Original Research Article

Retroaction of summer sesame (*Sesamum indicum* L.) towards foliar application of NPK and micronutrients on content and uptake of nutrients in medium black calcareous soil of South Saurashtra region

ABSTRACT

A field trial was steered to ascertain the outcome of foliar application of NPK and micronutrients on nutrient content and uptake by sesame crop during the summer season of 2022on medium black calcareous soil of Instructional Farm, Junagadh Agricultural University, Junagadh, India. The experiment was conducted with three replications and 10 treatments by using Randomized Block Design (RBD), the GJT-5 variety of sesame was tested in this experiment. The treatment consists of 100 % recommended dose of fertilizer (RDF), *viz*. 50:25:40 N-P_2O_5-K_2O kg /ha (T1), T1 + Foliar spray of multi micro. mixture grade-IV(MMMG) @ 0.25 % at 30 and 45 days after sowing (DAS) (T2), 75 % of RDF + 1.5 % Water Soluble Fertilizer at 30 and 45 DAS (T3), 75 % of RDF + 2.0 % Water Soluble Fertilizer at 30 and 45 DAS (T4), 50 % of RDF + 1.5 % Water Soluble Fertilizer at 30 and 45 DAS (T5), 50 % of RDF + 2.0 % Water Soluble Fertilizer at 30 and 45 DAS (T6), T3+ Foliar spray of multi micro mixture grade - IV @ 0.25 % at 30 and 45 DAS (T7), T4+ Foliar spray of MMMG- IV @ 0.25 % at 30 and 45 DAS (T8), T5 + Foliar spray of MMMG- IV @ 0.25 % at 30 and 45 DAS (T9) and T6+Foliar spray of MMMG- IV @ 0.25 % at 30 and 45 DAS (T10).The results of the experimentation revealed that the application of T4+ Foliar spray of MMMG- IV @ 0.25 % (T8) at 30 and 45 DAS) recorded the significantly higher content of N, P and K and micronutrients (Fe, Zn, Mn, Cu and B) in seed and stover of sesame and also enhanced the uptake of these nutrients by plant as well as the availability of Nitrogen, Phosphorous and Potassium in soil after harvest of the crop. Significantly, they were at par with the application of T3+ Foliar spray of MMMG- IV @ 0.25 % (T7) at 30 and 45 DAS). While, the significantly lowest values of nutrient content and uptake were recorded with 50 % of RDF + 1.5 % Water Soluble Fertilizer (T5) at 30 and 45 DAS.

Keywords -*Nutrient content, nutrient uptake, sesame, and WSF (water soluble fertilizer).*

INTRODUCTION

Since the ancient times, the sesame plant (*Sesamum indicum* L.) has been grown as an important oilseed crop throughout Asia, with India having the longest history of sesame production. The Arthashastra of Kautilya makes mention of sesame farming in India. Sesame has 36 wild

species, 19 of which are found in India and the rest only in Africa. The majority of Sesamum genus in the wild are native to sub-Saharan Africa, however Sesamum indicum was also previously discovered in India. One of the most significant and historic oilseed crops in the world, sesame (*Sesamum indicum* L.), has been farmed in Asia for thousands of years, with India having the longest history of sesame cultivation.

It is extensively cultivated in tropical and subtropical tracks in the world. In India, sesame occupies 1.722 million ha area and production of 0.816 million tonnes having an average productivity of 474 kg/ha. Gujarat is the foremost state in cultivation of sesame with an area, production and productivity about 2.588 lakh ha, 1.225 lakh tonnes and 473.43 kg/ha respectively, [1].

It is grown in less fertilized marginal and sub-marginal areas. Low grain yield is primarily caused by widespread flower shedding, nutritional deficits, hormonal abnormalities, and endogenous levels of growth regulators [2]. Midst the agronomic aspects recognized to enhance crop production, fertilizer stands first and is considered as one of the most productive inputs in agriculture. Of the major elements, nitrogen which is deficient in most of the Indian soils plays a considerably important role [3]. The application of nutrients through soil also be subjected to loss through leaching, fixation with clay and volatilization losses. In calcareous soil condition most of the nutrients are not readily available to the plants, specially N, P and micronutrients are deficient due to fixation in soil. These unavailability of nutrients causes poor absorption by plants which leads the deficiency and ultimately decreases the yield of crop plant.

Foliar nutrition is a useful technique for correcting nutrient shortages and getting around the soil's inefficiency in transferring nutrients to the plant. Foliar spray causes a rise in cellular activity, respiration, and chlorophyll production. Additionally, it stimulates a plant's response to increased soil water and nutrient uptake [4].

By considering the above facts within the view, an effort has been made during summer 2022 to increase the crop yield through foliar application of fertilizer along with a recommended dose of fertilizers. The main objective of this study is to find out the effect of foliar application of NPK and micro nutrients on soil nutrient status and uptake by the crop.

MATERIALS AND METHODS

The experiment was conducted during summer of 2022 on medium black calcareous soil at Instructional Farm, Junagadh Agricultural University, Junagadh, Gujarat, India. This location is situated at a geographical coordinate of 21.50 degrees North latitude and 70.50 degrees East longitude, with an altitude of 60 meters above mean sea level (MSL). The soil exhibited a slightly alkaline pH of 7.8, an electrical conductivity (EC) of 0.41 dS m-1, and possessed medium levels of organic carbon at 0.52%. It displayed a clayey texture. In terms of nutrient content, the soil registered low availability of nitrogen at 237.2 kg/ha, while it contained medium levels of available phosphorus (28.5 kg/ha) and potassium (252 kg/ha). Furthermore, the soil contained micronutrients, including iron (5.5 ppm), zinc (0.55 ppm), manganese (5.1 ppm), copper (0.51 ppm), and boron (0.65 ppm).

The experiment was laid out in RBD which consists of 3 replications having 10 treatments which is given in Table 1. The recommended dose of fertilizer (50:25:40 N-P2O5-K2O kg/ha) was supplied through Urea, DAP and MOP respectively, and applied according to treatments. While rest of the

nutrients were applied by means of foliar application of Water Soluble Fertilizer (19:19:19 N:P:K) and micronutrients through Multi micro. mixture grade –IV (MMMG- IV).

The sample for chemical analysis was drawn from 5 randomly selected plants at harvest, dried at 60^{o}C, grinded and used for analysis. The analysis for concentration of N, P, and K was performed using the procedure as recommended by Jackson [5]. Micronutrients viz., Fe, Mn, Zn, Cu and B content in the seed and stover was estimated by using triple acid extract-AAS method recommended by Lindsay and Norvell [6] and uptake of nutrients by the crop were calculated. The tentative data were analysed using analysis of variance techniques at 5% level of significance endorsed by Gomez and Gomez [7].

Table 1: Description of treatments

Treatment no.	Treatment details
T1	100 % RDF, viz. 50:25:40 N-P2O5-K2O kg /ha
T2	T1 + Foliar spray of MMMG-IV @ 0.25 % at 30 and 45 DAS
T3	75 % of RDF + 1.5 % Water Soluble Fertilizer at 30 and 45 DAS
T4	75 % of RDF + 2.0 % Water Soluble Fertilizer at 30 and 45 DAS
T5	50 % of RDF + 1.5 % Water Soluble Fertilizer at 30 and 45 DAS
T6	50 % of RDF + 2.0 % Water Soluble Fertilizer at 30 and 45 DAS
T7	T3 + Foliar spray of multi micro mixture grade - IV @ 0.25 % at 30 and 45 DAS
T8	T4 + Foliar spray of MMMG- IV @ 0.25 % at 30 and 45 DAS
T9	T5 + Foliar spray of MMMG- IV @ 0.25 % at 30 and 45 DAS
T10	T6 + Foliar spray of MMMG- IV @ 0.25 % at 30 and 45 DAS

EXPERIMENTAL RESULTS

Effect on nutrient content of plant

NPK content in seed

The results indicated that the NPK content in the seeds was markedly affected by various treatments. The highest levels of nitrogen (N) at 4.83%, phosphorus (P) at 0.52%, and potassium (K) at 0.64% were observed when treatment T8 was applied (which involved T4 along with a foliar spray of MMMG-IV at a rate of 0.25% at 30 and 45 DAS). These levels were comparable to treatment T7 in terms of phosphorus content, treatment T7 and treatments T2 and T10 for nitrogen content, and treatment T7, T2, T10, and T9 for potassium content in the seeds. On the other hand, the lowest content of nitrogen (3.72%), phosphorus (0.42%), and potassium (0.53%) in the seeds was significantly recorded with treatment T5 (Table 2).

Micronutrient content in seed

The results revealed that various treatments significantly influenced the micronutrient content in the seeds. The treatment T8 (T4 + Foliar spray of MMMG- IV @ 0.25% at 30 and 45 DAS) recorded the highest levels of micronutrients in the seeds, specifically iron (Fe) at 403.25 mg, zinc (Zn) at 64.22 mg, manganese (Mn) at 76.93 mg, copper (Cu) at 58.61 mg, and boron (B) at 40.89 mg. These values were statistically similar to treatments T7 and T2 for Zn content, treatments T7, T2, and T10 for

Fe, Mn, and Cu content, and treatments T7, T2, T10, and T9 for B content in the seeds. On the other hand, significantly lower values of nitrogen (N), phosphorus (P) and potassium (K) content in the stover were observed with treatment T5 (Table 3).

NPK content in stover

Regarding the NPK content in the stover of sesame, the application of T4 in combination with a foliar spray of MMMG-IV at a rate of 0.25% at 30 and 45 DAS (T8) resulted in the highest levels of nitrogen (N), phosphorus (P), and potassium (K), at approximately 1.77%, 0.27%, and 1.28%, respectively. These values were statistically comparable to those observed in treatment T7, T2, and T10 for nitrogen and phosphorus, and treatment T7, T2, T10, and T9 for potassium content in the stover. Conversely, the lowest micronutrient content in the stover was observed in treatment T5 (Table 2).

Micronutrient content in stover

Significantly the lower content of micronutrients in stover were recorded under treatment T5 (Table 3). The findings of this study demonstrate that different agricultural treatments have a significant impact on the micronutrient content in sesame stover. The application of treatment T4 with a foliar spray of MMMG-IV at a rate of 0.25% at 30 and 45 DAS (T8), resulted in notably higher levels of micronutrients in the stover. Specifically, iron (Fe) content was recorded at 348.5 mg, zinc (Zn) at 42.81 mg, manganese (Mn) at 66.38 mg, copper (Cu) at 39.07 mg, and boron (B) at 31.46 mg. These results align with those obtained from treatments T7 and T2 in terms of Zn content, and treatments T7, T2, and T10 concerning Fe, Mn, Cu, and B content in the sesame stover. Conversely, treatment T5 yielded significantly lower micronutrient content in the stover. This underscores the importance of the applied treatments in influencing the micronutrient composition of the crop's stover in the field of agriculture (Table 3).

Effect on nutrient uptake by plant

NPK uptake by seed

The results indicate that the application of treatment T4 with a foliar spray of MMMG-IV at a rate of 0.25% at 30 and 45 DAS (T8), resulted in significantly greater uptake of nitrogen (N), phosphorus (P), and potassium (K) by the seeds, measuring at 67.07 kg/ha, 7.14 kg/ha, and 8.91 kg/ha, respectively. This was statistically similar to the uptake of phosphorus in treatment T7 and the uptake of nitrogen and potash in treatments T7 and T2. Whereas, T5 yielded significantly lower NPK uptake by the seeds. These findings emphasize the importance of specific agricultural treatments in influencing the uptake of essential nutrients by seeds in the field of agriculture (Table 2).

Micronutrient uptake by seed

The results indicated that the uptake of micronutrients by sesame seeds was significantly influenced by various treatments. The treatment that combined T4 with a foliar spray of MMMG-IV at a rate of 0.25% at 30 and 45 DAS (T8) recorded notably higher values for micronutrient uptake by

seeds. Specifically, the uptake of iron (Fe) was 559.1 g/ha, zinc (Zn) was 88.93 g/ha, manganese (Mn) was 106.49 g/ha, copper (Cu) was 81.22 g/ha, and boron (B) was 56.82 g/ha. These results were statistically similar to the treatments T7 for Zn and B uptake, and T7 and T2 for Fe, Mn, and Cu uptake by sesame seeds.

NPK uptake by stover

The results revealed that different treatments significantly influenced the uptake of nitrogen, phosphorus and potassium by sesame stover. Notably, treatment T4, with a foliar spray of MMMG-IV at a rate of 0.25% at 30 and 45 DAS (T8), resulted in substantially higher uptake of Nitrogen (37.75 kg/ha), phosphorus (5.72 kg/ha), and potassium (27.29 kg/ha) by the sesame stover. These values were statistically comparable to those obtained in treatment T7 in the context of Nitrogen uptake, and to treatments T7 and T2 regarding phosphorus and Potassium uptake by the stover (Table 2).

Micronutrient uptake by stover

The results revealed that the uptake of micronutrients by sesame stover was significantly influenced by various treatments. Remarkably higher values of micronutrient uptake by the stover, such as iron (Fe) at 742.4 g/ha, zinc (Zn) at 90.87 g/ha, manganese (Mn) at 141.49 g/ha, copper (Cu) at 82.99 g/ha and boron (B) at 66.99 g/ha were recorded under treatment T8 (comprising T4 and a foliar spray of MMMG-IV at a rate of 0.25% at 30 and 45 DAS). These results align with those obtained in treatment T7 for Zn uptake, T7 and T2 for Fe, Cu and B uptake and T7, T2 and T1 in terms of Mn uptake by the sesame stover.

Effect on Post-harvest nutrient status of soil

The data in Table 4 reveals that different treatments had a significant impact on the available soil macronutrients after the crop's harvest. There was a significant increase in the accumulation of available nitrogen (N) at 272.73 kg/ha, phosphorus (P) at 34.37 kg/ha and potassium (K) at 272.20 kg/ha in the soil following the crop's harvest when treatment T4 was applied with a foliar spray of MMMG-IV at a rate of 0.25% at 30 and 45 DAS (T8). These values were statistically similar to those observed in treatments T7, T2, T10, T9, and T1 for available nitrogen and in treatments T7, T2, and T10 for available phosphorus and potassium in the soil.

DISCUSSION

The growth and maintenance of greater chlorophyll and photosynthetic area in terms of higher leaf area and leaf area index occurred from the foliar feeding of important nutrients, mainly N, which led to higher photosynthesis. Additionally, foliar K feeding promotes a higher transfer of photosynthates from the leaves to the growing seeds, improving seed output. These two elements worked together to improve the transfer of photosynthates to growing seeds, which led to the production of healthy, mature seeds. Similar to this, applying micronutrients through foliar application promotes the activation of various enzymes and increases basic metabolic rate in plants, which facilitated the synthesis of nucleic acids and hormones and increased seed yield due to greater availability of nutrients and photosynthates [8].

Increased availability of N, P, K, and micronutrients during combined foliar treatment may be the cause of the rise in N, P, and K content in seed and stover. The increased nutrient intake was caused by an increased supply of nutrients and a well-developed root system, which increased water and nutrient absorption. This may possibly be related to the increased availability of minerals in the treated soil and the role that micronutrients play in the activation of several enzymes that aid in nutrient uptake.

It depends on the concentration of nutrient ions in the plant system and is connected to the metabolic processes of the plant. The increase in micronutrients concentration in plant due to the foliar application of micronutrients which lead to the quick absorption and avoid nutrient loses. Combined soil and foliar application of NPK and micronutrients resulted in increased concentration of macro and micronutrients in sesame crop. The findings are in agreement with Manasa *et al*., [9].

This might be explained by their complementary effects, which increase availability in the root environment and facilitate extraction and transit to the plant system. Increased uptake of nitrogen, phosphorus, potassium, iron, zinc, manganese, copper, and boron follow better yield and nutrient absorption. These results of present investigation are in close agreements with the findings of [10-12] in case of soil application of NPK fertilizers and [13-15] in case of foliar application.

The amount of nutrients that remain in the soil after a crop is harvested mostly depends on both the input of nutrients from various sources and crop uptake. Higher levels of N, P_2O_5, and K_2O in soil may be the result of foliar spraying these nutrients, which reduced soil uptake. The conclusions of [9, 14–16] are highly supported by the findings of the current investigation.

CONCLUSION

Based on one year of experimentation, it can be concluded that fertilizing sesame with 75% of the recommended dose of fertilizers (37.5 kg N, 18.75 kg P2O5, and 30 kg K2O per hectare), in combination with a 2.0% application of Water Soluble Fertilizer at 30 and 45 DAS, as well as a foliar spray of MMMG-IV at 0.25% at 30 and 45DAS, resulted in significant improvements in nutrient content and uptake. This was achieved through efficient nutrient absorption by the plant from the soil and via foliar application, strengthening the plant's system and ultimately enhancing the performance of the crop.

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Table 2 Effect of foliar application of NPK and micronutrients on content and uptake of Macronutrients (N, P and K) by the crop

Treatments	N				P				K			
	Content (%)		Uptake (kg/ha)		Content (%)		Uptake (kg/ha)		Content (%)		Uptake (kg/ha)	
	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover
T_1	4.24	1.48	50.92	28.85	0.45	0.22	5.42	4.32	0.58	1.08	6.98	20.99
T_2	4.64	1.61	59.86	32.21	0.47	0.25	6.14	4.94	0.62	1.18	8.07	23.67
T_3	4.01	1.35	40.24	22.35	0.44	0.21	4.41	3.45	0.57	0.98	5.74	16.15
T_4	4.13	1.43	43.24	25.22	0.45	0.22	4.69	3.83	0.57	1.03	6.03	18.16
T_5	3.72	1.19	28.21	13.43	0.42	0.16	3.19	1.79	0.53	0.87	4.01	9.65
T_6	3.82	1.24	31.20	15.07	0.43	0.17	3.52	2.08	0.54	0.90	4.46	10.81
T_7	4.73	1.70	63.09	35.13	0.50	0.25	6.60	5.19	0.63	1.22	8.43	25.20
T_8	4.83	1.77	67.07	37.75	0.52	0.27	7.14	5.72	0.64	1.28	8.91	27.29
T_9	4.33	1.53	39.94	19.53	0.46	0.22	4.19	2.86	0.61	1.12	5.57	14.28
T_{10}	4.47	1.59	41.90	20.79	0.46	0.24	4.37	3.11	0.61	1.14	5.77	14.90
SEm ±	**0.13**	**0.06**	**2.82**	**1.76**	**0.01**	**0.01**	**0.25**	**0.35**	**0.02**	**0.06**	**0.45**	**1.50**
CD at 5%	**0.38**	**0.18**	**8.38**	**5.24**	**0.04**	**0.03**	**0.74**	**1.04**	**0.06**	**0.19**	**1.34**	**4.47**

Table 3: Effect of foliar application of NPK and micronutrients on content and uptake of micronutrients (Fe, Zn. Mn. Cu and B) by the crop

Tr. No.	Fe				Zn				Mn				Cu				B			
	Content		Uptake		Content		Uptake		Content		Uptake		Content		Uptake		Content		Uptake	
	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover
T_1	319.4	300.7	381.3	590.0	49.93	34.11	59.62	65.95	63.55	58.53	76.02	114.71	47.19	32.13	56.93	62.56	35.62	26.89	42.81	52.62
T_2	375.6	331.3	484.5	663.9	58.65	39.09	76.01	77.90	72.62	62.53	93.80	125.54	55.49	36.99	71.86	73.73	38.03	29.25	49.07	58.48
T_3	308.3	295.4	311.5	486.8	48.02	32.61	47.91	53.58	60.86	57.47	61.48	95.04	45.69	29.42	46.37	48.79	34.22	25.86	34.28	42.59
T_4	311.7	297.4	327.5	525.4	49.65	33.11	51.76	58.46	62.36	58.23	65.40	102.93	46.19	31.02	48.50	54.88	34.59	26.54	36.32	46.96
T_5	304.6	286.9	231.6	322.8	45.03	30.49	33.99	34.48	58.73	53.97	44.36	60.94	41.93	27.30	31.78	30.52	31.99	22.96	24.11	26.05
T_6	307.6	291.5	253.3	353.9	47.29	32.08	38.39	38.74	60.53	55.85	49.10	67.90	43.39	28.43	35.46	34.47	33.54	23.85	27.32	28.84
T_7	390.3	340.9	520.1	705.9	61.18	40.72	81.39	84.06	75.02	65.01	99.98	134.58	57.53	38.36	76.69	79.39	39.60	30.46	52.69	62.82
T_8	403.2	348.5	559.1	742.4	64.22	42.81	88.93	90.87	76.93	66.38	106.5	141.49	58.61	39.07	81.22	82.99	40.89	31.46	56.82	66.99
T_9	343.9	309.8	316.2	401.1	54.31	35.98	49.90	46.11	67.07	59.60	61.86	77.02	51.09	34.44	47.28	44.26	36.89	28.38	34.03	36.48
T_{10}	359.9	320.5	337.0	422.5	56.03	37.35	52.92	49.10	70.01	60.81	65.61	79.29	53.05	35.37	49.71	46.21	37.76	29.05	35.41	37.94
SEm ±	**16.8**	**11.06**	**25.32**	**46.9**	**2.61**	**1.78**	**3.51**	**3.87**	**3.20**	**2.09**	**4.81**	**9.03**	**2.34**	**1.55**	**4.58**	**4.34**	**1.54**	**0.91**	**2.58**	**3.52**
CD at 5%	**50.0**	**32.88**	**75.24**	**139.3**	**7.76**	**5.31**	**10.45**	**11.51**	**9.53**	**6.22**	**14.29**	**26.84**	**6.96**	**4.62**	**13.62**	**12.89**	**7.35**	**2.72**	**7.66**	**10.47**

Table 4: Effect of foliar application of NPK and micronutrients on post-harvest nutrient status of soil

Treatments	Post-harvest soil Available nutrients							
	Macronutrients (kg/ha)			Micronutrients (mg/kg)				
	N	P	K	Fe	Zn	Mn	Cu	B
T_1	237.81	28.73	244.71	5.60	0.54	5.78	0.94	0.42
T_2	260.92	31.97	259.58	6.00	0.58	5.95	0.98	0.49
T_3	226.11	26.33	236.15	5.44	0.53	5.77	0.93	0.40
T_4	230.39	27.53	240.66	5.55	0.54	5.80	0.94	0.41
T_5	213.25	24.28	229.39	5.24	0.48	5.53	0.88	0.39
T_6	217.64	25.31	232.09	5.42	0.50	5.61	0.90	0.40
T_7	266.98	33.86	266.34	6.09	0.58	6.08	0.98	0.51
T_8	272.73	34.37	272.20	6.21	0.59	6.15	0.99	0.52
T_9	246.49	29.41	249.67	5.71	0.55	5.83	0.95	0.45
T_{10}	252.24	30.95	252.82	5.89	0.58	5.93	0.98	0.48
SEm ±	**13.16**	**1.15**	**7.18**	**0.25**	**0.03**	**0.25**	**0.04**	**0.03**
CD at 5%	**39.11**	**3.43**	**21.33**	**NS**	**NS**	**NS**	**NS**	**NS**