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Response of phosphorus application on yield, quality and economics of sweet corn (*Zea mays* L. *Saccharata*) varieties

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Abstract
A field experiment was conducted during *kharif* 2016 at Crop Research Farm, Department of Agronomy, SHUATS, Allahabad, (U.P.). The soil of experimental site was sandy loam in texture, nearly neutral in soil reaction (pH 6.7), low in organic carbon (0.35%), available N (230 kg ha^{-1}), available P (20 kg ha^{-1}) and available K (189 kg ha^{-1}). The treatment consisted 5 levels of Phosphorus *viz.* P_1 (40 kg P_2O_5 ha^{-1}), P_2 (50 kg P_2O_5 ha^{-1}), P_3 (60 kg P_2O_5 ha^{-1}) P_4 (70 kg P_2O_5 ha^{-1}) and P_5 (80 kg P_2O_5 ha^{-1}) and two varieties of sweet corn *viz.* V_1 (Sweet Glory) and V_2 (Sweety). This experiment includes 10 treatments which were laid out in Randomized Block Design with three replications. The result revealed that green cob yield (5.32 t ha^{-1}) and green fodder yield (13.45 t ha^{-1}) were recorded maximum in 'sweety' variety in treatment T_8 (Sweety + 60 kg P_2O_5 ha^{-1}). These parameters were significantly influenced by application of 60 kg P_2O_5 ha^{-1}as DAP. However, quality parameters *viz.*, protein content (%) and sucrose content (%) were found to be non- significant but these were numerically superior in T_8 (Sweety + 60 kg P_2O_5 ha^{-1}). The same treatment *i.e.*, T_8 (Sweety + 60 kg P_2O_5 ha^{-1}) recorded maximum net return of ₹ 80228.00 and B.C. ratio 2.77.

Keywords: sweet corn, varieties, phosphorus levels, protein content, sucrose content

Introduction
Corn (*Zea mays* L.) is a versatile crop, also known as queen of cereals. It has found an important place in the human diet, animal feed as well as fodder including industrial raw material like starch and oil. Being C_4 plant maize has high yielding potential because this crop has greater ability to convert solar energy into food. Its grain contains about 10 % protein, 4 % oil, 70 % carbohydrate, 2.3 % crude fibre, 10.4 % albuminoids, and 1-4 % ash. It also contains vitamin A, nicotine acid and riboflavin, vitamin E. Maize is important crop in the world grown in more than 150 countries having 600 million ha area with 600 million ton of production. Special corn *viz*., sweet corn (*Zea mays* var. *saccharata* and *Zea mays* var. *rugosa*), popcorn (*Zea mays* var. *everta)*, baby corn (*Zea mays* L.), high-oil corn *etc*. assume tremendous market potential not only in the international market but also in India. These corns especially sweet corn with their high market value are perfectly suitable to *peri*-urban agriculture as they promise higher income to maize growers. 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) [2].

Among nutrient elements, 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.

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) [9]. The needs of a sweet corn crop for supplemental nutrient can vary greatly among field's seasons and crop growing conditions. Hence, there is need to evaluate sweet corn varieties under different phosphorus levels to find out optimum phosphorus dose under prevailing agro climatic conditions.

Materials and Methods

The experiment was conducted during *kharif* 2016 at the Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Allahabad. The Crop Research Farm is situated at 25^0 57' N latitude, 87^0 19' E longitude and at an altitude of 98 m above mean sea level. The soil of experimental plot was sandy loam in texture, neutral in soil reaction (pH 7.5), low in organic carbon (0.35%), available N (230 kg ha^{-1}), available P (20 kg ha^{-1}) and available K (189 kg ha^{-1}). The treatments comprised of 5 levels of Phosphorus *viz.* P_1 (40 kg P_2O_5 ha^{-1}), P_2 (50 kg P_2O_5 ha^{-1}), P_3 (60 kg P_2O_5 ha^{-1}) P_4 (70 kg P_2O_5 ha^{-1}) and P_5 (80 kg P_2O_5 ha^{-1}) and 2 sweet corn varieties *viz*. V_1 (Sweet Glory) and V_2 (Sweety). There were 10 treatments each replicated thrice. The experiment was laid out in Randomized Block Design. The seed was sown manually on 21 September 2016 by placing 2 seeds at a depth of 3–4 cm maintaining rows and plants spacing at 60 × 25 cm, respectively. Thinning was carried out 15 days after sowing to maintain required plant population. The green cobs were harvested 20 days after silking, when grains were in milky stage. Irrigation was not found mandatory due to moderate rain at frequent intervals at initial stages of the crop but, after that 3 irrigations was given at 50, 70 and 80 DAS. Phosphorus as per treatments was applied basal, whereas nitrogen was applied in 3 equal splits, viz. half as basal, one-fourth at knee high stage and remaining one-fourth at initiation of tassel and in case of potassium it is also applied as basal as per recommendation. Yield *viz.* green cob yield and green fodder yield likewise, quality parameters *viz.*, protein content and sucrose content were recorded and statistically analysed to find out the best treatment combination. In addition to yield and quality parameters, economics of treatments was also studied to find out the best treatment combination for higher yield, maximum net return and highest B: C ratio of sweet corn.

Results and Discussion

Performance of Varieties

Among both varieties 'Sweety' significantly recorded maximum green cob yield (5.32 t ha^{-1}) and green fodder yield (13.45 t ha^{-1}) as compared to 'Sweet glory' variety (Table 1). However, in case of quality parameters viz., protein content (%) and sucrose content (%) were found to be non- significant (Table 2). Under present investigation the better performance of 'Sweety' seems to be on account of higher uptake of nitrogen and phosphorus from soil and its reallocation in grain and plant. The higher availability of nitrogen and phosphorus seems to have promoted development of morphological structure by virtue of multiplication of cell division which is well reflected through increased crop growth rate and yield of maize (Kumar, 2008) [4]. Under optimal environmental conditions quality parameters of grain are largely determined by the genetic make-up of cultivar (Srivastava and Mahrotra, 1991) [11]. Higher protein and sucrose content in grain of the cultivar Sweety as compared to Sweet Glory cultivar could be due to its being *Zea mays* L. which is characterized by higher protein and starch content. Inverse relationship between soluble sugars and protein content in maize grain has also been reported by Logrono *et al.* (1991) [6].

Table 1: Response of phosphorus application on green cob yield and green fodder yield of Sweet corn varieties

Treatments		Green cob yield (t ha^{-1})	Green fodder yield (t ha^{-1})
T_1	Sweet Glory + 40 kg P_2O_5 ha^{-1}	5.03	11.84
T_2	Sweet Glory + 50 kg P_2O_5 ha^{-1}	5.15	12.87
T_3	Sweet Glory + 60 kg P_2O_5 ha^{-1}	5.32	13.44
T_4	Sweet Glory + 70 kg P_2O_5 ha^{-1}	5.32	13.45
T_5	Sweet Glory + 80 kg P_2O_5 ha^{-1}	5.32	13.45
T_6	Sweety + 40 kg P_2O_5 ha^{-1}	5.04	11.85
T_7	Sweety + 50 kg P_2O_5 ha^{-1}	5.16	12.88
T_8	Sweety + 60 kg P_2O_5 ha^{-1}	5.32	13.45
T_9	Sweety + 70 kg P_2O_5 ha^{-1}	5.33	13.46
T_{10}	Sweety + 80 kg P_2O_5 ha^{-1}	5.33	13.46
SE (d) ±		0.10	0.21
C. D. (P = 0.05)		0.21	0.44

Table 2: Response of phosphorus application on Protein Content and Sucrose Content of sweet corn varieties

Treatments		Protein Content (%)	Sucrose Content (%)
T_1	Sweet Glory + 40 kg P_2O_5 ha^{-1}	8.12	16.20
T_2	Sweet Glory + 50 kg P_2O_5 ha^{-1}	8.23	16.65
T_3	Sweet Glory + 60 kg P_2O_5 ha^{-1}	8.45	16.85
T_4	Sweet Glory + 70 kg P_2O_5 ha^{-1}	8.65	17.05
T_5	Sweet Glory + 80 kg P_2O_5 ha^{-1}	8.85	17.08
T_6	Sweety + 40 kg P_2O_5 ha^{-1}	8.20	16.40
T_7	Sweety + 50 kg P_2O_5 ha^{-1}	8.35	16.85
T_8	Sweety + 60 kg P_2O_5 ha^{-1}	8.56	17.12
T_9	Sweety + 70 kg P_2O_5 ha^{-1}	8.70	17.15
T_{10}	Sweety + 80 kg P_2O_5 ha^{-1}	8.90	17.20
SE (d) ±		0.420	0.380
C. D. (P = 0.05)		NS	NS

Table 3: Response of sweet corn varieties and phosphorus application on economics of treatment.

Treatments	Cost of Cultivation	Yield		Sale rate (₹)		Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C ratio
		Yield (t ha^{-1})	Green Fodder(t ha^{-1})	Green Cob(t ha^{-1})	Green Fodder (t ha^{-1})			
T_1	44261.61	5.03	11.84	80480.00	35520.00	116000.00	71738.00	2.62
T_2	44826.85	5.15	12.87	82240.00	38610.00	120850.00	76023.00	2.70
T_3	45392.09	5.32	13.44	84960.00	40320.00	125280.00	79888.00	2.76
T_4	45957.33	5.32	13.45	85120.00	40350.00	125470.00	79513.00	2.73
T_5	46522.57	5.32	13.45	85120.00	40350.00	125470.00	78947.00	2.70
T_6	44261.61	5.04	11.85	80640.00	35550.00	116190.00	71928.00	2.63
T_7	44826.85	5.16	12.88	82560.00	38640.00	121040.00	76213.00	2.70
T_8	45392.09	5.32	13.45	85120.00	40500.00	125620.00	80228.00	2.77
T_9	45957.33	5.33	13.46	85280.00	40380.00	125470.00	79513.00	2.73
T_{10}	46522.57	5.33	13.46	85280.00	40380.00	125660.00	79137.00	2.70

Selling price of green cob 16000 ₹/t
Selling price of green fodder 3000 ₹/t

Effect of phosphorus levels

Yield *viz.,* green cob yield and green fodder yield increased significantly in treatment T_8 with the application of 60 kg P_2O_5 ha^{-1}(Table 1). However, in case of quality parameters viz., protein content (%) and sucrose content (%) were found to be non-significant with the application 60 kg P_2O_5 ha^{-1} (Table 2). The maximum green cob yield (5.32 t ha^{-1}) and green fodder yield (13.45 t ha^{-1}) were recorded in treatment T_8 with the application of 60 kg P_2O_5 ha^{-1} followed by treatment T_5 and it was found to be at par to treatment T_8 (Table 1). Significant improvement in overall growth of the crop by virtue of increased photosynthetic efficiency. Thus greater availability of photosynthates, metabolites and nutrients to develop reproductive structures seems to have resulted in increased productive plants, with these fertility levels. The present findings are within the close vicinity of those reported by Massey and Guar (2006) [7] and Khazaei *et al.* (2010) [5]. Hence, marked increase in green cob yield and green fodder yield with balanced and higher level of fertilization seems to be due to more exploitation of crop genetic potential for vegetative and reproductive growth. The results of the present investigation indicating positive response of maize crop to balanced fertilization are alike to findings of several researchers (Tak, 2000, Goyal, 2002 and Raja, 2001) [12, 3]. Phosphorus being a component of sucrose metabolism hormones, nucleic acid and co-enzymes, might have helped in improving sugar content and quality of sweet corn under the present investigation. Increase in sucrose per cent and quality of sugarcane with increasing levels of phosphorus has also been reported by Chauhan *et al.* (1998) [1]. Further increase in nutrient level though increased green cobs and fodder yields but marginal increase in green cob and fodder yields unable to compensate higher prices of fertilizer (Nath *et al.,* 2009) [8].

Economics

A perusal of the table 3 clearly revels that treatment T_8 recorded maximum net return of (₹80228.00), followed by treatment T_3 (₹79888.00) giving a B: C ratio of (2.77) and (2.76) respectively.

Conclusion

Based on the findings, of this experiment it can be concluded that 'Sweety' is the best quality and economically profitable variety as compared to 'Sweet Glory' variety. Application of 60 kg P_2O_5 ha^{-1} as DAP is profitable for farmers because it has significantly recorded higher green cob yield and green fodder yield also given maximum net return of ₹ 80228.00 and B:C ratio of 2.77 in sweet corn crop. Although the finding is based on one year further research is needed to conform the findings and its recommendation.

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