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Performance of Sesamum (*Sesamum indicum* L.) Grown with Production Components under New Alluvial Zone of West Bengal

Koushik Mondal[1], Sunil Kumar Gunri[1], Saumi Goswami[2], Soumyajyoti Das[1], Anusree Paul[1], Kalyan Jana[1] and Sibaji Banerjee[1]

[1]Dept. of Agronomy, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal (741 252), India
[2]Dept. of Agronomy, School of Agriculture and Allied Sciences, The Neotia University, West Bengal (743 368), India

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Corresponding sgunri@gmail.com

0000-0002-6244-9933

ABSTRACT

Experiment was carried out in the Jaguli Instructional Farm, Jaguli, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal, India during the summer seasons (1st week of February to 3rd week of May) of 2020 and 2021 to study the performance of sesame with major production components for its economic yield. The experiment was laid down in a randomized block design with 3 replications, comprising of 12 combination of different resource management viz., T_1- F.P. (Fertilizer+Irrigation +Weeding+Plant protection), T_2- F.P. – Fertilizer, T_3- F.P. -Irrigation, T_4- F.P. – Weeding, T_5- F.P. – Plant protection, T_6- F.P. – (Fertilizer+Irrigation), T_7- F.P. – (Fertilizer+Weeding), T_8- F.P. – (Fertilizer+Plant protection), T_9- F.P. – (Weeding+Irrigation), T_{10}- F.P. – (Plant protection+Irrigation), T_{11}- F.P. – (Weeding+Plant protection), T_{12}- F.P. – (Fertilizer+Irrigation+Weeding+ Plant protection). Among the four production components (fertilizer+irrigation+weeding+plant protection) the most crucial component was fertilizer component followed by weeding, irrigation and plant protection associated with seed yield. Ignoring the fertilizer component resulted in a 25.6% decrease in seed output; this was followed by reductions of 23.9% in weeding, 14.3% in watering, and 3.7% in plant protection. The yield drop was noted more strongly when two components were omitted, and it was learnt in proportionally greater amounts when the fertilizer component was omitted together with the weeding. When all components were sacrificed the seed yield was reduced severely (83.7%). The higher BCR was found under the treatment [FP-(Weeding+PP)]. Hence, in order to maximize profit, the fertiliser component of sesame was an even more important resource component that could not be sacrificed.

KEYWORDS: Fertilizer, weeding, irrigation, sesamum, growth, yield, oil, economics

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Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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1. INTRODUCTION

India's need for vegetable oil is rising quickly due to the country's growing population, rising standard of living, growing industrial needs, and the present demand on biofuels globally (Ghosh et al., 2013). Over the past 20 years, India's oil consumption has been steadily rising daily. India holds a prominent position globally, with respect to both area and output. World total cultivation area under sesame was 15.2 mha, producing 8.02 mt in 2023, which has risen from 1.41 mt in the early 1961 (Anonymous, 2025). India ranks fourth globally in terms of edible oil economy (Sarkar et al., 2021) and produces about 10% of the world's oilseeds, 6–7% of its vegetable oil, and around 7% of its protein meal. Around the world, sesame (*Sesamum indicum* L.) is one of the most significant oil crops and is widely planted (Shilpi et al., 2014). It is one of the oldest and historically significant oilseed crops, valued for its high quality seed oil (Islam et al., 2016), produced globally for many years as a versatile oilseed crop (Mushtaq et al., 2020). Due to its exceptional qualities in seed, oil, and meal, sesame is referred to as the 'Queen of Oilseeds' (Kadvani et al., 2020). The seed's quality has been enhanced by the presence of all necessary fatty and amino acids (Shilpi et al., 2012). In addition to 18–25% protein, sesame has 38–54% very high-quality oil (Couch et al., 2017). India is the birthplace of the cultivated variety of Sesamum indicum, which leads the world in area and production but has the lowest productivity (Bhadauria et al., 2012). Because of its strong natural resilience to diseases and insects, sesame plants thrive in challenging environments requiring little in the way of water, fertilizer, and litter. As a result, pesticides are rarely used. Because sesame is cultivated either as a dry-land crop or irrigated crop, different sesame cultivars respond differently to mild or severe drought stress (Gholamhoseini, 2020). Sesame's potential yield is still much higher, could reach up to 2000 kg ha^{-1} (Mkamilo and Bedigian, 2007), than its actual yield due to a number of factors including untapped genetic potential, high levels of monocropping, insufficient weed control, pest and disease damage, and a lack of mechanization, which can lead to seed shattering when labour is scarce during harvest. Sesame yield, however, varies greatly based on cultivars, cultural techniques, and growing conditions. Being faster growth, short duration, and drought-tolerant capacity make sesame an advantageous plant that can be grown throughout the year (De et al., 2013). However, high-yielding varieties which leads to improve the productivity of this crop, availability of variability for seed yield and its component traits in populations is crucial (Sasipriya et al., 2023). Due in part to the use of improper management techniques, from soil preparation to sowing method, weeding, and post-harvest operations, it has been ignored up until this point. To get maximum yield of sesame recommended package of practices especially, proper nutrition is to be followed. By not following any one management practice yield may be reduced severely and it was also observed that delay in sowing, unbalanced does of fertilizer, untimely weed management and plant protection drastically reduced the grain yield of sesame (Raikwar and Srivastva, 2013). Inorganic nutrient management especially NPK had the greater impact to increase the seed yield in tropics. Not to follow the Good Agronomic Practices (GAP) like other staple crop; only sowing and harvesting in between no intervention. In order to determine the production component for sesame yield and growth under resource constraints, as well as to validate the results through economic analysis, four major production components-fertilizer, irrigation, weeding, and plant protection-had been taken into consideration with a view to study the major production component(s) for economic yield of sesame under limited resource use.

2. MATERIALS AND METHODS

The experiment was conducted at the Jaguli Instructional Farm, Bidhan Chandra Krishi Viswavidyalaya, Nadia district, West Bengal, India during the summer season of 2020 and 2021. The soil of the experimental field was alluvium sandy loam in texture with organic carbon content was 0.59% and available N, P_2O_5 and K_2O contents were 188.4, 24.9 and 159.8 kg ha^{-1} respectively. Three replications of the experiment were set up using a Randomized Block Design (RBD). Twelve numbers of treatment viz., T_1-F.P. (Fertilizer+Irrigation+Weeding+Plant protection), T_2-F.P. – Fertilizer, T_3-F.P.- Irrigation, T_4-F.P.– Weeding, T_5-F.P. – Plant protection, T_6-F.P.– (Fertilizer+Irrigation), T_7-F.P.– (Fertilizer+Weeding), T_8-F.P.– (Fertilizer+Plant protection), T_9-F.P.– (Weeding+Irrigation), T_{10}-F.P.– (Plant protection+Irrigation), T_{11}-F.P.– (Weeding+Plant protection), T_{12}-F.P.– (Fertilizer+Irrigation+Weeding+Pla nt protection) was considered. The sesame variety "Savitri" was sown with a 30×10 cm^2 spacing on February 11, 2020 and February 15, 2021. Squared Euclidian distances between the resource components were determined using the UPGMA method based on the performance of each component and the standardized data matrix. Observations includes growth, yield attributes and yield, economics and oil content were recorded.

3. RESULTS AND DISCUSSION

3.1. Crop growth

Plant height is the main architecture of the plant growth and is the crucial part to regulate all the processes related to growth and development. All aspects of production had a beneficial effect on plant height, although fertilizer was the most sensitive, followed by irrigation and weeding. Plant protection elements had no appreciable effect on growth. The dry matter production was significantly influenced by the production components; the treatment that got all of the production components produced a notably higher amount of dry matter (T_1). Dry matter production was significantly reduced when the fertilizer component (T_2) was excluded from the whole set of practices (T_1). When fertilizer component (T_2) was omitted along with irrigation (T_6), weeding (T_7), and plant protection (T_8), this decrease became much more noticeable. Table 1 also showed that the output of dry matter decreased (T_9) when irrigation was discontinued in addition to weeding, with this effect being more noticeable from the peak vegetative stage until maturity. Similar finding was also reported by Aref et al., 2013, when they stated that weeds are prevalent for longer periods of time, yield losses of about 80% occur when compared to fields of unwedded sesame. This happened as a result of the crop experiencing moisture stress during its growing period and the high temperatures that were common during that time. Weed infestation in sesame greatly hampered the growth by creating competition with the crop although critical period of weed competition.The presence of weeds is a major obstacle in sesame production and can negatively influence sesame yield (Sperry et al., 2016; Grichar et al., 2009; Ijlal et al., 2011). Ignoring the fertilizer component slowed down the pace of growth; this effect was aggravated when the fertilizer component was skipped together with components for irrigation, weeding, and plant protection. Therefore, there was a strong correlation between growth rate and the use of fertilizer (Hamedani et al., 2020), irrigation (Sadras et al., 2016)., and weed control (Chauhan and Johnson, 2011). Growth rate was not significantly impacted by skipping the plant protection component, either by alone or in combination with weeding and irrigation. Ignoring any production component resulted in fewer branches, and ignoring all production components (T_{12}) or production components like fertilizer, irrigation and weeding further reduced the number of branches.

Table 1: Effect of resource components on growth attributing characters of sesame (Pooled analysis over two years)

Treatments	Growth attributing characters			
	Plant height (cm) (Harvest)	Dry matter accumulation ($g\ m^{-2}$) (at harvest)	Crop growth rate ($g\ m^{-2}\ day^{-1}$) (45-60 DAS)	No. of primary branches $plant^{-1}$ (at harvest)
T_1	112.0	376.1	3.63	3.7
T_2	104.5	286.7	5.66	3.5
T_3	107.1	313.9	3.34	3.5
T_4	106.3	310.7	4.21	3.6
T_5	110.7	370.2	3.50	3.7
T_6	103.1	268.0	6.31	3.3
T_7	102.3	266.4	6.41	3.3
T_8	104.7	283.8	6.87	3.5
T_9	106.7	293.0	2.88	3.5
T_{10}	107.7	331.6	4.57	3.5
T_{11}	109.0	346.5	4.43	3.6
T_{12}	59.7	172.2	3.49	2.9
SEm±	1.27	5.07	0.50	0.07
LSD (0.05)	3.64	14.55	1.43	0.20

Twelve numbers of treatment viz.; T_1: F.P.-(Fertilizer+Irrigation+Weeding+Plant protection); T_2: F.P.-Fertilizer; T_3: F.P.-Irrigation; T_4: F.P-Weeding; T_5: F.P.-Plant protection; T_6: F.P.-(Fertilizer+Irrigation); T_7: F.P.-(Fertilizer+Weeding); T_8: F.P.-(Fertilizer+Plant protection); T_9: F.P.-(Weeding+Irrigation); T_{10}: F.P.-(Plant protection+Irrigation); T_{11}: F.P.-(Weeding+Plant protection); T_{12}: F.P.-(Fertilizer+Irrigation+Weeding+Plant protection)

3.2. Yield attributes

In comparison to the entire package that was followed,

Table 2: Effect of resource components on yield attributes of seasame (pooled analysis over two years)

Treatments	Yield attributes			
	No. of capsule $plant^{-1}$	No. of seeds $capsule^{-1}$	Length of capsule (cm)	1000 seed weight (g)
	Pooled	Pooled	Pooled	Pooled
T_1	59.5	54.6	2.5	2.8
T_2	51.8	48.9	2.2	2.5
T_3	55.6	53.0	2.3	2.6
T_4	54.9	52.5	2.2	2.6
T_5	58.2	53.9	2.4	2.8
T_6	50.7	48.2	2.2	2.5
T_7	49.8	47.1	2.2	2.5
T_8	52.1	48.7	2.3	2.6
T_9	51.7	50.6	2.3	2.5
T_{10}	52.6	51.5	2.3	2.5
T_{11}	54.1	52.3	2.4	2.6
T_{12}	41.9	41.3	1.9	2.4
SEm±	0.94	1.00	0.10	0.13
LSD (0.05)	2.69	2.87	NS	NS

the number of capsules per sesame plant decreased when individual or combination production components were skipped, and 14.8% was decreased when fertilizer components were skipped, followed by weeding components (8.27%) and irrigation components (7.0%).This difference was even larger when fertilizer, irrigation, and weeding were skipped (17.3%, 19.4%, and 14.2%, respectively); nevertheless, the number of capsules was drastically reduced by 42% when all production components were skipped. The fertilizer component, among the four, had the most significant impact on the number of seeds per capsule, as fertilizer application was closely associated with enhanced growth and yield traits. There was no discernible change in the weight or length of sesame seeds when production components were eliminated.

3.3. Yield, harvest index and oil content

Data presented in the table 3 showed that omitting any production component reduced the amount of seed produced by the entire package. With regard to seed output, the fertilizer component (Gholamhosein et al., 2013) was the most crucial of the four, followed by weeding, irrigation, and plant protection. In order to increase the seed yield, each component was essential, and if any of them either singly or in combination, were absent, the yield was greatly reduced. Representation of data in table 3 also revealed that omitting the fertilizer component reduced yield by 25.6% (Younis et al., 2020). Weeding came in second with 23.9% (Sperry et al., 2016; Zimdahl, 2004) watering with 14.3% (Dubey et al., 2021), and plant protection with 3.7%. When two components were left out, the yield was reduced further. It was found to be 31.1% when fertilizer was skipped along with weeding (T_7) and 30.7% when irrigation (T_6) was skipped (Pabuayon et al., 2019), whereas it was 10.4% when weeding+irrigation (T_9) was skipped. Similar observation was also reported by Hailu et al., 2018. When all components were omitted, the seed output was significantly reduced (83.7%). Thus, it can be inferred that the lack of production components significantly affected the output of sesame seeds, whereas the components that had the biggest effects on seed yield were fertilizer, weeding, and irrigation. The plant protection component did not have a substantial impact on seed output. The main elements that elevated the production of sesame stems were irrigation, weeding, and fertilizer. Sesame's resource components significantly influenced the seed's oil content, and as compared to other treatments, the entire package of recommended methods significantly increased both the oil content and oil yield. Ignoring the resource components of weeding and irrigation resulted in a significant decrease in both yield and oil content. This decrease in oil content and output was also noted when the weeding and irrigation components were skipped either together (T_9) or separately from fertilizer.

Table 3: Effect of resource components on seed yield, stem yield and oil yield of

Treatments	Yield and oil harvests					
	Seed yield (kg ha^{-1})	Stem yield (kg ha^{-1})	Harvest index (%)	Oil content (%)	Oil yield (kg ha^{-1})	BCR (Mean)
T_1	1331	3778	26.1	44.9	598	1.76
T_2	1059	2875	26.9	42.8	453	1.55
T_3	1164	3154	27.0	43.9	511	1.61
T_4	1074	3120	25.6	44.3	476	1.70
T_5	1283	3713	25.65	44.4	570	1.75
T_6	1018	2683	27.5	42.6	434	1.56
T_7	1016	2666	27.6	42.6	433	1.82
T_8	1070	2839	27.4	42.2	452	1.61
T_9	1205	3195	27.4	43.6	525	2.02
T_{10}	1246	3331	27.2	43.3	540	1.78
T_{11}	1261	3475	26.6	43.9	554	2.07
T_{12}	725	1737	29.4	41.9	304	1.43
SEm±	36.0	50.7	-	0.29	26.2	-
LSD (0.05)	103.5	145.5	-	0.83	75.2	-

Selling price of the harvested seed: ₹ 60.00 kg^{-1}

3.4. Divergence among the resource components

Based on the dendrogram (Figure 1) developed from squared Euclidian distance matrix it is evident that there are four distinct clusters were formed by the twelve treatments. Cluster I contains T_{12}, cluster II contains T_3, T_9, cluster III contains T_1, T_5, T_9, T_{10}, T_{11} and cluster IV contains T_2, T_4, T_6, T_7, T_8. T_1 demonstrated the largest intra-cluster distance inside cluster III, ultimately proving to be the most effective treatment among the twelve in the present study. The cluster I single resource component, T_{12}, on the other hand, had the greatest inter-cluster distance and turned out to be the poorest. When the tables and the dendrogram are compared, it is found that there is a high correlation between the two, allowing one to identify the best-performing component and separate out the undesirable or underperforming ones. The said dendrogram proved to be a classical presentation of cumulative performance of all the resource components under study.

3.5. Economics

In 2020, 2021, and the mean over two years, Treatment T_1 produced the highest gross return (₹ 81000/-; ₹ 78720/- and ₹ 79860/-). This happened as a result of the large seed output from treatment T_1. Additionally, the treatment T_{11}

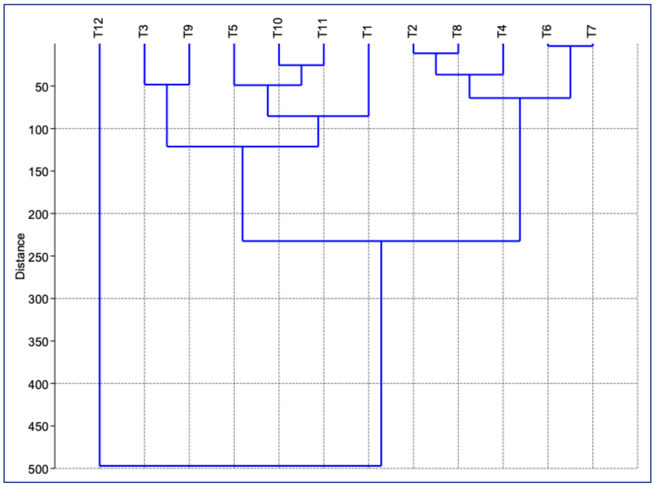

Figure I: Dendrogram explaining the resource component studies with relation to sesame cultivation under resource constraint condition. T_1: F.P.-(Fertilizer+Irrigation+Weeding+Plant protection); T_2: F.P.-Fertilizer; T_3: F.P.-Irrigation; T_4: F.P.-Weeding; T_5: F.P.-Plant protection; T_6: F.P.-(Fertilizer+Irrigation); T_7: F.P.-(Fertilizer+Weeding); T_8: F.P.-(Fertilizer+Plant protection); T_9: F.P.-(Weeding+Irrigation); T_{10}: F.P.-(Plant protection+Irrigation); T_{11}: F.P.-(Weeding+Plant protection); T_{12}: F.P.-(Fertilizer+Irrigation +Weeding+Plant protection); # FP : Full package of practices

demonstrated a higher net return (₹ 39960; ₹38400; and ₹ 39030) throughout the course of 2020, 2021, and the mean over two years.The treatment T_{11} recorded maximum net return as compared to T_1 where maximum gross return was recorded, due to in T_1 total cost was higher as compared to T_{11}. The higher BCR was found under the treatment T_{11} [FP-(Weeding+PP)] and lower was recorded with the treatment T_2 (FP-Fertilizer). Under treatment T_{11} [FP-(Weeding+PP)], the BCR was higher, while under treatment T_2 (FP-Fertilizer), it was lower. Sesame's fertilizer component was therefore a more valued resource that could not be sacrificed in order to boost profits.

4. CONCLUSION

When considering efficient agronomic practices, sesame was found to be more sustainable and profitable; however, omitting the fertilizer component from the entire package of practices resulted in a 25.6% decrease in sesame yield, followed by weeding (23.9%), irrigation (14.3%), and plant protection (3.7%). Therefore, in a circumstance when resources are scarce, irrigation and plant protection measures may be skipped, but in order to maximize productivity and boost profit, early development stage weeding and fertilizer application cannot be skipped.

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