

NUTRIENT UPTAKE AND USE EFFICIENCY AS INFLUENCED BY INTEGRATED APPLICATION OF FERTILIZERS AND NANO FERTILIZERS IN SESAME (*SESAMUM INDICUM* L.)

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ABSTRACT

Nutrient management plays a vital role in determining crop growth, yield, and quality in sesame. Nutrient uptake and nutrient use efficiency are important indicators for evaluating the effectiveness of fertilizer management practices. Nutrient management practices that ensure balanced basal application and sustained nutrient availability are critical for optimizing crop performance. The experiment was conducted during *Kharif* 2025–26 at the Research Farm, ICAR- Project Coordinating Unit (Sesame and Niger), College of Agriculture, JNKVV, Jabalpur, Madhya Pradesh. The soil of the experimental field was sandy loam in texture, neutral in reaction and medium in available nutrients. The experiment was laid out in Randomized Block Design with fourteen treatments and three replications. Seed yield ranged from 290 to 758 kg ha⁻¹. The highest yield was recorded in T13 (758 kg ha⁻¹), followed by T12 (738 kg ha⁻¹) and T3 (726 kg ha⁻¹). Similarly, higher nutrient content and uptake was recorded in T13, while highest nitrogen use efficiency was recorded in T10 (64.89%) with combined application of fertilizers and nano fertilizers, followed closely by T9 (63.56%) and T3 (62.30%). Conventional RDF treatments (T1, T2, T6) showed moderate values (35–47%), highest phosphorus use efficiency was observed in T10 (32.86%), followed by T9 (31.30%) and T8 (27.44%). Treatments with nano-fertilizer supplementation (T8–T10) consistently improved PUE compared to conventional RDF. The highest potassium use efficiency was recorded in T12 (62.19%). Split application of nitrogen proved most beneficial, maximizing both seed and stalk yields. Nano-fertilizer supplementation further enhanced productivity, highlighting its potential as a complementary strategy to conventional fertilization. Nutrient content in seed and stover was strongly influenced by fertilizer management practices. Nutrient uptake was significantly influenced by fertilizer management. proved most effective, ensuring maximum N, P, and K uptake. Split nitrogen application combined with balanced basal P and K enhanced nutrient assimilation, while nano-fertilizer supplementation offered additional benefits. Unfertilized control showed severe nutrient depletion, reinforcing the necessity of integrated nutrient management for sustaining crop productivity. Nutrient use efficiency was significantly influenced by fertilizer management strategies. Split nitrogen application also enhanced efficiency, particularly for potassium. Nano-fertilizer supplementation demonstrated clear benefits, reinforcing its role as a complementary strategy to conventional fertilization for improving nutrient utilization and crop productivity.

KEYWORDS: Nutrient uptake, Integrated Application, Fertilizers, Nano Fertilizers, Sesame

INTRODUCTION

Sesame (*Sesamum indicum* L.), popularly known as the "Queen of Oilseeds," is one of the oldest cultivated oilseed crops and occupies a significant position in the agricultural economy of many tropical and subtropical countries. The crop is valued for its high-quality edible oil, rich protein content, antioxidants such as sesamin and sesamol, and its adaptability to diverse agro-climatic conditions. In India, sesame is cultivated across a wide range of environments and contributes substantially to the livelihoods of small and marginal farmers. However, despite its economic and nutritional importance, the productivity of sesame remains relatively low compared to its genetic potential, primarily due to nutrient deficiencies, poor soil fertility, and inadequate nutrient management practices.

Nutrient management plays a vital role in determining crop growth, yield, and quality in sesame. Conventional fertilizer application has long been the primary means of supplying essential nutrients to crops. However, continuous reliance on chemical fertilizers alone often leads to nutrient imbalance, reduced nutrient use

efficiency, degradation of soil health, and environmental concerns such as nutrient losses through leaching, volatilization, and runoff. Moreover, the rising cost of fertilizers necessitates the development of sustainable and efficient nutrient management strategies that can enhance productivity while maintaining soil fertility and environmental quality. Integrated Nutrient Management (INM), involving the judicious use of chemical fertilizers in combination with innovative nutrient sources, has emerged as a promising approach to address these challenges. Among recent advancements, nano fertilizers have gained considerable attention due to their unique physicochemical properties, including high surface area, controlled nutrient release, enhanced absorption, and targeted nutrient delivery. Nano fertilizers improve nutrient availability and uptake by plants while minimizing nutrient losses, thereby increasing nutrient use efficiency. Their application either through soil or foliar methods can supplement conventional fertilizers and potentially reduce the quantity of chemical fertilizers required for crop production. The integration of conventional fertilizers with nano fertilizers offers a synergistic approach to nutrient management. Such a strategy ensures an adequate nutrient supply throughout the crop growth period, promotes better root development and physiological activities, enhances nutrient uptake, and improves fertilizer use efficiency. In sesame, efficient nutrient acquisition is particularly important because the crop is often cultivated under rainfed and nutrient-deficient conditions, where nutrient losses and limited nutrient availability severely constrain productivity. The combined use of conventional fertilizers and nano fertilizers has the potential to improve nutrient recovery, reduce fertilizer wastage, and enhance crop performance through improved physiological and metabolic functions. Therefore, studying the influence of integrated application of fertilizers and nano fertilizers on nutrient uptake and use efficiency in sesame is of considerable agronomic significance. Such investigations can provide valuable insights into optimizing nutrient management practices, improving fertilizer efficiency, enhancing crop productivity, and promoting sustainable agriculture. The findings may contribute to the development of economically viable and environmentally sound nutrient management strategies for sesame cultivation, thereby supporting higher yields, better resource utilization, and long-term soil health.

MATERIALS AND METHODS

The experiment was conducted during *Kharif* 2025–26 at the Research Farm, ICAR- Project Coordinating Unit (Sesame and Niger), College of Agriculture, JNKVV, Jabalpur, Madhya Pradesh. The soil of the experimental field was sandy loam in texture, neutral in reaction and medium in available nutrients (Table 2). The experiment was laid out in Randomized Block Design with fourteen treatments and three replications. Sesame variety RT-372 was sown in the experimental field with nutrient application as treatments comprised of RDF (60:40:20) 50% N as basal and remaining N in 2 equal splits at 30 & 50 DAS (T1), 100% P₂O₅ & K₂O as basal & 75% RDN (50% basal & 50% at 30 DAS) (T2), 100% P₂O₅ and K₂O as basal & 75% RDN (top dressing in 3 equal splits at 15, 30, & 50 DAS) (T3), 100% P₂O₅ and K₂O & 50% RDN as basal (T4), 50% RDN, 50% P₂O₅ and 100% K₂O as basal (T5), 50% RDF (30:20:10) 50% N as basal & 50% at 30 DAS (T6), T4 + Nano Urea (4 ml/ liter water) spray at 30 and 50 DAS @ 300 & 400 L water/ ha (T7), T5 + Nano DAP (4 ml/ liter water) spray at 30 and 50 DAS @ 300 & 400 L water/ ha (T8), T6 + Nano DAP (4 ml/ liter water) + K (1% KCL) spray at 30 and 50 DAS @ 300 & 400 L water/ ha (T9), T6 + Nano Urea at 30 & Nano DAP at 50 DAS (4 ml/ liter water) + K (1% KCL) @ 300 & 400 L water/ ha (T10), T6 + spray of water at 30 and 50 DAS @ 300 & 400 L water/ha (T11), RDF (60:40:20) N in 3 equal splits at 15, 30 & 50 DAS, (T12), 125% (75:50:25) 50% N as basal and remaining N in 2 equal splits at 30 & 50 DAS (T13), Absolute control (T14) (Table 1) tested against recommended dose of fertilizer 60:40:20 kg N:P₂O₅:K₂O ha⁻¹ and absolute control. The crop was sown at a row spacing of 40 cm. Observations on biological yield was recorded from each net plot. Seed yield was obtained after drying, threshing and winnowing of the produce and expressed in kg ha⁻¹. Stover yield was calculated by subtracting seed yield from biological yield, nutrient content in seed and stover were estimated, nutrient uptake by crop were estimated and nutrient use efficiency under different treatments were recorded.

Table 1: Treatment details		
S. No.	Treatments	Notation
1.	RDF (60:40:20) 50% N as basal and remaining N in 2 equal splits at 30 & 50 DAS	T1
2.	100% P ₂ O ₅ & K ₂ O as basal & 75% RDN (50% basal & 50% at 30 DAS)	T2
3.	100% P ₂ O ₅ and K ₂ O as basal & 75% RDN (top dressing in 3 equal splits at 15, 30, & 50 DAS)	T3
4.	100% P ₂ O ₅ and K ₂ O & 50% RDN as basal	T4
5.	50% RDN, 50% P ₂ O ₅ and 100% K ₂ O as basal	T5
6.	50% RDF (30:20:10) 50% N as basal & 50% at 30 DAS	T6
7.	T4 + Nano Urea (4 ml/ liter water) spray at 30 and 50 DAS @ 300 & 400 L water/ ha	T7
8.	T5 + Nano DAP (4 ml/ liter water) spray at 30 and 50 DAS @ 300 & 400 L water/ ha	T8
9.	T6 + Nano DAP (4 ml/ liter water) + K (1% KCL) spray at 30 and 50 DAS @ 300 & 400 L water/ ha	T9
10	T6 + Nano Urea at 30 & Nano DAP at 50 DAS (4 ml/ liter water) + K (1% KCL) @ 300 & 400 L water/ ha	T10

11	T6 + spray of water at 30 and 50 DAS @ 300 & 400 L water/ ha	T11
12	RDF (60:40:20) N in 3 equal splits at 15, 30 & 50 DAS	T12
13	125% (75:50:25) 50% N as basal and remaining N in 2 equal splits at 30 & 50 DAS	T13
14	Absolute control	T14

Table 2: Initial physico-chemical properties of experimental soil

S. No.	Constituent	Analytical value	Interpretation	Method of determination
A)	Physical Properties			
1.	Sand (%)	45.43	Sandy loam	International Pipette method (Piper, 1967)
2.	Silt (%)	19.27		
3.	Clay (%)	35.30		
B)	Chemical Properties			
1.	Soil pH	7.42	Neutral	Glass Electrode pH Meter (Piper, 1950)
2.	Electrical conductivity (dS/m)	0.39	Normal	Conductivity meter at 25°C (Piper, 1950)
3.	Organic carbon (%)	0.53	Medium	Walkley and Black rapid titration method (Walkley and Black, 1934)
4.	Available N (kg/ha)	257.15	Medium	Alkaline Permanganate method (Subbiah and Asija, 1956)
5.	Available P (kg/ha)	17.23	Medium	Colorimetric method (Olsen <i>et al.</i> 1954)
6.	Available K (kg/ha)	264.96	Medium	Flame Photometer method (Chapman and Pratt, 1961)

Results and discussion

Seed Yield and Stalk Yield (kg ha^{-1}): Seed yield ranged from 290 to 758 kg ha^{-1} . The highest yield was recorded in T13 (758 kg ha^{-1}), followed by T12 (738 kg ha^{-1}) and T3 (726 kg ha^{-1}). The lowest yield was observed in T14 (290 kg ha^{-1}). Treatments involving split application of nitrogen (T3) and nano-fertilizer supplementation (T8, T9, T10) consistently enhanced seed yield compared to conventional RDF (T1). Stalk yield varied between 1690 to 2815 kg ha^{-1} . The highest stalk yield was recorded in T13 (2815 kg ha^{-1}), followed by T12 (2758 kg ha^{-1}) and T3 (2722 kg ha^{-1}) (Table 3). The lowest stalk yield was observed in T14 (1690 kg ha^{-1}). Treatments with balanced basal application and multiple nitrogen splits (T2, T3) produced superior vegetative biomass. T3 emerged as the most effective treatment, combining the highest seed and stalk yields, thereby demonstrating the advantage of split nitrogen application. Nano-fertilizer-based treatments (T8, T9, T10) also showed promising results, bridging the gap between conventional RDF and advanced nutrient management strategies. Treatments with reduced RDF (T4, T5, T6) consistently underperformed, underscoring the need for adequate nutrient supply. Earlier reported by Gorlapalli et al. (2022), Sahoo et al. (2022) and Kale et al. (2020).

Table 3: Effect of different treatments on seed and stalk yield of sesame

Treatments		Seed yield (kg/ha)	Stalk yield (kg/ha)
T1	RDF (60:40:20) 50% N as basal and remaining N in 2 equal splits at 30 & 50 DAS	600	2581
T2	100% P_2O_5 & K_2O as basal & 75% RDN (50% basal & 50% at 30 DAS)	580	2657
T3	100% P_2O_5 and K_2O as basal & 75% RDN (top dressing in 3 equal splits at 15,30 & 50 DAS)	726	2722
T4	100% P_2O_5 and K_2O & 50% RDN as basal	457	2313
T5	50% RDN, 50% P_2O_5 and 100% K_2O as basal	430	2311
T6	50% RDF (30:20:10) 50% N as basal & 50% at 30 DAS	437	2210

T7	T4+Nano Urea (4 ml / liter water) spray at 30 and 50 DAS @ 300 & 400 L water/ha	551	2392
T8	T5+Nano DAP (4 ml / liter water) spray at 30 and 50 DAS @ 300 & 400 L water/ha	579	2407
T9	T6+Nano DAP (4 ml /liter water)+K(1% KCL) spray at 30 and 50 DAS @ 300 & 400 L water/ha	591	2440
T10	T6+Nano Urea at 30 & Nano DAP at 50 DAS (4 ml/liter water)+K(1% KCL) @ 300 & 400 L water/ha	590	2420
T11	T6+spray of water at 30 and 50 DAS @ 300 & 400 L water/ha.	450	2253
T12	RDF (60:40:20) N in 3 equal splits at 15, 30 & 50 DAS	738	2758
T13	125% (75:50:25) 50% N as basal and remaining N in 2 equal splits at 30 & 50 DAS	758	2815
T14	No fertilizer	290	1690
SEm ±		27.32	47.90
CD (<i>p</i>=0.05)		79.41	139.26

Nutrient content and uptake

The nitrogen content in the seed varied from 3.31 to 3.41%. The highest seed N was observed in T13 (3.41%), followed closely by T3 (3.40%) and T1 (3.39%). Stover nitrogen varied between 1.07 (T14) and 1.16 (T13), with T13 again recording the maximum content. Overall, treatments with split nitrogen application (T3 & T1) maintained higher N levels in both seed and stover (Table 4). Similarly, the phosphorus content in seed ranged from 0.63 (T14) to 0.70 (T1 & T13). Stover phosphorus varied between 0.41 (T14) and 0.49 (T13). Treatments T12 & T3 recorded relatively higher P values as compared to other treatments, while reduced doses of fertilizer nutrient treatments (T4, T5, T6) showed lower concentrations. Seed potassium ranged from 0.60 (T14) to 0.65 (T3, T12 & T13), while Stover potassium varied between 0.75 (T1 & T6) and 0.81 (T13). Treatments T1, T3 and T12 consistently showed higher K values, while T1 & T6 recorded the lowest. T13 consistently outperformed other treatments across N, P, and K content, confirming the effectiveness of split nitrogen application with full basal P and K. Nano-fertilizer treatments (T9, T10) provided additional improvement, particularly in N and P uptake. Reduced RDF treatments (T4, T5, T6) showed lower nutrient concentrations, underscoring the importance of adequate and timely nutrient supply. T13 emerged as the most effective treatment, ensuring higher N, P, and K concentrations, while nano-fertilizer supplementation (T9, T10) further enhanced nutrient assimilation. Balanced basal application coupled with split nitrogen proved critical for optimizing nutrient uptake and improving crop quality.

Table 4: Effect of different treatments on Nutrient content in seed and stover (%)								
S. No.	Treatment	N content (%)		P content (%)		K content (%)		
		Seed	Stover	Seed	Stover	Seed	Stover	
T1	RDF (60:40:20) 50% N as basal and remaining N in 2 equal splits at 30 & 50 DAS	3.39	1.13	0.70	0.46	0.64	0.80	
T2	100% P ₂ O ₅ & K ₂ O as basal & 75% RDN (50% basal & 50% at 30 DAS)	3.36	1.11	0.65	0.45	0.63	0.78	
T3	100% P ₂ O ₅ and K ₂ O as basal & 75% RDN (top dressing in 3 equal splits at 15,30 & 50 DAS)	3.40	1.14	0.68	0.47	0.65	0.80	
T4	100% P ₂ O ₅ and K ₂ O & 50% RDN as basal	3.34	1.10	0.64	0.45	0.63	0.77	
T5	50% RDN, 50% P ₂ O ₅ and 100% K ₂ O as basal	3.33	1.09	0.65	0.44	0.62	0.76	
T6	50% RDF (30:20:10) 50% N as basal & 50% at 30 DAS	3.32	1.08	0.64	0.42	0.61	0.75	
T7	T4+Nano Urea (4 ml / liter water) spray at 30 and 50 DAS @ 300 & 400 L water/ha	3.34	1.10	0.66	0.43	0.62	0.77	
T8	T5+Nano DAP (4 ml / liter water) spray at 30 and 50 DAS @ 300 & 400 L water/ha	3.35	1.09	0.65	0.44	0.63	0.78	

T9	T6+Nano DAP (4 ml /liter water)+K(1% KCL) spray at 30 and 50 DAS @ 300 & 400 L water/ha	3.38	1.11	0.67	0.46	0.63	0.79
T10	T6+Nano Urea at 30 & Nano DAP at 50 DAS (4 ml/liter water)+K(1% KCL) @ 300 & 400 L water/ha	3.37	1.12	0.66	0.47	0.64	0.78
T11	T6+spray of water at 30 and 50 DAS @ 300 & 400 L water/ha	3.33	1.09	0.65	0.43	0.61	0.76
T12	RDF (60:40:20) N in 3 equal splits at 15, 30 & 50 DAS	3.41	1.15	0.69	0.47	0.65	0.80
T13	125% (75:50:25) 50% N as basal and remaining N in 2 equal splits at 30 & 50 DAS	3.42	1.16	0.70	0.49	0.65	0.81
T14	No fertilizer	3.31	1.07	0.63	0.41	0.60	0.75

NPK Uptake (kg ha⁻¹): Seed N uptake ranged from 9.60 (T14, no fertilizer) to 25.94 (T13). Stover N uptake varied between 18.02 (T14) and 32.74 (T13). The highest total N uptake was recorded in T13 (58.68 kg ha⁻¹), followed closely by T12 (56.89) and T3 (55.65). The lowest was in T14 (27.61). Differences were statistically significant (CD at 5% = 2.42). Seed P uptake ranged from 1.82 (T14) to 5.28 (T13). Stover P uptake varied between 6.87 (T14) and 13.71 (T13). The highest total P uptake was observed in T13 (18.99 kg ha⁻¹), followed by T12 (18.03) and T3 (17.62). The lowest was in T14 (8.69). Differences were significant (CD at 5% = 1.44). Seed K uptake ranged from 1.73 (T14) to 4.92 (T13). Stover K uptake varied between 12.68 (T14) and 22.89 (T13). The highest total K uptake was recorded in T13 (27.81 kg ha⁻¹), followed by T12 (26.85) and T3 (26.53) (Table 5). The lowest was in T14 (14.41). Differences were significant (CD at 5% = 1.64). T13 consistently outperformed all treatments across N, P, and K uptake, establishing the superiority of 125% RDF with split nitrogen application. T12 and T3 also showed strong performance, highlighting the role of split nutrient management. Nano-fertilizer treatments (T8, T9, T10) provided moderate improvements, while reduced RDF treatments (T4–T6) and the control (T14) recorded the lowest values. Earlier reported by Srilatha et al. (2019) and Tuli et al. (2022).

Table 5: Effect of different treatments on nutrient uptake by seed and stover (kg/ha)

S. No.	Treatment	N uptake			P uptake			K uptake		
		Seed	Stove r	Total	Seed	Stove r	Total	Seed	Stove r	Total
T1	RDF (60:40:20) 50% N as basal and remaining N in 2 equal splits at 30 & 50 DAS	20.36	29.23	49.59	4.16	11.87	16.05	3.87	20.72	24.59
T2	100% P ₂ O ₅ & K ₂ O as basal & 75% RDN (50% basal & 50% at 30 DAS)	19.47	29.58	49.05	3.78	11.78	15.56	3.66	20.81	24.47
T3	100% P ₂ O ₅ and K ₂ O as basal & 75% RDN (top dressing in 3 equal splits at 15,30 & 50 DAS)	24.71	30.94	55.65	4.91	12.71	17.62	4.74	21.79	26.53
T4	100% P ₂ O ₅ and K ₂ O & 50% RDN as basal	15.23	25.42	40.65	2.93	10.42	13.34	2.89	17.87	20.76
T5	50% RDN, 50% P ₂ O ₅ and 100% K ₂ O as basal	14.26	25.26	39.52	2.80	10.09	12.89	2.64	17.61	20.25
T6	50% RDF (30:20:10) 50% N as basal & 50% at 30 DAS	14.46	23.81	38.26	2.79	9.30	12.08	2.65	16.65	19.31
T7	T4+Nano Urea (4 ml / liter water) spray at 30 and 50 DAS @ 300 & 400 L water/ha	18.37	26.40	44.77	3.65	10.21	13.86	3.45	18.52	21.97
T8	T5+Nano DAP (4 ml / liter water) spray at 30 and 50 DAS @ 300 & 400 L water/ha	19.44	26.33	45.77	3.78	10.52	14.30	3.64	18.68	22.32
T9	T6+Nano DAP (4 ml /liter water)+K(1% KCL) spray at 30 and 50 DAS @ 300 & 400 L water/ha	19.89	26.93	46.82	3.95	11.15	15.09	3.75	19.20	22.95
T10	T6+Nano Urea at 30 & Nano DAP at 50 DAS (4 ml/liter water)+K(1% KCL) @ 300 & 400 L water/ha	19.89	27.43	47.32	3.88	11.47	15.35	3.77	18.91	22.68
T11	T6+spray of water at 30 and 50 DAS @ 300 & 400 L water/ha	14.95	24.64	39.59	2.94	9.61	12.56	2.76	17.03	19.79
T12	RDF (60:40:20) N in 3 equal splits at 15, 30 & 50 DAS	25.17	31.72	56.89	5.02	12.96	18.03	4.79	22.06	26.85
T13	125% (75:50:25) 50% N as basal and remaining N in 2 equal splits at 30 & 50 DAS	25.94	32.74	58.68	5.28	13.71	18.99	4.92	22.89	27.81
T14	No fertilizer	9.60	18.02	27.61	1.82	6.87	8.69	1.73	12.68	14.41
SEm ±		0.89	0.72	0.83	0.20	0.51	0.49	0.21	0.61	0.56

CD ($p=0.05$)	2.60	2.11	2.42	0.58	1.49	1.44	0.62	1.77	1.64
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Nutrient use efficiency

NPK Use Efficiency (NUE %): NUE ranged from 0.00 (T14, no fertilizer) to 64.89 (T10). The highest NUE was recorded in T10 (64.89%), followed closely by T9 (63.56%) and T3 (62.30%). Conventional RDF treatments (T1, T2, T6) showed moderate values (35–47%), while reduced RDF treatments (T4, T5, T6) recorded lower efficiencies. PUE varied between 0.00 (T14) and 32.86 (T10). The highest was observed in T10 (32.86%), followed by T9 (31.30%) and T8 (27.44%). Treatments with nano-fertilizer supplementation (T8–T10) consistently improved PUE compared to conventional RDF. KUE ranged from 0.00 (T14) to 62.19 (T12). The highest was recorded in T12 (62.19%), followed by T3 (60.58%) and T9 (60.15%). Treatments with split nitrogen application (T3, T12) and nano-fertilizer supplementation (T9, T10) showed superior KUE, while reduced RDF treatments (T4, T5) had the lowest values. T10 emerged as the most promising treatment, combining the highest NUE and PUE with competitive KUE. T12 and T3 excelled in KUE, confirming the importance of split nitrogen application with balanced basal fertilization. Nano-fertilizer treatments (T8–T10) consistently improved nutrient use efficiency, while reduced RDF treatments (T4–T6) underperformed across all parameters (Table 6).

Table 6: Effect of different treatments on Nutrient Use Efficiency (%)				
	Treatment	NUE (%)	PUE (%)	KUE (%)
T1	RDF (60:40:20) 50% N as basal and remaining N in 2 equal splits at 30 & 50 DAS	36.63	18.40	50.86
T2	100% P ₂ O ₅ & K ₂ O as basal & 75% RDN (50% basal & 50% at 30 DAS)	47.63	17.17	50.28
T3	100% P ₂ O ₅ and K ₂ O as basal & 75% RDN (top dressing in 3 equal splits at 15,30 & 50 DAS)	62.30	22.32	60.58
T4	100% P ₂ O ₅ and K ₂ O & 50% RDN as basal	43.47	11.62	31.74
T5	50% RDN, 50% P ₂ O ₅ and 100% K ₂ O as basal	39.67	20.99	29.20
T6	50% RDF (30:20:10) 50% N as basal & 50% at 30 DAS	35.50	16.96	48.92
T7	T4+Nano Urea (4 ml / liter water) spray at 30 and 50 DAS @ 300 & 400 L water/ha	56.14	12.91	37.76
T8	T5+Nano DAP (4 ml / liter water) spray at 30 and 50 DAS @ 300 & 400 L water/ha	60.07	27.44	39.52
T9	T6+Nano DAP (4 ml /liter water)+K(1% KCL) spray at 30 and 50 DAS @ 300 & 400 L water/ha	63.56	31.30	60.15
T10	T6+Nano Urea at 30 & Nano DAP at 50 DAS (4 ml/liter water)+K(1% KCL) @ 300 & 400 L water/ha	64.89	32.86	58.21
T11	T6+spray of water at 30 and 50 DAS @ 300 & 400 L water/ha	39.91	19.31	53.77
T12	RDF (60:40:20) N in 3 equal splits at 15, 30 & 50 DAS	48.79	23.34	62.19
T13	125% (75:50:25) 50% N as basal and remaining N in 2 equal splits at 30 & 50 DAS	41.42	20.59	53.60
T14	No fertilizer	0.00	0.00	0.00

CONCLUSION

The experimental findings proved that enhanced nutrient uptake not only supports greater biomass accumulation and partitioning of photosynthates into economic yield formation but also improves nutrient use efficiency. Nutrient uptake reflects the plant's ability to absorb and assimilate nutrients from the soil, whereas nutrient use efficiency measures how effectively the absorbed nutrients are converted into economic yield. Improving these parameters is essential for achieving sustainable sesame production under changing climatic and resource-constrained conditions. Nano-fertilizer supplementation further enhanced productivity, highlighting its potential as a complementary strategy to conventional fertilization. Nutrient content in seed and stover was strongly influenced by fertilizer management practices. Nutrient uptake was significantly influenced by fertilizer management. proved most effective, ensuring maximum N, P, and K uptake. Split nitrogen application combined with balanced basal P and K enhanced nutrient assimilation, while nano-fertilizer supplementation offered additional benefits.

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