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Effect of inorganic fertilizers and humic acid on nutrient uptake of foxtail millet: Bengalgram cropping system

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Abstract

Humic acid is an eco-friendly product needed in lesser quantity when compared to other chemical fertilizers and manures. Humic Acid can be integrated into the soils in the form of manure; it improves the physical properties of the soil. A field experiment was conducted at the College Farm, Agricultural College, Mahanandi, ANGRAU during *kharif* & *rabi* seasons of 2020-21 and 2021-22. The experimental soil was sandy loam in texture with 7.52 pH, 0.42 dsm^{-1} EC, 0.32 % OC, low available N (175 kg ha^{-1}), medium in P (18.48 kg ha^{-1}), high in K (580 kg ha^{-1}) and sufficient in Zn status (0.85 ppm). The experiment was laid out in Split plot design with three replications with four main plots and six sub plots total twenty four treatments. The study revealed that N,P & K uptake in Foxtail millet at harvesting stage in grain & straw, by application of different humic acid treatments significantly influenced the plant nitrogen uptake at all the stages of crop growth. There is a significant increase in nitrogen uptake in treatments which received humic acid dose @ 20 Kg/ha along with 0.2% foliar spray of humic acid. In main plots, Highest Nitrogen uptake was recorded in treatment M4 (4.64, 6.32 kg ha^{-1} in 2020 and 5.42 & 7.39 kg ha^{-1} in 2021) which received 100% RDF through inorganics in kharif season recorded significantly higher nitrogen uptake at harvest stages (Grain and Straw) and it was on par with the treatment M3 i.e., 75% RDF through inorganics (4.27, 5.74 kg ha^{-1} in 2020 and 4.98, 6.71 kg ha^{-1} in 2021). Among the sub plots, the treatment S_6 which received 20 Kg humic acid per hectare recorded higher N uptake (4.51, 6.00 kg ha^{-1} in 2020 and 4.92,7.12 kg ha^{-1} in 2021) at harvesting stage (Grain and Straw) respectively in foxtail millet which was on par with treatment S_3. The interaction effects between main plots and sub plots was non significant. Similar results were reported in P & K uptake studies too. This might be due to higher availability of plant nutrients with fertilization, which resulted in enhanced nutrient uptake in plant tissues and more biomass production at higher total fertilizer application.

Keywords: Humic acid, in-organic fertilizers-nutrient uptake studies-foxtail millet-bengalgram cropping system.

Introduction

Prolonged use of chemical fertilizers alone in intensive cropping systems leads to unfavourable soil nutrient status, harmful effects on soil physico-chemical and biological properties and thus defines the concept of sustainable crop production.

Humic acid is an eco-friendly product needed in lesser quantity when compared to other chemical fertilizers and manures.Humic Acid can be integrated into the soils in the form of manure; it improves the physical properties of the soil. Advantage of humate based fertilizers to the soil is that the producer can again become a steward of the soil by developing a more ecologically sound agricultural production system (Ravichandran, 2011). Humates enhances the crop productivity not only through improving physical chemical and biological properties of soil (Keeling *et al*., 2003; Mikkelsen, 2005), but it also offers plants resistance to pest and disease, besides acting as the growth stimulant.

Humic substances are generated through organic matter decomposition and employed as soil fertilizers in order to improve soil structure and soil microorganisms. Soil organic matter has been fractionated on the basis of solubility in dilute mineral acid and alkali in to three groups *viz*. fulvic acid, humic acid and humin. Fulvic acids are soluble in both acid and alkali, humic acids are soluble in alkali but insoluble in acids and humins are insoluble in both. Fulvic acids are relatively simple in composition and assimilable by plants, are labile in the soil. Humins are highly complex of the three forms and are unavailable to the plants. Humic acids occupy an intermediate position between these three groups and persist in the soil for a prolonged period so as to be useful to the crop plants (Ravichandran, 2011).

Foxtail millet (*Setaria italica* L.) is one of the earliest cultivated crops, extensively grown in arid and semi-arid regions of Asia and Africa. Foxtail millet contains significant levels of protein, fiber, mineral and phytochemicals. Anti-nutrients such as phytic acid and tannin present in this millet can be reduced to negligible levels by using suitable processing methods (Hariprasanna, 2016). The millet is also reported to possess hypo lipidemic, low-glycemic index and antioxidant characteristics. In india, it is cultivated in Karnataka, A.P, M.P and U.P. In A.P. foxtail millet is suitable for dryland cultivation in Anantapur, Kurnool, Prakasam and Guntur districts. In A.P, it occupies an area of 1.74 lakh ha. with a total production of 0.85 lakh tonnes per annum.

Chickpea is a valued crop and provides nutritious food for an expanding world population and will become increasingly important with climate change. The nutritional value of chickpea in terms of nutrition and body health has been recently emphasized frequently by nutritionist in health and food area in many countries around the world. Production ranks third after beans with a mean annual production of over 11.5 million tons with most of the production centered in India. Land area devoted to chickpea has increased in recent years and now stands at an estimated 14.56 million hectares. Production per unit area has slowly but steadily increased since 1961 at about 6 kg ha^{-1} per annum. Over 2.3 million tons of chickpea enter world markets annually to supplement the needs of countries unable to meet demand through domestic production (Bulti Merga and Jema Haji, 2019). About 65% of global area with 68 % of global production of chickpea is contributed by India (Reddy and Mishra, 2010). As foxtail millet-bengalgram is an important cropping system in Scarce Rainfall zone of Andhra Pradesh, this experiment is planned to generate more information on combined application of humic acid and inorganic fertilizers with the following objectives.

Material and Methods: A field experiment was conducted at the College Farm, Agricultural College, Mahanandi, ANGRAU during kharif & rabi seasons of 2020-21 and 2021-22. Which was geographically situated at 15.510 N latitude, 78.610 E longitude with an altitude of 233.48 meters above the mean sea level in Scarce Rainfall Zone of Andhra Pradesh. The experimental soil was sandy loam in texture with 7.52 pH, 0.42 dsm-1 EC, 0.32 % OC, low available N (175 kg ha-1), medium in P (18.48 kg ha-1), high in K (580 kg ha-1) and sufficient in Zn status (0.85 ppm). The experiment was laid out in Split plot design with three replications with four main plots and six sub plots total twenty four treatments. Viz.,

Main plots	Subplots
M_1: control	S_1: No Humic acid application
M_2: 50% RDF	S_2: 10 kg ha^{-1} Humic acid as soil application
M_3: 75% RDF	S_3: 20 kg Humic acid as soil application
M_4: 100% RDF	S_4: 0.2% of foliar application of Humic acid
	S_5:10 kg ha^{-1}Humic acid as soil application + S4
	S_6: 20 kg ha^{-1}Humic acid as soil application + S4

The 100% RDF for foxtail millet crop is 40:20:0 kg N, P2O5 and K2O ha-1. P fertiliser was applied as basal dosage and half of the N was applied as basal and other half at 30 DAS. Similarly 50% RDF was also applied. Humic acid was applied as basal at the levels chosen and incorporated as per treatments mentioned.

Analysis of plant samples for nutrient uptakes: The N, P, K and Zn content of the plant samples were analysed at harvest stage of the crop. The plant samples were dried in hot air oven at 60oC and the dried samples were grinded in a Willey mill. The powdered samples were then used for analysis.

Nitrogen uptake (kg ha^{-1}): The nitrogen content in dried plant samples was determined by Microkjeldahl method (AOAC, 1960) after digestion of the sample with H_2SO_4 and H_2O_2.

N Uptake (kg ha^{-1}) = N content (%) x Dry matter production (kg ha^{-1})/ 100

Phosphorus uptake (kg ha^{-1}): The plant samples were digested with tri acid mixture consisting of HNO_3: $HClO_4$: H_2SO_4 (9:4:1) for the analysis of P, K and Zn in plant sample.

P Uptake (kg ha^{-1}) = P content (%) x Dry matter production (kg ha^{-1})/ 100

Potassium uptake (kg ha-1): The potassium content in the triacid mixture was determined by using flame photometer (Piper, 1967).

K Uptake (kg ha^{-1}) = K content (%) x Dry matter production (kg ha^{-1})/100

Nutrient uptake Zinc, copper, manganese, and iron in the diacid extract were determined using atomic absorption spectrophotometer as per the specifications mentioned by Lindsay and Norvell (1978). From the chemical analytical data, uptake of the each nutrient was calculated as shown below.

$$\text{Macronutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content (\%) x dry weight in kg ha}^{-1}}{100}$$

$$\text{Micronutrient uptake (g ha}^{-1}\text{)} = \frac{\text{Nutrient content (mg kg}^{-1}\text{) x dry weight in kg ha}^{-1}}{1000}$$

Results & Discussion:

N, P & K uptake in Foxtail millet at harvesting stage in grain & straw was furnished in the tables from 1 to 6. Perusal of data revealed that application different treatments significantly influenced the plant nitrogen uptake at all the stages of crop growth. There is a significant increase in nitrogen uptake in treatments which received humic acid dose @ 20 Kg/ha along with 0.2% foliar spray of humic acid. In main plots, Highest Nitrogen uptake was recorded in treatment M4 (4.64, 6.32 kg ha^{-1} in 2020 and 5.42 & 7.39 kg ha^{-1} in 2021) which received 100% RDF through inorganics in kharif season recorded significantly higher nitrogen uptake at harvest stages (Grain and Straw) and it was on par with the treatment M3 i.e., 75% RDF through inorganics (4.27, 5.74 kg ha^{-1} in 2020 and 4.98, 6.71 kg ha^{-1} in 2021).

Among the sub plots, the treatment S_6 which received 20 Kg humic acid per hectare recorded higher N uptake (4.51, 6.00 kg ha^{-1} in 2020 and 4.92,7.12 kg ha^{-1} in 2021) at harvesting stage (Grain and Straw) respectively in foxtail millet which was on par with treatment S_3. These two treatments were significantly superior over all treatments. The interaction effects between main plots and sub plots was non significant. This might be due to higher availability of plant nutrients with fertilization, which resulted in enhanced nutrient uptake in plant tissues and more biomass production at higher total fertilizer application (Islam and Munda, 2012). A significant increase in nitrogen uptake up to a HA dose of 20 kg ha^{-1} combined with 100% N and at a fertilizer level of 75% N, an increase upto a humic acid dose of 30 kg ha^{-1} was observed at all the stages of crop growth and also in grain. Thangavelu and Ramabadram (1993), Senthil Kumar and Arockiasamy (1995) in rice; Thenmozhi (2001) in groundnut; Nikbakht *et al.* (2008) in gerbera; Khan *et al.* (2014) in maize; Asri *et al.* (2015) in tomato observed similar results with application of humic acid.

Similar results of P & K uptake was observed in M4 and S6 treatments. Humic acid influenced the root growth which inturn helped in better assimilation of P. Hashimoto (1965) reported that increased P availability was due to reduced P fixation and also due to the formation of humophosphate complexes (Logvinova, 1939) which might have increased the P uptake by rice. Increase in K content and uptake recorded in this study might be due to the reduced K fixation on addition of HA. According to Samson and Viser (1989) application of humic acid increased the permeability of bio membranes for electrolytes and thereby accounted for increased K uptake.

Table 1: Effect of inorganic fertilizers and humic acid on Nitrogen uptake (Kg/ha) of Foxtail millet grain

Sub Plots (Humic Acid)	*Kharif 2020*				Mean	*Kharif 2021*				Mean
	Main Plots (In-Organics)					**Main Plots (In-Organics)**				
	M_1	M_2	M_3	M_4		M_1	M_2	M_3	M_4	
S_1	2.43	2.73	3.34	3.88	3.10	2.73	3.07	3.75	4.35	3.47
S_2	3.05	3.60	4.50	4.64	3.95	2.89	3.43	5.33	5.50	4.29
S_3	3.41	3.96	4.77	5.06	4.30	3.16	3.78	5.65	6.00	4.65
S_4	2.53	2.86	3.55	4.11	3.26	2.84	3.21	3.98	4.61	3.66
S_5	3.16	3.74	4.52	4.79	4.05	3.09	3.66	5.35	5.67	4.44
S_6	3.60	4.15	4.91	5.37	4.51	3.43	4.07	5.82	6.36	4.92
Mean	3.03	3.51	4.27	4.64		3.02	3.23	4.98	5.42	
	SEm ±		**CD (p=0.05)**		**CV (%)**	**SEm ±**		**CD (p=0.05)**		**CV (%)**
M	0.16		0.48		7.8	0.18		0.53		7.5
S	0.11		0.32		6.2	0.11		0.32		6.4
M X S	0.03		NS			0.04		NS		
S X M	0.04		NS			0.05		NS		

Table 2: Effect of inorganic fertilizers and humic acid on Nitrogen uptake (Kg/ha) of Foxtail millet straw

Sub Plots (Humic Acid)	*Kharif 2020*				Mean	*Kharif 2021*				Mean
	Main Plots (In-Organics)					**Main Plots (In-Organics)**				
	M_1	M_2	M_3	M_4		M_1	M_2	M_3	M_4	
S_1	2.90	3.33	4.23	4.86	3.83	3.25	3.73	4.74	5.45	4.30
S_2	3.28	3.96	5.85	6.46	4.89	3.89	4.70	6.93	7.66	5.79
S_3	3.66	4.33	6.56	7.02	5.39	4.33	5.13	7.77	8.32	6.39
S_4	3.08	3.55	4.24	4.88	3.94	3.46	3.98	4.76	5.47	4.42
S_5	3.47	4.01	6.08	6.73	5.08	4.12	4.75	7.21	7.98	6.01
S_6	3.93	4.62	7.45	7.97	6.00	4.66	5.56	8.83	9.44	7.12
Mean	3.39	3.97	5.74	6.32		3.95	4.64	6.71	7.39	
	SEm ±		**CD (p=0.05)**		**CV (%)**	**SEm ±**		**CD (p=0.05)**		**CV (%)**
M	0.22		0.66		8.4	0.24		0.72		8.5
S	0.14		0.43		7.7	0.17		0.51		7.8
M X S	1.04		NS			1.04		NS		
S X M	1.05		NS			1.05		NS		

Table 3: Effect of inorganic fertilizers and humicacid on Phosphorous uptake (Kg/ha) of Foxtail millet at Panicle initiation stage

Sub Plots (Humic Acid)	*Kharif 2020*				Mean	*Kharif 2021*				Mean
	Main Plots (In-Organics)					**Main Plots (In-Organics)**				
	M_1	M_2	M_3	M_4		M_1	M_2	M_3	M_4	
S_1	5.362	5.895	6.826	7.572	6.414	6.016	6.614	7.659	8.496	7.196
S_2	5.416	6.612	12.294	13.641	9.491	6.415	7.832	14.562	16.158	11.242
S_3	6.306	7.042	13.163	14.261	10.193	7.469	8.342	15.591	16.892	12.074
S_4	5.448	6.020	6.895	7.646	6.502	6.112	6.754	7.736	19.564	10.042
S_5	5.585	6.728	12.492	13.831	9.659	6.615	7.969	14.797	16.383	11.441
S_6	6.546	7.374	13.403	15.000	10.581	7.753	19.049	15.876	17.767	15.111
Mean	5.777	6.612	10.845	11.992		6.730	9.327	12.704	15.877	
	SEm ±		**CD (p=0.05)**		**CV (%)**	**SEm ±**		**CD (p=0.05)**		**CV (%)**

M	0.047	1.143	8.3	0.034	3.212	8.4
S	0.311	0.934	7.9	0.041	1.122	8.2
M X S	0.008	NS		0.011	NS	
S X M	0.008	NS		0.011	NS	

Table 4: Effect of inorganic fertilizers and humic acid on Phosphorous uptake (Kg/ha) of Foxtail millet grain

Sub Plots (Humic Acid)	***Kharif 2020***				**Mean**	***Kharif 2021***				**Mean**
	Main Plots (In-Organics)					**Main Plots (In-Organics)**				
	M_1	M_2	M_3	M_4		M_1	M_2	M_3	M_4	
S_1	0.966	1.085	1.286	1.445	1.195	1.083	1.185	1.443	1.621	1.333
S_2	1.019	1.220	1.672	1.746	1.414	1.123	1.409	1.981	2.068	1.645
S_3	1.143	1.322	1.758	1.856	1.520	1.204	1.491	2.082	2.199	1.744
S_4	0.990	1.091	1.300	1.459	1.210	1.111	1.210	1.459	1.637	1.354
S_5	1.061	1.280	1.700	1.805	1.461	1.151	1.443	2.014	2.138	1.686
S_6	1.193	1.393	1.802	1.997	1.596	1.265	1.547	2.134	2.366	1.828
Mean	1.062	1.232	1.586	1.718		1.156	1.381	1.852	2.005	
	SEm ±		**CD (p=0.05)**		**CV (%)**	**SEm ±**		**CD (p=0.05)**		**CV (%)**
M	0.073		0.221		8.1	0.084		0.254		8.0
S	0.030		0.090		7.4	0.026		0.078		7.2
M X S	0.005		NS			0.012		NS		
S X M	0.006		NS			0.013		NS		

Table 5: Effect of inorganic fertilizers and humic acid on Phosphorousuptake (Kg/ha) of Foxtail millet straw

Sub Plots (Humic Acid)	***Kharif 2020***				**Mean**	***Kharif 2021***				**Mean**
	Main Plots (In-Organics)					**Main Plots (In-Organics)**				
	M_1	M_2	M_3	M_4		M_1	M_2	M_3	M_4	
S_1	0.831	0.934	1.108	1.244	1.029	0.933	1.048	1.243	1.395	1.155
S_2	1.033	1.237	1.696	1.770	1.434	0.934	1.132	2.009	2.097	1.543
S_3	1.159	1.341	1.782	1.882	1.541	1.028	1.202	2.111	2.230	1.643
S_4	0.852	0.939	1.119	1.257	1.042	0.961	1.054	1.256	1.410	1.170
S_5	1.076	1.297	1.724	1.830	1.482	0.976	1.163	2.042	2.168	1.587
S_6	1.209	1.413	1.827	2.025	1.619	1.092	1.270	2.164	2.399	1.731
Mean	1.027	1.193	1.543	1.668		0.987	1.145	1.804	1.950	
	SEm ±		**CD (p=0.05)**		**CV (%)**	**SEm ±**		**CD (p=0.05)**		**CV (%)**
M	0.081		0.237		8.4	0.187		0.562		8.5
S	0.032		0.098		7.7	0.031		0.092		7.8
M X S	0.04		NS			0.04		NS		
S X M	0.05		NS			0.05		NS		

Table 6: Effect of inorganic fertilizers and humicacid on Potassium uptake (Kg/ha) of Foxtail millet at Panicle initiation stage

Sub Plots (Humic Acid)	***Kharif 2020***				**Mean**	***Kharif 2021***				**Mean**
	Main Plots (In-Organics)					**Main Plots (In-Organics)**				
	M_1	M_2	M_3	M_4		M_1	M_2	M_3	M_4	
S_1	8.20	9.34	10.98	12.58	10.28	9.21	10.48	12.32	14.11	11.53
S_2	8.55	11.17	30.73	32.99	20.86	10.13	13.23	36.40	39.08	24.71
S_3	9.30	11.89	32.14	35.19	22.13	11.01	14.08	38.06	41.68	26.21
S_4	8.47	9.47	11.25	13.14	10.58	9.50	10.63	12.63	19.56	13.08
S_5	8.83	11.73	31.61	34.31	21.62	10.46	13.89	37.45	40.64	25.61
S_6	9.77	12.88	33.12	37.36	23.28	11.57	19.05	39.23	44.25	28.52
Mean	8.85	11.08	24.97	27.59		10.31	13.56	29.35	33.22	
	SEm ±		**CD (p=0.05)**		**CV (%)**	**SEm ±**		**CD (p=0.05)**		**CV (%)**
M	2.34		7.12		8.3	2.86		8.58		8.6
S	0.37		1.12		7.9	0.41		1.23		8.2
M X S	0.08		NS			0.11		NS		
S X M	0.08		NS			0.11		NS		

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