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Vegetative growth of cabbage (*Brassica Oleracea* var. Capitata l.). cv. Pusa drum head in relation to plant spacing, boron and molybdenum

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Abstract
In order to evaluate the effect of boron, molybdenum and spacing on different growth and development of cabbage. Field experiment was conducted during the *rabi* of 2013-14 and 2014-15. Two spacing 60 x 60 (S_1) and 60 x 45 (S_2) and three levels of each Boron and Molybdenum i.e. B_{1-} (Boron @ 0%), B_{2-} (Boron @ 0.25%), B_{3-} (Boron @ 0.5%), and M_{1-} (Molybdenum @ 0%), M_{2-} (Molybdenum @ 0.25%), M_{3-} (Molybdenum @ 0.5%) were in FRBD with three replications. Foliar spray of boron and molybdenum was done at 30 and 50 days after planting (DAP) and all other cultivation practices were adopted as per recommendations. Spacing S_1 recorded higher value for plant height 36.94 cm, plant spread 94.43 cm^2, leaf length 27.90 cm, leaf width 23.85 cm, no. of open leaves 16.11 and diameter of head 17.06 cm. Among the boron levels 0.5% boric acid increased all the vegetative character viz. plant height 37.53 cm, plant spread 94.41 cm^2, leaf length 28.45 cm, leaf width 24.93 cm and diameter of head 16.15 cm. In case of molybdenum @ 0.5% recorded the maximum value for the plant height 36.41 cm, plant spread 93.28 cm^2, leaf length 27.32 cm, leaf width 23.50 cm and diameter of head 15.31 cm.

Keywords: Cabbage, boron, spacing, molybdenum, foliar spraying, plant height, leaf

1. Introduction
Cabbage (*Brassica oleracea var. capitata* L.) belongs to the family crucifereae is one of the important vegetables among the cole crops and grown in almost all parts of the world. It originated in Cyprus and around the Mediterranean region. Cabbage was reported to be grown in the subcontinent during the Mughal period, but the vegetable became popular during British rule (Bose and Som, 1986) [1]. The edible portion of cabbage is known as 'head' that is made up of numerous thick and overlapping smooth leaves. Among the leafy vegetables cabbage has a prominent place and grown as an annual crop prized for its compact green head. There is much variation amongst cabbage types, ranging in colour from green to purple, in leaf character from smooth to savoy leaves, in head shape from flat to pointed and in maturity from early to late maturing. The green, round headed types are the most common (Splittstoesser, 1979 and Phillips and Rix, 1993) [14, 10]. The other closely related members of the cole group are being Cauliflower, Broccoli, Brussels sprout and Knol-khol etc. have also economic importance. Cabbage is one of the nutritionally rich vegetables, liked by all classes of people and it has some medicinal values for diabetic patients. It is biennial and herbaceous in nature and is extensively grown during winter season.

A 100 g edible portion of cabbage contains 1.8 g protein, 0.1 g fat, 4.6 g carbohydrate, 0.6 g mineral, 29 mg calcium, 0.8 mg iron and 14.1 mg sodium. Moreover, it is a rich source of vitamins A and C (Prabhakar and Srinivas, 1993) [11]. It may be served in slaw, salads or cooked dishes. Cabbage is one of the five best vegetables in the world (Rashid, 1999) [13]. It is an important winter leafy vegetables grown in India.

India is the second largest producer of cabbage in the world next to China. It is commercially cultivated in U.P., Orissa, Bihar, Assam, West Bengal, Maharashtra and Karnataka states in the country. The area (in '000 Ha), production (in '000 MT) and productivity (in MT/ha) of cabbage in Madhya Pradesh are 19.7, 578.4, 29.4, in India 400.13, 9039.21, 22.6 and in the *World are 2416.88, 70644.19, 29.2, respectively (NHB, 2015 and *FAO, 2015) [9, 4].

Export of cabbage from India is approximately 385.22 MT that value of 56 lakh rupees. In order to maintain or even improve cabbage production, some factors have to be considered. Production of vigorous transplants is one such necessary factor for successful vegetable production. Again, correct cultural practices such as adequate application of fertilizers (Everaarts and Beusichem 1998) [3] and optimum plant population have to be adhered to in order to obtain good yields in cabbage production (Kumar and Rawat, 2002) [7].

Micronutrient plays a vital role in growth and development of plants besides being improving the quality of the produce. Though it required in small amount but equally indispensable for the normal growth of the plant and in deficient condition it leads to the occurrence of some physiological disorders and ultimately affected the yield and quality of the produce. Micronutrient improves the chemical composition of head and general condition of the plant. It increases seed germination, macronutrient uptake, production and quality of produce through enhanced photosynthetic activity and increased metabolite content of leaves. They also reduce the incidence of diseases, pests and disorders and improve the post-harvest quality of the crop produce (Hemphill *et al.* 1982) [5].

Boron regulates the metabolism of carbohydrates in plants. It plays an important role in enhancing the translocation of carbohydrates from site of synthesis to reproductive tissue in the head. It is essential for the process by which meristem cells differentiate to form specific tissues. In case of boron deficiency, plant cells may continue to divide, but structural components are not differentiated.

Molybdenum is taken up by plants as molybdate ions. It stimulates the photosynthesis and increase the metabolic process. It enables plants to make use of nitrogen without it plants cannot transform nitrate nitrogen to amino acids

Plant density for cabbage is an important criteria for attaining maximum yield. Densely planted crop obstruct the proper growth and development with hampering the basic requirement of plant growth. On the other hand wider spacing ensure the basic requirements but decrease the total number of plants as well as total yield.

2. Material and Methods

Cabbage (*Brassica oleracea* var. Capitata L.). cv. Pusa Drum Head" was used to explore its yield potential by different boron levels and spacing. The present investigation was conducted in nursery area, Dept. of Horticulture, College of Agriculture, Gwalior during rabi of 2013-14 and 2014-15. For the different treatment combinations, three levels of boron i.e. B_{1-} (Boron @ 0%), B_{2-} (Boron @ 0.25%), B_{3-} (Boron @ 0.5%), three levels of molybdenum i.e. M_{1-} (Molybdenum @ 0%), M_{2-} (Molybdenum @ 0.25%), M_{3-} (Molybdenum @ 0.5%) and two spacing 60 cm x 60 cm (S_1) and 60 cm x 45cm (S_2) were used, thus in the present investigation a total of 18 treatment combinations were made in Factorial Randomized Block Design with three replications. Foliar spray of boron and molybdenum was done at 30 and 50 days after transplanting (DAT) and all other cultivation practices were adopted as per recommendations. The plot size was 3.2 m x 3.2 m. Three raised nursery beds of 2 x 1 x 0.15 m size were prepared by mixing well rotten farm yard manure in soil @ 15 kg per square meter. Seeds of cabbage cv. Pusa Drum Head were sown on 22nd October 2013 in the first trial and on 25th October 2014 in second year trial @ 10 g seed per bed after treating with 0.3% thiram to check the infection of damping off and seed borne diseases. Five weeks old healthy and uniform sized seedlings were transplanted in the experimental plots on 25th November 2013 in first year trial and on 27th November 2014 in second year trial. Seed beds were watered in the morning before uprooting the seedlings in the afternoon of the same day to avoid damage to the roots. During transplanting a spacing of 60 cm × 60 cm and 60 cm x 40 cm were maintained, thus unit plot accommodated 25 and 40 seedlings respectively where the treatment was allocated at random. Two days before transplanting each plot was fertilized with a basal dose of NPKS. The recommended dose of nitrogen (120 kg/ha), phosphorus (80 kg/ha), potassium (60 kg/ha) and sulphur (20 kg/ha) were applied through urea, SSP, MOP and Gypsum, respectively. Half of the total quantity of nitrogen was applied as a basal dose. One-fourth of the total nitrogen was applied after 20 days of transplanting and remaining one-fourth at the time of head formation. Boron and Molybdenum was applied as foliar spray (at 30 and 50 DAP). Boric acid and Ammonium molybdate was used as source of boron and molybdenum.

All the observations recorded viz. plant height, plant spread, leaf length, leaf width and no. of open leaves at 80 days after transplanting except diameter of head which was measured just after the harvesting.

3. Results

The mean data pertaining to different vegetative parameters of different treatments were subjected to statistical calculations. Both spacing, boron and molybdenum levels influenced these parameter significantly. However, Interaction of spacing×boron, spacing×molybdenum and boron×molybdenum did not affect the vegetative parameters significantly. So the interaction effect did not consideration into this paper. The same trend was found in both the years. The results indicated that there was significant effect of spacing, boron and molybdenum levels on various vegetative characters. The mean data of pooled basis (both years) are only sawn here, the detailed year–wise results are sown in the Table no.1 and 2.

Plant height was affected significantly due to both the spacing (Table 1). Maximum plant height of 36.94 cm was recorded in S_1 (60 cm x 60 cm), while the minimum plant height was 34.37 cm in S_2 (60 cm x 40 cm). In case of boron levels, B_3 (Boron @ 0.5%) recorded maximum plant height of 37.53 cm followed by 35.85 cm in B_2 (Boron @ 0.25%) and 33.58 cm in B_1 (Boron @ 0%). Among the molybdenum levels, M_3 (Molybdenum @ 0.5%) showed the maximum plant height of 36.41 cm followed by 35.80 cm in M_2 (Molybdenum @ 0.25%) and 34.76 cm in M_1 (Molybdenum @ 0%).

Plant spread was affected significantly due to both the spacing (Table 1). Maximum plant spread of 94.43 cm^2 was recorded in S_1 (60 cm x 60 cm), while the minimum plant spread was 18.16 cm^2 in S_2 (60 cm x 40 cm). In case of boron levels, B_3 (Boron @ 0.5%) recorded maximum plant spread of 94.41 cm^2 followed by 35.85 cm in B_2 (Boron @ 0.25%) and 91.35 cm^2 in B_1 (Boron @ 0%). Among the molybdenum levels, M_3 (Molybdenum @ 0.5%) showed the maximum plant spread of 93.28 cm^2 followed by 91.30 cm in M_2 (Molybdenum @ 0.25%) and 89.30 cm^2 in M_1 (Molybdenum @ 0%).

Leaf length was affected significantly due to both the spacing (Table 1). Maximum leaf length of 27.90 cm was recorded in S_1 (60 cm x 60 cm), while the minimum leaf length was 25.25 cm in S_2 (60 cm x 40 cm). In case of boron levels, B_3 (Boron @ 0.5%) recorded maximum leaf length of 28.45 cm followed by 26.65 cm in B_2 (Boron @ 0.25%) and 24.63 cm in B_1 (Boron @ 0%). Among the molybdenum levels, M_3 (Molybdenum @ 0.5%) showed the maximum leaf length of 27.32 cm followed by 26.60 cm in M_2 (Molybdenum @ 0.25%) and 25.80 cm in M_1 (Molybdenum @ 0%).

Leaf width was affected significantly due to both the spacing (Table 2). Maximum leaf width of 23.85 cm was recorded in S_1 (60 cm x 60 cm), while the minimum leaf width was 22.23 cm in S_2 (60 cm x 40 cm). In case of boron levels, B_3 (Boron @ 0.5%) recorded maximum leaf width of 24.93 cm followed

by 23.24 cm in B_2 (Boron @ 0.25%) and 20.94 cm in B_1 (Boron @ 0%). Among the molybdenum levels, M_3 (Molybdenum @ 0.5%) showed the maximum leaf width of 23.50 cm followed by 23.15 cm in M_2 (Molybdenum @ 0.25%) and 22.46 cm in M_1 (Molybdenum @ 0%).
No. of open leaves was affected significantly due to both the spacing (Table 2). Maximum no. of open leaves of 16.11 was recorded in S_1 (60 cm x 60 cm), while the minimum no. of open leaves was 13.26 in S_2 (60 cm x 40 cm). In case of boron levels, it was found non-significant. B_3 (Boron @ 0.5%) recorded maximum no. of open leaves of 14.86. Among the molybdenum levels, it was aloso found non-significant. M_3 (Molybdenum @ 0.5%) showed the maximum no. of open leaves of 14.71.

Spacing S_1 (60 cm x 60 cm) has recorded maximum diameter of head i.e. 17.06 cm. While minimum diameter of head i.e. 13.23 cm was noted in case of S_2 (60 cm x 40 cm). Among the boron levels, diameter of head showed significant differences, B_3 (Boron @ 0.5%) recorded maximum diameter of head 16.15 cm followed by B_2 (Boron @ 0.25%) 15.17 cm. Minimum diameter of head was recorded in case of B_1 (Boron @ 0%) i.e. 14.11 cm. The difference between B_3, B_2 and B_2 and B_1 showed significant. Maximum diameter of head in case of molybdenum was found under M_2 (Molybdenum @ 0.25%) i.e.15.44 cm followed by M_3 (Molybdenum @ 0.5%) 15.31 cm. Minimum diameter of head was recorded 14.65 cm in M_1 (Molybdenum @ 0%), however, M_2 and M_3 was at par to each other (Table 2).

Table 1: Effect of spacing, boron and molybdenum on plant height, plant spread and leaf length of cabbage

Treatments	Plant height (cm)			Plant spread (cm^2)			Leaf length (cm)		
	Ist	IInd	Pooled	Ist	IInd	Pooled	Ist	IInd	Pooled
S_1	37.36	36.53	36.94	95.02	93.83	94.43	28.27	27.52	27.90
S_2	34.74	33.99	34.37	88.53	87.79	88.16	25.73	24.78	25.25
SEm+	0.35	0.28	0.20	0.71	0.90	0.51	0.31	0.25	0.18
CD(*p <0.05)	1.01	0.80	0.56	2.05	2.57	1.43	0.88	0.72	0.50
B_1	34.00	33.17	33.58	88.68	87.56	88.12	25.06	24.19	24.63
B_2	36.28	35.43	35.85	91.78	90.93	91.35	27.08	26.23	26.65
B_3	37.88	37.18	37.53	94.88	93.93	94.41	28.85	28.04	28.45
SEm+	0.43	0.34	0.24	0.87	1.10	0.62	0.38	0.31	0.22
CD(*p <0.05)	1.23	0.98	0.68	2.51	3.15	1.76	1.08	0.88	0.61
M_1	35.17	34.35	34.76	89.86	88.74	89.30	26.24	25.37	25.80
M_2	36.22	35.37	35.80	91.72	90.87	91.30	27.02	26.17	26.60
M_3	36.76	36.06	36.41	93.76	92.81	93.28	27.73	26.91	27.32
SEm+	0.43	0.34	0.24	0.87	1.10	0.62	0.38	0.31	0.22
CD(*p <0.05)	1.23	0.98	0.68	2.51	3.15	1.76	1.08	0.88	0.61

Table 2: Effect of spacing, boron and molybdenum on leaf width, no. of open leaves and diameter of head of cabbage

Treatments	Leaf width (cm)			No. of open leaves			Diameter of head (cm)		
	Ist	IInd	Pooled	Ist	IInd	Pooled	Ist	IInd	Pooled
S_1	24.63	23.06	23.85	16.40	15.82	16.11	17.75	16.36	17.06
S_2	22.85	21.60	22.23	13.47	13.04	13.26	13.82	12.64	13.23
SEm+	0.26	0.22	0.18	0.08	0.09	0.05	0.17	0.14	0.10
CD(*p <0.05)	0.74	0.62	0.50	0.22	0.26	0.15	0.48	0.40	0.28
B_1	20.97	20.91	20.94	14.79	14.31	14.55	14.78	13.44	14.11
B_2	23.97	22.51	23.24	14.90	14.40	14.65	15.87	14.48	15.17
B_3	26.29	23.58	24.93	15.12	14.59	14.86	16.71	15.59	16.15
SEm+	0.31	0.26	0.22	0.10	0.11	0.07	0.20	0.17	0.12
CD(*p <0.05)	0.90	0.76	0.61	NS	NS	NS	0.58	0.49	0.34
M_1	23.12	21.79	22.46	14.93	14.44	14.69	15.32	13.98	14.65
M_2	23.85	22.46	23.15	14.91	14.40	14.66	16.12	14.82	15.47
M_3	24.26	22.74	23.50	14.97	14.46	14.71	15.92	14.71	15.31
SEm+	0.31	0.26	0.22	0.10	0.11	0.07	0.20	0.17	0.12
CD(*p <0.05)	0.90	0.76	0.61	NS	NS	NS	0.58	0.49	0.34

4. Discussion

An attempt has been made to establish the relationship amongst the vegetative characters as affected by the different treatments under study. Data recorded for various vegetative parameters reveals several points of interest which can be discussed in conjunction with the findings of other workers. It is realized that the assessment of experimental treatments by such supplementary data has been reasonably justified.

4.1: Effect of Spacing

Widders and Price (1989) [15] defined spacing as the distance between the plants in the row and between the rows of sowing crops. Plant density for cabbage is an important criterion for attaining maximum yield. Densely sowing crop obstructs the proper growth and development with hampering the basic requirement of plant growth. On the other hand wider spacing ensure the basic requirements but decrease the total number of plants as well as total yield. Yield may be increased by 25% by using optimum spacing (Moniruzzaman, 2011) [8].
The data presented denoted that both the plant spacing significant influenced the various plant growth characters. In case of different growth and development parameters. Values were found to be maximum at wider spacing i.e. S_1 (60 x 60 cm) for the plant height (cm), plant spread, length of leaf (cm), width of leaf (cm) and diameter of head (cm) in both years followed by S_2 (60 x 40 cm). There was a linear increase in spacing S_1 (60 x 60 cm) and it was found better than spacing S_2. Diameter of head (cm) was also significantly

influenced by both spacing and attained maximum diameter in spacing S_1 (60 x 60 cm) followed by S_2 (60 x 40 cm), this trend was also seen in number of open leaves per plant.

4.2: Effect of Boron

Different boron levels significant influenced the various plant growth characters except number of open leaves per plant. In case of different growth and development parameters. Values were found to be maximum in B_3 i.e. (Boron @ 0.5 %) for the plant height (cm), plant spread, length of leaf (cm) and width of leaf (cm) in both years followed by B_2 (Boron @ 0.25 %) and minimum values for these parameters were found under B_1 (Boron @ 0%). There was a linear increase in ascending order B_3, B_2 and B_1 in both the years. Diameter of head (cm) was also significantly influenced by different boron levels and attained maximum diameter in B_3 i.e. (Boron @ 0.5 %) followed by B_2 (Boron @ 0.25 %) while minimum diameter was noted under B_1 (Boron @ 0%) this trend was also seen in the second year. It is essential for the process by which meristem cells differentiate to form specific tissues (Prasad and Yadav, 2003) [12]. This might be due to that boron can fix the organic matter in initial stage that would be helps in better plant growth. Root elongation is the result of cell elongation and cell division, and evidence suggests that boron is required for both processes. Better roots results in more absorption of nutrient which result in more plant growth.

4.3: Effect of Molybdenum

Different molybdenum levels significant influenced the various plant growth characters except number of open leaves per plant. In case of different growth and development parameters. Values were found to be maximum in M_3 i.e. (Molybdenum @ 0.5 %) for the plant height (cm), plant spread, length of leaf (cm) and width of leaf (cm) in both years followed by M_2 (Molybdenum @ 0.25 %) and minimum values for these parameters were found under M_1 (Molybdenum @ 0%). There was a linear increase in ascending order M_3, M_2 and M_1 in both the years. Diameter of head (cm) was also significantly influenced by different molybdenum levels and attained maximum diameter in M_2 i.e. (Molybdenum @ 0.25 %) followed by M_3 (Molybdenum @ 0.5 %) while minimum diameter was noted under M_1 (Molybdenum @ 0%) this trend was also seen in the second year. Promotional effect of molybdenum on plant development of cauliflower plants may be due to the regulatory effects of molybdenum on plant development through molybdenum functions largely in the enzyme systems of nitrogen fixation and nitrate reduction (Kanujia, 2006) [6]. Plants that cannot adequate N or incorporate nitrate into their metabolic system because of inadequate molybdenum may become nitrogen deficient. This results to a reduced growth of plant. The results were in harmony with those obtained by Elkhatib, 2009 [2] on common bean.

5. Conclusion

Based on the findings of the experiment, it may be concluded that for better growth and development, efficient production of cabbage and maintenance of soil productivity, it is judicial to use different micronutrients with NPKS fertilizer with recommended dose. Application of micronutrients is one of the important management practices to improve soil productivity. Crop growth, development, yield and profit are important to a farmer. Soil health is also very important for sustainable production. Higher yield may also be achieved using higher plant population. Thus considering crop productivity, economic return and soil fertility together combined application of micronutrient and reduced plant spacing may be helpful for sustainable crop production. So it may be recommended at farmer’s level for profitable crop production without affecting the soil health.

6. Suggestions for further work

For the sustainable crop production and in point of soil health and also higher crop production and economic return, it will better to provide basal NPKS nutrients through manures as it may also provide the required nutrient and balance the soil health.

7. References

1. Bose TK, Som MG. Vegetable Crops in India. Naya Prokash, Calcutta, India, 1986, 167-180.
2. Elkhatib HA. Growth and yield of common bean *(Phaseolus vulgaris* L.) in nitrogen fixation and assimilation of metabolites in nodulated legume: A special reference to *Phaseolus vulgaris*. African J Biotech. 2009; 8:2482-2489.
3. Everaarts AP, Van Beusichem ML. The Effect of Planting Date and Plant Density on Potassium and Magnesium Uptake and Harvest by Brussels Sprouts. Journal of Agronomy and Crop Science. 1998; 181:201-207.
4. FAO. Food and Agriculture Organization of the United Nations, 2015. www.fao.org.
5. Hemphill DD, Weber MS, Jackson TL. Table beet yield and boron deficiency as influenced by lime, nitrogen and boron. Soil Science of America Journal. 1982; 46:1190-1192.
6. Kanujia SP, Ahmed N, Chattoo MA, Nayeema Jabeen Naryan S. Effect of micronutrients on growth and yield of cabbage (*Brassica oleracea* var. capitata L.). Applied Biological Research. 2006; 8(1/2):15-18.
7. Kumar M, Rawat TS. Effect of nitrogen and spacing on the quality and yield of cabbage (*Brassica oleracea* L. var. *capitata*). Agricultural Science Digest. 2002; 22(2):90-92.
8. Moniruzzaman M. Effect of plant spacings on the performance of hybrid cabbage (*Brassica oleracea var. capitata*) varieties. Bangladesh Journal of Agricultural Research. 2011; 36(3):495-506.
9. NHB. National horticulture board, Database, 2015. www.nhb.gov.in.
10. Phillips R, Rix M. "The Random House Book of Vegetables", Random House, NY, 1993.
11. Prabhakar BS, Srinivas K. Effect of spacing and fertilizer on head yield of cabbage. Progressive Horticulture. 1993; 22(1-4):112-116.
12. Prasad VM, Yadav D. Effect of foliar application of boron and molybdenum on the growth and yield of cauliflower (*Brassica oleracea* var. botrytis) cv. Snowball-16. New Agriculturist. 2003; 14(1/2):121-122.
13. Rashid MM. “Shabjibiggayan (In Bengali)”. Rashid Publishing House, 94, Old, DOHS, Dhaka-1206, 1999, 233.
14. Splittstoesser WE. Vegetable growing handbook. The AVI Publishing Company, Inc., USA., 1979.
15. Widders IE, Price HC. Effects of plant density on growth and biomass partitioning in pickling cucumbers. J Amer. Soc. Hort. Sci. 1989; 114:751-755.