

Response of Different Doses of NPK and Boron on Growth and Yield of Broccoli (*Brassica oleracea* L. var. *italica*)

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Abstract

The present investigation was carried out to examine the optimum doses of NPK and boron application on broccoli in irrigated agro-ecosystem of western Uttar Pradesh during *rabi* 2009-10 and 2010-11. Seven different treatments including control were used in Randomized Block design (RBD). The results revealed significant response on growth and yield of broccoli for different treatments. Application of 120 kg N+60 kg P₂O₅+40 kg K₂O+15 kg B ha⁻¹ gave maximum plant height plant⁻¹ (65.33 cm), number of leaves plant⁻¹ (18.26), length longest leaf (52.99 cm), width of longest leaf (17.98 cm), spread of plant (55.53 cm) and stem diameter (4.47 cm), whereas in control was minimum pronounced plant height plant⁻¹ (58.66 cm), number of leaves plant⁻¹ (12.33), length longest leaf (42.70 cm) width of longest leaf (14.18 cm), spread of plant and stem diameter (3.04 cm). Similar, pattern on the curd diameter (13.69 cm), length of curd (16.33 cm), weight of curd plant⁻¹ (286.89 g), weight of sprout plant⁻¹ (126.89 g), weight of curd and sprout plant⁻¹ (0.390 kg) and total yield Curd+sprout (148.51 q ha⁻¹) was recorded with the application of 120 kg N+60 kg P₂O₅+40 kg K₂O+15 kg B ha⁻¹ and minimum was under control treatment.

1. Introduction

Broccoli (*Brassica oleracea* L. var. *italica*) is a member of the Brassicaceae family as a wild form of this family, which found along the Mediterranean region (Decoteau, 2000). Broccoli is an Italian vegetable, native to the Mediterranean region, cultivated in Italy in ancient roman times and about 1720 in England. On the other hand, the USA it first appeared in 1806, but it was commercially cultivated of broccoli was started around 1923 (Decoteau, 2000). In Jordan, broccoli is cultivated on a limited area (Anonymous, 2006). However, due to increase in its popularity; there is a trend to increase cultivation by farmers as well as consumption by consumers. Broccoli is an important vegetable crop and has high nutritional and good commercial value (Yoldas et al., 2008). It is low in sodium food, fat free and calories, high in vitamin C and good source of vitamin A, B₁, vitamin B₂ and calcium (Decoteau, 2000). Now-a-days, broccoli attracted more attention due to its multifarious use and great nutritional value (Rangkadilok et al., 2004). It has 130 times more vitamin A content than cauliflower and 22 times than cabbage (Thamburaj and

Singh, 2003). The consumption of broccoli in daily diet, it minimizes the incidence of various types of cancer disease in human beings. It has some cancer fighting substances like Phytochemicals, β -carotenes, Indoles and isothiocyanates. It also contains sulforaphane; it checks the growth of tumors and reduces the risk of cancer. In Indian scenario, broccoli is mainly grown in hilly area of Himachal Pradesh, Uttarakhand, Jammu and Kashmir, Tamil Nadu and Northern plains. Recently, in western Uttar Pradesh it is gaining popularity due to increasing awareness of nutritional security and quality produce as well as reasonable that most of districts comes in the national capital region (NCR) and well connected with national capital Delhi as fresh supply is concerned. The area is negligible under broccoli cultivation in India. The area under the vegetable cultivation is 9205.20 thousand hectares and there production 162186.60 thousand metric tons. The productivity of vegetable is about 17.80 metric tons per hectare and 912.66 thousand hectare area is under vegetable cultivation and production 16.70 thousand metric tons with annual productivity 21.40 metric tons per hectare in Uttar Pradesh (Anonymous, 2013).

Food security for the rapid expanding population is a big



challenge and can be achieved by increasing crop productions and healthy foods. However, the objectives of food security cannot be attained without availability of essential plant nutrients (Ali et al., 2008). Therefore, plant nutrients are the essential component of sustainable agriculture. Undoubtedly, for optimum plant growth and production, the essential nutrients must be readily available in sufficient amounts and balanced proportion. The readily available sources, which provide essential nutrients and maintain a favorable balance, are chemical fertilizers. However, suitable and balance combination of macro and micro nutrients are not only essential for plant growth and production, but also good for environment.

Macro nutrients play an important role in growth and development process of the plant such as nitrogen encourages vegetative growth (Haq et al., 2012) and phosphorus encourages root development and also providing energy by forming ATP and potassium play an important for carbohydrate metabolism, enzyme activation and osmotic regulation (Shaheen et al., 2007). Similarly, micro nutrients are essential as macro nutrients because important growth processes depend on them (Ali et al., 2008). For example, boron is essential for plant growth and development as translocation of sugar and quality production depend on boron (Vasconcelos et al., 2011). However, the boron deficiency in soil caused by removal of boron by crops is not fully replenished by fertilizer applications. In contrast, high concentration and unbalance ratios of both macro and micro nutrients lead to undesirable plant growth and development (Hall, 2002). As reported by Ouda et al. (2008) that plant growth is severely depressed by boron deficiency, but high concentration of boron also reduces quality of crop (Islam et al., 2009). It was found that balance fertilization of macro and micro nutrients is essential for the production of high yield and quality products (Swan et al., 2001; Ali et al., 2008), while foliar application of micronutrients to plant is the most effective and safest way (Aghtape et al., 2011). However, little information is available to show the effects of macro and micro nutrients on growth and yield parameters of crop (May and Pritts, 1993; Islam et al., 2009). Although, broccoli is a high value vegetable crop of the world, but there is lack of research, particularly under field condition, to show the effects of nitrogen, phosphorus, potassium and boron on broccoli. Therefore, the current experiment was conducted to study the Effect of different doses of NPK and boron on growth and yield of broccoli (*Brassica oleracea* L.var.*italica*).

2. Materials and Methods

An experiment was conducted at Horticultural Research Centre, of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh (28°40'07"N to

29°28'11"N, 77°28'14"E to 77° 44' 18"E) during 2009-10 & 2010-11. The climate of the area is semi-arid, with an average annual rainfall of 665 mm 75-80% of which is received during July to September), minimum temperature of 4°C in January, maximum temperature of 41-45°C in June and relative humidity of 67-83% during the year. The soil of the experimental plot was sandy and low to medium in organic matter content. Soil with a bulk density of 1.48 Mg m⁻³, pH=7.81, Organic carbon.=0.42% g, Available N=153.49 kg ha⁻¹, Available P=29.98 kg ha⁻¹, and Available K=144.60 kg ha⁻¹. Groundwater pumping was the predominant method of irrigation in Western UP. The present experiment entitled "Effect of different doses of NPK and boron on growth and yield of broccoli (*Brassica oleracea* L.var.*italica*)." was formulated in Randomized Block design (RBD) with three replications. The experiment was consisted of seven treatments with different doses of fertilizer combinations and boron applications in combinations and alone. The details of applied treatment were T₁-100 kg N+40 kg P₂O₅+20 kg K₂O ha⁻¹, T₂-120 kg N+60 kg P₂O₅+40 kg K₂O ha⁻¹, T₃-140 kg N+80 kg P₂O₅+60 kg K₂O ha⁻¹, T₄-100 kg N+40 kg P₂O₅+20 kg K₂O+10 kg B ha⁻¹, T₅-120 kg N+60 kg P₂O₅+40 kg K₂O+15 kg B ha⁻¹, T₆-140 kg N+80 kg P₂O₅+60 kg K₂O+20 kg B ha⁻¹, T₇-control (No fertilizer application). In present investigation, a Takki hybrid variety of broccoli was taken. The seeds of earlier mentioned variety of broccoli were sown in IIIrd week of September in well prepared nursery beds. Thereafter, 30 days old seedlings of broccoli were transplanted in well prepared experimental field in classified plots at a distance 50×50 cm². At the transplanting time, Half dose of nitrogen, full dose of phosphorus and potash were applied in experimental plots and thoroughly mixed in soil. Remaining half dose of nitrogen was applied after one month of transplanted crop. All the crop management practices were adopted during cropping season. The plant protection measures were also followed to control of pest and diseases infestation. To find out the effect of treatments, three sample plants were selected to obtain field data according to observations on growth and yield during the cropping periods for research purposes. The field data were analyzed statistically as suggested by Gomez and Gomez (1996).

3. Results and Discussion

3.1. Effect of NPK and boron application on growth parameters

Data exhibited from the Table 1 showed that the application of nitrogen, phosphorus, potash and boron had significant effect on the plant height of broccoli cv. Takki. Each increment of NPK and boron doses up to 120 kg N+60 kg P₂O₅+40 kg K₂O+15 kg boron ha⁻¹ were obtained significantly higher plant height in both the cropping seasons, thereafter a detrimental effect



was noted in plant height with the higher dose of NPK+boron. The maximum plant height (65.36 cm) was recorded with an application of 120 kg N+60 kg P_2O_5 +40 kg K_2O +15 kg Boron ha^{-1} followed by T_4 (100 kg N+40 kg P_2O_5 +20 kg K_2O +10 kg B ha^{-1}) and T_6 (140 kg N+80 kg P_2O_5 +60 kg K_2O +20 kg B ha^{-1}), whereas minimum plant height $plant^{-1}$ (58.66 cm) was recorded under control treatment. The maximum number of leaves $plant^{-1}$ (18.26) noted with a dose of 120 kg N+60 kg P_2O_5 +40 kg K_2O +15 kg boron ha^{-1} and minimum number of leaves $plant^{-1}$ were recorded under control treatment. It is might be due to the nitrogen synthesizes proteins and formed the carbohydrates in crop plant; it favored plant height and number of leaves. Similarly, phosphorus also plays a vital role in plant growth and energy captures. The plant height and number of leaves relatively increased by optimum dose of potassium because, it is necessary for carbohydrate metabolism and efficient use of water. The micro element like boron is also play a significant role in terms of translocation of sugar and nitrogen element. These findings are in close conformity with earlier findings of Singh et al. 2006, Supe and Marbhal 2008 and Moniruzzaman et al. 2007. The length and width of longest leaf showed a significant effect with increasing application of NPK and boron as composed to control once. The length of longest leaves significantly increased up to a nutrients level of 120 kg N+60 kg P_2O_5 +40 kg K_2O +15 kg boron ha^{-1} after that a significantly markedly decrease trend was noted in the length of longest leaf. Maximum length (52.99 cm) and width (17.99) of longest leaf were recorded in treatment T_5 -120 kg N+60 kg P_2O_5 +40 kg K_2O +15 kg boron ha^{-1} , whereas minimum length (42.70 cm) and width (14.18 cm) were noted under control plots. It may be due to the optimum NPK accumulation and translocation in leaves with the help of microelement like boron. Similar finding were also reported by Magd et al. (2005) and Saha et

al. (2006). The significant affects on plant spread by NPK and boron application from lower level to higher level as compared to control treatment were recorded, while the each increment levels zero to 120 kg N+60 kg P_2O_5 +40 kg K_2O +15 kg boron ha^{-1} performed a significant superficial increase in plant spread after that a decreased trend was observed in plant spread in both the consecutive years. Similarly, growth trend was also recorded in respect of diameter of stem. The maximum (4.72 cm) stem diameter was recorded with an application of 120 kg N+60 kg P_2O_5 +40 kg K_2O +15 kg boron ha^{-1} (T_5) and minimum (3.04 cm) stem diameter under control treatment. Similar results were obtained earlier by Prasad and Yadav (2003) and Moniruzzaman et al. (2007).

3.2. Effect of NPK and boron application on yield parameters

The significant results on yield and yield attributing parameters were noticed with each increasing dose of NPK and boron up to a level of 120 kg N+60 kg P_2O_5 +40 kg K_2O +15 kg boron ha^{-1} (Table 2) as compared to control, therefore markedly declined in terms of days taken to curd formation, diameter and length of curd, weight of curd $plant^{-1}$, number of sprout and weight of sprout $plant^{-1}$, weight of curd and sprout $plant^{-1}$, yield of curd and sprouts ($q ha^{-1}$). Minimum (56.48 days) taken to curd formation under T_5 -120 kg N+60 kg P_2O_5 +40 kg K_2O +15 kg boron ha^{-1} , and maximum (63.11 days) taken under control treatment. Similar results were obtained in terms of diameter and length of curd. Maximum diameter (13.69 cm) and length (16.33 cm) of curd were recorded at T_5 -120 kg N+60 kg P_2O_5 +40 kg K_2O +15 kg boron ha^{-1} and minimum (9.44 cm) and (10.87 cm) were obtained in control treatment. The minimum days taken to curd formation and size of curd is directly associated for higher yield of broccoli. The minimum days

Table 1: Effect of Different doses of NPK and boron application on growth parameters of broccoli (*Brassica oleracea* var. *italica*) during 2009 and 2010 (pooled)

Treatments	Plant Height $plant^{-1}$ (cm)	Number of leaves $plant^{-1}$	Length of longest leaf	Width of longest leaf (cm)	Plant spread (cm)	Stem diameter (cm)
T_1	59.66	13.34	45.52	15.24	49.66	3.48
T_2	60.66	14.77	46.67	16.11	51.44	3.88
T_3	62.00	15.22	47.53	16.26	51.61	4.19
T_4	62.65	17.11	49.89	17.39	53.44	4.40
T_5	65.33	18.26	52.99	17.98	55.53	4.72
T_6	63.00	16.44	49.11	16.87	52.72	4.24
T_7	58.66	12.31	42.70	14.18	47.49	3.04
SEm \pm	0.47	0.60	1.83	0.64	1.49	0.12
CD ($p=0.05$)	1.48	1.87	5.72	1.99	4.66	0.38

T_1 : 100 kg N+40 kg P_2O_5 +20 kg K_2O ha^{-1} ; T_2 : 120 kg N+60 kg P_2O_5 +40 kg K_2O ha^{-1} ; T_3 : 140 kg N+80 kg P_2O_5 +60 kg K_2O ha^{-1} ; T_4 : 100 kg N+40 kg P_2O_5 +20 kg K_2O +10 kg B ha^{-1} ; T_5 : 120 kg N+60 kg P_2O_5 +40 kg K_2O +15 kg B ha^{-1} ; T_6 : 140 kg N+80 kg P_2O_5 +60 kg K_2O +20 kg B ha^{-1} ; T_7 : Control (Without fertilizer dose)



Table 2: Effects of different doses of NPK and boron application on yield and its attributing traits in broccoli (*Brassica oleracea* var. *italica*) during 2009 and 2010 (pooled)

Treatments	Days taken to curd formation (Days)	Curd diameter (cm)	Length of curd (cm)	Weight of curd plant ⁻¹ (cm)	Number of sprout plant ⁻¹ (cm)	Weight of sprout plant ⁻¹ (g)	Weight of curd and sprout plant ⁻¹ (kg)	Total yield of curd and sprouts (q ha ⁻¹)
T ₁	61.88	10.48	12.05	149.42	6.40	54.33	0.220	81.43
T ₂	60.87	11.09	12.50	183.77	6.77	54.85	0.250	95.44
T ₃	60.33	11.61	13.00	188.34	6.99	93.42	0.310	118.22
T ₄	59.44	12.29	14.83	247.39	7.77	108.55	0.370	142.55
T ₅	56.48	13.69	16.33	286.89	9.37	126.89	0.390	148.51
T ₆	58.15	11.86	14.00	239.45	7.44	107.24	0.343	133.25
T ₇ Control	63.11	9.44	10.87	142.65	6.22	44.86	0.200	75.27
SEm±	1.09	0.46	0.70	0.14	0.54	0.09	0.003	0.39
CD (p=0.05)	3.43	1.44	2.20	0.45	1.68	0.31	0.008	1.21

taken to curd formation and size of curd is directly associated for higher yield of broccoli. It is due to proper utilization of carbohydrates doses which is formed by protein synthesis through the nitrogen application. Phosphorus is responsible for root development and early maturity due to recovery of reactions. In other hand, potassium also give a significant role in many functions like carbohydrate metabolism and enzyme activation in plant body and boron act as proper translocation of sugars, starch and nitrogen compound in plant body. These findings are in close conformity with the earlier results obtained by (Bahadur et al., 2004) and (Singh, et al., 2009).

The maximum weight (286.89 g) of curd plant⁻¹ was also found in treatment T₅-120 kg N+60 kg P₂O₅+40 kg K₂O+15 kg boron ha⁻¹, and minimum curd weight (142.65 g) was recorded in the unfertilized plot. Similarly, the number of sprout and weight of sprout plant⁻¹ were recorded significantly higher by using various doses of NPK and boron combinations. The maximum number of sprout (9.37) and weight of sprout (126.89 g) plant⁻¹ were recorded with a dose of 120 kg N+60 kg P₂O₅+40 kg K₂O+15 kg boron ha⁻¹. However control gave the minimum number of sprouts and weight of sprout plant⁻¹ i.e., 6.22 and 44.86 g, respectively. Maximum weight of curd and sprout plant⁻¹ (0.343 kg) was recorded at 120 kg N+60 kg P₂O₅+40 kg K₂O+15 kg boron ha⁻¹, and minimum (0.200 kg) was noticed under control plot. The total yield of curd and sprouts (148.51 q ha⁻¹) was obtained under the applied doses i.e., 120 kg N+60 kg P₂O₅+40 kg K₂O+15 kg boron ha⁻¹ followed by treatments T₄ and T₅, respectively, Table 2. Whereas, minimum total yield of curd and sprout (75.27 q) ha⁻¹ was recorded under control plot. It might be due to proper utilization of carbohydrates, proteins and accumulation photosynthetic and many functions like carbohydrate metabolism and enzyme activation and translocation of sugars and starch by the supply of optimum level of NPK and boron in broccoli. These findings are also

confirmed with the earlier workers (Supe and Marbhal 2008, Shahah et al., 2010.)

4. Conclusion

The effects of nitrogen, phosphorus, potassium and boron on growth and yield of broccoli indicated that growth and yield of broccoli were significantly related to suitable combinations of nitrogen, phosphorus, potassium and boron. The growth and yield were maximum and minimum by combination of N at 120 kg ha⁻¹, P at 60 kg ha⁻¹, K at 40 kg ha⁻¹, boron at 15 kg ha⁻¹ and N at 140 kg ha⁻¹ P at 60 kg ha⁻¹, K at 40 kg ha⁻¹, boron at 15 kg ha⁻¹, it can be concluded that these combination proved better performance with boron irrigated agro-ecosystem of western Uttar Pradesh.

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