Response of Potassium Humate Extracted from Different Organic Sources on Yield and Quality of Green Chilli

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ABSTRAT

Aim -: In recent trend of organic farming, use of humic substances plays important role, as it act as biostimulants to boost the yield of crop. Humic substances can be easily obtained by locally available organic sources. Hence, three different organic sources *viz.* Farm Yard Manure (FYM), vermicompost, lignite were characterized for their physico-chemical properties and quality parameters along with nutrients to judge their quality and maturity to extract humic substances. The potassium salt of humic acid extracted from these three sources were used as foliar application at different concentrations to study their effects on yield and quality of green chilli.

Study Design-: The pot culture experiment was conducted in Completely Randomized Design comprising eleven treatments with three replications.

Place and Duration of the Study-: The experiment was conducted in *rabi* season 2021-22 at College of Agriculture, Karad, Maharashtra, India.

Methodology-: Three organic sources *viz.* Farm Yard Manure *(*FYM), vermicompost and lignite were used to extract humic substances (humic and fulvic acid). These organic sources were studied for their physico-chemical properties and quality parameters along with their nutrient status to compare their quality and maturity for extraction of humic substances. Humic substances obtained from these different sources were studied for their content and characteristics. The potassium humate extracted from these organic sources were used in a pot culture study on green chilli, comprising eleven treatments and three replications. The different levels of potassium humate (200 to 600 ppm) were used as foliar application on transplanted chilli at 30 and 45 days after transplanting (DAT) along with recommended dose of fertilizers (GRDF) for studying its effects on yield and quality of green chilli.

Results -: Among all the three organic sources, vermicompost was reported as the best organic source to extract humic substances from its physico-chemical properties *viz.* pH (6.9), EC (0.3 dS m^{-1}), water soluble organic carbon (0.76 %) and C:N ratio (18.0), which are considered as quality and maturity parameters to obtain good quality humic substances. Nutrient status for macro and micronutrients were reported to be higher in vermicompost followed by FYM and least content in lignite. In the pot culture experiment, the foliar application of potassium humate extracted from vermicompost resulted in significant improvement in fresh and dry yield of chilli fruit and stalk as compared to potassium humate application extracted from FYM and lignite. Among the various concentrations used (200-600 ppm) for the foliar application of potassium humate, application @ 400 ppm extracted from vermicompost along with GRDF (T_7) was reported as the best treatment resulting in significantly increase in the fresh and dry yield of chilli fruits and stalk. Further, it was noticed that the same treatment was observed to be effective in significant improvement of the ascorbic acid content as quality parameter in fresh green chilli fruits.

Key words: Organic sources, potassium humate, green chilli, yield and quality

1. INTRODUCTION

Humic substances comprised of the largest fraction of soil organic matter [1] which are most biologically active component of soil. Humic acid possess phytoharmones like activities which are beneficial to both soil and plants [2]. Humic substances are excellent foliar fertilizer carrier and activators. Foliar application of humic acid are more economic because smaller quantities are required to obtain significant plant response and are rapidly absorbed by plant leaves. Actively growing plant tissues are more responsive to the foliar application of humic substances. Humic acid as carrier of nutrient uptake have great scope through foliar application for sustainable crop production. The polymerization and condensation of humic substances are associated with good quality organic sources. Hence, three organic sources *viz.*FYM, vermicompost and lignite were tested for their quality and maturity by comparing the physico-chemical properties and quality parameters as per the standard quality parameters for the extraction of good quality humic substances. Nutritive value of these sources for macro and micronutrients as well as humic substances extracted from them were also characterized in the present study. Further, the potassium humate extracted from these organic sources were used as foliar sprays in different concentrations (200-600 ppm) at 30 and 45 days after transplanting on yield and quality of green chilli along with GRDF in the pot culture experiment.

2. MATERIALS AND METHODS

2.1 Extraction of potassium humate from different organic sources

Fractionation of humic substances from FYM, vermicompost and lignite were worked out by treating 10 g air dried samples with 50 ml 0.5 M KOH solution. After centrifugation, the dark-coloured supernatant was decanted and filtered through glass wool. The upper supernatant brown liquid i.e., potassium fulvate and the dark-coloured precipitate of potassium humate were separated, dried on hot water bath, as per the modified method [3, 4]. The powder of potassium humate obtained from FYM, vermicompost and lignite were further utilized for preparation of 1000 ppm stock solution.

2.2 Characterization of organic sources for their physico-chemical properties, quality parameters and nutrient status

The organic sources used for the extraction of potassium humate were studied for their physico-chemical and quality parameters to judge their quality to extract humic substance by following standard methods of analysis for determination of pH, EC, C/N ratio and water soluble organic carbon, [5] chemical properties *viz.* total organic carbon [6] and nutrients content.

2.3 Content and characteristics of humic substances extracted from organic sources

The humic substances extracted from these organic sources were characterized for the content of humic and fulvic acid, E_4/E_6 ratio [7] and HA/FA ratio.

2.4 Treatments and Pot culture experimental procedure

The pots were filled with Inceptisol soil collected from College of Agriculture Farm, Karad. Initial soil properties were determined by following standard methods of soil analysis. The pots were filled with 20 kg soil along with general recommended dose of fertilizers (GRDF : FYM 20 t ha^{-1} + $N:P_2O_5:K_2O$ - 100:50:50 kg ha^{-1}) to all treatments except absolute control. The experiment was conducted at College of Agriculture, Karad, which comprised of eleven treatments (Table 1) with three replications in Completely Randomized Design (CRD) during *rabi* season 2021-22. The one month age chilli seedlings were transplanted in the pots keeping two healthy plants per pot. Treatment wise concentrations of potassium humate extracted from different organic sources were used for first foliar spray at 30 days after transplanting (DAT) and second foliar spray at 45 DAT. The water spray applied at 30 and 45 days to the treatment T_2.

Table 1. Treatment details

Tr. No.	Treatment details
T_1	Absolute control (No GRDF + No spray)
T_2	GRDF + Water sprays
T_3	GRDF + 200 ppm potassium humate as foliar spray extracted from FYM
T_4	GRDF + 400 ppm potassium humate as foliar spray extracted from FYM
T_5	GRDF + 600 ppm potassium humate as foliar spray extracted from FYM
T_6	GRDF + 200 ppm potassium humate as foliar spray extracted from vermicompost
T_7	GRDF + 400 ppm potassium humate as foliar spray extracted from vermicompost
T_8	GRDF + 600 ppm potassium humate as foliar spray extracted from vermicompost
T_9	GRDF + 200 ppm potassium humate as foliar spray extracted from lignite
T_{10}	GRDF + 400 ppm potassium humate as foliar spray extracted from lignite
T_{11}	GRDF + 600 ppm potassium humate as foliar spray extracted from lignite

Note : i) GRDF - (20 t ha^{-1} FYM + 100:50:50 kg ha^{-1} N: P_2O_5: K_2O)

ii) Two sprays at 30 and 45 days after transplanting

2.5 Data collection

2.5.1 Physico chemical properties and quality parameters of organic sources

Three organic sources used for the extraction of humic substances were analyzed for their physico chemical properties and quality parameters *viz.* pH, EC, water soluble organic carbon and C:N ratio.

2.5.2 Nutrient status of organic sources

The nutrient content of organic sources used to extract potassium humate was also studied and the data were recorded.

2.5.3 Content and characteristics of humic substances extracted from organic sources

The content and characteristics of humic substances obtained from these three organic sources *viz.* FYM, vermicompost and lignite were recorded.

2.5.4 Yield of fresh green and dry chilli fruits

Fresh green chilli fruits harvested for six times were used to determine yield of green chilli fruits (g pot^{-1}). After complete drying of these fruits, yield of dry chilli fruits were recorded.

2.5.5 Fresh and dry straw yield of chilli

After harvesting of fresh fruits of green chilli at last picking, plants were cut at ground level, straw samples were used to record fresh and dry straw weight.

2.5.6 Quality in respect of ascorbic acid content

After harvesting of fruits, sample from each treatment were used to estimate ascorbic acid by using standard method [8].

2.6 Data analysis

The data regarding fresh and dry fruit yield, fresh and dry stalk yield and ascorbic acid content were tabulated and analyzed statistically by applying standard method [9].

3. RESULTS AND DISCUSSION

3.1 Physico chemical properties and quality parameters of organic sources

Three organic sources *viz.* FYM, vermicompost and lignite collected from different locality were analyzed for different physico-chemical properties and quality parameters to study their quality and degree of maturity for extraction of humic substances. The data presented in Table 2 revealed that the FYM recorded the good quality and maturity for pH (7.4), EC (0.4 dS m^{-1}) and water soluble organic carbon (0.95%) but found poor for C:N ratio (25.06) indicated less formation of humic substances. The vermicompost recorded good quality and maturity parameters in respect of pH (6.9), EC (0.3 dS m^{-1}), water soluble organic carbon (0.76 %) and C:N ratio (18.0), while, most widely used organic source as lignite for extraction of humic substances showed poor quality for C:N ratio (39.80%) and pH (5.6) with good quality for the properties like EC (0.68 dS m^{-1}) and water soluble organic carbon (0.43 %) content. The quality parameters of organic manures to extract good quality humic substances reviewed [10] the critical limits investigated by different scientist for judging the good quality of organic manures reported that the pH of good quality organic manures must be between 6.5 to 8, C/N ratio must be less than 20.0. [11] While, the electrical conductivity of good quality manures must be less than 1.5 dS m^{-1} [12]. However, the results recorded in present investigation are in conformity with the results of [13].

Table 2. Physico-chemical properties and quality parameters of organic sources

Sr. No.	Properties	FYM	Vermicompost	Lignite
1	pH (1:10) *	7.4	6.9	5.6
2	EC (dS m^{-1}) * (1:10)	0.4	0.31	0.68
3	Moisture content (%)	29.4	22.6	14.6
4	Ash (%)	35.6	33.33	33.24
5	Total organic carbon (%)	20.3	25.56	30.25
6	Total organic matter (%)	35.00	44.07	52.16
7	Water soluble organic carbon (%) *	0.95	0.76	0.43
8	C/N ratio *	25.06	18	39.80
9	C/P ratio	101.5	28.08	-

10	C/S ratio	61.51	7.26	15.59

***** **(**Standard Quality parameter properties [11])

3.2 Nutrient status of organic sources

These organic sources were analyzed for nutrient status for macro and micronutrients content and data presented in Table 3 reported that the higher content of macro and micronutrients were noticed for vermicompost followed by FYM and least content in lignite, indicated more mineralization of vermicompost than the FYM and lignite. In vermicompost the percent content of total N, P, K, S to the tune of 1.42, 0.91, 1.27, 0.38 and micronutrient cations *viz.* Fe, Mn, Zn and Cu were 2804, 800, 246 and 188 mg kg^{-1}, respectively. Similar trend of nutrients content was also observed in FYM. While, in lignite total N and total S was observed as 0.76 and 1.94 percent, respectively but the total P and total K content was in traces and micronutrient cations content were also low as compared to vermicompost and FYM. High nutritive value of vermicompost compare to FYM regarding macro and micronutrient content were reported by [14, 15]. Similar trend of observations regarding nutrient content was reported in respect of FYM [13], which might be associated with composition of residue and climatic condition with time.

Table 3. Nutrient status of Organic sources

S.N.	Nutrients content	FYM	Vermicompost	Lignite
1	**Macronutrients (%)**			
i)	Total N	0.81	1.42	0.76
ii)	Total P	0.2	0.91	Traces
iii)	Total K	0.98	1.27	Traces
iv)	Total S	0.33	0.38	1.94
2	**Micronutrients (mg kg^{-1})**			
i)	Iron	2200	2804	1058
ii)	Manganese	765	800	632
iii)	Zinc	214	246	118

iv)	Copper	157	188	98

3.3 Content and characteristics of humic substances extracted from organic sources

The data pertaining to humic acid and fulvic acid in the form of potassium humate and potassium fulvate by using 0.5 M KOH solution extracted from FYM, vermicompost and lignite are presented in Table 4, revealed that highest humic acid (54.27 g100 g^{-1} OM) extracted from lignite followed by vermicompost (13.20 g100 g^{-1} OM) and least by FYM (11.48 g100 g^{-1} OM) while, fulvic acid content (27.62 g100 g^{-1} OM) found highest due to lignite followed by FYM (21.10 g100 g^{-1} OM) and least in vermicompost (18.70 g100 g^{-1}OM), indicated high degree of humification and polymerization in lignite than the vermicompost and FYM leads the formation of high molecular weight humic substances [13, 16]. While, in respect to vermicompost and FYM the extraction of humic substances were quite low up to 30 percent. High humic acid content (73.26 per cent) in lignite coal as compared to FYM (18.48 per cent), the recovery of HA from lignite was more as compared to that from FYM with higher E_4/E_6 ratio of 5.01 was recorded by [16]. However, humic acid (HA) extracted from vermicompost is significantly superior over the HA from FYM. Higher recovery per cent (5.20), E_4/E_6 ratio (4.73), total organic carbon- 360.80 g Kg^{-1}, C/N ratio- 13.14 with total macro and micronutrients was reported by [17] in their study.

Table 4. Content and characteristics of humic substances extracted from Organic sources

1.	**Humic substances (g 100g^{-1} OM)**	**FYM**	**Vermicompost**	**Lignite**
A	Humic acid (HA)	11.48	13.20	54.27
B	Fulvic acid (FA)	21.10	18.70	27.62
C	HA/FA ratio	0.54	0.70	1.96
2.	**E_4/E_6 ratio**			
A	Humic acid	3.17	4.61	5.10
B	Fulvic acid	5.72	6.21	6.33

The HA/FA ratio found higher (>1.0) in lignite (1.96) than vermicompost (0.70) and FYM (0.54), but the content of HA+FA found approximately similar in FYM (32.58 g100 g^{-1} OM) and in vermicompost (31.90 g100 g^{-1} OM). The E_4/E_6 (Extinction coefficient) is the important characteristics of humic substances associated with molecular weight and degree of humification. The humic acid extracted from FYM, vermicompost and lignite recorded E_4/E_6 as 3.17, 4.61 and 5.10, respectively indicated that during humification FYM and vermicompost form high molecular weight substances and was aromatic in nature. While, the humic acid formed in lignite might be low molecular weight compound and aliphatic in nature. While, the fulvic acid formed under FYM, vermicompost and lignite were low molecular weight aliphatic compounds because all organic sources showed E_4/E_6 ratio >5. The results are in conformity with results reported by [13, 15, 16, 17].

3.4 Initial soil fertility status of the soil used for pot culture experiment

The soil used for pot culture experiment was slightly alkaline (pH-7.7), medium in organic carbon content (0.62%), calcareous in nature (5.5 %). The available N, P and K content of the soil was low (200.7 kg ha^{-1}), medium (17.7 kg ha^{-1}) and very high (560.4 kg ha^{-1}) respectively. The soil was sufficiently supplied with DTPA extractable Fe (6.8 mg kg^{-1}), Mn (12.2 mg kg^{-1}), Zn (1.12 mg kg^{-1}) and Cu (2.8 mg kg^{-1}). Similar observations for Inceptisol soil were recorded at college of Agriculture, Karad [18] in earlier study.

3.5 Effect of foliar application of potassium humate extracted from different organic sources on yield of fresh green and dry chilli fruits

The foliar application of different concentration of potassium humate (200-600 ppm) extracted from FYM, vermicompost and lignite along with GRDF significantly improved the fresh green chilli fruit yield (74.78 to 94.75 g $plant^{-1}$) as compared to the GRDF + water sprays (T_2) (68.22 g $plant^{-1}$) and absolute control (T_1) (66.65 g $plant^{-1}$) (Table 5). Among the different sources used for extraction of potassium humate, the foliar application of 400 ppm potassium humate extracted from vermicompost along with GRDF (T_7) resulted in significantly highest yield of fresh green chilli fruits (94.75 g plant^{-1}) over the rest of the concentrations of the potassium humate extracted either from FYM, vermicompost and lignite except treatment T_8 (90.19 g plant^{-1}), which found statistically at par with treatment T_7. Similar trend of observation in respect to dry green chilli fruits were also recorded due to same treatments (Table 5). The results obtained might be because of the positive effect of humic substances on plant metabolism and growth [19]. The studies conducted at different locations [13, 20, 21, 22] reported that foliar spray of humic acid increased the yield of chilli.

3.6 Effect of foliar application of potassium humate extracted from different organic sources on yield of fresh and dry stalk yield of chilli

The application of different levels of potassium humate (200-600 ppm) extracted from FYM, vermicompost and lignite along with GRDF significantly improved the fresh stalk yield of chilli (121.60 – 157.36 g plant^{-1}) as compared to the GRDF + water sprays (T_2) (112.23 g plant^{-1}) and absolute control (T_1) (109.13 g plant^{-1}) (Table 5). Among the different sources the foliar application of potassium humate @400 ppm extracted from vermicompost along with GRDF (T_7) noticed significantly highest (157.36 g plant^{-1}) fresh stalk yield as compared to the potassium humate extracted from FYM and lignite, but found at par with treatment T_8 (GRDF + 600 ppm potassium humate as foliar spray extracted from vermicompost) (153.13 g plant^{-1}) as

Table 5. Effect of foliar application of potassium humate extracted from different organic sources on yield and quality of green chilli

Tr. No.	Treatment	Yield (g plant^{-1})				Quality aspect ascorbic acid content (mg 100 g^{-1})
		Green fruit		Stalk		
		Fresh	Dry	Fresh	Dry	
T_1	Absolute control (No GRDF + No spray)	66.65	13.42	109.13	27.34	76.0
T_2	GRDF + Water sprays	68.22	14.26	112.23	29.36	80.0
T_3	GRDF + 200 ppm potassium humate as foliar spray	88.11	18.03	146.91	38.64	96.0

	extracted from FYM					
T_4	GRDF + 400 ppm potassium humate as foliar spray extracted from FYM	83.95	16.85	128.27	33.27	96.0
T_5	GRDF + 600 ppm potassium humate as foliar spray extracted from FYM	78.80	16.93	124.98	32.76	92.0
T_6	GRDF + 200 ppm potassium humate as foliar spray extracted from vermicompost	86.97	18.43	145.43	36.31	100.0
T_7	GRDF + 400 ppm potassium humate as foliar spray extracted from vermicompost	94.75	20.21	157.36	43.62	112.0
T_8	GRDF + 600 ppm potassium humate as foliar spray extracted from vermicompost	90.19	19.88	153.13	42.93	104.0
T_9	GRDF + 200 ppm potassium humate as foliar spray extracted from lignite	74.78	15.67	121.60	31.60	84.0
T_{10}	GRDF + 400 ppm potassium humate as foliar spray extracted from lignite	85.12	17.54	130.30	33.35	88.0
T_{11}	GRDF + 600 ppm potassium humate as foliar spray extracted from lignite	84.12	17.85	136.17	34.16	84.0
	S.E. $\pm$	1.89	0.47	2.98	0.68	4.35
	C.D. at 5%	5.55	1.39	8.75	2.01	2.75

compared to GRDF + water sprays (T_2) and absolute control (T_1).

3.7 Effect of foliar application of potassium humate extracted from different organic sources on quality in respect of ascorbic acid content in fresh green chilli fruits

The foliar application of potassium humate at various concentrations (200-600 ppm) extracted from FYM, vermicompost and lignite along with GRDF significantly increased ascorbic acid content (mg 100 g^{-1} green fruit) over the GRDF + water spray (T_2) and absolute control; (T_1) (Table 5). The significantly highest (112.0 mg 100 g^{-1}) content of ascorbic acid noticed under treatment T_7, applied with two sprays of potassium humate @ 400 ppm with GRDF but found at par with treatments T_6 and T_8 applied with two sprays of potassium humate @ 200 ppm and

600 ppm extracted from vermicompost with GRDF, but at higher concentrations of potassium humate (600 ppm) the content of ascorbic acid declined, might be associated with effect on physiological activity during synthesis of ascorbic acid. The good quality of vermicompost enriched with biostimulants is helpful for enhancing the physiological activity at the site of cell.

The quality and maturity of organic sources play important role in degree of humification and polymerization of humic substances. As the vermicompost found to be good quality associated with high nutrient status, resulted in positive impact on absorption of nutrients than the poor quality of FYM and lignite for one or more quality parameters. These results are in conformity with the results reported for FYM [16, 23], lignite [24] and vermicompost [15].

4. CONCLUSION

Among the three organic sources used for extraction of humic substances, vermicompost was reported as best source to extract good quality humic substances by judging its physico-chemical properties and quality parameters as well as nutrient status as compared to FYM and lignite. Further, two foliar application of potassium humate @ 400 ppm extracted from good quality vermicompost along with GRDF significantly increased yield of green chilli fruits and ascorbic acid content (vitamin C) over the potassium humate extracted either from FYM and lignite having poor quality for one or more quality parameters as well as GRDF + water spray and absolute control treatment under pot culture condition. These studies need to be confirmed by further elaborate investigation under field condition.

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