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Amipara HV
Department of Agricultural
Chemistry & Soil Science, B. A.
College of Agriculture, Anand
Agricultural University, Anand,
Gujarat, India

Viradiya MB
Department of Agricultural
Chemistry & Soil Science, B. A.
College of Agriculture, Anand
Agricultural University, Anand,
Gujarat, India

Corresponding Author:
Amipara HV
Department of Agricultural
Chemistry & Soil Science, B. A.
College of Agriculture, Anand
Agricultural University, Anand,
Gujarat, India

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Effect of humic acid on growth, yield and quality of wheat

Amipara HV and Viradiya MB

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Abstract

A field experiment was conducted during the *rabi* seasons of 2023–24 and 2024–25 at the Pulse Research Station, Anand Agricultural University, Vadodara, Gujarat, to evaluate the effect of humic acid on growth, yield and nutrient dynamics in wheat. The experiment was laid out in a randomized block design comprising ten treatments with different levels of recommended dose of fertilizers (RDF) in combination with soil and foliar application of humic acid. The results indicated that humic acid application significantly influenced growth, yield and quality parameters of wheat. Among the treatments, application of 100% RDF along with soil application of humic acid @ 10 kg ha⁻¹ recorded significantly higher plant height (82.94 cm), number of tillers (330.83 m⁻¹), grain yield (5242 kg ha⁻¹), straw yield (6137 kg ha⁻¹), chlorophyll content at 45 DAS (34.95 SPAD value) and protein content in grain (14.76%) on a pooled basis. The findings suggest that integration of humic acid with recommended fertilization enhances crop performance and improves grain quality in wheat under the agro-climatic conditions of Gujarat.

Keywords: Humic acid, *Triticum aestivum*, fertilizer management, grain yield, soil fertility, protein content

Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops globally and plays a crucial role in ensuring food and nutritional security. In India, it is a major *rabi* crop cultivated across diverse agro-climatic regions due to its wide adaptability and high productivity. Wheat contributes significantly to the national food basket and serves as a primary source of carbohydrates, proteins, minerals and dietary fiber. Over the years, its production has increased substantially due to the adoption of high-yielding varieties, improved irrigation and intensive use of fertilizers. (FAO, 2022) [5].

However, continuous and imbalanced application of chemical fertilizers has led to deterioration of soil health, decline in organic matter and reduced nutrient use efficiency. These challenges highlight the need for sustainable nutrient management practices. Integrated nutrient management (INM), which combines inorganic fertilizers with organic inputs, has emerged as an effective approach to maintain soil fertility and enhance crop productivity. (Nardi *et al.*, 2016; Canellas *et al.*, 2015) [10, 2].

Among the various organic inputs, humic substances especially humic acid have attracted considerable interest due to their positive influence on soil properties and plant growth. As an essential component of soil organic matter, humic acid contributes to improved soil aggregation, enhances moisture retention and promotes beneficial microbial activity, thereby supporting overall soil fertility (Canellas and Olivares, 2014) [1]. In addition, it plays a crucial role in increasing nutrient availability by forming complexes with essential elements, which helps in minimizing nutrient losses and improving their uptake by plants. Considering these advantages, the integration of humic acid with conventional fertilization practices offers a promising strategy for achieving higher productivity and maintaining soil sustainability in wheat cultivation.

Materials and Methods

A field experiment was conducted during the *rabi* seasons of 2023–24 and 2024–25 at the Pulse Research Station, Anand Agricultural University, Vadodara, Gujarat, India, representing the middle Gujarat agro-climatic zone with a semi-arid climate. The experimental soil was loamy

sand (Goradu), slightly alkaline in reaction with low electrical conductivity. It was low in organic carbon and available nitrogen and medium in available phosphorus, potassium and micronutrients. The experiment was laid out in a randomized block design with ten treatments and three replications. The treatments consisted of different levels of recommended dose of fertilizers (RDF: 120-60-40 kg N-P₂O₅-K₂O ha⁻¹) combined with soil and foliar application of humic acid: T₁: Absolute Control, T₂: 100% RDF, T₃: 100% RDF + Soil application of humic acid @ 5 kg/ha, T₄: 100% RDF + Soil application of humic acid @ 10 kg/ha, T₅: 75% RDF + Soil application of humic acid @ 5 kg/ha, T₆: 75% RDF + Soil application of humic acid @ 10 kg/ha, T₇: 75% RDF + Soil application of humic acid @ 15 kg/ha, T₈: T₅ + Foliar application of humic acid @ 0.2% (30 & 45 DAS), T₉: T₆ + Foliar application of humic acid @ 0.2% (30 & 45 DAS), T₁₀: T₇ + Foliar application of humic acid @ 0.2% (30 & 45 DAS). The experimental crop was wheat (*Triticum aestivum* L.) and the variety GW 451, which is well adapted to the region. Sowing was carried out by the line sowing method, maintaining a row spacing of 22.5 cm to ensure optimum plant population and efficient resource utilization. The crop was grown under recommended agronomic practices. Nitrogen was applied in split doses, while phosphorus and potassium were applied as basal. Observations on growth parameters, yield attributes, grain yield, straw yield and quality parameters were recorded using standard analytical procedures.

Results and Discussion

Plant population

Plant population per meter row length recorded at 15 DAS did not show any statistically significant variation among treatments during both experimental years as well as in pooled analysis. This indicates that humic acid application had no noticeable influence on germination or initial plant establishment.

Plant height

Plant height at 30 DAS remained unaffected by different treatments during individual years; however, pooled data

indicated a slight improvement under higher levels of humic acid application. At harvest, a clear treatment effect was observed, wherein application of 100% RDF + humic acid @ 10 kg ha⁻¹ recorded the significantly highest plant height (33.51 cm). At harvest, T₄ recorded the tallest plants during both 2023–24 (82.80 cm) and 2024–25 (83.07 cm), remaining significantly superior to the control (T₁), while T₃ (100% RDF + humic acid @ 5 kg ha⁻¹) remained statistically at par with T₄ in both years and pooled analysis. The pooled data further observed that T₄ recorded the significantly highest plant height (82.94 cm). The increase in plant height with humic acid application may be attributed to improved soil physical properties, enhanced nutrient availability and stimulation of root growth and physiological processes such as cell elongation and division, resulting in improved vegetative growth. Similar finding reported by Patel *et al.*, 2018^[11], Manjeera *et al.*, 2021^[9] and Kumar *et al.*, 2023^[6].

Spike length

Spike length of wheat was significantly influenced by humic acid and fertilizer treatments during both years and in pooled analysis. The combined application of 100% RDF and humic acid @ 10 kg ha⁻¹ (T₄) recorded the significantly highest spike length (8.94 and 9.10 cm during 2023–24 and 2024–25, respectively) with a pooled mean of 9.02 cm, and was significantly superior to T₁, T₂, and all 75% RDF treatments. Treatment T₃ (100% RDF + humic acid @ 5 kg ha⁻¹) remained statistically at par with T₄ in both individual years and pooled analysis.

The improvement in spike length may be attributed to enhanced nutrient availability, chelation of micronutrients, and improved cation exchange capacity due to humic acid, leading to better nutrient uptake. Additionally, humic substances promote root growth, membrane permeability and enzymatic activity, resulting in improved plant vigour and spike development, as also reported by Patel *et al.* (2018)^[11], Manjeera *et al.* (2021)^[9], and Kumar *et al.* (2023)^[6].

Table 1: Effect of humic acid on plant population and plant height at 30 DAS of wheat

Tr. No.	Treatment details	Plant population per meter row length at 15 DAS			Plant height at 30 DAS (cm)		
		2023–24	2024–25	Pooled	2023–24	2024–25	Pooled
T ₁	Absolute control	34.01	34.41	34.21	23.95	23.73	23.84
T ₂	100% RDF	34.25	34.43	34.34	26.93	26.80	26.86
T ₃	100% RDF + Soil application of humic acid @ 5 kg/ha	35.13	34.25	34.69	32.22	33.43	32.83
T ₄	100% RDF + Soil application of humic acid @ 10 kg/ha	36.25	37.25	36.75	32.92	34.10	33.51
T ₅	75% RDF + Soil application of humic acid @ 5 kg/ha	35.31	35.61	35.46	30.40	30.27	30.34
T ₆	75% RDF + Soil application of humic acid @ 10 kg/ha	35.49	36.38	35.93	30.99	30.48	30.74
T ₇	75% RDF + Soil application of humic acid @ 15 kg/ha	36.02	36.22	36.12	31.04	30.69	30.87
T ₈	T ₅ + Foliar application of humic acid @ 0.2% (30 & 45 DAS)	35.55	35.65	35.60	30.06	30.43	30.25
T ₉	T ₆ + Foliar application of humic acid @ 0.2% (30 & 45 DAS)	35.71	36.25	35.98	30.73	31.03	30.88
T ₁₀	T ₇ + Foliar application of humic acid @ 0.2% (30 & 45 DAS)	36.05	36.57	36.31	31.40	31.37	31.39
T	S S.Em±	1.71	1.74	1.22	1.75	1.93	1.30
	C CD. at 5%	NS	NS	NS	NS	NS	3.73
Y	S. S.Em±	-	-	0.54	-	-	0.58
	C. CD. at 5%	-	-	NS	-	-	NS
Y X T	S. S.Em±	-	-	1.72	-	-	1.84
	C. CD. at 5%	-	-	NS	-	-	NS
C. CV.%		8.36	8.43	8.39	10.10	11.04	10.58

Number of total tillers

The significantly highest number of tillers count (329.67, 332.00 and 330.83 m⁻¹ row length during 2023–24, 2024–25 and pooled, respectively) was observed under treatment T₄ (100%

RDF + humic acid @ 10 kg ha⁻¹) compare to the control, which was statistically comparable with the treatment receiving 100% RDF with soil application of humic acid @ 5 kg ha⁻¹ in both years and pooled analysis. The increase in tiller number may be

attributed to improved nutrient availability, enhanced root growth and better translocation of assimilates, along with stimulation of hormonal activity (auxin-like effects), leading to enhanced tillering (Nardi *et al.*, 2016 and Canellas *et al.*, 2015)^[10, 2]. These findings are consistent with the research of Kumar *et al.* (2023)^[6], Porchelvan *et al.* (2024)^[12] and Chaubey *et al.* (2025)^[4].

Protein content

Grain protein content of wheat exhibited a significant response to different treatments. The application of 100% RDF and humic

acid @ 10 kg ha⁻¹ resulted the highest protein content (14.60, 14.92 and 14.76% during 2023–24, 2024–25 and pooled, respectively), followed by T₃. Treatments involving soil and foliar application of humic acid showed intermediate protein content, with foliar application exerting a slight additive effect. The increase in protein content may be attributed to improved nitrogen availability, enhanced uptake and assimilation, better translocation of photosynthates and stimulation of protein synthesis. Similar findings were reported by Chaitra *et al.* (2024)^[3], Labade *et al.* (2024)^[7] and Mane *et al.* (2024)^[8].

Table 2: Effect of humic acid on plant height at harvest and spike length of wheat

Tr. No.	Treatment details	Plant height at harvest (cm)			Spike length (cm)		
		2023–24	2024–25	Pooled	2023–24	2024–25	Pooled
T ₁	Absolute control	54.13	54.67	54.40	7.02	7.07	7.05
T ₂	100% RDF	67.97	67.46	67.72	7.94	7.96	7.95
T ₃	100% RDF + Soil application of humic acid @ 5 kg/ha	79.65	79.89	79.77	8.61	8.66	8.64
T ₄	100% RDF + Soil application of humic acid @ 10 kg/ha	82.80	83.07	82.94	8.94	9.10	9.02
T ₅	75% RDF + Soil application of humic acid @ 5 kg/ha	69.87	71.37	70.62	7.71	7.75	7.73
T ₆	75% RDF + Soil application of humic acid @ 10 kg/ha	70.27	71.40	70.83	7.81	7.85	7.83
T ₇	75% RDF + Soil application of humic acid @ 15 kg/ha	72.87	73.33	73.10	7.92	8.02	7.97
T ₈	T ₅ + Foliar application of humic acid @ 0.2% (30 & 45 DAS)	71.73	72.43	72.08	7.78	7.83	7.81
T ₉	T ₆ + Foliar application of humic acid @ 0.2% (30 & 45 DAS)	72.20	73.30	72.75	7.89	7.94	7.91
T ₁₀	T ₇ + Foliar application of humic acid @ 0.2% (30 & 45 DAS)	73.27	74.02	73.64	7.95	8.07	8.01
T	S.Em±	2.93	2.98	2.09	0.33	0.34	0.24
	CD. at 5%	8.70	8.86	6.00	0.97	1.01	0.68
Y	S.Em±	-	-	0.93	-	-	0.11
	CD. at 5%	-	-	NS	-	-	NS
Y X T	S.Em±	-	-	2.96	-	-	0.33
	CD. at 5%	-	-	NS	-	-	NS
C.V.%		7.10	7.17	7.13	7.11	7.36	7.24

Yield of wheat

Both grain and straw yields were markedly influenced by the application of humic acid in conjunction with fertilizers (Table 4). The treatment receiving 100% RDF along with humic acid @ 10 kg ha⁻¹ produced the significantly highest grain yield (5200, 5283 and 5242 kg ha⁻¹ during 2023–24, 2024–25 and pooled, respectively) and was superior to all other treatments, though it remained statistically at par with T₃. The lowest grain yield was recorded under control (T₁). The increase in yield may be attributed to improved soil properties, enhanced nutrient availability and use efficiency, better growth and tillering and increased photosynthetic activity leading to greater assimilate translocation to grains. Similar findings were reported by Sharma *et al.* (2023)^[14], Vinod *et al.* (2024)^[16], Labade *et al.* (2024)^[7] and Chaubey *et al.* (2025)^[4].

Similarly, straw yield followed a trend comparable to grain yield (Table 4). The significantly highest straw yield (6120, 6153 and 6137 kg ha⁻¹ during 2023–24, 2024–25 and pooled, respectively) was found in application of 100% RDF + humic acid @ 10 kg ha⁻¹, followed by T₃. The increase in straw yield may be attributed to improved soil fertility, enhanced nutrient availability and uptake and better plant growth attributes such as

plant height, tiller number and dry matter accumulation. Similar findings were reported by Sharma *et al.* (2023)^[14], Vinod *et al.* (2024)^[16] and Chaubey *et al.* (2025)^[4].

Chlorophyll content

Humic acid treatments significantly effect in chlorophyll content at 30 and 45 DAS during both years and in pooled analysis (Table 5). At 30 DAS, chlorophyll content was not significantly affected during individual years; however, T₄ (100% RDF + humic acid @ 10 kg ha⁻¹) noted comparatively higher chlorophyll content (32.80 SPAD) in pooled analysis and remained at par with T₃, T₈, T₉ and T₁₀.

At 45 DAS, chlorophyll content was significantly influenced by treatments, with T₄ recording the significantly highest values (34.83, 35.08 and 34.95 SPAD during 2023–24, 2024–25 and pooled, respectively), while control (T₁) recorded the lowest (28.85 SPAD). The increase in chlorophyll content may be attributed to improved nitrogen availability, enhanced enzymatic activity and stimulation of chlorophyll biosynthesis due to humic acid application, as also reported by Thakur *et al.* (2018)^[15], Rajamani *et al.* (2021)^[13] and Chaitra *et al.* (2024)^[3].

Table 3: Effect of humic acid on number of total tiller and protein content of wheat

Tr. No.	Treatment details	Number of total tiller/m row length			Protein content (%)		
		2023–24	2024–25	Pooled	2023–24	2024–25	Pooled
T ₁	Absolute control	195	192	194	6.40	6.79	6.59
T ₂	100% RDF	275	279	277	12.08	12.54	12.31
T ₃	100% RDF + Soil application of humic acid @ 5 kg/ha	313	311	312	13.83	14.25	14.04
T ₄	100% RDF + Soil application of humic acid @ 10 kg/ha	330	332	331	14.60	14.92	14.76
T ₅	75% RDF + Soil application of humic acid @ 5 kg/ha	267	271	269	11.38	11.52	11.45
T ₆	75% RDF + Soil application of humic acid @ 10 kg/ha	274	277	276	11.50	11.69	11.59
T ₇	75% RDF + Soil application of humic acid @ 15 kg/ha	283	289	286	11.75	11.92	11.83
T ₈	T ₅ + Foliar application of humic acid @ 0.2% (30 & 45 DAS)	275	278	277	11.46	11.56	11.51
T ₉	T ₆ + Foliar application of humic acid @ 0.2% (30 & 45 DAS)	282	286	284	12.19	12.23	12.21
T ₁₀	T ₇ + Foliar application of humic acid @ 0.2% (30 & 45 DAS)	290	291	291	13.02	13.13	13.07
T	S.Em±	13.2	13.4	9.42	0.51	0.58	0.39
	CD. at 5%	39.3	39.9	27.0	1.53	1.71	1.11
Y	S.Em±	-	-	4.21	-	-	0.17
	CD. at 5%	-	-	NS	-	-	NS
Y X T	S.Em±	-	-	13.3	-	-	0.55
	CD. at 5%	-	-	NS	-	-	NS
C.V.%		8.23	8.28	8.25	7.54	8.28	7.93

Table 4: Effect of humic acid on grain and straw yield of wheat

Tr. No.	Treatment details	Grain Yield (kg ha ⁻¹)			Straw Yield (kg ha ⁻¹)		
		2023–24	2024–25	Pooled	2023–24	2024–25	Pooled
T ₁	Absolute control	2413	2443	2428	3197	3210	3203
T ₂	100% RDF	4240	4297	4268	5283	5277	5280
T ₃	100% RDF + Soil application of humic acid @ 5 kg/ha	4657	4747	4702	5827	5787	5807
T ₄	100% RDF + Soil application of humic acid @ 10 kg/ha	5200	5283	5242	6120	6153	6137
T ₅	75% RDF + Soil application of humic acid @ 5 kg/ha	4263	4293	4278	5093	5107	5100
T ₆	75% RDF + Soil application of humic acid @ 10 kg/ha	4337	4383	4360	5167	5173	5170
T ₇	75% RDF + Soil application of humic acid @ 15 kg/ha	4448	4497	4473	5243	5277	5260
T ₈	T ₅ + Foliar application of humic acid @ 0.2% (30 & 45 DAS)	4297	4310	4303	5170	5150	5160
T ₉	T ₆ + Foliar application of humic acid @ 0.2% (30 & 45 DAS)	4360	4450	4405	5227	5297	5262
T ₁₀	T ₇ + Foliar application of humic acid @ 0.2% (30 & 45 DAS)	4487	4543	4515	5337	5373	5355
T	S.Em±	237	248	171	262	260	185
	CD. at 5%	704	735	491	778	774	530
Y	S.Em±	-	-	76.6	-	-	82.5
	CD. at 5%	-	-	NS	-	-	NS
Y X T	S.Em±	-	-	242	-	-	261
	CD. at 5%	-	-	NS	-	-	NS
C.V.%		9.61	9.91	9.76	8.78	8.71	8.74

Table 5: Effect of humic acid on chlorophyll content of wheat

Tr. No.	Treatment details	Chlorophyll content at 30 DAS (SPAD Value)			Chlorophyll content at 45 DAS (SPAD Value)		
		2023–24	2024–25	Pooled	2023–24	2024–25	Pooled
T ₁	Absolute control	27.45	27.94	27.69	28.75	28.95	28.85
T ₂	100% RDF	28.96	29.86	29.41	29.62	29.84	29.73
T ₃	100% RDF + Soil application of humic acid @ 5 kg/ha	31.47	31.57	31.52	32.84	33.11	32.97
T ₄	100% RDF + Soil application of humic acid @ 10 kg/ha	32.74	32.86	32.80	34.83	35.08	34.95
T ₅	75% RDF + Soil application of humic acid @ 5 kg/ha	28.83	29.98	29.41	28.92	28.98	28.95
T ₆	75% RDF + Soil application of humic acid @ 10 kg/ha	29.14	29.73	29.44	30.68	30.70	30.69
T ₇	75% RDF + Soil application of humic acid @ 15 kg/ha	29.07	29.41	29.24	31.12	31.72	31.42
T ₈	T ₅ + Foliar application of humic acid @ 0.2% (30 & 45 DAS)	30.97	31.10	31.04	30.45	30.79	30.62
T ₉	T ₆ + Foliar application of humic acid @ 0.2% (30 & 45 DAS)	31.22	31.40	31.31	30.78	31.04	30.91
T ₁₀	T ₇ + Foliar application of humic acid @ 0.2% (30 & 45 DAS)	31.16	31.81	31.48	31.38	31.68	31.53
T	S.Em±	1.16	1.14	0.81	1.14	1.18	0.82
	CD. at 5%	NS	NS	2.34	3.40	3.49	2.35
Y	S.Em±	-	-	0.36	-	-	0.37
	CD. at 5%	-	-	NS	-	-	NS
Y X T	S.Em±	-	-	1.15	-	-	1.16
	CD. at 5%	-	-	NS	-	-	NS
C.V.%		6.69	6.47	6.58	6.40	6.53	6.47

Conclusion

The results of the study concluded that integration of humic acid with the recommended dose of fertilizers significantly enhances growth, yield and grain quality of wheat. The combination of

100% RDF along with humic acid @ 10 kg ha⁻¹ underscores its potential to enhance nutrient use efficiency and optimize crop productivity, indicating that such integration is a viable strategy for improving productivity and sustaining soil health.

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