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Short Communication

Response of chilli (*Capsicum annuum*) to sulphur and zinc application in Indo-Gangetic alluvial soil of Varanasi

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Chilli is best suited to sandy loam and clay loam with proper drainage. India produces about 1.298 mt of chillies from an area of 0.806 mha with average productivity of 1611 kg ha^{-1}. The alluvial soils of the Indo-Gangetic plains of Varanasi are grouped under Inceptisols (*Typic Ustocherpts*). Majority of the farmers are growing chilli as a cash crop to reap higher economic returns. The actual rate of application of N fertilizer in the farmers' field is 2-3 times higher than the recommended dose of N. The indigenous technical knowledge of the chilli growers of this region lead to a common practice of top dressing more N fertilizer after every picking of green chilli and applying lesser quantity of basal dose of P and K fertilizers against the recommended dose of N, P and K fertilizers. This practice has aggravated the problems of emerging multi-nutrients deficiencies in soils. Imbalanced N, P and K fertilization which accelerates excessive nutrient mining, is the root cause of poor and stagnant chilli production and deteriorating soil health too. Among the several constraints, balanced fertilization is most important for obtaining higher yield of chilli. Intensively vegetables growing regions of Varanasi showed S and Zn deficiencies to the tune of 36.0 and 48.0% (Singh et. al. 2012). The present investigation was carried out with N, P, K, S and Zn fertilization based on soil tests over the existing recommended dose of N, P and K fertilizers for higher yield and nutrients uptake by chilli grown in Indo-Gangetic alluvial soils.

Experiments were conducted at farmer's field in Shahanshahapur village under Araziline block of Varanasi district on low soil available N, P, K, S and Zn content during *kharif* season of 2015-16 and 2016-17 for two consecutive years. Treatments were as follows: T_1, Recommended dose of N, P and K fertilizers (RDF); T_2, Soil test based N, P and K fertilizers; T_3, Soil test based N, P and K fertilizers + 40 kg S ha^{-1}; T_4, Soil test based N, P and K fertilizers + 5 kg Zn ha^{-1}; and T_5, Soil test based N,P and K fertilizers + 40 kg S ha^{-1} + 5 kg Zn ha^{-1}. The treatments were replicated four times in randomized block designed. Hybrid Chilli was transplanted during *Kharif* season, 2015-2016 and 2016-2017, on 05th and 10th September, respectively. Recommended dose of N, P, and K fertilizers were 120 kg N, 60 kg P_2O_5 and 60 kg K_2O kg ha^{-1}. Soil test based levels were 150 kg N, 75 kg P_2O_5 and 75 kg K_2O ha^{-1} which were determined on the basis of deficient levels of these nutrients in soils of the farmer's field from intensively chilli growing area. A basal recommended dose of 60:60:60 and soil test based dose of 75:75:75 N, P_2O_5 and K_2O kg ha^{-1} were applied uniformly during field preparation before transplanting of chilli through urea, di-ammonium phosphate and muriate of potash fertilizers, respectively. Remaining 60 kg N ha^{-1} of recommended dose and 75 kg N ha^{-1} of soil test based dose were applied to chilli crop in two split doses at 30 and 60 days after transplanting. The basal dose of S and Zn @ 40 and 5 kg ha^{-1} were applied through phosphogypsum (15% S) and zinc sulphate (21% Zn), respectively along with doses of nitrogen, phosphorus and potassium. All crop management practices and protection measures were followed.

The chilli fruits were dried in oven at 65 ^{0}C. Total nitrogen in chilli fruit was estimated after digestion in H_2SO_4 in automatic digestion system. Total P, K, S and Zn were estimated after digestion in di-acid mixture (HNO_3:$HClO_4$ 9:1 ratio) using the standard methods. Uptake of N, P, K S and Zn was computed by multiplying with total nutrient concentration of green fruits with their respective green chilli fruit yields. Before conducting the experiment, composite surface soil samples (0-15 cm) were collected from the farmers' field during both the years. These samples were air-dried and pulverized to pass through 2 mm sieve. Soils were analysed by using standard procedures as described for soil texture Bouyoucos

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hydrometer (Bouyoucos 1962), pH (Jackson 1973), organic carbon (Walkley and Black 1934), available nitrogen (Subbiah and Ashija 1956), available phosphorus (Olsen et. al. 1954), available potassium (Jackson 1973), available sulphur (Williams and Steinbergs 1959) by turbidity method of Chesnin and Yien (1950) and available Zn with DTPA extractant (Lindsay and Norvell 1978). The data were analyzed statistically to find out the treatment differences following the standard methods given by Gomez and Gomez (1984). The soils of the experimental farmers' field were sandy loam in texture with pH 7.7 and 7.5, organic carbon 0.64 and 0.69%, available N 170.6 and 174.2 kg ha^{-1}, available P_2O_5 21.1 and 22.3 kg ha^{-1}, available K_2O 121.4 and 124.7 kg ha^{-1}, available S 6.7 and 8.2 kg ha^{-1} and available Zn 0.52 and 0.55 mg kg^{-1} during the year 2015-16 and 2016-17, respectively.

The highest yield of green chilli fruit of the two years was recorded (26425 and 30440 kg ha^{-1}) with pooled value of 28432 kg ha^{-1} by application of soil test based 150 kg N, 75 kg P_2O_5, 75 kg K_2O, 40 kg S and 5 kg Zn ha^{-1} during both the years 2015-16 and 2016-17, respectively (Table 1). The values of yield (19892 and 20306 kg ha^{-1}) were recorded minimum with the recommended doses @ 120 kg N, 60 kg P_2O_5 and 60 kg K_2O ha^{-1}. The present investigation indicated that an additional application of 30 kg N, 15 kg P_2O_5, 15 kg K_2O, 40 kg S and 5 kg Zn ha^{-1} over the recommended dose leads to an additional increase in yield (6533 and 9720 kg ha^{-1}) of green chilli during both the years, respectively. The increase in green chilli yield was due to increased ionic balance of nitrogen and potassium as a result increase in chlorophyll synthesis, assimilation of carbohydrate and proteins ultimately enhance cell division and increased vegetative growth (Singh et al. 1996). Since experimental soil of the farmer's field was deficient in available S and Zn, an increase in green chilli yield may be expected due to increased availabilities of these nutrients in soil solution through added phosphogypsum and zinc sulphate, respectively.

The perusal of pooled data of two consecutive years (Table 2) showed that application of sulphur and zinc in combination with soil test based nitrogen, phosphorus and potassium application increased total N, K, S and Zn uptake by crop over recommended dose of N, P and K fertilizers, except total P uptake. The maximum total N (99.8 kg ha^{-1}) and K (75.6 kg ha^{-1}) uptake, was recorded with treatment comprising application of 40

Table 1: Effect of sulphur and zinc application on yield of green chilli fruits

Treatment	Green fruit yield (kg ha^{-1})										Pooled total green fruit yield of the two years 2015-16 and 2016-17
	2015-16					2016-17					
	1st picking	2nd picking	3rd picking	4th picking	Total	1st picking	2nd picking	3rd picking	4th picking	Total	
Recommended dose of NPK fertilizers	4687	4979	5699	4527	19892	5020	5500	6140	4060	20720	20306
Soil test based N,P and K fertilizers	5335	5868	6411	4698	22312	6150	6900	6930	4820	24800	23556
Soil test based N,P and K fertilizers+ 40 kg Sha^{-1}	5668	6218	6605	5273	23764	6620	7200	7230	5750	26800	25282
Soil test based N,P and K fertilizers + 5 kg $Znha^{-1}$	5870	6415	7125	5661	25071	7010	7600	7690	6020	28320	26695
Soil test based N,P and K fertilizers + 40 kg Sha^{-1}+5 kg $Znha^{-1}$	6240	6685	7886	5914	26725	7560	7920	8420	6540	30440	28583
CD (P=0.05)	235	181	208	223	-	130	170	240	210	-	

Table 2: Effect of sulphur and zinc application on total uptake of N, P, K,S and Zn by green chilli fruits

Treatments	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})			K uptake (kg ha^{-1})			S uptake (kg ha^{-1})			Zn uptake (g ha^{-1})		
	2015-16	2016-17	pooled	2015-16	2016-17	pooled	2015-16	2016-17	pooled	2015-16	2016-17	pooled	2015-16	2016-17	pooled
Recommended dose of NPK fertilizers	70.0	86.6	78.3	6.89	8.84	7.9	75.41	53.83	64.6	12.02	12.98	12.5	21.93	123.01	122.47
Soil test based N,P and K fertilizers	74.7	93.8	84.3	8.48	9.85	9.2	79.55	54.85	67.2	12.46	14.02	13.24	22.44	124.91	123.67
Soil test based N,P and K fertilizers + 40 kg Sha^{-1}	77.3	97.8	87.6	8.99	10.5	9.7	83.14	56.48	69.8	12.96	14.68	13.82	22.90	126.2	124.55
Soil test based N,P and K fertilizers + 5.0 kg $Znha^{-1}$	80.9	101.5	91.2	8.36	9.49	8.9	85.84	57.95	71.9	13.41	15.87	14.64	27.29	129.3	128.29
Soil test based N,P and K fertilizers + 40.0 kg Sha^{-1}+5.0 kg $Znha^{-1}$	87.7	112.2	99.8	8.87	9.10	9.0	91.30	59.9	75.6	13.97	17.1	19.1	32.46	135.6	134.03
CD (P=0.05)	2.1	2.3		0.24	0.5		2.30	0.91		0.2	0.7		0.3	1.9	

kg S and 5 kg Zn ha $^{-1}$ along with soil test based application of 150 kg N, 75 kg P_2O5 and 75 kg K_2O ha^{-1}, which was significantly superior over recommended dose of fertilizers. The minimum total N (78.3 kg ha^{-1}) and K (64.6 kg ha^{-1}) uptake by green chilli fruits was recorded with application of recommended dose of NPK fertilizers. The increase in total N and K uptake could be attributed to synergistic effect among N, S and Zn and due to the positive interaction of K and Zn, respectively. Total P uptake was reduced when 5.0 kg ha^{-1} Zn applied with either 40 kg S ha^{-1} or soil test based N, P and K application as compared to rest of the treatments. It might be due to antagonistic effect of P with Zn. Zn was found to inhibit the translocation of P from roots to the tops. Such types of finding were also reported by Alam et al. (2000). Application of sulphur and zinc in conjunction with soil test based N, P and K fertilizers gave significantly higher total uptake of S and Zn by chilli. The highest total S uptake (19.1 kg ha^{-1}) and Zn uptake (134.03 g ha^{-1}) by green chilli fruits were recorded with soil test based N, P and K fertilizers along with 40 kg S and 5 kg Zn ha^{-1} over the recommended dose of N, P and K fertilizers. The lowest uptake of S (12.5 kg ha^{-1}) and Zn (122.4 kg ha^{-1}) by green chilli fruits was recorded with recommended dose of N, P and K fertilizers. Poor availability of S and Zn in experimental soil and application of only recommended dose of N, P and K fertilizers resulted in lower S and Zn uptake by green chilli fruits during both the years.

Economic analysis (Table 3) of data for recommended dose of N,P and K fertilizers and soil test based N, P and K along with sulphur and zinc application indicated that cost of cultivation was found to Rs. 28440 and Rs. 31850 ha^{-1}, respectively. Net return over cost of cultivation was Rs. 73090 and 111065 ha^{-1} and input-output ratio at cost was 1:2.57 and 1; 3.49, respectively. From the results it is evident that there is a need of balanced fertilization of N, P, K, S and Zn in adequate amount over the existing recommended dose of N, P and K fertilizers. The results further suggest that application of soil test based 150 kg N, 75 kg P_2O5 and 60 kg K_2O ha^{-1} along with 40 kg S and 5 kg Zn ha^{-1} are imperative to maintain soil health for sustained higher productivity of chilli in terms of yield and nutrients uptake for the Indo-Gangetic plains of Varanasi.

Table 3: Economics of chilli production with soil test based application of N, P and K along with sulphur and zinc.

S. No.	Particulars	With recommended dose of N,P and K ferilizers	With soil test based N, P and K along with sulphur and zinc application
1.	Yield of green chilli fruits (kg ha^{-1})	20306	28583
2.	Average price of received green chilli	Rs. 5 kg $^{-1}$	Rs. 5 kg $^{-1}$
3	Gross return	Rs. 101530	Rs. 142915
4.	Cost of cultivation		
	(i) Field preparation	Rs.2000	Rs.2000
	(ii) Seeds	Rs.4000	Rs.4000
	(iii) Labour	Rs. 3500	Rs.3500
	(iv) Intercultural operations	Rs.5500	Rs.5500
	(v)Fertilizers	Rs.3240	Rs.6650
	(vi) Irrigation	Rs.4200	Rs.4200
	(vii)Picking	Rs.6000	Rs.6000
	Total	Rs.28440	Rs.31850
5.	Net return over cost	Rs.73090	Rs.111065
6.	Input-output ratio	1:2.57	1:3.49

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References

Alam S M, Zafar I and Latif A (2000) Effect of P and Zn application by fertigation on P use efficiency and yield of wheat. Trop Agric Res Ext 3: 17-20.

Bouyoucos G J (1962) Hydrometer method improved for making particle size analysis of soil Agron J 54: 464-465.

Chesnin L and Yien CH (1950) Turbidimetric determination of available sulphur. Soil Sci Soc Amer Proc 15: 149-151.

Gomez KA and Gomez AA (1984) Statistical Procedures for Agricultural Research. John Wily and Sons, New York.

Jackson M L (1973) Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi.

Lindsay WL and Norvell WA (1978) Development of DTPA soil test for zinc, iron, manganese and copper. Soil Sci Soc Amer J 42: 421-428.

Olsen SR, Cole CV, Watanabe FS and Dean JA (1954) Estimation of available phosphorus in soils by extraction with sodium bicarbonate. USDA Circular 939.

Singh DN, Sahu A and Parid AK (1996) Response of chilli (*Capsicum annuum*) to applied nitrogen and potassium in clay loam soils of Orissa. Indian J Agri Sci 69: 287-288.

Singh S and Kumar P (2012) Soil fertility status of vegetable growing area of Varanasi and pulses growing area of Mirzapur. J Indian Soc Soil Sci 60: 233-236.

Subbiah B and Asija GL (1956) A rapid procedure for the determination of available nitrogen in soils. Current Sci 25: 259-260.

Walkley A and Black IA (1934) An estimation of the Degtjareft method for determining soil organic matter and a proposed modification of chromic acid titration method. Soil Sci 37: 29-38.

Williams CH and Steinbergs A (1959) Soil sulphur fractions as chemical indices of available sulphur in some Australian soils. Australian J Agric Res 10: 340-350.