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Characterization, Extraction and Foliar Spray of Fortified Humic Acid on Quality of Capsicum

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A B S T R A C T

The experiment was undertaken to study the Characterization, extraction and foliar spray of fortified humic acid on quality of capsicum. The results showed that, the humic acid extracted from the poultry manure was acidic in pH, low in EC and higher content oftotal carbon, hydrogen, N/C and O/C ratios. Whereas the coffee pulp showed acidic pH, low EC and higher content of nitrogen, oxygen and H/C ratio. The results of the field experiment revealed that significantly higher content of quality parameters viz., total soluble solids (6.44 ^{o}Brix) and ascorbic acid (140.64 mg 100 g^{-1}) were recorded in the treatment receiving RDF + FYM applied to soil and 3 foliar sprays of zinc fortified humic acid extracted from poultry manure @0.50% compared to control (only RDF + FYM).

Introduction

Modern day soils have been over-cropped, abused and depleted of organic matter and certain essential elements. Modern day agricultural practices greatly increase the rate of utilization and destruction of humic material. Any changes in natural conditions will result in changes in humus content of the soil. Some of these changes are irrigation, drainage, deforestation, frequent tillage and intensive cultivation of crops. All these changes lead to a rapid and marked change of the humus balance of the soil. The integrated use of organic manures and inorganic fertilizers not only increases the efficiency but can help in the substitution of chemical fertilizers. The use of HA is a promising natural resource to be utilized as an alternative for increasing crop production.

It is a naturally occurring polymeric-heterocyclic organic compound with carboxylic ($COOH^-$), phenolic (OH^-), alcoholic and carbonyl fractions extracted from various sources such as lignite, peat, coal, farmyard manure and coir pith besides natural persistence in soil (Sharif *et al.*, 2006).

The organic waste materials mainly of animal and plant origin are potential source of organic matter and plant nutrients. Nowadays, humic acid is extracted on a large scale from various sources and their exact composition varies from one source to another. The benefits derived from the utilization of these organic materials range from improvement of soil fertility to a reliable means of waste disposal. Among them poultry manure, coffee pulp and press mud etc., are the main sources to extract humic acid.

As a result of energy crisis and associated detrimental effects on soil health and environmental problems, there is a renewed interest in the organic manures all over the world which forms the basis of sustainable agriculture. One of such potential residues likely to get importance in Indian agriculture is poultry manure which is a valuable resource of plant nutrition. Although poultry manure is a nitrogen rich material and of economically important as nutrient source and energy source. Coffee pulp is a rich source of nutrient containing about 2.05 per cent N, 0.56 per cent P and 2.56 per cent K in composted pulp. The use of this as organic material helps to improve soil properties thus increasing yield and it also helps to reduce the need to buy inorganic fertilizers, thus saving the farmers money (Preethu *et al.,* 2007). Therefore, considering the above facts, we have studied the Characterization, extraction and foliar spray of fortified humic acid on quality of capsicum

Materials and Methods

Characterization of manures (Poultry manure and coffee pulp) and humic acid

The samples were analysed for pH, EC, total nitrogen, phosphorus, potassium, sodium, calcium, magnesium, micronutrients (Zn, Cu, Fe, Mn and B) and heavy metal contents (Table 1).

Extraction of humic substances

The ten gram of air dried sample was taken in 250 ml conical flask to which 100 ml 0.1 N NaOH was added, stoppered and shaken for 24 hours using end to end shaker. The dark coloured supernatant was separated by centrifugation and collected. The extraction was repeated thrice with 50 ml of extractant for complete extraction of the humic substances (Schnitzer and Skinner, 1968).

Fractionation and purification of humic acid

The precipitated humic acid fraction was separated by centrifugation. Precipitation and centrifugation were repeated to attain partial purification of humic acid fraction as described by Stevenson (1981). The fractions were further purified by treating with HCI-HF mixture (5ml of each HCI and HF acids were dissolved in 990 ml of double distilled water) for 24 hours and this acid mixture was separated by centrifugation. The residue obtained was thoroughly washed with distilled water.

Characterization of humic acid extracted from poultry manure and coffee pulp

The humic acid was analysed pH, electrical conductivity, total phosphorus, potassium, calcium, magnesium, micronutrients (Zn, Cu, Fe, Mn and B) and heavy metal contents (Table 2). The carbon, hydrogen, sulphur, oxygen and nitrogen were analysed by using CHNS analyser (Table 3).

Fortification and preparation of humic acid for foliar application

Humic acid extracted from poultry manure and coffee pulp was fortified with zinc @ 50 ppm using zinc sulphate and boron @ 25 ppm using borax. The foliar spray solutions were prepared by dissolving calculated quantities

of humic acid, zinc sulphate and borax in water and sprayed to the respective plots at different intervals. The three foliar sprays were given at 15 days interval starting from 45 days after transplanting.

Quality parameters

Total soluble solids (^{o}Brix) content

A drop of capsicum fruit juice was used to determine the TSS with the help of hand refractometer and the value was recorded as ^{o}Brix at room temperature.

Ascorbic acid (mg 100g^{-1}) content

The ascorbic acid content was estimated titrimetrically using 2, 6 Dichlorophenol indo phenol dye as per modified procedure AOAC (1997). The result was expressed as mg of ascorbic acid per 100 g of fruit juice (Srivastava and Singh, 1993).

Statistical analysis and interpretation of data

The analyses and interpretation of the data was done using the Fisher's method of analysis and variance technique as given by Panse and Sukhatme (1967). The level of significance used in 'F' and 't' test was 5 per cent probability.

Results and Discussion

Characterization of organic waste materials viz., poultry manure and coffee pulp

The data on the characteristics of organic waste materials like poultry manure and coffee pulpare presented in the Table 1. The analysis of the samples revealed that the poultry manure was alkaline (pH 8.32). Electrical conductivity was medium (1.26 dS m^{-1}). Bulk density was low (0.57 g m^{-3}), water holding capacity was 40.05 per cent and total organic carbon content was 22.29 per cent. This is mainly because of higher surface area and porosity. Similar results were reported by Devi *et al.,* (2012). The poultry manure was rich in nitrogen (2.85 %) and the total P, K, Ca, Mg and sulphur contents were 1.56, 1.69, 2.89, 1.23 and 0.50 per cent respectively which could be supported by the results of Mohamed *et al.,* (2010). The total Fe, Mn, Cu, Zn and B contents were 4850, 541.3, 66.00, 276.0 and 300.0 mg kg^{-1} respectively. Hence it can be considered as a good source of all the essential elements. It also contained some quantity of heavy metals like Cr and Ni to an extent of 19.23 and 27.89 mg kg^{-1}, respectively, but Pb and Cd were not detected.

The coffee pulp was slightly alkaline (7.78), electrical conductivity was 1.89 dS m ^{1}, the bulk density was low 0.53 g m^{-3}, water holding capacity was 40.86 per cent and the total organic carbon content was 33.36 per cent. The total N, P, K, Ca, Mg and sulphur contents were 2.01, 0.52, 1.56, 2.44, 1.65 and 0.41 per cent, respectively (Table 1). The total Fe, Mn, Cu, Zn and B contents of coffee pulp were found to be 2870.0, 480.7, 63.50, 225.0 and 185.5 mg kg^{-1}. Similar results were obtained by Kasongo *et al.,* (2011) and according to them, the nutrient content of coffee pulp acts as an alternative to fertilizer with beneficial effect in improving soil properties and supply of sufficient nutrients for adequate growth and development of plants. It also contained some quantity of heavy metals likeCr and Ni to an extent of 25.03 and 30.19 mg kg^{-1}, respectively, but Pb and Cd were not detected in the samples.

Characterization of humic acid extracted from poultry manure and coffee pulp

The analysis of the samples revealed that the humic acid extracted from poultry manure

was acidic in reaction (pH 5.89) and electrical conductivity was low (0.32 dS m^{-1}). The concentration of nitrogen, phosphorus, potassium, calcium, magnesium and sulphur were 6.01, 0.71, 0.25, 0.18, 0.029 and 1.92 per cent, respectively. The average concentration of iron, manganese, copper, zinc and boron were 7354.5, 492.3, 90.0, 78.5 and 220 mg kg^{-1}, respectively (Table 2).

It also contained some quantity of heavy metals likeCr and Ni to an extent of 12.00 and 13.3 mg kg^{-1}, respectively, but Pb and Cd were not detected. Jindo *et al.,* (2012) opined that humic acid extracted from different sources contains all the nutrients and hence can be used as organic manure.

The humic acid extracted from coffee pulp was acidic in reaction (pH 5.46) and had low EC (0.11 d Sm^{-1}). The concentration of nitrogen, phosphorus, potassium, calcium, magnesium and sulphur were 5.07, 0.48, 0.11, 0.10, 0.08 and 1.74 per cent, respectively. The average concentration of iron, manganese, copper, zinc and boron were 5645.0, 395.8, 78.5, 78.5 and 165 mg kg^{-1}, respectively. It also contained some quantity of total heavy metals like Cr and Ni to an extent of 5.70 and 10.0 mg kg^{-1}, respectively, but Pb and Cd were not detected in the samples (Table 2). Similar observations were made by Satishkumar (1997) and Herviyanti *et al.,* (2010) with respect to humic acid extracted from lignite and rice straw compost.

Table.1 Physical and chemical properties of poultry manure and coffee pulp

Parameters	Organic wastes	
	Poultry manure	**Coffee pulp**
pH (1:5)	8.32	7.78
EC(dS m^{-1})	1.26	1.89
Organic carbon (%)	22.29	33.36
Bulk density (g m^{-3})	0.57	0.53
Maximum Water holding capacity (%)	40.05	40.86
Total N (%)	2.85	2.01
Total P (%)	1.56	0.52
Total K (%)	1.69	1.56
Total Ca (%)	2.89	2.44
Total Mg (%)	1.23	1.65
Total S (%)	0.50	0.41
Total Fe (mg kg^{-1})	4850.00	2870.00
Total Cu (mg kg^{-1})	66.00	63.50
Total Mn (mg kg^{-1})	541.30	480.70
Total Zn (mg kg^{-1})	276.00	225.0
Total B (mg kg^{-1})	300.00	182.5
Total Cr (mg kg^{-1})	19.23	25.03
Total Ni (mg kg^{-1})	27.89	30.19
Total Pb (mg kg^{-1})	**BDL**	**BDL**
Total Cd (mg kg^{-1})	**BDL**	**BDL**

Note: BDL – Below Detectable Limit

Table.2 Chemical properties of humic acid extracted from poultry manure and coffee pulp

Parameters	Sources of humic acid	
	Poultry manure	Coffee pulp
pH	5.89	5.46
EC(d Sm^{-1})	0.32	0.11
Total N (%)	6.01	5.07
Total P (%)	0.71	0.48
Total K (%)	0.25	0.11
Total Ca (%)	0.18	0.10
Total Mg (%)	0.029	0.08
Total S (%)	1.92	1.74
Total Fe (mg kg^{-1})	7354.5	5645.0
Total Cu (mg kg^{-1})	90.0	78.50
Total Mn (mg kg^{-1})	492.30	395.80
Total Zn (mg kg^{-1})	95.0	78.50
Total B (mg kg^{-1})	220.0	165.0
Total Cr (mg kg^{-1})	12.0	5.70
Total Ni (mg kg^{-1})	13.30	10.0
Total Pb (mg kg^{-1})	**BDL**	**BDL**
Total Cd (mg kg^{-1})	**BDL**	**BDL**

Note: BDL – Below Detectable Limit

Table.3 Elemental composition and molar ratios of humic acid (HA) extracted from coffee pulp and poultry manure

Sources	Contents of elements (%)				Molar ratios of elements		
	C	N	H	O	H/C	N/C	O/C
Poultry manure	45.06	6.01	4.08	44.85	0.090	0.133	0.995
Coffee pulp	47.1	5.07	4.40	43.43	0.093	0.110	0.922

Table.4 Effect of RDF applied to soil and foliar spray of fortified humic acid on quality parameters of capsicum at 90 DAT

Treatments	Quality parameters	
	TSS (^{0}Brix)	Ascorbic acid mg 100 g^{-1}
T_1 - RDF (150:100:150 kg NPK ha^{-1}) + FYM (25 t ha^{-1})	4.03	123.43
T_2 -T_1 + FS of unfortified HA extracted from PM @ 0.25 %	5.05	130.18
T_3 - T_1 + FS of unfortified HA extracted from PM @ 0.50 %	5.73	137.94
T_4 - T_1 + FS of unfortified HA extracted from CP @ 0.25 %	4.72	128.58
T_5 - T_1 + FS of unfortified HA extracted from CP @ 0.50 %	5.32	135.19
T_6 - T_1 + FS of zinc fortified HA extracted from PM @ 0.25 %	5.99	133.88
T_7 - T_1 + FS of zinc fortified HA extracted from PM @ 0.50 %	6.44	140.64
T_8 - T_1 + FS of zinc fortified HA extracted from CP @ 0.25 %	5.53	132.58
T_9 - T_1 + FS of zinc fortified HA extracted from CP @ 0.50 %	6.32	138.65
T_{10} -T_1 + FS of boron fortified HA extracted from PM @ 0.25 %	5.08	133.68
T_{11} - T_1 + FS of boron fortified HA extracted from PM @ 0.50 %	6.12	139.07
T_{12} - T_1 + FS of boron fortified HA extracted from CP @ 0.25 %	4.92	131.47
T_{13} - T_1 + FS of boron fortified HA extracted from CP @ 0.50 %	5.59	136.98
T_{14} - T_1 + FS of 50 ppm zinc solution only	4.69	127.05
T_{15} - T_1 + FS of 25 ppm boron solution only	4.48	126.32
T_{16} - T_1 + FS of 50 ppm zinc and 25 ppm boron solution	4.73	128.99
S. Em±	**0.13**	**0.64**
C. D. at 5%	**0.39**	**1.91**

Note: FS-foliar spray HA-humic acid PM-poultry manure CP-coffee pulp

Elemental composition and molar ratios of humic acid

The humic acid extracted from coffee pulp had higher in carbon and hydrogen (47.1 and 4.40 %). Whereas poultry manure has higher content of nitrogen and oxygen (6.01 and 44.85 %). Riffaldi *et al.,* (1983) reported that higher content of C, H, N and O in humic acid extracted from FYM. Similar results were reported by Ushashree *et al.,* (1989), Gurunathan and Kaliyaperumal (1989) and Satisha and Devarajan (2011) for the humic acid extracted from different sources.

The humic acid extracted from poultry manure has higher molar ratios viz., N/C and O/C (0.133 and 0.995) where as higher H/C ratio (0.09) was recorded in humic acid extracted from coffee pulp and it also recorded lower molar ratios viz., N/C and O/C of, 0.11 and 0.992 per cent (Table 3). Similar results were obtained by Chandrasekaran (1992) and Jindo *et al.,* (2012). According to them, the N/C and O/Cratios were considerably high for the humic acid compared to fulvic acid extracted from lignite and sewage sludge.

Quality parameters

Ascorbic acid (mg 100 g^{-1})

The higher ascorbic acid content of capsicum was observed in T_7 (140.64 mg 100 g^{-1}) which received RDF + FYM + + foliar spray of zinc fortified humic acid extracted from poultry manure at 0.50 per cent (Table 4) and it was on par with the treatment T_{11} (139.07 mg 100 g^{-1}) receiving RDF + FYM + foliar spray of boron fortified humic acid extracted from poultry manure at 0.50 per cent.

However, lower ascorbic acid content was recorded in T_1 (123.43 mg 100 g^{-1}) treatment receiving only RDF + FYM. Since humic acid contains all the essential elements, upon foliar application along with RDF increases the vegetative growth of capsicum and thus enhanced nutrients uptake that resulted in increased assimilation rate and there by fruit quality has been enhanced.

Total soluble sugar (TSS – ^{0}Brix)

The maximum TSS content was recorded with T_7 (6.44 ^{0}Brix) receiving RDF + FYM + foliar spray of zinc fortified humic acid extracted from poultry manure at 0.50 per cent followed by T_9 (6.32) receiving RDF + FYM + foliar spray of zinc fortified humic acid extracted from coffee pulp at 0.50 per cent, T_{11} (6.12) receiving RDF + FYM + foliar spray of boron fortified humic acid extracted from poultry manure at 0.50 per cent and T_6 (5.99) receiving RDF + FYM + foliar spray of zinc fortified humic acid extracted from poultry manure at 0.25 per cent (Table 4).

Whereas the minimum total sugar was recorded with T_1 (4.03 ^{0}Brix) with the application of only RDF + FYM. The increase in qualitative parameters is mainly due to increased carbohydrates production during photosynthesis and increased activity of enzymes. These findings were similar that of Shahmaleki *et al.,* (2014) for tomato, Ferrara *et al.,* (2012) for grapes and Yildirim *et al.,* (2006).

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