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Effect of different levels of boron on growth and yield in knol-khol (*Brassica oleracea* var. *gongylodes*)

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Abstract
An experiment was undertaken to determine the effect of different levels of boron application on vegetative growth, physical quality and yield of knob and tackle problem of knob cracking in knolkhol cv. White Vienna, at VNMKV, Parbhani, Maharashtra.
The treatment T_9 (RDF + Borax 2 kg soil application +0.2% B through borax as foliar application) recorded maximum plant height (33.33 and43.93 cm), number of leaves per plant (8.63 and 15.06), leaf length (16.73 and 32.16 cm) and leaf width (10.56 and 17.20 cm) at 30 DAT and at harvest. This treatment also showed higher leaf area at knob initiation (368.73 cm^2), leaf area at knob harvest (655.5 cm^2), earliest days to 50% knob initiation (23.03),diameter of knob (8.74 cm), volume of knob (323.83 cc), average weight of knob (183.7 g) and knob yield ha^{-1} (98.43) compared to other treatments. Overall precise boron application was proved to be beneficial for vegetative growth, physical characters and yield of knob in knolkhol.

Keywords: Knolkhol, white vienna, boron, borax, knob cracking

Introduction
Knol-khol is a annual temperate vegetable crop originated in western coastal Europe, belongs to the family Brassicaceae or Cruciferae which is generally called as cole crops. As it is not under commercial cultivation we can see it is being cultivated in some parts of the country and world. It is now popular in different parts of India like Kashmir, West Bengal, Maharashtra, Uttar Pradesh, Assam, Punjab and some parts of south India. The knob is a rich source of minerals like Ca, Mg, P, K, Na, S and also rich in antioxidants which helps in fighting cancer, contain high amount of Vitamin A, C, carotene and dietary fibers. Presence of sulphoraphane and Isothicyanates which produce protective enzymes in body and have anti diabetic activity. It grows very well in the soils which are fertile and have good amount of organic matter. It can also be grown in soils ranging from acidic to saline soils and for optimum growth it prefers soil pH of 6.0-7.0.
Boron (B) is an important micronutrient required in small amount. It involved in various plant functions like cell wall formation and stability, cell wall synthesis, nucleic acid metabolism, tissue differentiation, sugar translocation, pollen germination, maintenance of structural and functional integrity of biological membranes, lignifications, and pollination and seed set. B is the most widespread micronutrient deficiency problem worldwide after zinc. Commonly appearing deficiency symptoms are distortion thickening and cracking of stems, bushy growth and multiple branching, formation of rosettes, root crops fail to develop properly and fails to develop edible economic parts. (Dell and Huang, 1997) [7].
Boron deficiency is seen in many of the cruciferous crops those are Knol khol (Knob cracking, Brown heart), cauliflower and broccoli (hollow stem). Cole crops include Knol khol which require higher quantity of Boron for proper growth and development (Gupta, 1979) [9]. Boron deficiency was seen in earlier cultivated knol khol as knob cracking. It is also seen that water soaked patches on the knobs, leaves become brittle and curl down blistering is seen on midribs and petioles of the leaves. Pith of the stem below the knobs of knol khol break down and cracks are seen. From this we can say that boron is very essential for the cole crops especially knol-khol. Keeping the above facts in view, present investigation was carried out.

Materials and Methods
A field experiment was conducted at Department of Horticulture, V.N.M.K.V. Parbhani during winter (Rabi) 2020-21. In experiment of knolkhol White Vienna variety was used. There were ten treatments along with a control and each treatment was replicated thrice in a complete

Randomized Block Design (RBD). The treatments contain different levels of boron application. The treatments were T_1: RDF (100:50:50 kg NPK/ha +20t/ ha FYM) – control, T_2: RDF + Borax 1 kg soil application, T_3: RDF + Borax 2 kg soil application, T_4: RDF + Borax 3 kg soil application, T_5: RDF + 0.1% B through boric acid as foliar application, T_6: RDF + 0.2% B through boric acid as foliar application, T_7: RDF + 0.3% B through boric acid as foliar application, T_8: RDF + Borax 1 kg soil application + 0.1% B through boric acid as foliar application, T_9: RDF + Borax 2 kg soil application + 0.2% B through boric acid as foliar application, T_{10}: RDF + Borax 3 kg soil application + 0.3% B through boric acid as foliar application,

The experimental field was uniform with gentle slope and it was thoroughly prepared. Farm yard manure is applied at the rate of 20t ha^{-1} at the time of land preparation. The half dose of nitrogen and full dose of phosphorous and potash were applied as basal dose remaining half dose of nitrogen given as top dressing 30 days after transplanting. The boron applied after 30 days of transplanting. The plant spacing was kept 45cm x 30 cm. The observations for the growth parameters likes plant height (cm), number of leaves/ plant, leaf length (cm), leaf width (cm), leaf area (cm^2), days to 50% initiation of knob and the yield attributing parameters namely diameter of knob (cm), volume of knob (cc), average weight of knob (g) and knob yield were taken from randomly selected five plants from each plot of all the replications.

Results and Discussion

The perusal of the data presented in Table 1 and Table 2 regarding growth and yield aatributing characters of knolkhol as influence by different levels of boron are discussed below.

Plant height (cm)

The treatment T_9 (RDF + Borax 2 kg soil application + 0.2% B through borax as foliar application) was showed significantly maximum plant height (33.33and 43.93cm) than other treatments whereas lowest plant height (24.00 and 3516cm) was recorded in T_1 (control) treatment at 30 DAT and at the time of harvesting respectively. The increase in the plant height with the application of boron might be due to the tissue differentiation and differentiation of meristematic tissue in the plant which leads to production and differentiation of more cells at meristem. The discoveries are as per the discoveries of Metwaly, E.E (2016) [13] in broccoli, similar result were found by Kannan *et al*. (2016) [11] in cauliflower, Singh *et al*. (2017) [19] in cauliflower.

Number of leaves per plant

Number of leaves per plant showed significantly higher number of leaves per plant (8.63 and 15.06) in T_9 (RDF + Borax 2 kg soil application + 0.2% B through borax foliar application) while lowest number of leaves per plant (6.00 and 10.60) were recorded in T_1 (Control) treatment at 30 DAT and at harvest respectively. Increase in number of leaves might be due to tissue differentiation which leads to increase in number of cells and size and sugar translocation and carbohydrate metabolism which helps in supply of food materials for the growth of new leaves. The discoveries are as per the results acquired by Nazir *et al*. (2017) [15] in cauliflower, Jakhar *et al*. (2017) [10] in broccoli and Ashraf *et al* (2018) [2] in tomato.

Leaf length (cm)

The significantly highest leaf length (16.73 and 32.16 cm) was recorded in T_9 (RDF + Borax 2 kg soil application + 0.2% B through borax foliar application) treatment whereas lower leaf length (12.1and 24.16 cm) was recorded in T_1 (control) at 30 DAT and at the time of harvest respectively. The increase in leaf length might be due to the cell division due to boron which leads to production of more number of cells and tissue differentiation an also translocation of sugars an carbohydrates helps to increase the length of leaves. The results are in accordance with the finding of Bhat *et al*. (2018) [4] in onion, Kumar *et al*. (2004) [12] in cauliflower and Panda *et al*. (2019) [17] in knol-khol.

Leaf width (cm)

The significantly highest leaf width (9.80 cm and 15.66 cm) was recorded in treatment T_9 (RDF + Borax 2 kg soil application + 0.2% B through borax foliar application) however lower leaf length (5.56 cm and 10.53 cm) was recorded in T_1 (control) treatment at 30DAT and the time of harvest respectively. The increase in leaf width might be due to the K^+ transport towards leaf stomata, cell division, elongation and cell differentiation which results in increase the width of leaves. The results confirmed the findings of Rana *et al*. (2019) [18] in cabbage, Kumar *et al*. (2004) [12] in cauliflower, Chowdhury *et al*. (2019) [6] in broccoli.

Leaf area (cm^2)

The leaf area was recorded significantly highest (368.73 cm^2 and 655.50 cm^2) in treatment T_9 (RDF + Borax 2 kg soil application + 0.2% B through borax foliar application) whereas lower leaf area (263.86 cm^2 and 533.4 cm^2) was recorded in T_1 (control) treatment at 30DAT and at the time of harvest of knolkhol respectively. The result got in the present investigation are also supported by the discoveries of Nawrin *et al*. (2020) [14] in chilli. Similar results were found by Chander *et al*. (2009) [5] in cauliflower, Panda *et al*. (2019) in knol-khol. The increase in leaf area might be due to the action of boron due to cell division and elongation, tissue differentiation, increase in photosynthesis and chlorophyll content which helps to increase the leaf size and leaf area.

Days to 50% initiation of knobs

The significantly minimum days taken for 50% initiation of knobs (23.03) was recorded in T_9 (RDF + FYM + Borax 2 kg soil application + 0.2% B through borax foliar application) treatment and maximum number of days for 50% initiation of knobs (27.83) was observed in T_1 (control) treatment. Less days taken for 50% initiation of knobs might be due to the action of boron on active cell division and cell differentiation in knobs and also due to increased translocation of sugars and carbohydrate and nucleic acid metabolism which supplies food materials for the growth and development of cells present in knobs.

Diameter of knob (cm)

Treatment T_9 (RDF + Borax 2 kg soil application + 0.2% B through borax foliar application) showed significantly higher knob diameter (8.74 cm) however lower knob diameter (5.3 cm) was recorded in T_1 (Control) treatment. The increase in diameter of knob might be due to the cell division, cell elongation and accumulation of photosynthates, carbohydrates and translocation of sugars in the knobs which leads to

increase in the size and diameter of knobs. The findings are as per the discoveries of Singh *et al*. (2009) [19] in broccoli and Rana *et al*. (2019) [18] in cabbage.

Knob volume (cm^3)

It was observed that among different level of boron treatment significantly higher knob volume (323.83 cm^3) was recorded in T_9 (RDF + Borax 2 kg soil application + 0.2% B through borax foliar application) while lower knob volume (150.86 cm^3) was recorded in T_1 (control) treatment at the time of harvesting. The increase in the knob volume might be due to the increase in the size of the knob due to the action of boron on cell growth and enlargement and cell wall formation and synthesis of cells which increases the density of cells and size and accumulation of photosynthates also increases the volume of the knob.

Average weight of knob (g)

The data uncovered significant difference among different treatment relating to average weight of knob. Treatment T_9 (RDF + Borax 2 kg soil application + 0.2% B through borax as foliar application) recorded significantly highest knob weight (183.70 g) but lowest average knob weight (143.25 g) was recorded in T_1 (control).The increase in the weight of knob might be due to the sugar translocation and carbohydrate metabolism, increased photosynthesis and accumulation of photosynthates. The results are in line with the findings of Osman *et al*. (2019) [16] in tomato, Bhadra *et al*. (2019) [3] in broccoli, and Ashraf *et al*. (2020) [1] in bitter gourd.

Knob yield/ ha (q).

The data disclosed significant difference among different treatment relating to knob yield ha^{-1}. The treatment T_9 (RDF + Borax 2 kg soil application + 0.2% B through borax as foliar application) recorded significantly higher knob yield (98.45 q ha^{-1}) while treatment T_1 (control) recorded lowest knob yield (77.32 q ha^{-1}). The results are in accordance with the findings of Eimon *et al*. (2018) [8] studied effect of variety and NPKZnB on yield of cauliflower. The increase in knob yield/ha might be due to the translocation of sugars, carbohydrates and accumulation of photosynthates in storage

Table 1: Effect of different level of boron on growth of knol-khol cv. White Vienna

Treatments	Plant height (cm)		Number of leaves plant $^{-1}$		Leaf length (cm)		Leaf width (cm)		Leaf area (cm^2)	
	30 DAT	Harvest	30 DAT	Harvest	30 DAT	Harvest	30 DAT	Harvest	30 DAT	Harvest
T_1-Control (RDF)	24.00	35.16	6.00	10.60	12.10	24.16	5.56	9.86	263.86	533.40
T_2-RDF + Borax 1 kg soil application	25.06	36.23	6.50	11.16	13.60	25.93	6.10	11.23	273.30	557.40
T_3-RDF + Borax 2 kg soil application	26.53	38.16	7.06	12.46	13.66	26.56	6.56	12.23	295.80	574.50
T_4-RDF + Borax 3 kg soil application	28.33	39.16	7.20	13.23	14.53	27.50	7.16	12.76	316.06	592.50
T_5-RDF + 0.1% B through borax as foliar application	26.36	37.20	6.80	11.53	13.63	26.10	7.36	12.66	284.83	573.20
T_6-RDF + 0.2% B through borax as foliar application	28.00	38.50	7.60	12.16	14.83	27.33	8.70	13.56	293.20	582.53
T_7-RDF + 0.3% B through borax as foliar application	29.16	39.50	7.86	12.66	15.36	28.50	7.60	14.43	317.86	605.53
T_8-RDF + Borax 1 kg soil application + 0.1% B through borax as foliar application	31.43	40.16	8.10	13.10	16.16	29.80	8.83	16.50	324.70	616.83
T_9-RDF + Borax 2 kg soil application + 0.2 % B through borax as foliar application	33.33	43.93	8.63	15.06	16.73	32.16	10.56	17.20	368.73	655.50
T_{10}-RDF + Borax 3 kg soil application + 0.3% B through borax as foliar application	31.53	42.43	8.26	13.33	16.26	31.70	9.03	16.53	342.70	635.16
S.Em±	2.11	1.80	0.58	0.80	0.80	1.73	0.47	0.80	15.37	12.53
CD (5%)	6.27	5.36	1.72	2.39	2.39	5.16	1.40	2.37	45.68	38.43

Table 2: Effect of different level of boron on yield characters of knol-khol cv. White Vienna

Treatments	50% knob initiation (Days)	Diameter of knob (cm)	Volume of knob (cc)	Average weight of knob (g)	Knob yield ha^{-1} (q)
T_1-Control (RDF)	27.83	5.30	150.86	143.25	77.32
T_2-RDF + Borax 1 kg soil application	26.70	5.71	188.23	152.56	81.59
T_3-RDF + Borax 2 kg soil application	26.46	6.06	195.83	163.61	87.66
T_4-RDF + Borax 3 kg soil application	26.26	6.26	219.83	172.90	93.26
T_5-RDF + 0.1% B through borax as foliar application	26.20	5.96	178.84	154.75	83.64
T_6-RDF + 0.2% B through borax as foliar application	26.17	6.30	193.83	159.34	84.75
T_7-RDF + 0.3% B through borax as foliar application	26.00	6.86	252.16	165.52	88.63
T_8-RDF + Borax 1 kg soil application + 0.1% B through borax as foliar application	25.56	7.31	285.50	169.34	91.03
T_9-RDF + Borax 2 kg soil application + 0.2% B through borax as foliar application	23.03	8.74	323.83	183.70	98.43
T_{10}-RDF + Borax 3 kg soil application + 0.3% B through borax as foliar application	24.93	7.65	305.50	177.59	94.59
S. Em±	1.88	0.42	9.87	4.98	3.22
CD (5%)	5.58	1.25	29.33	14.90	9.56

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