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Effect of foliar application of humic acid on yield parameters and quality of chilli

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Abstract
An experiment was carried out to study the "Effect of foliar application of humic acid on yield parameters and quality of chilli" during *kharif* 2020-21 at Research Farm, Chili and Vegetable Research Unit, Dr. PDKV, Akola. The experiment had eight treatments replicated thrice in Randomized block design. The treatments included: T_1 -Absolute control, T_2 - 100% RDF (100:50:50 kg N, P_2O_5 and K_2O ha^{-1}), T_3, T_4 & T_5 -100% RDF +3 spray of HA @ 0.5, 1.0 and 1.5% respectively, T_6, T_7 & T_8 -100% RDF +6 spray of HA @ 0.5, 1.0 and 1.5% respectively. Among all the treatments T_8 (100% RDF + 6 spray humic acid @ 1.5%) treatment was found most effective treatment and recorded significantly maximum yield parameters and chlorophyll content of chilli. However, ascorbic acid content, capsaicin content, soil available nutrients and micro nutrients showed no significant change in response to humic acid treatment.

Keywords: Chilli, humic acid (HA), chlorophyll, capsaicin, available nutrients

Introduction
Chilli (*Capsicum annum* L.) belonging to Solanaceae family is one of the major commercial crops of India, which is grown largely for its fruits all over the country. The origin of chilli is Central America. It is widely used in the manufacture of curry powder, curry paste and all kinds of pickles and preparing soups and salads. It is considered as an important source of nutrients, vitamin A and C as well as phenolic compounds, which are important antioxidants in human diet (Litoriya *et al.*, 2014) [1]. The presence of an alkaloid "capsaicin" in chilli is responsible for its pungency and has significant physiological action is used in many pharmaceutical preparations like ointments for cold, sore throat, chest congestion etc. In Maharashtra, chilli is cultivated in an area of 0.30 lakh hectares with production of 3.42 lakh tonnes and productivity of 2124 kg per hectare (Anon., 2020) [2]. Humic substances is formed through the chemical and biological humification of plant and animal matter by the biological activities of microorganisms. Humic acid application along with recommended dose of fertilizers and organic manures plays a greater role in plant biochemical and physiological activities and soil fertility, consequently resulting in better growth and yield of crops (Kalaichelvi *et al.*, 2006) [3]. Humic acid attracts positive ions, forms chelates with micronutrients and releases them slowly when require by plants and act as chelating agents there by prevents formation of precipitation, fixation, leaching and oxidation of micronutrients in soil. Humic substances with its auxin activity induce hormonal effect on catalytic activity, cell permeability and increases nutrient uptake and dry matter yield (Eshwar *et al.*, 2017) [4]. Humic acids as carrier of nutrients have great scope through foliar application for sustainable crop production.

Material and Methods
The experiment was carried out at Research farm, Chilli and Vegetable Research unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *kharif* season in 2020-21. The trial was laid out in Randomized Block Design with three replications. The experiment was framed with eight treatments *viz*, T_1 -Absolute control, T_2 - 100% RDF (100:50:50 kg N, P_2O_5 and K_2O ha^{-1}), T_3, T_4 & T_5 -100% RDF +3 spray of HA @ 0.5, 1.0 and 1.5% respectively, T_6, T_7 & T_8 -100% RDF +6 spray of HA @ 0.5, 1.0 and 1.5% respectively were laid out in plots of 6.00 m x 3.60 m. The soil of the experimental field was slightly alkaline in reaction (pH 8.03), non-saline (0.30 dS m^{-1}), medium in organic carbon (6.5 g kg^{-1}), low in available N (184.54 kg ha^{-1}), moderately high in available P_2O_5 (22.42 kg ha^{-1}), high in available K_2O (288.56 kg ha^{-1}) and deficient in available S (7.26 mg kg^{-1}). Among the micronutrients Zinc (0.65 mg kg^{-1}), Iron (4.79 mg kg^{-1}), Manganese (13.26 mg kg^{-1}) and Copper (1.64 mg kg^{-1}) are in sufficient range.

Healthy seeds of PDKV Hirkani variety selected for sowing. Seedlings of chilli were transplanted to the plots with polythene mulch with 60 cm × 60 cm spacing. The desired plant population was maintained uniformly by gap filling. Recommended fertilizer dose of 100:50:50 kg N, P and K ha^{-1} were applied through urea, single super phosphate and murate of potash respectively as fertigation in 30 equal splits. Humic acid source used in experiment was prepared from vermicompost at Dr. PDKV soil science and agricultural chemistry laboratory. Spraying of HA with different concentrations include first spray at flowering, second spray at first fruit setting, third spray at 15 days after 1st picking, fourth spray at 15 days after 2nd picking, fifth spray at 15 days after 3rd picking, sixth spray at 15 days after 4th picking. Data on yield parameters *viz*. fruit weight per plant, fruit length and fruit width were recorded from randomly selected ten fruits of each tagged plant of each treatment in each replication and further analyzed. Chlorophyll content was recorded on standing crop in the field with the help of SPAD chlorophyll meter (Arnon, 1949) [5]. Twenty fruits per plot were collected randomly as sub-samples for quality assessment. Dried fruit samples were homogenized in a blender and portions of the homogenate were taken to determine the capsaicin content and ascorbic acid content by adopting standard methods. The capsaicin content was estimated by colorimetrically using a spectrophotometer at 650 nm (Quagliottil, 1971) [6]. The ascorbic acid content was determined volumetrically by reducing 2,6-dichlorophenol indophenol dye, and expressed in mg per 100g fruits (AOAC., 1984) [7]. The composite soil sample from 0 to 15 cm depth was collected from the experimental area before land preparation using standard methods. Five plants were selected randomly in the net plot area and labelled for recording observations in each treatment. After harvesting of the crop, surface soil sample (0-15 cm) were collected from all the plots treatment wise. The soil samples were air dried ground and passed through 2 mm sieve for analysis of physico-chemical properties following standard protocol as pH, EC (dS m^{-1}) by Jackson (1973) [8], organic carbon (g kg^{-1}) by Nelson and Sommers (1982) [9], available N (kg ha^{-1}) by Subbiah and Asija (1956) [10], available P_2O_5 (kg ha^{-1}) by Watanabe and Olsen (1965) [11], available K_2O (kg ha^{-1}) by Jackson (1973) [8], available S (mg kg^{-1}) by Cheshin and Yien (1973) [12]. Fe, Zn, Mn and Cu were estimated by the method of Lindsay and Norvell (1978) [13]. The data obtained from the experiment were analyzed for analysis of variance (ANOVA) and the difference between treatment means was tested for their statistical significance with appropriate critical difference (CD) at 5% level of probability (Gomez and Gomez, 1984) [14].

Result and discussion

Yield parameters

Significantly highest fruit weight per plant (327 gm) was recorded in treatment T_8 (100% RDF + 6 sprays of HA @ 1.5%), which was found statistically at par with treatments T_6 and T_7. While, significantly lowest fruit weight per plant was recorded in T_1 (Absolute control) i.e. 295 gm (Table 1). The increase in fruit weight per plant in response to humic acid might be due to enhanced plant growth, plant canopy due to which plant can intercept light in a good way and as a result fruit weight of plant increased (Kasperbauer, 1987) [15]. Similar findings were also reported by Yildirim (2007) [16] in tomato and El-Nemr *et al*. (2016) [17] in cucumber. Significantly, highest fruit length (12.00 cm) was recorded in treatment T_8 (100% RDF +6 spray of HA @ 1.5%), which was found statistically at par with the treatments T_3, T_4, T_5, T_6 and T_7. While, significantly lowest fruit length was recorded in T_1 (Absolute control) i.e. 8.15 cm (Table 1). It might be due to the hormone-like activity of humic acids i.e. auxin, gibberellin and cytokinin like activity (Ferrara and Brunetti, 2008) [18]. Similar findings were also reported by Ibrahim *et al.* (2019) [19] in red sweet pepper and El-Sayed *et al*. (2019) [20] in sweet pepper. Significantly highest fruit width (0.86 cm) was recorded in treatment T_5 (100% RDF + 3 spray of HA @1.5%) and T_8 (100% RDF + 6 spray of HA @1.5%) which was found statistically at par with treatments T_4 T_5, T_6 and T_7. While, significantly lowest fruit width was recorded in T_1 (Absolute control) i.e. 0.56 cm (Table 1). The application of humic acid significantly increased the rate of photosynthesis, root development and plant nutrients content of the plant and thus increased the fruit weight and width (Liu *et al*., 1998) [21]. Similar findings were also reported by Yildirim (2007) [16] in tomato and Unlu *et al*. (2011) [22] in cucumber.

Quality parameters

Significantly highest chlorophyll content (51.95 mg g^{-1}) was recorded in treatment T_8 (100% RDF+ 6 spray of HA @ 1.5%) which was found statistically at par with all the humic acid spray treatments. While, significantly lowest chlorophyll content was recorded in T_1 (Absolute control) i.e. 37.10 mg g^{-1} (Table 1). The increased leaf chlorophyll content by the foliar application of humic acid might be due to the acceleration of N and NO_3 uptake, enhancing N metabolism and production of protein by humic acid that ultimately increase Chlorophyll contents (Haghighi *et al*., 2012) [23]. Similar findings were also reported by Thakur *et al*. (2018) [24] in sunflower, Dawood *et al.* (2018) [25] in faba bean, and Kakakurt *et al*. (2009) [26] in pepper. The ascorbic acid content was numerically increased with the application of varying levels of humic acid. However, statistically ascorbic acid content was found non- significant. The highest ascorbic acid content (142.50 mg 100^{-1}g) was recorded in the treatment T_8 (100% RDF+ 6 spray of HA @ 1.5%). While, lowest ascorbic acid content was recorded in T_1 (Absolute control) i.e. 125.20 mg 100^{-1}g (Table 1). It might be due to humic acid increase the permeability of bio membranes for electrolytes accounted for increased uptake of phosphorus and potassium which increase the ascorbic acid percentage of the fruit (Reuther, 1973) [27]. Similar findings were also reported by Barzegar *et al*. (2016) [28] in okra, shahmaleki *et al*. (2014) [29] in tomato and Agharifard *et al*. (2016) [30] in strawberry. The capsaicin content was numerically increased with the application of varying levels of humic acid. However, statistically capsaicin content was found non- significant. Highest capsaicin content (1.24%) was recorded in the treatment T_8 (100% RDF + 6 spray of HA @ 1.5%). Lowest capsaicin content was recorded in T_1 (Absolute control) i.e. 1.19% (Table 1). These results are in harmony with those noticed by Aminifard *et al*. (2012) [31] who stated that capsaicin content was affected by nutritional fertility and increased by humic acid application. Similar result was also reported by Wang *et al*. (2010) [32].

Soil chemical properties

The application of various levels of humic acid did not have significantly influenced the soil pH. Lowest pH was recorded in T_6 (100% RDF + 6 spray of HA@ 0.5%) i.e. 8.01 (Table 2). The electrical conductivity of soil was found to be non-significantly influenced by foliar application of humic acid. The marginal increase in electrical conductivity might be due to accumulation of soluble salts at the surface where fertilizers were applied alone. Lowest EC was recorded in T_1 (Absolute control) i.e. 0.26 dS m^{-1} (Table 2). The data pertaining to the organic carbon content of soil as influenced by different treatments was statistically non-significant. However, the highest organic carbon (6.00 g kg^{-1}) was recorded in the treatment T_8 (100% RDF + 6 spray of HA @ 1.5%). Lowest organic carbon was recorded in T_1 (Absolute control) i.e. 5.30 g kg^{-1} (Table 2).

Soil available nutrients

Available nitrogen content was numerically increased with the application of varying levels of humic acid. However, statistically available nitrogen status of soil after the harvest of chilli was found non-significant. The highest available nitrogen content was recorded in the treatment T_6 (100% RDF + 6 spray of HA @ 0.5%). The lowest status of available nitrogen (186.08 kg ha^{-1}) was recorded in T_1 (Table 3). Available phosphorus content was numerically increased with the application of varying levels of humic acid. However, statistically available phosphorus status of soil after the harvest of chilli was found non-significant. The highest available phosphorus content (27.69 kg ha^{-1}) was recorded in the treatment T_2 (100% RDF). The lowest status of available phosphorus (20.78 kg ha^{-1}) was recorded in T_1 (Table 3). Available potassium content was numerically increased with the application of varying levels of humic acid. However, statistically available potassium status of soil after the harvest of chilli was found non-significant. The highest available potassium content (305.54 kg ha^{-1}) was recorded in the treatment T_6 (100% RDF + 6 spray of HA @ 0.5%). The lowest status of available potassium (284.74 kg ha^{-1}) was recorded in T_1 (Table 3). Available sulphur content was numerically increased with the application of varying levels of humic acid. However, statistically available sulphur status of soil after the harvest of chilli was found non-significant. The highest available sulphur content (10.26 mg kg^{-1}) was recorded in the treatment T_4 (100% RDF + 3 spray of HA @ 1.0%). The lowest status of available sulphur (8.24 mg kg^{-1}) was recorded in T_1 (Table 3).

Available zinc content was numerically increased with the application of varying levels of humic acid. However, statistically available zinc status of soil after the harvest of chilli was found non-significant. The highest available zinc content (0.69 mg kg^{-1}) was recorded in the treatment T_7 (100% RDF + 6 spray of HA @ 1.0%). The lowest status of available zinc (0.65 mg kg^{-1}) was recorded in T_1 (Table 3). Available iron content was numerically increased with the application of varying levels of humic acid. However, statistically available iron status of soil after the harvest of chilli was found non-significant. The highest available iron content (4.82 kg^{-1}) was recorded in the treatment T_5 (100% RDF + 3 spray of HA @ 1.5%). The lowest status of available iron (4.78 mg kg^{-1}) was recorded in T_1 (Table 3). Available copper content was numerically increased with the application of varying levels of humic acid. However, statistically available copper status of soil after the harvest of chilli was found non-significant. The highest available copper content (1.69 mg kg^{-1}) was recorded in the treatment T_2, T_4, T_6, T_7 and T_8. The lowest status of available copper (1.67 mg kg^{-1}) was recorded in T_1 (Table 3). Available manganese content was numerically increased with the application of varying levels of humic acid. However, statistically available manganese status of soil after the harvest of chilli was found non-significant. The highest available manganese content (13.28 mg kg^{-1}) was recorded in the treatment T_3, T_4, T_5, T_6, T_7 and T_8. The lowest status of available manganese (13.26 mg kg^{-1}) was recorded in T_1 (Table 3).

Table 1: Effect of foliar application of humic acid on yield parameters and quality parameters of chilli

Tr	Treatments	Yield parameters			Quality parameters		
		Fruit weight/plant (g)	Fruit length (cm)	Fruit width (cm)	Chlorophyll (mg g^{-1})	Ascorbic acid (mg 100 g^{-1})	Capsaicin (%)
T_1	Absolute Control	295.00	8.15	0.56	37.10	125.20	1.19
T_2	100% RDF (100:50:50 kg N, P_2O_5 and K_2O ha^{-1})	305.00	9.60	0.63	41.73	129.02	1.20
T_3	100% RDF +3spray of HA @ 0.5%	307.00	11.50	0.70	46.68	139.78	1.21
T_4	100% RDF +3spray of HA @ 1.0%	308.00	11.60	0.80	50.63	139.20	1.22
T_5	100% RDF +3 Spray of HA @ 1.5%	311.00	11.65	0.86	51.59	142.50	1.22
T_6	100% RDF +6 spray of HA @ 0.5%	319.00	11.68	0.81	51.85	141.17	1.21
T_7	100% RDF +6 spray of HA @ 1.0%	325.00	11.70	0.85	51.90	141.27	1.22
T_8	100% RDF +6 spray of HA @ 1.5%	327.00	12.00	0.86	51.95	142.50	1.24
SE (m) ±		4.07	0.762	0.030	2.46	4.75	0.013
CD@ 5%		12.28	2.301	0.091	7.46	NS	NS

*RDF (Recommended doses of fertilizers), HA (Humic Acid), NS (Not Significant)

Table 2: Effect of foliar application of humic acid on soil chemical properties

Tr	Treatment Details	Soil properties		
		pH	EC (dS m^{-1})	Organic Carbon (g kg^{-1})
T_1	Absolute Control	8.04	0.26	5.30
T_2	100% RDF (100:50:50 kg N, P_2O_5 and K_2O ha^{-1})	8.07	0.28	5.60
T_3	100% RDF +3 spray of HA @ 0.5%	8.07	0.29	5.83
T_4	100% RDF +3spray of HA @ 1.0%	8.07	0.30	5.73
T_5	100% RDF +3 spray of HA @ 1.5%	8.03	0.28	5.80
T_6	100% RDF +6 spray of HA @ 0.5%	8.01	0.30	5.73
T_7	100% RDF +6 spray of HA @ 1.0%	8.05	0.30	5.77
T_8	100% RDF +6 spray of HA @ 1.5%	8.14	0.28	6.00
SE (m) ±		0.027	0.009	0.13
CD@ 5%		NS	NS	NS

*RDF (Recommended doses of fertilizers), HA (Humic Acid), NS (Not Significant)

Table 3: Effect of foliar application of humic acid on soil available nutrients and soil available micronutrients after harvest of the chilli crop

Tr	Treatments	Soil available nutrients				Soil available micronutrients			
		N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	S (mg kg^{-1})	Zn (mg kg^{-1})	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Cu (mg kg^{-1})
T_1	Absolute Control	186.08	20.78	284.74	8.24	0.65	4.78	1.67	13.26
T_2	100% RDF (100:50:50 kg N, P_2O_5 and K_2O ha^{-1})	201.43	27.69	302.12	9.59	0.66	4.81	1.69	13.27
T_3	100% RDF +3spray of HA @ 0.5%	204.25	26.66	299.96	10.09	0.67	4.81	1.68	13.28
T_4	100% RDF +3spray of HA @ 1.0%	206.12	26.51	303.19	10.26	0.68	4.81	1.69	13.28
T_5	100% RDF +3 Spray of HA @ 1.5%	204.28	26.34	304.04	9.53	0.67	4.82	1.68	13.28
T_6	100% RDF +6 spray of HA @ 0.5%	206.22	25.70	305.54	9.29	0.68	4.81	1.69	13.28
T_7	100% RDF +6 spray of HA @ 1.0%	205.91	25.59	305.10	9.25	0.69	4.80	1.69	13.28
T_8	100% RDF +6 spray of HA @ 1.5%	205.54	25.38	303.58	9.18	0.67	4.79	1.69	13.28
SE (m) ±		4.94	1.29	4.44	0.43	0.008	0.0093	0.007	0.009
CD@ 5%		NS	NS	NS	NS	NS	NS	NS	NS

*RDF (Recommended doses of fertilizers), HA (Humic Acid), NS (Not Significant)

Conclusion

Based on the findings of the above investigation it may be concluded that foliar application of 6 spray humic acid @ 1.5% with 100% RDF was found beneficial and enhanced the yield parameters and chlorophyll content of chilli under climatic conditions of Akola.

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