



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; 9(4): 689-694
Received: 19-02-2026
Accepted: 23-03-2026

MD Vaishnav
Department of Agronomy,
Junagadh Agricultural University,
Junagadh, Gujarat, India

PD Vekariya
Research Scientist (Agronomy),
Main Dry Farming Research
Station, JAU, Targhadia, Gujarat,
India

BP Solanki
Department of Agronomy,
Junagadh Agricultural University,
Junagadh, Gujarat, India

MH Vasoya
Department of Soil Science and
Agricultural Chemistry, Junagadh
Agricultural University, Junagadh,
Gujarat, India

Corresponding Author:
MD Vaishnav
Department of Agronomy,
Junagadh Agricultural University,
Junagadh, Gujarat, India

Sustainable wheat production through integrated nutrient management: Effects on growth, yield and soil health

MD Vaishnav, PD Vekariya, BP Solanki and MH Vasoya

DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i4i.5461>

Abstract

The study "Integrated nutrient management in wheat (*Triticum aestivum* L.) and its residual effect on succeeding summer greengram (*Vigna radiata* L.)" was carried out in the *rabi* and summer seasons of 2023–2024 and 2024–2025 at the Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh. Eight treatment combinations were used in the experiment, which was set up in a randomized block design and replicated three times. The results showed that application of 75% RDF + 25% N through vermicompost + Bio NPK in wheat crop resulted in significantly higher growth parameters, yield attributes, grain yield (5200 kg/ha), straw yield (7416 kg/ha), quality parameters, NPK content and uptake of wheat. It also produced the highest net return (45516 ₹/ha) and BCR (1.53). Application of 75% RDF + 25% N through FYM + Bio NPK to wheat crop recorded significantly higher available nutrients (N, P₂O₅ and K₂O) in soil after harvest of wheat.

Keywords: Wheat, FYM, Vermicompost and Castor cake

Introduction

Integrated nutrient management (INM) is a holistic approach aimed at sustaining soil fertility and crop productivity by integrating inorganic fertilizers with organic manures, crop residues and biological sources of nutrients. The increasing reliance on chemical fertilizers alone has led to a widening gap between nutrient application and removal, resulting in soil nutrient mining, degradation, groundwater contamination and greenhouse gas emissions (Singh *et al.*, 2017) ^[21]. Excessive use of synthetic inputs has also depleted soil organic matter and disrupted ecological balance, posing serious threats to long-term agricultural sustainability (Bajjiya *et al.*, 2017; Fixen *et al.*, 2014) ^[5, 9]. In contrast, organic manures such as farmyard manure, vermicompost, and castor cakes improve soil physical, chemical and biological properties, enhancing nutrient availability and microbial activity (Diacono and Montemurro, 2010; Andrews *et al.*, 2013) ^[7, 2]. However, due to their relatively low nutrient content, organic sources alone cannot meet crop nutrient demands, necessitating their integration with inorganic fertilizers and biofertilizers like Bio-NPK to ensure balanced nutrition (Meena *et al.*, 2020) ^[16]. Therefore, INM serves as a sustainable strategy to optimize nutrient use efficiency, maintain soil health and achieve stable crop yields while minimizing environmental degradation.

Wheat (*Triticum aestivum* L.) is one of the world's most important cereal crop, belonging to the Poaceae (Gramineae) family. It is a staple food crop for around two billion people, which makes up 36% of the total world population. It contributes about 55% of carbohydrates and 20% of total food calories consumed worldwide. Among the various species under the genus *Triticum*, common wheat (*Triticum aestivum*) is the most extensively cultivated. Wheat is known as the "King of Cereals," wheat continues to hold a prominent position due to its high nutritional value and versatility, providing essential amino acids and also serving as the most widely consumed grain globally.

Wheat ranks first in the world among the cereals both in respect of area and production. In India, wheat is second most important food crop next to rice and played a vital role in the Green Revolution. Wheat was produced on 32.804 million hectares in 2024–2025, yielding 117.945

million tons with an average productivity of 3595 kg/ha (Anon., 2025a). India ranks second only to China in global wheat production. Wheat is cultivated in almost all the states of India, but its extensive cultivation is confined to Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Rajasthan, Bihar and Gujarat. In India, Uttar Pradesh leads in area and total production, whereas Punjab ranks highest in productivity. In Gujarat, wheat occupies 1.24 million hectares area with a production of 3.9 million tonnes and a productivity of 3131 kg/ha during the year of 2023-24 (Anon., 2025b). The major wheat cultivated areas in Gujarat are Junagadh, Ahmedabad, Sabarkantha, Rajkot, Banaskantha, Mehsana and Bhavanagar. Wheat generally follows rainy season crops viz., paddy, maize, sorghum and pearl millet, which are highly nutrient-exhaustive.

Materials and Methods

An experiment was laid out on C-8 Plot of Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh during *rabi* and summer seasons of 2023-24 and 2024-25, situated at 21.5° N latitude and 70.5° E longitude with an altitude of 60 m above the mean sea level and 80 km away from Arabian Sea coast on western side at the foothill of mountain 'Girnar' under South Saurashtra Agro-climatic Zone of Gujarat state and enjoys a typically subtropical climate characterized by fairly cold and dry winter, hot and dry summer and warm and moderately humid monsoon. The soil of experimental site was medium black calcareous soil. The soil was low in available nitrogen (231 and 236 kg/ha in 2023-24 and 2024-25, respectively), medium in available phosphorus (25.30 and 26.51 kg/ha in 2023-24 and 2024-25, respectively) and available potassium (246 and 249 kg/ha in 2023-24 and 2024-25, respectively). The treatments consisted of integrated nutrient management viz., T₁: 100% RDF (120-60-60 kg/ha N-P-K), T₂: 100% RDF + Bio NPK, T₃: 75% RDF + 25% N through FYM, T₄: 75% RDF + 25% N through vermicompost, T₅: 75% RDF + 25% N through castor cake, T₆: 75% RDF + 25% N

through FYM + Bio NPK, T₇: 75% RDF + 25% N through vermicompost + Bio NPK and T₈: 75% RDF + 25% N through castor cake + Bio NPK to wheat in *rabi* season and replicated three times in randomized block design. The experiment was conducted on the same site without changing the randomization of the treatments for the successive year to assess the treatment effect of integrated nutrient management in wheat.

Results and Discussion

Effect on growth attributes of wheat

- The plant height was recorded at 30, 60 DAS and at harvest and the results of the analyzed data are depicted in Table 1. Difference among the treatments was non-significant for plant height at 30 DAS. Significantly higher plant height at 60 DAS and at harvest, number of total tillers and effective tillers per meter row length at harvest were recorded with application of 75% RDF + 25% N through vermicompost + Bio NPK (T₇) and was remained at par with 75% RDF + 25% N through FYM + Bio NPK (T₆). It might due to combined application of organic and inorganic fertilisers, which enhances nutrient mobility and plant uptake by minimizing nutrient losses, thereby improving nutrient use efficiency. Organic manures stimulated plant growth by increasing microbial activity and soil enzyme activity, creating a biologically active rhizosphere. The superior performance of vermicompost is mainly attributed to its rapid mineralization and the presence of a large proportion of nitrogen, phosphorus, and potassium in readily available inorganic forms. In addition, organic amendments promoted colonization of beneficial microorganisms and the synthesis of plant growth-promoting hormones, which further stimulated crop growth. Improved chlorophyll content enhanced light interception and photosynthetic efficiency, leading to greater dry matter accumulation and overall crop vigor, in agreement with the findings of Fazily *et al.* (2021)^[8], Rahevar *et al.* (2024)^[18] and Sharma *et al.* (2024)^[19].

Table 1: Effect of integrated nutrient management on plant height, number of total tillers and number of effective of wheat (Pooled of 2 years)

Treatments	Plant height (cm)			Total tillers/meter row length	Effective tillers/meter row length
	30 DAS	60 DAS	At Harvest		
T ₁ : RDF (120-60-60 kg/ha N-P ₂ O ₅ -K ₂ O)	28.59	66.08	69.84	76.17	67.82
T ₂ : 100% RDF + Bio NPK @ 3 l/ha	28.99	67.14	70.55	77.67	70.25
T ₃ : 75% RDF + 25% N through FYM	29.41	69.57	73.15	81.23	71.44
T ₄ : 75% RDF + 25% N through Vermicompost	29.61	71.30	75.13	83.85	74.43
T ₅ : 75% RDF + 25% N through Castor cake	28.01	64.92	67.43	70.53	62.69
T ₆ : 75% RDF + 25% N through FYM + Bio NPK	30.46	81.50	84.18	91.34	86.46
T ₇ : 75% RDF + 25% N through Vermicompost + Bio NPK	31.12	84.93	88.93	98.01	89.23
T ₈ : 75% RDF + 25% N through Castor cake + Bio NPK	29.92	74.61	78.27	84.69	76.07
S.Em. ±	1.31	2.40	2.47	3.09	3.04
C.D. at 5%	NS	6.94	7.15	8.95	8.80
C.V. (%)	10.90	8.09	7.96	9.13	9.95
Year					
S.Em. ±	0.66	1.20	1.24	1.55	1.52
C.D. at 5%	NS	NS	NS	NS	NS
Y x T					
S.Em. ±	1.86	3.39	3.49	4.37	4.29
C.D. at 5%	NS	NS	NS	NS	NS

Effect on yield attributes and yield

The pooled data pertaining to length of spike, number of spikelets/spike, number of grains/spike, grain yield and straw yield were significantly affected by the various integrated nutrient management treatments (Table 2). Yield attributing characters (length of spike, number of spikelets/spike, number of grains/spike), grain and straw yields were recorded significantly

higher with application of 75% RDF + 25% N through vermicompost + Bio NPK (T₇). It was statistically equivalent to application of 75% RDF + 25% N through FYM + Bio NPK (T₆). Due to application of vermicompost with Bio NPK, the activity of beneficial microbes and colonization of mycorrhizal fungi and enzymes activity increased which play an important role in mobilization of nutrients and thereby leading to better

availability of nutrients facilitating in better growth and yield parameters viz., plant height, length of spike, number of seeds per spike. Similar increase in yield of wheat with application of organic manure and chemical fertilizers was reported by

Kaushik *et al.* (2012) ^[11], Singh (2017) ^[21], Kaur *et al.* (2018) ^[10], Ahmad and Tripathi (2022) ^[1], Patyal *et al.* (2022) ^[17] and Kumar *et al.* (2023) ^[13].

Table 2: Effect of integrated nutrient management on length of spike, number of spikelets/spike, number of grains/spike, grain and straw yield of wheat (Pooled of 2 years)

Treatments	Length of spike (cm)	No. of spikelets/spike	No. of grains/spike	Grain yield (kg/ha)	Straw yield (kg/ha)
T ₁ : RDF (120-60-60 kg/ha N-P ₂ O ₅ -K ₂ O)	7.53	16.50	40.35	3940	5538
T ₂ : 100% RDF + Bio NPK @ 3 l/ha	8.05	16.84	41.31	4019	5762
T ₃ : 75% RDF + 25% N through FYM	8.18	17.12	42.36	4125	5993
T ₄ : 75% RDF + 25% N through Vermicompost	8.33	17.57	42.97	4195	6129
T ₅ : 75% RDF + 25% N through Castor cake	7.25	15.56	39.62	3825	5313
T ₆ : 75% RDF + 25% N through FYM + Bio NPK	9.50	19.93	49.79	4865	7093
T ₇ : 75% RDF + 25% N through Vermicompost + Bio NPK	9.75	20.47	52.08	5200	7416
T ₈ : 75% RDF + 25% N through Castor cake + Bio NPK	8.43	17.67	43.43	4391	6234
S.E.m. ±	0.31	0.63	1.80	188	269
C.D. at 5%	0.88	1.83	5.23	546	778
C.V. (%)	8.93	8.74	10.05	10.68	10.63
Year					
S.E.m. ±	0.15	0.32	0.90	94	134
C.D. at 5%	NS	NS	NS	NS	NS
Y x T					
S.E.m. ±	0.43	0.89	2.55	266	380
C.D. at 5%	NS	NS	NS	NS	NS

Economics

Among the different integrated nutrient management treatments, application of 75% RDF + 25% N through vermicompost + Bio NPK (T₇) recorded the maximum gross return (132154 ₹/ha), net

return (45516 ₹/ha) and BCR (1.53). In accordance with Devi *et al.* (2011) ^[6], applying NPK fertilizers in combination with vermicompost to field crops not only affects plant development and yield but also lowers production costs.

Table 3: Effect of integrated nutrient management on economics of wheat (Average of 2023-24 and 2024-25)

Treatments	Gross returns (₹/ha)	Cost of cultivation (₹/ha)	Net returns (₹/ha)	BCR
T ₁ : RDF (120-60-60 kg/ha N-P ₂ O ₅ -K ₂ O)	100047	79925	20122	1.25
T ₂ : 100% RDF + Bio NPK @ 3 l/ha	102138	80375	21762	1.27
T ₃ : 75% RDF + 25% N through FYM	104931	83797	21135	1.25
T ₄ : 75% RDF + 25% N through Vermicompost	106749	86188	20561	1.24
T ₅ : 75% RDF + 25% N through Castor cake	97075	84559	12516	1.15
T ₆ : 75% RDF + 25% N through FYM + Bio NPK	123791	84247	39545	1.47
T ₇ : 75% RDF + 25% N through Vermicompost + Bio NPK	132154	86638	45516	1.53
T ₈ : 75% RDF + 25% N through Castor cake + Bio NPK	111537	85009	26528	1.31

Effect on quality

A perusal of data in Table 4 indicated that protein content and protein yield were significantly influenced by treatments. 75% RDF + 25% N through vermicompost + Bio NPK (T₇) gave significantly higher protein content and protein yield during both experimental year as well as pooled analysis. Treatment T₇ was statistically at par with T₆ (75% RDF + 25% N through FYM + Bio NPK). This may be attributed to the improved supply of nitrogen and phosphorus through vermicompost, which enhanced the absorption and efficient utilization of nutrients by the crop. Organic manures increase availability of nitrogen in the soil, leading to higher nitrogen accumulation in the grain

and, consequently, increased protein content, since nitrogen is a fundamental constituent of amino acids, the building blocks of proteins. Nitrogen being an integral component of proteins and phosphorus being a key constituent of co-enzymes involved in protein synthesis, their increased concentration in plants ultimately results in higher protein content in the grain. Similar results were also reported by Singh *et al.* (2019) ^[23] and Singh *et al.* (2020) ^[24]. The increase in protein yield was mainly due to higher protein content in wheat grain and higher grain yield of wheat due to application of 75% RDF + 25% RDN through vermicompost + Bio NPK (T₇). Similar research results were reported by Singh (2017) ^[21] and Sharma and Tomar (2025) ^[19].

Table 4: Effect of integrated nutrient management on protein content and protein yield of wheat (Pooled of 2 years)

Treatments	Protein content (%)	Protein yield (kg/ha)
T ₁ : RDF (120-60-60 kg/ha N-P ₂ O ₅ -K ₂ O)	9.40	370.46
T ₂ : 100% RDF + Bio NPK @ 3 l/ha	10.04	404.55
T ₃ : 75% RDF + 25% N through FYM	10.37	427.75
T ₄ : 75% RDF + 25% N through Vermicompost	10.52	438.90
T ₅ : 75% RDF + 25% N through Castor cake	9.13	348.62
T ₆ : 75% RDF + 25% N through FYM + Bio NPK	11.43	557.19
T ₇ : 75% RDF + 25% N through Vermicompost + Bio NPK	11.65	603.38
T ₈ : 75% RDF + 25% N through Castor cake + Bio NPK	11.05	485.74
S.E.m. ±	0.26	21.08

C.D. at 5%	0.76	61.04
C.V. (%)	6.12	11.36
Year		
S.Em. $\pm$	0.13	10.54
C.D. at 5%	NS	NS
Y x T		
S.Em. $\pm$	0.37	29.80
C.D. at 5%	NS	NS

Effect on nutrient content

Application of 75% RDF + 25% N through vermicompost + Bio NPK (T₇) revealed a significant influence on NPK content in grain and straw of wheat in both the year as well as in pooled data. The significantly higher nutrient content in grain and straw with the application of vermicompost may be attributed to improved soil nutrient availability through mineralization of organic matter and enhanced microbial activity. Vermicompost

releases nutrients in readily available forms and improves soil cation exchange capacity, thereby reducing fixation and leaching losses. In addition, better root growth and rhizospheric activity under organic amendments enhance P and K solubilization and uptake efficiency, leading to greater translocation and accumulation of nutrients in both grain and straw. These outcomes closely align with those of Kumar *et al.* (2021) [12].

Table 5: Effect of integrated nutrient management on NPK content in grain and straw of wheat (Pooled of 2 years)

Treatments	Content in grain			Content in straw		
	N content (%)	P content (%)	K content (%)	N content (%)	P content (%)	K content (%)
T ₁ : RDF (120-60-60 kg/ha N-P ₂ O ₅ -K ₂ O)	1.504	0.291	0.653	0.670	0.176	1.068
T ₂ : 100% RDF + Bio NPK @ 3 l/ha	1.606	0.313	0.662	0.677	0.180	1.116
T ₃ : 75% RDF + 25% N through FYM	1.660	0.324	0.687	0.686	0.186	1.145
T ₄ : 75% RDF + 25% N through Vermicompost	1.683	0.337	0.718	0.744	0.190	1.176
T ₅ : 75% RDF + 25% N through Castor cake	1.461	0.251	0.640	0.646	0.172	1.051
T ₆ : 75% RDF + 25% N through FYM + Bio NPK	1.829	0.378	0.757	0.805	0.216	1.269
T ₇ : 75% RDF + 25% N through Vermicompost + Bio NPK	1.864	0.389	0.819	0.835	0.230	1.295
T ₈ : 75% RDF + 25% N through Castor cake + Bio NPK	1.768	0.345	0.736	0.773	0.207	1.180
S.Em. $\pm$	0.042	0.010	0.019	0.020	0.005	0.027
C.D. at 5%	0.121	0.029	0.054	0.058	0.015	0.077
C.V. (%)	6.12	7.55	6.46	6.69	6.68	5.59
Year						
S.Em. $\pm$	0.021	0.005	0.009	0.001	0.003	0.013
C.D. at 5%	NS	NS	NS	NS	NS	NS
Y x T						
S.Em. $\pm$	0.059	0.014	0.026	0.028	0.008	0.038
C.D. at 5%	NS	NS	NS	NS	NS	NS

Effect on nutrient uptake

Results of 75% RDF + 25% N through vermicompost + Bio NPK (T₇) revealed a significant influence on NPK uptake by grain and straw in both years as well as in pooled data. In terms of statistics, treatments T₆ (75% RDF + 25% N through FYM + Bio NPK) was at par with T₇. This might be attributed to greater grain and straw production as well as nutrient concentrations

with combined use of organic and inorganic fertilizers. Better performance under these treatments might also be due to a favourable soil environment which encouraged better root proliferation and ensured higher nutrient uptake. These results corroborate with the findings of Devi *et al.* (2011) [6], Singh (2017) [22] and Sharma and Tomar (2025) [19].

Table 6: Effect of integrated nutrient management on NPK uptake by grain and straw of wheat (Pooled of 2 years)

Treatments	NPK uptake by grain (kg/ha)			NPK uptake by straw (kg/ha)		
	N	P	K	N	P	K
T ₁ : RDF (120-60-60 kg/ha N-P ₂ O ₅ -K ₂ O)	59.27	11.44	25.77	37.05	9.72	59.32
T ₂ : 100% RDF + Bio NPK @ 3 l/ha	64.73	12.63	26.77	39.03	10.38	64.28
T ₃ : 75% RDF + 25% N through FYM	68.44	13.32	28.37	41.18	11.15	68.71
T ₄ : 75% RDF + 25% N through Vermicompost	70.22	14.17	30.18	45.65	11.64	72.15
T ₅ : 75% RDF + 25% N through Castor cake	55.78	9.60	24.44	34.25	9.11	55.87
T ₆ : 75% RDF + 25% N through FYM + Bio NPK	89.15	18.41	36.92	57.08	15.23	90.04
T ₇ : 75% RDF + 25% N through Vermicompost + Bio NPK	96.54	20.27	42.47	62.00	17.09	95.98
T ₈ : 75% RDF + 25% N through Castor cake + Bio NPK	77.72	15.16	32.24	48.29	12.94	73.68
S.Em. $\pm$	3.37	0.84	1.64	2.46	0.58	3.92
C.D. at 5%	9.77	2.44	4.75	7.11	1.69	11.34
C.V. (%)	11.36	14.34	13.01	13.20	11.76	13.23
Year						
S.Em. $\pm$	1.68	0.42	0.82	1.23	0.29	1.96
C.D. at 5%	NS	NS	NS	NS	NS	NS
Y x T						
S.Em. $\pm$	4.76	1.19	2.32	3.47	0.82	5.54
C.D. at 5%	NS	NS	NS	NS	NS	NS

Effect on available nutrients status in soil

Application of 75% RDF + 25% N through FYM + Bio NPK (T₆) recorded significantly higher available nutrients (N, P, and K) in soil, which was at par with treatment T₇ and T₈ during both the year. The significantly higher available nitrogen, phosphorus and potassium in soil may be attributed to FYM acting as a slow-release source of nitrogen and improves soil organic carbon, microbial activity and mineralization processes, thereby increasing the pool of plant-available nutrients. Simultaneously,

Bio-NPK inoculation enhances biological nitrogen fixation, nitrogen transformation, and nutrient solubilization through increased microbial proliferation and enzymatic activity in the rhizosphere. The combined application also improves soil physical properties, aggregation, moisture retention, and reduces nutrient losses through leaching, volatilization and fixation resulting in greater nutrient conservation in the soil system. These results corroborated with finding of Singh (2017) ^[22], Meena *et al.* (2018) ^[15] and Kushwaha and Tripathi (2022) ^[14].

Table 4: Effect of integrated nutrient management on available NPK status in soil after harvest of wheat (Pooled of 2 years)

Treatments	Available N (kg/ha)	Available P ₂ O ₅ (kg/ha)	Available K ₂ O (kg/ha)
T ₁ : RDF (120-60-60 kg/ha N-P ₂ O ₅ -K ₂ O)	234.17	31.07	249.98
T ₂ : 100% RDF + Bio NPK @ 3 l/ha	236.07	31.91	251.17
T ₃ : 75% RDF + 25% N through FYM	252.79	36.37	272.75
T ₄ : 75% RDF + 25% N through Vermicompost	243.05	34.15	263.76
T ₅ : 75% RDF + 25% N through Castor cake	248.22	35.56	267.18
T ₆ : 75% RDF + 25% N through FYM + Bio NPK	272.99	40.10	293.95
T ₇ : 75% RDF + 25% N through Vermicompost + Bio NPK	254.84	37.77	278.44
T ₈ : 75% RDF + 25% N through Castor cake + Bio NPK	263.60	38.81	286.85
S.E.m. ±	4.55	0.62	4.86
C.D. at 5%	13.17	1.80	14.08
C.V. (%)	4.44	4.26	4.40
Year			
S.E.m. ±	2.27	0.31	2.43
C.D. at 5%	NS	NS	NS
Y x T			
S.E.m. ±	6.43	0.88	6.87
C.D. at 5%	NS	NS	NS
Initial	233	38.55	247.5

Conclusion

Based on findings of two years of experimentation, it is concluded that 75% RDF + 25% N through vermicompost + Bio NPK (T₇) will ensure greater wheat growth and production, higher NPK content and uptake by wheat, better residual fertility, and more compensation than RDF alone.

Acknowledgment

The authors would like to thank JAU and colleagues who technically supported this work, from conducting field experiment to data analysis. The authors also would like to express their gratitude and thanks to his guide Dr. P.D. Vekariya and the Department of agronomy for him honestly support during experiment.

Conflicts of Interest

There were no any conflicts of interest exist during the experiment.

References

- Ahmad M, Tripathi SK. Effect of integrated use of vermicompost, FYM and chemical fertilizers on soil properties and productivity of wheat (*Triticum aestivum* L.) in alluvial soil. *The Journal of Phytopharmacology*. 2022;11(2):101-106.
- Andrews M, Raven JA, Lea PJ. Do plants need nitrate? The mechanisms by which nitrogen form affects plants. *Annals of Applied Biology*. 2013;163:174-199.
- Anonymous. Department of Agriculture and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Government of India, New Delhi. Unified Portal for Agricultural Statistics: UPAG. 2025a.
- Anonymous. District-wise area, production and yield of important food and non-food crops in Gujarat state for years 2021-22, 2022-23 and 2023-24. Directorate of Agriculture, Gujarat State, Gandhinagar. 2025b.
- Bajiya R, Lakhra H, Kumar S, Seema. Biochar for enhancing agricultural sustainability under climate change. *International Journal of Current Microbiology and Applied Science*. 2017;6(2):1876-1883.
- Devi KN, Singh MS, Singh NG, Athokpam HS. Effect of integrated nutrient management on growth and yield of wheat (*Triticum aestivum* L.). *Journal of Crop and Weed*. 2011;7(2):23-27.
- Diacono M, Montemurro F. Long term effects of organic amendments on soil fertility: a review. *Agronomy for Sustainable Development*. 2010;30(2):401-422.
- Fazily T, Thakral SK, Dhaka AK. Effect of integrated nutrient management on growth, yield attributes and yield of wheat. *International Journal of Advances in Agricultural Science and Technology*. 2021;8(1):106-118.
- Fixen P, Brentrup F, Bruulsema T, Garcia F, Norton R, Zingore S. Nutrient/fertiliser use efficiency: measurement, current situation and trends. In: *Managing water and fertilizer for sustainable agricultural intensification*. IFA/IWMI/IPNI/IPI. 2014;270:1-30.
- Kaur R, Kumar S, Kaur R, Kaur J. Effect of integrated nutrient management on growth and yield of wheat (*Triticum aestivum* L.) under irrigated conditions. *International Journal of Chemical Studies*. 2018;6(4):1800-1803.
- Kaushik MK, Bishnoi NR, Sumeriya HK. Productivity and economics of wheat as influenced by inorganic and organic sources of nutrients. *Annals of Plant and Soil Research*. 2012;14(1):61-64.
- Kumar A, Tiwari US, Yadav KK, Singh PK, Narayan A. Effect of integrated nutrient management on nutrient concentration of wheat crop (*Triticum aestivum* L.). *Journal*

- of Experimental Agriculture International. 2021;43(8):1-15.
13. Kumar K, Maurya NK, Lakshman. Influence of integrated nutrient management on growth and yield of wheat (*Triticum aestivum* L.). The Pharma Innovation Journal. 2023;12(7):3420-3423.
 14. Kushwaha A, Tripathi S. Response of chemical fertilizers and integrated nutrient management on productivity of wheat (*Triticum aestivum* L.) and properties of soil. The Journal of Phytopharmacology. 2022;11(1):51-56.
 15. Meena KB, Alam MS, Singh H, Bhat MA, Singh AK, Mishra AK, Thomas T. Influence of farmyard manure and fertilizers on soil properties and yield and nutrient uptake of wheat. International Journal of Chemical Studies. 2018;6(3):386-390.
 16. Meena RS, Kumar S, Datta R, Lal R, Vijayakumar V, Brtnicky M. Impact of agrochemicals on soil microbiota and management: a review. Land. 2020;9(2):34-34.
 17. Patyal A, Shekhar C, Sachan R, Kumar D, Yadav A, Kumar G. Effect of integrated nutrient management (INM) on growth parameters and yield of wheat (*Triticum aestivum* L.). International Journal of Plant and Soil Science. 2022;34(22):962-967.
 18. Rahevar HD, Bhanvadia AS, Mor VB, Panchal PS, Makwana SN. Response of integrated nutrient management on growth and yield character of Bt cotton-groundnut cropping sequence. International Journal of Research in Agronomy. 2024;7(5):38-45.
 19. Sharma AK, Tomar TS. Influence of integrated nutrient management on growth, yield and quality of wheat (*Triticum aestivum* L.). Journal of Experimental Agriculture International. 2025;47(7):301-312.
 20. Sharma A, Singh I, Behl RK, Mehla OP, Tomar V, Yadav G. Effect of integrated nutrient management on growth, yield and economics of late sown wheat (*Triticum aestivum* L.). International Journal of Research in Agronomy. 2024;7(7):202-205.
 21. Singh G, Virk HK, Khanna V. Integrated nutrient management for high productivity and net returns in lentil (*Lens culinaris*). Journal of Natural and Applied Science. 2017;9(3):1566-1572.
 22. Singh SP. Productivity, quality and uptake of nutrients in wheat (*Triticum aestivum*) as influenced by integrated nutrient management. Annals of Plant and Soil Research. 2017;19(1):12-16.
 23. Singh V, Pyare R, Singh GK. Yield, economics and quality improvement of wheat (*Triticum aestivum* L.) as affected by integrated nutrient management under late sown condition. Journal of Pharmacognosy and Phytochemistry. 2019;8(3):3266-3268.
 24. Singh H, Ingle SR, Pratap T, Raizada S, Singh K, Singh R, Parihar AKS. Effect of integrated nutrient management on nitrogen content, uptake and quality of wheat (*Triticum aestivum* L.) under partially reclaimed sodic soil. Cogent Environmental Science. 2020;9(5):299-301.