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EFFECT OF ORGANICS WITH BORON AND SILICON FERTILIZATION ON THE YIELD OF TOMATO AND SOIL PROPERTIES IN COASTAL SOIL

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Abstract

A field experiment was conducted to find out the effect of organics with boron and silicon fertilization on the yield of tomato and soil properties in coastal soil. The experiment was carried out in a farmer's field at Perampattu coastal village, near Chidambaram Taluk, Cuddalore district, Tamil Nadu. The Physico- chemical properties and nutrient status of initial soil were: pH- 8.41, EC- 2.85 d Sm^{-1}, organic carbon- 2.31g kg^{-1} and Silicon – 84.0 mg kg^{-1}, and Boron 0.07 mg kg^{-1}, respectively. T_1-Control (RDF alone), T_2– RDF + Composted coirpith (CCP) @ 12.5 t ha^{-1}, T_3 –RDF + Borax @ 15 kg ha^{-1} + Silixol granules @ 20 kg ha^{-1} soil application (SA), T_4-RDF + Borax + Silixol granules foliar application (FA) @ 0.5% twice at pre- flowering (PFS) and flowering stage (FS), T_5-RDF + CCP + Borax @ 15 kg ha^{-1} + Silixol granules @ 20 kg ha^{-1} (SA), T_6-RDF + CCP + Borax + Silixol granules (FA) and T_7–RDF + CCP + Borax + Silixol granules (SA+FA) were the treatments studied in a Randomized Block Design (RBD) with four replications, using tomato variety Shivam Hybrid. Composted coirpith (CCP) @ 12.5 t ha^{-1} were applied basally and well incorporated into the soil as per the treatment schedule. Required quantities of boron and silicon as per the treatment schedule were applied through soil as well as foliar. Foliar application of B and Si @ 0.5 per cent at pre flowering and flowering stage was applied as per the treatment. The results clearly indicated that, combined application of recommended dose of NPK fertilizer + borax @ 15 kg ha^{-1} + silixol granules @ 20 kg ha^{-1} (SA) through soil as well as foliar spray of borax @ 0.5% + silixol @ 0.5 per cent twice at pre flowering and flowering stage along with CCP @ 12.5 t ha^{-1} application significantly increased the nutrient availability, enzymatic activity and microbial population in soil and yield of tomato. This treatment recorded the highest fruit yield of 24.25 t ha^{-1} and stover yield of 15.01 t ha^{-1} as compared 100% recommended NPK alone 6.15 and 7.77 t ha^{-1} of fruits and stover yield, respectively.

Key words : Boron, Silicon, Tomato, Coastal Soil, Yield, Nutrient Availability, Enzyme Activity and Microbial Population.

Introduction

Coarse textured sandy soils have specific soil constraints *viz.*, light texture, poor exchange property, low nutrient and water retention capacity, low status of organic carbon and deficiency of both macro and micronutrients. These problems severely affect the productivity of crops in this region. Even the applied nutrients are leached to the lower layers due to poor physical properties, poor nutrient retention and low organic carbon content, which further aggravates the problem of nutrient deficiency. The coastal farmers are cultivating the lands by adopting traditional management practices and realizing very low yield of crops as compared to other regions. Further, coastal salt affected soils are most commonly suffered due to boron deficiency. Zinc, iron, manganese and copper are also deficient in some locations. Boron plays an important role in various enzymatic activities in the growth and development of tomato. It is now established that micronutrient deficiency is the prime factor responsible for that low productivity of tomato in coastal areas.

Silicon is a beneficial or quasi element to alleviate the salinity stress and enhance the boron availability and

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also increased the available beneficial cations. Moreover, it present in excess, Si is not detrimental to plants. It is most commonly found in soils in the form of solution as silicic acid (H_4SiO_4) and plants take up directly as silicic acid (Ma, *et al.,* 2001). Hence, inclusion of boron as micronutrient and silicon as beneficial nutrient in the fertilization programme becomes an imperative need to improve the yield of tomato (Jarosz, 2014 and Swetha *et al.* 2018). Further, the poor nutrient retention and leaching of applied nutrients necessitates the application of increased rate of nutrients and bulky organic manures. Organic manures improve the organic carbon status, available nutrients, biological properties soil, organic matter increases the population of beneficial soil microorganisms (Taalab *et al.,* 2013 and Ganesh and Suresh Kumar, 2016). It is more vivid that application of organic manure along with boron and silicon fertilization sustains soil health and crop productivity in coastal saline soil. Hence, in the present study was undertaken to find out the effect of organics with boron and silicon fertilization on the yield of tomato and soil properties in coastal soil.

Materials and Methods

A field experiment was carried out in a farmer's field during July – October, 2018 at Perampattu coastal village, to find out the effect of organics with boron and silicon fertilization on the yield of tomato and soil fertility in coastal soil. The various treatments included were, T_1- Control (RDF alone), T_2–RDF + Composted coirpith (CCP) @ 12.5 t ha^{-1}, T_3–RDF + Borax @ 15 kg ha^{-1} + Silixol granules @ 20 kg ha^{-1} soil application (SA), T_4-RDF + Borax + Silixol granules foliar application (FA) @ 0.5%, T_5-RDF + CCP + Borax @ 15 kg ha^{-1} + Silixol granules @ 20 kg ha^{-1} (SA), T_6-RDF + CCP + Borax + Silixol granules (FA) and T_7–RDF + CCP + Borax + Silixol granules (SA+FA).The experiment was carried out in a Randomized Block Design (RBD), with three replications, using tomato variety Shivam Hybrid. The experimental soil had sandy loam texture with pH- 8.41; EC- 2.85 d Sm^{-1}; organic carbon- 2.31 g kg^{-1}, Boron 0.07 mg kg^{-1} and Silicon status of 84.0 mg kg^{-1}. The alkaline $KMnO_4$–N; Olsen-P and NH_4OAc-K, were low, low and medium status, respectively. Calculated amount of inorganic fertilizer doses of Nitrogen (200 kg N ha^{-1}), Phosphorus (250 kg P_2O_5 ha^{-1}) and Potassium (250 kg K_2O ha^{-1}) were applied through urea, single super phosphate and muriate of potash, respectively. Required quantities of borax and silixol granules as per the treatment schedule were applied through soil as well as foliar. Foliar application of B and Si @ 0.5 per cent at pre flowering and flowering stage was applied as per the treatment. The soil samples were collected at flowering stage (FS), fruit formation (FFS) and harvest stages (HS) and analyzed for major (N, P and K) and micronutrients (Zn and B) status of soil (Jackson, 1973). The soil samples were also analysed enzymatic activity (Tabatabai and Bremner, 1972) and microbial population (Subba Rao, 1995). At harvest stage, pod and haulm yield were also recorded.

Results and Discussion

Yield of tomato

The significant influence of Boron and Silicon fertilization along with organics in increasing the fruit and stover yield of tomato was well evidenced in the present study. The highest fruit yield (24.25 t ha^{-1}) and stover yield (15.01 t ha^{-1}) was recorded with combined application of recommended dose of NPK fertilizer + borax @ 15 kg ha^{-1} + silixol granules @ 20 kg ha^{-1} (SA) through soil as well as foliar spray of borax @ 0.5% + silixol @ 0.5 per cent twice at pre flowering and flowering stage along with CCP @ 12.5 t ha^{-1} (T_7). This was followed by the treatments T_5 (RDF + borax @ 15 kg ha^{-1} (SA) + silixol granules @ 20 kg ha^{-1} (SA) + CCP @ 12.5 t ha^{-1}), T_6 (RDF + Borax @ 0.5% (FA) + Silixol granules @ 0.5% (FA) + CCP @ 12.5 t ha^{-1}), T_3 (RDF +Borax @ 15 kg ha^{-1}+ Silixol granules @ 20 kg ha^{-1} (SA) through soil alone, T_4 (RDF +borax + silixol @ 0.5% (FA) through foliar spray alone and T_2 (RDF + CCP @ 12.5 t ha^{-1}). Of all the treatments, the treatment (T_7), which received recommended dose of NPK + composted coirpith along with boron and silicon nutrients through both soil (Borax @ 15 kg ha^{-1} + Silixol granules @ 20 kg ha^{-1}) and foliar (Borax @ 0.5% + Silixol granules @ 0.5%) application recorded a fruit and stover yield of 24.25 t ha^{-1} and 15.01 t ha^{-1} which was 74.63 and 48.23 per cent increase over control or 100 per cent NPK alone (without B + Si nutrition and organics). The control treatment T_1, 100 per cent NPK alone recorded a lower fruit (6.15 t ha^{-1}) and stover (7.77 t ha^{-1}) yield of tomato, respectively.

The overall improvement in yield attributing characters of tomato was obtained with application of boron + silicon through soil as well as foliar spray along with composted coirpith and recommended dose of NPK. Supply of both micronutrient as well as beneficial nutrient recommended NPK fertilizers play a major role in physiological activities of tomato. Further, the betterment of yield characters might be ascribed to the effect of B and Si which enhanced the photosynthetic activity resulting in the higher biomass production and accumulation of carbohydrates. Further, the increase in the yield should be explained by better flowering and better fruit set in silicon-feed plants. Usage of silicon alleviating abiotic stress (thermal, light, salt stress) can improver flowering and fruit set. Similar results were reported by Sanchez *et al*., (2012) and Jarosz (2014).

Soil physico-chemical properties

The influence of boron and silicon (B and Si nutrition) fertilization along with organics and recommended dose of NPK fertilizer in altering the pH, EC and organic carbon content of the soil at different critical stages of tomato was not significant. But slightly decreased the soil pH and EC and slightly increased the soil organic carbon status as compared to initial status of soil in the treatments applied with composted coirpith and silicon fertilizer.

Available major nutrients

Alkaline $KMnO_4$-N

The availability of nitrogen in coastal soils are very low due to poor crop residues and microbial activity and leaching of nutrients associated with poor structure and low use efficiency of applied nutrients. In the present study, the application of recommended NPK, boron and silicon nutrition along with organics exerted favourable influence in increasing the availability of nitrogen in soil.

The availability of N in the soil significantly increased at all the stages of tomato growth. Among the various treatments, the highest available N status at flowering (167.14 kg ha^{-1}), fruit formation stage (203.74 kg ha^{-1}) and at harvest stage (150.14 kg ha^{-1}) was recorded with the combined application of borax @ 15 kg ha^{-1} + silixol granules @ 20 kg ha^{-1} through soil and foliar spray of borax + silixol @ 0.5% twice along with CCP @ 12.5 t ha^{-1} and recommended dose fertilizer (T_7). This was followed by treatments individual or sole application of boron + silicon nutrition and mode of fertilization either through soil or foliar except T_5, application of 100 per cent RDF + CCP + borax (SA) @ 15 kg ha^{-1} + silixol granules (SA) @ 20 kg ha^{-1} by soil alone, which is on par with treatment T_7. This was followed by application of RDF + CCP +borax + silixol (FA) @ 0.5% by foliar alone (T_6) which recorded nitrogen (151.39, 184.21 and 134.14 kg ha^{-1}) availability at flowering, fruit formation and at harvest stage, respectively. This was followed by the treatments T_3, T_4 and T_2. The control treatment recorded the lowest soil N availability at all the critical stages of tomato.

The application of composted coirpith along with borax @ 15 kg ha^{-1} + silixol granules @ 20 kg ha^{-1} through soil as well as foliar spray of silicon and boron each @ 0.5% recorded significantly higher available nitrogen content in the soil. It may be due to increase in mineralization and higher nitrogen use efficiency in that treatment. This might also be due to the fact that addition of silicon to soil has synergistic effect on nitrogen. Lower nitrogen content was recorded in control treatment. The application of silicon has the potential to raise the optimum N rate thus enhancing productivity of existing crops in coastal saline soils and synergistic effect of added N on performance of Si fertilizer. These results are in accordance with the earlier reports of Ahmed *et al*. (2008) and also it reduces leaching loss of nitrogen (Lalithya *et al.,* 2014).

Olsen-P

The available P in the soil was significantly increased due to the different modes of boron and silicon application along with organics and recommended NPK at all the critical stages like flowering, fruits formation and at harvest stages of tomato. The treatment 100 per cent recommended dose of fertilizer + CCP @ 12.5 t ha^{-1} + borax @ 15 kg ha^{-1} + silixol granules @ 20 kg ha^{-1} through soil and foliar application of borax + silixol @ 0.5 per cent twice (T_7) recorded the highest available P content of 22.36, 16.12 and 11.38 kg ha^{-1} at FS, FFS and at the harvest stage, respectively. This was comparable with treatment T_5, which received RDF + CCP +borax + silixol granules (SA) through soil alone is supplied which recorded a comparable Olsen-P content of 21.98, 16.04 and 11.19 kg ha^{-1} at FS, FFS and at the harvest stage, respectively. This was followed by the treatments arranged in the descending order *viz.,* $T_6 > T_4 > T_3$ and T_2. These treatments were also statistically significant with each other. The control treatment T_1, recorded the lowest Olsen-P content of 7.93 kg ha^{-1} at harvest.

The increased availability of phosphorus increases in organic amendments soil due to large reduction in P sorption. Phosphorus sorption decreased possibly due to competition between phosphate ion and organic compounds that is phenolic and carboxylic and heterocyclic compound, for P retention sites in soil. The added organic forms coating on sesquioxide that reduced phosphorus fixing capacity of soil and increase the availability of phosphorus, the observation was consistent with the finding of Kumar *et al*., (2015).

NH_4OAc-K

The positive influence of B and Si fertilization either through soil or foliar and or both along with organics and recommended dose of NPK was also significantly increased the NH_4OAc-K content of the soil in the present investigation. The application of recommended dose of NPK + borax @ 15 kg ha^{-1} + silixol granules @ 20 kg ha^{-1} by soil along with foliar spray of borax + silixol @ 0.5 per cent twice and CCP @ 12.5 t ha^{-1} (T_7) registered the highest NH_4OAc-K content of 214.02, 201.42 and 173.64

kg ha^{-1} at FS, FFS and at the harvest stages, respectively. However, this was on par with the treatment T_5, RDF + CCP + borax + silixol (SA) through soil alone which shows a comparable K availability of 209.02, 194.97 and 168.28 kg ha^{-1} at FS, FFS and at the harvest stages, respectively. This was followed by the treatments, application of boron and silicon either through soil or foliar alone and recommended NPK along with or without organics significantly decreased the K availability as compared to above said treatments (both SA + FA). The application of RDF + borax + silixol granules through soil (T_3) and RDF + borax + silixol FA (T_4) without organics treatments recorded the lowest K availability in soil as compared to above said treatments. The treatment which received RDF along with organics (T_2) recorded a NH_4OAc-K content of 132.62 kg ha^{-1} at harvest. The control treatment recorded the lowest soil K availability at all the critical stages of tomato.

With the application of recommended dose of NPK + borax @ 15 kg ha^{-1} + silixol granules @ 20 kg ha^{-1} as soil and foliar application of both borax and silixol @ 0.5% twice at pre flowering and flowering stage along with CCP was significant increase in NH_4OAc-K content in the soil. This might be due to higher native K in addition to added potassium. These findings are in conformity with Sainath Nagula (2014). Further, the addition of organic along with NPK fertilizers reduced the K fixation and more K was released due to the clay organic matter interaction contributing higher K to soil available pool. This corroborates the earlier report of (Bipin Bihari, 2017).

Available boron and silicon

The effect due to the different methods of (boron + silicon nutrition) application of borax and silixol granules along with NPK and composted coirpith had significant influence on boron and silicon availability in soil at different stages.

Hot water soluble - Boron

There was significant difference with soil boron availability due to application of boron, silicon and organics. The soil available boron between application of NPK, composted coirpith along with borax and silixol granules through soil as well as foliar application was found to be comparable with the treatment T_5 (RDF + Composted coirpith @ 12 t ha^{-1} + boron and silicon @ 0.5 % as foliar spray) which record a boron content of 1.31 and 1.30 mg kg^{-1} at harvest stage, respectively. This was followed by the treatments significantly arranged in the descending order as $T_6 > T_3 > T_4 >$ and T_2. These treatments were also statistically significant. The lowest Hot water soluble - B was recorded with T_1, the control treatment (RDF alone) that did not received organics, boron and silicon.

The highest B content was recorded with the treatment silixol granules + borax + RDF along with composted coirpith application. The increased use efficiency of applied fertilizer and their availability along with organics in complexing and mobilizing property might have increased the boron content of the soil. This finding was in accordance with the earlier workers (Elayaraja, 2008 and Reddy Bheemanna, 2015). Further, the increased boron availability might be attributed to the direct addition of these nutrients by fertilizer and organic manures, which maintain maximum available boron status in post harvest soil. Further, the complexation of micronutrient with applied organics might have mobilized and increased the availability of B in soil. These results are in line with Beema (2016) and Sivaranjani (2017).

Silicon

A significant increase in silicon nutrition due to the application of NPK + organics and boron + silicon fertilization was well evidenced in the present investigation. As like boron availability, the highest Si availability was recorded with the application of recommended dose of NPK fertilizer + composted coirpith @ 12.5 t ha^{-1} + borax @ 15 kg ha^{-1} + silixol granules @ 20 kg ha^{-1} through soil and foliar spray of borax + silixol granules @ 0.5 per cent (T_7). It recorded a Si availability of 118.42,124.36 and 93.75 mg kg^{-1} which is on par with the treatment T_5 (RDF + Composted coirpith @ 12 t ha^{-1} + boron and silicon @ 0.5% as foliar spray) which records 116.22, 122.71 and 90.23 mg kg^{-1} at flowering, fruit formation and harvest stage, respectively. This was followed by the treatments $T_6 > T_3 > T_4$ and T_2. These treatments were also statistically significant. The control (100% NPK alone) treatment recorded the lowest Si availability at all the critical stages of crop growth (without boron + silicon nutrition and organics).

The silicon availability naturally showed a concomitant increase with application of silicon as soil and foliar spray. Soil application of silixol granules was superior to foliar application. The silicon availability increased from flowering stage to fruit formation stage and then slightly decreased at harvesting stage. This decrease may be due to increased absorption of silicon by the plant at vegetative and reproductive stages. These findings are in agreement with those reported by Sainath Nagula (2014).

Biological properties of soil

Microbial population

Microbial populations of soil microorganisms *viz.*,

Table 1: Effect of organics with boron and silicon fertilization on the physico-chemical properties of soil.

Treatments	pH			EC (dS m^{-1})			OC (g kg^{-1})		
	FS	CFS	HS	FS	CFS	HS	FS	CFS	HS
T_1	8.38	8.34	8.30	2.56	2.45	2.26	2.35	2.37	2.41
T_2	8.27	8.16	8.13	2.36	2.34	2.13	2.57	2.78	2.84
T_3	8.29	8.20	8.19	2.35	2.37	2.14	2.36	2.76	2.40
T_4	8.31	8.24	8.18	2.38	2.36	2.15	2.35	2.36	2.42
T_5	8.25	8.15	8.11	2.35	2.33	2.12	2.55	2.74	2.81
T_6	8.27	8.16	8.14	2.37	2.34	2.14	2.55	2.75	2.82
T_7	8.25	8.15	8.11	2.34	2.33	2.11	2.57	2.73	2.84
SE_D	0.14	0.13	0.11	0.025	0.024	0.022	0.06	0.07	0.08
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2: Effect of organics with boron and silicon fertilization on the nutrients availability in soil.

Treatments	Alkaline $KMnO_4$-N (kg ha^{-1})			Olsen-P(kg ha^{-1})			NH_4OAc-K(kg ha^{-1})			Hot water-B (mg kg^{-1})			Silicon (mg kg^{-1})		
	FS	FFS	HS	FS	FFS	HS	FS	FFS	HS	FS	FFS	HS	FS	FFS	HS
T_1	118.69	143.56	100.97	11.67	10.88	7.93	155.19	140.99	123.88	0.068	0.066	0.064	90.27	93.44	68.45
T_2	127.25	154.24	109.23	13.25	11.77	8.49	164.87	150.77	132.62	0.074	0.073	0.070	95.29	99.24	72.70
T_3	143.45	174.43	126.29	17.30	13.53	9.69	184.88	171.74	149.63	0.082	0.081	0.079	105.97	111.03	81.23
T_4	135.90	164.11	117.64	15.56	12.69	9.10	175.19	161.72	141.07	0.078	0.076	0.074	100.98	105.24	76.90
T_5	163.24	198.89	147.16	21.98	16.04	11.19	209.02	194.97	168.28	0.092	0.090	0.086	116.22	122.71	90.23
T_6	151.39	184.21	134.14	19.27	14.43	10.29	195.13	181.97	157.55	0.087	0.086	0.083	110.92	116.83	85.58
T_7	167.14	203.74	150.14	22.36	16.12	11.38	214.02	201.42	173.64	0.096	0.093	0.090	118.42	124.36	93.75
SE_D	3.43	4.34	3.32	0.48	0.34	0.22	4.20	4.10	3.37	0.001	0.002	0.001	2.23	2.66	1.85
CD (p=0.05)	7.45	9.43	7.22	1.06	0.74	0.48	9.12	8.91	7.32	0.003	0.001	0.002	4.84	5.78	4.02

bacteria, fungi and actinomycetes was significantly increased with different modes of micronutrient application along with organics. An increase in the microbial population upto fruit formation stage and a decline thereafter was noticed (at harvest stage).

Among the various treatments, the combined application of recommended dose of NPK fertilizer + composted coirpith @ 12.5 t ha^{-1} + borax SA @ 15 kg ha^{-1} + silixol @ 20 kg ha^{-1} through soil and foliar spray of borax + silixol @ 0.5 per cent (T_7) recorded the highest population of bacteria (22.98 ´ 10^6 g^{-1} soil), fungi (16.37 ´ 10^5 g^{-1} soil) and actinomycetes (10.97 ´ 10^4 g^{-1} soil) at fruit formation stage. This was followed by the treatment T_5 (RDF + CCP + B + Si as soil application. Regarding micronutrient applied (without organics) treatments *viz*., T_3, (RDF + B @ 15 kg ha^{-1} + Si @ 20 kg ha^{-1} as soil applied), T_4 (RDF + B @ 15 kg ha^{-1} + Si @ 20 kg ha^{-1} as foliar applied) recorded the lowest microbial population count noticed as compared to organics applied treatments. The lowest microbial population of soil was noticed with application of NPK alone as compared to organics along with micronutrients applied treatments. The control treatment T_1, application of recommended dose of fertilizer alone (100% NPK alone) recorded a comparatively lowest microbial population counts of bacteria (16.09 × 10^6), fungi (11.51 × 10^5) and actinomycetes (7.78 × 10^4) at fruit formation stage as compared to application of RDF along with CCP (T_2) which recorded a microbial population of bacteria (17.21 × 10^6), fungi (12.31 × 10^5) and actinomycetes (7.22 × 10^4) at fruit formation stage, respectively.

Soil quality or health does not depend just on physical and chemical properties of soil but it is closely limited to the biological properties of soil. There is positive correlation between soil organic matter content and soil microbial activity. Soil organic matter content hence to be greater in cropping system through incorporation of organic manure along with micronutrients than individual application of RDF alone or without organics and or both micronutrient (B) and beneficial element (Si) alone. Decreased soil organic carbon content and microbial population and increasing erodability are strong indicators of decreasing soil quality. Hence, microbial population and its activities are integral part of soil quality (Thingujam

Table 3: Effect of organics with boron and silicon fertilization on the enzyme activity and microbial population of soil.

Treatments	Dehydrogenase(mg TTF/g soil/24 hrs)			Phosphatase(mg *p*-nitrophenol/g soil/hrs)			Urease(mg NH_4-N/g soil/24 hrs)			Bacteria (x 10^6□□□g soil)			Fungi (x 10^5/ g soil)			Actinomycetes (x 10^4□□□g soil)		
	FS	FFS	HS	FS	FFS	HS	FS	FFS	HS	FS	FFS	HS	FS	FFS	HS	FS	FFS	HS
T_1	43.41	55.01	50.11	7.29	11.07	9.14	12.75	21.34	18.07	12.56	16.09	12.36	10.62	11.51	10.26	5.51	7.78	6.70
T_2	46.51	59.22	53.45	7.92	11.89	9.81	13.71	22.89	19.39	13.58	17.21	13.27	11.33	12.31	10.97	5.95	8.33	7.22
T_3	52.59	67.14	60.10	9.11	13.42	11.05	15.60	25.94	21.91	16.27	19.47	15.10	12.78	13.97	12.44	6.74	9.38	8.18
T_4	49.49	63.14	56.76	8.51	12.62	10.43	14.65	24.39	20.67	15.24	18.36	14.20	12.06	13.16	11.74	6.35	8.85	7.69
T_5	58.70	75.95	66.77	10.40	15.09	12.40	17.55	29.20	24.51	18.68	22.02	17.10	14.32	15.75	14.01	7.69	10.49	9.20
T_6	55.56	71.13	63.38	9.73	14.19	11.70	16.52	27.47	23.17	17.23	20.59	16.02	13.48	14.76	13.18	7.19	9.90	8.66
T_7	61.55	79.07	69.88	10.88	15.74	12.94	18.31	30.49	25.71	19.46	22.98	17.84	14.89	16.37	14.59	8.02	10.97	9.64
SE_D	1.35	1.77	1.47	0.23	0.33	0.27	0.40	0.68	0.55	0.41	0.50	0.38	0.30	0.35	0.31	0.17	0.23	0.20
CD (p=0.05)	2.95	3.86	3.21	0.52	0.72	0.59	0.87	1.48	1.21	0.89	1.09	0.83	0.66	0.78	0.69	0.38	0.51	0.45

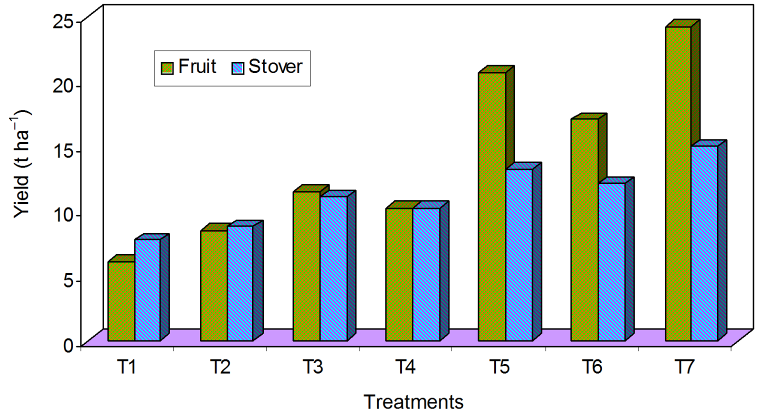

Fig. 1: Effect of organics with boron and silicon fertilization on the yield of tomato.

et al., 2016). In the over all improvement of microbial counts in soil with application of organics along with micronutrients may be due to better soil biological environment of coastal saline soil (Prasad, 2008 and Aminum Nahar *et al.*, 2013).

Enzyme activity

Among the various treatments, the combined application of recommended dose of NPK fertilizer + composted coirpith @ 12.5 t ha^{-1} + borax SA @ 15 kg ha^{-1} + silixol @ 20 kg ha^{-1} through soil and foliar spray of borax + silixol @ 0.5 per cent (T_7) recorded the highest enzyme activity at all formation stage. This was followed by the treatment T_5 (RDF + CCP + B + Si as soil application) and T_6. Regarding micronutrient applied (without organics) treatments *viz.*,

T_3, (RDF + B @ 15 kg ha^{-1} + Si @ 20 kg ha^{-1} as soil applied), T_4 (RDF + B @ 15 kg ha^{-1} + Si @ 20 kg ha^{-1} as foliar applied) recorded the enzyme activity noticed as compared to organics applied treatments. The lowest enzyme activity was noticed in control (NPK alone).

The increased rate of nitrogen application and organics added to the soil as well as the root exudates promoted the nitrogenase substances which have induced the urease activity. Urease activity in soil originated from soil microbes containing urease and approximately 17-77% soil bacteria and 78-98% soil fungi have capacity to hydrolyze urea into ammonia. From the result obtained, the enzyme activity enhanced with application of silicon. The results of the present findings are agreeable with the results obtained by Chai *et al.*, (2016). The increase in the soil alkaline phosphatase activity with the addition of organics could have been due to the soil substrate enrichment caused by the addition of mineral fertilizers. The phosphates added through organics and fertilizer improved the phosphatase activity, which may be ascribed to the stabilized extra cellular fraction of enzyme. Many authors in the past (Gopal Reddy, 1997 and Singaram and Kamalakumari, 2000) also reported the increasing phosphatase activity by the application of organics. The increased dehydrogenase activity might be due to the incorporation of organics, owing to increase in microbial activity of the soil. Similar results were reported by Liang *et al.*, (2005). The application of silicon at increasing rate can increases the enzyme activities such as urease, catalase and fluorescein diacetate hydrolase (FDA) and the results confirmed the capability of silicon to maintain or enhance the microbial activity in stimulating nutrient availability and to promote microbial deoxygenation of the micro environments. These findings are in conformity with Chai *et al*., (2016).

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