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Effect of different organic and inorganic fertilizers on nutrient content and uptake by summer sesamum (*Sesamum indicum* L.) in loamy sand

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Abstract
A filed experiment was conducted at Agronomy Instructional Farm, C.P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar, during summer, 2018. The experiment entitled "effect of different organic and inorganic fertilizers on nutrient content and uptake by summer sesamum (*Sesamum indicum* L.) in loamy sand of North Gujarat. The experiment consisted of total ten treatments of integrated nutrient management *viz*., T_1 - 100% RDF (50 + 25 + 00 kg NPK ha^{-1}), T_2 - 100% RDF + PSB + *Azotobacter*, T_3 - 50% RDF + 5.0 t FYM ha^{-1}, T_4 - 75% RDF + 2.5 t FYM ha^{-1}, T_5 - 50% RDF + 2.0 t vermicompost ha^{-1}, T_6 - 75% RDF + 1.0 t vermicompost ha^{-1}, T_7 - 50% RDF + 5.0 t FYM ha^{-1} + PSB + *Azotobacter*, T_8 - 75% RDF + 2.5 t FYM ha^{-1} + PSB + *Azotobacter*, T_9 - 50% RDF + 2.0 t vermicompost ha^{-1} + PSB + *Azotobacter*, T_{10} - 75% RDF + 1.0 t vermicompost ha^{-1} + PSB + *Azotobacter* were tested in randomized block design with three replications. The results revealed that significantly higher seed yield (978 kg ha^{-1}) and stalk yield (2368 kg ha^{-1}) were recorded under treatment of 50% RDF + 5.0 t FYM ha^{-1} + PSB + *Azotobacter*. Significant improvement in N (3.04%) and P (0.769%) content in seed was noted under INM treatment of 50% RDF + 5.0 t FYM ha^{-1} + PSB+*Azotobacter* (T_7), while K (0.689%, and S (0.489%) content in seed did not differ significantly, but numerically higher values was obtained under the same treatment (T_7). Content of N, P, K and S in stalk did not differ significantly, but their numerically higher value were obtained under the treatment of 50% RDF + 5.0 t FYM ha^{-1} + PSB + *Azotobactor* (T_7). Similarly, significantly higher N, P, K, and S uptake by seed (29.75, 7.52, 6.74, 4.78 kg ha^{-1}, respectively) and stalk (27.68, 12.45, 22.18, 9.84 kg ha^{-1}, respectively) were obtained under the T_7 treatment (50% RDF + 5.0 t FYM ha^{-1} + PSB + *Azotobactor*).

Keywords: Sesamum, yield, nutrient, content, uptake

Introduction
Sesamum (*Sesamum indicum* L.) is an important oil seed crop in India grown next to ground nut, rapeseed and mustard. It has been believed that sesamum probably originated in Africa. It is also a robust crop that needs little farming support to grow in drought conditions. It can also be cultivate and with residual moisture as semi *rabi* crop with suitable variety. The crop thrives best on moderately fertile, well-drained soil with a pH range of 6.5 to 8.0, but it is sensitive to salinity. Sesamum is cultivated in an area of 19.53 lakh hectares in India with an annual production of 8.50 lakh tonnes and productivity of 463 kg ha^{-1}. Gujarat is the largest producer of sesamum followed by West Bengal, Maharashtra, Rajasthan, Tamil Nadu and Karnataka. These six states account for about 64 per cent of the total area and 78 per cent of the production of sesamum in the country. Kheda, Bhavnagar Sabarkantha, Amerli and Kutch districts are main producer of sesamum. The estimated area of sesamum in Gujarat is 1.64 lakh hectares, with a production of 0.64 lakh tonnes and productivity is 390 kg ha^{-1}.

The post green revolution scenario of Indian agriculture encompasses many problems such as stagnation or even decline in production and productivity of major crops, deterioration of soil fertility, decline in factor productivity, low diversity of production systems and increasing cost of production. These constraints have cropped-up partially as a result of continuous cropping without proper nutrient management and indiscriminate use of agrochemicals on soil and crops. Indiscriminate use of high analysis chemical fertilizers resulted in the deficiency of nutrients other than the applied and disturbed the natural equilibrium of nutrient elements in soils. The problems of micronutrients deficiencies arise due to the use of only high analysis chemical fertilizers having one or two nutrient elements. The decline in productivity of intensive cropping systems over the years was associated with deficiencies of secondary and micronutrients. Sustainability of crop production is not a viable proposition either through use of organic manures or chemical fertilizers alone. Use of chemical fertilizers alone increased the crop yields in the initial years but adversely affected the sustainability at a later stage.

Sesamum nutrition remained very controversial for a long time (Okpara *et al*., 2007) [9]. While most researchers were of the opinion that sesamum does not require any fertilization, some believed that the crop needed to be fertilized. Adequate supply of nitrogen is beneficial for carbohydrates and protein metabolism, promoting cell division and cell enlargement. Similarly, good supply of phosphorus is usually associated with increased root density and proliferation, which aid in extensive exploration and supply nutrients and water to the growing plant part, resulting in increased growth traits thereby ensuring more seed and dry matter yield (Maiti and Jana., 1985) [7]. Understanding the dynamics of these nutrients in terms of their uptake, translocation and distribution in sesamum plant is an important aspect that will help in taking decision for improving its production and management (Shehu *et al*., 2010) [15]. It will also help in adaptation of proper package and practice for sesamum crop and reduce the cost of fertilization.

The chemical fertilizers are in short supply, derived from non-renewable sources of energy and are costly. Under these situations, bioinoculants are the route to alternative strategy and many workers also reported the beneficial effects of integrating biofertilizers on crop growth, yield and maintenance of soil fertility. *Azospirillium*, an associative diazotroph has been identified as potential microbial inoculants for increasing the productivity of various non legume crops. Biofertilizer helps in nitrogen fixation, synthesizes and secretes many amino acids which influences seed germination, plant growth and yield. Phosphorous is an important primary plant nutrient which helps in root formation and plant growth and thereby better yield. Integrated use of organic manures and chemical fertilizers in sesamum helps in maintaining stability of crop production; besides these it improves the soil physical conditions.

Materials and Methods

A field experiment was conducted on Plot No. C-5 at Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Banaskantha (Gujarat). The geographical situation of the experimental site is located at 72º 19' East longitude and 24º 19' North latitude at 154.52 meters above the mean sea level. The climate of this region is sub-tropical monsoon type and falls under semi arid region. In general, monsoon is warm and moderately humid, winter is fairly cold and dry, while summer is largely hot and dry. Generally, monsoon commences in the last week of June and retreats by the middle of September and most of the precipitation is received from the south-west monsoon, concentrating in the months of July and August. The seasonal average rainfall (1981-2017) is about 626.44 mm in about 25 rainy days and seasonal rainfall of 2017 was about 589.6 mm in about 32 rainy days. The experimental field had an even topography with a gentle slope having good drainage. The soil samples were taken randomly from different spots to a depth of 0-15 cm before layout of experiment and composite soil sample was prepared and analysed it for physical as well as chemical properties of soil. The values obtained and the methods used for the determination are presented in Table 1.

The field experiment was conducted during summer, 2018 consisted of total ten treatments of integrated nutrient management *viz*., T_1 - 100% RDF (50 + 25 + 00 kg NPK ha^{-1}), T_2 - 100% RDF + PSB + *Azotobacter*, T_3 - 50% RDF + 5.0 t FYM ha^{-1}, T_4 - 75% RDF + 2.5 t FYM ha^{-1}, T_5 - 50% RDF + 2.0 t vermicompost ha^{-1}, T_6 - 75% RDF + 1.0 t vermicompost ha^{-1}, T_7 - 50% RDF + 5.0 t FYM ha^{-1} + PSB + *Azotobacter*, T_8 - 75% RDF + 2.5 t FYM ha^{-1} + PSB + *Azotobacter*, T_9 - 50% RDF + 2.0 t vermicompost ha^{-1} + PSB + *Azotobacter*, T_{10} - 75% RDF + 1.0 t vermicompost ha^{-1} + PSB + *Azotobacter* were tested in randomized block design with three replications. The statistical analysis of the data collected for different parameters were carried out by the procedure as described by Panse and Sukhatme (1985) [12] using computer system at the Computer Centre, Department of Agricultural Statistics, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar. The value of calculated 'F' was worked out and compared with the value of table "F" at 5 per cent level of significance. The standard error of Mean (S.Em.), Critical Difference at 5 per cent, Co-efficient of variation were worked out and are presented in respective tables.

Results and Discussions

Yield

An assessment of data obtainable in Table 2 exposed that differences in seed yield due to different nutrient management treatments were found significant. The application of 50% RDF + 5.0 t FYM ha^{-1} + PSB + *Azotobacter* (T_7) produced significantly the highest seed yield (978 kg ha^{-1}) of sesamum over rest of the treatments, but remained at par with T_8, T_9 and T_{10} treatments. Application of only 100% RDF (T_1) to sesamum crop gave the lowest seed yield (780 kg ha^{-1}). The highest seed yield of sesamum was obtained due to higher and balanced supply of nutrients through organic and inorganic sources of nutrients throughout the lifecycle of plants resulted in improvement in tissue differentiation from somatic to reproductive stage helped in the more flowers and number of capsules per plant which resulted in increase in seed yield of sesamum. These results are in line of the findings of Tiwari *et al.* (1995) [21], Palaniappan *et al.* (1999) [11], Singh *et al.* (2001) [18] and Duhoon *et al.* (2004) [1]. Data presented in Table 2 explicit that significantly the highest stalk yield (2368 kg ha^{-1}) was obtained under the treatment of 50% RDF + 5.0 t FYM ha^{-1} + PSB + *Azotobacter* (T_7) over rest of the treatments but it remained at par with T_8, T_9, T_{10}, T_3 and T_4 treatments. The lowest stalk yield (1921 kg ha^{-1}) was noted under the treatment of 100% RDF (T_1) only to sesamum crop. Increase in stalk yield can be ascribed due to overall improvement in plant organs (plant height and branches) associated with faster and uniform vegetative growth of the crop under the influence of INM treatments as compared to chemical fertilizers (only through inorganic sources) resulted in increase in stalk yield. Similar results were observed by Ghosh (2000) [3] and Sujathamma *et al.* (2003) [20].

Nutrient content

The data given in Table 2 revealed that an application of 50% RDF + 5.0 t FYM ha^{-1} + PSB + *Azotobacter* gave significantly higher N content in seed (3.04%) over the treatment T_1 (100% RDF) and T_2 (100% RDF + PSB + *Azotobacter*); but it remained at par with rest of the treatments. While an application of different INM treatments did not show any significant impact on N content in sesamum stalk. The positive influences of INM on nutrient content of crop seem to be due to improved nutritional environment both in the rhizosphere and the plant system. The nitrogen content in plant system increased significantly under the diversified nutrient supply system may be due to constant supply of nitrogen to the plants through INM sources compared to chemical treatment. Similar results were also reported by Khade *et al*. (1996) [6] and Singh *et al*. (1997) [17].

Data given in Table 2 revealed that application of various integrated nutrient management treatments significantly affected the P content in seed; but did not differ the P content in stalk of sesamum. Significantly the highest P content in seed (0.769%) was noted under the influence of 50% RDF + 5.0 t FYM ha^{-1} + PSB + Azotobactor (T_7) treatment over rest of the treatments and it remained at par with T_8 and T_9 treatments. The lowest P content in seed (0.667%) was found under the application of 100% RDF (T_1). Significant increase in P content in plant parts may be due to the application of FYM solubilise more native phosphate by the organic acids released during the decomposition of FYM. Similar results were noted by Vaiyapuri *et al.* (2003) [23] and Deshmukh and Duhoon (2008) [1]. The data given in Table 2 revealed that integrated nutrient management treatments did not show any significant effect on the potassium content (%) in seed and stalk of sesamum but, numerically higher potassium content in seed (0.689%) and stalk (0.936%) was obtained under the treatment of 50% RDF + 5.0 t FYM ha^{-1} + PSB + *Azotobactor* (T_7); but, the minimum potassium content (%) in seed (0.634%) and stalk (0.878%) was found under the application of 100% RDF alone (T_1).

Data pertaining to sulphur content (%) in seed and stalk as influenced by application of nutrient management treatments are presented in Table 2. It is evident from the data presented in Table 2 revealed that differences in sulphur content in sesamum seed and stalk did not differ significantly due to the application of different nutrient management treatments. But, numerically higher value of S content in seed and stalk was found under the treatment of 50% RDF+5.0 t FYM ha^{-1} + PSB+ *Azotobactor* (T_7).

Nutrient uptake

The results of N uptake by seed and stalk are presented in Table 3 revealed that significantly the maximum N uptake by seed (30.20 kg ha^{-1}) and stalk (27.68 kg ha^{-1}) of sesamum were recorded with an application of 50% RDF +5.0 t FYM ha^{-1} + PSB + *Azotobactor* (T_7) over rest of the treatments; but, nitrogen uptake by seed and stalk were remained at par with the treatments of $T_{8,}$ $T_{9,}$ T_{10} and $T_{8,}$ $T_{9,}$ $T_{10,}$ T_3 and T_4 respectively. The lowest N uptake by seed (22.29 kg ha^{-1}) and stalk (20.67 kg ha^{-1}) was recorded when only 100% RDF (T_1) applied to the crop. Higher uptake of N by seed and stalk might be due to application of organic sources especially FYM improved the physico-chemical and biological properties of soil and also improved the availability of macro and micronutrients and microbial activity in the root zone of plant to support vegetative growth. Similar findings were also reported by Tripathy and Bastia (2012) [22].

The data given in Table 3 revealed that significantly the highest P uptake by seed (7.52 kg ha^{-1}) and stalk 12.45 (kg ha^{-1}) were recorded under the treatment of 50% RDF+5.0 t FYM ha^{-1} +PSB+ *Azotobactor* over rest of the treatments; but, ***it*** remained at par with treatment T_8 and T_9 in use of seed and treatment $T_{8,}$ $T_{9,}$ T_{10} and T_3 in case of stalk. The lowest P uptake by seed (5.21 kg ha^{-1}) and straw (9.18 kg ha^{-1}) were found under the application of 100% RDF (T_1) alone. Higher P uptake by the crop under the INM treatments was obtained mainly due to higher seed and stalk yields and higher P content in the crop under the treatment resulted in increase in P uptake by the crop. These results are in close conformity with those reported by Singaravel *et al*. (2002) [16].

The data given in Table 3 revealed that significantly the highest K uptake by seed (6.74 kg ha^{-1}) and stalk (22.18 kg ha^{-1}) was recorded with the application of 50% RDF + 5.0 t FYM ha^{-1}+ PSB + *Azotobactor* (T_7) over rest of the treatments; but, it remained at par with T_8 and T_9 treatments in case of seed and treatments $T_{8,}$ T_9, T_{10} and T_3 in case of stalk. While the lowest potash uptake by seed and stalk was noted with the application of 100% RDF (T_1) alone. Organic manures increased the concentration of nutrients in soil solution which increased the supply of potassium and also favours root development making them more efficient for absorbing nutrients. Higher potassium uptake could be attributed due to additive effect of increased seed and stalk yield and higher content of potassium in seed and stalk. The results are in line with those reported by Kene *et al*. (1991) [5] and Rao (1992) [14].

The data indicated that significantly the highest S uptake by seed (4.78 kg ha^{-1}) and stalk (9.84 kg ha^{-1}) were observed with an application of 50% RDF + 5.0 t FYM ha^{-1} + PSB + Azotobactor (T_7) over rest of the treatments and it remained at par with the treatments T_8 and T_9 in case of seed and T_8**,** T_9 and T_3 in case of stalk of sesamum (Table 3). While the lowest sulphur uptake by seed (3.57 kg ha^{-1}) and stalk (6.54 kg ha^{-1}) was observed with the application of 100% RDF (T_1) only. Higher S uptake may be due to the higher dry matter production and higher nutrient content in different parts of plants, which are in line of the findings of Mohapatra and Dixit (2010) [8].

Table 1: Initial physico-chemical properties of the experimental soil

Sr. No.		Properties	Values of soil depth 0-15 (cm)	Method	Reference
1		**Mechanical Properties**			
	(a)	Sand (%)	84.32	International Pipette method	Piper, 1966
	(b)	Silt (%)	7.34		
	(c)	Clay (%)	8.05		
	(d)	Textural classes	Loamy sand		
2		**Chemical Properties**			
	(a)	Soil $pH_{1:2.5}$	7.62	Potentiometry	Jackson (1973)
	(b)	$EC_{1:2.5}$ (dSm^{-1})	0.11	Conductometry	Jackson (1973)
	(c)	Organic carbon (%)	0.18	Modified Walkley and Black method	Walkley and Black (1934)
	(d)	Available N (kg ha^{-1})	140.31	Alkaline $KMnO_4$ method	Subbiah & Asija (1956)
	(e)	Available P_2O_5 (kg ha^{-1})	42.00	Olsen's method (0.5 M $NaHCO_3$, pH 8.5	Olsen *et al.* (1954)
	(f)	Available K_2O (kg ha^{-1})	204.02	Neutral N NH_4OAc Flame photometry method	Jackson (1973)
	(g)	Available S (mg kg^{-1})	9.80	Turbidimetric method (0.15% $CaCl_2$)	Williams & Steinbergs (1959)

Table 2: Effect of integrated nutrient management on nutrients content in sesamum

Treatments	Nitrogen (%)		Phosphorus (%)		Potassium (%)		Sulphur (mg kg^{-1})		Yield (kg ha^{-1})	
	Seed	Stalk	Seed	Stalk	Seed	Stalk	Seed	Stalk	Seed	Stalk
T_1	2.82	1.07	0.66	0.47	0.63	0.87	0.45	0.34	780	1921
T_2	2.87	1.14	0.70	0.50	0.63	0.89	0.46	0.34	782	1940
T_3	3.01	1.13	0.70	0.50	0.67	0.92	0.47	0.39	863	2201
T_4	3.00	1.13	0.68	0.50	0.67	0.92	0.47	0.38	825	2120
T_5	2.93	1.11	0.68	0.50	0.66	0.92	0.46	0.35	803	2070
T_6	2.91	1.10	0.68	0.49	0.64	0.91	0.46	0.35	794	1997
T_7	3.04	1.17	0.76	0.52	0.68	0.93	0.48	0.41	978	2368
T_8	3.02	1.17	0.74	0.52	0.68	0.93	0.47	0.40	940	2298
T_9	2.98	1.16	0.73	0.52	0.66	0.93	0.46	0.38	933	2256
T_{10}	2.97	1.14	0.70	0.50	0.65	0.93	0.46	0.36	892	2225
S.Em.±	0.045	0.033	0.01	0.01	0.01	0.012	0.01	0.017	37	88
C.D. at 5%	0.134	NS	0.04	NS	NS	NS	NS	NS	100	261
C.V.%	2.64	4.98	3.58	3.09	3.28	2.29	3.36	7.95	6.79	7.12

Table 3: Effect of integrated nutrient management on nutrients uptake by sesamum

Treatments	Nutrients uptake (kg ha^{-1})							
	Nitrogen		Phosphorus		Potassium		Sulphur	
	Seed	Stalk	Seed	Stalk	Seed	Stalk	Seed	Stalk
T_1	22.29	20.67	5.21	9.18	4.94	16.87	3.57	6.54
T_2	22.76	22.10	5.52	9.80	4.98	17.31	3.60	6.68
T_3	26.01	24.86	6.04	11.07	5.82	20.34	4.10	8.58
T_4	24.73	23.95	5.67	10.65	5.56	19.56	3.89	7.96
T_5	23.52	23.01	5.47	10.34	5.33	19.05	3.69	7.25
T_6	23.13	21.91	5.40	9.98	5.09	18.31	3.66	6.93
T_7	30.20	27.68	7.52	12.45	6.74	22.18	4.78	9.84
T_8	29.32	26.83	7.04	11.99	6.42	21.41	4.49	9.30
T_9	27.78	26.07	6.85	11.73	6.23	21.03	4.36	8.58
T_{10}	26.48	25.32	6.30	11.32	5.85	20.73	4.15	7.99
S.Em.±	1.27	1.26	0.26	0.53	0.25	0.86	0.17	0.56
C.D. at 5%	3.76	3.76	0.77	1.56	0.75	2.56	0.52	1.68
C.V.%	8.56	9.73	7.36	8.39	7.51	7.58	7.46	12.27

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