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Effect of micronutrient and NPK on growth, yield and quality of bottle gourd [*Lagenaria siceraria* (*Molina*) Standl.] cv. Pusa hybrid-3

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Abstract
The present experiment was carried out during September to December, 2018 in Research Field of Department of Horticulture, SHUATS, Prayagraj. The experiment was conducted in Randomized Block Design (RBD), with twelve treatments, replicated thrice of Micronutrients and NPK. the treatments were T_0 (Control (100% RDF)), T_1 (NPK @ 100%), T_2 (25% RDF + 75% FYM), T_3 (B @ 0.3%), T_4 ($ZnSO_4$ @ 0.5% + B @ 0.3%), T_5 $ZnSO_4$ @ 0.3% + B @ 0.1%), T_6 (NPK @ 100% + $ZnSO_4$ @ 0.3%), T_7 (NPK @ 50% + $ZnSO_4$ @ 0.5%), T_8 (NPK @ 100% + B @ 0.1%), T_9 (NPK @ 50% + B @ 0.3%), T_{10} (NPK @ 100% + $ZnSO_4$ @ 0.5% + B @ 0.3%) and T_{11} (NPK @ 50% + $ZnSO_4$ @ 0.3% + B @ 0.1%). From the present experimental findings it is found that the treatment T_{10} (NPK @ 100% + $ZnSO_4$ @ 0.5% + B @ 0.3%) was found superior over other treatments in terms of growth, yield and quality of Bottle gourd, followed by treatment T_8 (NPK @ 100% + B @ 0.1%), in terms of economics treatment T_1 (NPK @ 100%) maximum cost benefit ratio 1:6.32 and lowest readings was recorded in T_0 (Control) in all the parameters.

Keywords: Bottle gourd, NPK, micronutrients, zinc and boron

Introduction
Vegetable play an important role in the balance diet by providing not only energy but also supplying vital protective nutritive nutrients either mineral or vitamins. Thus, Vegetables are getting increasingly higher importance in India as well as in the world due to their relevance in achieving nutritional security from emerging nutritional problems in human beings. Today India is the second largest producer of Vegetable in worlds after china. In the year 2016, the total vegetable production of country was 169064 million tones from 10106 million hectares of land (IIVR, 2016).

Bottle gourd [*Lagenaria siceraria* Mol. Standl.] belong to the family of Cucurbitaceae having chromosome no. 2n = 22. Bottle gourd originated in Tropical Africa and domesticated in Asia, Africa and New World. India is the second largest producer of vegetable in worlds after china. According to recommendation given by India Council of Medical Research (ICMR) an average man with vegetarian or Non- Vegetarian food habit should consume 300 g vegetable per day, which include 125 mg leafy vegetable, 100 g of root vegetable and 75 g of other vegetable (Fagaria *et al*., 2010) [4]. In the year 2002, the total vegetable production of country was 97.5 million tons from 7.59 million hectares of land (Gupta *et al.,* 2010). In the country, vegetable crops are grown only in 2.8% of total cultivated land and share 10% of the world's vegetable production with productivity of 13.6 t ha^{-1}, which is quite low as compared to other advanced countries (Shanmugasundram, 2001) [16].

It is a warm season vegetable, which thrives well in warm and humid climate but it can be grown throughout the year in Northern India as off – season vegetable. The young and tender fruit of bottle gourd are mostly used in rayata, halwa, petha etc. dry shells of the mature fruits are used to make containers and musical instruments.

In subtropical climate of north and central India two crops, one in summer and the other in rainy season are taken in a year. Most of the cultivars in this region are specific to the crop season but some of them perform well in both the crops seasons. During summer the crop is sown in February- March and the vines are allowed to spreads on the ground. The rainy season crop is grown in unirrigated upland condition and sown in July – August; the vines are trained to climb on some artificial structure. The area and production of summer season crop is higher than the rainy season crop.

In the temperate climate, the crop may be grown during summer – rainy season, if the temperature ranges from 15 ^{0}C to 25 ^{0}C available for a period of 100-120 days. In tropical conditions it can be grown throughout the year under irrigated conditions.

During the last two decades there has been a constant progress in the production of bottle gourd by farmers, particularly with the traditional method of cultivation. However, the influence of micronutrients on growth, development and yield of bottle gourd are of immense magnitude. It is realized that productivity of crop is being adversely affected in different areas due to deficiencies of micro nutrients (Bose and Tripathi, 1996) [1].

Materials and Methods

The Experimental was conducted in Randomized Block Design (RBD) with 12 treatments of Micronutrients and NPK with three replications in the Research field, Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during September to December 2018. Total number of treatments were Twelve *viz.* T_0 (Control (100% RDF)), T_1 (NPK @ 100%), T_2 (25% RDF + 75% FYM), T_3 (B @ 0.3%), T_4 ($ZnSO_4$ @ 0.5% + B @ 0.3%), T_5 $ZnSO_4$ @ 0.3% + B @ 0.1%), T_6 (NPK @ 100% + $ZnSO_4$ @ 0.3%), T_7 (NPK @ 50% + $ZnSO_4$ @ 0.5%), T_8 (NPK @ 100% + B @ 0.1%), T_9 (NPK @ 50% + B @ 0.3%), T_{10} (NPK @ 100% + $ZnSO_4$ @ 0.5% + B @ 0.3%) and T_{11} (NPK @ 50% + $ZnSO_4$ @ 0.3% + B @ 0.1%) Hybrid - Pusa Hybrid – 3 was used for cultivation.

Climatic condition in the experimental site

The area of Prayagraj district comes under subtropical belt in the south east of Utter Pradesh, which experience extremely hot summer and fairly cold winter. The maximum temperature of the location reaches up to 46 ºC- 48 ºC and seldom falls as low as 4 ºC- 5 ºC. The relative humidity ranges between 20 to 94%. The average rainfall in this area is around 1013.4 mm annually. However, occasional precipitation is also not uncommon during winter months.

Results and Discussion

The present investigation entitled "Effect of Micronutrient and NPK on Growth, Yield and Quality of Bottle Gourd [*Lagenaria siceraria* (Molina) Standl.] cv. Pusa Hybrid-3" was carried out during September to December 2018 in Research Field, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) India. The results of the present investigation, regarding the effect of Micronutrients and NPK on growth, yield and quality of Bottle gourd, have been discussed and interpreted in the light of previous research work done in India and abroad. The experiment was conducted in Randomized block design with 12 treatments, three replications and one variety of bottle gourd.

The results of the experiment are summarized below

In terms of Vine length, treatment T_{10} (NPK @ 100% + $ZnSO_4$ @ 0.5% + B @ 0.3%) recorded maximum (8.53 m) vine length, followed by T_8 (NPK @ 100% + B @ 0.1%) with (8.05 m) and minimum (5.38 m) was recorded in treatment T_0 (Control). The improvement in vine length as a result of foliar feeding of micronutrients might be due to enhanced photosynthetic and other metabolic activities which lead to increase in various plant metabolites responsible for cell division and elongation as opined by Hatwar *et al.* (2003) [6]. These results are in agreement with the findings of earlier workers Narayanamma *et al.* (2009) [12] in bitter gourd, Rab and Haq (2012) [14] in tomato and Kumar *et al.* (2010) [8] in cauliflower.

In terms of Number of branches/plant, treatment T_{10} (NPK @ 100% + $ZnSO_4$ @ 0.5% + B @ 0.3%) recorded maximum (6.60) branches/plant, followed by T_8 (NPK @ 100% + B @ 0.1%) with (6.32 branches/plant) where as minimum (3.49) was recorded in treatment T_0 (Control). The increased number of branches/vine might be due to better sink developed by auxiliary branches to a large amount of available nutrients as reported by Maya (1996) in sweet pepper cv. (Califlornia Wonder). The results of present experiment are in consonance with the findings of Sabina (1995) [15] in geraminium, Meenakshi and Vadivel (2003) [10] in bitter gourd, Rab and Haq (2012) [14] in tomato, Shukla (2011) [17] in gooseberry and Narayanamma *et al.* (2009) [12] in bitter gourd.

In terms of Length of lateral branches, treatment T_{10} (NPK @ 100% + $ZnSO_4$ @ 0.5% + B @ 0.3%) recorded maximum (4.04 m) Length of lateral branches, followed by T_8 (NPK @ 100% + B @ 0.1%) with (3.94 m) where as minimum (3.19 m) was recorded in treatment T_0 (Control). The improvement in Length of Lateral Branches, as a result of feeding of micronutrients might be due to enhanced photosynthetic and other metabolic activities which lead to increase in various plant metabolites responsible for cell division and elongation as opined by Hatwar *et al.* (2003) [6]. These results are in agreement with the findings of earlier workers Narayanamma *et al.* (2009) [12] in bitter gourd, Rab and Haq (2012) [14] in tomato and Kumar *et al.* (2010) [8] in cauliflower.

In terms of Leaf area, treatment T_{10} (NPK @ 100% + $ZnSO_4$ @ 0.5% + B @ 0.3%) recorded maximum (505.31 cm^2) Leaf area, followed by T_8 (NPK @ 100% + B @ 0.1%) with (501.55 cm^2) where as minimum (459.87 cm^2) was recorded in treatment T_0 (Control). The improvement in Leaf area, as a result of feeding of micronutrients might be due to enhanced photosynthetic and other metabolic activities which lead to increase in various plant metabolites responsible for cell division and elongation as opined by Hatwar *et al.* (2003) [6]. These results are in agreement with the findings of earlier workers Narayanamma *et al.* (2009) [12] in bitter gourd, Rab and Haq (2012) [14] in tomato and Kumar *et al.* (2010) [8] in cauliflower.

In terms of Days to appearance of first male flower, treatment T_{10} (NPK @ 100% + $ZnSO_4$ @ 0.5% + B @ 0.3%) recorded minimum (64.92 days) for appearance of first male flower, followed by T_8 (NPK @ 100% + B @ 0.1%) with (67.14 days) where as maximum (79.31 days) was recorded in treatment T_0 (Control).

In terms of Days to appearance of first female flower, treatment T_{10} (NPK @ 100% + $ZnSO_4$ @ 0.5% + B @ 0.3%) recorded minimum (68.23 days) for appearance of first female flower, followed by T_8 (NPK @ 100% + B @ 0.1%) with (70.63 days) where as maximum (83.48 days) was recorded in treatment T_0 (Control). It may be due to the fact that the boron has significant role in mobilization of food materials from source to sink. Similar results were have also been obtained by Shukla (2011) [17] in Gooseberry.

In terms of Node No. to first female flower, treatment T_{10} (NPK @ 100% + $ZnSO_4$ @ 0.5% + B @ 0.3%) recorded minimum (11.83) for Node No. to first female flower emergence, followed by T_8 (NPK @ 100% + B @ 0.1%) with

(12.35) where as maximum (15.82) was recorded in treatment T_0 (Control). The improvement in Node No. to first female flower emergence as a result of feeding of micronutrients might be due to enhanced photosynthetic and other metabolic activities which lead to increase in various plant metabolites responsible for cell division and elongation as opined by Hatwar *et al.* (2003) [6]. These results are in agreement with the findings of earlier workers Narayanamma *et al.* (2009) [12] in bitter gourd, Rab and Haq (2012) [14] in tomato and Kumar *et al.* (2010) [8] in cauliflower.

In terms of Number of male flower per plant, treatment T_{10} (NPK @ 100% + $ZnSO_4$ @ 0.5% + B @ 0.3%) recorded maximum (77.25) Number of male flower per plant, followed by T_8 (NPK @ 100% + B @ 0.1%) with (74.34) where as minimum (63.97) was recorded in treatment T_0 (Control).

In terms of Number of female flower per plant, treatment T_{10} (NPK @ 100% + $ZnSO_4$ @ 0.5% + B @ 0.3%) recorded maximum (34.17) Number of female flower per plant, followed by T_8 (NPK @ 100% + B @ 0.1%) with (30.87) where as minimum (17.01) was recorded in treatment T_0 (Control). It may be due to the fact that the boron has significant role in mobilization of food materials from source to sink. Similar results were have also been obtained by Shukla (2011) [17] in Gooseberry.

In terms of Fruit length, treatment T_{10} (NPK @ 100% + $ZnSO_4$ @ 0.5% + B @ 0.3%) recorded maximum (47.16 cm) Fruit length, followed by T_8 (NPK @ 100% + B @ 0.1%) with (42.53 cm) where as minimum (26.77 cm) was recorded in treatment T_0 (Control).

In terms of Fruit weight, treatment T_{10} (NPK @ 100% + $ZnSO_4$ @ 0.5% + B @ 0.3%) recorded maximum (2.32 kg) Fruit weight, followed by T_8 (NPK @ 100% + B @ 0.1%) with (2.04 kg) where as minimum (1.23 kg) was recorded in treatment T_0 (Control).

In terms of Fruit diameter, treatment T_{10} (NPK @ 100% + $ZnSO_4$ @ 0.5% + B @ 0.3%) recorded maximum (18.54 cm) Fruit diameter, followed by T_8 (NPK @ 100% + B @ 0.1%) with (17.66 cm) where as minimum (11.95 cm) was recorded in treatment T_0 (Control). Increased fruit size and weight attributed due to micronutrients application might be attributed to enhanced photosynthesis, accumulation of carbohydrates and favourable effect on vegetative growth which increased the fruits variety besides increasing the fruit size. These results get support from the findings of Kumbhar and Deshmukh (1993) [9], Bose and Tripathi (1996) [1] in tomato, Meenakshi *et al.* (2007) [11] and Narayanamma *et al*., (2009) [12] in bitter gourd.

In terms of Number of fruits per plant, treatment T_{10} (NPK @ 100% + $ZnSO_4$ @ 0.5% + B @ 0.3%) recorded maximum (23.35) fruits per plant, followed by T_8 (NPK @ 100% + B @ 0.1%) with (21.66 fruits) where as minimum (12.42) was recorded in treatment T_0 (Control).

In terms of Yield per plant, treatment T_{10} (NPK @ 100% + $ZnSO_4$ @ 0.5% + B @ 0.3%) recorded maximum (39.45 kg) Yield per plant, followed by T_8 (NPK @ 100% + B @ 0.1%) with (33.78 kg) where as minimum (15.25 kg) was recorded in treatment T_0 (Control). There was a marked effect of foliar spray of micro nutrients on number of fruits per vine which leads to fruits yield per plant. Significantly highest number of fruits/vine was recorded with the application of boron 0.3%. The fruit growth and final yield depends on the continued supply of food material and water (Huett and Deltmann, 1988) [7]. Since boron helps in the absorption of water and carbohydrates metabolism (Haque *et al.,* 2011) [5], its deficiency may cause sterility, small fruit size and poor yield (Davis, *et al.,* 2003). The results of the present investigation in terms of number of fruits/vine are in collaborative with the findings of Narayanamma *et al.* (2009) [12] in bitter gourd and Meenakshi *et al.* (2007) [11] in bitter gourd and Venkatasalam and Krishnasamy (2011) [18], Rab & Haq (2012) in tomato.

In terms of Yield tones/ha, treatment T_{10} (NPK @ 100% + $ZnSO_4$ @ 0.5% + B @ 0.3%) recorded maximum (148.98 tones) Yield/ha, followed by T_8 (NPK @ 100% + B @ 0.1%) with (127.38 tones) where as minimum (57.57 tones) was recorded in treatment T_0 (Control). The increase in yield and yield attributes due to micronutrients application might be attributed to enhanced photosynthesis, accumulation of carbohydrates, development of cell wall and cell differentiations as they boost up overall vegetative growth, biological activity of the plants and retention of more flowers and fruits which increased number of fruits per vine and size of fruits besides increasing the yield. The production of more number of hermaphrodite flowers in watermelon by the application of calcium and boron might be due to attraction in the GA metabolism (Brantley and Warren, 1960) [2]. These results are in agreement with the findings of Kumbhar and Deshmukh, (1993) [9] and Bose and Tripathi (1996) [1] in tomato, Meenakshi *et al.* (2009) Narayanamma *et al.* (2009) [12] and Patil *et al.* (2013) [13] in bitter gourd.

In terms of Total Soluble Solids, treatment T_{10} (NPK @ 100% + $ZnSO_4$ @ 0.5% + B @ 0.3%) recorded maximum (5.04 ^{0}Brix) TSS, followed by T_8 (NPK @ 100% + B @ 0.1%) with (4.77 ^{0}Brix) where as minimum (3.92 ^{0}Brix) was recorded in treatment T_0 (Control). This lead to higher concentration of NPK and micronutrients in leaves and fruits and resulted in better accumulation of assimilates resulting in better quality parameters (Meenakshi *et al.,* 2007) [11] in bitter gourd. The TSS content of tomato fruits have been shown to correlate with available boron and are increased by both foliar and soil application of boron (Sathya *et al*., 2010). These results are in consonance with the findings of Shukla (2011) [17] in Indian goose berry and Rab and Haq (2012) [14] in tomato.

In terms of economics the treatment T_1 (NPK @ 100%) recorded Gross Return Rs. 567920, and Net Return Rs. 835571.00 and cost benefit ratio 1:6.32 followed by treatment T_8 (NPK @ 100% + B @ 0.1%) with Gross return Rs. 1019040.00, Net Return Rs. 835571.00 and Cost benefit Ratio 1:5.55 and minimum Gross Return, Net Return and Cost Benefit Ratio (Rs. 775760.00, Rs. 26003.00 and 1:1.03 respectively) was recorded in treatment T_4 ($ZnSO_4$ @ 0.5% + B @ 0.3%).

Table 1: Effects of Micronutrients and NPK on Vine length (m), Number of branches/plant, Length of lateral branches, Leaf area (cm^2), Days to appearance of first male flower, Days to appearance of first female flower, Node no. of first female flower emergence, Number of male flower per plant and Number of female flower per plant Bottle Gourd.

Treatment Symbol	Treatment Combinations	Vine Length (m)	Number of Branches/ plant	Length of lateral Branches (m)	Leaf Area (cm^2)	Days to appearance of first male flower	Days to appearance of first female flower	Node No. to first female flower emergence	Number of male flower per plant	Number of female flower per plant
T_0	Control	5.38	3.49	3.19	459.87	79.31	83.48	15.82	63.97	17.01
T_1	NPK @ 100%	6.16	5.33	3.58	484.54	73.97	77.92	14.60	65.54	20.72
T_2	$ZnSO_4$ @ 0.5%	7.37	5.67	3.71	485.30	74.50	77.26	13.79	67.59	23.05
T_3	B @ 0.3%	7.51	6.03	3.76	494.32	69.92	73.17	13.11	71.92	28.20
T_4	$ZnSO_4$ @ 0.5% + B @ 0.3%	7.32	5.70	3.70	491.77	71.35	74.98	13.50	69.41	27.20
T_5	$ZnSO_4$ @ 0.3% + B @ 0.1%	6.98	5.46	3.69	488.76	73.46	77.10	13.84	70.98	26.35
T_6	NPK @ 100% + $ZnSO_4$ @ 0.3%	7.56	5.77	3.69	490.19	72.30	75.92	13.49	70.44	23.72
T_7	NPK @ 50% + $ZnSO_4$ @ 0.5%	7.11	4.98	3.72	491.91	73.98	77.83	14.02	68.78	23.46
T_8	NPK @ 100% + B @ 0.1%	8.05	6.32	3.94	501.55	67.14	70.63	12.35	74.34	30.87
T_9	NPK @ 50% + B @ 0.3%	6.82	5.87	3.65	482.85	71.88	75.51	13.49	70.44	25.98
T_{10}	NPK @ 100% + $ZnSO_4$ @ 0.5% + B @ 0.3%	8.53	6.60	4.04	505.31	64.92	68.23	11.83	77.25	34.17
T_{11}	NPK @ 50% + $ZnSO_4$ @ 0.3% + B @ 0.1%	6.61	5.05	3.25	477.64	73.19	77.28	13.75	74.40	25.71
F-Test		S	S	NS	S	S	S	S	S	S
SE(d)		0.272	0.376	0.293	7.287	1.326	1.190	0.538	1.457	1.012
C.V.		4.684	8.346	9.811	1.829	2.251	1.923	4.837	2.534	4.852
C.D. at 5%		0.568	0.786	N/A	15.209	2.768	2.483	1.124	3.041	2.112

Table 2: Effects of Micronutrients and NPK on Fruit length (cm), fruit weight (kg), Fruit diameter (cm), Number of fruit per plant, Total yield per plant (kg), Yield tones/ha, Total Soluble Solids (°Brix) and Cost Benefit Ratio of Bottle Gourd.

Treatment Symbol	Treatment Combinations	Fruit length (cm)	Fruit weight (Kg)	Fruit diameter (cm)	Number of Fruits per plant	Total Yield per plant (Kg)	Yield tones/ha	Total Soluble Solids (°Brix)	Cost Benefit Ratio
T_0	Control	26.77	1.23	11.95	12.42	15.25	57.57	3.92	1:4.73
T_1	NPK @ 100%	33.63	1.32	13.28	14.20	18.80	70.99	4.02	1:6.32
T_2	$ZnSO_4$ @ 0.5%	34.28	1.43	13.54	17.19	24.24	91.51	4.19	1:1.62
T_3	B @ 0.3%	37.13	1.76	16.41	18.45	30.90	116.69	4.29	1:2.63
T_4	$ZnSO_4$ @ 0.5% + B @ 0.3%	38.18	1.71	15.27	17.55	27.70	104.60	4.07	1:1.14
T_5	$ZnSO_4$ @ 0.3% + B @ 0.1%	31.42	1.63	14.96	13.42	21.69	81.90	4.18	1:1.66
T_6	NPK @ 100% + $ZnSO_4$ @ 0.3%	34.42	1.58	13.84	12.85	20.06	75.52	4.27	1:1.90
T_7	NPK @ 50% + $ZnSO_4$ @ 0.5%	31.42	1.67	13.51	13.93	23.34	88.13	4.01	1:1.50
T_8	NPK @ 100% + B @ 0.1%	42.53	2.04	17.66	21.66	33.78	127.38	4.77	1:5.55
T_9	NPK @ 50% + B @ 0.3%	32.67	1.55	16.28	16.66	25.69	96.97	4.11	1:2.14
T_{10}	NPK @ 100% + $ZnSO_4$ @ 0.5% + B @ 0.3%	47.16	2.32	18.54	23.35	39.45	148.98	5.04	1:1.59
T_{11}	NPK @ 50% + $ZnSO_4$ @ 0.3% + B @ 0.1%	35.29	1.49	14.93	15.56	23.20	87.60	4.14	1:1.74
F-Test		S	S	S	S	S	S	S	
SE(d)		1.459	0.129	0.806	1.070	2.227	8.392	0.09	
C.V.		5.046	9.621	6.574	7.971	10.764	10.745	2.54	
C.D. at 5%		3.045	0.270	1.682	2.233	4.649	17.517	0.183	

Conclusion

From the present experimental findings it is concluded that the treatment T_{10} (NPK @ 100% + $ZnSO_4$ @ 0.5% + B @ 0.3%) was found superior over other treatments in terms of growth, yield and quality of Bottle gourd, followed by treatment T_8 (NPK @ 100% + B @ 0.1%), in terms of economics treatment T_1 (NPK @ 100%) maximum cost benefit ratio 1:6.32 and lowest readings was recorded in T_0 (Control) in all the parameters.

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