Original Research Article

Response of Potassium Humate 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.* FYM, vermicompost, lignite were used for extraction of potassium salt of humic acid. The potassium humate 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-: Completely Randomized Design with eleven treatments and three replications.

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

Methodology-: Three organic sources *viz.* FYM, vermicompost and lignite were used for extraction of potassium salt of humic acid, with studying the physico-chemical quality parameters of organic sources and characteristics of humic substances namely humic acid and fulvic acid for HA/FA ratio and E_4/E_6 ratio. The pot culture experiment was conducted comprising eleven treatments for the different levels of potassium humate (200 to 600 ppm), extracted from three sources and imposed on transplanted chilli for studying the yield and quality of green chilli, as foliar application at 30 and 45 DAT of chilli with general recommended dose of fertilizer (GRDF).

Results -: Among all three sources, the foliar application of potassium humate extracted from good quality vermicompost significantly increased the growth contributing

Comment [TE1]: It is better to write down the abbreviation for the first time mentioned

characters, fresh and dry yield of chilli fruits and stalk yield, as well as significantly improved the ascorbic acid content in fresh green chilli fruits as compared to other concentrations of potassium humate extracted from FYM and lignite. This might be associated with degree of condensation of humic acid, status of aromacity of the structure of humic acid reflected in higher absorption through foliage of chilli.

Comment [TE2]: An abstract should explain the state of the art, research objectives, research parameters, and conclusions of research results in a structured but concise manner, usually 250 - 300 words. The structure of the abstract written is still not systematic.

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]. Application of humic acid within fairly wide range of concentrations are highly beneficial to plant shoot and root development. They 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 studied for their physico chemical properties and quality parameters to extract the humic acid in the form of salt of potassium humate. Considering today's importance of organic sources, their effect as foliar sprays of potassium humate at 30 and 45 days after transplanting on yields and quality as content of ascorbic acid in green chilli fruits were studied.

Comment [TE3]: The introduction section does not show the state of the art of research clearly, what other research has been done and the research gaps.

2. MATERIALS AND METHODS

2.1 Extraction of potassium humate from different organic sources

Fractionation of humic substances from three organic sources *viz.* FYM, vermicompost and lignite were worked out by using 0.5 M KOH solution, by following modified method [3, 4].

Comment [TE4]: The method explanation in this section does not finish explaining the 'modified method'.

2.2 Characterization of humic substances

Potassium salt of humic substances obtained from these three organic sources were analyzed for different physio-chemical quality parameters like pH, EC, C/N ratio, water soluble organic carbon and chemical properties *viz.* total organic carbon, total N, P, K, S and micronutrient cations (Fe, Mn, Zn, Cu), content of HA and FA, E_4/E_6 ratio of HA and FA, HA/FA ratio by adopting standard methods.

Comment [TE5]: Clarify the intended standard method.

2.3 Treatments and Pot culture experimental procedure

The Inceptisol soil collected from College of Agriculture Farm, Karad was used for pot culture study and was analyzed for initial soil properties by following standard method of analysis. The pots were filled with 20 kg soil and general recommended dose of fertilizers (GRDF : FYM @ 20 t ha^{-1} + N:P_2O_5:K_2O @ 100:50:50 kg ha^{-1}) were applied to all treatments except absolute control. The study comprised of eleven treatments (Table 1) with three replications. The one month age chilli seedlings were transplanted in the pots keeping two plants in pots with Completely Randomized Design (CRD) at College of Agriculture, Karad during *rabi* season. 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.

Comment [TE6]: The method explanation in this section is confusing because it uses many unexplained abbreviations and symbol (@) in sentence.

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

2.4 Data collection

2.4.1 Physico chemical properties and quality parameters of organic sources

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

2.4.2 Nutrient status of organic sources

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

2.4.3 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.

2.4.4 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.

2.4.5 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.

2.4.6 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 [5].

2.5 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 [6].

3. RESULTS AND DISCUSSION

3.1 Physico chemical properties and quality parameters of organic sources

Comment [TE7]: The discussion in section 3.1 does not provide an analysis of the recorded results, while section 3.2 has an analysis but is less comprehensive.

Three organic sources *viz.* FYM, vermicompost and lignite collected from different locality were used for extraction of humic substances, analyzed for different physico chemical properties and quality parameters for degree of maturity (Table 2), The physico-chemical properties *viz.* pH, EC, water soluble organic carbon and C:N ratio considered as quality and

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 [7]).

maturity parameters, these parameters were reported and also reviewed by [8] and compared with data reported for these organic sources which reflected the amount of extraction of humic substances. The FYM showed 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) while good quality for the properties like EC (0.68 dS m^{-1}) and water soluble organic carbon (0.43 %) content. [7, 9, 10] reported similar results for FYM and vermicompost.

3.2 Nutrient status of organic sources

The three organic sources were analyzed for nutrient status as macro and micronutrients content and data presented in Table 3 reported that the higher content of all nutrients 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 organic sources (Table 3). Similar

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

trends of observations in respect of lignite, FYM and vermicompost was also reported by [11, 12, 8] might be associated with composition of residue and climatic condition with time.

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, 11]. While, in respect to vermicompost and FYM the extraction of humic substances were quite low up to 30 percent. These results are in conformity with the findings [1, 12].

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 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 >5 E_4/E_6 ratio. The results are in conformity with results reported by [11, 12, 13, 14].

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}).

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

Comment [TE8]: The conclusions in section 3.5 should be further deepened regarding increasing yield.

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 application of 400 ppm potassium humate as foliar sprays 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. The positive effect of humic substances on plant metabolism and growth [15]. The studies conducted [9, 16, 17, 18] at different locations 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

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 extracted from FYM	88.11	18.03	146.91	38.64	96.0
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	84.12	17.85	136.17	34.16	84.0

	humate as foliar spray extracted from lignite					
	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

The application of different levels of potassium humate (0-600 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 compared to GRDF + water sprays (T_2) and absolute control (T_1). Similar trend of observations were noticed in respect of dry stalk yield of chilli (Table 5).

Comment [TE9]: Section 3.6 should provide more analysis than the observations shown in the table.

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 (200-600 ppm) extracted from FYM, vermicompost and lignite along with RDF 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 potassium humate extracted from FYM and lignite found beneficial for increasing ascorbic acid as compared to treatment (T_2) GRDF + water spray and treatment (T_1) absolute control.

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 [13] for FYM, [11] for lignite, while [19] for FYM and [12] for vermicompost.

4. CONCLUSION

The foliar application of potassium humate @ 400 ppm for two times, extracted from good quality vermicompost significantly increased yield of green chilli fruits and ascorbic acid content (vitamin C) over the potassium humate extracted from FYM and lignite having poor quality for one more quality parameters as well as GRDF + water spray and absolute control under pot culture condition.

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