P_{20}K_{20}$ +$B_{1.5}$+FYM	73194	52172	15134	300	14834
T_4- $N_{30}P_{20}K_{20}$ +Zn_5+FYM	68178	52172	10120	300	9820
T_5- $N_{30}P_{20}K_{20}$ +$Zn_{10.5}$+FYM	78122	52502	20064	630	19434
T_6- $N_{30}P_{20}K_{20}$ + $B_{1.0}$+ Zn_5+FYM	85701	52372	27643	500	27143
T_7- $N_{30}P_{20}K_{20}$ + $B_{1.5}$+ $Zn_{10.5}$+FYM	100265	52802	42207	930	41277
T_8- $N_{30}P_{20}K_{20}$ + $B_{1.0}$+ Zn_5+FYM + Biofertilizer (Azospirillum, PSB and KSB each @ 50gm/Kg seed as seed treatment)	90123	52572	32065	700	31365
T_9-$N_{30}P_{20}K_{20}$+ $B_{1.5}$+ $Zn_{10.5}$+FYM+ Biofertilizer (Azospirillum, PSB and KSB each @ 50gm/Kg seed as seed treatment)	105017	53002	46959	1130	45829

returns over that of T_1 without applying any biofertilizer and micronutrient (Table 2). Further increase in its level to 1.5 $kgha^{-1}$ of boron and 10.5kg of zinc along with seed treatment of Azospirillum, PSB and KSB each @ 50gm/ Kg seed provided the highest net returns of Rs 52015ha^{-1}. This level of zinc fertilization at 10kg/ha in combination with boron @ 1.5$kgha^{-1}$and Azospirillum, PSB and KSB each @ 50gm /kg seed as seed treatment provided an additional net returns of Rs 45829ha^{-1} over that of T_1. Treatment T_7 provided the next highest return at Rs 47463ha^{-1} by applying 5 kg zinc, 1.5kg boron and Azospirillum, PSB and KSB each @50gm kg^{-1} seed as seed treatment. It is further apparent from Table 2 that application of zinc sulphate and boron fertilization fetched significantly higher net returns in sesame over preceding levels up to 10.5 $kgha^{-1}$and 1.5kg ha^{-1}, respectively.

The benefit-cost (B:C) ratio analysis reveals that treatments involving organic manures and bio-fertilizers significantly enhance the economic viability of sesame cultivation. Notably, the treatment with FYM @ 3 $tonha^{-1}$ + Biofertilizer (*Azospirillum*, PSB and KSB each @ 50gmKg^{-1} seed as seed treatment (T_9) achieved a B:C ratio of 1.9 : 1.0 implying that one rupee investment by adopting this particular technology could fetch an income of two rupees with a net profit of ninety paisa. The result of the analysis showed that the BCR was at par with T_7. This indicated that T_9 and T_7 can be adopted by the farmers but from the net return side the farmers can adopt T_9 to get higher monetary profit. From the analysis it can be said that this particular technology with fertilization of FYM @ 3 ton/ha + Biofertilizer (*Azospirillum*, PSB and KSB each @ 50gmKg^{-1} seed as seed treatment is the most profitable one as compared to others and is found to be economically most viable for achieving highest profit from sesame production.

Partial Budgeting

Partial budgeting is an extremely useful type of budget to analyze the profitability of a proposed change inthe technology or various treatment that are included in the production of any cropor in other words the profitability of a proposed change in the operation. In partial budgeting the sum of additional costs and reduced revenue is subtracted from thesum of additional revenue and reduced costs to find the expected change incosts and expected change in profit. Net incremental profit (A- B) was estimated and the result is showed in Table 3. From the table it is revealed that with the increased in the cost over the treatment T_1 the net profit also increases except T_4 where the net incremental profit was reduced to Rs 9820ha^{-1} as compared to T_3 which produced an incremental benefit of Rs 14834 ha^{-1} though the added cost was same for both the treatments. This might be due to that, the fertility of the soil is poor and deficient in the zinc nutrient which was applied at 5$kgha^{-1}$. But when zinc level was increased to 10.5$kgha^{-1}$ the net incremental was almost doubled than that of the previous one. From the Table it clearly indicates that when fertilization was carried out with FYM @ 3 $tonha^{-1}$ + Biofertilizer (Azospirillum, PSB and KSB each @ 50gmKg^{-1} seed as seed treatment that involved minimal added cost of Rs 1130/ha it produced an incremental profit of Rs 45829ha^{-1} indicating that if a farmer invested an extra cost of Rs 1130ha^{-1} he can earned a net profit of more than five times than that of T_1. In addition, if he still wants to reduce the extra cost to Rs 930ha^{-1} (T_7) he can still have earned a net incremental benefit of Rs 41277ha^{-1}.

From the above results it can thus be concluded that soil application with recommended dose of fertilizer (@N_{30}+P_{20}+K_{20}), FYM @ 3$tonha^{-1}$, zinc sulphate @ 10.5$kgha^{-1}$ and boron @ 1.5$kgha^{-1}$ along with seed treatment of Azospirillum, PSB and KSB each @ 50gm Kg^{-1} seed was found to be the most superior treatment combination for obtaining higher seed yield (9.64qha^{-1}) and net returns (Rs 53049ha^{-1}) with a benefit Cost Ratio of 1.90:1.00 in sesame. Besides, the extra investment cost for this fertilization was minimal at Rs 1130ha^{-1} which an incremental benefit of Rs 45829ha^{-1}. Therefore, the technology is highly profitable and economically feasible.

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