International Journal of Research in Agronomy 2025; 8(10): 576-580

E-ISSN: 2618-0618
P-ISSN: 2618-060X

NAAS Rating (2025): 5.20
www.agronomyjournals.com
2025; 8(10): 576-580
Received: 26-08-2025
Accepted: 29-09-2025

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Effect of diverse nutrient sources and liquid organic manures on soil nutrient status of sesame (*Sesamum indicum* L.)

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DOI: https://www.doi.org/10.33545/2618060X.2025.v8.i10h.4056

Abstract
A field experiment was conducted to study "Organic nutrient management in *rabi* sesame (*Sesamum indicum* L.)" during 2024-25 at the Agricultural College Farm, Naira. The experiment was laid out in a split-plot design with three replications. The study consists of three main plot treatments *viz.,* 100% RDN through inorganic fertilizers, 100% RDN through organics with biofertilizers and biofertilizers alone. The sub-plots included four foliar applications: Vermiwash, *Panchgavya*, *Jeevamrut* and water spray. The results showed thaT$_{10}$0% RDN organic manures + biofertilizers (M_2) significantly improved post-harvest nitrogen, phosphorus and potassium and foliar application of *Panchgavya* @ 3% (S_3),whereas organic carbon was maximum under 100% RDN through organic manures + application of liquid biofertilizers (M_2) and foliar application of *Jeevamrut*@ 10% (S_3) and microbial activity was highest under 100% RDN through organic manures +application of liquid biofertilizers (M_2) and foliar application of *Jeevamrut* @ 10%(S_3).The study concludes that applying 100% RDN through organic manures along with biofertilizers, combined with foliar spraying of *Jeevamrut* @ 10%, is the most effective practice for improving soil fertility, microbial activity and sustaining sesame cultivation during the *rabi* season

Keywords: Sesame, Jeevamrut, panchgavya, vermiwash, biofertilizers and organics

Introduction

Sesame (*Sesamum indicum* L.), often referred as the "Queen of Oilseeds," is one of the oldest cultivated oilseed crops known for its high oil (50-52%) and protein (17-19%) content, along with carbohydrates and essential fatty acids (Kahyaoglu and Kaya, 2006) [9]. Sesame oil, popularly termed as "poor man's ghee," is highly nutritious and holds several health benefits. The seeds are rich in calcium, magnesium, zinc, antioxidants like sesamin and sesamol and vitamin E, which support heart health, digestion, skin and bone strength. Sesame is versatile in its use as it can be consumed raw, roasted or processed into oil, tahini and it can be used in cosmetics and ayurvedic medicine. In India, sesame is cultivated in an area of 15.31 lakh hectares with a production of 8.47 lakh tonnes and productivity of 553kg ha^{-1}. However, in Andhra Pradesh, despite its significance, productivity remains low aT$_3$76 kg ha^{-1} due to poor soil fertility, minimal inputs and suboptimal agronomic practices (Indiastat, 2023-2024) [6]. *Rabi* sesame, predominantly grown in the north coastal regions of Andhra Pradesh, often receives only one or two irrigations, making foliar nutrient application more practical than soil fertilization. The limited attention to crop nutrition has contributed to consistently low yields.

Conventional sesame farming relies heavily on synthetic fertilizers, which, though effective in the short term but adversely affect soil health, microbial diversity and the environment. As sesame is particularly sensitive to nutrient imbalances, sustainable alternatives are crucial. Organic nutrient management offers a promising approach by enhancing soil organic matter, microbial activity and overall fertility while reducing environmental harm. Additionally, organically grown sesame is gaining international demand due to consumer preference for eco-friendly and chemical-free produce. Organic inputs like press mud cake, a byproduct rich in nutrients and organic matter, improve soil structure, water retention and microbial activity. Similarly, vermicompost is rich in plant growth regulators from microbial-earthworm interactions, has been shown to enhance plant growth, flowering and yields (Arancon and

Edwards, 2009; Jayashree *et al.*, 2011) [1, 8]. Biofertilizers, through phytohormone production and nutrient mobilization, further aid in plant development in an eco-friendly way. Foliar applications of liquid organic manures also play a critical rolein boosting crop performance. *Jeevamrut, Panchgavya* and Vermiwash are effective natural formulations rich in nutrients, beneficial microbes and plant hormones. *Jeevamrut* improves nutrient availability and soil microbial activity, which boosts sesame growth and yield. Its application produces a healthy, biologically active rhizosphere that increases plant vigor, oil content and seed quality. *Panchgavya*, for instance, supplies key macro and micronutrients along with microbial inoculants like *Azotobacter* and phosphor bacteria (Praneeth *et al*., 2021) [15], while vermiwash contains bioactive compounds and microbial enzymes that stimulate plant metabolism and nutrient uptake. In this context, integrating soil-applied organic and inorganic nutrient sources with foliar sprays of liquid organic manures may serve as an effective strategy to improve the growth, yield and profitability of *rabi* sesame, particularly under low-input conditions.

Materials and Methods

The present field experiment was conducted during *Rabi*, 2024-25, laid out in block-A, field No.6 of Agricultural College Farm, Naira, Acharya N.G. Ranga Agricultural University, Andhra Pradesh, which is geographically situated at 18.240° N latitude, 83.840° E longitude with an altitude of 27 m above mean sea level in the North Coastal Zone of Andhra Pradesh. The mean maximum and minimum temperatures ranged from 30.1°C to 37.8°C and 16.8°C to 25.6°C, respectively, while the average maximum and minimum temperatures during the crop period were 33.95°C and 14.3°C. During the corresponding period, the mean relative humidity of the forenoon is 82.88 per cent and the afternoon is 56.95 per cent, with an average of 69.91 per cent. A total rainfall of 19.8 mm was received in 2 rainy days during the crop growth period. Favorable weather conditions prevailed for the successful growth of the sesamum. The experiment was laid out in a split-plot design with three main plot treatments involving different nutrient sources: 100% RDN through inorganic fertilizers(M_1), 100% RDN through organics with biofertilizers (M_2) and biofertilizers alone (M_3). The sub-plots included four foliar applications: Vermiwash (S_1), *Panchgavya* (S_2), *Jeevamrut* (S_3) and water spray (S_4). Data was collected on various characters such as the nutrient uptake (kg ha^{-1}), soil quality indicators, soil nutrient status (kg ha^{-1}) and soil microbial population.

Results and Discussion

1. NPK Uptake

1.1 Nitrogen uptake (kg ha^{-1})

Nitrogen uptake in sesame was significantly affected by nutrition sources and foliar organic manures. Among nutrition sources, 100% RDN through inorganic fertilizers (M_1) recorded the highest uptake, owing to the immediate availability of mineral N and was superior to organics + biofertilizers (M_2) and soil-applied biofertilizers (M_3), corroborating Kumar *et al.* (2022) [12] and Bhavana *et al.* (2021) [2]. Among foliar sprays, *Jeevamrut* @ 10% (S_3) achieved maximum uptake, followed by Vermiwash (S_1) and *Panchgavya* (S_2), while water spray (S_4) was lowest. The higher uptake with *Jeevamrut* is attributed to its microbial diversity and nutrient richness, supporting Gabhane *et al.* (2019) [5] and Kranthikumar *et al.* (2025) [11]. Interaction effects were nonsignificant.

1.2 Phosphorus uptake (kg ha^{-1})

Phosphorus uptake in sesame was significantly influenced by nutrition sources and foliar organic manures. Among sources, 100% RDN through inorganic fertilizers (M_1) recorded the highest uptake due to readily available water-soluble P, followed by organics + biofertilizers (M_2), with the lowest in soil-applied biofertilizers (M_3), supporting Chandrasekaran *et al.* (2024) [3]. Among foliar sprays, *Jeevamrut* @ 10% (S_3) gave the highest uptake, on par with Vermiwash (S_1) and superior to *Panchgavya* (S_2) and water spray (S_4), likely due to enhanced microbial activity and P mobilization, as noted by Pattnayak *et al.* (2024) [14]. Interaction effects were nonsignificant.

1.3 Potassium uptake (kg ha^{-1})

Potassium uptake in sesame was significantly influenced by nutrition sources and foliar sprays. Among sources, 100% RDN through inorganic fertilizers (M_1) recorded the highest uptake due to the quick solubility of K, followed by organics + biofertilizers (M_2) and soil-applied biofertilizers (M_3), aligning with Singh *et al.* (2024) [17] and Bhavana *et al.* (2021) [2]. Among foliar sprays, *Jeevamrut* @ 10% (S_3) achieved maximum uptake, surpassing *Panchgavya* (S_2) and water spray (S_4), likely due to microbial-mediated K solubilization, corroborating Gabhane *et al.* (2019) [5] and Kranthikumar *et al.* (2025) [11]. Interaction effects were nonsignificant.

2. Soil quality indicators

2.1 Electrical conductivity (ds m^{-1})

Post-harvest soil EC was significantly affected by foliar organic manures but not by nutrient sources. Among sources, 100% RDN through inorganic fertilizers (M_1) showed slightly higher EC than M_2 and M_3, though differences were nonsignificant, aligns with Bhavana *et al.* (2021) [2]. Among foliar sprays, *Jeevamrut* @ 10% (S_3) recorded the highest EC, followed by Vermiwash (S_1) and *Panchgavya* (S_2), while water spray (S_4) was lowest. The rise in EC under *Jeevamrut* may be due to its nutrient-rich composition and fermentative by-products, as also noted by Gabhane *et al.* (2019) [5]. Interaction effects were nonsignificant.

2.2 Soil pH

Post-harvest soil pH was not significantly affected by nutrient sources or foliar organic manures. Among sources, M_2 (organics + biofertilizers) showed the lowest pH, likely from organic acid release during decomposition, while M_1 (inorganics) recorded the highest, aligning with Singh *et al.* (2024) [17]. Among foliar sprays, *Jeevamrut* (S_3) had the highest pH, followed by Vermiwash (S_1), *Panchgavya* (S_2) and lowest under water spray (S_4), possibly due to the buffering effect of *Jeevamrut*, as noted by Kranthikumar *et al.* (2025) [11]. Interaction effects were nonsignificant.

2.3 Organic Carbon (%)

Post-harvest soil organic carbon (OC) was significantly influenced by both nutrient sources and foliar organics. Among sources, organics + biofertilizers (M_2) recorded the highest OC, followed by biofertilizers alone (M_3), with the lowest under inorganics (M_1), due to continuous organic matter addition and microbial stimulation, supporting Pattnayak *et al.* (2024) [14] and Chandrasekaran *et al.* (2024) [3]. Among foliar sprays, *Jeevamrut* (S_3) showed the highest OC, followed by Vermiwash (S_1) and *Panchgavya* (S_2), all superior to water spray (S_4), consistent with Gabhane *et al.* (2019) [5]. Interaction effects were significant, with M_2S_3 giving the highest OC, followed by M_2S_1 and M_2S_2, owing to combined organic matter inputs and microbial enhancement. These results align with Kiruthika *et al.* (2022b) [10] and Singh *et al.* (2024) [17], highlighting that integrating organics with biologically rich foliar sprays improves soil carbon reserves, fertility and long-term sustainability.

Table 1: Nutrient uptake by plant and soil quality indicators at harvest (kg ha^{-1}) of sesame as influenced by different sources of nutrition and foliar application of liquid organic manures

Treatments	Nutrient uptake by plant (kg ha^{-1})			Soil quality indicators		
	N	P	K	EC (ds m^{-1})	pH	OC (%)
Main plots: Sources of nutrition						
M_1: 100% RDN through inorganic fertilizers	57.28	17.20	36.20	0.19	6.77	0.39
M_2: 100% RDN through organic (1/3rd each through Press Mud cake + Vermicompost + FYM) + liquid bio fertilizers (*Azospirillum*+ PSB + KRB @ 1.25 Lit ha^{-1}).	48.57	15.08	29.87	0.18	6.57	0.51
M_3: Soil application of liquid bio-fertilizers (*Azospirillum* + PSB + KRB @ 1.25 Lit ha^{-1})	38.18	13.22	22.98	0.17	6.74	0.42
S.Em±	1.62	0.38	0.59	0.01	0.12	0.02
CD (P=0.05)	6.37	1.49	2.33	NS	NS	0.06
CV (%)	11.70	8.65	6.91	7.43	6.32	11.96
Sub plots: Foliar application of liquid organic manures						
S_1: Vermiwash spraying twice @ 10% conc. at flower initiation and capsule development	50.32	15.79	31.80	0.18	6.78	0.45
S_2: *Panchgavya* spraying twice @ 3% conc. at flower initiation and capsule development	49.24	15.15	31.03	0.17	6.62	0.43
S_3: *Jeevamrut* spraying twice @ 10% conc. at flower initiation and capsule development	55.36	16.59	32.61	0.22	6.86	0.50
S_4: Water spray	37.13	13.15	23.3	0.15	6.52	0.38
S.Em±	1.85	0.36	0.68	0.01	0.16	0.01
CD (P=0.05)	5.50	1.08	2.03	0.02	NS	0.03
CV (%)	11.56	7.18	6.89	10.69	6.97	7.26
Interaction						
S.Em±	3.21	0.66	1.18	0.01	0.26	0.02
Interaction (M at S)	NS	NS	NS	NS	NS	0.05
Interaction (S at M)	NS	NS	NS	NS	NS	0.08
Initial status	-	-	-	0.17	6.72	0.41

Table 1.1: Interaction effect of different sources of nutrition and foliar application of liquid organic manures on organic carbon (%) of sesame

Treatments	S_1	S_2	S_3	S_4	Mean
M_1	0.40	0.36	0.43	0.36	0.39
M_2	0.54	0.51	0.55	0.42	0.51
M_3	0.41	0.40	0.51	0.37	0.42
Mean	0.45	0.43	0.50	0.38	
		S.Em±	CD (P=0.05)	CV (%)	
		0.01	0.06	11.95	
		0.01	0.03	7.25	
Interaction					
M X S		0.02	0.08	-	
S X M		0.02	0.05	-	

3. Soil nutrient status (kg ha^{-1})
3.1 Available Nitrogen (N)
Soil available nitrogen was significantly influenced by both nutrient sources and foliar organics. Among sources, organics + biofertilizers (M_2) recorded the highest N, superior to inorganics (M_1) and biofertilizers alone (M_3), due to combined effects of organic manures and microbial inoculants, supporting Pattnayak *et al.* (2024) [14] and Singh *et al.* (2024) [17]. Among foliar sprays, *Panchgavya* (S_2) gave the highest N, followed by Vermiwash (S_1), with *Jeevamrut* (S_3) lowest, consistent with Gabhane*et al.* (2019) [5]. Interaction effects were significant, with M_2S_2 (organics + *Panchgavya*) showing maximum N, followed by M_2S_1, while M_1S_2 improved residual N under inorganics. The lowest was under M3S3 (biofertilizers + *Jeevamrut*). These findings align with Yadav *et al.* (2009) [18] and Kiruthika *et al.* (2022) [10], highlighting the role of organics in sustaining soil fertility.

3.2 Available Phosphorus (P_2O_5)
Soil available phosphorus was significantly influenced by nutrient sources and foliar organics. Among sources, organics + biofertilizers (M_2) recorded the highest P, followed by inorganics (M_1), with the lowest under biofertilizers alone (M_3), due to PSB activity and organic acid release, as noted by Chandrasekaran *et al.* (2024) [3] and Bhavana *et al.* (2021) [2]. Among foliar sprays, *Panchgavya* (S_2) gave the highest P, while *Jeevamrut* (S_3) was lowest, likely from slower microbial action, differing from Kranthikumar *et al.* (2025) [11]. Interaction effects were nonsignificant.

Table 2: Soil nutrient status and soil microbial population of sesame as influenced by different sources of nutrition and foliar application of liquid organic manures

Treatments	Soil Nutrient status (kg ha^{-1})			Soil microbial population		
	N	P_2O_5	K_2O	Bacteria (CFU^{x}10^{-7}g^{-1} soil)	Fungi (CFU^{x}10^{-5}g^{-1}soil)	Actinomycetes (CFU^{x}10^{-4}g^{-1} soil)
Main plots: Sources of nutrition						
M_1: 100% RDN through inorganic fertilizers	221.8	24.41	239.7	20.45	18.70	11.85
M_2: 100% RDN through organic (1/3rd each through Press Mud cake + Vermicompost + FYM) + liquid bio fertilizers (*Azospirillum*+ PSB + KRB @ 1.25 Lit ha^{-1}).	255.4	27.08	266.7	26.54	23.36	16.14
M_3: Soil application of liquid bio-fertilizers (*Azospirillum* + PSB + KRB @ 1.25 Lit ha^{-1})	198.8	20.01	235.4	21.66	20.89	14.05
S.Em±	5.88	0.70	6.37	0.54	0.58	0.41
CD (P=0.05)	23.1	3.08	25.2	2.11	2.29	1.62
CV (%)	9.04	11.3	8.93	8.15	9.63	10.23
Sub plots: Foliar application of liquid organic manures						
S_1: Vermiwash spraying twice @ 10% conc. at flower initiation and capsule development	233	15.79	31.80	22.69	20.83	13.36
S_2: *Panchgavya* spraying twice @ 3% conc. at flower initiation and capsule development	241.3	15.15	31.03	24.26	22.92	14.98
S_3: *Jeevamrut* spraying twice @ 10% conc. at flower initiation and capsule development	204.6	16.59	32.61	26.17	25.04	16.96
S_4: Water spray	221	13.1	23.3	18.41	15.15	10.59
S.Em±	1.85	0.36	0.68	0.89	0.68	0.56
CD (P=0.05)	5.50	1.08	2.03	2.64	2.01	1.66
CV (%)	11.5	7.18	6.89	11.66	9.66	11.94
Interaction						
S.Em±	9.37	1.38	14.8	1.44	1.17	0.93
Interaction (M at S)	31.3	NS	NS	NS	NS	NS
Interaction (S at M)	25.2	NS	NS	NS	NS	NS
Initial status	225	22.5	262	16.56	12.83	8.37

Table 2.1: Interaction effect of different sources of nutrition and foliar application of liquid organic manures on soil available nitrogen of sesame (kg ha^{-1})

Treatments	S_1	S_2	S_3	S_4	Mean
M_1	237.1	246.6	195.7	207.9	221.8
M_2	256.2	257	253	255.5	255.4
M_3	205.8	222.1	165.1	202.2	198.8
Mean	233	241.9	204.6	221.9	
		S.Em±	CD (P=0.05)	CV (%)	
		5.88	23.10	9.04	
		4.86	14.44	6.47	
Interaction					
M X S		9.37	31.37	-	
S X M		8.42	25.02	-	

3.3 Available Potassium (K_2O)

Soil available potassium was significantly influenced by nutrition sources and foliar sprays. Among sources, organics + biofertilizers (M_2) recorded the highest K_2O, followed by inorganics (M_1) and biofertilizers alone (M_3), due to mineral-rich organics and K-releasing bacteria, supporting Singh *et al.* (2024) [17] and Pattnayak *et al.* (2024) [14]. Among foliar sprays, *Panchgavya* (S_2) gave the highest K_2O, followed by Vermiwash (S_1), with *Jeevamrut* (S_3) lowest. Interaction effects were nonsignificant.

4. Soil microbial population

4.1 Bacterial Population (CFU × 10^{-7} g^{-1}soil)

Post-harvest soil bacterial population was significantly affected by nutrient sources and foliar organics. Organics + biofertilizers (M_2) recorded the highest count, followed by biofertilizers alone (M_3), while inorganics (M_1) were lowest, due to organic substrates and inoculated strains, supporting Singh *et al.* (2024) [17] and Jalilian *et al.* (2022) [7]. Among foliar sprays, *Jeevamrut* (S_3) had the highest bacterial population, followed by *Panchgavya* (S_2) and Vermiwash (S_1), with water spray (S_4) lowest, owing to its rich microbial consortium, as noted by Mokariya *et al.* (2021) [13] and Gabhane *et al.* (2019) [5]. Interaction effects were nonsignificant.

4.2 Fungal Population (CFU × 10^{-5} g^{-1}soil)

Soil fungal population was significantly influenced by nutrient sources and foliar organics. Organics + biofertilizers (M_2) recorded the highest count, followed by biofertilizers alone (M_3), with inorganics (M_1) lowest, due to greater availability of complex organic substrates. Among foliar sprays, *Jeevamrut* (S_3) had the highest fungal population, followed by *Panchgavya* (S_2), Vermiwash (S_1) and water spray (S_4), indicating rhizosphere stimulation through nutrient deposition. These results agree with Salman *et al.* (2022) [16]. Interaction effects were nonsignificant.

4.3 Actinomycetes Population (CFU × 10^{-4}g^{-1} soil)

Post-harvest actinomycetes population varied significantly with nutrient and foliar inputs. Organics + biofertilizers (M_2) recorded the highest population, followed by biofertilizers alone (M_3), with inorganics (M_1) lowest, due to improved carbon availability and microbial habitat, consistent with Jalilian *et al.* (2022) [7] and Faiza *et al.* (2022) [4]. Among foliar sprays, *Jeevamrut* (S_3) was superior, followed by *Panchgavya* (S_2), Vermiwash (S_1) and water spray (S_4), likely due to its diverse microflora and role in decomposition. Interaction effects were nonsignificant.

Conclusion

The study concluded that application of 100% RDN through inorganic fertilizers along with foliar spray of *Jeevamrut* @ 10% (M_1S_3) significantly enhanced nutrient uptake in sesame under North Coastal Andhra Pradesh conditions. Although the integration of organics with biofertilizers(M_2) improved soil quality and microbial activity, their performance was comparatively lower in terms of nutrient uptake.

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