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Response of Varied Levels of Phosphorus on Growth and Yield Performance of Sweet Corn, *Zea mays* L.

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Abstract: A field experiment was conducted during Kharif season 2019 at Zonal Agricultural Research Station, GKVK, University of Agricultural Sciences, Bengaluru. The soil of the experimental site was red loamy sandy in nature having medium nitrogen, low phosphorus and high potassium content, and was slightly acidic in nature. The treatment consisted of 5 levels of phosphorus viz. T_1 (50% Recommended Dose of Fertilizer (RDF) P_2O_5), T_2 (75% RDF P_2O_5), T_3 (100% RDF P_2O_5), T_4 (125% RDF P_2O_5) and T_5 (150% RDF P_2O_5) in the presence of static dose of nitrogen and potassium. There were 5 treatments each replicated four times. The experiment was laid out in randomized complete block design. The result showed that application of 150% RDF of P_2O_5 recorded significantly higher growth attributes viz., plant height (T_5: 128.125 cm) and the number of leaves per plant (T_5: 11.1 at 60 Days after Sowing (DAS)). However, the application of 100% RDF of P_2O_5 treatment recorded a significantly higher seed yield (T_3: 296.25 g).

Key words: Zea Mays, nutrient, fertilizer, Phosphorus, yield

1. Introduction

Maize (*Zea mays* L.) is a C4 plant. It is a versatile crop and is also known as the queen of cereals. It has found an important place in the human diet, animal feed, as well as fodder including industrial raw materials like sawdust, starch and oil. Being a C4 plant, maize has high yield potential because it has a greater ability to convert solar energy into food. It is a primary staple food in many countries. It is an exhaustive crop. It is suitable for temperate, tropical and subtropical regions. Optimum temperature is around 28-35 ℃. Rainfall required is around 500-1,000 mm. It is grown in all three seasons. In India, the Kharif season is very important covering 80% of the total area of maize.

Maize is an important crop in the world grown in more than 150 countries having 600 million ha area with 600 million tons production. Production is high in the USA, followed by China and Brazil. The USA has the highest area and production in the world. Italy has the highest productivity (9,500 kg/ha) followed by France (8,800 kg/ha). India stands 5th, 4th and 3rd in area, production and productivity of maize respectively on a global level.

It contains about 10% protein, 4% oil, 70% carbohydrate, 2.3% crude fiber, 10.4% albuminoids and 1.4% starch, also contains vitamin A, nicotinic acid, etc. Among nutrient elements, phosphorus plays a vital role including vigour, plant root growth, cell division, carbohydrate synthesis, etc. It is important for seed and fruit formation and crop maturation. It also affects the quality of grains and may increase the resistance of plants to diseases.

The research is conducted to know the variation on yield and growth of plants by varying the fertilizer levels with 5 treatments and 4 blocks. It also shows the graded classes of phosphorus in the presence of static dose of nitrogen and potassium on the growth and yield of sweet corn. The objective of the research is to know the effect of different levels of phosphorus on the growth and yield of sweet corn (*Zea mays* L. var saccharata).

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2. Material and Methods

A field experiment entitled "Response of varied levels of Phosphorus on growth and yield performance of Sweet Corn" was conducted during Kharif season 2019 at ZARS, GKVK, UAS (University of Agricultural Sciences), Bangalore. The details of the material used and the experimental techniques adopted during the investigation are furnished in this chapter.

2.1 Experimental Site

The experiment was conducted at ZARS, GKVK, UAS, Bangalore. This centre is located in the agro-climatic zone 5 (Eastern dry Zone of Karnataka) which is located at 12 ℃58′ N latitude 77 ℃35′ E longitude with an altitude of 930 m from mean sea level. The soil of the experimental site was red loamy sandy in nature having medium nitrogen, low phosphorus and high potassium content and was slightly acidic in nature. The soil was found to be crusty during the initial stage of crop growth and development. Hence frequent irrigation was given to reduce the crusting of the soil.

2.2 Experimental Details

Crop: sweet corn
Spacing: 60 ×30 cm
RDF: 150:75:40 kg/ha
Season: Kharif
Design: RCBD
Number of treatments: 5
Number of replications: 4
Plot size: 1 m ²
Date of sowing: 21/08/2019
Date of harvesting: 07/12/2019

2.3 Treatment Details

T_1 → 50% RDF of phosphorus + 100% of nitrogen and potassium

T_2 → 75% RDF of phosphorus + 100% of nitrogen and potassium

T_3 → 100% RDF of phosphorus + 100% of nitrogen and potassium

T_4 → 125% RDF of phosphorus + 100% of nitrogen and potassium

T_5 → 150% RDF of phosphorus + 100% of nitrogen and potassium

2.4 Layout of the Experiment

T_5	T_1	T_2	T_3	**S** ↓
T_4	T_3	T_1	T_2	
T_3	T_4	T_5	T_1	
T_2	T_3	T_4	T_5	
T_1	T_2	T_3	T_4	**N**

2.5 Observation and Data Collection

Five plants were randomly selected in each plot for secondary observations on various growth and yield attributing parameters at periodical intervals. From these observations, the data were converted from unclassified data into classified data for subjecting data into statistical analysis with suitable experimental design.

2.6 Statistical Analysis and Interpretation of Data

The experimental data collected on growth and yield component were subjected to Fisher's method of analysis of variance (ANOVA). Wherever *F*-test was found to be significant, the treatment means were compared with the value of the critical difference (CD value) to draw a suitable conclusion. If *F*-test was found to be non-significant, there will not be any significant difference among treatment means and data are said to be on par.

3. Result and Discussion

The result of the study entitled "Response of varied levels of Phosphorus on growth and yield performance of Sweet Corn" conducted at Agronomy Field Unit, Zonal Agricultural Research Station, GKVK, UAS, Bangalore 2019 of Kharif season is discussed in this chapter under the following headings.

3.1 Weather and Crop Growth

The normal and actual weather data that prevailed during Kharif 2019 and deviation from the normal with respect to rainfall, maximum and minimum temperature, relative humidity and duration of sunshine hours are presented in Table 1.

Weather condition during the experiment was favourable for the growth and development of sweet corn, the normal annual rainfall of a GKVK is 899.16 mm. The major portion of rainfall was derived from May-November with 2 peaks in May and October. The mean maximum air temperature ranged from 26 ℃ to 34.7 ℃. The mean minimum air temperature ranged between 13.1 ℃ and 20.7 ℃.

The highest mean temperature of 34.7 ℃ was recorded during April followed by March (33.7%). The mean monthly RH ranged from 77.7% in April to 92.9% in August month. There were larger variations in the rainfall during the experimental period compared to the normal rainfall. The excess rainfall received during September (186.6 mm) and in October (234 mm) of 2019 affected the flowering stage of the crop in general. The mean temperature and relative humidity that existed during the period of experimentation was found to be suitable for crop growth and yield. In general, the crop experienced favourable weather conditions during crop growth and development.

3.2 Effect of Different Levels of Phosphorus on Growth Attributes of Sweet Corn

3.2.1 Plant Height (cm)

The data on the plant height of sweet corn at 30 and 60 DAS are presented in Table 2.

The data pertaining to the plant height of sweet corn differed significantly.

At 30 DAS, the plant height of sweet corn differs significantly. Application of 75% RDF recorded a significantly higher plant height of 62.01 cm as compared to all other treatments. However, it was found to be on par with T_1 (59.81 cm) and T_4 (54.02cm).

Significantly, lower plant height was recorded with T_5 treatment (49.4 cm). At 60 DAS, the plant height of sweet corn differed significantly. Application of T_5 treatment 150% RDF (128.125 cm) recorded significantly higher plant height as compared to all other treatments. However, it was found to be on par with T_1 treatment (126.6 cm), T_4 (123.4 cm) and T_3 (118.75 cm). Significantly lower plant height was recorded with T_2 treatment (110.9cm).

Table 1 Meteorological data of monthly normal and actual for the year 2019 at ZARS, GKVK, UAS, Bangalore.

Month in the Year 2019	Rainfall during the month (mm)	No. of rainy days	Average rainfall (from 1988 to 2018)	Deviation (%)	Class	Temperature		Relative humidity		Sunshine hours
						Maximum (℃)	Minimum (℃)	7.00 hrs	14.00 hrs	
January	0.00	0	1.13	-100.00	NR	27.9	13.1	88.7	53.7	8.5
February	24.00	2.0	3.18	654.29	E	30.6	17.2	87.1	47.1	9.4
March	0.00	0.0	26.33	-100.00	NR	33.7	20.1	81.1	36.9	9.1
April	22.60	2.0	50.05	-54.85	D	34.7	20.7	77.0	35.2	8.6
May	126.40	7.0	136.60	-7.47	N	33.7	20.3	80.5	37.2	7.9
June	89.20	5.0	69.74	27.91	E	30.6	19.5	85.7	49.1	7.1
July	34.20	5.0	104.29	-67.21	S	29.5	18.8	90.0	52.6	4.9
August	173.40	11.0	130.94	32.43	E	27.5	18.1	92.9	62.0	4.1
September	186.00	9.0	160.19	16.49	N	27.9	18.5	91.9	57.4	3.5
October	234.00	13.0	133.26	75.59	E	27.7	18.3	92.5	58.2	4.9
November	10.00	1.0	60.49	-83.47	S	27.6	16.9	89.8	57.7	6.5
December	1.60	0	10.93	-85.36	S	26.0	16.4	91.4	62.1	5.0
Total/average	902.00	55	899.16	0.32	N	-	-	-	-	-

Table 2 Effect of different levels of phosphorus on plant height (cm) at various growth stages of sweet corn.

Treatment	30 DAS(cm)	60 DAS (cm)
T_1	59.81	126.6
T_2	62.81	110.9
T_3	53.485	118.75
T_4	54.02	123.4
T_5	49.4	128.125
SEM	2.78	3.32
CD at 5%	8.38	10.03

Table 3 Effect of different levels of phosphorus on the number of leaves per plant of sweet corn at various growth stages.

Treatment	30 DAS	60 DAS
T_1	7.65	10.8
T_2	7.65	10.8
T_3	6.7	10.65
T_4	7.05	10.4
T_5	6.95	11.1
SEM	0.19	0.12
CD at 5%	0.59	0.38

3.2.2 Number of Leaves per Plant

The data on the number of leaves per plant of sweet corn at 30 DAS and 60 DAS are presented in Table 3.

The data pertaining to the number of leaves per plant of sweet corn differed significantly.

At 30 DAS, the number of leaves per plant of sweet corn differed significantly. Application of both T_1 (50% RDF) and T_2 (75% RDF) recorded a significantly higher number of leaves per plant of 7.65 as compared to all other treatments. Significantly, a lower number of leaves per plant was recorded with T_3 (100% RDF) treatment (6.7).

At 60 DAS, the number of leaves per plant of sweet corn differed significantly. Application of treatment T_5 (150% RDF) recorded a significantly higher number of leaves per plant of 11.1. However, it was found to be on par with both T_1 (100% RDF) and T_2 (75% RDF) of 10.8 number of leaves per plant. A significantly lower number of leaves was recorded with T_4 (125% RDF) treatment as 10.4 number of leaves per plant.

The application of higher levels of phosphorus recorded significantly higher growth attributes of sweet corn, i.e., plant height and the number of leaves per plant at different stages of the crop compared to all other treatments. At higher levels of phosphorus application, a synergistic effect of nutrients occurs. These increased uptakes of nutrients help in expressing better growth parameters in sweet corn. Application of higher levels of nitrogen and phosphorus helps in the better synthesis of amino acids and it is an essential constituent of proteins, nucleic acid, chlorophyll, phospholipids, alkaloids, vitamins, etc. Further, it also accelerates cell division, cell elongation, and better photosynthetic rate and thereby increases the supply of carbohydrates to plants which may be the reason for increased dry matter accumulation and higher growth components or growth attributes in the present investigation.

Application of higher levels of potassium which activates enzymes and enzymatically catalyzes the system involved in photosynthesis, metabolism and translocation of carbohydrates and proteins. The carbohydrate generated by photosynthesis stimulates the growth of new root hair as well as nodule development and function. The application of potassium enhances plant vigour, strengthens the stalk and increases the availability of nitrogen and phosphorus which results in better plant growth.

Even though there was a higher dose of application of phosphorus, the higher response was rewarded with a lower dose of treatment. This might be due to the availability of more soil phosphorus. The plant system first goes to uptake nutrient availability from soil satisfactorily and if there is any deficit to meet the nutrition requirement of the plant, the plant depends on externally added nutrients. In that situation, the response of the crop will be more at the lower levels of treatments as compared to higher levels of treatments. However, applied higher levels of nutrients will transform in the soil by different means and also it will be going to be subjected to nutrient losses.

3.3 Effects of Different Levels of Phosphorus on Seed Yield of Sweet Corn (in g)

The data on seed yield of sweet corn are presented in Table 4.

The data pertaining to the seed yield of sweet corn differed significantly. Application of 100% RDF in T_3 treatment recorded a significantly higher seed yield of 296.25 g as compared to all other treatments. However, it is found to be on par with T_4 treatment (275 g) and T_1 treatment (285 g). A significantly lower seed yield was recorded with T_2 treatment (248.75 g).

Application of higher levels of phosphorus recorded significantly higher seed yield of sweet corn. The increased seed yield was a result of better growth and growth components recorded in that treatment.

In turn, this might be attributed to enhanced availability of nutrients, as a result, higher photosynthetic activity, accumulation and translocation of assimilates from source to sink resulting in the formation of heavier and bold seeds. Application of higher levels of balanced fertilization resulted in attaining a higher yield of sweet corn. It seems to be on account of their potential role in modifying soil and plant environment conducive for better development of both morphological and biochemical components of the plants that increased the efficiency of physiological processes in the plant system and ultimately led to the realization of higher productivity of the crops.

These results are in conformity with the finding of Krishnaprabhu (2015) (1), Khan and Singh (2017) (2), and Patel and Wallace (1975) (3). Krishnaprabhu (2015) (1) noticed that application of phosphorus significantly increased plant height at all crop growth stages and higher grain yield (1,633 kg/ha) and straw yield (5,783 kg/ha) was recorded with 120 kg and 160 kg N ha respectively. The net realization of Rs 30,525 and Rs 29,255/ha was recorded with 101 kg FYM/ha seed inoculation gave Rs 31,465 /ha and application of P_2O_5 at 0 and 50 kg. P_2O_5 /ha gave 6.7% and 4.43% higher grain and straw yield, respectively. Khan and Singh (2017) (2) reported that growth parameters were

Table 4 Effect of different levels of phosphorus on yield (g) of Sweet Corn.

Treatments	Seed yield (g)
T_1	285
T_2	248.75
T_3	296.25
T_4	275
T_5	268.75
SEM	8.45
CD at 5%	25.48

significantly influenced by the application of 60 kg P_2O_5/ha as DAP. However, quality parameters like protein content and beer sucrose content were found to be non-significant, but these were numerically superior in T_8 (Sweety + 60 kg P_2O_5/ha). The same treatment recorded a maximum net return of Rs. 80,288 and BC ratio 2.77. Patel and Wallace (1975) (3) found that salinity increased with an increase in P fertility levels often decreasing Cu, Fe, Mn, Si, Mo, Zn in plant tissues of tomato, sweet corn and Sudan grass. The high Cu levels of the saline treatment and increased R were causative agents.

Few investigations have evaluated the combinations of fertilizers to test the response of yield in maize. Arun Kumar et al. (2007) (4) revealed that the fresh cob yield of Sweet Corn in its treatment which received 75 per cent RDN (Recommended Dose of Nitrogen) along with 100 per cent RDF of Phosphorus and RDK (Recommended Dose of Potassium) was on par with the highest yield obtained in treatment indicating the possibility of reducing N level by 25 per cent without affecting yield levels of Sweet Corn. Khan et al. (2017) (5) concluded that growth attributes viz., plant height (213.00 cm) at 80 DAS, number of green leaves per plant (5.87) at 40 DAS, dry weight (200.77 g) at 80 DAS and CGK (32.52 g/m^2/day) at 80 DAS and others yield attributes were recorded maximum in 'Sweety' variety in treatment T_8 (Sweety +60 kg P_2O_5/ha). These parameters were significantly influenced by the application of 60 kg P_2O_5/ha as DAP. However, the number of green leaves per plant at 80 DAS, RGR, cob length and the number of cobs per plant were found to

be non-significant. Mohammadi et al. (2011) (6) revealed that the highest grain yield (7781.1kg/ha) was that of application of 200 kg urea/ha concluded that optimum doses of Phosphorus or nitrogen for Sweet Corn crop is 200 kg/ha. It is also suggested that further research should be done under different environmental conditions.

Onasanya et al. (2001) (7) reported that an application rate of 120 kg N/ha + 40 kg P/ha may be recommended for increasing maize yield, particularly in the study area. However, the application of 60kg N/ha + 40kg P/ha can also bring about an increase in the yield of maize. That will greatly benefit farmers in areas where the supply of nitrogen fertilizer is low and cases where farmers cannot afford the cost of high fertilizer input. Also, Reddy et al. (2018) (8) noticed that the highest and lowest grain yields were recorded with N levels of 300 kg/ha and 200kg/ha and with P levels of 60 kg/ha and 40 kg/ha respectively. The combination of 250 kg N and 60 kg P_2O_5/ha resulted in a higher yield of maize during the Kharif season.

Some researchers have given priority to marketable approach to use of phosphorus fertilization. Geleta et al. (2004) (9) observed that utilization of Sweet Corn in processing, profitability is determined mainly by the yield of marketable ears. Therefore, the small, inconsistent increase in sugar content and ear weight in response to P fertilization, without an increase in yield is not of major significance to the farmer. On high P soils, P fertilization is unnecessary for the production of quality, high yield processing Corn. The use of rye cover crops is suggested as a method of reducing the risk of P loss into the surrounding world. Finally, Singh et al. (2010) (10) concluded that the integrated use of chemical and organic fertilizer on yield and growth components of maize is very crucial for assurance of food security through the improvement of the stock of plant nutrients in the soil. Hence an effort has been made in this discussion to elaborate effects of INM on various growth parameters and yield of maize.

4. Significant Findings

Application of T_5 recorded significantly higher growth attributes viz., plant height (T_5: 128.125 cm) and the number of leaves per plant (T_5: 11.1 at 60 DAS). Application of T_3 treatment recorded significantly higher seed yield (T_3: 296.25 g).

5. Summary

A field experiment on “Response of Varied Levels of Phosphorus on Yield Performance of Sweet Corn” was conducted at the Agronomy field unit, Zonal Agricultural Research Station (ZARS), GKVK, UAS, Bengaluru, in 2019. The salient findings of the study are summarized in this chapter.

The experiment was laid out in randomized complete block design (RCBD) with 5 treatments and 4 blocks. The treatments include:

- T_1 = 50% RDF of P,100% RDF of N, 100 % RDF of K
- T_2 = 75% RDF of P, 100% RDF of N, 100 % RDF of K
- T_3 = 100% RDF of P, 100% RDF of N, 100 % RDF of K
- T_4 = 125% RDF of P, 100% RDF of N, 100 % RDF of K
- T_5 = 150% RDF of P, 100% RDF of N, 100 % RDF of K

The growth and growth attributes of sweet corn differed significantly with respect to different levels of phosphorus. Application of 150% of RDF of phosphorus recorded significantly higher growth attributes namely plant height (128.125 cm) and number of leaves per plant (11.1).

Application of 100% RDF of phosphorus (T_3) recorded a significantly higher seed yield (296.25 g).

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