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Effect of Soil and Foliar Application of Humic Acid on Nutrient Uptake, Grain and Straw Yield of Black Gram (*Vigna mungo* L.) under Inceptisols

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Black gram is a type of legume that is widely cultivated and consumed in various parts of the world. It is believed to have originated in the Indian subcontinent and is one of the oldest cultivated legumes in the world. The field experiment was carried out to during *kharif* season of the year 2022

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at departmental farm of Soil Science and Agricultural Chemistry, College of Agriculture, Latur. The experiment was laid out in randomized block design with three replications and eight treatments *viz.,* T1 (RDF), T2 (RDF + Foliar application of humic acid @ 0.2 % at 20 & 35 DAS), T3 (RDF + soil application of humic acid @ 10 kg ha^{-1}), T4 (RDF + soil application of humic acid @ 15 kg ha^{-1}), T5 (RDF + soil application of humic acid @ 20 kg ha^{-1}), T6 (T3 + foliar application of humic acid @ 0.2% at 20 & 35 DAS), T7 (T4 + foliar application of humic acid @ 0.2% at 20 & 35 DAS), T8 (T5 + foliar application of humic acid @ 0.2% at 20 & 35 DAS). The field study indicated that the nutrient uptake and content and grain and straw yield of black gram crop were significantly influenced due to soil and foliar application of humic acid and RDF. The uptake of N, P and K were recorded at harvest. Significant and maximum uptake of N, P and K were noticed with application of treatment T_8 (RDF + soil application of humic acid @ 20 kg ha^{-1}+ foliar application of humic acid @ 0.2% at 20 and 35 DAS), whereas the T_1 (RDF) showed least values. grain and straw yield significantly affected due to T_8 (RDF + soil application of humic acid @ 20 kg ha^{-1} + foliar application of humic acid @ 0.2% at 20 and 35 DAS) and the lowest grain and straw yield were recorded in T_1 (RDF). Thus, it can be concluded that the soil and foliar application of humic acid increase the nutrient uptake and grain and straw yield. The significantly superior result recorded by treatment T_8 (RDF + soil application of humic acid @ 20 kg ha^{-1} + foliar application of humic acid @ 0.2% at 20 and 35 DAS) next to this treatment T_7 (RDF + soil application of humic acid @ 10 kg ha^{-1} + foliar application of humic acid @ 0.2% at 20 and 35 DAS) was best option. The significant increase in grain and straw yield of black gram was due to application of RDF with soil and foliar application of humic acid which mitigates scarcity, increased absorption effectively and increased photosynthetic activity which leads to higher grain and straw yield.

Keywords: Humic acid; nutrient uptake; black gram; grain; straw.

1. INTRODUCTION

"Black gram is a type of legume that is widely cultivated and consumed in various parts of the world. It is believed to have originated in the Indian subcontinent and is one of the oldest cultivated legumes in the world. It is an excellent source of protein (24%) with lysine also contains carbohydrate (67%), fiber (3.5%), making it a healthy food choice for vegetarians and vegans. It also contains significant fat (1.74%) and major vitamins and minerals, including folate, iron, magnesium, potassium, and zinc. In India, it is commonly used to make dal, a lentil soup that is a staple food in many households. The United Nations declared 2016 as "International Year of Pulses" (IYP) to heighten public awareness of the nutritional benefits of pulses as part of sustainable food production aimed at food security and nutrition" [1].

"Black gram producing major states in India are Andhra Pradesh, Madhya Pradesh, Rajasthan, Uttar Pradesh, Tamilnadu and Maharashtra. In kharif 2021-22, black gram production was 20.5 lakh tonnes (1st advance estimates) in an area of 39.43 lakh hectares" [2]. Andhra Pradesh produced 3.65 lakh according to recent estimates during 2021-22, black gram was grown in 3.93 lakh hectares with a production of 3.65 lakh tonnes and productivity was 929 kg ha^{-1}. The major black gram producing districts in Marathwada region are Parbhani, Nanded, Latur, Hingoli, Beed, Sambhajinagar and Dharashiv. The area under black gram in Latur districts is about 1,017.13 hundred ha^{-1}, with total production 497.84 hundred tones in per hectare productivity of 489.46 kg ha^{-1}. Maintaining food production for a growing global population without sacrificing natural resources for future generations is one of the greatest challenges for agricultural science, even compared with the green revolution in the 20th century. Within this context, humic substance- based products may provide a potential technology to promote plant growth and plant adaptation to new ways of food production.

Humic acid is a type of organic matter that is found in soils, peat, and other natural sources. It is composed of complex molecules that are formed by the decay of plant and animal material over long periods of time. It has a wide range of applications in agriculture, and other fields, and is considered to be an important component of healthy soils. it is a complex mixture of organic compounds that includes a variety of functional groups, such as carboxylic acids, phenolic groups, and quinones. It is formed by the decay of organic matter. its composition varies depending on the source of the material. Generally, humic acid has a dark brown to black color and is highly soluble in water.

Humic acid has a wide range of functions and benefits, particularly in agriculture and soil management. It can improve soil structure and fertility, increase nutrient uptake by plants, and promote the growth of beneficial microorganisms. It can also help to reduce soil erosion and water runoff, and can enhance the resilience of crops to stress and disease. One of the key function of humic acid is to improve soil structure. It can act as a binding agent, helping to bind together soil particles and create larger aggregates. This can improve soil porosity and aeration, which in turn can enhance water infiltration and retention. Humic acid can also help to reduce soil compaction, which can be a major problem in many agricultural soils. Humic acid can also help to increase nutrient uptake by plants. It can chelate nutrients, such as iron, zinc, and manganese, making them more available to plant roots [3]. It can also help to buffer soil pH, which can improve the availability of certain nutrients, such as phosphorus. In addition to these functions, humic acid can also help to promote the growth of beneficial microorganisms in the soil. Humic acid improves soil quality, enhance plant growth, yield, and quality. It also increase plant resistance to stress, disease, and pests. It can chelate, or bind with nutrients such as iron, calcium and magnesium, making them more available to plants. It stimulate the growth of beneficial microorganisms in soil, such as bacteria and fungi, which further improve soil health and nutrient cycling [4].

In recent years, applications of solution and solid state product of humic acid received the most attention for higher crop yield, savings of fertilisers and reduced losses to the environment on several crops.

2. MATERIALS AND METHODS

The experiment was conducted during *kharif* 2022 at Soil Science and Agricultural Chemistry Department Research Farm, College of Agriculture, Latur, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. the test variety was BDU-1, sown in the first week of july and harvested in the final week of september. The experimental field's soil had good drainage neutral reaction and a black color. There were eight treatments and three replications in the randomized block design experiment. "The treatment comprised of T_1 - RDF, T_2- RDF + foliar application of humic acid @ 0.2 % at 20 & 35 DAS, T_3 - RDF + soil application of humic acid @ 10 kg ha^{-1}, T_4- RDF+ soil application of humic acid @ 15 kg ha^{-1} , T_5- RDF + soil application of humic acid @ 20 kg ha^{-1}, T_6 - T_3 + foliar application of humic acid @ 0.2 % at 20 & 35 DAS, T_7- T_4 + foliar application of humic acid @ 0.2 % at 20 & 35 DAS , T_8 - T_5 + foliar application of humic acid @ 0.2 % at 20 & 35 DAS". [16] The experiment's yields, growth analysis and various morphological observations were recorded at 30,45 and harvest stages in order to assess the treatment's impact. For black gram, fertilizer dosage recommendations are 25:50:25 kg N and P_2O_5, K_2O ha^{-1}, respectively. The crop was threshed manually, with grain and straw being collected in separate plots.

3. RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads.

3.1 Impact of Humic Acid on Nutrient Content and Nutrient Uptake of Black Gram

3.1.1 Nitrogen

The content and uptake of nitrogen significantly affected after application of humic acid through soil application and foliar spraying. Treatment T_8 (RDF + soil application @ 20 kg ha^{-1} + foliar application of humic acid @ 0.2 %) which showed significant and maximum N content from straw and grain noted as 1.31 and 3.49 % respectively as compared to all other treatments, which was followed by Treatments T_7 (RDF + soil application @ 15 kg ha^{-1} + foliar application of humic acid @ 0.2 %) which noted as 1.18 and 3.30 % respectively. Where least N content from straw and grain recorded due to T_1 (RDF) noted as 0.56 and 2.56 % respectively.

Due to application of humic acid N uptake in straw, grain and total uptake were significantly affected. Treatment T_8 (RDF + soil application @ 20 kg ha^{-1} + foliar application of humic acid @ 0.2%) was found significantly superior in terms of N uptake in straw, grain and total uptake and their values recorded as 27.19, 46.65 and 73.84 kg ha^{-1} respectively as compared to all other treatments. Which was followed by treatments T_7 (RDF + soil application @ 15 kg ha^{-1} + Foliar application of humic acid @ 0.2%) and values noted as 22.95, 42.82 and 65.77 kg ha^{-1}, Where least N content from straw and grain recorded due to T_1 (RDF) noted as 7.52, 24.49 and 32.02 kg ha^{-1} N uptake in straw, grain and total uptake respectively.

Combined use of RDF soil and foliar application of HA showed better performance as compared only soil application. The higher content and uptake may be due to increased development of secondary roots with improved permeability thus better absorbtion of nutrients takes place. Similar result found by, El-Syed *et al*. [5] and Lingaraju *et al*. [6].

3.1.2 Phosphorus

Phosphorus content from straw and grain shows significant effect. Treatment T_8 (RDF + soil application @ 20 kg ha^{-1} + foliar application of humic acid @ 0.2 %) was found significantly superior in respect of phosphorus content from straw and grain, noted as 0.35 and 0.73 % respectively as compared to all other treatments, which was followed by treatments T_7 (RDF + soil application @ 15 kg ha^{-1} + foliar application of humic acid @ 0.2%) values noted as 0.32 and 0.69 % of phosphorus from grain and straw. Where least phosphorus content in straw and grain recorded due to T_1 and noted as 0.17 and 0.43 % respectively.

Data showed that application of humic acid P uptake from straw, grain and total uptake significantly affected. Treatment T_8 (RDF + soil application @ 20 kg ha^{-1} + foliar application of humic acid @ 0.2 %) was found significantly superior in respect of P uptake in straw, grain and total uptake (7.38, 9.75 and 17.14 kg ha^{-1} respectively) as compared to all other treatments, which was followed by Treatments T_7 (RDF + soil application @ 15 kg ha^{-1} + foliar application of humic acid @ 0.2 %) noted as 6.22, 8.02 and 15.23 kg ha^{-1} respectively. Where least P content from straw and grain recorded due to T_1 (RDF) recorded as 2.24, 4.17 and 5.61 kg ha^{-1} respectively. Combined use of soil and foliar application show better performance as compare to alone soil application. Similar finding has been published by Hemati *et al*. [7] Kiran *et al*. [8] and Tuncturk *et al*. ([9].

3.1.3 Potassium

Due to application of humic acid K content in straw and grain shows significant effect. Treatment T_8 (RDF + soil application @ 20 kg ha^{-1} + foliar application of humic acid @ 0.2 %) which superiorly significant in terms of K content in straw and grain which recorded as 0.78 and 1.74 % respectively as compared to all other treatments, which was followed by treatments T_7 (RDF + soil application @ 15 kg ha^{-1} + foliar application of humic acid @ 0.2 %) values recorded as 0.72 and 1.64 % respectively and then T_6 (RDF + soil application @ 10 kg ha^{-1} + foliar application of humic acid @ 0.2 %) values recorded as 0.66 and 1.55 % respectively. Where least K content from straw and grain recorded due to T_1 (RDF) and noted as 0.41 and 1.25 % respectively.

Due to application of humic acid K uptake from straw, grain and total uptake showed significant effect. Treatment T_8 (RDF + soil application @ 20 kg ha^{-1} + foliar application of humic acid @ 0.2%) which found significantly superior in respect of K uptake in straw, grain and total uptake noted as 16.29, 23.34 and 39.63 kg ha^{-1} respectively as compared to all other treatments, which was followed by treatments T_7 (RDF + soil application @ 15 kg ha^{-1} + foliar application of humic acid @ 0.2 %) which was noted as 13.99, 21.25 and 35.25 kg ha^{-1} K uptake from straw, grain and total uptake and then T_6 (RDF + soil application @ 10 kg ha^{-1} + foliar application of humic acid @ 0.2 %) which was noted as 12.24, 19.28 and 31.52 kg ha^{-1} K uptake from straw, grain and total uptake respectively. Where least K content from straw and grain recorded due to T_1 (RDF) noted as 5.54, 11.98 and17.53 kg ha^{-1} respectively.

This could because of high absorption, translocation and assimilation of micro and macronutrients which enhanced by humic acid sources. Similar finding was proposed by followings, Donder and Togay [10] Kiran *et al*. [8] Osman and Rady [11].

3.2 Effect of Humic Acid on Straw and Grain Yield of Black Gram Crop

3.2.1 Grain yield

Effect of soil and foliar application of humic acid along with full dose of RDF was clearly noted that humic acid has beneficial effect on grain yield and increased yield as compared to treatment T_1 (RDF). Grain yield was varied from 957.26 to 1337.12 kg ha^{-1}. Combined use of soil and foliar spray produces maximum yield. Treatment T_8 (T_5 + foliar application of humic acid @ 0.2 %) was significantly superior over rest of all treatment and gave maximum yield recorded as 1337.12 kg ha^{-1}, Which was followed by treatments T6 (T3 + foliar application of humic acid @ 0.2 %) and T5 (RDF + soil application of humic acid @ 20 kg ha^{-1}) which gave 1242.16 and 1188.97 kg ha^{-1} grain yield respectively. Whereas treatment T7 (T4 + foliar application of humic acid @ 0.2 %) was found at par with T8 in terms of grain yield and recorded as 1295.34 kg ha^{-1}. T1 (RDF) produced 957.26 kg ha^{-1} grain yield and recorded least grain yield as compared to other.

Table 1. Nitrogen content and uptake in grain and straw of black gram crop after harvest as influenced with application of humic acid

Treatments	N Content (%)		N Uptake (kg ha^{-1})		
	Grain	**Straw**	**Grain**	**Straw**	**Total**
T1: RDF	2.56	0.56	24.49	7.52	32.02
T2 : RDF + foliar application of humic acid @ 0.2 % (@ 20 & 35 DAS)	2.62	0.62	26.52	8.71	35.24
T3 : RDF + soil application of humic acid @ 10 kg ha^{-1}	2.73	0.76	28.97	11.84	40.81
T4 : RDF+ soil application of humic acid @ 15 kg ha^{-1}	2.83	0.84	32.56	13.64	46.20
T5 : RDF + soil application of humic acid @ 20 kg ha^{-1}	3.06	0.96	36.41	16.73	53.14
T6 : T3 + foliar application of humic acid @ 0.2 % (20 & 35 DAS)	3.2	1.05	39.74	19.64	59.38
T7 : T4 + foliar application of humic acid @ 0.2 % (20 & 35 DAS)	3.30	1.18	42.82	22.95	65.77
T8 : T5 + foliar application of humic acid @ 0.2 % (20 & 35 DAS)	3.49	1.31	46.65	27.19	73.84
SE±	0.014	0.022	0.819	0.509	0.929
CD at 5%	0.043	0.069	2.485	1.544	2.818

Table 2. Phosphorus content and uptake in grain and straw of black gram crop after harvest as influenced with application of humic acid

Treatments	P Content (%)		P Uptake (kg ha^{-1})		
	Grain	**Straw**	**Grain**	**Straw**	**Total**
T1: RDF	0.43	0.17	4.17	2.24	5.61
T2 : RDF + foliar application of humic acid @ 0.2 % (@ 20 & 35 DAS)	0.49	0.19	4.95	2.75	7.7
T3 : RDF + soil application of humic acid @ 10 kg ha^{-1}	0.50	0.20	5.37	3.21	8.58
T4 : RDF+ soil application of humic acid @ 15 kg ha^{-1}	0.56	0.22	6.52	3.59	10.12
T5 : RDF + soil application of humic acid @ 20 kg ha^{-1}	0.60	0.253	7.16	4.36	11.53
T6 : T3 + foliar application of humic acid @ 0.2 % (20 & 35 DAS)	0.64	0.28	8.02	5.25	13.27
T7 : T4 + foliar application of humic acid @ 0.2 % (20 & 35 DAS)	0.69	0.32	8.94	6.22	15.23
T8 : T5 + foliar application of humic acid @ 0.2 % (20 & 35 DAS)	0.73	0.356	9.75	7.38	17.14
SE±	0.015	0.019	0.242	0.369	0.533
CD at 5%	0.0457	0.059	0.736	1.119	1.619

Table 3. Potassium content and uptake in grain and straw of black gram crop after harvest as influenced with application of humic acid

Treatments	K Content (%)		K Uptake (kg ha^{-1})		
	Grain	Straw	Grain	Straw	Total
T1: RDF	1.25	0.41	11.98	5.54	17.53
T2 : RDF + foliar application of humic acid @ 0.2 % (@ 20 & 35 DAS)	1.29	0.47	13.11	6.63	19.74
T3 : RDF + soil application of humic acid @ 10 kg ha^{-1}	1.35	0.51	14.38	8.02	22.41
T4 : RDF+ soil application of humic acid @ 15 kg ha^{-1}	1.44	0.56	16.64	9.01	25.65
T5 : RDF + soil application of humic acid @ 20 kg ha^{-1}	1.51	0.62	18.03	10.74	28.78
T6 : T3 + foliar application of humic acid @ 0.2 % (20 & 35 DAS)	1.55	0.66	19.28	12.24	31.52
T7 : T4 + foliar application of humic acid @ 0.2 % (20 & 35 DAS)	1.64	0.72	21.25	13.99	35.25
T8 : T5 + foliar application of humic acid @ 0.2 % (20 & 35 DAS)	1.74	0.78	23.34	16.29	39.63
SE±	0.025	0.021	0.419	0.573	0.845
CD at 5%	0.077	0.064	1.273	1.740	2.564

Table 4. Grain and Straw yield of black gram as influence with application of humic acid

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T1: RDF	957.26	1327.63
T2 : RDF + foliar application of humic acid @ 0.2 % (@ 20 & 35 DAS)	1012.34	1407.40
T3 : RDF + soil application of humic acid @ 10 kg ha^{-1}	1061.72	1553.65
T4 : RDF+ soil application of humic acid @ 15 kg ha^{-1}	1150.99	1612.53
T5 : RDF + soil application of humic acid @ 20 kg ha^{-1}	1188.97	1730.29
T6 : T3 + foliar application of humic acid @ 0.2 % (20 & 35 DAS)	1242.16	1857.54
T7 : T4 + foliar application of humic acid @ 0.2 % (20 & 35 DAS)	1295.34	1941.11
T8 : T5 + foliar application of humic acid @ 0.2 % (20 & 35 DAS)	1337.12	2068.37
SE±	28.09	45.57
CD at 5%	85.20	138.23

Application of FYM, RDF, soil and foliar application of humic acid increases absorption of nutrients and water, translocation of nutrients ultimately produces high foliage, pods, reproductive parts cause high grain yield. This may also because of nitrogen play important role in vegetative growth aids to stimulates chlorophyll and branching. Phosphorous aids to development of flower initiation, root development, decreases lodging, seed formation etc. Potassium aids in catalysing of enzymatic processes, translocation of assimilated sugars and increases drought resistance. Also superior data recorded might be attributed to increased dry matter accumulation in reproductive parts and formation of higher sink capacity with the addition of organics like FYM and humic acid. The results are as conformity with findings of Hivare *et al*. [12] and Girijesh (2019)

3.2.2 Straw yield

Combined application of soil and foliar spray produces maximum straw yield. Treatment T8

(T_5 + foliar application of humic acid @ 0.2 %) were significantly superior over rest of all treatment and gave straw yield 2068.37 kg ha^{-1}, which was followed by treatments T_6 (T_3 + foliar application of humic acid @ 0.2 %) and T_5 (RDF + soil application of humic acid @ 20 kg ha^{-1}) gave straw yield 1857.54 and 1730.29 kg ha^{-1} respectively. Whereas treatment T_7 (T_4 + foliar application of humic acid @ 0.2 %) is at par with T_8 in terms of straw yield and recorded as 1941.11 kg ha^{-1}. T_1 (RDF) produced 1327.63 kg ha^{-1} straw yield and recorded least straw yield as compared to other.

These results are as conformity with findings of Dange *et al*. [13] Tripura *et al*. [14] and Kamalakannan [15,16].

4. CONCLUSION

The content and uptake of nutrients by grain and straw was maximum due to greater supply of nutrients. Humic acid forms chelate and reduces losses and make available to plants. High cation exchange capacity resulted high absorption of nutrients. The significant increase in grain and straw yield of black gram was due to application of RDF with soil and foliar application of humic acid which mitigates scarcity, increased absorption effectively and increased photosynthetic activity which leads to higher grain and straw yield.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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