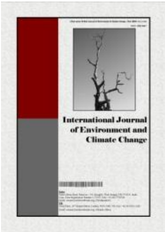

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Effect of Tillage and Nutrient Management Practices on Growth, Yield and Oil Quality of Rice Fallow Sesame

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during year 2021-22 at ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad to study the effect of tillage and nutrient management practices on growth, yield and quality of sesame grown in rice fallows. The experiment was laid out in split plot design with 18 treatments comprised of three main plot treatments i.e., A_1: Reduced tillage (Cultivator once) , A_2: Conventional tillage (Cultivator twice with rotavator once) and A_3: Minimum tillage (tillage in the row zone/uprooting soil in the seed zone with hand held dibbler) with six sub-plot treatments i.e., B_1: Control , B_2: 25% RDF, B_3: 50% RDF, B_4 : 75% RDF, B_5 : 100% RDF and B_6 : 125 % RDF replicated three times. Results revealed that there was a significant improvement in growth and yield of rice fallow sesame with conventional tillage and application of 125% RDF. Significantly taller plants, higher drymatter production, seed yield and stalk yield was obtained with

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conventional tillage. While,125% RDF recorded significantly higher growth and yield parameters when compared to lower fertilizer doses. There was no significant influence of tillage and nutrient management practices on oil content and fatty acid composition. However, with increase in fertilizer dose upto 125% RDF there was a slight change in oil content. Significant effect of tillage and nutrient management was observed in oil yield. Conventional tillage proved to be beneficial as it increased oil yield significantly. With increase in fertilizer doses there was appreciable increase in linoleic and oleic acid content. But stearic acid, palmitic acid and linolenic acid contents decreased at higher fertilizer doses.

Keywords: Tillage; nutrient management practices; rice fallow sesame.

1. INTRODUCTION

Next to cereals, oilseed crops are the second most significant factor affecting the agricultural economy. India ranks among the top importers of vegetable oils today despite generating the fifth-largest amount of oilseed crops globally. Vegetable oil utilisation, for both edible and industrial purposes, has increased significantly in recent years [1]. Nearly 72% of the total oilseeds area is restricted to rainfed cultivation, which is primarily practiced by marginal and small farmers. The main reasons for the low productivity of oilseeds are a lack of appropriate technology, production under input-starved conditions, and dealing with biotic and abiotic stresses. The nation produced 361.009 (4^{th} adv est) lakh tonnes of oilseeds in 2020–21, followed by 332.192 lakh tonnes in 2019–20, with a high productivity level of 1284 kg ha^{-1} in 2017–18 and 1254 kg ha^{-1} in 2020–21 (DOD) [2].

Sesame is grown on 16.23 lakh hectares in India, producing 6.57 lakh tonnes, for an average productivity of 405 kg ha^{-1} [3]. Rainfed cultivation in marginal and submarginal soils under suboptimal management and input deficient conditions are the main causes of the crop's low output. However, there is potential to boost sesame yield by using more advanced production techniques. Some of the major determinants for poor adaptation can be rice soil compaction, tillage adoption, poor moisture availability, waterlogged conditions, nutrient management. The usage of heavy machinery in puddled fields of rice creates a compact layer and is detrimental to rice fallow sesame. Excessive compaction decreases porosity, increases bulk density and hinders root growth. Moreover, compacted soils arrest the water loss through percolation and this would severely affect the crop growth. Balanced fertilization along with residual nutrient status of preceding crop would significantly impact the growth and yield of sesame. Thus, adequate tillage and nutrient management practices may have a profound impact on the growth of sesame in rice fallows. Sesame seed contain about 50% oil, 25% protein and 15% carbohydrate. The oil is utilised in margarine, salad dressings, and cooking (contains about 40% oleic and 40% linoleic acid). Due to the antioxidant, sesame oil has a long shelf life. The oil can be used to make soap, paint, fragrances, medicines, and pesticides. Sesame oil is considered to be anticholesterol and very therapeutic for heart conditions. Paradoxically, while being an energy-rich crop, sesame is grown in low-energy environments. Ranganatha, [4]. In most parts of country sesame is being grown in suboptimal conditions with poor management practices. With adoption of proper technologies improved seed yields and oil quality can be achieved. Suboptimal fertilizer application can considerably hinder oil quality Ramesh et al. [5]. With this scenario, an experiment was conducted to analyze the effect of tillage and nutrient management practices on growth, yield and oil quality of rice fallow sesame.

2. MATERIALS AND METHODS

An experiment was conducted on rice fallow sesame during late rabi, 2021-22 at ICAR-IIRR, Rajendranagar, Hyderabad. The farm is situated at an altitude of 494 m above mean sea level on 17^0 32' N latitude and 78^0 38' E longitude. The soil of the experimental field was low in organic carbon (0.42%), available N (215 kg ha^{-1}), high in available P (37 kg ha^{-1}) and K (365 kg ha^{-1}). The experiment was laid out in a split-plot design with 18 treatments comprised of three main plot treatments i.e., A_1: Reduced tillage (Cultivator once), A_2: Conventional tillage (Cultivator twice with rotavator once) and A_3: Minimum tillage (tillage in the row zone/uprooting soil in the seed zone with hand held dibbler) with six sub-plot treatments i.e., B_1 : Control , B_2 : 25% RDF, B_3 : 50% RDF, B_4 : 75% RDF, B_5: 100% RDF and B_6: 125% RDF replicated three times.

(Recommended dose of fertilizer: 80:20:20 kg N, P_2O_5, K_2O ha^{-1}).

The land preparation was done accordingly with respect to main plot treatments. In reduced tillage treatment, the field was ploughed with cultivator once. In conventional tillage treatment, the field was ploughed twice with cultivator followed by once with rotavator. Whereas in minimum tillage treatment combinations, tillage was done only in the row zone by uprooting the soil with help of hand held dibbler. Fertilizer application was done in accordance with the sub-plot treatment imposition. Nitrogen was applied in form of urea, phosphorous in form of diammonium phosphate and potassium was applied in form of murate of potash. In all the treatment combinations, the entire dose of P_2O_5 and K_2O were applied at the time of sowing. Whereas, nitrogen was applied in two equal splits (half each at basal and at 30 DAS). No fertilizer was applied in the control plot. The variety used in the experiment was Swetha with a seed rate of 5 kg ha^{-1}.The gross plot size was 5 m ×4 m with a spacing of 30 cm × 10 cm. For recording non-destructive sampling parameters like plant height five plants were selected randomly and tagged from each experimental plot and five plants were uprooted from the destructive sampling area of each plot at and dried in a hot air oven at 60 ^{0}C till constant weights were obtained. Final weights were expressed in kg ha^{-1}. The seed yield and stalk yield was measured from net plot of each treatment and computed as yield in kg ha^{-1}. Proper crop management practices were followed with need based irrigation and plant protection measures. Crop was harvested at 95 DAS and seeds were analyzed for oil content and fatty acid composition. The oil content of the seed for each treatment was determined with the help of continuous type pulsed Nuclear Magnetic Resonance (NMR-oxford MQC) as suggested by Tiwari et al. [6]. Fatty acid composition was determined using a gas chromatograph (GC). The data recorded was statistically analyzed following procedure described by Gomez and Gomez [7].

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

3.1.1 Plant height (cm)

Plant height significantly differed among tillage practices. At harvest, significantly taller plants were recorded under conventional tillage (114.2 cm) which was statistically similar to plant height obtained under reduced tillage (108.6 cm). Lowest plant height was observed minimum tillage (102.3 cm). At harvest, application of 125% RDF recorded significantly taller plants (124.2 cm) which were at par with application of 100% RDF (119.1 cm) followed application of 75% RDF (113.7 cm) over corresponding lower levels of fertilizer application i.e., 50% RDF (105.6 cm), 25% RDF (96.4 cm) and control. Significantly lowest plant height was recorded with control (90.9 cm). Compared to minimum tillage, conventional tillage might have promoted better seed germination and increased seedling vigour, which might have benefited plant growth. The development of a compacted layer in minimum tillage severely inhibited plant growth. Similar findings were reported by Sarder and Rosario [8].

Plants that received 125% RDF might have grown taller than those that received lower fertilizer doses because of more availability of nutrients. Increased nutrient intake caused cell growth and elongation, which ultimately increased plant height. Similar findings were reported by Malek et al. [9]

3.1.2 Dry matter production (kg ha^{-1})

Dry matter production significantly varied among tillage practices. At harvest, conventional tillage recorded significantly higher dry matter production (2670 kg ha^{-1}) which was statistically on par with reduced tillage (2507 kg ha^{-1}). Significantly lower dry matter production was observed under minimum tillage (2429 kg ha^{-1}). There was a significant variation in the dry matter production with nutrient management practices. Highest dry matter production at harvest was obtained with the application of application of 125% RDF (2928 kg ha^{-1}) which was at par with application of 100% RDF (2779 kg ha^{-1}) and application of 75% RDF (2530 kg ha^{-1}). This was significantly superior over application of 50% RDF (2479 kg ha^{-1}), application of 25% RDF (2281 kg ha^{-1}) and control (2217 kg ha^{-1}). Dry matter production significantly increased with the increase in tillage intensity. Favourable soil environment created under conventional tillage significantly increased plant height and enhanced crop growth which considerably increased drymatter. Similar results were reported by Gangwar et al. [10]. Application of 125% RDF might have provided increased nutrient availability which promoted in vigorous plant growth and significantly increased the dry matter production compared to control. Increased nutrient uptake led to better assimilation and crop growth which enhanced overall dry matter production. Similar results were found by Thentu et al. [11].

3.2 Yield

3.2.1 Seed yield (kg ha^{-1})

Seed yield was found to be significant among tillage and nutrient management practices. Significantly highest seed yield was achieved conventional tillage (394 kg ha^{-1}) followed by reduced tillage (361 kg ha^{-1}) while lowest seed yield was obtained under minimum tillage (336 kg ha^{-1}). Seed yield significantly varied with nutrient management practices. Application of 125 % RDF resulted in higher seed yield (421 kg ha^{-1}) which was statistically similar with 100% RDF (407 kg ha^{-1}) and 75% RDF (385 kg ha^{-1}). Significantly lower seed yields were obtained with application of 50% RDF (364 kg ha^{-1}), 25% RDF (317 kg ha^{-1}) and control (288 kg ha^{-1}). Conventional tillage provided optimum soil conditions for better crop growth which enhanced the seed yield. Whereas under minimum tillage conditions soil tilth was not favorable for small seeded crops like sesame which resulted in significantly poor crop growth thereby affecting the yield. Application of higher doses of fertilizer resulted in better crop growth due to higher nutrient availability thereby increasing the seed yield of rice fallow sesame. Thus application of 125% RDF might have resulted in higher seed yield. While application of lower fertilizer doses significantly resulted in poor crop growth which affected seed yield. Thus lower fertility doses such as 25% RDF, 50% RDF and control have recorded significantly lower yields. Similar results were reported by Gaikwad et al. [12] and Ramesh et al. [13].

3.2.2 Stalk yield (kg ha^{-1})

Stalk yield was significantly higher under conventional tillage (1467 kg ha^{-1}) which was on par with reduced tillage (1394 kg ha^{-1}) while lowest stalk yield was obtained under minimum tillage (1295 kg ha^{-1}). Stalk yield of rice fallow sesame significantly varied with nutrient management practices. Highest stalk yield was recorded with application of 125% RDF (1553 kg ha^{-1}) which was at par with 100% RDF (1511 kg ha^{-1}) and 75% RDF (1455 kg ha^{-1}). Significantly lower stalk yields were obtained with application of 50% RDF (1386 kg ha^{-1}), 25% RDF (1250 kg ha^{-1}) and control (1157 kg ha^{-1}). Stalk yield is correlated with the growth parameters such as plant height and drymatter accumulation etc. Increased stalk yield might be due to increase in plant height and drymatter production favoured by conventional tillage. Application of 125% RDF might have resulted in higher stalk yield due to increased nutrient availability which favoured better plant growth. Increased fertilizer doses improved the nutrient uptake and translocation of nutrients which promoted better crop growth. Thus increased nutrient availability favoured stalk yield. Whereas with application of lower fertilizer doses the nutrient availability was reduced which significantly hindered the crop growth which led to accumulation of less drymatter thereby hindering the stalk yield. Similar results were reported by Patel et al. [14] and Mukherjee [15].

3.3 Quality Parameters

3.3.1 Oil content (%)

Results indicated that oil content of rice fallow sesame was not significantly influenced by tillage and nutrient management practices. However higher oil content was achieved under conventional tillage (52.13%) over minimum (51.96%) and reduced tillage (51.83%). Among nutrient management practices highest oil content was obtained with application of 125% RDF (52.43%) over application of 100% RDF (52.33%), 75% RDF (52.24%), 50% RDF (52.04%), 25% RDF (51.49%). Lowest oil content was obtained with control treatment (51.32%). There was an increase in oil content with increased fertilizer doses. Results were in conformity with Malik et al. [16], Mukherjee [15] and Patel et al. [17]. However no significant difference was observed with nutrient management practices. Interaction effect was also found to be non significant.

3.3.2 Oil yield (kg ha^{-1})

Oil yield of rice fallow sesame was significantly influenced by tillage and nutrient management practices. Conventional tillage recorded highest oil yield (205.35 kg ha^{-1}) over reduced (187.50 kg ha^{-1}) and minimum tillage (174.85 kg ha^{-1}). Lowest oil yield was recorded with minimum tillage treatment. These results were corroborated with Sree et al. [18] and Umesh et al. [19]. With increase in tillage intensity there

Table 1. Growth and yield of rice fallow sesame as influenced by different tillage and nutrient management practices

Treatments	Plant height (cm)	Dry matter production (kg ha^{-1})	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})
Main plot treatments				
A_1: Reduced tillage (Cultivator once)	108.6	2507	361	1394
A_2: Conventional tillage (Cultivator twice with rotavator once)	114.2	2670	394	1467
A_3 : Minimum tillage (tillage in the row zone/uprooting soil in the seed zone with hand held dibbler)	102.3	2429	336	1295
SEm (±)	1.7	45.5	6.9	25.6
CD (p=0.05)	6.9	178.6	27.4	100.6
Subplot treatments				
B_1 : Control	90.9	2217	288	1157
B_2 : 25% RDF	96.5	2281	317	1250
B_3 : 50% RDF	105.6	2479	364	1386
B_4 : 75% RDF	113.8	2530	385	1455
B_5 : 100% RDF	119.1	2779	407	1511
B_6 : 125 % RDF	124.3	2928	421	1553
SEm (±)	4.2	110.2	15.4	48.8
CD (p=0.05)	12.0	318.3	44.3	140.9
Interaction				
Sub treatment at same level of main treatment				
SEm (±)	4.3	111.4	17.1	62.7
CD (p=0.05)	NS	NS	NS	NS
Main treatment at same/different level of sub treatment				
SEm (±)	6.8	180.1	25.2	81.3
CD (p=0.05)	NS	NS	NS	NS

Table 2. Oil content, Oil yield and Fatty acid composition of rice fallow sesame as influenced by different tillage and nutrient management practices

Treatments	Oil content (%)	Oil yield (kg ha^{-1})	Palmitic acid (%)	Stearic acid (%)	Oleic acid (%)	Linoleic acid (%)	Linolenic acid (%)
Main plot treatments							
A_1: Reduced tillage (Cultivator once)	51.83	187.50	10.27	5.09	41.27	42.54	0.35
A_2: Conventional tillage (Cultivator twice with rotavator once)	52.13	205.35	9.84	5.00	41.49	43.07	0.30
A_3 : Minimum tillage (tillage in the row zone/uprooting soil in the seed zone with hand held dibbler)	51.96	174.85	9.90	4.91	41.38	42.87	0.35
SEm (±)	0.29	4.22	0.27	0.06	0.13	0.41	0.02
CD (p=0.05)	NS	16.56	NS	NS	NS	NS	NS
Subplot treatments							
B_1 : Control	51.32	147.70	10.38	5.30	40.90	42.18	0.36
B_2 : 25% RDF	51.49	163.17	10.34	4.99	41.14	42.57	0.37
B_3 : 50% RDF	52.04	189.13	10.08	5.07	41.26	42.76	0.35
B_4 : 75% RDF	52.24	201.38	9.85	4.97	41.37	42.85	0.34
B_5 : 100% RDF	52.33	213.11	9.69	4.90	41.67	43.12	0.31
B_6 : 125 % RDF	52.43	220.91	9.68	4.76	41.95	43.48	0.28
SEm (±)	0.40	7.99	0.23	0.12	0.27	0.37	0.03
CD (p=0.05)	NS	23.07	NS	NS	NS	NS	NS
Interaction							
Sub treatment at same level of main treatment							
SEm (±)	0.70	10.61	0.67	0.16	0.32	1.01	0.05
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS
Main treatment at same/different level of sub treatment							
SEm (±)	0.70	13.35	0.46	0.21	0.45	0.71	0.05
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS

was progressive increase in oil yield. Appreciable increase in oil content and seed yield under conventional tillage might be attributed to increased oil yield. An increase in oil yield was noticed with increase in fertilizer doses up to 125% RDF. Significantly highest oil yield was achieved with application of 125% RDF (220.91 kg ha^{-1}) which was statistically similar with application of 100 % RDF (213.11 kg ha^{-1}) and 75% RDF (201.38 kg ha^{-1}). Considerably lower oil yields were recorded with application of 50% RDF (189.13 kg ha^{-1}), 25% RDF (163.17 kg ha^{-1}) and control (147.70 kg ha^{-1}). Significantly lowest oil yield was obtained with control treatment. Significant increase in seed yield under higher fertilizer doses can be attributed to higher oil yield. These research findings were in similarity with Reddy et al. [20], Thanki et al. [21] and Umesh et al. [19].

3.3.3 Fatty acid composition

Results revealed that fatty acid profile of rice fallow sesame was not influenced by tillage and nutrient management practices. Conventional tillage managed to obtain comparatively lesser amounts of palmitic acid (9.84%) and linolenic acid (0.30%) but higher amounts of oleic (41.49%) and linoleic acid (43.07%). Highest palmitic acid content was seen in reduced tillage (10.27%) followed by minimum tillage (9.90%). Stearic acid content was found to be maximum with reduced tillage (5.09%) followed by conventional tillage (5.00%). While lowest stearic acid content was found in minimum tillage (4.91%). Comparatively lower oleic acid (41.27%) and linoleic acid (42.54%) was seen with reduced tillage when compared with minimum tillage. A considerable reduction in contents of palmitic acid, stearic acid and linolenic acid was noticed with application of higher fertilizer doses upto 125% RDF. However, oleic and linoleic acid content increased with higher fertilizer doses as reported by Boydak et al. [22]. Highest linoleic acid content was obtained with 125% RDF (43.48%) and lower content was recorded with control treatment (42.18%). Lowest palmitic acid (9.68%), stearic acid (4.76%) and linolenic acid (0.28%) was observed with 125% RDF. These results were in conformity with Ali and Ullah [23], Ramesh et al. [5] and Zapletalova et al. [24]. Comparatively increased palmitic acid, stearic acid and linolenic acid content was noticed with lower fertilizer doses. Conversely increased linolenic acid content with nitrogen treatment was observed by Yalcin [25].

4. CONCLUSION

Sesame cultivation is mainly restricted to rainfed cultivation under sub optimal management conditions. Sesame being oilseed crop demands appreciable nutrition for a profitable production. When crop is grown in rice fallows, adequate fertilization is must to ensure optimum yields. Further poor physical condition of soil in rice fallows require adequate tillage practices. Thus tillage and nutrient management practices plays a significant role in enhancing sesame yield in rice fallow. This impact of yield as affected by tillage and nutrient management practices is reflected on oil quality. From results of the study it is evident that tillage and nutrient management practices significantly affected plant height, drymatter production, seed yield, stalk yield and oil yield. Conventional tillage proved to improve crop growth and yield when compared with minimum tillage. This might be due to better soil conditions under conventional tillage. Application of 125% RDF resulted in higher growth and yield parameters when compared with corresponding lower fertilizer doses. Improved nutrient availability and nutrient uptake caused better crop growth thereby enhancing yield of sesame. However there was no significant influence of tillage and nutrient management on oil content and fatty acid composition. There was a slight increase in oil content with increase in fertilizer doses. Similarly, data on fatty acid composition revealed that there was an increase in oleic and linoleic acid content with increase in fertilizer doses, but stearic, palmitic and linolenic acid content got decreased with increased nutrient levels.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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