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Response of Lime, B and Zn on Growth and Yield of Broccoli (*Brassica oleracea* var. *italica*) var. Palam Samridhi

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ABSTRACT

The present field investigation was conducted at Department of Vegetable Science, College of Agriculture, OUAT, Bhubaneswar, Odisha, India during *rabi* season of 2017-18 to study the effect of lime, boron and zinc on growth and yield of broccoli (*Brassica oleracea* var. *italica*). The experiment was conducted with seven levels of micronutrient as soil application of borax @ 1kg ha⁻¹, ZnSO₄ @ 5kg ha⁻¹ and their combinations as well as foliar spray of 0.2% borax, 0.5% ZnSO₄ and their combinations along with control as sub plot and two level of lime (with and without lime) as main plot, in split plot design replicated thrice. The results revealed that combined foliar application of 0.2% borax with 0.5% ZnSO₄, irrespective of lime application recorded significantly maximum plant height (46.27 cm), leaves plant⁻¹ (24.62), stem girth (16.85 cm), plant spread (62.20 cm), leaf area (557.50 cm²), weight and diameter of central head (313.67g, 17.37cm), secondary head (88.83g, 5.33cm), total head weight (402.50g) with total head yield (136.80 qha⁻¹) in broccoli var. Palam Samridhi. Similarly, lime application, irrespective of micronutrient significantly influence both vegetative growth, *viz*: plant height (42.09 cm), leaves plant⁻¹ (23.46), stem girth (16.30 cm), plant spread (58.65 cm) and leaf area (486.62 cm²) as well as yield and yield attributing parameters, *viz*: weight and diameter of central head (305.52g, 17.18cm), secondary head (84.36g, 5.34cm) and total head weight (389.88g) with maximum total head yield (134.73 qha⁻¹) in broccoli var. "Palam Samridhi". Hence, it may be concluded combined application of borax @ 0.2% with ZnSO₄ @ 0.5% along with lime as soil application not only increases the growth but also yield in broccoli.

Keywords

Lime, B and Zn,
Broccoli (*Brassica oleracea* var. *italica*)

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Introduction

Broccoli (*Brassica oleracea* var. *italica*) is one of the most nutritious edible green plants of Brassicaceae family, whose large flowering head is edible. The word *broccoli* comes from the Italian plural *broccolo*, means the

"flowering crest of cabbage", and the diminutive form of *brocco*, means "small nail" or "sprout". It is cultivated as an under exploited vegetable in India. Broccoli has 14 times more beta-carotene than cultivated cabbage (Sharma, 2000). As it rich in vitamin C, thus reduces the risk of cardiovascular

disease (Du *et al.*, 2012). The American Society of Cancer recommended broccoli as anti-cancer food, due to presence of higher concentration of compound, Sulphoraphane. Successful production of broccoli includes many factors of which application of micronutrients such as B and Zn is most important. Even though micronutrients are required in small quantities, are very much essential for good crop growth and achieving profitable yield. Soil pH does play a vital role in nutrient availability to plants. Low or acidic pH in soil restricted assimilation of many important nutrients. Application of lime in acidic soil helps to adjust the pH, which facilitates the optimum availability of nutrients. So application of micronutrient without concurrent use of lime may not be adequate to improve growth and productivity of micronutrient sensitive crops (Das *et al.*, 2017). Foliar application of micronutrient is beneficial during active growth phase of crop (Kolota and Osinska, 2001). Both B and Zn are two most important micro-nutrients essential for cell division, nitrogen and carbohydrate metabolism as well as water relation in plant growth (Brady, 1990). Application of B significantly helps in increasing the vegetative growth and head yield in broccoli (Yang *et al.*, 2000). Similarly, Zn helps in many enzymatic activities in plant, chlorophyll synthesis and carbohydrate formation accelerates the plant growth (Tisdale *et al.*, 1985). Keeping in view, the present study was undertaken to find out the efficacy of lime, boron and zinc on growth and yield of broccoli var. "Palam Samridhi".

Materials and Methods

The study was carried out at Department of Vegetable Science, College of Agriculture, OUAT, Bhubaneswar, Odisha, India during *rabi* season of 2017-18. The experiment was laid out in split-plot design with three

replications. Main plot consisted of two lime treatments- without lime (L_0), with lime (L_1) and seven levels of micronutrients in subplots, viz; soil application of borax @ 1 kg ha^{-1} (M_1), foliar application of borax @ 0.2% (M_2), soil application of ZnSO_4 @ 5 kg ha^{-1} (M_3), foliar application of ZnSO_4 @ 0.5% (M_4), combined soil application of borax @ 1 kg ha^{-1} + ZnSO_4 @ 5 kg ha^{-1} (M_5), combined foliar spray of borax @ 0.2% + ZnSO_4 @ 0.5% (M_6), control (without borax and ZnSO_4) (M_7). A uniform dose of FYM @ 25 tha^{-1} and 150:100:50 NPK kg ha^{-1} was applied. Three sprayings were done at 20, 35 and 50 days after transplanting according to the treatment schedule. During the crop growth period regular and normal intercultural operations and insect pest and disease control measures were carried out as per requirement to maintain crop health. Observations were recorded from five randomly selected plants on vegetative growth, head yield and yield attributing parameters and more, subjected to statistical analysis by adopting standard procedures (Panse and Sukhatme, 1985).

Results and Discussion

Vegetative growth parameters

Significant variations for all the vegetative growth parameters were observed due to application of lime and micronutrient (B and Zn) which is presented in table 1. Significantly highest plant height (42.09 cm), leaves plant^{-1} (23.46), stem girth (16.30 cm), plant spread (58.65 cm) and leaf area (486.62 cm^2) was recorded in plots treated with lime than the plots without lime (38.92 cm, 21.17, 15.43 cm, 54.22 cm and 458.67 cm^2 , respectively). This might be due to application of lime in acid soil helps in adjusting the soil pH which in turns optimize the availability of many nutrients, affect positively the plant growth and development.

Table.1 Effect of Lime, B and Zn on vegetative growth parameters in Broccoli var. Palam Samridhi

Treatment	Plant height (cm)			Number of leaves plant ⁻¹			Stem girth (cm)			Plant spread (cm)			Leaf area (cm ²)		
	Lime			Lime			Lime			Lime			Lime		
	L ₀	L ₁	Mean	L ₀	L ₁	Mean	L ₀	L ₁	Mean	L ₀	L ₁	Mean	L ₀	L ₁	Mean
M₁	36.47	38.37	37.42	19.33	22.23	20.78	15.43	15.77	15.60	53.47	55.07	54.27	404.33	412.67	408.50
M₂	41.67	46.21	43.94	21.57	22.37	21.97	15.57	16.00	15.78	55.17	59.43	57.30	421.67	432.67	427.17
M₃	35.77	39.17	37.47	20.57	24.10	22.33	14.20	15.83	15.02	52.47	54.27	53.37	412.67	438.33	425.50
M₄	41.63	47.23	44.43	22.03	25.47	23.75	15.80	16.33	16.07	55.67	63.10	59.38	530.00	551.67	540.83
M₅	38.93	41.87	40.40	21.67	22.27	21.97	15.97	17.13	16.55	55.30	58.10	56.70	510.00	584.00	547.00
M₆	45.17	47.37	46.27	23.77	25.47	24.62	16.13	17.57	16.85	59.27	65.13	62.20	542.00	573.00	557.50
M₇	32.83	34.40	33.62	19.27	22.33	20.80	14.93	15.47	15.20	48.20	55.47	51.83	390.00	414.00	402.00
Mean	38.92	42.09	40.51	21.17	23.46	22.32	15.43	16.30	15.87	54.22	58.65	56.44	458.67	486.62	472.64
	SE	CD	CV	SE	CD	CV	SE	CD	CV	SE	CD	CV	SE	CD	CV
	(m)±	(5%)	(%)	(m)±	(5%)	(%)	(m)±	(5%)	(%)	(m)±	(5%)	(%)	(m)±	(5%)	(%)
Lime	0.32	1.96	3.64	0.34	2.05	6.91	0.14	0.83	3.95	0.27	1.65	2.20	4.49	27.31	4.35
Micro-nutrients	0.97	2.84	5.88	0.38	1.12	4.20	0.27	0.80	4.24	1.08	3.15	4.68	12.40	36.19	6.43
Interaction	1.38	NS		0.54	NS		0.39	NS		1.53	NS		17.54	NS	

L₀: Without lime; L₁: With lime

M₁: Soil application of boron@1kg ha⁻¹; M₂: Foliar spray of borax @ 0.2%

M₃: Soil application of zinc @5kg ha⁻¹; M₄: Foliar spray of ZnSO₄ @ 0.5%

M₅: Combined soil application of @1kg ha⁻¹ + zinc @5kg ha⁻¹; M₆: Combined foliar spray of borax @ 0.2% + ZnSO₄ @ 0.5%

M₇: Control (Without lime, boron and zinc)

Table.2 Response of lime, boron and zinc on head weight parameters in Broccoli var. Palam Samridhi

Treatment	Average weight of central head (g)			Average weight of secondary head (g)			Average head weight plant ⁻¹			Central head to secondary head ratio		
	Lime			Lime			Lime			Lime		
	L ₀	L ₁	Mean	L ₀	L ₁	Mean	L ₀	L ₁	Mean	L ₀	L ₁	Mean
M1	301.00	305.00	303.00	70.17	81.67	75.92	371.17	386.67	378.92	4.29	3.75	4.02
M2	305.00	309.33	307.17	76.00	80.00	78.00	381.00	389.33	385.17	4.02	3.90	3.96
M3	236.50	261.33	248.92	71.67	83.33	77.50	308.17	344.67	326.42	3.31	3.14	3.23
M4	276.17	322.67	299.42	77.33	88.33	82.83	353.50	411.00	382.25	3.58	3.66	3.62
M5	268.00	318.00	293.00	78.00	87.00	82.50	346.00	405.00	375.50	3.45	3.65	3.55
M6	285.33	342.00	313.67	85.67	92.00	88.83	371.00	434.00	402.50	3.33	3.74	3.54
M7	215.00	280.33	247.67	71.67	78.17	74.92	286.67	358.50	322.58	3.00	3.59	3.30
Mean	269.57	305.52	287.55	75.79	84.36	80.07	345.36	389.88	367.62	3.57	3.64	3.60
	SE(m)±	CD(5%)	CV(%)	SE (m)±	CD(5%)	CV (%)	SE (m)±	CD (5%)	CV (%)	SE (m)±	CD (5%)	CV(%)
Lime	2.59	15.78	2.59	1.36	8.25	1.36	2.06	12.52	2.57	0.08	NS	10.33
Micronutrients	7.33	21.39	7.33	2.00	5.83	2.00	7.41	21.62	4.93	0.14	0.40	9.24
Interaction	10.36	NS	10.36	2.82	NS	2.82	10.47	NS		0.19	NS	

L₀: Without lime; L₁: With lime

M₁: Soil application of boron@1kg ha⁻¹; M₂: Foliar spray of borax @ 0.2%

M₃: Soil application of zinc @5kg ha⁻¹; M₄: Foliar spray of ZnSO₄ @ 0.5%

M₅: Combined soil application of @1kg ha⁻¹ + zinc @5kg ha⁻¹; M₆: Combined foliar spray of borax @ 0.2% + ZnSO₄ @ 0.5%

M₇: Control (Without lime, boron and zinc)

Table.3 Response of lime, boron and zinc on head yield attributing parameters in Broccoli var. Palam Samridhi

Treatment	Diameter of central head (cm)			Diameter of secondary head(cm)			Days to central curd maturity			Days taken for last harvesting of secondary head		
	Lime			Lime			Lime			Lime		
	L ₀	L ₁	Mean	L ₀	L ₁	Mean	L ₀	L ₁	Mean	L ₀	L ₁	Mean
M1	13.97	16.17	15.07	4.86	5.22	5.04	67.40	63.40	65.40	78.73	75.90	77.32
M2	14.67	17.50	16.08	4.88	5.30	5.09	67.70	67.00	67.35	79.53	79.50	79.52
M3	15.30	17.77	16.53	5.00	5.12	5.06	65.00	64.93	64.97	77.50	77.43	77.47
M4	16.30	18.73	17.52	4.73	5.50	5.12	64.53	64.37	64.45	76.77	75.27	76.02
M5	16.00	16.97	16.48	5.22	5.27	5.24	65.63	65.40	65.52	78.13	75.87	77.00
M6	16.93	17.80	17.37	4.48	6.17	5.33	65.33	64.13	64.73	76.77	74.97	75.87
M7	12.73	15.33	14.03	4.65	4.83	4.74	74.20	69.87	72.03	84.83	83.03	83.93
Mean	15.13	17.18	16.15	4.83	5.34	5.09	67.11	65.59	66.35	78.90	77.42	78.16
	SE(m)_±	CD(5%)	CV(%)	SE (m)_±	CD(5%)	CV(%)	SE (m)_±	CD (5%)	CV (%)	SE(m)_±	CD (5%)	CV (%)
Lime	0.16	1.00	4.67	0.04	0.25	3.72	0.14	0.86	0.98	0.13	0.78	0.76
Micronutrients	0.31	0.92	4.76	0.22	NS	10.69	0.84	2.45	3.10	1.14	3.32	3.56
Interaction	0.44	NS		0.31	NS		1.19	NS		1.61	NS	

L₀: Without lime; L₁: With lime

M₁: Soil application of boron@1kg ha⁻¹; M₂: Foliar spray of borax @ 0.2%

M₃: Soil application of zinc @5kg ha⁻¹; M₄: Foliar spray of ZnSO₄ @ 0.5%

M₅: Combined soil application of @1kg ha⁻¹ + zinc @5kg ha⁻¹; M₆: Combined foliar spray of borax @ 0.2% + ZnSO₄ @ 0.5%

M₇: Control (Without lime, boron and zinc)

Table.4 Response of lime, boron and zinc on head yield (kg plot⁻¹) in Broccoli var. Palam Samridhi

Treatment	Marketable yield (qha ⁻¹)			Unmarketable yield (q ha ⁻¹)			Total yield (q ha ⁻¹)		
	Lime			Lime			Lime		
	L ₀	L ₁	Mean	L ₀	L ₁	Mean	L ₀	L ₁	Mean
M1	107.78	116.44	112.11	11.79	9.56	10.67	119.57	126.00	122.78
M2	109.33	126.22	117.78	11.42	9.29	10.36	120.76	135.51	128.13
M3	113.11	129.56	121.33	10.62	10.54	10.58	123.73	140.10	131.92
M4	127.11	124.44	125.78	10.31	8.81	9.56	137.43	133.25	135.34
M5	109.78	132.44	121.11	9.29	8.04	8.67	119.07	140.49	129.78
M6	121.33	135.11	128.22	9.20	7.96	8.58	130.53	143.07	136.80
M7	104.44	114.22	109.33	12.89	10.49	11.69	117.33	124.71	121.02
Mean	113.27	125.49	119.38	10.79	9.24	10.01	124.06	134.73	129.40
	SE (m)±	CD (5%)	CV (%)	SE (m)±	CD (5%)	CV (%)	SE (m)±	CD (5%)	CV (%)
Lime	1.06	6.46	4.07	0.24	1.46	10.98	1.03	6.29	3.66
Micronutrients	2.28	6.66	4.68	0.50	1.45	12.15	2.31	6.74	4.37
Interaction	3.23	9.58		0.70	NS		3.27	9.70	

L₀: Without lime; L₁: With lime

M₁: Soil application of boron@1kg ha⁻¹; M₂: Foliar spray of borax @ 0.2%

M₃: Soil application of zinc @5kg ha⁻¹; M₄: Foliar spray of ZnSO₄ @ 0.5%

M₅: Combined soil application of @1kg ha⁻¹ + zinc @5kg ha⁻¹; M₆: Combined foliar spray of borax @ 0.2% + ZnSO₄ @ 0.5%

M₇: Control (Without lime, boron and zinc)

This result is in conformity with Adams (1984). Similarly, significant highest plant height (44.43 - 46.27 cm), leaves plant⁻¹ (23.75 - 24.62), stem girth (16.07 - 16.85 cm), plant spread (59.38 - 62.20 cm) and leaf area (540.83 - 557.50 cm²) was recorded by combined foliar spray of 0.2% borax with 0.5% ZnSO₄ closely followed by foliar spray of 0.5% ZnSO₄ than rest of the treatments. This might be due to enhancement of cell multiplication and cell elongation due to boron. These results are in agreement with those of Mishra and Singh (1986), Patel (2002) and Sitapara *et al.*, (2011). Similar report of increased plant height with boron and zinc in broccoli was reported by Ain *et al.*, (2016). Abd El-All (2014) also reported a positive effect of foliar zinc spaying in broccoli.

Yield and yield attributing parameters

The data presented in table 2 and 3 revealed that there was significant effect on application of lime and different levels of micronutrient on head yield attributing parameters of broccoli. Significantly maximum average weight of central head (305.52 g), secondary head (84.36 g), total head weight plant⁻¹ (389.88 g), head ratio of central head to secondary head (3.64), diameter of central head (17.18 cm), diameter of secondary head (5.34 cm) was recorded with application of lime while that of minimum (269.57g, 75.79g, 345.36g, 3.57, 15.13g, 4.83g) without lime application, irrespective of micronutrient applications. This might be due to enhancement of soil pH by application of lime, improve the phosphorus availability to

broccoli plant. Also provide calcium for better growth and development (Rahman *et al.*, 2002 and Das *et al.*, 2017). Combined foliar spray of 0.2% borax with 0.5% ZnSO₄ resulted in production of heaviest central head (313.67g), secondary head (88.83g) and average head weight plant⁻¹ (402.50g) than the rest of the treatments. Maximum diameter of central head (17.37 cm) and secondary head (5.33 cm) was observed with combined foliar application of 0.2% borax with 0.5% ZnSO₄, closely followed by foliar application of 0.5% ZnSO₄ (17.52 cm and 5.12 cm), soil application of ZnSO₄ @ 5kg ha⁻¹ (16.53 cm and 5.06 cm) . The better efficacy of combined application of boron and zinc or sole application of zinc in broccoli might be due to better availability of soil nutrients, facilitates good vegetative growth, which reflected head diameter (Sanjay *et al.*, 2002; Narayanama *et al.*, 2007; Saha *et al.*, 2010 and Singh *et al.*, 2017). On the other hand, combined foliar spray of 0.2% borax with 0.5% ZnSO₄ significantly reduced the days to central head maturity and days taken to last harvest of secondary head (64.73 days and 75.87 days), than control (72.03 and 83.93 days). Lime application significantly increased the yield of broccoli in terms of marketable yield (125.49 ha⁻¹), total head yield (134.73 qha⁻¹) with reduced unmarketable head yield (9.24 qha⁻¹) as compared to control, without lime (113.27, 124.06 and 10.79 qha⁻¹), irrespective of micronutrients. Similar positive effect of lime in cauliflower was observed by Kotur (1993) and justified that addition of calcium in the soil increased the availability of micronutrient in general; boron in particular eventually promotes the growth and yield (Table 4).

Irrespective of lime application, significantly higher marketable head yield of 112.11 to 128.22 qha⁻¹ and total head yield of 122.78 to 136.80 qha⁻¹ were recorded as compared to control (109.33 and 121.02 qha⁻¹). Further,

combined foliar application of 0.2% borax with 0.5% ZnSO₄ produced significantly highest total marketable and total head yield than rest of the micronutrients. Application of boron and zinc might be attributed to their role enhancing the translocation of carbohydrates from the site of their synthesis to the storage tissue in cauliflower (Kant *et al.*, 2013). These results are in conformity with those obtained by Mishra and Singh (1986) and Sitapara *et al.*, (2011).

From the present study it may be concluded that application of lime is essential in acid soils. Application of micronutrients (B and Zn) not only increases the vegetative growth but also the head yield and attributing parameters in broccoli. Invariably, foliar application of micronutrients recorded significantly better growth and yield than corresponding soil application in broccoli var. "Palam Samridhi".

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