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Effect of different levels of boron on quality and shelf life of Knol-Khol (*Brassica oleracea* var. *gongylodes*)

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Abstract
An experiment was undertaken to determine the 'Effect of different levels of boron on chemical composition and shelf life of knol-khol (*brassica oleracea* var. *gongylodes*) cv**.** White Vienna, at VNMKV, Parbhani, Maharashtra. There was problem of knob cracking in knolkhol, so to tackle problem of knob cracking this experiment was considered.

The effect of different level of boron yield, quality and shelf life of knol-khol indicated that the boron level T_9 (RDF + Borax 2 kg soil application +0.2% B through borax as foliar application) recorded maximum average weight of knob (183.7 g), knob yield/ ha (98.43 q), marketable knob yield per plot (8.51 kg), marketable yield per ha (91.64 q) and B:C ratio (2.43). Where as treatment T_{10} (RDF + Borax 3 kg soil application + 0.3% B through borax as foliar application) recorded significantly better quality parameters i.e. total soluble solids (5.2°Brix), dry matter (7.14%), ascorbic acid content (55.21 mg/100 g), less cracking percentage (5.15%) and shelf life (7.66 days) as compared to others. Overall precise boron application was proved to be beneficial for good knob, less cracking percentage, higher marketable yield, better quality and more shelf life of knol-khol.

Keywords: Knolkhol, white Vienna, boron, borax, knob cracking, marketable yield

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 sulforaphane and Isothiocyanates 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, lignification, 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) [2].

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. 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 +20 t/ 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 20 t 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 yield, quality parameters and shelf life of knolkhol 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 regarding physical quality, chemical composition and shelf life of knolkhol as influence by different levels of boron are discussed below.

Table 1: Effect of different levels of boron on yield, quality and shelf life of knolkhol cv. White Vienna

Treatments	Knob yield ha^{-1} (q)	Marketable knob yield (kg/plot)	Marketable Knob yield (q/ha)	Total soluble solid (°Brix)	Dry matter (%)	Ascorbic acid (mg/100 g)	Knob Cracking percentage (%)	Shelf life (days)	B:C ratio
T_1-Control (RDF)	77.32	5.93	63.93	2.66	3.03	34.30	13.16	5.46	1.32
T_2-RDF + Borax 1 kg soil application	81.59	6.56	70.75	2.40	3.65	37.07	7.73	5.80	1.59
T_3-RDF + Borax 2 kg soil application	87.66	7.16	77.10	2.74	3.85	41.16	9.13	6.20	1.84
T_4-RDF + Borax 3 kg soil application	93.26	7.72	83.14	2.52	4.19	43.6	8.50	6.73	2.08
T_5-RDF + 0.1% B through borax as foliar application	83.64	6.87	74.02	3.52	3.67	39.66	9.00	6.00	1.73
T_6-RDF + 0.2% B through borax as foliar application	84.75	7.06	76.07	3.31	4.23	45.13	8.53	6.63	1.81
T_7-RDF + 0.3% B through borax as foliar application	88.63	7.44	80.19	3.80	4.87	48.16	7.77	6.93	1.98
T_8-RDF + Borax 1 kg soil application + 0.1% through borax as foliar application	91.03	7.71	83.02	4.14	5.64	51.70	7.16	7.10	2.09
T_9-RDF + Borax 2 kg soil application + 0.2% B through borax as foliar application	98.43	8.51	91.64	4.24	6.55	53.24	5.20	7.20	2.43
T_{10}-RDF + Borax 3 kg soil application + 0.3% B through borax as foliar application	94.59	8.26	89.02	5.20	7.14	55.21	5.15	7.66	2.32
S.Em±	3.22	0.39	4.20	0.27	0.41	2.02	0.88	0.50	
CD (5%)	9.56	1.16	12.49	0.81	1.21	6.00	2.63	1.50	

Knob yield / plot (kg)

The data showed significant difference among different treatments. Significantly highest knob yield $plot^{-1}$ (kg) was recorded in treatment T_9 (RDF + Borax 2 kg soil application + 0.2% B through borax as foliar application)whereas s lowest yield $plot^{-1}$ (7.18kg) was recorded in T_1 (control).The discoveries are as per the results acquired by Yadav *et al.* (2018) in bottle gourd, Increase in knob yield/plot might be due to the accumulation of photosynthates in storage organs and boron which helps in enhancing the translocation of carbohydrates from the site of synthesis to the storage tissue.

Knob yield/ ha (q).

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}) which was significantly at par with $T_{10,}$ T_8 and T_4 treatments 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) [3] in cauliflower. The increase in knob yield/ha might be due to the translocation of sugars, carbohydrates and accumulation of photosynthates in storage organs.

Marketable knob yield (kg/plot)

The data pertaining to marketable knob yield showed significant differences among different treatments. The treatment T_9 (RDF + Borax 2 kg soil application + 0.2% B through borax as foliar application) recorded significantly higher marketable knob yield $plot^{-1}$ (8.51 kg) at harvest. Whereas lowest marketable yield per plot (5.93 kg) was recorded in T_1 (control). The results confirmed the findings of Eimon *et al.* (2018) [3] in cauliflower, Panda *et al.* (2019) [8] in knol-khol, Increase in marketable knob yield/plot might be due to the accumulation of carbohydrates an photosynthates in storage tissue.

Marketable knob yield (q/ha)

Highest marketable yield (91.64 q) was recorded in treatment T_9 (RDF + Borax 2 kg soil application + 0.2% B through borax as foliar application) and which was significantly at par with $T_{10,}$ $T_{8,}$ T_7 and T_4 treatments whereas lowest marketable knob yield $ha^{-1`}$ (63.93 q) was recorded in T_1 (control) treatment. The result found in the present investigation are also supported by the discoveries of Manna *et al*. (2010) [6] on influence of foliar application of boron and zinc on yield of onion. The increase in marketable yield/ha might be due to the accumulation of carbohydrates and photosynthates in storage tissue.

Total soluble solid (°Brix)

The treatment T_{10} (RDF + Borax 3 kg soil application + 0.3% B through borax as foliar application) recorded significantly higher TSS (5.2 ^{0}Brix) at harvest stage. The results are in accordance to findings of Salam *et al*. (2010) [11] studied effect of boron and zinc on quality of tomato an similar results were found by Manna *et al*. (2010) [6] in onion, Pushpanjali Pankaj *et al*. (2018) [9] in broccoli, The increase in TSS might be due to the translocation of sugars from source to the economically important parts of the plant i.e. knob

Dry matter (%)

The data disclosed significant difference among different treatments. The treatment T_{10} (RDF + Borax 3 kg soil application + 0.3% B through borax as foliar application) recorded significantly higher dry matter content (7.14%) at harvest however lowest dry matter content (3.03%) was recorded in T_1 (control). Similar results were found by Rashid *et al*. (2019) [10] when studied effect of boron on quality onion, Metwaly, E.E. (2016) [7] in broccoli. The increase in the dry matter might be due to the accumulation of photosynthates and carbohydrates due to high chlorophyll activity and photosynthesis.

Ascorbic acid (mg/100 g)

The Ascorbic acid content (55.21mg 100 g^{-1}) was found significantly highest with treatment T_{10} (RDF + Borax 3 kg soil application + 0.3% B through borax as foliar application) which was at par with T_9 and T_8 treatments but Lower ascorbic acid content (34.3 mg 100 g^{-1}) was recorded in T_1 (control).The results are in line with the findings of Panda *et al*. (2019) [8] when studied effect of boron on quality of knol-khol and similar results were found by Kumar *et al*. (2004) [5] in cauliflower, Senthilkumar (2012) [12] in tomato, Jakhar *et al*. (2017) [4] in broccoli, Ali *et al* (2019) [1] in cauliflower. The increase in ascorbic acid might be due to the translocation of sugars and carbohydrate and nucleic acid from source to the economically important parts of the plant.

Cracking percentage (%)

The data disclosed significant difference among different treatments related to cracking percentage. The treatment T_{10} (RDF + Borax 3 kg soil application + 0.3% B through borax as foliar application) recorded significantly less knob cracking percentage (5.15%) but higher knob cracking percentage (13.16%) was found in T_1 (control). The discoveries are as par in the results acquired by Panda *et al*. (2019) [8] on effect of soil application of 1.5 kg ha^{-1} boron on quality of knol-khol and resulted 0% cracking. Less cracking of knobs might be due to the action of boron. When boron is applied to soil or sprayed the translocation of sugars and synthesis of cell wall materials takes place by this action less cracking is seen. Dell and Huang, 1997 [2] observed that deficiency of boron leads to cracking in knolkhol knob.

Shelf life (days)

The treatment T_{10} (RDF + Borax 3 kg soil application + 0.3% B through borax as foliar application) recorded significantly higher shelf life (7.66 days) after harvest and significantly lower shelf life (5.46 days) was recorded in T_1 (control).The results are in accordance with the finding of Panda *et al*. (2019) [8] on effect of boron on quality of knol-khol. Soil application of 1.5 kg boron recorded shelf life of 5.03 days and similar results were found by Salam *et al*. (2010) [11] in tomato. Increased shelf life of knob might be due to the action of boron where accumulation of photosynthates and carbohydrates which acts as stored food during storage and synthesis of cell wall materials.

B:C ratio

The effect of different level of boron on benefit cost ratio of knol-khol was presented in table 2. Higher B:C ratio of 2.43 was recorded in the treatment T_9 (RDF + Borax 2 kg soil application + 0.2% B through borax as foliar application) while least B:C ratio (1.32) was recorded in T_1 (RDF + FYM) treatment. The results are in line with the findings of Meena *et al*. (2016) [14] when studied effect of fertility level an boron on economics of cauliflower. The increase in B:C ratio might be due to the good marketable knobs which are less affected by knob cracking and deformation in shape due to the action of boron.

Conclusion

Overall precise boron application (RDF + Borax 2 kg soil application +0.2% B through borax as foliar application)was proved to be beneficial for physical quality of knob, marketable yield, less knob cracking percentage, better chemical composition and more shelf life with good economics of knolkhol

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