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Influence of lime and micronutrients on head quality and economics of Broccoli (*Brassica oleraceae* var. *italica*) var. Palam Samridhi

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Abstract
The experiment was conducted at Department of Vegetable Science, College of Agriculture, OUAT, Bhubaneswar, Odisha during *Rabi* 2017-18 to find out the efficacy of lime and micronutrients (Boron and Zinc) on production of quality heads with higher benefit cost (BC) ratio in broccoli variety "Palam Samridhi". The experiment was laid out in split plot design with lime (with or without) as main plot while 7 levels of micronutrients (Boron and Zinc) in sub-plot replicated thrice. The results revealed that, invariably lime application increased better head quality (*viz;* TSS-7.06^0 Brix, ascorbic acid- 94.70 mg 100g^{-1}, protein-1. 48% and total sugar-1.73%) with higher BC ratio (1.80) than treatment without lime (*viz;* TSS-6.67 ^{0}Brix, ascorbic acid- 86.86 mg 100g^{-1}, protein-1.34% and total sugar-1.62% and BC ratio-1.72), irrespective of micronutrients. Similarly, combined foliar spray with borax @ 0.2% and $ZnSO_4$ @ 0.5% recorded good quality heads (*viz;* TSS-7.03^{0}Brix, ascorbic acid- 97.25 mg 100g^{-1}, protein-1.70% and total sugar-1.79%) and higher BC ratio than rest of other treatments, irrespective of lime. Invariably, foliar spray of micronutrients were recorded better head quality (*viz;* TSS-7.03^{0}Brix, ascorbic acid- 97.25 mg 100g^{-1}, protein-1.70% and total sugar-1.79%) with higher BC ratio (1.85) than corresponding soil application of micronutrients (*viz;* TSS-6.95^{0}Brix, ascorbic acid- 90.77 mg 100g^{-1}, protein-1.66% and total sugar-1.73% and BC ratio-1.73). It may be concluded that soil application of lime with combined foliar spray of borax @ 0.2% and $ZnSO_4$ @ 0.5% not only produced good quality heads but also higher profits in broccoli var. "Palam Samridhi" in acidic soil.

Keywords: *Brassica oleraceae*, Palam Samridhi, Bhubaneswar

Introduction
Broccoli (*Brassica oleracea* var. *italica* L.) is treated as an under-exploited vegetable crop having high nutritive value and export potential. The vitamin C content of fresh broccoli is almost twice than that of cabbage and cauliflower (Islam *et al*., 2015) [6]. It is also rich source of carotene and contains appreciated quantities of thiamine, riboflavin, niacin and iron (Thomson and Kelly, 1985) [18]. Broccoli is rich in sulphoraphane having powerful anticancer activities. Sulphoraphane is connected with reduced risk of prostate and lung cancer (Spitz *et al*., 2000) [17]. Besides, Sulphoraphane, broccoli also rich in vitamin C which act as an anticarcinogenic agent and reduces risk of cardiovascular disease (Du *et al*., 2012) [5]. Its medical properties are steadily gaining more importance in the world. Thus, it is now essential to produce good quality broccoli with higher benefit cost ratio for commercialization in India. It has been reported that the quality of produce is primarily contributed by soil factors and micronutrients. Keeping these in view, the present experiment was conducted to assess the role of lime and micronutrients in quality and economics of broccoli cultivation.

Materials and method
The study was carried out at Department of vegetable science, College of Agriculture, OUAT, Bhubaneswar, Odisha, India during *Rabi* season of 2017-18, by adopting spilt-plot design replicated thrice. Main plot consisted of two lime treatments- without lime(L_O), with lime(L_1) while seven levels of micronutrients in sub-plots, *viz;* soil application of B @ 1kg ha^{-1} (M_1), foliar application of Borax @ 0.2% (M_2), soil application of Zn @ 5kg ha^{-1} (M_3), foliar application of $ZnSO_4$ @ 0.5% (M_4), combined soil application of B @ 1kg ha^{-1} + Zn @ 5kg ha^{-1} (M_5), combined foliar spry of Borax @ 0.2% + $ZnSO_4$ @ 0.5% (M_6),

control (without B and Zn) (M_7). A uniform dose of FYM @ 25 tha^{-1} and fertilizer dose of 150:100:50 NPK kg ha^{-1} was applied. Borax and boric acid used as source of boron, while zinc sulphate ($ZnSO_4$) was used as source of Zn. Three sprayings were done at 20, 35 and 50 days after transplanting as per the treatment schedule. Recommended package of practices were adopted uniformly to raise a good crop except nutrient management. Observations on quality parameters were estimated from randomly five selected plants by adopting standard procedure. The data were subjected to statistical analysis (Panse and Sukhatme, 1985) [11].

Results and discussion

Head quality parameters

The result data on various head quality parameters of broccoli presented in table no. 1 revealed significant variations among the treatment schedules. Invariably, application of lime significantly increased head quality of broccoli inform of TSS (7.06ºbrix), ascorbic acid (94.70mg $100g^{-1}$), protein content (1.48%), total sugar content (1.73%), reducing sugar (1.29%) and non-reducing sugar (0.42%) as compared to without lime (6.67ºbrix, 86.86mg $100g^{-1}$,1.34%, 1.62%,1.26% and 0.34%) irrespective of micronutrients (6.67ºbrix, 86.86 mg $100g^{-1}$, 1.62%, 0.34% and 1.34%, respectively).The significant increase of head quality by the lime application might be due to the increasing in soil pH in acidic soils coupled with availability of both macro and micro-nutrients. Similar report of increased in quality of produce has also been reported by Jena *et al.* (2009) [7] and Sen *et al.* (2017) [15]. Similarly, among the micronutrients, combined foliar spray of borax @ 0.2% and $ZnSO_4$ @ 0.5% significantly increased head quality in terms of TSS (7.03 ^{0}Brix), ascorbic acid (97.25 mg $100g^{-1}$), total sugar (1.79%), reducing sugar (1.35%), non-reducing sugar (0.42%) and crude protein (1.69%) than there sole application irrespective of lime application. The improvement in TSS content of broccoli heads with application of micronutrients might be attributed to enhanced metabolic processes involved in biosynthesis of total soluble solid, such as carbohydrates, organic acid, amino acid and other inorganic constituents (Acharya *et al*., 2015) [1]. This might be due to increased carbohydrates production during the process of photosynthesis. Both zinc and boron plays a vital role in photosynthetic activity of plant (Lal *et al*., 2015) [9]. Vasconcdes *et al.* (2011) [19] reported the impact of boron on quality of plants. Similarly, Kotur (1993) [8] and Singh (2003) [14] reported the significant effect of boron on quality in cauliflower. Better efficacy of zinc with respect to broccoli quality suggested by Liang *et al.* (2006) [10]. Slosar *et al.* (2016) [16] recommended foliar spray of zinc to produce quality broccoli. Application of boron also increased the ascorbic acid content in broccoli head, as evidenced in the present study, also conforms with the findings of Chattopadhyay and Mukhopadhyay (2003) [4] in cauliflower while Saha *et al*. (2010) [13] in broccoli. The present study also revealed that invariably foliar spray of micronutrient showed better quality of broccoli heads than the corresponding soil application.

Economics

Results presented in table 3 on economics of production of broccoli as influenced by lime and micronutrients showed variation among the treatment schedules. The results showed that application of lime, recorded higher gross income (1.35 lakh ha^{-1}), net income (0.60 lakh ha^{-1}) and finally higher benefit cost(BC) ratio (1.80) as compared to control, without any lime application (1.24 lakh ha^{-1}, 0.52 lakh ha^{-1} and 1.72, respectively), whereas, application of micronutrients recorded wide variations in gross income (1.21 to 1.37 lakh ha^{-1}), net income (0.49 to 0.63 lakh ha^{-1}) as well as B:C ratio (1.68 to 1.85). This was due to significantly increased head quality of broccoli.

Similarly, the results revealed invariably better performance of combined foliar spray of 0.2% borax with 0.5% $ZnSO_4$ (1.37 lakh ha^{-1}, 0.63lakh ha^{-1} and 1.85), closely followed by foliar application of 0.5% $ZnSO_4$ (1.35lakh ha^{-1}, 0.62lakh ha^{-1} and 1.84) for gross income, net income and B:C ratio, respectively. This was obviously due to better performance of these two treatments towards significantly higher head yield. The result also showed that application of micronutrients as foliar spray was better than soil application. This was due to the increased head yield which fetches higher price in the market with minimum production cost. These results are in conformity with findings of Patil *et al*. (2008) [12] and Yadav *et al*. (2009) [20].

Conclusion

It may be concluded that for production of quality heads with high BC ratio, broccoli crop should be supplied with lime as soil application before transplanting along with combined foliar spray of borax @ 0.2% and $ZnSO_4$ @ 0.5% at 20, 35 and 50 days after transplanting.

Table 1: Response of lime, boron and zinc on TSS, ascorbic acid and crude protein content in Broccoli var. Palam Samridhi

	TSS (^{0}Brix)			Ascorbic acid (mg $100g^{-1}$)			Protein content (%)		
Treatment	**Lime**			**Lime**			**Lime**		
	L_0	**L_1**	**Mean**	**L_0**	**L_1**	**Mean**	**L_0**	**L_1**	**Mean**
M1	6.63	6.77	6.70	82.83	90.40	86.62	0.81	1.07	0.94
M2	6.90	7.37	7.13	86.27	93.30	89.78	1.51	1.63	1.57
M3	6.27	6.77	6.52	86.73	92.07	89.40	1.59	1.67	1.63
M4	6.70	7.30	7.00	89.13	95.80	92.47	1.68	1.71	1.70
M5	6.80	7.10	6.95	83.67	97.87	90.77	1.62	1.70	1.66
M6	6.95	7.10	7.03	90.67	103.83	97.25	1.56	1.82	1.69
M7	6.47	7.00	6.73	88.70	89.63	89.17	0.60	0.74	0.67
Mean	6.67	7.06	6.87	86.86	94.70	90.78	1.34	1.48	1.41
	SE(m)±	CD(5%)	CV(%)	SE(m)±	CD(5%)	CV(%)	SE(m)±	CD(5%)	CV(%)
Lime	0.04	0.25	2.77	1.26	7.66	6.35	0.02	0.11	5.65
Micronutrients	0.10	0.29	3.58	1.30	3.79	3.51	0.02	0.07	3.88
Interaction	0.14	NS		1.84	5.46		0.03	0.09	

- L_0: Without lime; L_1: With lime
- M_1: Soil application of boron@1kg ha^{-1} ; M_2: Foliar spray of borax @ 0.2%
- M_3: Soil application of zinc @5kg ha^{-1}; M_4: Foliar spray of $ZnSO_4$ @ 0.5%
- M_5: Combined soil application of @1kg ha^{-1} + zinc @5kg ha^{-1}; M_6: Combined foliar spray of borax @ 0.2% + $ZnSO_4$ @ 0.5%
- M_7: Control (Without lime, boron and zinc)

Table 2: Response of lime, boron and zinc on sugar content of Broccoli var. Palam Samridhi

Treatment	Total sugar (%)			Reducing sugar (%)			Non-reducing sugar (%)		
	Lime			Lime			Lime		
	L_0	L_1	Mean	L_0	L_1	Mean	L_0	L_1	Mean
M1	1.57	1.59	1.58	1.27	1.29	1.28	0.28	0.29	0.28
M2	1.60	1.68	1.64	1.29	1.32	1.31	0.29	0.35	0.32
M3	1.59	1.77	1.68	1.28	1.31	1.30	0.30	0.44	0.37
M4	1.68	1.84	1.76	1.31	1.32	1.31	0.35	0.50	0.43
M5	1.70	1.76	1.73	1.29	1.31	1.30	0.39	0.43	0.41
M6	1.72	1.86	1.79	1.33	1.37	1.35	0.37	0.47	0.42
M7	1.51	1.60	1.56	1.06	1.10	1.08	0.43	0.48	0.45
Mean	1.62	1.73	1.68	1.26	1.29	1.28	0.34	0.42	0.38
	SE(m)±	CD(5%)	CV(%)	SE(m)±	CD(5%)	CV(%)	SE(m)±	CD(5%)	CV(%)
Lime	0.01	0.08	3.63	0.00	0.02	0.00	0.02	NS	0.02
Micronutrients	0.03	0.09	4.61	0.01	0.04	0.01	0.03	0.08	0.03
Interaction	0.04	NS		0.02	NS	0.02	0.04	NS	0.04

- L_o: Without lime; L_1: With lime
- M_1: Soil application of boron@1kg ha^{-1} ; M_2: Foliar spray of borax @ 0.2%
- M_3: Soil application of zinc @5kg ha^{-1}; M_4: Foliar spray of $ZnSO_4$ @ 0.5%
- M_5: Combined soil application of @1kg ha^{-1} + zinc @5kg ha^{-1}; M_6: Combined foliar spray of borax @ 0.2% + ZnSO4 @ 0.5%
- M_7: Control (Without lime, boron and zinc)

Table 3: Economics of Broccoli var. Palam Samridhi as influenced by lime, boron and zinc

Treatment	Gross income (Rs. In lakhs)			Net income (Rs. In lakhs)			Benefit cost ratio		
	Lime			Lime			Lime		
	L_0	L_1	Mean	L_0	L_1	Mean	L_0	L_1	Mean
M1	1.20	1.26	1.23	0.48	0.51	0.50	1.67	1.69	1.68
M2	1.21	1.36	1.28	0.49	0.61	0.55	1.69	1.82	1.75
M3	1.24	1.40	1.32	0.51	0.64	0.58	1.70	1.84	1.77
M4	1.37	1.33	1.35	0.65	0.59	0.62	1.90	1.78	1.84
M5	1.19	1.40	1.30	0.46	0.64	0.55	1.62	1.83	1.73
M6	1.31	1.43	1.37	0.58	0.68	0.63	1.80	1.90	1.85
M7	1.17	1.25	1.21	0.47	0.51	0.49	1.68	1.70	1.69
Mean	1.24	1.35	1.29	0.52	0.60	0.56	1.72	1.80	1.76

- L_o: Without lime; L_1: With lime
- M_1: Soil application of boron@1kg ha^{-1} ; M_2: Foliar spray of borax @ 0.2%
- M_3: Soil application of zinc @5kg ha^{-1}; M_4: Foliar spray of $ZnSO_4$ @ 0.5%
- M_5: Combined soil application of @1kg ha^{-1} + zinc @5kg ha^{-1}; M_6: Combined foliar spray of borax @ 0.2% + ZnSO4 @ 0.5%
- M_7: Control (Without lime, boron and zinc)

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