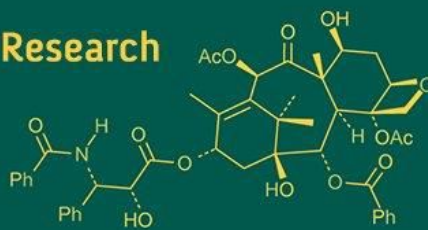


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Interactive effects of foliar applied biostimulants and different fertilizer levels on Nutrient Content and Uptake (NPK) of aerobic rice (*Oryza sativa* L.)

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Abstract

A field experiment entitled “Interactive effects of foliar applied biostimulants and different fertilizer levels on nutrient content and uptake (NPK) of aerobic rice (*Oryza sativa* L.)” was conducted at College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari (Gujarat) during *kharif* seasons of the year 2023 and 2024. The experiment was laid out in a randomized block design with ten treatments and three replications. Results showed that treatment T₆ significantly increased the N content in grain and straw of rice, but it remained at par with treatment T₃ and T₅. Phosphorus and potassium contents in both grain and straw of rice were not significantly influenced by the different treatments. The maximum nitrogen uptake by rice crop was noted under treatment T₆, which was statistically at par with treatment T₃ during the years of 2023 and 2024, but in pooled analysis treatment T₆ was not at par with any treatments. The highest phosphorus uptake by rice crop was noted under treatment T₆, which was statistically at par with treatment T₃ during the years of 2023, 2024 and in pooled analysis. Additionally, in the year of 2024, treatment T₆ exhibited statistical equivalence with treatment T₅. Treatment T₆ recorded highest potassium uptake by rice crop, but it remained at par with treatment T₃ during the years of 2023, 2024 and in pooled analysis. Furthermore, in 2024, treatment T₆ was also found on par with treatment T₅. Significantly lowest nitrogen content in grain and straw, uptake of nitrogen, phosphorus and potassium were recorded under control (T₁).

Keywords: Aerobic rice, NPK content (%), NPK uptake (kg/ha)

Introduction

Agriculture is the foundational bridge between natural ecosystems and human civilization, increasingly defined by the synergy between chemical precision and biological enhancement (Dodiya *et al.*, 2025) [6, 7, 8]. As demonstrated by the research on aerobic rice, modern farming is no longer just about the bulk application of NPK fertilizers; it is a sophisticated management system where foliar-applied biostimulants act as physiological catalysts (Dodiya *et al.*, 2023) [5].

Rice (*Oryza sativa* L.) is an important cereal crop belonging to the family Poaceae with a chromosome number $2n = 24$. It is one of the most widely cultivated staple food crops globally and serves as the primary dietary source in about 17 countries, particularly in Asia. More than two billion people in Asia depend on rice for nearly 80 percent of their daily energy intake. Globally, rice provides calories to approximately 40 percent of the population (Ghosh and Bhat, 1998) [9], although it occupies only about 11 percent of the total cultivated area. In Asia, rice is grown under diverse agro-ecosystems, including irrigated conditions (56.1%), rainfed lowlands (26%), uplands (9.2%) and deep-water systems (8.7%) (Swain *et al.*, 2005) [20].

The escalating cost of chemical fertilizers and the instability in crop production necessitate the adoption of more sustainable and economically viable nutrient management strategies. In this context, partial substitution of inorganic fertilizers with innovative approaches such as foliar application of biostimulants offers a promising solution. Biostimulants enhance nutrient use efficiency, improve plant growth and increase tolerance to abiotic stresses, thereby contributing to stable yields. Furthermore, to ensure these yields are protected from biotic pressures, innovative biotechnological interventions like CRISPR/Cas9-mediated gene

disruption have emerged as a novel strategy to manage devastating pests (Dodiya *et al.* 2025, Dodiya *et al.* 2025)^[6, 7, 8]. In this context, integrated nutrient management through the judicious use of inorganic fertilizers along with foliar application of bio stimulants has emerged as a promising approach to enhance soil productivity and sustain crop production systems over the long term (Patra *et al.*, 2000 and Kumar *et al.*, 2001)^[14, 12].

Materials and Methods

A field experiment entitled “Interactive effects of foliar applied biostimulants and different fertilizer levels on nutrient content and uptake (NPK) of aerobic rice (*Oryza sativa* L.)” was conducted at College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari (Gujarat) during *kharif* seasons of the year 2023 and 2024. The experiment was laid out in a randomized block design with ten treatments *viz.*, T₁: control, T₂: 100 percent RDF, T₃: 100 percent RDF + three foliar spray of 3 percent *panchgavya*, T₄: 100 percent RDF + three foliar spray of 2 percent vermibed-wash, T₅: 100 percent RDF + three foliar spray of 1 percent NOL, T₆: 100 percent RDF + three foliar spray of 0.25 percent seaweed extract, T₇: 75 percent RDF + three foliar spray of 3 percent *panchgavya*, T₈: 75 percent RDF + three foliar spray of 2 percent vermibed-wash, T₉: 75 percent RDF + three foliar spray of 1 percent NOL and T₁₀: 75 percent RDF + three foliar spray of 0.25 percent seaweed extract and three replications. RDF was 100-30-00 N-P₂O₅-K₂O kg/ha (Nitrogen: 40% as basal, 40% at tillering stage and 20% at panicle initiation stage; Phosphorus: 100% as basal). Foliar application of biostimulants was given at 30, 45 and 60 DAS. During the experimentation spacing between row to row was 30 cm with 50 kg/ha seed rate and variety used in the experiment was GNR-8 (Aarti). The soil of the experimental field in Navsari campus is classified

under order ‘Inceptisols’ comprising of montmorillonitic, iso-hyperthermic family of Vertic Ustrochrepts and soil series Jalalpor (Desai and Patel, 1970)^[4]. The predominant clay mineral is montmorillonite. A representative soil samples were drawn from 0 to 15 cm depth covering entire area of experimental field before sowing of the crop. The samples were thoroughly mixed and composite sample was obtained and then analysed for physico-chemical properties of the soil as represented in Table 1.

Nitrogen content (%)

The nitrogen concentration of plant and grain sample was analyzed by the micro-Kjeldahl technique by using kelplus N analyser. Finely grounded samples were digested with concentrated H₂SO₄ along with a catalyst mixture as per the procedure outlined by Piper (1943)^[15].

Phosphorus content (%)

The phosphorus content of the sample was analyzed after digestion with a di-acid mixture (HNO₃:HClO₄ in 9:4 proportion) following the procedure of piper (1943)^[15]. Phosphorus was quantified by the vanadomolybdophosphoric acid yellow colour method as described by Jackson (1973)^[10] and absorbance was recorded at 420 nm using a spectrophotometer. The values were expressed in percentage.

Potassium content (%)

The potassium content in the diacid digested mixture was determined by using flame photometer (Jackson, 1973)^[10].

N, P and K uptake by grain and straw (kg/ha)

N, P and K uptake in grain and straw were obtained in kg/ha by using following formula:

$$\text{Nutrient uptake by grain (kg/ha)} = \frac{\text{Nutrient content in grain (\%)} \times \text{Grain yield (kg/ha)}}{100}$$

$$\text{Nutrient uptake by straw (kg/ha)} = \frac{\text{Nutrient content in Straw (\%)} \times \text{Straw yield (kg/ha)}}{100}$$

$$\text{Total nutrient uptake (kg/ha)} = \text{Nutrient uptake by grain} + \text{Nutrient uptake by straw}$$

Soil analysis

Representative soil samples from each treatment were collected replication-wise from a depth of 0-15 cm using an auger. Sampling was carried out from five randomly selected locations within each net plot and the collected samples were composited and thoroughly mixed. The composite samples were placed in separate polythene bags, properly labelled and transported to the laboratory. The samples were then shade-dried, grounded using a mortar and pestle and passed through a 2 mm sieve. Finally, the processed samples were stored in polythene bags for subsequent analysis. The standard methods adopted for analysing the physical and chemical properties *viz.*, pH, EC, organic carbon (OC) and available nitrogen, P₂O₅ and K₂O as described in Table 1.

Results and Discussion

Nutrient Content (%)

The results regarding major nutrient content, *i.e.* N, P and K in grain and straw were analysed and depicted in Tables 2 to 4.

Nitrogen content (%) in grain and straw

The mean data on nitrogen content in grain and straw of rice crop as influenced by different treatments are presented in Table 2.

A detailed analysis of the data revealed that significantly higher nitrogen content in rice grain (1.04, 1.07 and 1.05%) was obtained with the application of 100 percent RDF + three foliar sprays of 0.25 percent seaweed extract (T₆) during 2023, 2024 and in pooled analysis, respectively. However, this treatment was found to be statistically at par with 100 percent RDF + three foliar sprays of 3 percent *panchgavya* (T₃), which recorded nitrogen contents of 1.02, 1.03 and 1.03 percent, respectively, as well as with 100 percent RDF + three foliar sprays of 1 percent NOL (T₅), showing values of 1.01, 1.03, and 1.02 percent, respectively. In contrast, the lowest nitrogen content in rice grain (0.62, 0.65, and 0.64%) was observed under the control treatment (T₁) during both years and in the pooled data.

Table 1: Initial physio-chemical properties of the experimental field

Particulars	Values (0-15 cm)		Methods adopted
	2023	2024	
Mechanical composition			
Sand (%)	15.15	15.25	International pipette method (Piper, 1966) ^[15]
Silt (%)	19.38	19.33	
Clay (%)	65.47	65.42	
Textural class	Clay	Clay	
Physical analysis of Soil			
Bulk density (g/cc)	1.42	1.35	Core method (Black, 1965)
Chemical analysis of Soil			
Soil pH (1:2.5, Soil:Water)	8.03	7.95	Potentiometric method (Jackson, 1973) ^[10]
EC (dS/m) (1:2.5, Soil:Water at 25 °C)	0.32	0.41	Conductometric method (Jackson, 1973) ^[10]
Organic carbon (%)	0.42	0.49	Walkley and Black method (Jackson, 1973) ^[10]
Available N (kg/ha)	210.38	224.80	Alkaline KMnO ₄ (Subbiah and Asija, 1956)
Available P ₂ O ₅ (kg/ha)	43.18	38.75	Olsen’s method (Jackson, 1973) ^[10]
Available K ₂ O (kg/ha)	345.11	370.82	Flame photometric method (Jackson, 1973) ^[10]

A similar trend was observed in rice straw. The data presented in Table 2 indicated that significantly higher nitrogen content in straw (0.51, 0.52 and 0.52%) was recorded with the application of 100 percent RDF + three foliar sprays of 0.25 percent seaweed extract (T₆) during 2023, 2024 and in pooled analysis, respectively. This treatment remained statistically at par with 100 percent RDF + three foliar sprays of 3 percent *panchgavya* (T₃), which registered nitrogen content of 0.51, 0.51 and 0.51 percent, respectively, and with 100 percent RDF + three foliar sprays of 1 percent NOL (T₅), which recorded 0.49, 0.50 and 0.50 percent nitrogen, respectively. However, significantly lower nitrogen content in rice straw (0.31, 0.32 and 0.32%) was observed under the control treatment (T₁) during the first year, second year and in pooled analysis, respectively. The nitrogen content in grain and straw was significantly influenced by the combined application of RDF and biostimulants. The increase in nitrogen content under these treatments might be attributed to improved nitrogen uptake, assimilation and translocation due to the synergistic effect of

RDF and biostimulant application. Consequently, plants under these treatments absorbed and assimilated more nitrogen, resulting in higher N content in both grain and straw. These findings are consistent with those reported by Siddaram *et al.* (2010) ^[18], Layek *et al.* (2018) ^[13] in rice, Shah *et al.* (2013) ^[17] in wheat, Chaudhary *et al.* (2021) in pearl millet and Joshi *et al.* (2023) ^[11] in black gram.

Phosphorus content (%) in grain and straw

Results depicted in Table 3 revealed that phosphorus content in rice grain and straw was not significantly influenced by the treatments, as only marginal differences were observed across all treatments.

Potassium content (%) in grain and straw

Data presented in Table 4 revealed that potassium content in rice grain and straw was not significantly affected by varying levels of RDF along with foliar application of biostimulants.

Table 2: Nitrogen content (%) in grain and straw of rice as influenced by different treatments

Treatment		Nitrogen content (%)					
		Grain			Straw		
		2023	2024	pooled	2023	2024	pooled
T ₁		0.62	0.65	0.64	0.31	0.32	0.32
T ₂		0.92	0.94	0.93	0.47	0.47	0.47
T ₃		1.02	1.03	1.03	0.51	0.51	0.51
T ₄		0.95	0.98	0.97	0.47	0.48	0.47
T ₅		1.01	1.03	1.02	0.49	0.50	0.50
T ₆		1.04	1.07	1.05	0.51	0.52	0.52
T ₇		0.91	0.98	0.95	0.45	0.45	0.45
T ₈		0.85	0.84	0.84	0.40	0.42	0.41
T ₉		0.90	0.93	0.92	0.42	0.44	0.43
T ₁₀		0.89	0.93	0.91	0.46	0.47	0.47
Mean (Year)		0.91	0.94	0.93	0.45	0.46	0.46
SEm ± (T)		0.03	0.03	0.02	0.01	0.01	0.01
CD ($p \leq 0.05$)		0.08	0.08	0.05	0.03	0.04	0.02
CV (%)		5.24	4.82	5.03	4.34	4.58	4.46
Year	SEm ±	-	-	0.008	-	-	0.004
	CD ($p \leq 0.05$)	-	-	NS	-	-	NS
Interaction (Y x T)	SEm ±	-	-	0.026	-	-	0.012
	CD ($p \leq 0.05$)	-	-	NS	-	-	NS

Table 3: Phosphorus content (%) in grain and straw of rice as influenced by different treatments

Treatment		Phosphorus content (%)					
		Grain			Straw		
		2023	2024	pooled	2023	2024	pooled
T ₁		0.259	0.265	0.262	0.176	0.177	0.176
T ₂		0.271	0.276	0.274	0.183	0.185	0.184
T ₃		0.285	0.291	0.288	0.185	0.191	0.188
T ₄		0.272	0.277	0.275	0.183	0.188	0.186
T ₅		0.281	0.286	0.283	0.185	0.191	0.188
T ₆		0.286	0.292	0.289	0.187	0.192	0.190
T ₇		0.265	0.271	0.268	0.180	0.184	0.182
T ₈		0.262	0.268	0.265	0.179	0.183	0.181
T ₉		0.264	0.269	0.267	0.180	0.182	0.181
T ₁₀		0.268	0.274	0.271	0.183	0.184	0.184
Mean (Year)		0.271	0.277	0.274	0.182	0.186	0.184
SEm ± (T)		0.009	0.010	0.007	0.005	0.004	0.003
CD ($p \leq 0.05$)		NS	NS	NS	NS	NS	NS
CV (%)		5.63	6.21	5.93	4.36	4.03	4.19
Year	SEm ±	-	-	0.003	-	-	0.001
	CD ($p \leq 0.05$)	-	-	NS	-	-	NS
Interaction (Y x T)	SEm ±	-	-	0.009	-	-	0.005
	CD ($p \leq 0.05$)	-	-	NS	-	-	NS

Table 4: Potassium content (%) in grain and straw of rice as influenced by different treatments

Treatment		Potassium content (%)					
		Grain			Straw		
		2023	2024	pooled	2023	2024	pooled
T ₁		0.460	0.455	0.458	1.223	1.208	1.216
T ₂		0.474	0.464	0.469	1.253	1.277	1.265
T ₃		0.487	0.472	0.480	1.282	1.306	1.294
T ₄		0.480	0.468	0.474	1.261	1.287	1.274
T ₅		0.481	0.470	0.476	1.268	1.296	1.282
T ₆		0.499	0.478	0.489	1.289	1.315	1.302
T ₇		0.466	0.462	0.464	1.248	1.257	1.253
T ₈		0.461	0.456	0.459	1.231	1.237	1.234
T ₉		0.465	0.458	0.462	1.246	1.248	1.247
T ₁₀		0.469	0.464	0.467	1.251	1.266	1.259
Mean (Year)		0.474	0.465	0.470	1.255	1.270	1.263
SEm ± (T)		0.013	0.013	0.009	0.029	0.032	0.022
CD ($p \leq 0.05$)		NS	NS	NS	NS	NS	NS
CV (%)		4.65	4.98	4.82	4.04	4.38	4.21
Year	SEm ±	-	-	0.004	-	-	0.010
	CD ($p \leq 0.05$)	-	-	NS	-	-	NS
Interaction (Y x T)	SEm ±	-	-	0.013	-	-	0.031
	CD ($p \leq 0.05$)	-	-	NS	-	-	NS

Nutrient Uptake (kg/ha)

The results regarding nutrient uptake by rice crop *i.e.*, N, P and K as affected by different treatments are summarized in Tables 5 to 7.

Nitrogen uptake (kg/ha)

The results of the experiment on total nitrogen uptake by rice crop as affected by different treatments are presented in Table 5.

A detailed analysis of the data revealed that the application of 100 percent RDF + three foliar sprays of 0.25 percent seaweed extract (T₆) resulted in significantly higher total nitrogen uptake by rice (61.77, 64.25 and 63.01 kg/ha) during 2023, 2024 and in pooled analysis, respectively. This treatment was found statistically at par with T₃ (100 percent RDF + three foliar sprays of 3 percent *panchgavya*), which recorded total nitrogen uptake of 56.98 and 58.97 kg/ha during 2023 and 2024, respectively. However, in pooled

analysis, T₆ proved significantly superior over the remaining treatments. The lowest total nitrogen uptake (16.05, 16.91 and 16.48 kg/ha) was observed under the control treatment (T₁) during both years and in pooled results.

Phosphorous uptake (kg/ha)

Total phosphorus uptake by the rice crop was significantly affected different treatments are presented in Table 6.

The data on phosphorus uptake by the rice crop indicated that the application of 100 percent RDF + three foliar sprays of 0.25 percent seaweed extract (T₆) resulted in significantly higher total phosphorus uptake (19.09, 19.86 and 19.47 kg/ha) during the first year, second year and in pooled analysis, respectively. This treatment remained statistically at par with treatment T₃ (100 percent RDF + three foliar sprays of 3 percent *panchgavya*), which recorded total phosphorus uptake of 17.73, 18.75 and 18.24 kg/ha during 2023, 2024 and in pooled analysis, respectively. It was also

comparable with T₅ (100 percent RDF + three foliar sprays of 1 percent NOL) during 2024, which registered total phosphorus uptake of 18.11 kg/ha. The lowest total

phosphorus uptake (7.77, 8.02 and 7.89 kg/ha) was observed under the control treatment (T₁) during 2023, 2024 and in pooled results, respectively.

Table 5: Nitrogen uptake (kg/ha) by rice crop as influenced by different treatments

Treatment		Nitrogen uptake (kg/ha)								
		Grain			Straw			Total		
		2023	2024	Pooled	2023	2024	Pooled	2023	2024	Pooled
T ₁		8.50	9.08	8.79	7.54	7.82	7.68	16.05	16.91	16.48
T ₂		27.98	29.23	28.60	18.48	19.25	18.86	46.46	48.48	47.47
T ₃		35.01	35.68	35.34	21.97	23.29	22.63	56.98	58.97	57.98
T ₄		29.60	31.44	30.52	19.15	19.80	19.48	48.74	51.24	49.99
T ₅		34.20	34.99	34.59	20.40	22.00	21.20	54.59	56.99	55.79
T ₆		38.06	39.74	38.90	23.71	24.51	24.11	61.77	64.25	63.01
T ₇		27.39	29.88	28.64	17.24	17.76	17.50	44.64	47.64	46.14
T ₈		18.58	18.87	18.73	12.60	13.49	13.05	31.19	32.37	31.78
T ₉		22.25	23.38	22.81	14.55	15.40	14.97	36.80	38.78	37.79
T ₁₀		27.12	28.53	27.83	18.07	18.81	18.44	45.19	47.34	46.27
Mean (Year)		26.87	28.08	27.48	17.37	18.21	17.79	44.24	46.30	45.27
SEm ± (T)		1.96	1.59	1.26	1.00	1.00	0.71	2.40	1.91	1.53
CD (<i>p</i> ≤0.05)		5.81	4.72	3.61	2.98	2.97	2.03	7.14	5.67	4.40
CV (%)		12.62	9.79	11.23	9.99	9.51	9.74	9.41	7.14	8.30
Year	SEm ±	-	-	0.56	-	-	0.32	-	-	0.68
	CD (<i>p</i> ≤0.05)	-	-	NS	-	-	NS	-	-	1.96
Interaction (Y x T)	SEm ±	-	-	1.78	-	-	1.00	-	-	2.17
	CD (<i>p</i> ≤0.05)	-	-	NS	-	-	NS	-	-	NS

Table 6: Phosphorous uptake (kg/ha) by rice crop as influenced by different treatments

Treatment		Phosphorous uptake (kg/ha)								
		Grain			Straw			Total		
		2023	2024	Pooled	2023	2024	Pooled	2023	2024	Pooled
T ₁		3.53	3.72	3.62	4.23	4.30	4.27	7.77	8.02	7.89
T ₂		8.27	8.56	8.42	7.22	7.59	7.41	15.49	16.15	15.82
T ₃		9.76	10.11	9.94	7.97	8.64	8.30	17.73	18.75	18.24
T ₄		8.42	8.88	8.65	7.37	7.84	7.61	15.80	16.73	16.26
T ₅		9.46	9.77	9.62	7.64	8.34	7.99	17.10	18.11	17.60
T ₆		10.45	10.77	10.61	8.64	9.09	8.86	19.09	19.86	19.47
T ₇		7.98	8.32	8.15	6.91	7.27	7.09	14.89	15.59	15.24
T ₈		5.73	6.05	5.89	5.63	5.89	5.76	11.37	11.94	11.65
T ₉		6.50	6.79	6.65	6.23	6.44	6.34	12.73	13.23	12.98
T ₁₀		8.11	8.45	8.28	7.14	7.37	7.25	15.25	15.82	15.54
Mean (Year)		7.82	8.14	7.98	6.90	7.28	7.09	14.72	15.42	15.07
SEm ± (T)		0.51	0.53	0.36	0.34	0.35	0.24	0.59	0.62	0.43
CD (<i>p</i> ≤0.05)		1.50	1.56	1.05	1.00	1.04	0.70	1.75	1.85	1.23
CV (%)		11.19	11.18	11.19	8.48	8.30	8.39	6.93	6.99	6.96
Year	SEm ±	-	-	0.16	-	-	0.11	-	-	0.19
	CD (<i>p</i> ≤0.05)	-	-	NS	-	-	0.31	-	-	0.55
Interaction (Y x T)	SEm ±	-	-	0.52	-	-	0.34	-	-	0.61
	CD (<i>p</i> ≤0.05)	-	-	NS	-	-	NS	-	-	NS

Potassium uptake (kg/ha)

Data regarding total potassium uptake by rice crop as influenced by different treatments are presented in Table 7. A critical analysis of the data revealed that the application of 100 percent RDF + three foliar sprays of 0.25 percent seaweed extract (T₆) resulted in significantly higher total potassium uptake (77.72, 79.81 and 78.77 kg/ha) during 2023, 2024 and in pooled analysis, respectively. However, this treatment remained statistically at par with T₃ (100 percent RDF + three foliar sprays of 3 percent *panchgavya*), which recorded total potassium uptake of 72.08, 75.50 and 73.79 kg/ha during both years and in pooled analysis, respectively. It was also comparable with T₅ (100 percent RDF + three foliar sprays of 1 percent NOL) during 2024, which registered total potassium uptake of 72.65 kg/ha. In contrast, the control treatment (T₁) recorded significantly lowest total potassium uptake (35.69, 35.86 and 35.77

kg/ha) during the first year, second year and in pooled results, respectively.

The total uptake of nitrogen, phosphorus and potassium by the crop (grain + straw) were significantly affected by the combined application of RDF and biostimulants. The enhanced nutrient uptake under these treatments may be attributed to improved nutrient availability, uptake and assimilation resulting from the synergistic interaction between RDF and biostimulants. Biostimulants, being rich in plant growth-promoting substances, beneficial microorganisms and micronutrients, likely stimulate root development, thereby enhancing nutrient absorption and translocation within the plant system. Additionally, increased biomass production and grain yield under these treatments further contributed to higher total nutrient uptake. Similar findings were also reported by Layek *et al.* (2018)^[13] and Borgohainl *et al.* (2020)^[12] in rice.

Table 7: Potassium uptake (kg/ha) by rice crop as influenced by different treatments

Treatment		Potassium uptake (kg/ha)								
		Grain			Straw			Total		
		2023	2024	Pooled	2023	2024	Pooled	2023	2024	Pooled
T ₁		6.26	6.40	6.33	29.43	29.46	29.45	35.69	35.86	35.77
T ₂		14.46	14.42	14.44	49.29	52.28	50.79	63.75	66.70	65.23
T ₃		16.69	16.36	16.52	55.39	59.15	57.27	72.08	75.50	73.79
T ₄		14.89	14.99	14.94	50.66	53.57	52.12	65.55	68.56	67.06
T ₅		16.23	16.10	16.16	52.45	56.56	54.50	68.68	72.65	70.67
T ₆		18.20	17.65	17.93	59.53	62.15	60.84	77.72	79.81	78.77
T ₇		13.99	14.15	14.07	47.80	49.59	48.70	61.79	63.74	62.77
T ₈		10.05	10.32	10.18	38.88	39.95	39.41	48.93	50.27	49.60
T ₉		11.55	11.60	11.58	43.09	44.05	43.57	54.64	55.65	55.15
T ₁₀		14.22	14.28	14.25	48.78	50.70	49.74	63.00	64.98	63.99
Mean (Year)		13.65	13.63	13.64	47.53	49.75	48.64	61.18	63.37	62.28
SEm ± (T)		0.85	0.82	0.59	2.30	2.51	1.70	2.45	2.50	1.75
CD ($p \leq 0.05$)		2.52	2.43	1.69	6.84	7.45	4.88	7.29	7.42	5.02
CV (%)		10.77	10.39	10.58	8.39	8.73	8.57	6.94	6.82	6.88
Year	SEm ±	-	-	0.26	-	-	0.76	-	-	0.78
	CD ($p \leq 0.05$)	-	-	NS	-	-	2.18	-	-	NS
Interaction (Y x T)	SEm ±	-	-	0.83	-	-	2.41	-	-	2.47
	CD ($p \leq 0.05$)	-	-	NS	-	-	NS	-	-	NS

Table 8: Grain yield (kg/ha) and straw yield (kg/ha) of rice as influenced by different treatments

Treatment		Grain yield (kg/ha)			Straw yield (kg/ha)		
		2023	2024	pooled	2023	2024	pooled
T ₁		1361	1405	1383	2409	2427	2418
T ₂		3043	3104	3074	3934	4097	4016
T ₃		3429	3463	3446	4321	4530	4426
T ₄		3104	3202	3153	4035	4159	4097
T ₅		3373	3412	3393	4137	4374	4255
T ₆		3652	3700	3676	4620	4725	4673
T ₇		3001	3065	3033	3833	3945	3889
T ₈		2191	2258	2225	3143	3226	3184
T ₉		2463	2525	2494	3458	3527	3493
T ₁₀		3029	3086	3057	3900	4005	3953
Mean (Year)		2865	2922	2893	3779	3902	3840
SEm ± (T)		153	148	106	181	172	142
CD ($p \leq 0.05$)		454	439	305	538	511	425
CV (%)		9.25	8.76	9.00	8.30	7.64	7.97
Year	SEm ±	-	-	47.55	-	-	55.86
	CD ($p \leq 0.05$)	-	-	NS	-	-	NS
Interaction (Y x T)	SEm ±	-	-	150.35	-	-	176.66
	CD ($p \leq 0.05$)	-	-	NS	-	-	NS

Soil analysis

Examination of data revealed that the foliar spray of biostimulants with different levels of RDF did not impart significant changes on electrical conductivity (dS/m), soil pH, organic carbon (%), available P₂O₅ (kg/ha) and available K₂O (kg/ha) of soil after harvest of rice crop. Significantly higher available nitrogen with values of 202.10 and 204.78 kg/ha was recorded with treatment T₆ (100% RDF + Three foliar sprays of 0.25% seaweed extract) during 2023 and 2024, but it remained at par with treatment T₃ (100% RDF + Three foliar sprays of 3% *panchgavya*), which recorded values of 186.64 and 191.92 kg/ha, respectively. Further, during 2024, treatment T₆ was also found at par with treatment T₅ (100% RDF + three foliar sprays of 1% NOL), which recorded an available nitrogen content of 186.75 kg/ha. In contrast, the significantly lower available nitrogen in the soil was observed with treatment T₁ (control) (145.24 and 155.86 kg/ha) during the individual years of 2023 and 2024, respectively.

Table 9: Electrical conductivity (dS/m), pH and organic carbon (%) of soil after harvest of rice crop as influenced by different treatments

Treatment		EC (dS/m)		pH		OC (%)	
		2023	2024	2023	2024	2023	2024
T ₁		0.396	0.486	7.91	7.96	0.355	0.472
T ₂		0.358	0.460	7.71	7.74	0.393	0.496
T ₃		0.338	0.430	7.64	7.54	0.399	0.515
T ₄		0.352	0.451	7.69	7.69	0.398	0.498
T ₅		0.341	0.434	7.64	7.64	0.398	0.506
T ₆		0.338	0.430	7.60	7.45	0.402	0.517
T ₇		0.364	0.466	7.75	7.86	0.387	0.487
T ₈		0.366	0.469	7.85	7.93	0.367	0.480
T ₉		0.366	0.470	7.81	7.81	0.375	0.485
T ₁₀		0.361	0.461	7.71	7.78	0.388	0.495
Mean (Year)		0.358	0.456	7.731	7.740	0.386	0.495
SEm ± (T)		0.012	0.014	0.20	0.17	0.012	0.013
CD ($p \leq 0.05$)		NS	NS	NS	NS	NS	NS
CV (%)		5.57	5.25	4.52	3.75	5.284	4.715
Initial value		0.32	0.41	8.03	7.95	0.42	0.49

Table 10: Available nitrogen (kg/ha), P₂O₅ (kg/ha) and K₂O (kg/ha) in soil after harvest of rice crop as influenced by different treatments

Treatment		Available nitrogen (kg/ha)		Available P ₂ O ₅ (kg/ha)		Available K ₂ O (kg/ha)	
		2023	2024	2023	2024	2023	2024
T ₁		145.24	155.86	36.74	43.31	350.26	371.17
T ₂		165.24	176.87	41.71	48.98	357.03	385.80
T ₃		186.64	191.92	43.59	50.64	358.16	393.94
T ₄		169.99	178.91	43.71	49.75	357.27	386.84
T ₅		171.62	186.75	43.65	51.04	357.31	391.99
T ₆		202.10	204.78	44.67	52.01	359.25	396.86
T ₇		160.86	169.66	39.43	45.81	354.41	377.71
T ₈		150.28	163.07	37.44	43.49	352.56	373.34
T ₉		155.24	165.74	38.61	45.34	353.65	376.77
T ₁₀		161.43	176.56	40.36	48.03	355.26	382.91
Mean (Year)		166.86	177.01	40.99	47.84	355.52	383.73
SEm ± (T)		5.821	6.739	1.84	2.05	13.04	12.74
CD ($p \leq 0.05$)		17.29	20.02	NS	NS	NS	NS
CV (%)		6.04	6.59	7.79	7.41	6.35	5.75
Initial value		210.38	224.80	43.18	38.75	345.11	370.82

Conclusion

Based on two years experimentation, it can be concluded that aerobic rice fertilized with 100 percent RDF + three foliar spray of 0.25 percent seaweed extract or 3 percent *panchagavya* or 1 percent NOL (Novel organic liquid) at 30, 45 and 60 DAS resulted higher NPK content and NPK uptake. Therefore, integration of inorganic fertilizer application with foliar application of biostimulants is reaccommodate to optimize NPK content and uptake of aerobic rice.

Reference

- Black CA, Evans DD, Ensminger LE, White JL, Clark FE, editors. Methods of soil analysis. Madison (WI): ASA; 1983.
- Borgohain L, Borgohain H, Konwar B, Dutta AK, Panging U. Panchagavya: A multidimensional review article through the lens of an agriculture scholar. Asian Soil Res J. 2020;3(4):32-38.
- Chaudhary MG, Malav JK, Vala YB, Desai NA. Influences of different organic sources and seaweed extract on quality, nutrient content, uptake, soil fertility status and soil microbial population after harvest of summer green gram (*Vigna radiata* L.). Pharma Innov J. 2021;10(11):1390-1394.
- Desai RG, Patel MD. Report on soil survey of Navsari Taluka. Tech Bull. 1970;(41):1-7.
- Dodiya RD, Barad AH, Pathan NP, Raghunandan BL. Trichogramma: A promising biocontrol agent. Int J Econ Plants. 2023;10:192-199.
- Dodiya RD, Italiya JV, Patel PS, Pathan NP, Barad AH. CRISPR/Cas9-mediated gene disruption: A novel strategy against fall armyworm. Farming Manag. 2025;10(1):1-6.
- Dodiya RD, Koosi ST, Chaudhary FK, Patel PS, Barad AH. CRISPR/Cas9: A new frontier in biocontrol strategies for insect pest management. In: Bio-control agents for sustainable agriculture: diversity, mechanisms and applications. Singapore: Springer Nature Singapore; 2025. p. 511-530.
- Dodiya R, Patel P, Pathan N, Deb S. Temporal patterns of aphid infestations in coriander. J Agric Ecol. 2025;20:77-83.
- Ghosh BC, Bhat R. Environmental hazards of nitrogen loading in wetland rice fields. Environ Pollut. 1998;102(1):123-126.
- Jackson ML. Soil chemical analysis. New Delhi: Prentice Hall of India Pvt Ltd; 1973. p. 151-498.
- Joshi D, Yadav LR, Ratore BS, Srivastava H, Verma RS, Gurjar BS, *et al.* Enhancing nutrient uptake and economics of black gram through vermicompost and vermiwash application. Int J Environ Clim Change. 2023;13(9):3186-3193.
- Kumar N, Verma LP, Singh R, Prasad K. Soil properties, nutrient uptake and productivity of rice under integrated nutrient management system. Ann Plant Soil Res. 2001;3(1):54-57.
- Layek J, Das A, Idapuganti RG, Sarkar D, Ghosh A, Zodape ST, *et al.* Seaweed extract as organic bio-stimulant improves productivity and quality of rice in eastern Himalayas. J Appl Phycol. 2018;30(1):547-558.
- Patra AK, Nayak BC, Mishra MM. Integrated nutrient management in rice (*Oryza sativa* L.)-wheat (*Triticum aestivum*) cropping system. Indian J Agron. 2000;45(3):453-457.
- Piper CS. Soil and plant analysis. Soil Sci. 1943;56(1):68-68.
- Prasad S. Effect of panchagavya and recommended dose of fertilizers on growth, nutrient content and productivity of transplanted rice (*Oryza sativa* L.) under middle Gangetic plain of India. Indian J Agric Sci. 2018;88(6):931-936.
- Shah MT, Zodape ST, Chaudhary DR, Eswaran K, Chikara J. Seaweed sap as an alternative liquid fertilizer for yield and quality improvement of wheat. J Plant Nutr. 2013;36(2):192-200.
- Siddaram S, Murali K, Manjunatha BN, Ramesha YM, Basavaraja MK, Policepatil AS. Effect of nitrogen levels through organic sources on growth, dry matter production and nutrient uptake of irrigated aerobic rice (*Oryza sativa* L.). Int J Agric Sci. 2010;2:426-429.
- Subbiah BV, Asija GL. A rapid procedure for the estimation of available nitrogen in soil. Curr Sci. 1956;25:29-29.
- Swain DK, Herath S, Pathirana A, Mittra BN. Rainfed lowland and flood-prone rice: A critical review on ecology and management technology for improving productivity in Asia. 2005. Available from: www.mekongnet.org/images/e/e9/Dillip.pdf