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Effect of Inorganic Fertilizers and Humic Acid on Soil Nutrients of Foxtail Millet Crop under Foxtail Millet-Bengal Gram Cropping System

Y S Satish Kumar, Ch Sujani Rao, P R K Prasad, K Jayalalitha, S Jaffar Basha and TVenkata Sridhar

Department of Soil cience and Agricultural Chemistry, Agricultural College, Bapatla, A. P.

ABSTRACT

A field experiment was conducted at the College Farm, Agricultural College, Mahanandi, Andhra Pradesh 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 available nutrient status of Nitrogen and Phosphorous were significantly increased with the increasing level of fertilizers from 0 (M_1) to 100 kg RDF ha^{-1} (M_4). Among humic acid levels, available N & P were recorded significantly highest in S_6 (20 kg ha^{-1}Humic acid as soil application + 0.2% foliar application of Humic acid) treatment and this was on par with S_3(20 kg ha^{-1}Humic acid as soil application alone) treatment at panicle initiation and at harvest stage of foxtail millet. The soil available Nitrogen and Phosphorous differed significantly due to inorganic fertilizer treatments and levels of humic acid, but not by their interaction during both the years of study. Application of inorganic fertilizers and humic acid levels showed non significant difference on soil potassium at panicle initiation and at harvest stage of foxtail millet.

Keywords: *Humic acid-Inorganic fertilizers-Nutrient availability studies-Foxtail millet-Bengalgram cropping system.*

To improve the organic contents of soils for growing crops, application of organic mineral fertilizers such as humic acid in agriculture has increased in recent years (Renner *et al*., 2007). Humic acid is heterogeneous in nature, which include in the same macromolecule, hydrophilic acidic functional groups and hydrophobic groups, thus increasing the water retention capacity in soils (Stevenson, 1994). Humates possess extremely high ion-exchange capacities, which allow them to hold cations in a way that makes them more easily available to plant roots and thus improve micronutrient transfer to the plants circulation system.

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 diseases, besides acting as the growth stimulant. They have indirect influence on plant growth because they can improve soil properties such as aggregation, aeration, permeability, water holding capacity, hormonal activity, microbial growth, organic matter mineralization and solubilisation and availability of micro nutrients (Fe, Zn and Mn) and some macro (K, Ca and P) nutrients (Sharif *et al*., 2002). Humic acid (HA) producers claim that 1 kg of HA is as much beneficial as 1 tonne of cattle manure because manure needs a lot of time for humidification, the form that can be utilized and assimilated by plants (Anonymous., 2012).

Foxtail millet (*Setaria italica* L.) contains significant levels of protein, fiber, mineral and phytochemicals. 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. As foxtail millet-bengalgram is an important cropping system in Scarce Rainfall zone of Andhra Pradesh, this experiment was conducted to generate more information on combined application of humic acid and inorganic fertilizers on soil nutrients status under foxtail millet-bengalgram cropping system.

MATERIAL AND METHODS

A field experiment was conducted at the college farm, Agricultural College, Mahanandi, Andhra Pradesh during *kharif & rabi* seasons of 2020-21 and 2021-22. The experimental site was geographically situated at 15.51^0 N latitude, 78.61^0 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.*, Control (M_1), 50 % RDF (M_2) , 75 % RDF (M_3) and 100% RDF (M_4) as main plots and six humic acid levels to foxtail millet crop comprising of No Humic acid application (S_1), 10 kg ha^{-1} Humic acid as soil application (S_2) , 20 kg Humic acid as soil application (S_3), 0.2% of foliar application of Humic acid (S_4), 10 kg ha^{-1}Humic acid as soil application + 0.2% foliar application of Humic acid (S_5) and 20 kg ha^{-1}Humic acid as soil application + 0.2% foliar application of Humic acid (S_6) as sub- plot treatments. These treatments were imposed to foxtail millet crop during *kharif* season and bengalgram crop during *rabi* season.

The 100% RDF for foxtail millet crop is 40:20:0 kg N, P_2O_5 and K_2O ha^{-1}. P fertiliser was applied as basal doses and half of the N was applied as basal and other half at 30 DAS. Humic acid was applied as basal as per treatments mentioned. Available nitrogen in soil was estimated by alkaline permanganate method using macro Kjeldahl distillation unit (Subbiah and Asija, 1956). Available phosphorus in the soil was extracted with 0.5 M $NaHCO_3$ buffered at pH 8.5 and the phosphorus in the extract was estimated by ascorbic acid method using spectrophotometer at 660 nm (Watanabe and Olsen, 1965). Available Potassium was extracted with neutral normal ammonium acetate and estimated with the help of flame photometer (Jackson, 1973).

RESULTS AND DISCUSSIN

Available Nitrogen

Data pertaining to available nitrogen of soil as influenced by different levels of inorganic fertilizers and humic acid is presented in tables 1 and 2. Perusal of the data revealed that available nitrogen in the soil differed significantly due to inorganic fertilizer treatments and levels of humic acid, but not by their interaction during both the years of study. At all the growth stages of foxtail millet, in main plots, significantly highest soil available nitrogen was recorded in 100% RDF (M_4-210, 195 and 216,209 kg ha^{-1}) However, this treatment was on par with the application of 75% RDF (M_3-204, 190 and 209, 203 kg ha^{-1}) during 2020 and 2021 at panicle initiation and harvest stages, respectively. The lower available nitrogen content was recorded in control (M_1-179, 173, 160 and 155 kg ha^{-1}). Among the sub plots (humic acid levels), significantly highest soil available N content was observed with 20 kg ha^{-1}Humic acid as soil application+ 0.2% foliar application (S_6-201, 189, and 209,203 kg ha^{-1}) in 2020 and 2021 at panicle initiation and harvest stages, respectively and this treatment was on par with the treatment 20 kg ha^{-1}Humic acid as soil application (S_3). Lower available Nitrogen content was observed in control (S_1- 192, 182 and 171, 165 kg ha^{-1}).

On application of humic acid combined with urea, it allows the controlled release of urea and provides continuity in supply of nitrogen. The increase in availability of nitrogen might be due to N contributed by native nitrogen by the increased microbial activities induced by HA. Independent application of urea could also suffer severe volatilization losses as ammonia not engaged by plants is quickly oxidized. This chemo litho autotrophic oxidation of ammonia to NO_2 is restricted by NH_3 availability. The increased N availability might be due to decreased number of nitrifying micro-organisms (Manjeera, 2020).

Available Phosphorus (P_2O_5)

Data pertaining to the soil available phosphorus (P) at all growth stages of foxtail millet is presented in the tables 3 and 4. The data revealed that available P in the soil differed significantly due to inorganic fertilizer treatments and levels of humic acid, but not by their interaction during both the years of study. At all growth stages of foxtail millet, among the main plots, significantly highest soil available Phosphorus was recorded in 100% RDF (M_4-31.28, 29.56 and 49.13,46.83 kg ha^{-1}) which was on par with the application of 75% RDF (M_3-30.33, 28.43 and 47.69, 45.08 kg ha^{-1}) during 2020 and 2021 at panicle initiation and harvest, respectively. Lower available Phosphorus content was recorded in control (M_1-18.68, 18.10 and 16.87,15.52 kg ha^{-1}). Yadav *et al*. (2012) reported similar trend and it is due to phosphor bacteria would have caused more mobilization and solubilisation of insoluble P in the soil and improved the availability of phosphorus which would have caused an increased uptake of phosphorus in plants.

Among the sub plots (humic acid levels), at all growth stages of foxtail millet, significantly highest soil available Phosphorus content was observed with 20 kg ha^{-1}Humic acid as soil application+ 0.2% foliar application (S_6-29.41, 27.54; 43.29 and 41.22 kg ha^{-1}) in 2020 and 2021, respectively and this treatment was on par with the treatment 20 kg ha^{-1}Humic acid as soil application (S_3) alone. Significantly lower available phosphorus content was observed in control (S_1-23.23, 22.65; 32.47 and 30.42 kg ha^{-1}). However, the soil available phosphorus was decreased with advancement of crop stage during both the years with the application of chemical fertilizers. This decrease in phosphorus might be due to absorption of P by the growing plants or due to refixation of solubilized phosphorus. Humic acid has the ability to reduce P fixation and solubilize insoluble

Table 1. Effect of Inorganics and humic acid on available nitrogen content (kg ha^{-1}) in soil at panicle initiation stage of Foxtail millet

Sub Plots (Humic Acid)	*Kharif*					*Kharif 2021*				
	Main Plots (Inorganics)				Mean	Main Plots (Inorganics)				Mean
	M_1	M_2	M_3	M_4		M_1	M_2	M_3	M_4	
S_1	175	191	199	201	192	155	169	176	183	171
S_2	179	194	202	212	197	159	205	224	231	205
S_3	182	197	204	214	200	163	208	226	231	207
S_4	176	191	200	202	192	156	173	177	181	172
S_5	180	194	208	212	199	160	206	224	231	205
S_6	183	198	209	215	201	164	209	226	237	209
Mean	179	194	204	210		160	195	209	216	
	SEm ±		CD (p=0.05)		CV (%)	SEm ±		CD (p=0.05)		CV (%)
M	2.8		8.3		7.9	2.8		8.6		8.2
S	0.6		1.7		6.7	0.6		1.8		6.8
M X S	1.5		NS			1.4		NS		
S X M	1.6		NS			1.7		NS		

Table 2. Effect of Inorganics and humic acid on available nitrogen content (kg ha^{-1}) in soil at harvest stage of Foxtail millet

Sub Plots (Humic Acid)	*Kharif 2020*					*Kharif 2021*				
	Main Plots (Inorganics)				Mean	Main Plots (Inorganics)				Mean
	M_1	M_2	M_3	M_4		M_1	M_2	M_3	M_4	
S_1	168	181	188	193	182	151	163	171	174	165
S_2	172	184	190	196	186	154	200	218	225	199
S_3	176	187	192	196	188	158	202	221	226	202
S_4	169	182	188	191	183	152	168	171	176	167
S_5	174	185	191	196	185	156	200	219	224	200
S_6	178	187	193	196	189	160	203	221	229	203
Mean	173	184	190	195		155	189	203	209	
	SEm ±		CD (p=0.05)		CV (%)	SEm ±		CD (p=0.05)		CV (%)
M	1.9		5.8		8	2.3		7.2		7.8
S	0.4		1.2		7.2	0.4		1.2		6.9
M X S	1.43		NS			1.4		NS		
S X M	1.22		NS			1.8		NS		

Table 3. Effect of inorganic fertilizers and humic acid on available phosphorus content (kg P_2O_5 ha^{-1}) in soil at panicle initiation stage of Foxtail millet

Sub Plots (Humic Acid)	*Kharif 2020*					*Kharif 2021*				
	Main Plots (Inorganics)				Mean	Main Plots (Inorganics)				Mean
	M_1	M_2	M_3	M_4		M_1	M_2	M_3	M_4	
S_1	18.50	23.28	24.88	26.25	23.23	16.48	35.43	37.92	40.06	32.47
S_2	18.60	25.48	30.25	32.54	26.72	16.98	39.25	47.32	51.20	38.69
S_3	18.70	28.54	33.77	34.65	28.92	16.99	44.43	53.28	54.77	42.37
S_4	18.60	23.84	25.05	26.52	23.50	16.51	36.30	38.19	40.48	32.87
S_5	18.80	26.88	33.88	32.88	28.11	17.08	37.16	55.53	52.62	40.60
S_6	18.90	29.75	34.12	34.85	29.41	17.18	46.48	53.88	55.64	43.29
Mean	18.68	26.30	30.33	31.28		16.87	39.84	47.69	49.13	
	SEm ±		CD (p=0.05)		CV (%)	SEm ±		CD (p=0.05)		CV (%)
M	1.24		3.88		7.7	1.45		5.17		7.5
S	0.45		1.25		6.1	0.68		2.05		6.8
M X S	0.85		NS			0.9		NS		
S X M	0.69		NS			0.72		NS		

Table 4. Effect of inorganic fertilizers and humic acid on available phosphorus content (kg P_2O_5 ha^{-1}) in soil at harvesting stage of Foxtail millet

Sub Plots (Humic Acid)	*Kharif 2020*					*Kharif 2021*				
	Main Plots (In-Organics)				Mean	Main Plots (In-Organics)				Mean
	M_1	M_2	M_3	M_4		M_1	M_2	M_3	M_4	
S_1	17.92	22.70	24.30	25.67	22.65	15.16	33.13	35.62	37.76	30.42
S_2	18.02	23.18	27.95	30.24	24.85	15.62	36.95	45.02	48.90	36.62
S_3	18.12	26.24	31.47	32.35	27.05	15.63	42.13	50.98	52.47	40.30
S_4	18.02	23.26	24.47	25.94	22.92	15.19	34.00	35.89	38.18	30.81
S_5	18.22	24.58	30.54	30.58	25.98	15.72	34.86	51.40	50.32	38.07
S_6	18.32	27.45	31.82	32.55	27.54	15.80	44.18	51.58	53.34	41.22
Mean	18.10	24.57	28.43	29.56		15.52	37.54	45.08	46.83	
	SEm ±		CD (p=0.05)		CV (%)	SEm ±		CD (p=0.05)		CV (%)
M	0.81		2.56		6.8	1.35		4.05		7.1
S	0.48		1.45		6.3	0.74		2.15		6.2
M X S	0.86		NS			0.88		NS		
S X M	0.71		NS			0.71		NS		

Table 5. Effect of inorganic fertilizers and humic acid on available potassium status (kg K_2O ha^{-1}) in soil at panicle initiation stage of Foxtail millet

Sub Plots (Humic Acid)	*Kharif 2020*					*Kharif 2021*				
	Main Plots (Inorganics)				Mean	Main Plots (Inorganics)				Mean
	M_1	M_2	M_3	M_4		M_1	M_2	M_3	M_4	
S_1	580	581	581	581	581	530	530	531	532	531
S_2	580	585	585	587	584	531	535	535	536	534
S_3	580	584	584	587	584	531	534	534	536	534
S_4	580	584	583	585	583	530	534	533	535	533
S_5	580	583	582	584	582	531	533	533	535	533
S_6	581	582	590	583	584	531	533	540	534	534
Mean	580	583	584	585		531	533	534	535	
	SEm ±		CD (p=0.05)		CV (%)	SEm ±		CD (p=0.05)		CV (%)
M	0.42		NS		7.4	0.66		NS		7.5
S	0.91		NS		6.3	0.89		NS		6.5
M X S	0.54		NS			0.58		NS		
S X M	0.44		NS			0.42		NS		

Table 6. Effect of inorganic fertilizers and humic acid on available potassium (kg K_2O ha^{-1}) in soil at harvest stage of Foxtail millet crop

Sub Plots (Humic Acid)	*Kharif 2020*					*Kharif 2021*				
	Main Plots (Inorganics)				Mean	Main Plots (Inorganics)				Mean
	M_1	M_2	M_3	M_4		M_1	M_2	M_3	M_4	
S_1	551	551	552	552	552	520	520	520	521	520
S_2	551	556	556	557	555	520	524	524	526	523
S_3	551	555	555	557	555	520	523	523	526	523
S_4	551	555	554	556	554	520	523	522	525	522
S_5	551	553	553	555	553	520	522	522	524	522
S_6	551	553	561	554	555	520	522	529	523	524
Mean	551	554	555	555		520	522	523	524	
	SEm ±		CD (p=0.05)		CV (%)	SEm ±		CD (p=0.05)		CV (%)
M	1.12		NS		6.8	1.08		NS		6.3
S	1.15		NS		6.5	1.03		NS		6.1
M X S	1.02		NS			1.02		NS		
S X M	1.05		NS			1.08		NS		

P compounds and hence increases the P concentration in soil. Application of humic acid increases the phosphatase activity in soil. Phosphatase enzyme which is responsible for hydrolysis of phosphate esters into inorganic phosphorus might have contributed to increased P availability in the soil. Similar results were reported by Kumar and Singh (2017).

Available Potassium (K_2O)

The data pertaining to available soil potassium as influenced by different levels of inorganic fertilizers and humic acid is presented in table 5 and 6. Perusal of the data revealed that, different levels of inorganic fertilizers and humic acid applied in *kharif* have not shown any significant effect on available soil potassium at panicle initiation and harvest stages of foxtail millet crop and during both the years of study. Among the different levels of fertilizer doses, the minimum available soil potassium (580, 551 in 2020 and 531, 520 kg ha^{-1} in 2021 at panicle initiation and at harvest stages, respectively) was recorded in the main plot where no fertilizers were applied (Control or 0% RDF), and maximum available soil potassium (584, 555 in 2020 and 534 and 524 kg ha^{-1} in 2021) was recorded in the main plot that received 100% RDF (M_4).

Available soil potassium was increased with the application of different doses of humic acid levels during both the years of study but these differences were not statistically significant. The mean values pertaining to available soil potassium by applying levels of humic acid ranged from 580-584, 551-554 kg ha^{-1} in 2020, whereas in 2021 it ranged from 530-534 and 520-523 kg ha^{-1} at panicle initiation and harvest stages, respectively. The minimum available soil potassium values were recorded in Control (S_1**).** Increase in soil available potassium may be contributed due to the reduced K fixation as well as release of fixed K by humic acid. The humic compounds are capable of penetrating the inter-micellar spaces of clays and reach the specific sorption sites for K^+ ions where they might compete for sites with K and increase in K availability in soil (Bharath and Madhavi 2015). Sathiyabama (2002) reported that there is a significant increase in $KMnO_4$-N (240 kg ha^{-1}), Olsen-P (18.2 kg ha^{-1}) and NH_4OAc-K (799 kg ha^{-1}) due to soil application of humic acid @ 30kg ha^{-1} combined with 100% RDF.

CONCLUSION

The available nutrient status of Nitrogen and Phosphhorous were significantly increased with the increasing level of fertilizers from 0 (M_1) to 100 kg RDF ha^{-1} (M_4). Among humic acid levels, available N & P were recorded significantly highest in S_6 (20 kg ha^{-1}Humic acid as soil application + 0.2% foliar application of Humic acid) and this treatment was on par with S_3 (20 kg ha^{-1}Humic acid as soil application alone). The soil differed significantly due to inorganic fertilizer treatments and levels of humic acid, but not by their interaction during both the years of study. Results pertaining to soil available potassium, revealed that different levels of inorganic fertilizers and humic acid applied in *kharif* have not shown any significant effect on available soil potassium at panicle initiation and harvest stages of foxtail millet crop during both the years of study.

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