Effect of Phosphorus and Boron on growth, yield and economics of Sweet Corn (*Zea mays* L.)

ABSTRACT

A research trail was conducted in *Kharif* 2022, at crop research form, SHUATS, Prayagraj. To Study the "Effect of Phosphorus and Boron on growth, yield and economics of Sweet Corn (*Zea mays* L.)". The treatments consisted of 3 Levels of Phosphorus (50kg/ha ,100kg/ha, 150kg/ha) and Boron (200g/ha, 300g/ha, 400g/ha). The experiment was laid out in Randomized Block Design with ten treatments each replicated thrice. Application of Phosphorus 150kg/ha and Boron 400g/h produced higher Plant height(196.33cm),dry weight/plant(70.97g), maximum number of cobs per plant (1.93), cob length (20.27cm), Number of grain rows per cobs (26.65), Cob yield (6.5t/ha), Stover yield (12.23t/ha), Seed index (21.51), Harvest index (34.75), Maximum gross return (256150INR/ha), net return (198768.98INR/ha), and benefit cost ratio (3.46) when compared to the other treatment.

Keywords- *Sweet corn, Phosphorus, Boron,growth, Yield and Economics*

1. INTRODUCTION

Maize (*Zea mays* L.) is a cereal crop and it is called as "queen of cereals" and "non-tillering plant". Maize is one of the three major world food crops, is recognized as the "golden food" because of its high grain yield and nutrition value, and plays a very important role in the daily calorie intake of humans. “Maize is the third most important crop in India after rice and wheat. In the world, India's ranks 5th in acreage and 8th in production of maize” (USDA 2018) [1]. “Globally, total area of maize was 186.86 m/ha, production 1078.56 million tone and in India area under maize cultivation is about 9.63 m/ha, production 25.90 million tone in 2017. maize is grown in an area of 9.43million hectares with production of 24.35 m t and productivity of 2583 kg/ha” (Government of India, 2020). “In UP, maize is grown in area of 0.83 m/ha with production 1.56 m t and productivity of 2376 kg/ha” (State wise 2020).

“Sweet corn is a medium plant type and provides green Cobs in 65 to 75 days after sowing. These are harvested earlier by 35 to 45 days compared to normal grain maize. The demand for sweet corn as a crunchy bite in the amusement parks, theatres, circus and exhibitions is increasing with increasing urban population. Due to its increasing demand, there is an increasing tendency for commercial production of sweet corn” (Thakur *et al.* 2015) [2]. Of late, sweet corn is emerging as one of the important enterprises projecting diversified and value-added uses of maize.

“Sustainability of sweet corn scientific cultivation practices must be ensured to attain the goal of agricultural sustainability. Sweet corn is picked at milk stage and eaten as a vegetable, rather than a grain. Its consumption at immature stage as roasted and boiled ears is a popular practice as the kernels are sweet (12-20% sugar). Maize is an exhaustive crop and requires high quantities of nitrogen and phosphorus. Low soil fertility is one of the bottlenecks to sustain agricultural production and productivity in India. Judicious use of fertilizers play an important role to boost up the productivity of maize, they alone can contribute 40-60 percent of the crop yield” (Dayanand, 1998) [3].

“Phosphorus is an essential factor for cell division because it is a constituent element of nucleoproteins which are involved in the cell reproduction processes. It is also a component of a chemical essential to the reactions of carbohydrate synthesis and degradation. It is important for seed and fruit formation and crop maturation. Phosphorus hastens the ripening of fruits thus counteracting the effect of excess nitrogen application to the soil. It helps to strengthen the skeletal structure of the plant thereby preventing lodging. It also affects the quality of the grains and it may increase the plant resistance to diseases. Since the phosphate availability is usually low in the soils, the plants have developed special adaptations to acquire the same with the help of multiple high affinity transporters” (Raghothama, 1999) [4].

“Phosphorus plays a vital role besides nitrogen in plant nutrient that influences vigour of plant, root growth and improves the quality of crop yield. Phosphorus is an essential factor for cell division because it is a constituent element of nucleoproteins which are involved in the cell reproduction processes. It is also a component of a chemical essential to the reactions of carbohydrate synthesis and degradation. It is important for seed and fruit formation and crop maturation. Phosphorus hastens the ripening of fruits thus counteracting the effect of excess nitrogen application to the soil. It helps to strengthen the skeletal structure of the plant thereby preventing lodging. It also affects the quality of the grains and it may increase the plant resistance to diseases". (Umeri *et. al* 2016) [5].

"Boron application improves growth, and enhances stress tolerance in plants and improves grain production" Hussain *et al*., 2012 [6]. "World-wide Boron deficiency is more extensive then the any other plant micro nutrient deficiency" Gupta 1979 [7]. Goldbach.H *et al*., 2007 [8] reported that, "boron deficiency caused sterility in maize, in sufficient levels of available boron soil reduce crop yield, impair grain quality, and increase the susceptibility of crops to diseases". "Boron is considered as an essential element for plant growth and development, sexual reproduction in plant is more sensitive to B deficiency, then vegetative growth" Ahmad et al., 2009 [9]. "The main function of Boron relate to cell wall strength and development, cell division, fruit and seed development sugar transport and hormone development. Boron deficiency depresses commercial corn yield primarily through grain set failure. Boron deficiencies are usually apparent on the new leaves of maize since it is during the development of new tissue that nutrients are most required" (Reid et al., 2004) [10]. "Boron deficiency inhibits root elongation through limiting of cell enlargement and enlargement and cell division in the growth zone of root tips and that in severe boron deficiency cases, root growth is ceases due to the death of root tips", (dell et al., 1997) [11]. "Maize has been previously considered to have a relatively low boron (B) requirement compared with other cereals" (Martens et al., 1991) [12].

2. MATERIALS AND METHODS:

The field experiment was conducted during kharif season 2022 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil of the experimental field was sandy loam in texture, nearly neutral in soil reaction (pH 7.6), organic carbon level in medium condition (0.87%), medium available N (225 Kg/ha), high in available P (41.8 kg/ha) and medium available K (261.2 kg/ha). The treatment consists of 3 levels of Phosphorus 50, 100kg/ha and 150 kg/ha with combination of different levels of Boron 200 g/ha, 300 g/ha and 400 g/ha. The experiment was laid out in Randomized Block Design with 10 treatments each replicated thrice. The treatment combinations are T1 Phosphorus (50 kg/ha) + Boron (200 g/ha). T2 Phosphorus (50 kg/ha) + Boron (300 g/ha), T3 Phosphorus (50 kg/ha) + Boron (400 g/ha), T4 Phosphorus (100 kg/ha) + Boron (200 g/ha), T5 Phosphorus (100 kg/ha) +Boron (300 g/ha), T6 Phosphorus (100 kg/ha) + Boron (400 g/ha), T7 Phosphorus (150 kg/ha) + Boron (200 g/ha), T8 Phosphorus (150 kg/ha)+ Boron (300 g/ha), T9 Phosphorus (150 kg/ha) + Boron (400 g/ha), T10 (Control) N:P:K 100:60:40 kg/ha. "All agronomic practices are followed in order in the crop period. Experimental data collected was subjected to statistical analysis by adopting Fisher’s method of analysis of variance (ANOVA) as outlined by Gomez and Gomez (1984). Critical Difference (CD) values were calculated wherever the ‘F’ test was found significant at 5 percent level”. [13].

3. RESULT AND DISSCUSSION

3.1 GROWTH PARAMETERS

3.1.1 Plant height (cm)

There was a significant increase in plant height (196.33cm) was observed with application of 150kg P/ha along with 400g/ha B. However, treatment Phosphorus 150kg/ha +Boron 200g/ha (189.11cm) and treatment Phosphorus 150kg/ha +Boron 300g/ha (193.27cm) were statistically at par with application of 150kg/ha Phosphorus along with 400g/ha Boron. Boron will also play a major role in plant height which might be attribute to greater photosynthesis activity and chlorophyll synthesis resulting into better vegetative growth. The improvement in plant height was due to interaction of both Phosphorus and Boron application in sweet corn crops. Similar results were reported by **Tahir *et al*. 2012 [14].**

3.1.1 Dry weight (g)

There was significant increase in dry weight (70.97g) observed with the application of Phosphorus 150kg/ha +Boron 400g/ha. However, treatment Phosphorus 150kg/ha + 200g/ha (69.23g) and treatment Phosphorus 150kg/ha + 300g/ha (67.84g) were statistically at par with application of 150kg/ha Phosphorus along with 400g/ha Boron. "The higher dry matter was mainly due to more leaf area exposed to sunlight with which rapid photosynthetic rate helped accumulation of higher dry matter in plant. Similar results indicating increased dry matter production due to increased levels of NPK" was reported by Arunkumar et al. (2007) [15], and Arya and Singh (2000) [16].

3.2 YIELD PARAMETERS

3.2.1 Cob / Plant

At the time of harvest, significantly maximum number of cobs per plant (1.93) recorded in treatment Phosphorus 150kg/ha +Boron 400g/ha. However, treatment 50kg/ha +Boron 300g/ha (1.66) were statistically at par with application of 150kg/ha Phosphorus along with 400g/ha Boron. The increase in number of cob/plant due to the application of Boron and positive effect of boron may due to key role in plant metabolism and in the synthesis of nucleic acid., similar result found by (**Tahir *et.al* 2012**) [17]. However maximum number of cobs/plant was observed in sweet heart variety with application of Phosphorus 150kg/ha. it might be due to the fact that optimum availability of Phosphorus has associated with increase rapid growth and development thus those plots which received optimum Phosphorus produced more cobs/plant as compared to 50kg/ha Phosphorus. similar result found by (**Sabu *et.al* 202.1) [18]**

3.2.2 Cob Length

At the time of harvest, significantly maximum cob length was recorded (20.27cm) recorded in treatment Phosphorus 150kg/ha +Boron 400g/h. However, treatment Phosphorus 150kg/ha +Boron 300g/ha (18.95cm) were statistically at par with application of 150kg/ha Phosphorus along with 400g/ha Boron. However, maximum cob length was observed in sweet heart variety with application of Phosphorus 150kg/ha + Boron 400g/ha. It might be due to the fact that optimum availability of P has been associated with increased rapid growth and development, thus those plots which received optimum P produced maximum cob length. They argued that minimum cob length with application of Phosphorus 50kg/ha. similar result found by (**Wasim *et. al* 2017)** [19].

3.2.3 Grain row

At the time of harvest, significantly maximum Grain row was recorded (26.65) recorded in treatment Phosphorus 150kg/ha +Boron 400g/h. However, treatment Phosphorus 150kg/ha +Boron 300g/ha (25.16), Phosphorus 150kg/ha +Boron 300g/ha (24.13), and 24 respectively. were statistically at par with application of 150kg/ha Phosphorus along with 400g/ha Boron. The probable reason for recording maximum grain row in sweat heart variety of with application of Phosphorus + Boron might be due to the increased availability of photosynthates with increased fertility level might have enhanced number of flowers and their fertilization resulting in higher number of filled cobs or grain per cob. Further , in most of cereals greater assimilating surface at reproductive developments results in better grains formation because of adequate production of metabolites and their translocation towards grains. Similar result found with (**Sankadiya *et.al* 2021) [20].**

3.2.4 Seed index

The maximum seed index was observed with application of Phosphorus 150kg/ha +Boron 400g/h (21.51g). which was significantly superior over all the treatment .However, the treatment with application of Phosphorus 150kg/ha + Boron 300g/ha (20.92g) was found to be statistically at par with application of 150kg/ha Phosphorus along with 400g/ha Boron. The probable reasons for recording maximum seed index with application of Phosphorus and Boron might be due to greater contribution of P and B by producing healthy grain i-e well filled grains and bigger grains while minimum grain weight was obtained at lower level of P&B kg/ha The interaction of varieties and fertilizer from the data is also significant. Similar result found by (**Mehta *et. al* 2005) [21].**

3.2.5 Harvest index

The highest harvest index was recorded with the application of Phosphorus 150kg/ha +Boron 400g/h (41.07). which was significantly superior over all the treatment .However, the treatment with application of Phosphorus 150kg/ha + Boron 300g/ha (38.55) , and Phosphorus 150kg/ha + Boron 200g/ha (38.04) was found to be statistically at par with application of 150kg/ha Phosphorus along with 400g/ha Boron. (**Kumar *et.al* 2019) [22].**

3.2.6 Grain Yield

The data showed that the grain yield (6.5 t/ha) of sweet corn was found with application of Phosphorus 150kg/ha + Boron 400g/ha which was superior over all other treatments. respectively, treatment with application of Phosphorus 150kg/ha + Boron 300g/ha(6.26t/ha) and treatment with application of Phosphorus 150kg/ha + Boron 200g/ha (6.16t/ha) was found to be statistically at par with application of 150kg/ha Phosphorus along with 400g/ha Boron. Phosphorus and Boron play a vital role in increasing grain yield because Boron takes place in many physiological process of plant such as chlorophyll formation , stomatal regulation, starch utilization which enhances grain yield .Boron required for many physiological processes and plant growth, also adequate nutrition is a critical for increase yields and quality of crops. These results are in confirmatory with the work of (**Humtsoe *et al.* 2018) [23]** and (**Tahir *et .al* 2012) [24].**

3.2.7 Stover Yield

The maximum stover yield was recorded (12.23t/ha) with the application of Phosphorus 150kg/ha + Boron 400g/ha which was superior over all other treatments. respectively, treatment with application of Phosphorus 150kg/ha + Boron 300g/ha (11.83t/ha) and treatment with application of Phosphorus 150kg/ha + Boron 200g/ha (11.63t/ha) was found to be statistically at par with application of 150kg/ha Phosphorus along with 400g/ha Boron. Phosphorus and Boron play a vital role in increasing stover yield because application of Phosphorus might be the optimum rate of trigger an increase in production of stover per unit area. It improves the root growth which has a great effect on the overall plant growth performance. With the increase in levels of boron the plant height gradually increased which might be attributable to greater photosynthesis activity and chlorophyll synthesis due to boron fertilizer resulting into better vegetative growth. Similar result found by (**Soomro *et al.* 2011) [25].**

4. ECONOMICS

The result showed (Table 3) that maximum grass return (INR256150/ha), net return (198768.98/ha) and B:C ratio (3.46) was recorded in treatment 9 [Phosphorus (150kg/ha)+Boron (400g/ha)] as compared to other treatment. Higher Gross return, Net return and Benefit cost ratio was recorded with application of Phosphorus 150kg/ha along with application of Boron 400g/ha . From the one year experiment it can be concluded that treatment 9 Phosphorus 150kg/ha+ Boron 400g/ha gave maximum Plant height, dry weight, No. of cobs/plant, cob length, grain rows, seed index, cob yield, stover yield and Harvest index.

5. CONCLUSION

It can be concluded that in sweet corn with the application of Phosphorus 150 kg/ha along with the application of Boron 400 g/ha (Treatment 9) was observed highest Cob yield and benefit cost ratio. Since the findings are based on one season, further trails may be required for further confirmation.

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Table 1. Influence of Phosphorus and Boron on growth attributes of Sweet corn.

S. No.	Treatment combination	At 60 DAS	
		Plant height (cm)	dry weight (g)
1.	Phosphorus 50kg/ha + Boron 200g/ha	164.67	57.43
2.	Phosphorus 50kg/ha + Boron 300g/ha	169.91	58.56
3.	Phosphorus 50kg/ha + Boron 400g/ha	164.92	59.92
4.	Phosphorus 100kg/ha + Boron 200g/ha	174.79	62.08
5.	Phosphorus 100kg/ha + Boron 300g/ha	170.07	63.44
6.	Phosphorus 100kg/ha + Boron 400g/ha	176.35	64.04
7.	Phosphorus 150kg/ha + Boron 200g/ha	189.11	67.84
8.	Phosphorus 150kg/ha + Boron 300g/ha	193.27	69.23
9.	Phosphorus 150kg/ha + Boron 400g/ha	196.33	70.97
10.	(Control) N:P: K 100:60:40 kg/ha	161.48	52.05
	F-test	S	S
	SEm (±)	5.94	2.09
	CD (p=0.05)	17.67	6.21

Table 2. Effect of Phosphorus and Boron on Yield attributes and Yield of Sweet corn

S.No.	Treatments	Yield and Yield attributes						
		Cob/Plant	Cob length	Grain Row	Seed index	Harvest Index (%)	Cob yield (t/ha)	Stover yield (t/ha)
1.	Phosphorus 50kg/ha +Boron 200g/ha	1.20	15.92	20.94	17.62	31.57	4.2	9.13
2.	Phosphorus 50kg/ha +Boron 300g/ha	1.33	15.76	22.03	17.91	33.08	4.5	9.13
3.	Phosphorus 50kg/ha +Boron 400g/ha	1.40	16.56	22.36	18.11	33.33	5.1	10.2
4.	Phosphorus 100kg/ha +Boron 200g/ha	1.40	16.69	23.02	18.58	32.91	5.2	10.6
5.	Phosphorus 100kg/ha +Boron 300g/ha	1.46	16.68	23.60	18.59	33.12	5.4	10.9
6.	Phosphorus 100kg/ha +Boron 400g/ha	1.53	16.36	24.00	19.12	33.74	5.5	10.8
7.	Phosphorus 150kg/ha +Boron 200g/ha	1.53	17.10	24.13	19.30	34.46	6.1	11.6
8.	Phosphorus 150kg/ha +Boron 300g/ha	1.66	18.95	25.16	20.92	34.44	6.2	11.8
9.	Phosphorus 150kg/ha +Boron 400g/ha	1.93	20.27	26.65	21.51	34.75	6.5	12.2
10.	Control Plot (N:P: K 100:60:40)	1.06	16.60	21.00	16.73	31.34	4.2	9.26
	F test	S	S	S	S	S	S	S
	SEm(±)	0.12	0.49	0.89	0.61	1.15	0.30	0.33
	CD(p=0.05)	0.37	1.47	2.66	1.82	0.98	0.89	1.00

Table 3. Effect of Phosphorus and Boron on economics of Sweet corn.

S. No.	Treatment combination	Economics			
		Cost of cultivation (₹/ha)	**Gross return (₹/ha)**	**Net return (₹/ha)**	**B:C ratio**
1.	Phosphorus 50 kg/ha + Boron 200 g/ha	51731.52	171650	119918.48	2.31
2.	Phosphorus 50 kg/ha + Boron 300 g/ha	51931.52	180650	128718.46	2.47
3.	Phosphorus 50 kg/ha + Boron 400g/ha	52131.52	204000	151868.47	2.91
4.	Phosphorus 100 kg/ha + Boron 200g/ha	54356.52	209000	154643.43	2.84
5.	Phosphorus 100 kg/ha + Boron 300g/ha	54556.52	216500	161943.54	2.96
6.	Phosphorus 100 kg/ha + Boron 400g/ha	54756.52	219000	164243.62	2.99
7.	Phosphorus 150 kg/ha + Boron 200g/ha	56981.52	241150	184168.76	3.23
8.	Phosphorus 150 kg/ha + Boron 300g/ha	57181.52	245150	187968.88	3.28
9.	Phosphorus 150 kg/ha + Boron 400g/ha	57381.52	256150	198768.98	3.46
10.	Control + RDF (NPK-100:60:40 kg/ha)	48706.52	172000	123293.11	2.53