Enhancing Rainfed Sesame (*Sesamum Indicum* L) Productivity and Economics through Organic Inputs and Legume Intercropping

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Abstract— *This study explores the impact of combining farmyard manure (FYM) with legume intercropping on sesame (Sesamum indicum L.) yield, and economics under rainfed conditions in Arunachal Pradesh. The experiment included 7 treatments that is T1 (control), T2 (FYM6t +Intercropping 2:1), T3 (FYM6t+intercropping 2:2), T4 (FYM7t+Intercropping 2:1), T5 (FYM7t +Intercropping 2:2), T6 (FYM8t + Intercropping 2:1) and T7 (FYM 8t +, Intercropping 2:2). The layout used was Randomized Block Design (RBD) with 3 replications. Results showed that FYM at 8 t/ha with a 2:1 sesame-to-black gram intercropping pattern (T6) recorded highest yield attributes of number of capsule per plant (33.00), number of seed per capsule (25.33), capsule length (3.07 cm), test weight (2.90 g), seed yield (0.39t/ha), straw yield (1.29t/ha) and harvest index (22.57%) as compared to all other treatments. It was also observed that the treatment T6 (FYM8t + Intercropping 2:1) recorded highest cost of cultivation (₹33,000), gross return (₹117,000), net returns (₹84,000/ha), and B.C ratio (3.55) as compared to all other treatments.*

This study confirms that integrating FYM and legume intercropping improves sesame performance while supporting ecological sustainability.

Keywords— Sesame, Farmyard Manure, Intercropping, Rainfed Agriculture, Yield, cost of cultivation, gross return, net return and B.C ratio.

I. INTRODUCTION

Sesame (Sesamum indicum L.) is one of the most ancient and significant oilseed crops cultivated in India, known for its high oil content (42–50%) and protein-rich seeds (20–25%) (Miah *et al*., 2015). It is particularly well-suited to rainfed conditions due to its short growth duration, adaptability to marginal soils, and drought tolerance. However, sesame productivity remains far below its genetic potential, especially in northeastern India, where it averages only 367 kg/ha (Anonymous, 2019), primarily due to low soil fertility, mono-cropping, and poor crop management practices (Pathak *et al*., 2017).

In the context of sustainable intensification of rainfed farming, the integration of organic nutrient sources and legume-based cropping systems offers an ecologically sound approach. Farmyard manure (FYM) is a valuable organic input that improves soil structure, microbial activity, and nutrient availability while reducing dependence on chemical fertilizers (Ramesh *et al*., 2010). It also enhances moisture retention and long-term soil productivity, making it suitable for dryland and hill agriculture (Zerihun *et al*., 2019).

Legume intercropping, particularly with crops like black gram (Vigna mungo), offers multiple benefits, including biological nitrogen fixation, improved land-use efficiency, weed suppression, and increased system stability (Mandal and Prama nick, 2014; Horwith, 1985). Intercropping has also been shown to improve the economic viability of smallholder farms by providing additional income and reducing input costs (Moola *et al*., 2020).

Although FYM and legume intercropping have been studied individually, there is limited research on their combined influence on sesame performance, especially in the rainfed hill ecosystems of Arunachal Pradesh. Understanding the interaction between different FYM levels and sesame-legume intercropping patterns is essential to developing sustainable and location-specific crop management strategies.

Therefore, the present study was undertaken to investigate the combined effect of organic inputs (FYM) and black gram intercropping on the growth, yield, quality, and economics of sesame under rainfed conditions. The results aim to provide integrated, low-input solutions for improving sesame productivity and farmer profitability in marginal environments.

II. MATERIALS AND METHODS

The experimental trial was carried out during kharif 2024 at Agriculture research farm of Himalayan University. The agriculture Research Farm is situated at 27.14ºN latitude and 93.62º E longitudes. The location of jollang was tropical climate zone with an average rainfall of 3500-4000mm at an average meters from mean sea level. The soil of experimental plot was sandy loam and loamy sandy in texture with pH ranges from 4 to 6. The site comes under the Eastern Himalayan region and the Agro - climatic zone is under sub- tropical zone of Arunachal Pradesh. Sesame variety INDO US-5 and Black gram variety Jaigrow 75 were used. Data were recorded on Yield Attributes like capsules/plant, seeds/capsule, Test weight (1000 seed weight), seed yield (t/ha) straw yield (t/ha), harvest index (%) and Economic analysis included cost of cultivation, gross return, net return and B.C ratio were recorded and statistically analyzed using analysis of variance (ANOVA) as applicable to Randomized Block Design.

III. RESULTS AND DISCUSSION

3.1 The statistical data regarding yield and yield Attributes is presented in Table no:1:

3.1.1 No. of capsule plant^{-1}:

Maximum number of capsule plant^{-1} was recorded in treatment T6 (FYM8t+Intercropping2:1) i.e., 33.00 which is at par with treatment T7 (FYM8t+Intercropping2:2) i.e., 32.67. Lowest number of capsule plant^{1} recorded at T1 (control) i.e., 21.

The probable reason for recording higher number of capsule plant^{-1} in T6 (FYM+ Intercropping 2:1) the possible reason could be due to higher nutrient uptake and improved physiological functions. Similar improvements in yield attributes due to FYM and legume intercropping were reported by Sharma *et al*. (2020), Arpita *et al*. (2021) and Aglawe *et al*. (2021).

TABLE 1
EFFECT OF FARMYARD MANURE AND INTERCROPPING ON YIELD AND YIELD ATTRIBUTES OF SESAME

Treatments	No. of capsule plant^{-1}	No. of seed capsule^{-1}	Capsule length(cm)	Test weight (g)	Seed yield (t/ha)	Straw yield (t/ha)	Harvest index (%)
T	21.00	18.00	2.60	2.17	0.16	0.88	15.04
T_2	29.00	19.67	2.97	2.43	0.22	1.12	16.12
T_3	28.67	20.33	2.63	2.60	0.22	1.27	15.62
T_4	31.67	21.67	2.93	2.80	0.22	1.24	15.07
T_5	32.33	23.67	2.90	2.77	0.24	1.25	16.06
T_6	33.00	25.33	3.07	2.90	0.39	1.29	22.57
T_7	32.67	24.00	3.00	2.87	0.31	1.27	19.48
SED	2.48	1.62	0.38	0.38	0.06	0.14	3.22
SEM (±)	1.75	1.14	0.27	0.24	0.04	0.10	2.28
CD	5.40	3.52	0.82	0.73	0.14	0.30	7.02

3.1.2 No. of seed capsule^{-1}:

Maximum number of seed capsule^{-1} was recorded in treatment T6 (FYM8t+Intercropping2:1) i.e., 25.33 which is at par with treatment T7 (FYM8t+Intercropping2:2) i.e., 24. Lowest number of seed capsule^{-1} recorded at T1 (control) i.e., 18.

The probable reason for recording higher number of seed capsule^{-1} in T6 (FYM8t+Intercropping2:1) the possible reason could be due to application of FYM and legume intercropping, improved physiological functions or due to better pollination and ovary development supported by balanced nutrition from FYM and black gram intercropping. Similar improvements in yield attributes due to FYM and legume intercropping were reported by Arpita *et al*. (2021), Saad *et al*. (2022) and Ahmed *et al*. (2023).

3.1.3 Capsule Length (cm):

Maximum number of capsule length was recorded in treatment T6 (FYM8t+Intercropping2:1) i.e., 3.07cm which is at par with treatment T7 (FYM8t+Intercropping2:2) i.e., 3cm. Lowest number of capsule length recorded at T1 (control) i.e., 2.6cm.

The probable reason for recording higher number of capsule length in T6 (FYM8t+Intercropping 2:1) could be due to higher nutrient uptake especially phosphorous and potassium and improved physiological functions. Similar improvements in yield attributes due to FYM and legume intercropping were reported by Nadeem *et al*. (2015), Parmar *et al*. (2020) and Arpita *et al*. (2021).

3.1.4 Test weight (g):

Maximum number of test weight was recorded in treatment T6 (FYM8t+Intercropping2:1) i.e., 2.9g which is at par with treatment T7 (FYM8t+Intercropping2:2) i.e., 2.87g. Lower number of test weight recorded at T1 (control) i.e., 2.17g.

The probable reason for recording higher number of test weight in T6 (FYM8t+Intercropping 2:1) the possible reason could be due to application of FYM and intercropping with legume. Similar improvements in yield attributes due to FYM and legume intercropping were reported by Ali et al. (2012), Moola *et al.* (2020), and Arpita *et al* (2021)

3.1.5 Seed yield (tonne ha^{-1}):

The significant and highest seed yield (0.39t ha^{-1}) was recorded in treatment T6 (FYM8t+Intercropping2:1) which is at par with treatment T7 (FYM8t+Intercropping2:2) i.e., (0.31t ha$^{-1)}$. Lowest number of grain yield recorded at T1 (control) i.e., (0.16t ha^{-1}).

The probable reason for recording higher seed yield (0.39t ha^{-1}) in T6 (FYM8t+Intercropping2:1) due to improved nutrient cycling and nitrogen fixation from legumes. This is supported by studies like those of puste *et al*. (2014), Moola *et al.* (2020) and Sharma *et al*. (2020).

3.1.6 Straw yield (tonne ha^{-1}):

The significant and highest straw yield (1.29t ha^{-1}) was recorded in treatment T6 (FYM8t+Intercropping2:1) which is at par with treatment T7 (FYM8t+Intercropping2:2) i.e., (1.27t ha$^{-1)}$. Lowest number of straw yield recorded at T1 (control) i.e., (0.88t ha^{-1}).

The probable reason for recording higher straw yield (1.29t ha^{-1}) in T6 (FYM8t+Intercropping2:1) may be due to balance nutrient supplied and nitrogen fixation from legumes. Similar findings was reported by puste *et al*. (2014), Moola *et al.* (2020) and Parmar *et al*. (2020).

3.1.7 Harvest index (%):

The significant and highest harvest index (22.57%) was recorded in treatment T6 (FYM8t+Intercropping2:1) which is at par with treatment T7 (FYM8t+Intercropping2:2) i.e., (19.48%). Lowest number of harvest index recorded at T1 (control) i.e., (15.04%).

The probable reason for recording higher harvest index (22.57%) in T6 (FYM8t+Intercropping2:1) may be due to integrated nutrient and intercropping. This is supported by studies like those of puste *et al*. (2014), Moola *et al*. (2020), Reddy and Goud (2022). Who reported improved HI under integrated nutrient and intercropping systems?

3.2 The statistical data regarding Economics is presented in Table no:2:

3.2.1 Cost of cultivation (INR ha^{-1}):

In Cost of cultivation (33,000 INR ha^{-1}) was found to be highest in treatment T6 (FYM8t+Intercropping2:1), and the minimum cost of cultivation (20,000 INR ha^{-1}) was found to be in treatment T1 (control).

3.2.2 Gross return (INR ha^{-1}):

Gross return (117,000 INRha^{-1}) was found to be highest in treatment T6 (FYM8t+Intercropping2:1), and the minimum gross returns (48,000 INR ha^{-1}) was found to be in treatment T1 (control) as compare to other treatments.

TABLE 2
ECONOMIC EFFECTS OF FARMYARD MANURE AND INTERCROPPING ON SESAME

Treatments	Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B.C ratio
T1	20,000	48,000	28,000	2.40
T2	27,000	66,000	39,000	2.44
T3	27,000	66,000	39,000	2.44
T4	29,000	72,000	43,000	2.48
T5	29,000	72,000	43,000	2.48
T6	33,000	117,000	84,000	3.55
T7	32,500	114,000	81,500	3.51

3.2.3 Net returns (INR ha^{-1}):

Net returns (84,000 INR ha^{-1}) was found to be highest in treatment T6 (FYM8t+Intercropping 2:1), and the minimum net returns (28,000 INR ha^{-1}) was found to be in treatment T1 (control) as compare to other treatments.

3.2.4 Benefit cost ratio (B:C):

Benefit cost ratio (3.55) was found to be highest in treatment T6 (FYM8t+Intercropping 2:1), and the minimum benefit ratio (2.40) was found to be in treatment T1 (control) as compare to other treatments.

Significant difference with regard to net returns and B:C ratio were observed in treatment T6 (FYM8t+Intercropping (2:1) *i.e.*,3.55 was significantly superior to other treatments with highest net return value of 84,000 INR. However, minimum net return value of 28,000 INR and B:C ration 2.40 was observed in treatment T1 (control).

The probable reason for recording significant and higher net return and B:C ratio under treatment T6 (FYM8t+Intercropping 2:1) this might be due to efficient utilization of resources through FYM application and legume-based intercropping. FYM improves soil structure, microbial activity, and nutrient availability, while legumes like black gram helps in biological nitrogen fixation, further boosting sesame productivity. These results are supported by the findings of Sarma *et al*. (2016), Arpita *et al*. (2021), who reported that sesame intercropped with green gram and supplemented with organic inputs produced significantly higher net returns and profitability compared to sole cropping. Similarly, Parmar *et al*. (2020) observed a B:C ratio above 1.5 in sesame under integrated nutrient management with FYM and biofertilizers.

In contrast, the control treatment (T1) recorded the lowest net return (28,000 INR/ha) and lowest B:C ratio (2.40), mainly due to reduced crop performance under nutrient-deficient conditions and absence of intercrop benefit.

IV. CONCLUSION

The combined application of FYM (8 t/ha) and legume intercropping (2:1) significantly improves sesame productivity and profitability under rainfed conditions. This approach offers a sustainable and eco-friendly alternative to intensive chemical inputs.

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