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Assessment of phosphorus placement techniques and it's levels on growth, yield attributes and yield of rice fallow zero tillage maize

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ABSTRACT

A field experiment entitled "Phosphorus management in zero tillage maize" was conducted during *rabi*, 2025-2026 at Agricultural College Farm, Naira, Andhra Pradesh. The experiment was laid out in a split plot design with four methods of phosphorus application *viz*., farmer's practice (check) (M_1) - application of basal phosphatic fertilizer at first irrigation (15-20 DAS), broadcasting of basal phosphatic fertilizer 10 days before harvest of paddy (M_2), pocketing of basal phosphatic fertilizer at the time of seed dibbling (M_3) and drenching of basal phosphatic fertilizer at 10 DAS (M_4) as main plot treatments and three phosphorus levels viz., 40 kg P_2O_5 ha $^{-1}$ (S_1), 80 kg P_2O_5 ha^{-1} (S_2) and 120 kg P_2O_5 ha^{-1} (S_3) as sub plot treatments with three replications. The results revealed that phosphorus management practices significantly influenced growth and yield attributes of zero tillage maize. Among the different methods of phosphorus application, drenching of basal phosphatic fertilizer at 10 DAS (M_4) recorded superior growth performance with higher plant height (201.5 cm), number of leaves plant^{-1} (12.8), drymatter production (11,795 kg ha^{-1}), number of kernel rows cob^{-1} (15.4), number of kernels row^{-1} (41.7), cob weight (119.7 g), kernel weight cob^{-1} (105.5 g) and kernel yield (9,311 kg ha^{-1}). The treatment M,, recorded 16.4 and 8.5 per cent higher kernel yield over farmer's practice (M) and broadcasting (M_2), respectively and remained statistically on par with pocketing at seed dibbling (M_3). Further, M_4 hastened crop phenology by recording lower days to 50% tasseling (55.1 days), 50% silking (58.2 days) and maturity (106.0 days). Among the phosphorus levels, application of 120 kg P_2O_5 ha^{-1} (S_3) registered significantly higher plant height (195.8 cm), number of leaves plant^{-1} (13.0), drymatter production (11,454 kg ha^{-1}), number of kernel rows cob^{-1} (15.2), number of kernels row^{-1} (40.3), cob weight (118.2 g), kernel weight cob^{-1} (104.1 g) and kernel yield (9,155 kg ha^{-1}) which was on par with 80 kg P_2O_5 ha^{-1} (S_2). The kernel yield under 120 kg P_2O_5 ha^{-1} (S_3) was 10.9 and 3.6 per cent higher than that obtained with 40 kg P_2O_5 ha^{-1} (S_2) and 80 kg P_2O_5 ha^{-1} (S_2), respectively. The interaction effect between methods of phosphorus application and phosphorus levels was non-significant for all growth, phenological and yield parameters.

Key Words: *Application methods, crop phenology, kernel yield, phosphorus levels, yield attributes and zero tillage maize*

Maize (*Zea mays L*.) is an important cereal crop belonging to the family Poaceae and is widely cultivated under diverse agro-climatic conditions due to its high yield potential, wider adaptability and multiple uses as food, feed and industrial raw material. The crop is mainly grown in several states of India including Andhra Pradesh, Karnataka, Telangana, Bihar and Madhya Pradesh, where it plays a vital role in food security, livestock production and sustainable agricultural development (Directorate of Agriculture and Farmers Welfare, Government of India, 2025-26). Maize is valued not only for its versatility and economic importance but also for its contribution to the starch, biofuel, poultry feed and processing industries, being an important source of food and income for millions of farmers (Food and Agriculture Organization, 2023). As a highly productive cereal crop, it is popularly known as the "Queen of Cereals" owing to its superior genetic yield potential among cereal crops (Shiferaw *et al.*, 2011). In India, maize is cultivated in about 12.83 million hectares with a production of 46.14 million tonnes and a productivity of 3.5 t ha^{-1} (Directorate of Agriculture and Farmers Welfare, Government of India, 2025–26). In Andhra

Pradesh, the crop occupies about 3.85 lakh hectares with a production of 27.51 lakh tonnes and an average productivity of 7138 kg ha^{-1} (DES, 2022–23). Among the various agronomic factors influencing crop productivity, phosphorus management plays a crucial role in determining crop growth, nutrient uptake and yield performance of maize crop. Adequate phosphorus nutrition promotes vigorous root development, efficient energy transfer, photosynthesis and reproductive growth, whereas its deficiency limits crop establishment and productivity (Johnston and Bruulsema, 2014; Colombo *et al.*, 2024). Suitable phosphorus application methods and optimum phosphorus levels improve phosphorus-use efficiency, nutrient availability and productivity of maize under varying soil conditions (Gong *et al.*, 2022; Chen *et al.*, 2024). Under zero tillage conditions, phosphorus stratification and limited mobility often influence phosphorus availability and uptake by maize plants, making efficient phosphorus management essential for sustaining crop productivity and soil fertility (Yadav *et al.*, 2020). Proper phosphorus management not only enhances nutrient-use efficiency and crop productivity but also contributes to long-term soil health and sustainability of conservation agriculture-based cropping systems (Colombo *et al.*, 2024).

MATERIALS AND METHODS

A field experiment was conducted during the *rabi*, 2025-2026 at the Agricultural College Farm, Naira of Acharya N.G. Ranga Agricultural University, Andhra Pradesh, situated at 18.38° N latitude, 83.94° E longitude and at an altitude of 27 m above mean sea level in the North Coastal Andhra Pradesh. The soil of the experimental field was sandy loam in texture, slightly acidic in reaction (pH 6.82), with low electrical conductivity (0.04 ds m^{-1}), medium organic carbon (0.46%) and low available nitrogen (232 kg ha^{-1}), phosphorus (20.3 kg ha^{-1}) and potassium (249 kg ha^{-1}). During the crop growth period, the weekly mean maximum temperature ranged from 31.9° C with minimum temperature of 14.4° C and with a total rainfall of 11.5 mm received in 3 rainy days. The experiment was laid out in a split plot design with three replications comprising four methods of application viz., farmer's practice (check)-application of basal dose of phosphatic fertilizer 10-15 DAS at first irrigation (M_1), broadcasting of basal dose of phosphatic fertilizer 10 days before harvest of paddy (M_2), pocketing of basal dose of fertilizer phosphatic fertilizer at the time of seed dibbling (M_3) and drenching of basal dose of phosphatic fertilizer at 10 DAS (M_4) as main plots treatments and three phosphorus levels viz., 40 kg P_2O_5 ha^{-1} (S_1), 80 kg P_2O_5 ha^{-1} (S_2) and 120 kg P_2O_5 ha^{-1} (S_3) as subplot treatments. Maize was sown at a spacing of 60 x 20 cm using a seed rate of 23 kg ha^{-1}. The recommended fertilizer dose of 200 kg N ha^{-1} was applied at basal and in three splits at 20 days interval and 80 kg K_2O ha^{-1} was applied in two splits at basal and 60 DAS maize. Standard agronomic practices and plant protection measures were followed uniformly for all treatments during the crop growth period. Observations on plant height, dry matter production, number of leaves $plant^{-1}$, days to 50 per cent tasseling, days to 50 per cent silking, days to maturity, number of kernel rows cob^{-1}, number of kernels per row^{-1}, kernel weight cob^{-1} and kernel yield were recorded by following standard procedures. The experiment data were statistically analyzed by the method of analysis of variance (ANOVA) as described by Pense and Sukhatme (1985) and treatment differences were tested at 5 per cent level of significance.

RESULTS AND DISCUSSION

Different application methods and phosphorus levels had a significant influence on the growth, phenological behavior, yield attributes and kernel yield of maize (Table 1 and 2). Among the methods of application, drenching of phosphatic fertilizer 10 DAS (M_4) consistently recorded relatively superior growth performance which was on par with pocketing of at the time of seed dibbling (M_3) over the other methods of application. The phosphorus level 120 kg P_2O_5 ha^{-1}(S_3) registered significantly higher plant height (195.8 cm), drymatter production (11454 kg ha^{-1}), number of leaves $plant^{-1}$(13.0) at tasseling which was comparable with 80 kg P_2O_5 ha^{-1}(S_2) and minimum values are recorded under 40 kg P_2O_5 ha^{-1} (S_1). The better growth observed under drenching and pocketing methods might be due to improved phosphorus availability and efficient nutrient absorption have enhanced photosynthetic efficiency, assimilate accumulation and reproductive growth throughout the crop growth period. Similar findings were reported by Islam *et al.* (2024) and Rafiullah *et al.*(2020).

Phenological observations revealed that application methods not significantly influenced days

Table 1. Effect of phosphorus application methods and levels on growth parameters of zero tillage maize

Treatment		Plant height (cm)	No. of leaves plant-1	Dry matter production (kg ha-1)	Days to 50% tasseling	Days to 50% silking	Days to maturity
Method of application (M)							
M_1 : Farmer's practice (check)- application of basal dose of phosphatic fertilizer at 1st irrigation 15-20 DAS		178.3	11.4	9830	57.1	60.5	108.1
M_2 : Broadcasting of basal dose of basal dose of phosphatic fertilizer 10 days before harvest of paddy		185	11.7	10402	56.6	59.7	107.8
M_3 : Pocketing of basal dose of basal dose of phosphatic fertilizer at the time of seed dibbling		195.2	12.1	11621	56.4	59.5	107.6
M_4 : Drenching of basal dose of phosphatic fertilizer 10 DAS		201.5	12.8	11795	55.1	58.2	106
S. Em (±)		4.73	0.29	346	1.83	1.81	3.9
CD (*p=0.05*)		16.3	1	1197	NS	NS	NS
CV (%)		7.5	7.36	9.51	9.73	9.22	10.9
Phosphorus levels (S)							
S_1: 40 kg P_2O_5 ha^{-1}		181.2	10.7	10249	56.9	60.1	108
S_2: 80 kg P_2O_5 ha^{-1}		192.1	12.2	11033	56.6	59.7	107.6
S_3: 120 kg P_2O_5 ha^{-1}		195.8	13	11454	55.6	58.8	106.4
S. Em (±)		3.39	0.24	292	1.19	1.21	2.21
CD (*p=0.05*)		10.1	0.7	876	NS	NS	NS
CV (%)		6.21	7.06	9.27	7.35	6.97	7.2
Interaction							
M x S	S. Em (±)	7.28	0.49	589	2.6	2.7	5.3
	CD (*p=0.05*)	NS	NS	NS	NS	NS	NS
S x M	S. Em (±)	6.78	0.49	584	2.4	2.3	4.5
	CD (*p=0.05*)	NS	NS	NS	NS	NS	NS

Table 2. Effect of phosphorus application methods and levels on yield attributes and yield of zero tillage maize

Treatment		No. of kernel rows cob^{-1}	No. of kernels row^{-1}	Dried cob weight (g)	Kernel weight cob-1	Kernel yield (kg ha-1)
Method of application (M)						
M_1 : Farmer's practice (check)- application of basal dose of phosphatic fertilizer at 1st irrigation 15-20		13.8	35.4	106.5	92.2	7998
M_2 : Broadcasting of basal dose of basal dose of phosphatic fertilizer 10 days before harvest of paddy.		14	37.4	112	97.7	8505
M_3 : Pocketing of basal dose of basal dose of phosphatic fertilizer at the time of seed dibbling.		15.2	40	118.7	104.4	9184
M_4 : Drenching of basal dose of phosphatic fertilizer 10 DAS.		15.4	41.7	119.7	105.5	9311
S. Em (±)		0.36	1.1	2.8	2.8	212
CD (*p=0.05*)		1.2	3.9	9.7	9.6	734
CV (%)		7.3	8.7	7.3	8.3	7.3
Phosphorus levels (S)						
S_1: 40 kg P_2O_5 ha^{-1}		13.7	36.5	109.2	95	8257
S_2: 80 kg P_2O_5 ha^{-1}		14.7	39	114.9	100.8	8837
S_3: 120 kg P_2O_5 ha^{-1}		15.2	40.3	118.2	104.1	9155
S. Em (±)		0.31	0.9	2.1	2.1	157
CD (*p=0.05*)		0.9	2.6	6.3	6.3	471
CV (%)		7.2	7.7	6.3	7.3	6.2
Interaction						
M x S	S. Em (±)	0.62	1.8	4.42	4.4	333
	CD (*p=0.05*)	NS	NS	NS	NS	NS
S x M	S. Em (±)	0.61	1.71	4.2	4.21	314
	CD (*p=0.05*)	NS	NS	NS	NS	NS

to 50 percent tasseling, silking and maturity behavior of maize. The farmer's practice (M_1) took more number of days to attain 50 per cent tassseling (49.37 days), silking (49.37 days) and maturity (99.26 days), whereas drenching and pocketing method accelerated crop development and reduced crop duration. Among the phosphorus levels, 120 kg P_2O_5 ha^{-1}(S_3) took less number of days to 50 percent tasseling (49.37 days), silking (49.37 days) and (49.37 days) maturity due increased phosphorus availability might have enhanced assimilate partitioning, energy metabolism and reproductive efficiency, which ultimately accelerated crop phenological development and shortened the crop growth period. These results are in agreement with the findings of Dube and Chimdi (2021) and Medhi(2019).

The superior yield attributes, viz., number of kernel rows cob^{-1}, number of kernels row^{-1}, dried cob weight (g) and kernel weight cob^{-1} were significantly influenced by application methods and phosphorus levels. Drenching of phosphatic fertilizer 10 DAS (M_4) recorded the higher yield attributes was found to be on par with pocketing at the time of seed dibbling (M_3). However, both methods of application were significantly superior to broadcasting of basal dose of phosphatic fertilizer 10 days before harvest of paddy (M_2) and farmer's practice (M_1), farmer's practice record the lowest yield attributes. Among the phosphorus levels, application of 120 kg P_2O_5 ha^{-1} (S_3) recorded superior yield attributes, which was on par with 80 kg P_2O_5 ha^{-1}(S_2) and the lowest values

were recorded with application of 40 kg P_2O_5 ha^{-1} (S_1). Adequate phosphorus nutrition might have promoted efficient photosynthate accumulation, better kernel filling and improved sink strength, which ultimately contributed to increased yield attributes of the crop. These observations are in agreement with the reports of Ramesh *et al.* (2021) and Pela *et al.* (2019)

Kernel yield was significantly influenced by methods of application. The application method drenching of basal dose of phosphatic fertilizer 10 DAS (M_4) recorded the highest kernel yield which was on par with pocketing at the time of seed dibbling (M_3), followed by broadcasting of basal dose of phosphatic fertilizer 10 days before harvest of paddy (M_2) with increase in 16.4, 14.8 and 6.3 percent over farmer's practice. The favourable response under drenching and pocketing methods might be attributed to efficient phosphorus availability near the root zone, improved nutrient absorption and enhanced translocation of photosynthates towards developing kernels, which ultimately promoted higher grain production. Similar observations were reported by Ramesh *et al.* (2021) and Rafiullah *et al.* (2020).

Among levels of phosphorus, significant differences were observed in kernel yield. 120 kg P_2O_5 ha^{-1} (S_3) registered the highest seed yield which was on par with 80 kg P_2O_5 ha^{-1}(S_2) and significantly superior over 40 kg P_2O_5 ha^{-1} (S_1) by 10.8 and 7.02 per cent. Adequate phosphorus nutrition might have improved root activity, energy transfer and grain filling efficiency, thereby contributing to better kernel development and increased productivity. These findings are in close conformity with the reports of Singh *et al.* (2024) and Ramesh *et al.* (2021)

CONCLUSION

From the experiment, conclude that application of phosphatic fertilizer through drenching at 10 DAS and pocketing at the time of seed dibbling resulted in superior growth and higher kernel yield of zero tillage maize compared to the other methods of phosphorus application. Among the phosphorus levels, application of 120 kg P_2O_5 ha^{-1} exhibited better growth, yield attributes and productivity. Therefore, application of phosphatic fertilizer through drenching at 10 DAS along with 120 kg P_2O_5 ha^{-1} was found to be the most suitable option for achieving higher productivity of zero tillage maize in North Coastal Zone of Andhra Pradesh.

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