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Effect of integrated nutrient management on growth and yield of sesamum (*Sesamum indicum* L.) under pigeonpea based intercropping system

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Abstract

An Experiment entitled "Effect of integrated nutrient management on growth and yield of Sesamum (*Sesamum indicum* L.) under pigeonpea based intercropping system in Eastern Uttar Pradesh" was conducted at the Agronomy research farm of Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya (U.P.), INDIA, during the *Kharif* season (2019-20 and 2020-21). The treatments comprised as different integrated nutrient management levels. On the basis of two year results, Among the integrated nutrient management practices, application of N_5 (75% RDF + FYM@ 5t ha^{-1} + Sulphur@ 40kg ha^{-1} + $ZnSO_4$@ 25kg ha^{-1} + Boron @ 1.5kg ha^{-1}) recorded maximum plant height (154.41 and 157.27cm), number of branches $plant^{-1}$ (17.40 and 17.59), dry matter production (g) $plant^{-1}$ (12.74 and 12.96), number of capsules $plant^{-1}$ (86.60 and 91.71), number of seeds $capsule^{-1}$ (55.58 and 57.13), test weight (3.25 and 3.79g), seed yield (495 and 499 kg ha^{-1}) and stover yield (1934.64 and 1945.00 kg ha^{-1}), biological yield (2429.97 and 2443.67 kg ha^{-1}), and harvest index (20.38 and 20.41%) which was found higher over N_1 (RDF alone).

Keywords: Integrated nutrient management, intercropping, yield, sesamum crop

1. Introduction

Sesamum (*Sesamum indicum* L.) also known as Till or Gingelly belongs to the genus sesamum and family Pedaliaceae. Sesamum is one of the important oilseed crops in India. Most sesamum wild relatives are found in sub-Saharan Africa (Bedigian 2003) [13], but these are also present in India in small numbers (Desai, 2004) [6]. Its archeological pieces of evidence are documented in Pakistan (2250 and 1750bc) at Harappa in the Indus valley. These species have spread from African to Asian and South American countries. The Sesamum plant is an annual in habit, with indeterminate growth and possesses a diploid chromosome number of 2n = 26. Due to the presence of high oil, protein and other nutritional elements, its seed has become an important ingredient in food and feed. Plants are erect to semi-erect depending on branching types; ovate to lanceolate leaves with pointed apices, the leaf margins are entire to serrate, and stem is round or square type. Flowers range in size containing small-sized tubular calyx and five-lobed corollas and colors, e.g., white, violet, red or maroon. Corolla is campanulate having a lower corolla lobe longer than the upper one with one sterile and four functional epipetalous stamens. (Ullah *et al*., 2012) [11]. Sesamum is a pioneer among the domesticated oilseed crops being still cultivated throughout the world in about 70 countries, out of which 26 are located in Africa and 24 in Asia. It is grown worldwide over an area of 75 million hectares producing 60,000 t seeds (FAOSTAT, 2008) [7]. Myanmar, Sudan, China and India are the leading sesamum-producing countries in the world. In India, total Oilseeds production is (33.42mt). Major states of the total Oilseeds production in Rajasthan (6.79mt), Gujarat (6.66mt), and Madhya Pradesh (6.57mt) (Anonymous, 2020) [3]. Excessive use of agrochemicals has raised concerns regarding depleting soil productivity and overall nutrient imbalance. Use of organic and inorganic fertilizers in a balanced proportion for sustainable production of sesamum. Integrated use of organic manures and mineral fertilizers helps in maintaining stability in crop production, besides improving soil physical conditions. Sulphur has long been recognized as one of the essential elements for plant growth, particularly for oilseed crops. Sulphur is a constituent of three amino acids commonly found in plants *viz*., cystine, cystenine, and methionine, which are essential components of proteins. Sowing of sesamum as an intercrop with pigeonpea may fulfill this requirement as the growth habit of sesamum is mostly suited for modification in the planting systems (Darshan *et al*. 2009) [5].

2. Materials and Methods

2.1 Experimental site

A field experiment was carried out during the *Kharif* session of 2019-20 and 2020-21 at the Agronomy research farm of Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, and Ayodhya (U.P.). The experimental site was situated about 42 km away from Ayodhya city, on Ayodhya – Rai Bareilly road at 26.47^{0}N latitude, 82.12^{0}E longitude, and an altitude of 113 meters above mean sea level. The allocation of treatment in the plots was done randomly. The data recorded on different characters during the investigation were subjected to statistical analysis by using the analysis of variance technique for randomized block design as suggested by Panse and Sukhatme (1967). The treatment differences were tested by the "F" test of significance at a 5% level of significance; critical differences were calculated to compare the significant differences between the treatments.

2.2 Experimental design and treatment details

The experiment was laid out in a Factorial randomized block design (Two Factors) with fifteen treatments and three replications. The treatments were comprised as three intercropping systems (pigeonpea sole, pigeonpea + sesamum and pigeonpea + sorghum) and five integrated nutrient management system (N_1-RDF alone, N_2- RDF + FYM @5t ha^{-1}, N_3- RDF+FYM @ 5t ha^{-1} + sulphur@40kg ha^{-1}, N_4-RDF + FYM @ 5t ha^{-1} + sulphur @ 40kg ha^{-1} + $ZnSo_4$ @ 25kg ha^{-1} and N_5- RDF+FYM @ 5t ha^{-1} + sulphur @ 40kg ha^{-1} + $ZnSo_4$@ 25kg ha^{-1} + B @ 1.5kg ha^{-1}. The required quantity of organic manures, *viz*., FYM was applied in moist soil as per treatment about one week before sowing of grains. The recommended dose of fertilizers was given for Sesamum at 60 kg N, 30 kg P and 30 kg K kg ha^{-1}in the form of urea, DAP and muriate of potash were applied as basal dose.

3. Results and Discussion

3.1 Growth observations

Data regarding the plant height, number of branches plant^{-1} and dry matter production plant^{-1} of sesamum as influence by integrated nutrient management have been furnished in Table (1). This might be ascribed to differential growth habit of pigeonpea and sesamum crop grow in a non-competitive environment. Different fertility levels significantly influence the plant height was recorded under N_5 (75% RDF + FYM@5t ha^{-1} + Sulphur@40kg ha^{-1} + $ZnSO_4$@25kg ha^{-1} + Boron@1.5kg ha^{-1}) during both the years of experimentation. Maximum plant height (154.41cm in 2019-20 and 157.27cm in 2020-21) was recorded with N_5 (75% RDF + FYM@5t ha^{-1} + Sulphur@40kg ha^{-1} + $ZnSO_4$@25kg ha^{-1} + Boron@1.5kg ha^{-1}) which was significantly higher over N_1 (RDF alone) and while, at par with N_4 (75% RDF + FYM@5t ha^{-1} + Sulphur@40kg ha^{-1} + $ZnSO_4$@25kg ha^{-1}) during both the years of experimentation. Minimum plant height was recorded in RDF alone (135.95cm in 2019-20 and 138.12cm in 2020-21) respectively. The beneficial effect of organic manure (FYM) on plant height also is due to the increased supply of all essential nutrients in available form by FYM which is good organic manure applied in combination with the nutrient management system. Maximum number of branches plant^{-1} (17.40 in 2019-20 and 17.59 in 2020-21) was found with the treatment N_5 (75% RDF + FYM@5t ha^{-1} + Sulphur@40kg ha^{-1} + $ZnSO_4$@25kg ha^{-1} + Boron@1.5kg ha^{-1}) which was significantly higher over N_1 (RDF alone) and statically at par with N_4 (75% RDF + FYM@5t ha^{-1} + Sulphur@40kg ha^{-1} + $ZnSO_4$@25kg ha^{-1}) during both the years of experimentation. Minimum number of branches plant^{-1} was recorded in RDF alone (9.28 in 2019-20 and 9.66 in 2020-21) respectively. Dry matter production plant^{-1} was increased significantly under application of N_5 (75% RDF + FYM@5t ha^{-1} + Sulphur@40kg ha^{-1} + $ZnSO_4$@25kg ha^{-1} + Boron@1.5kg ha^{-1}) over N_1 (RDF alone) during both the year study. Maximum dry matter production plant^{-1} (12.47g and 12.61g) was found with N_5 (75% RDF + FYM@5t ha^{-1} + Sulphur@40kg ha^{-1} + $ZnSO_4$@25kg ha^{-1} + Boron@1.5kg ha^{-1}) followed by N_4 (75% RDF + FYM@5t ha^{-1} + Sulphur@40kg ha^{-1} + $ZnSO_4$@25kg ha^{-1}), N_3 (75% RDF + FYM@5t ha^{-1} + Sulphur@40kg ha^{-1}), N_2 (75% RDF + FYM@5t ha^{-1}) and N_1 (RDF alone) during both the years of experimentation. Minimum dry matter production plant^{-1} was recorded in RDF alone (12.47g plant^{-1} in 2019-20 and 12.61g plant^{-1} in 2020-21) respectively. The higher production of dry matter in plant might have improved the value of stover yield due to combination of inorganic and organic (FYM) fertilizers. It indicates the role of integrated nitrogen management for improving the seed and stover yield during the both year of experimentation. This suggested that plant responded to nitrogen application more in comparison to P and K application. The growth characters such as plant height, number of branches and number of leaves provided better opportunity for higher sunlight interception. Similar result found by the Ahirwar, *et al*. (2017), Salame *et al.* (2020), Haruna, I.M., (2011), Yadav *et al*. (2019) and Ghosh, *et al.* (2013) [1, 10, 9, 12, 8].

Table 1: Growth of sesamum as influenced by integrated nutrient management practices under pigeonpea based intercropping system

Treatments	Plant height (cm)		Number of branches plant^{-1}		Dry matter production (g plant^{-1})	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Nutrient Management System						
N_1- RDF	135.95	138.12	9.28	9.66	12.47	12.61
N_2-75%RDF + FYM@ 5t ha^{-1}.	143.95	145.52	10.01	12.04	12.60	12.69
N_3-75%RDF + FYM@5t ha^{-1} + Sulphur@40kg ha^{-1}.	146.46	148.88	11.86	13.77	12.64	12.76
N_4-75%RDF + FYM@5t ha^{-1} + Sulphur @ 40 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1}.	151.60	155.29	15.11	16.04	12.68	12.84
N_5-75% RDF + FYM@5t ha^{-1} + Sulphur@40kg ha^{-1} + $ZnSO_4$@25kg ha^{-1} + Boron@1.5kg ha^{-1}.	154.41	157.27	17.40	17.59	12.74	12.96
S.Em±	1.73	3.25	0.55	1.03	0.05	0.05
C.D.at 5%	5.19	9.75	1.67	3.09	0.16	0.17

3.2 Yield attributes

Data regarding the capsules plant^{-1}, number of seeds capsule^{-1} and test weight (g) of sesamum as influence by integrated nutrient management have been furnished in Table 2. Among the all integrated nutrient management systems that significantly affected the capsules plant^{-1} under the application of N_5 (75% RDF + FYM@5t ha^{-1} + Sulphur@40kg ha^{-1} + $ZnSO_4$@25kg ha^{-1} + Boron@1.5kg ha^{-1}) over the RDF alone during both year of experimentation. Further, application of N_5 (75% RDF + FYM@5t ha^{-1} + Sulphur@40kg ha^{-1} + $ZnSO_4$@25kg ha^{-1} + Boron@1.5kg ha^{-1}) gave maximum number of capsules plant^{-1} (86.60 in 2019-20 and 91.71 in 2020-21) which was followed by N_4 (75% RDF + FYM@5t ha^{-1} + Sulphur@40kg ha^{-1} + $ZnSO_4$@25kg ha^{-1}), N_3 (75% RDF + FYM@5t ha^{-1} + Sulphur@40kg ha^{-1}), N_2 (75% RDF + FYM@5t ha^{-1}) and N_1 (RDF alone) during both the years of study. Minimum number of capsules plant^{-1} was recorded in RDF alone (64.39 in 2019-20 and 67.51 in 2020-21) respectively. Application of N_5 (75% RDF + FYM@5t ha^{-1} + Sulphur@40kg ha^{-1} + $ZnSO_4$@25kg ha^{-1} + Boron@1.5kg ha^{-1}) gave maximum number of seeds capsule^{-1} (55.58 in 2019-20 and 57.13 in 2020-21) which was followed by N_4 (75% RDF + FYM@5t ha^{-1} + Sulphur@40kg ha^{-1} + $ZnSO_4$@25kg ha^{-1}), N_3 (75% RDF + FYM@5t ha^{-1} + Sulphur@40kg ha^{-1}), N_2 (75% RDF + FYM@5t ha^{-1}) and N_1 (RDF alone) during both the years of study. Minimum Number of seeds capsule^{-1} was recorded in RDF alone (43.46 in 2019-20 and 45.01 in 2020-21) respectively. Application of N_5 (75% RDF + FYM@5t ha^{-1} + Sulphur@40kg ha^{-1} + $ZnSO_4$@25kg ha^{-1} + Boron@1.5kg ha^{-1}) gave maximum test weight (3.25g plant^{-1} in 2019-20 and 3.79g plant^{-1} in 2020-21) which was followed by N_4 (75% RDF + FYM@5t ha^{-1} + Sulphur@40kg ha^{-1} + $ZnSO_4$@25kg ha^{-1}), N_3 (75% RDF + FYM@5t ha^{-1} + Sulphur@40kg ha^{-1}), N_2 (75% RDF + FYM@5t ha^{-1}) and N_1 (RDF alone) during both the years of study. Minimum test weight was recorded in RDF alone (2.86g plant^{-1} in 2019-20 and 2.92g plant^{-1} in 2020-21) respectively. Similar to growth parameters, yield attributes i.e. average number of capsules per plant and number of seed per capsule increased significantly with the application of different fertility levels. Similar result found by the Ahirwar, *et al*. (2017), Bunphan *et al*. (2021) and Ghosh, *et al*. (2013) [1, 4, 8].

Table 2: Yield attributes of sesamum as influenced by integrated nutrient management practices under pigeonpea based intercropping system

Treatments	Number of capsule plant^{-1}		Number of seeds capsule^{-1}		Test Weight (g)	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Nutrient Management System						
N_1- RDF	64.39	67.51	43.13	45.01	2.86	2.92
N_2-75%RDF + FYM@ 5t ha^{-1}.	69.93	71.35	46.77	50.86	2.90	3.19
N_3-75%RDF + FYM@5t ha^{-1} + Sulphur@40kg ha^{-1}.	76.12	79.40	49.53	52.97	2.95	3.33
N_4-75%RDF + FYM@5t ha^{-1} + Sulphur @ 40 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1}.	82.45	85.35	52.62	55.03	3.20	3.40
N_5-75% RDF + FYM@5t ha^{-1} + Sulphur@40kg ha^{-1} + $ZnSO_4$@25kg ha^{-1} + Boron@1.5kg ha^{-1}.	86.60	91.71	55.58	57.13	3.25	3.79
S.Em±	1.38	2.10	1.32	1.34	0.42	0.52
C.D.at 5%	4.14	6.30	3.96	4.03	NS	NS

3.3 Yields

Data regarding the grain yield (kg ha^{-1}), Stover yield (kg ha^{-1}), biological yield (kg ha^{-1}), and harvest index (%) of sesamum as influence by integrated nutrient management system have been furnished in Table 3. Is evident from the data, that significant variation in grain yield (kg ha^{-1}) of sesamum was found due to different integrated nutrient management systems during both the years. Application of N_5 (75% RDF + FYM@5t ha^{-1} + Sulphur@40kg ha^{-1} + $ZnSO_4$@25kg ha^{-1} + Boron@1.5kg ha^{-1}) were recorded significantly higher grain yield over RDF alone. Further, data revealed that amongst the integrated nutrient management system, application of N_5 (75% RDF + FYM@5t ha^{-1} + Sulphur@40kg ha^{-1} + $ZnSO_4$@25kg ha^{-1} + Boron@1.5kg ha^{-1}) recorded maximum seed yield (495 kg ha^{-1} in 2019-20 and 499 kg ha^{-1} in 2020-21) which was significantly higher rest of the fertility levels during both the years of study. Minimum seed yield was recorded in RDF alone (315kg ha^{-1} in 2019-20 and 330kg ha^{-1} in 2020-21) respectively. Combined application of inorganic nutrients along with micronutrients and sulphur has a great role to increase the seed yield of sesamum as compared to only inorganically treated nutrients. Data revealed that amongst the integrated nutrient management system, application of N_5 (75% RDF + FYM@5t ha^{-1} + Sulphur@40kg ha^{-1} + $ZnSO_4$@25kg ha^{-1} + Boron@1.5kg ha^{-1}) recorded maximum stover yield (1934.64kg ha^{-1} in 2019-20 and 1945.00kg ha^{-1} in 2020-21) which was significantly higher over N_1 (RDF alone). Minimum stover yield was recorded in RDF alone (1655.30kg and 1675.30kg ha^{-1}) during both the years of investigation. Data on indicated that there was significant variation in the biological yield of sesamum due to integrated nutrient management system over RDF alone. Further, data revealed that amongst integrated nutrient system, the application of N_5 (75% RDF + FYM@5t ha^{-1} + Sulphur@40kg ha^{-1} + $ZnSO_4$@25kg ha^{-1} + Boron@1.5kg ha^{-1}) recorded maximum biological yield (2429.97kg ha^{-1} in 2019-20 and 2443.67kg ha^{-1} in 2020-21) which was significantly higher over N_1 (RDF alone). Minimum biological yield was recorded in RDF alone (1970.30kg and 2005.64kg ha^{-1}) during both the years of investigation. Application of N_5 (75% RDF + FYM@5t ha^{-1} + Sulphur@40kg ha^{-1} + $ZnSO_4$@25kg ha^{-1} + Boron@1.5kg ha^{-1}) recorded maximum harvest index (20.38% in 2019-20 and 20.41% in 2020-21) which was significantly higher over N_1 (RDF alone). Minimum harvest index was recorded in RDF alone (15.99% and 16.47%) during both the years of investigation. Integrated nutrient management was reported to be the best option to increase the yield of the crops and maintaining soil health. It is interesting to note that application of B, Mo or Zn along with N, P and K boosted the yield of sesamum significantly. This may be due to supply of nutrients from diversified sources and prolonged availability of nutrients to the growing plants. The beneficial role of free living nitrogen fixing microorganisms for enhancing plant growth through their ability in nitrogen fixation as well as the effect of their metabolites secretion on the crop may also be attributed for the same. Similar result was found by Ahirwar, *et al.* (2017) and Ahmad *et al.* (2018) [1, 2].

Table 3: Yields and harvest index of sesamum as influenced by integrated nutrient management practices under pigeonpea based intercropping system

Treatments	Seed yield (Kg ha^{-1})		Stover yield (Kg ha^{-1})		Biological yield (Kg ha^{-1})		Harvest index (%)	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Nutrient Management System								
N_1- RDF	315	330	1655.30	1675.30	1970.30	2005.64	15.99	16.47
N_2-75%RDF + FYM@ 5t ha^{-1}.	400	405	1780.11	1800.11	2179.78	2204.78	18.33	18.35
N_3-75%RDF + FYM@5t ha^{-1} + Sulphur@40kg ha^{-1}.	455	450	1836.60	1856.60	2291.60	2321.60	19.86	20.03
N_4-75%RDF + FYM@5t ha^{-1} + Sulphur @ 40 kg ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1}.	480	485	1879.91	1895.98	2360.24	2380.98	20.35	20.37
N_5-75% RDF + FYM@5t ha^{-1} + Sulphur@40kg ha^{-1} + $ZnSO_4$@25kg ha^{-1} + Boron@1.5kg ha^{-1}.	495	499	1934.64	1945.00	2429.97	2443.67	20.38	20.41
S.Em±	4.98	4.13	13.80	17.00	22.80	25.42	0.067	0.113
C.D.at 5%	14.36	12.40	45.00	55.43	74.35	82.88	0.223	0.376

4. Conclusion

Maximum plant height, number of branches plant^{-1} and dry matter production plant^{-1} was recorded with N_5 (75% RDF + FYM@ 5t ha^{-1} + Sulphur@ 40kg ha^{-1} + $ZnSO_4$@ 25kg ha^{-1} + Boron @ 1.5kg ha^{-1}) which was significantly higher over N_1 (RDF alone) while, at par with N_4(75% RDF + FYM@ 5t ha^{-1} + Sulphur@ 40kg ha^{-1} + $ZnSO_4$@ 25kg ha^{-1}) during both years of experimentation. Yield attributes and yield was increased significantly with increasing system of integrated nutrients management during both the years. Application of N_5 (75% RDF + FYM@ 5t ha^{-1} + Sulphur@ 40kg ha^{-1} + $ZnSO_4$@ 25kg ha^{-1} + Boron @ 1.5kg ha^{-1}) gave maximum number of capsules plant^{-1}, number of grains capsule^{-1} and test weight (g) which was found at par with N_4 (75% RDF + FYM@ 5t ha^{-1} + Sulphur@ 40kg ha^{-1} + $ZnSO_4$@ 25kg ha^{-1}), while, significantly higher over N_1 (RDF alone) during both the years of study. Application of N_5 (75% RDF + FYM@ 5t ha^{-1} + Sulphur@ 40kg ha^{-1} + $ZnSO_4$@ 25kg ha^{-1} + Boron @ 1.5kg ha^{-1}) recorded maximum seed yield (kg ha^{-1}), Stover yield (kg ha^{-1}, Biological yield (kg ha^{-1}) and Harvest index (%) which was significantly higher over N_1 (RDF alone).

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