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Short communication

Fertilizer-use efficiency, nutrient uptake and water requirement of capsicum under fertigation in open field conditions

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ABSTRACT

Three experiments were conducted on capsicum during 2012-2014 at Dr YS Parmar University of Horticulture & Forestry, Solan, Himachal Pradesh, wherein four fertigation levels were tried. The experiment comprising eight treatment combinations in randomized block design was replicated four times. Humic acid significantly increased plant height (9%), leaf area index (10%), nutrient uptake, fruit yield (8%) and fertilizer-use efficiency (29%) over control. Fruit quality was also significantly influenced by humic acid application. Interaction of fertigation and humic acid was statistically significant. Further, crop response was comparable between combined fertigation with 80 percent recommended dose and fertigation with 100 percent recommended dose with and without humic acid. It is therefore concluded that the efficacy of fertigation can further be increased by humic substances.

Key words: Capsicum, fertigation, humic acid, nutrient uptake, water requirement.

In Himachal Pradesh, capsicum it is generally grown under rainfed condition and covered almost 50 percent of state's area and production. In the recent past, monsoon distribution pattern in the state has become highly erratic. In 2009-10, all the twelve districts were declared as drought hit. Undulating topography, steep slopes and shallow soils with poor retentivity of water and nutrient further aggravate the problems. Under such conditions, use of drip irrigation becomes imperative to produce good quality crop as drip irrigation can be used to maximize water-use efficiency and production (Spehia *et al.*, 6). Furthermore, in the era of intensive agriculture, the use of chemical fertilizers has tremendously increased all over the world which can also be efficiently and effectively utilized by the plants through fertigation. Hence, fertigation can help in reduction of ground water pollution by indiscriminate use of fertilizers. In addition, humic acid (HA) can be used to lower the concentration of inorganic fertilizers. One of the functions of HA is the positive effect on promotion of root development (Trevisan *et al.*, 9). Humic substances are recognized as a key component of soil fertility properties, since they control chemical and biological properties of the rhizosphere leading to higher soil moisture and nutrient content (Nardi *et al.*, 2). Combined fertigation of chemical fertilizers and humic acid could, therefore, affect the productivity of crops in a different ways and hence the present investigation was carried out.

A field experiment was conducted at the experimental farm of Precision Farming Development Centre, Department of Soil Science and Water Management, Dr YSPUH&F, Solan, Himachal Pradesh during 2012-14. Study area lies between 31°45'30'' N latitude and 77°25'30'' E longitude with an altitude of 1720 m above mean sea level. Experimental soil was moderately acidic loamy sand having 0.63 per cent organic carbon and EC 0.31 dS m^{-1}. Volumetric soil water content at field capacity and permanent wilting point was 25.8 and 8.4 per cent, respectively. Available N content at 0-15, 15-30 and 30-45 cm soil depth was 112.1, 102.5, 88.7 mg kg^{-1}. Such values of available P and K were 16.9, 11.9, 4.6 and 120.8, 110.0, 93.2 mg kg^{-1}, respectively. Capsicum cv. California Wonder was planted at 60 cm x 45 cm distance in open field conditions. Water was applied based upon pan evaporation (0.75 class 'A' pan evaporation), using the equation $V = \sum (Ep \times Kc \times Kp \times A \times N - Re \times A)$, where, V = is the volume of water required in litres; Ep = pan evaporation (mm day^{-1}); Kc = crop co-efficient; Kp = pan factor (0.75); A = Area of plot (9 m^2), Re = effective rainfall (mm) and N = number of days in a month. Crop factor (Kc) were taken as 0.68, 0.73, 0.81 and 0.87 for May, June, July and August, respectively, based on existing relative humidity, wind velocity and crop growth stage. Water requirement (WR) of capsicum during entire growth season is presented in Table 1.

Water soluble fertilizers-MAP (12:61:0), muriate of potash (60% K_2O) and urea (46% N) were used for fertigation. For humic acid, super potassium

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Table 1. Water requirement (WR) of capsicum under open field fertigation.

Month	No. of days	Ep (mm/ day)	Kc	Kp	Re (mm)	ET. crop (mm)	Crop WR (mm)
May	15	6.5	0.7	0.8	16.8	49.0	65.8
June	30	4.9	0.7	0.8	11.2	80.3	91.5
July	31	3.7	0.8	0.8	15.3	69.1	84.4
August	31	2.7	0.9	0.8	35.7	53.6	89.3
Total							331.0

*excluding 5 cm water application in field preparation

f-humate (75% potassium humate and 15% fulvic acid) was used. The following six treatments, in triplicate, were tried in randomized block design. Treatments were T_1 = Drip fertigation with NPK (sole application) at recommended dose (RDF); F = control; T_2 = sole fertigation of NPK at 80% RD; T_3 = sole fertigation of NPK at 60% RD; T_4 = Fertigation of NPK and HA (combined application) at RD; T_5 = combined fertigation at 80 percent RD and T_6 = combined fertigation at 60 percent RD. Fertilizers and humic acid was applied as per recommendations. Drip system comprised inline emitters spaced at 50 cm distance having emitter's discharge rate 4 lph. Uniformity coefficient of the system was 90-92 percent and operating pressure was 1.16 kg cm^{-2}. Fertigation was done through venturi having suction rate of 1013 ml per min., at bi-weekly intervals starting from four leaf stage. Nutrient concentration in irrigation water was well within the prescribed limits.

Soil moisture was recorded after 72 h of irrigation/ fertigation at weekly interval using virtual soil moisture sensors. Observations were also made on plant height, leaf area index (LAI), number of fruits per plant, fruit weight and fruit yield. Plant N, P and K contents were determined as per standard methods. Nutrient uptake (NPK) was estimated by multiplying total NPK content in plant parts (root, shoot, leaf and fruit) with the respective dry weight of plant part. Available N, P and K contents of soil was also determined following standard procedures (Tandon, 8).

Soil moisture decreased with increasing soil depth (Fig. 1). Treatment received humic acid registered higher soil moisture as compared to sole fertigation. At 0-15 and 15-30 cm soil depth, moisture content in T_4 was 2.8 and 2.0 percent unit higher, respectively. Such an increase at 30-45 cm depth was only 0.5 percent unit. The HA may have increased the water retention property of soil especially in surface 0-30 cm soil depth because of its high content of hydrophilic groups. Higher soil moisture in combined fertigation may be attributed to addition of humic acid which added considerable organic matter in soil. Piccolo *et al.* (16) also reported that humic substances significantly improved moisture retention property of soil owing to the presence of hydrophilic functional groups.

Among different fertigation levels (Table 2), T_1 registered significantly maximum plant height (69.7 cm) over T_2 (62.6 cm) and T_3 (55.7 cm). Fruit yield was also significantly superior in T_1, which was 20 and 25 percent higher over T_2 and T_3, respectively. Higher growth parameters in T_1 can be attributed to higher leaf area. Leaf area index (LAI) is a measure of source size which directly contributes in chlorophyll synthesis and consequently in plant growth and yield. Significantly higher LAI was recorded in T_1 (2.9) compared to T_2 (2.6) and T_3 (2.3). Since, experimental soil was medium in available N, P and K content; therefore, higher responses were expected at higher fertigation levels. This resulted in higher LAI in T_1. Higher LAI at higher fertigation level has also been reported by Shedeed *et al.* (5). Increased fruit yield in T_1 may have resulted from higher average fruit weight (74.3 gm) over T_2 (70.4 g) and T_3 (65.9 g). Hebbar *et al.* (1) also reported more number of fruits, higher average fruit weight and consequently higher fruit yield of tomato at higher fertigation level. Similar trend was noticed in T_4, T_5 and T_6.

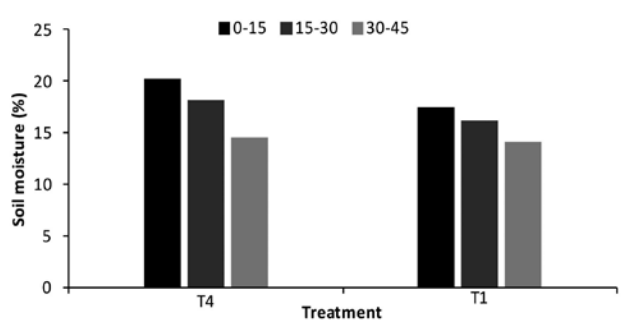

Fig. 1. Soil moisture content under combined and sole fertigation. Humic acid resulted in 2-3 percent higher moisture especially in 0-30 cm soil depth.

Table 2. Effect of different treatment on growth, yield and FUE of capsicum under open field fertigations (pooled data).

Treat.	Plant ht. (cm)	LAI	Fruits per plant	Fruit wt. (g)	Yield (kg $plant^{-1}$)	FUE (kg kg^{-1})
T_1	69.7^b	2.8^b	14.8^b	78.0^b	1.2^b	119.3^c
T_2	62.6^c	2.5^c	13.5^c	70.4^c	1.0^c	128.9^c
T_3	55.7^d	2.2^d	12.7^d	62.9^d	0.8^d	151.2^b
T_4	75.8^a	3.1^a	16.9^a	86.1^a	1.4^a	154.2^b
T_5	68.7^b	2.8^b	15.1^{bc}	77.4^b	1.2^b	154.4^b
T_6	61.6^c	2.5^c	13.5^c	72.5^b	1.0^c	176.9^a
$CD_{0.05}$	5.5	0.2	1.3	7.2	0.1	13.3

Data in column followed by the same letters are not significantly different but statistically significant over other treatment combinations.

Furthermore, combined NPK fertilizer at all fertigation levels, in general, influenced the productivity of capsicum significantly over sole fertigation. Fruit yield was 17-27 percent higher under combined fertigation over sole application. Also, growth, yield and quality of capsicum were statistically at par between T_1 and T_5. These results could be attributed to the improvement of moisture retention and nutrient supply potentials of soil after humic acid application. This may have resulted in higher LAI and thereby, higher plant growth and yield under combined fertigation. Similar observations were made by Suganya and Sivasamy (7) and Selim *et al*. (4). This contention also gets support from higher nutrient uptake in combined fertigation of NPK and HA compared to NPK alone (Table 3).

Irrespective of the levels, fertigation with humic acid had significantly higher N uptake over sole application (Table 3). Similar trend in the uptake of P and K was noticed. The higher uptake was the result of significantly higher dry matter production at 120 days after transplanting (DAT) and higher nutrient contents in different plant parts. The increased N uptake was supposed to be due to the better use efficiency of applied N fertilizers in the presence of humic acid coupled with retarded nitrification process enabling the slow availability of applied N. The increase in P uptake may be due to the prevention of P fixation in the soil and the formation of humophospho complexes, which are easily assimilable by the plants. According to Samson and Visser (19), humic acid induced increase in permeability of bio-membranes for electrolytes accounted for increased uptake of K.

Treatment comprising T_1, T_2 and T_3 registered FUE to the tune of 119.3, 128.9 and 151.2 kg kg^{-1}, respectively. This implies higher FUE at lower fertigation level (Table 2). Higher FUE in treatments receiving HA may be attributed to improvement of moisture retention and nutrient supply potentials of soil. Hence, fertigation of chemical fertilizers and humic acid resulted in significantly higher growth and yield of capsicum over sole application of NPK. Use of humic acid alongwith inorganic fertilizers increased the fruit yield by 08% besides increasing fertilizer-use efficiency upto 29% over sole application of fertilizers.

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Table 3. Effect of different treatment on dry matter production, plant nutrient content and nutrient uptake of capsicum.

Treat.	Dry matter (mg $plant^{-1}$)	Plant nutrient content (%)			Nutrient uptake (kg ha^{-1})		
		N	P	K	N	P	K
T_1	204.1^a	2.94^b	0.32^c	4.38^b	221.9^b	24.0^c	330.6^b
T_2	192.0^b	2.78^c	0.32^c	4.00^c	197.2^c	22.8^c	284.4^c
T_3	180.3^c	2.64^d	0.31^c	3.73^d	175.8^d	20.5^d	248.9^d
T_4	212.4^a	3.12^a	0.40^a	4.77^a	245.0^a	32.0^a	374.9^a
T_5	204.0^{ab}	2.95^b	0.37^b	4.40^b	222.9^b	28.0^b	332.2^b
T_6	190.4^{bc}	2.78^c	0.32^c	4.00^c	196.1^c	22.8^c	281.7^c
$CD_{0.05}$	13.6	0.13	0.02	0.25	18.4	2.2	20.4

Data in column followed by the same letters are not significantly different but statistically significant over other treatment combinations.

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