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Yield and economics of rice fallow sesame (*Sesamum indicum* L.) as influenced by nutrient management practices

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Abstract
Field experiment was conducted on sandy loam of Agricultural College Farm, Bapatla, Andhra Pradesh during *summer* season to study the different nutrient levels and foliar nutrition for rice fallow sesame (*Sesamum indicum* L.). The experiment was laid out in a randomized block design and replicated four times. The treatments consisted of five levels of nutrient management. Among the different nutrient levels, 125% RDF combined with 1% foliar spray of 19:19:19 at early budding stage and early capsule formation stages showed its superiority by recording significantly higher seed yield (827 kg ha^{-1}), oil yield (419 kg ha^{-1}), gross returns (Rs. 65671 ha^{-1}), net returns (Rs. 41409 ha^{-1}), and B:C ratio (1.71) to the rest of the all the treatments.

Keywords: Sesame, rice fallow, nitrogen management, foliar application, yield, economics

Introduction
Sesame (*Sesamum indicum* L.) is the most ancient oil seed crop that thrives in tropics and warm temperate regions. It has been valued for its rich composition of anti-oxidants, oil content (40-50%), proteins (8%), vitamins and minerals like iron, copper and zinc which provide significant benefits for both human and animal nutrition. The linoleic acid (40%) present in sesame oil contributes to its anti-bacterial, anti-fungal, anti-viral, and anti-inflammatory properties. Sesame oil has excellent nutritional, medicinal, cosmetic and cooking qualities for which, it is known as 'Queen of Oilseeds'. The seeds of sesame are often referred to as "the seeds of immortality" and are considered auspicious due to their potent antioxidant properties.

Rice fallow regions provide ample scope for area expansion of oil seeds. In India, rice is cultivated both under irrigated and rainfed conditions in various cropping systems across the length and width of the country occupying about 43 million hectares area (Anonymous, 2018) [3]. Rice-rice, rice-sugarcane, rice-groundnut, rice-vegetables, rice-pulses, rice-sunflower, rice-sesame and rice-fallows are the prevalent rice-based cropping systems in various parts of the country. Major area under rice production during *Kharif* season in India remains fallow in the subsequent *Rabi* due to various reasons, but lack of production technologies is considered as a major determinant. Being short duration in nature, sesame is an ideal crop for cultivation in rice fallows (Chauhan *et al.*, 2016) [6]. To cope up with the increasing demand of oilseeds in the country, sesame should be included as an integral part in rice fallow areas with a dual advantage of crop diversification for sustainable production and increasing the area under sesame. To utilize the rice fallow areas with sesame, location specific and economically viable technology for better performance of sesame are required to be evaluated through a proper understanding of the system ecology and constraints for adoption.

Cereal-oil seed systems occupy an important position in crop rotation, especially in Krishna western delta command area of Krishna Zone of Andhra Pradesh. Rice in *Kharif* season and sesame during *summer* season is the newly followed cropping system in Krishna agro climatic zone under irrigated conditions. Sesame is considered as the best rotation crop in the binary rotation system with cereals. Continuous rice-rice crop rotation has led to decline and deterioration of soil physical properties. This problem can be partly overcome by changing from rice-rice crop rotation to growing of cereal-oilseed rotation system. Promotion of rice fallow sesame would also improve sustainability of the rice production system besides enhancing production and augmenting income. It should be considered appropriate to identify the constraint sin *rabi* cropping that can be addressed through appropriate technological intervention. Considering the scope for area expansion in rice fallow areas, this study was conducted to identify suitable sesame variety and nutrient levels for rice fallow / follow sesame cropping system.

Material and Methods

Field experiment was conducted on sandy loam of Agricultural College Farm, Bapatla, Andhra Pradesh during *summer* season to study the different nutrient levels and foliar nutrition for rice fallow sesame (*Sesamum indicum* L.). The experiment was laid out in a randomized block design and replicated four times. The treatments consisted of five levels of nutrient management *viz*., control (T_1), 50% RDF + 1% foliar spray of 19:19:19 at early budding stage and early capsule formation stage (T_2),75% RDF + 1% foliar spray of 19:19:19 at early budding stage and early capsule formation stage (T_3), 100% RDF + 1% foliar spray of 19:19:19 at early budding stage and early capsule formation stage (T_4), 125% RDF + 1% foliar spray of 19:19:19 at early budding stage and early capsule formation stage (T_5).During the crop season, light irrigation was given and inter-cultural operations *viz.*, thinning and weeding were done on 15 and25 DA Sir respective of treatments.

Results and Discussion

Seed Yield

Increasing the fertilizer levels, there was a significant increased seed yield. Application of 125% RDF + 1% foliar spray of 19:19:19 at early budding stage and early capsule formation stage (T_5) recorded highest seed yield of 827 kg ha^{-1}. This was significantly superior to other fertilizer tried. Applying 100% RDF +1% foliar spray of 19:19:19 at early budding stage and early capsule formation stage gave (T_4) 720 kg ha^{-1} was on par with 100% RDF +1% foliar spray of 19:19:19 at early budding stage and early capsule formation stage (T_3). The percent increase in seed yield with a fertilizer level was 14.8, 27.8, 63.1 and 42.7 over T_4, T_3, T_2 and T_1 treatments respectively. The gain in seed yield due to 25%enhancement in fertilizer dose (125% RDF + 1% foliar spray of 19:19:19 at early budding stage and early capsule formation stage) over the recommended dose of NPK applied to soil (100% RDF + + 1% foliar spray of 19:19:19 at early budding stage and early capsule formation stage) was worked out to be 14.8.0%, clearly showing that the currently recommended dose of NPK (40:20:20 kg NPK ha^{-1}) was suboptimal.The lowest seed yield (429 kg ha^{-1}) was recorded with control (T_1) and found statistically inferior to rest of the treatments.

The improvement in seed yield with enhanced fertilizer level might be attributed to better availability and uptake of nutrients which in turn might have lead to efficient metabolism. Higher levels of biomass accumulation and efficient translocation of photosynthetic from source to sink might be responsible for the increased seed yields. The increase in sink capacity resulted in improved yield attributes which was evidence through Table 1 and consequently raised the grain yield of sesame. This is further supported by the fact that the soil of experimental field was low in nitrogen (238 kg ha^{-1}). Thus, an increase in nitrogen supply might have increased all the growth parameters, yield attributing characters which ultimately contributed to increase in seed yield. The above results are in conformity with the findings of several researchers such as Hasan *et al.* (2013) [8] and Maryam Jasemi *et al.* (2013) [12], Yogesh (2020) [20], Sutaliya and Jakhar (2020) [16], Zebeneand Negash (2022) [21].

Oil yield

The oil yield of sesame was significantly affected by fertilizer levels. With respect to fertilizer levels, the highest oil yield (419 kg ha^{-1}) was obtained with the application of 125% RDF + 1% foliar spray of 19:19:19 at early budding stage and early capsule formation stage(T_5) which was significantly superior to rest of the treatments. The lowest oil yield (173 kg ha^{-1}) was obtained with control (T_1).

Significantly higher oil content as well as oil yield realized with application of the highest dose (125% RDF + 1% foliar spray of 19:19:19 at early budding stage and early capsule formation stage) of NPK applied to soil could be ascribed to the fact that the supply of liberal quantities of nitrogen duly balanced with P and K might have helped in absorption of greater amounts of nitrogen which is an important constituent of nucleic and fatty acids and phospholipids and thus played a crucial role in promoting oil accumulation in the seed. Besides, liberal supply of N and P through foliar feeding, the positive effect of potassium showed higher oil content as it has an important role in enhancing enzyme activity and lipid metabolism. The highest oil yield obtained with the highest level of nutrient dose applied was also evidenced by earlier researchers Shehu *et al.* (2010) and Kashani *et al.* (2015) [15], Hasan *et al.* (2013) [8], Akhtar *et al.* (2015) [2], Maryam Jasemi *et al.* (2013) [12], Ahmad *et al.* (2018) [1], Yogesh (2020) [20], Sutaliya and Jakhar (2020) [16], Zebene and Negash (2022) [21].

Economics

The net returns were affected by fertilizer levels. The highest net returns (Rs. 41,409 ha^{-1})was obtained with the application of 125% RDF + 1% foliar spray of 19:19:19 at early budding stage and early capsule formation stage(T_5) which was superior to rest of the fertilizer levels. The lowest net returns (Rs. 14,399 ha^{-1}) was obtained with control (T_1).Which was superior to rest of the fertilizer levels. The lowest net returns (14399 ₹ ha^{-1}) was obtained with control (T_1). The highest B:C ratio (1.71) was obtained with the application of 125% RDF + 1% foliar spray of 19:19:19 at early budding stage and early capsule formation stage(T_5) and next highest B:C ratio obtained with 100% RDF +1% foliar spray of 19:19:19 at early budding stage and early capsule formation stage (T_4). The lowest B:C ratio (0.72) was obtained with control (T_1). These results were in agreement with those reported by Jamdhade *et al.* (2017) [9], Tulasi Lakshmi *et al.* (2014) [19], Bikram Singh *et al.* (2013) [4] and Mian *et al.* (2011) [14]. Deepthi *et al.* (2020) [7], Yogesh (2020) [20] and Zebene *et al.* (2022) [21].

Table 1: Seed yield (kg ha^{-1}) and oil yield (kg ha^{-1}) of sesame as influenced by different nutrient levels during *summer* season

Treatments	Seed yield (kg ha^{-1})	Oil yield (kg ha^{-1})
T_1: Control	429	173
T_2: 50% RDF + 1% foliar spray of 19:19:19 at early budding stage and early capsule formation stage	507	217
T_3: 75% RDF + 1% foliar spray of 19:19:19 at early budding stage and early capsule formation stage	649	290
T_4: 100% RDF +1% foliar spray of 19:19:19 at early budding stage and early capsule formation stage	721	353
T_5: 125% RDF + 1% foliar spray of 19:19:19 at early budding stage and early capsule formation stage	827	419
SEm (+)	25.30	11.85
CD (P=0.05)	73	34

Table 2: Gross returns (Rs. ha^{-1}), Net returns (Rs. ha^{-1}) and BC ratio of sesame as influenced by different nutrient levels during *summer* season

Treatments	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	BC ratio
T_1: Control	34342	14399	0.72
T_2: 50% RDF + 1% foliar spray of 19:19:19 at early budding stage and early capsule formation stage	40478	18111	0.81
T_3: 75% RDF + 1% foliar spray of 19:19:19 at early budding stage and early capsule formation stage	51518	28530	1.24
T_4: 100% RDF +1% foliar spray of 19:19:19 at early budding stage and early capsule formation stage	57959	34341	1.45
T_5: 125% RDF + 1% foliar spray of 19:19:19 at early budding stage and early capsule formation stage	65671	41409	1.71

Conclusion

Cultivating sesame in rice fallow areas with optimal nutrient management enhances yields, profitability, and sustainability. Integrating sesame into rice-based systems addresses oilseed demand, improves soil health, and ensures long-term agricultural resilience and economic viability.

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