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Studies on the Soil Test Crop Response (STCR) nutrients on Growth, Yield, Quality of Onion (*Allium cepa* L.) and Fertility Status of Alfisols

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ABSTRACT

Soil test crop response (STCR) nutrient management is an advanced approach for productivity of crop and sustaining soil health. On the basis of this technology, field experiment was conducted at Agriculture College and Research Institute, Killikulam, Tamil Nadu during the Rabi season of 2019-20 and 2020-21 to study the effect of soil test crop response (STCR) application of N, P, and K along with zinc and boron on growth, yield, quality of onion and soil fertility status. The growth, yield, and quality were significantly influenced by the soil and foliar application of zinc and boron with STCR dose of NPK. Application of STCR (106:97:54 kg of NPK ha^{-1}) + $ZnSO_4$ @ 25 kg ha^{-1} + 0.5% foliar spray significantly influenced the growth, yield characters, bulb yield, bulb quality and maintained soil fertility status. The lowest growth, yield characters, bulb yield, and quality with lower fertility status were recorded under control. The fertilizer treatment of STCR (106:97:54 kg of NPK ha^{-1}) + $ZnSO_4$@ 25 kg ha^{-1} with 0.5% foliar spray was found to be the best suitable method and dose for onion production in the semi-arid tract of southern Tamil Nadu.

Keywords: *Onion, STCR, Zinc, Boron, Growth, Bulb yield, Total soluble solid, Ascorbic acid, Pyruvic acid, Available nutrient*

INTRODUCTION

Onion (*Allium cepa* L.), the *'Queen of Kitchen'* is one of the major important commercial vegetable crops cultivated extensively in India. It belongs to the family Alliaceae. Onion is the cool season crop. However, it can be grown under a wide range of agro-climatic conditions. It grows well under mild climates without extreme heat cold or extreme rainfall. The edible part of an onion is green leaves, and immature and mature bulbs. Onion has a strong flavor due to presence of sulphur-containing compound in very small quantities in the form of volatile oil allyl propyl disulphide responsible for the distinctive smell and pungency. It is cultivated for food, medicines, religious purpose, spices and condiments since early times. It has medicinal and diuretic properties, relieves heat sensation, hysterical faintness, insect bites and also heart stimulation [14].

India ranks second position in both area and production after China in the world. In India, onion is being grown in an area of 12.94 lakhs ha with a production of 2017.18 tonnes and the productivity is 16.8 t ha^{-1} during 2016-17. The total area under onion production in Tamil Nadu was 347.03 MT in an area of 34.08 thousand ha with a productivity of 10.18 t ha^{-1} [2]. The low production of onion is due to improper application of fertilizers and growing unsuitable varieties under the agro-climatic condition of an area.

Optimum fertilizer application for onions and cultivation of suitable varieties in the proper environment are necessary for obtaining a good yield of onion. Among the many constraints for low productivity in onion, imbalanced nutrition is the main limiting factor [6]. Micro nutrients play an active role in the plant metabolic process from cell wall development to respiration, photosynthesis, chlorophyll formation, enzyme activity, nitrogen fixation etc. It also plays an essential role in improving growth, yield, and quality [3].

Soil application of micronutrients during crop growth period was successfully used for correcting their deficits and improving the mineral status of plants. The onion like any other crop not only needs macronutrients, but also micronutrients in adequate and balanced amounts [4].

Zinc is a micronutrient which is required plant growth and development relatively in small amounts. Zinc is involved in the formation of chlorophyll and carbohydrates and is also involved in a diverse range of enzyme system [32]. Improvement in onion growth and yield has been reported through micronutrients by many scientist in different types of soils. However little information is available on the use of zinc and boron with inorganic fertilizers for onion in semi-arid tract of southern Tamil Nadu tract. Keeping this in view, the experiment was undertaken.

MATERIALS AND METHODS

Experimental site

The investigation was carried out at Agricultural College and Research Institute, Killikulam, Tamil Nadu during the *rabi* season of 2019-20 and 2020-21 in onion variety of CO (On) 5, to study the effect of soil test crop response application of N, P, K

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along with zinc and boron. Killikulam is under semi-arid tract of southern Tamil Nadu in the Thoothukudi district at 80°46' latitude and 77°42' longitude and at an altitude of 40 m above MSL. The mean annual rainfall at Agricultural College and Research Institute, Killikulam is 750 mm. The minimum and maximum temperatures prevailed during the crop growing season are from 26.3°C to 35°C respectively.

The experimental soil reaction (pH) was nearly neutral and non-saline with the permissible value of electrical conductivity. The experimental soil was reddish-brown sandy clay loam low in organic carbon, available nitrogen, medium in available phosphorus and available potassium (Table 2.). The available zinc and boron were deficit. The experiment consisted of eight treatments laid out randomized block design with 3 replications (Table 1). The nitrogen, phosphorus, and potassium were applied as per the recommendation of soil test crop response (STCR). A soil test crop response (STCR) dose of 106:97:54 kg of NPK ha^{-1} was applied. Zinc sulfate as a zinc source and borax for boron were used in different doses. Nitrogen was applied in two equal split doses, at 30 and 45 days after transplanting. Foliar application was done at 30 and 45 days after transplanting. A standard package of practices was followed to grow onion crops. The crop was harvested after attaining the maturity during last week of March in both years. Observations on growth, yield characters and bulb yield were recorded.

Methods of analysis

Representative plant samples (twenty plants) were collected for the biochemical and nutritional analysis. Chopped samples were dried in a hot air oven at 105°C till the constant weight was attained. The samples were ground and passed through a 2 mm sieve and used for nutrient analysis. The plant samples were digested using tri-acid and di-acid digestion methods and analyzed for phosphorus by vanadomolybdate method potassium by flame photometry [12], Zn by atomic absorption spectrophotometer [21], and B by azomethene-H method [5]. The nutrient analysis of plant samples was carried out in accordance with the methods reported by [20]. The nutrient uptake was calculated by multiplying nutrient concentration with dry matter yield. Soil samples from 0-15 cm were collected randomly using an auger after harvest for soil analysis soil samples were analyzed as per the standard procedures. For soil organic carbon, chromic acid wet oxidation method [34], for available nitrogen, alkaline permanganate method [29], for available phosphorus, Olsen method [19], available potassium, neutral normal ammonium acetate extract method, [28] for available zinc, DTPA extractant using AAS [16] and for available boron, hot water extraction method [5] were followed for analysis.

Fresh onion bulbs were used for determining protein, total soluble solids (TSS), pyruvic acid, and ascorbic acid content in bulbs. A protein of onion bulbs was estimated using micro - kjeldahl method [11], the TSS of onion bulbs was estimated using hand refractor meter method [22], pyruvic acid content was estimated using modified dinitrophenyl hydrazine (DNPH) method [25] and ascorbic acid was estimated by dye method [24]. The two-year data was pooled and subjected to statistical analysis as prescribed by Gomez and Gomez [9].

RESULTS AND DISCUSSION

Crop growth and yield attributes

The growth characters such as plant height, number of leaves, yield attributes, and bulb yield were influenced significantly due to the application of soil test crop response (STCR) application of N: P:K as 106:97:54 kg/ha along with zinc and boron (Table 3).

The application of STCR as N: P: K @106:97:54 kg/ha+ $ZnSO_4$ @ 25 kg/ ha + 0.5% foliar spray (T4) significantly exhibited its superiority in increasing the maximum plant height (55.2 cm), number of leaves (17.2), yield attribute characters *viz.*, polar diameter of bulb (3.35 cm), equatorial diameter (2.98 cm), bulb lets per clump (6.4), bulb weight (85.2 g) and the bulb yield (16.55 t/ha)were recorded for this treatment. The next better performances were recorded for the treatment applied with STCR as N: P: K @106:97:54 kg/ha+ Borax @ 10 kg/ ha + 0.5% foliar spray (T7) which recorded the next maximum plant height (52.2 cm), number of leaves (16.2), yield attribute characters viz., polar diameter of bulb (2.97 cm), equatorial diameter (2.62 cm), bulb lets per clump (6.1), bulb weight (81.5 g) and the bulb yield (15.92 t/ha). The application of STCR as N: P: K @106:97:54 kg/ha alone (T1) recorded the lower values of plant height (46.8cm), number of leaves (12.8), yield attribute characters viz., polar diameter of bulb (2.12 cm), equatorial diameter (1.94 cm), bulb lets per clump (4.3), bulb weight (62.8 g) and the bulb yield (12.42 t/ha). The lowest values of plant height (44.8cm), number of leaves (11.9), yield attribute characters viz., polar diameter of bulb (1.84 cm), equatorial diameter (1.63 cm), bulb lets per clump (3.7), bulb weight (57.8 g) and the bulb yield (9.67 t/ha) were recorded for the absolute control (T8). The increase in total bulb yield for T4 over T1 was 35.66 % and for absolute control (T8) it was 74.25 %. It is quite obvious that the experimental soil was deficient in zinc and boron and external application would have favorably enhanced the growth of onion. The results conform with the findings of [3] and [17]. The improvement on growth and yield attributes is due to the adoption of nutrient management through soil test crop response (STCR). Further, the improvement of bulb yield was due to better vegetative growth as observed in the present study. This result corroborates the findings of [6] who reported that a high yield was a reflection of vigorous vegetative growth and healthy plants. Similar findings have also been reported in onion by [13]; [30] and [15].

Quality parameters

The quality parameters *viz.,* total soluble solid (TSS), ascorbic acid, protein and pyruvic acid contents were significantly influenced for the application of STCR recommended NPK with Zn and B (Figure 1-4). A similar trend as that of growth and yield attributes was recorded for the combined application of STCR recommended NPK with Zn and B. Among the treatments, the highest contents of total soluble solid (TSS) (15.7 °Brix), Ascorbic acid (13.95 mg/100 g), Protein (8.46% and pyruvic acid (4.82 µmole/g) were recorded for the treatment with the application of STCR as N: P: K @106:97:54 kg/ha+ $ZnSO_4$ @ 25 kg/ ha + 0.5% foliar spray (T4) recorded the highest content and uptake of N, P, K, Zn and B as followed by the contents of total soluble solid (TSS) (13.97 °Brix), Ascorbic acid (12.67 mg/100 g), Protein (8.21% and pyruvic acid (4.52 µmole/g) for the treatment of STCR as N: P: K @106:97:54 kg/ha+ Borax @ 10 kg/ ha + 0.5% foliar spray (T7). These two treatments are on par with each other. The increase in quality parameters in onion bulbs in these treatments was due to the combined application of macro and micronutrients which were readily available to the plants [31] and [8]. The application of STCR as N: P:K @106:97:54 kg/ha alone (T1) recorded the lower values of quality parameters *viz.,* total soluble solid (TSS) (10.3 °Brix), Ascorbic acid (9.72 mg/100 g), Protein (7.88% and pyruvic acid

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(3.12 µmole/g).The absolute control (T8) recorded the lowest contents of total soluble solid (TSS) (9.2 °Brix), Ascorbic acid (7.92 mg/100 g), Protein (7.03% and pyruvic acid (2.82 µmole/g). The lower content of quality parameters could be due to application of without micronutrients of Zn and B against the application of Zn and B through the soil and foliar application. Previous studies have also showed that application of micronutrients with macronutrients increased the quality parameters content in onion bulb. The applied zinc responded well in total soluble solids content by activating the carbonic anhydrase, fructose-1, 6-bisphosphate and aldolase enzymes. These enzymes are active in the chloroplasts and cytoplasm, six-carbon sugar molecules are separated between chloroplasts and cytoplasm by fructose-1, 6-bisphosphate and three-carbon sugars molecule in photosynthesis are transported from cytoplasm to chloroplasts by aldolase. These results are in accordance with the findings of [27] and [4]. The quality of the seed was enhanced by the application of integrated nutrient management by both organic and inorganic. These findings are also in accordance with the finding of [26] and [33].

Nutrient content and uptake

The influence STCR recommended dose of NPK with zinc and boron fertilization enhanced better the nutrient content and uptake in plant and bulb of onion (Table 4). Among the treatments, the application of STCR as N: P:K @106:97:54 kg/ha+ $ZnSO_4$ @ 25 kg/ ha + 0.5% foliar spray (T4) registered the highest content of N, P, K and Zn as 1.37, 0.29, 1.63 % and 18.68 mg/ kg, respectively which recorded the highest uptake of N, P, K and Zn as 95.04, 20.02, 110.98 kg/ha and 128.03 g/ha, respectively. The highest content (12.51mg/kg) and uptake (79.49 g/ha) of B was recorded for the treatment applied with STCR as N: P:K @106:97:54 kg/ha+ Borax @ 10 kg/ ha + 0.5% foliar spray (T7). The major nutrients content and uptake by onion was increased significantly due to combined application of zinc and boron through soil and foliar application. The increase in uptake of major nutrients was mainly due to higher biological yield with higher nutrient content of these major nutrients by onion. The increased content and uptake of nutrients by onion could be attributed due to synergistic effect between N and Zn. Interaction occurred between the zinc and nitrogen influenced the nitrogen content and uptake of nitrogen in plant and bulbs of onions. This might be due to readily available of nutrients at all growth stages of crop growth. Further, increased uptake of N, P, K, Zn and B with advancement of age of crop might be attributed to the increased dry matter production with age of the crop. This finding are in accordance with [7] and [23]. The highest boron content and uptake might be due to adequate supply of boron to increase the growth, yield and dry matter production components of onion. Boron applied with balanced level of NPK resulted in higher content and uptake. These finding are in agreement with the observation of [10].

Soil fertility status

The soil fertility status were influenced significantly by to application of soil test crop response (STCR) application of N: P: K as 106:97:54 kg/ha along with zinc and boron (Table 5) the application of soil test crop response (STCR) application of N: P:K as 106:97:54 kg/ha along with zinc and boron did not influence the soil pH after harvest. The application of STCR as N: P: K @106:97:54 kg/ha+ $ZnSO_4$ @ 25 kg/ ha + 0.5% foliar spray (T4) registered the highest values of fertility status *viz.,* organic carbon (0.62%), N, P, K (198, 14.2, 192.6 kg/ ha, respectively and Zn (1.12 mg/kg) followed by the treatment applied with STCR as N: P:K @106:97:54 kg/ha+ Borax @ 10 kg/ ha + 0.5% foliar spray (T7) which recorded the next highest values of fertility status *viz.,* organic carbon (0.57%), N, P, K (194, 13.1, 191.4 kg/ ha, respectively and Zn (1.05 mg/kg). The maximum content of available boron (0.65 mg/kg) was noticed for the treatment applied with STCR as N: P:K @106:97:54 kg/ha+ Borax @ 10 kg/ ha + 0.5% foliar spray (T7). The soil organic carbon content after harvest in all the treatments was significantly improved than the initial values of 0.36%. The increase in organic carbon due to the combined application of macro and micronutrients improved the root biomass and vegetative growth of onion [18].The lowest values of fertility status *viz.,* organic carbon (0.35%), N, P, K (174, 11.2, 168.5 kg/ ha, respectively, and Zn and B (0.68 and 0.28 mg/kg) were observed in absolute control (T8). The soil available N,P,K, Zn, and B status showed that the soil N,P,K, Zn, and B status after harvest was maintained in all the treatments. Besides plant nutrient addition, as soil test crop response of N,P,K with Zn and B conserve and enhance the native soil nutrients. The earlier report of [1] also supported this finding.

CONCLUSION

Based on the experimental findings, it can be concluded that application of soil test crop response application of N, P and K along with zinc and boron could improve plant growth, yield parameters, onion bulbs yield, quality parameter, nutrient content, and fertility status of soil. The combined application of the fertilizer treatment of STCR (106:97:54 kg of NPK ha^{-1}) + $ZnSO_4$ @ 25 kg ha^{-1} with 0.5% foliar spray is the best practice in sustaining productivity and soil health and hence can be practiced by the growers effectively under the semi-arid tract of southern Tamil Nadu.

CONFLICT OF INTEREST

The author(s) declare(s) that there is no conflict of interest.

FUTURE SCOPE OF THE STUDY

Several investigations were carried out on nutrient management on crop growth, yield and quality with the soil properties. The soil test crop response (STCR) will give effective nutrient management for crop productivity and soil fertility. Which will be used as site specific technology. This approach will give possible effort for the benefit of farmers at any region. This approach is technically saves the cost and environment.

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Table 1. Soil Test Crop Response (STCR) treatment details

Sl. No	Treatment details
T1	STCR as 106:97:54 kg of NPK ha^{-1}
T2	STCR + $ZnSO_4$ @ 25 kg ha^{-1}
T3	STCR + $ZnSO_4$ @ 0.5% foliar spray
T4	STCR + $ZnSO_4$ @ 25 kg ha^{-1} + 0.5% foliar spray
T5	STCR + Borax @ 10 kg ha^{-1}
T6	STCR + Borax @ 0.5% foliar spray
T7	STCR + Borax @ 10 kg ha^{-1} + 0.5% foliar spray
T8	Absolute Control

Table 2. Initial soil properties of experimental filed

Parameter	Value of type
Soil texture	Scl (sandy clay loam)
pH	6.68
EC (dS/m)	0.22
SOC (%)	0.36
Available N (kg/ ha)	236
Available P (kg/ ha)	16.8
Available K (kg/ ha)	245
Available Zn (mg/kg)	0.78
Available Cu (mg/kg)	1.01
Available Mn (mg/kg)	3.84
Available Fe (mg/kg)	7.55
Available B (mg/kg)	0.23

Table 3. Effect of STCR fertilizer along with Zinc and Boron on growth, yield attributes, and bulb yield (pooled data of two years)

Treatments	Plant height (cm)	Number of leaves/ plant	Polar diameter (cm)	Equatorial diameter (cm)	Bulb lets/ clump	Bulb weight (g/plant)	Bulb yield (t/ha)
T1	46.8	12.8	2.12	1.94	4.3	62.8	12.42
T2	50.2	15.2	2.74	2.56	5.6	77.6	15.14
T3	48.4	14.1	2.53	2.32	5.1	69.8	13.73
T4	55.2	17.2	3.35	2.98	6.4	85.2	16.85
T5	49.5	14.3	2.58	2.37	5.3	73.7	14.30
T6	46.6	13.4	2.38	2.18	4.8	66.6	13.23
T7	52.2	16.2	2.97	2.62	6.1	81.5	15.92
T8	44.8	11.9	1.84	1.63	3.7	57.8	9.67
SEd	0.68	0.43	0.1	0.12	0.11	1.74	0.35
CD (p = 0.05)	1.47	0.90	0.22	0.26	0.26	3.54	0.74

Table 4. Effect of STCR fertilizer along with Zinc and Boron on nutrient content and uptake(pooled data of two years)

Treatments	Nutrient content (%)			Nutrient content (mg/kg)		Nutrient uptake (kg/ha)			Nutrient uptake (g/ha)	
	N	P	K	Zn	B	N	P	K	Zn	B
T1	0.91	0.18	1.08	12.36	7.80	35.11	6.85	41.86	50.01	29.9
T2	1.2	0.25	1.45	18.28	8.19	74.37	15.30	87.33	112.69	49.78
T3	1.07	0.22	1.28	17.01	8.59	52.98	10.76	60.82	81.74	40.46
T4	1.37	0.29	1.63	18.68	8.48	95.04	20.02	110.98	128.03	55.53
T5	1.15	0.23	1.38	11.01	12.05	62.93	12.92	73.61	62.41	64.90
T6	0.97	0.2	1.22	12.28	11.56	43.95	8.83	53.36	58.39	51.57
T7	1.29	0.27	1.53	11.91	12.51	82.77	17.48	97.04	81.48	79.49
T8	0.79	0.15	0.98	10.52	7.41	27.26	5.21	33.21	37.59	24.68
SEd	0.029	0.005	0.035	0.36	0.26	3.45	0.70	2.87	2.70	1.46
CD (p = 0.05)	0.064	0.012	0.085	0.80	0.57	7.48	1.52	6.23	5.88	3.18

Table 5. Effect of STCR fertilizer along with Zinc and Boron on soil available nutrient status after harvest of crop(pooled data of two years)

Treatments	pH	SOC (%)	N	P	K	Zn	B
			(kg/ha)			(mg/kg)	
T1	6.68	0.38	178.0	11.2	170.0	0.74	0.31
T2	6.81	0.53	190.0	12.6	191.2	0.74	0.35
T3	6.77	0.45	182.1	12.3	183.6	0.88	0.29
T4	6.85	0.62	198.0	14.2	192.6	1.12	0.34
T5	6.78	0.49	192.0	13.3	175.3	0.76	0.60
T6	6.75	0.42	184.4	12.2	171.0	0.78	0.54
T7	6.82	0.57	194.0	13.1	191.4	1.05	0.65
T8	6.65	0.35	174.0	11.2	168.5	0.68	0.28
SEd	NS	0.011	3.23	0.20	3.9	0.008	0.005
CD (p = 0.05)	NS	0.027	6.65	0.50	8.02	0.017	0.011

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Figure 1. Effect of treatments on total soluble solid (TSS) content (°Brix) in onion bulb

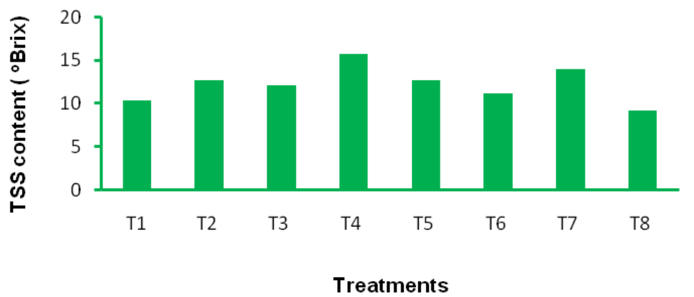


Figure 2. Effect of treatments on ascorbic acid content (mg/100g) in onion bulb

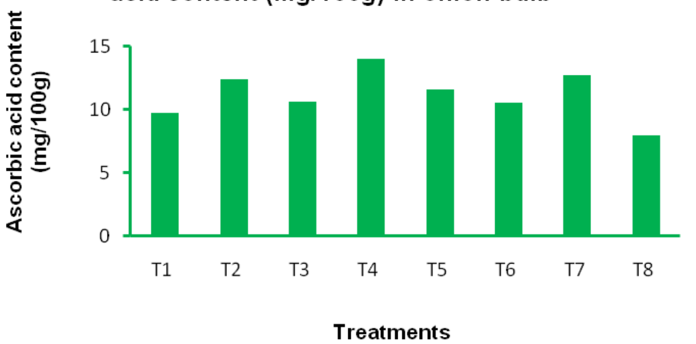


Figure 3. Effect of treatments on protein content (%) in onion bulb

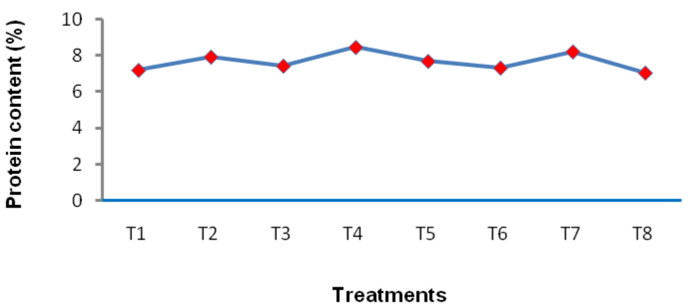
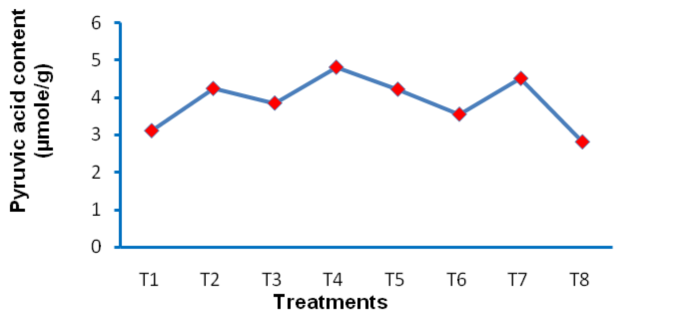


Figure 4. Effect of treatments on pyruvic acid content (µmol/g) in onion bulb



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