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Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid in cucumber (*Cucumis sativus* L.) on yield and nutrient status of alfisols of Konkan

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Abstract
The field experiment was carried on alfisols of Konkan to evaluate the "Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid in cucumber (*Cucumis sativus* L.) on yield and nutrient status of alfisols of Konkan" The experiment was laid out in Randomized Block Design (RBD) comprising ten treatment combinations replicated thrice, where the effect of soil and foliar supplementation of nitrogen, boron and salicylic acid either alone or in combinations applied along with the recommended dose of fertilizers (135:60:30 NPK kg ha^{-1}) and an absolute control (to judge the fate of native nutrients) were studied. The investigation was revealed that the yield and available nutrients i.e., available nitrogen, phosphorus, potassium and boron found influenced due to application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) along with 15 t ha^{-1} FYM, significantly.

Keywords: Cucumber, boron, nutrient status, salicylic acid

1. Introduction
Cucumber (*Cucumis sativus* L.), a native of Asia and Africa, is popular vegetable among cucurbitaceous family. It is grown for its edible tender fruits in almost all often world under tropical and subtropical conditions and in all parts of India for last three thousand years. It is said to be the native of northern India (Pursglove, 1969) [32]. Nutritionally 100g of edible portion of cucumber contains 96.3 g moisture, 2.5 g carbohydrates, 0.4 g protein, 0.1 g fat, 0.3 g minerals, 10 mg calcium, 0.4 g fiber and traces of vitamin C and iron. The fruits of cucumbers possesses various medicinal properties e.g. cooling effect, prevents constipation, checks jaundice and indigestion (Nandkarni, 1927) [27]. Nitrogen plays a most important role in various physiological processes. It imparts dark-green colour in plants, promotes leaves, stem and other vegetative part's growth and development. Moreover, it also stimulates root growth. It encourages the uptake and utilization of other nutrients including potassium, phosphorous and controls overall growth of plant (Bloom, 2015 and Hemerly, 2016) [9, 18]. In 1923, it was first time reported that B is essential for cell structure of plants (Warington, 1923) [38]. The possible roles of B include sugar transport, cell wall synthesis, lignification, cell wall structure integrity, carbohydrate metabolism, ribose nucleic acid (RNA) metabolism, respiration, indole acetic acid (IAA) metabolism, phenol metabolism, and as part of the cell membranes (Parr and Loughman, 1983; Ahmad *et al*., 2009) [29, 1]. Exogenous application of SA may influence a range of diverse processes in plants, including stomatal closure, ion uptake and transport (Gunes *et al*., 2005) [17], membrane permeability (Barkosky and Einhellig, 1993) [4], as well as photosynthetic and growth rates (Khan *et al*., 2003) [24].
Among the methods of fertilizer application, foliar nutrition is recognized as an important method of fertilization, since foliar nutrients usually penetrate the leaf cuticle or stomata and enters the cells facilitating easy and rapid utilization of nutrients (Latha and Nadanassababady, 2003) [25]. As cucumber is one of the important summer sown economic crop of Konkan and foliar fertilization may provide a new approach to improve cucumber quality and productivity and such no work on foliar application has been done on summer grown cucumber in lateritic soils of Konkan, the present study on "Effect of foliar supplementation of nitrogen, boron and

salicylic acid in cucumber (*Cucumis sativus* L.) on yield and nutrient status of alfisols of Konkan" is proposed to be undertaken.

2. Material and Methods

The experiment was conducted during the summer season of 2018 at Research and Education Farm Department of agricultural Botany, College of Agriculture; Dapoli is situated in the tropical region on 17º 45' N latitude and 73º 11' E longitude. The town is located at altitude of 800 ft. (240m) and 8 km from Arabian sea having hot and humid climate with well-expressed three seasons *viz*., Summer (March to May), Rainy (June to October) and Winter (November to February). The region receives very high rainfall (above 3000 mm, annually) on lateritic soil, which is a member of fine, mixed, isohyperthermic family of Fluventic Ustropepts (Bhattacharjee *et al*, 1978) [6]. The soil was moderately acidic in reaction and having normal electrical conductivity, moderately high in organic carbon, low in available nitrogen and very low and very high in available phosphorus and available potassium, respectively (Table 1)

Table 1: Initial Physico-chemical properties of the experimental field

Sr. No.	Property		Content
1.	Physico-Chemical Properties		
	I)	pH (1:2.5)	5.51
	II)	Electrical conductivity (dS m^{-1})	0.013
	III)	Organic Carbon (g kg^{-1})	11.4
	IV)	Available N (kg ha^{-1})	179.0
	V)	Available P_2O_5 (kg ha^{-1})	8.54
	VI)	Available K_2O (kg ha^{-1})	383.0
	VII)	Available B (mg kg^{-1})	0.26
	VIII)	Available Fe (mg kg^{-1})	33.86
	IX)	Available Mn (mg kg^{-1})	61.6
	X)	Available Zn (mg kg^{-1})	0.23
	XI)	Available Cu (mg kg^{-1})	3.44

The experiment was laid out in Randomized Block Design with ten treatments and replicated thrice. The treatment comprised *viz* T_1-Absolute control, T_2-135:60:30 kg $N:P_2O_5:K_2O$ only, T_3- RDF+ Foliar spray of nitrogen through urea @ 1%, T_4-RDF + Foliar spray of boron through boric acid @ 0.5%, T_5 -RDF+ Soil application of boron through borax @ 2 kg ha^{-1}, T_6 - RDF + Foliar spray of salicylic acid @ 0.2%, T_7 -RDF + Foliar spray of boron @ 0.5% + Foliar spray of salicylic acid @ 0.2%, T_8 -RDF + Foliar spray of nitrogen @1% + Foliar spray of boron @ 0.5% + Foliar spray of salicylic acid @ 0.2%, T_9-RDF + Foliar spray of nitrogen through urea @ 0.1% + Soil application of boron @ 2 kg ha^{-1} + Foliar Spray of salicylic acid @ 0.2%, T_{10} -RDF + Foliar boron through Amrashakti @ 2%. After the preparation of plots, FYM was added @ 15 t ha^{-1} as common to all treatments except control Nitrogen @ 135 kg ha^{-1} was applied in two splits *viz*., first dose of 50 per cent N before sowing and second dose of 50 per cent at 30 days after sowing in the pertinent treatments. Phosphorus @ 60 and potassium @ 30 kg ha^{-1} were applied in a single dose before the time of sowing in the pertinent treatments. For foliar application, nitrogen through urea @ 1%, boron through boric acid @ 0.5%, salicylic acid @ 0.2% and Amrashakti @ 0.2% solutions for foliar application were prepared by dissolving the respective weight of chemical in respective quantity of water by continuous stirring and were applied during early morning using a Knapsack Sprayer at 30 and 60 Days after sowing (DAS).

The Cucumber cv. Sheetal released by Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli in 1984; was sown at 15 March 2018 by dibbling method with spacing of 4.0 m x 3.0 m. The fruits collected from each net plot were weighed on monopan balance and fruit yield per plot was recorded which was subsequently expressed on hectare basis. In case of soil analysis, treatment wise representative surface soil samples (up to 22.5 cm) were collected at 30 DAS, 60 DAS and at harvest of the crop with the help of screw auger. Then the treatment wise composite samples were prepared by mixing the soil and following the principle of quartering. These samples were air dried in shade, pounded in wooden mortar and pestle, sieved through 2 mm sieve and 0.5 mm sieve (for organic carbon) and stored in plastic bags in corrugated boxes. Available nitrogen was determined by alkaline permanganate (0.32% $KMnO_4$) method (Subbiah and Asija 1956). Available phosphorus - Bray II method by developing blue colour with ammonium molybdate and stannous chloride outlined by Black (1965) [8], available potassium estimated on flame Photometer model using neutral-normal-ammonium acetate (NH_4OAc, pH 7.0) as per procedure given by Jackson (1973) [20] and hot water extractable method of Berger and Troug (1939) [5] using Azomethine-H reagent and then B was estimated by colorimetrically at 420 nm on spectrophotometer.

3. Results and Discussion

3.1 Yield

Application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + Foliar spray of nitrogen through urea 1% + Soil application of boron through borax @ 2 kg ha^{-1}+ Foliar spray of salicylic acid 0.2% (i.e. treatment T_9) recorded the maximum fruit yield (231.22 q ha^{-1}) shown in table 2. In case boron application, the foliar spray of boric acid 0.5% (T_4) recorded the significant higher values compared with the soil application of borax @ 2 kg ha^{-1} (T_5) indicating thereby the superiority of foliar over the soil application method. Increase in yield of plant might be due to foliar application of boron which is involved in development of cell wall, cell differentiation and root and shoot elongation. It is also involved in ovary developments, seed development and maturity of crop plant. This may be attributed to greater photosynthetic activity, resulting the increased production and accumulation of carbohydrates and favourable effect on retention of flowers and fruits, which might have increased number and weight of fruits (Patidar *et al*. 2017 and Brown 1979) [30]. Results are in conformity with Ghayal (2016) [15] and Torane (2014) [37] in lateritic soils of Konkan region.

3.2 Nutrient status

3.2.1 pH

The soil pH at various observational periods ranged from4.68 to 5.21 at 30 DAS, 5.18 to 5.44 at 60 DAS and 5.13 to 5.70 at harvest stage (Table 2). The data further indicated that the application of soil and foliar application of nitrogen, boron and salicylic acid did not influence significantly on pH of the soil at various growth stages. In general, the soil pH appears to increase with the advancement of crop from 30 to 60 DAS irrespective of the treatment without any specific trend of increase or decrease was observed at harvest.

The mechanism responsible for this increased in soil pH was due to ion exchange reactions which occur when terminal

OH- of Al or Fe^{2+} hydroxyl oxides are replaced by organic anions, which are decomposed products of the manure such as malate, citrate and tartarate (Eshoo and Bell, 1992; Pocknee and Summer, 1997 and Hue and Amiens, 1989) [14, 31, 19]. Further, non-significant effect of foliar application of urea and Amrashakti on soil pH was stated by Jadhav (2018) [31] and Palsande (2011) [28]. In lateritic soils of Konkan, Kadu (2015) also reported non-significant effect of foliar spray of boron on soil pH applied to water melon.

3.2.2 Electrical conductivity (EC) (dS m^{-1})

The data shown in table 2 indicated that the application of soil and foliar application of nitrogen, boron and salicylic acid did not influence significantly on EC of the soil at various observational periods. In the present investigation, the soils showed slight increase due to the application of FYM @ 15 t ha^{-1} along with RDF during the period of study with the exception of T_2 at 30 DAS and T_2, T_4 and T_5 at 60 DAS which might be due to the possible built up of the soluble nutrient drawn from manures on mineralization. In lateritic soils of Konkan, Kadu (2015) also reported non-significant effect of foliar spray of boron applied to water melon on EC of soil.

3.2.3 Organic Carbon

The ranges given in table 2 indicated that the organic carbon in the soil was in "very high range" as per the ranges proposed by Bangar and Zende (1978) [3]. These figures are in conformity with reported earlier (Anonymous, 1990 and Diwale, 1994) [2, 13]. In general, the data indicated that the organic carbon content of the soil decreased from 30 DAS to 60 DAS (except T_4 at 60 DAS) and from 60 DAS to harvest of the crop (except T_8 at harvest). This is probably due to the decomposition of applied and native organic matter. The application of soil and foliar application of nitrogen, boron and salicylic acid did not showed significant result at various growth stages of crop. Also, Mondal *et al*. (1991) [26] and De *et al*. (1994) [12] studied the relationship of B with various soil properties and found negative correlation with organic carbon of the soil. Similarity, in lateritic soils of Konkan, Kadu (2015) also reported non-significant effect of foliar spray of boron on organic carbon applied to water melon.

3.2.4 Available Nitrogen (kg ha^{-1})

The soil application of borax @ 2 kg ha^{-1} in the treatments T_9 and T_5 recorded the significant higher values of available nitrogen in the soilindicating thereby the role of boron in increasing the available nitrogen in soil. Significantly highest available nitrogen i.e. 371.20 kg ha^{-1} at 30 DAS, 357.64 at 60 DAS and 293.74 kg ha^{-1} at harvest stage was recorded treatment T_9 with the application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + foliar spray of nitrogen through urea (1%) + Soil application of boron through Borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) which was found to be at par with the treatments T_5 at all growth stages of crop. In general, the data (Table 3) indicated that the soil having high organic matter content showed high available N. The increase in organic matter may be due to accumulation of leaf litter fall during the period of fruit development as the numbers of leaves were enhanced with foliar spray over the control. Organic matter mineralization provides a continuous, although limited, supply of plant available N, in addition to P and S (Tisdale *et al*., 1995) [36]. Available nitrogen from soil reported here are in agreement with Ghayal (2016) [15], Gite (2018) [16], Kadu (2015) and Bhosale (2016) [7] in lateritic soils.

3.2.5 Phosphorus (P_2O_5) (kg ha^{-1})

Data given in table 3 indicated significantly highest available phosphorus i.e. 19.97 kg ha^{-1} at 30 DAS, 18.39 kg ha^{-1} at 60 DAS and 15.12 kg ha^{-1} at harvest stage was recorded in treatment T_9, which was significantly superior over rest of all treatments at 60 DAS; while was at par with T_5 at 30 DAS and at harvest. Among other treatments, T_2 and T_3 were at par with each other at 30 DAS and at harvest; while T_2, T_3 and T_5 were at par with each other at 60 DAS. The increased in phosphorous availability might be also due to synergistic effect of N with phosphorus which increased the availability of P in the soil (Shrivastava, 2002). Mondal *et al*. (1991) [26] and De *et al*. (1994) [12] studied the relationship of B with various soil properties and found positive correlation with available phosphorus in the soil. The results are in agreement with Gite (2018) [16], Kadu (2015) and Bhosale (2016) [7].

3.2.6 Available Potassium (K_2O) (kg ha^{-1})

Significantly highest available potassium (Table 3) i.e. 356.89 kg ha^{-1} at 30 DAS, 341.11 kg ha^{-1}at 60 DAS and 310.30 kg ha^{-1} at harvest stage was recorded in treatment T_9, which was found to be at par with the treatments T_5 at 30 DAS, 60 DAS and at harvest stage. Thus, the higher values of available potassium in soil were noted with the soil application of borax @ 2 kg ha^{-1} in treatments T_9 and T_5 thereby indicating the role of boron in increasing the available potassium in soil.Graded increase in available K_2O content of soil with the graded doses of boron applied through briquettes in lateritic soils of Konkan was also reported by Kadam (2016) [22]; Mondal *et al*. (1991) [26] and De *et al*. (1994) [12] studied the relationship of B with various soil properties and found positive correlation with available potassium in the soil. In addition, available K tended to decline with time irrespective of different treatments. This decrease in K_2O content may probably attributed to leaching of soluble K fractions and removal of solutions K^+ by crop (Tisdale *et al*., 1995) [36].

3.2.7 Hot water extractable Boron (mg kg^{-1})

Hot water extractable boron in soil was significantly affected due to the soil and foliar supplementation of nitrogen, boron and salicylic acid. Treatment T_9 recorded significantly highest available boron i.e.0.426 mg kg^{-1}at 30 DAS, 0.400 mg kg^{-1} at 60 DAS and 0.378 mg kg^{-1}at harvest stage and also it found at par with T_5 and T_8 at all observational periods.The treatment T_2 i.e. application of recommended dose of fertilizer and treatment T_{10} i.e.RDF+ Amrashakti @ 2% were at par with each other at all the periods of observations (Table 3). The decrease boron content in plant may be attributed to the dilution effect of dry matter production. The availability of boron decrease sharply under drought conditions, possible because of both a decrease in B mobility by mass flow to the roots and polymerization of boric acid (Das, 2007) [11]. In the present investigation, the soil application of boron recorded the higher values of hot water extractable boron content in soil with the soil application of borax @ 2 kg ha^{-1} in treatments T_9 and T_5. The results are reported here are similar with Kadu (2015) and Savkare (2018) [33].

Table 2: Effect of soil and foliar application of nutrients on fruit yield of cucumber, pH, electrical conductivity and organic carbon of soil

Tr code	Treatments	Fruit yield (q ha^{-1})	pH			EC (dS m^{-1})			Organic carbon (g kg^{-1})		
			30 DAS	60 DAS	At Harvest	30 DAS	60 DAS	At Harvest	30 DAS	60 DAS	At Harvest
T_1	Control (No Fertilizer)	58.53	5.05	5.41	5.13	0.14	0.15	0.06	17.41	16.93	15.21
T_2	Recommended Dose of Fertilizer 135:60:30 NPK kg ha^{-1}	85.21	5.11	5.18	5.09	0.13	0.14	0.12	18.98	18.72	18.07
T_3	RDF+ Foliar spray of Urea (1%)	153.41	4.68	5.28	5.34	0.15	0.21	0.10	18.59	18.20	16.37
T_4	RDF+ Foliar spray of Boric acid (0.5%)	170.73	4.92	5.07	5.26	0.17	0.08	0.12	17.67	17.68	17.16
T_5	RDF+ Soil application of Borax @ 2 kg ha^{-1}	144.95	4.98	5.29	5.09	0.29	0.10	0.09	18.59	17.28	17.02
T_6	RDF+ Foliar spray of Salicylic acid (0.2%)	175.31	4.80	5.12	5.42	0.20	0.20	0.06	18.85	17.75	16.01
T_7	RDF+ Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	206.16	5.08	5.44	5.70	0.15	0.17	0.07	17.54	17.03	16.88
T_8	RDF+ Foliar spray of Urea (1%) + Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	216.87	4.88	5.17	5.39	0.17	0.25	0.07	17.81	17.19	17.60
T_9	RDF+ Foliar spray of Urea (1%) + Soil application of Borax @ 2 kg ha^{-1}+ Foliar spray of Salicylic acid (0.2%)	231.22	5.21	5.32	5.15	0.28	0.26	0.14	19.26	18.59	17.16
T_{10}	RDF+ Amrashakti @ 2%	129.96	4.92	5.17	5.39	0.26	0.21	0.08	17.42	18.46	16.38
	S.E. +	17.20	0.156	0.124	0.139	0.14	0.15	0.06	0.77	0.62	0.84
	C.D. (P=0.05)	51.10	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3: Effect of soil and foliar application of nutrients on available nitrogen, phosphorus, potassium and hot water extractable boron of soil

Tr no	Treatments	Available Nitrogen (kg ha^{-1})			Available Phosphorus (kg ha^{-1})			Available Potassium (kg ha^{-1})			Hot water extractable Boron (mg kg^{-1})		
		30 DAS	60 DAS	At Harvest	30 DAS	60 DAS	At Harvest	30 DAS	60 DAS	At Harvest	30 DAS	60 DAS	At Harvest
T_1	Control (No Fertilizer)	229.42	246.03	189.17	11.15	10.72	9.92	233.22	225.91	120.85	0.231	0.204	0.197
T_2	Recommended Dose of Fertilizer 135:60:30 NPK kg ha^{-1}	328.81	344.54	277.54	17.03	16.01	13.36	336.77	273.86	264.70	0.269	0.242	0.238
T_3	RDF+ Foliar spray of Urea (1%)	324.38	300.71	264.02	17.05	15.22	12.75	258.24	251.64	219.17	0.287	0.260	0.240
T_4	RDF+ Foliar spray of Boric acid (0.5%)	314.41	274.56	250.51	14.47	12.82	11.29	267.77	252.44	256.82	0.238	0.211	0.202
T_5	RDF+ Soil application of Borax @ 2 kg ha^{-1}	361.42	348.06	287.39	18.24	16.28	14.44	348.30	322.50	299.09	0.394	0.367	0.355
T_6	RDF+ Foliar spray of Salicylic acid (0.2%)	319.35	281.24	263.72	16.50	13.49	10.41	284.53	275.47	261.43	0.247	0.227	0.237
T_7	RDF+ Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	265.40	250.36	221.76	13.23	11.05	10.05	254.48	244.78	197.34	0.290	0.263	0.244
T_8	RDF+ Foliar spray of Urea (1%) + Foliar spray of Boric acid (0.5%) + Foliar spray of Salicylic acid (0.2%)	305.64	260.21	256.51	13.72	12.10	10.49	325.73	292.63	286.92	0.335	0.308	0.288
T_9	RDF+ Foliar spray of Urea (1%) + Soil application of Borax @ 2 kg ha^{-1}+ Foliar spray of Salicylic acid (0.2%)	371.20	357.64	293.74	19.97	18.39	15.12	356.89	341.11	310.30	0.426	0.400	0.378
T_{10}	RDF+ Amrashakti @ 2%	255.38	253.82	209.27	13.12	11.17	9.92	250.44	233.46	159.01	0.242	0.220	0.219
	S.E. +	4.26	3.97	4.11	0.73	0.65	0.50	3.90	8.85	4.04	0.03	0.03	0.03
	C.D. (P=0.05)	12.67	11.80	12.22	2.17	1.93	1.49	11.59	26.29	12.02	0.11	0.11	0.10

4. Conclusion

Application of recommended dose of fertilizer (135:60:30 kg ha-1) + foliar spray of Nitrogen through urea (1%) + soil application of boron through borax @ 2 kg ha^{-1}+ foliar spray of salicylic acid (0.2%) resulted in significant increase in fruit yield of cucumber as well as available nitrogen, available phosphorus, available potassium and hot water soluble boron content in soils indicating buildup of soil fertility.

5. References

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