International Journal of Statistics and Applied Mathematics

ISSN: 2456-1452
Maths 2023; SP-8(4): 463-466

https://www.mathsjournal.com
Received: 05-04-2023
Accepted: 11-05-2023

Lalita Ramteke
Subject Matter Specialist, Krishi Vigyan Kendra Pahanda (A) Durg, Chhattisgarh, India

KK Sahu
Professor, Department of Soil science and Agricultural Chemistry IGKV Raipur, Chhattisgarh, India

SS Porte
Professor, Department of Soil Science and Agricultural Chemistry IGKV Raipur, Chhattisgarh, India

GK Shrivastav
Professor, Department of Agronomy, IGKV Raipur, Chhattisgarh, India

AK Verma
Professor, Department of Agronomy, IGKV, Raipur, Chhattisgarh, India

Vijay Jain
Senior Scientist and Head KVK Durg Pahanda (A), Chhattisgarh, India

Anjali Patel
SRF IARI Delhi, Department of Agronomy, New Delhi, India

Corresponding Author:
Lalita Ramteke
Subject Matter Specialist, Krishi Vigyan Kendra Pahanda (A) Durg, Chhattisgarh, India

Impact of phosphorus and zinc application on seed yield and economics of fodder maize (*Zea mays* L.) in a *Vertisols*

Lalita Ramteke, KK Sahu, SS Porte, GK Shrivastav, AK Verma, Vijay Jain and Anjali Patel

Abstract
A field experiment was carried out during R*abi* season of 2020-21 and 2021-22 at Agricultural Farm of Krishi Vigyan Kendra, Pahanda (A), Durg, and Chhattisgarh. The experiment was laid out in split plot design with three replications and 16 treatment combinations. The main plot comprised of four phosphorus levels (0, 30, 60 and 90 kg P_20_5 ha^{-1}) and sub plot consisted four levels of $ZnS0_4$ (0, 10, 20 and 30 kg $ZnS0_4$ ha^{-1}). The results revealed that the application of 90 kg P_2O_5 ha^{-1} and 30 kg $ZnSO_4$ ha^{-1} recorded significantly higher grain yield as well as Stover yield of fodder maize for seed purpose. However, it was comparable to 60 kg P_2O_5 ha^{-1} and 20 kg $ZnSO_4$ ha^{-1}, respectively. The highest mean net return of fodder maize was found under the combined application of 60 kg P_2O_5 and 30 kg $ZnSO_4$ ha^{-1} (Rs. 112596 ha^{-1}) followed by 90 kg P_2O_5 and 20 kg $ZnSO_4$ ha^{-1} (Rs. 112317 ha^{-1}), 90 kg P_2O_5 and 30 kg $ZnSO_4$ ha^{-1} (Rs. 111893 ha^{-1}), 60 kg P_2O_5 and 20 kg $ZnSO_4$ ha^{-1} (Rs. 111240 ha^{-1}). Whereas, the maximum mean B:C ratio (2.45) was recorded under the combination of 60 kg P_2O_5 and 20 kg $ZnSO_4$ ha^{-1} followed by 60 kg P_2O_5 and 30 kg $ZnSO_4$ ha^{-1} (2.42) and 90 kg P_2O_5 and 20 kg $ZnSO_4$ ha^{-1} (2.39).

Keywords: Phosphorus, zinc, seed yield, economics, fodder maize

Introduction
Maize is grown both as food for man and feed for animal. It is a dual purpose crop cultivated by farmers for human consumption, poultry feed, cattle feed, com flakes and popcorn and other industrial purposes (mainly starch, dextrose, corn syrup etc.). In India it is grown in 8.85 million hectares area with production of 22.84 million tonnes and average yield of 2580 kg ha^{-1} during *Rabi* 2016 (Agricultural Statistics at a glance 2016). Rajasthan, Uttar Pradesh, Madhya Pradesh, Bihar, Karnataka, Andhra Pradesh, Gujarat and Maharashtra are the major maize growing states. The average yield of maize in the state is 27.14 million tonnes (Agricultural Statistics, 2017-18).

Phosphorus is second major nutrient after nitrogen for high fodder crop yield especially for maize, because it is frequently deficient for seed production of fodder maize and is required by crops in relatively large amounts. In plants, P is necessary for photosynthesis, respiration, cellular function, gene transfer and reproduction. Once aware of the critical link between P and life itself, it becomes apparent that “Without P, there is no cell, plant and grain and without adequate P, there is a lot of hunger”. Lack of phosphorus is as important as the lack of nitrogen limiting maize performance. It is a constituent of ADP and ATP which plays a key role in energy transformation and also helps in assimilation of photosynthesis into other metabolites.

Zinc is one of the most important micronutrients. It is required in a minute quantity but positively influence the yield, fruit set and fruit quality. It is also involved in carbonic anhydrase activity, carbohydrate metabolism and maintenance of membrane integrity, regulation of auxin and protein production and synthesis of pollen grains. In Chhattisgarh state, two major sources of fodder supply are crop residual and fodder from common property resources like forests, permanent pastures and grazing land. The availability of cultivated fodder is very rare. As majority area in the state follows mono cropping or Rice-Rice cropping systems, the availability of different varieties of fodder is also scarce.

The non-availability of green fodder has posed major threat for dairy development in the state. Cultivated fodder is only three percent in the state. Farmers are only dependent on paddy straw to feed the livestock, paddy straw contribute 89% of dry fodder in the state. Therefore, identification of suitable fodder crops and varieties and suitable cultivation practices are necessary to boost fodder production on marginal and wastelands in the state. Fodder maize have become popular among the farmers and the state depends on other states for seeds. Availability of fodder seed have also become the main constraint for fodder production. Therefore it is required to start the seed production in the state.

Materials and Methods

The field experiment was carried out during *Rabi* season of 2021 and 2022 at Agricultural Farm, Krishi Vigyan Kendra, Pahanda (A), Durg (Chhattisgarh). Krishi Vigyan Kendra, Pahanda (A), Durg is situated in central part of Chhattisgarh and lies at latitude, longitude of 21°20' N, 81°53' E, respectively and 291.79 meters above mean sea level. In Chhattisgarh, this region falls under agro climatic zone of C.G. plains.

The general climatic condition of Durg is sub-humid to semi-arid. The average annual rainfall is 1144 mm, out of which 85% rainfall is received during rainy season (June to September) and the rest during winter and summer season (October to May). May is the hottest and December is the coolest month of the year. The pattern of rainfall particularly during June to September months has great variation from year-to-year. The maximum temperature rise as high as 44.8 °C during summer. The relative humidity is high from June to October and wind velocity is high from May to August with its peak in June-July months. The experiment was laid out in split plot design with three replications and 16 treatment combinations. The main plot comprised of four phosphorus levels (0, 30, 60 and 90 kg P_2O_5 ha^{-1}) and sub plot consisted four levels of$ZnSO_4$ (0, 10, 20 and 30 kg $ZnSO_4$ ha^{-1}). The recommended dose of Nitrogen was applied form of urea @ 120 kg ha^{-1} (46% N) in three equal splits (*viz.*, 1/3rd each at sowing, at 30 and 50 DAS). Recommended dose of potassium @ 40 kg ha^{-1} was applied through murate of potash (60% K_2O) of the time of sowing. In treatment P_0, P_{30}, P_{60} and P_{90} phosphorus was applied through SSP @ 0, 30, 60 and 90 kg P_2O_5 ha^{-1}, respectively at the time of sowing. In treatment Zn_0, Zn_{30}, Zn_{60} and Zn_{90} $ZnSO_4$ ha^{-1} Zinc was applied through zinc sulphate @ 0, 10, 20, 30 kg $ZnSO_4$ ha^{-1}, respectively, at the time of sowing.

Result and Discussion

A perusal of data presented in Table 1 revealed that application of phosphorus significantly affected grain yield of fodder maize for seed production. Significantly higher grain yield (24.13, 25.01 and 24.57 q ha^{-1}) was obtained with application of 90 kg P_2O_5 ha^{-1} as compared to control and 30 kg P_2O_5 ha^{-1}, but it was at par to 60 kg P_2O_5 ha^{-1}with seed yield of 22.81, 23.96 and 23.68 q ha^{-1} during both the years and on mean basis, respectively. Application of 0 kg P_2O_5 ha^{-1}(Control) resulted lowest grain yield of 11.99, 12.15 and 12.07 q ha^{-1} during 2020-21, 2021-2022 and on mean basis, respectively.

In plants, P is necessary for photosynthesis, respiration, cellular function, gene transfer and reproduction. Once aware of the critical link between P and life itself, it becomes apparent that "Without P, there is no cell, plant and grain and without adequate P, there is a lot of hunger". Lack of phosphorus is as important as the lack of nitrogen limiting maize performance (Gul *et al.,* 2015) [3]. The significantly highest grain yield (21.69, 21.75 and 21.80 q ha^{-1}) was recorded with 30 kg $ZnSO_4$ ha^{-1} which registered 29.2% higher seed yield over control (15.52, 17.20 and 16.43 q ha^{-1}), however, 20 kg ha^{-1} $ZnSO_4$ recorded at par grain yield (21.23, 21.41 and 21.39q ha^{-1}) during 2020-21, 2021-22 and on mean basis, respectively. This increase in yields due to Zn application may be attributed to the fact that Zn is main yield limiting plant nutrient in Zn deficient soils. Applied Zn is reported to enhance the absorption of native as well as added major nutrients and there by improves overall growth and development of plant and ultimately the yields.

The increase grain yield of maize might be due to the increased availability of essential nutrients from the enhanced level of nutrients applied to the crop. These findings are in close conformity with the earlier findings of Ramachandrappa *et al*. (2007) [7].

Application of P @ 30, 60 and 90 kg ha^{-1} resulted in increased grain yield of maize respectively over no use of phosphorus. This trend indicates that balance use of N, P and K encourages the root formation, growth and development of maize plant. Mehta *et al.* (2005) [6] reported that 60 kg P ha^{-1} increased significantly the grain yield of maize over 30 kg P ha^{-1}.

The grain yield depends on the synthesis and accumulation of photosynthates and their distribution among various plant parts. The synthesis, assembly, and translocation of photosynthates depend upon the efficient photosynthetic structure and the extent of translocation into the sink (grains) and plant growth and development during the early crop growth stages. The production and translocation of synthesized photosynthates depend upon mineral nutrition through soil or foliar application. Zn, among micronutrients, is indispensable for plants as it acts as a structural, catalytic and co-catalytic component in many enzymes. It has thoughtfully been assumed that its rational use, particularly dose and time, can significantly contribute to growth and yield of plants (Saharan *et al.,* 2015) [8].

Application of phosphorus to fodder maize significantly affected the Stover yield (Table 2). The significantly higher Stover yield (45.40, 46.92 and 46.16 q ha^{-1}) was recorded at 90 kg P_2O_5ha^{-1}as compared to others, but at par with P level receiving 60 kg P_2O_5 ha^{-1} (41.88, 45.71, and 43.79 q ha^{-1}) during both the years and on mean basis, respectively. Application of 30 kg P_2O_5 ha^{-1}recorded Stover yield of 31.77, 34.05, and 32.91 q ha^{-1}, whereas, control recorded Stover yield of 21.54, 21.38, and 21.46 q ha^{-1}during both the years and on mean basis, respectively).

As regards to Zn application, significantly higher Stover yield (39.90, 41.17 and 40.54 q ha^{-1})was recorded with 30 kg $ZnSO_4$ha^{-1}as compared to control and 10 kg $ZnSO_4$ha^{-1}, but it was at par to 20kg $ZnSO_4$ha^{-1} with Stover yield of 38.64, 39.18 and 38.91q ha^{-1}during 2020-21, 2021-22 and on mean basis, respectively. The response of maize to different levels of zinc application noticed that grain and Stover yield increased significantly with increasing levels of zinc application up to 30 kg $ZnSO_4$ ha^{-1} Similar results were also reported by Arya and Singh (2000) [1].

The application of phosphorus resulted in higher grain and Stover yield of fodder maize. It might be due to the fact that native phosphorus in soil was low and the application of soluble phosphorus to the crop. The overall improvement in crop growth and yield with P application seems to be on account of its pivotal role in early root development. This might have improved effective utilization of soil nutrient by the crop and greater nitrogen fixation through enhancement in nitrogenous activity. Phosphorus application increased nitrogen and phosphorus uptake by the system because applied phosphorus increased N and P content in grain and straw by providing a balanced nutritional environment inside the plant and higher photosynthetic efficiency which favored better crop yield. The increased grain and Stover yields with higher N and P content together resulted in greater uptake of nutrients. These results are in good agreement with the findings of Jat and Ahlawat (2006) [4].

Application of phosphorus at the rate of 90 kg ha^{-1} showed significantly highest grain and Stover yields. Increase in grain yield of fodder maize might be due to the increased availability of essential nutrients from the enhanced level of nutrients applied to the crop. The grain and Stover yields of fodder maize were recorded significantly highest under 30 kg$ZnSO_4$ ha^{-1}which was found at par with 20 kg $ZnSO_4$ ha^{-1}.
Ghodpage *et al.* (2008) [2] assessed the response of maize to different levels of zinc (0, 10 and 20 kg Zn ha^{-1}) and noticed that grain and fodder yield increased significantly with increasing levels of zinc application up to 20 kg ha^{-1}.

Table 1: Effect of phosphorus and zinc level on grain and Stover yield of fodder maize for seed purpose

Treatment	Grain yield (q ha^{-1})			Stover yield(q ha^{-1})		
	2020-21	2021-22	Mean	2020-21	2021-22	Mean
Level of phosphorus (kg ha^{-1})						
P_0: Control	11.99	12.15	12.07	21.54	21.38	21.46
P_{30}: 30 kg P_2O_5	18.56	19.36	18.96	31.77	34.05	32.91
P_{60}: 60 kg P_2O_5	22.81	23.96	23.68	41.88	45.71	43.79
P_{90}: 90 kg P_2O_5	24.13	25.01	24.57	45.40	46.92	46.16
S.Em ±	0.46	0.58	0.27	1.02	0.98	0.85
CD (P=0.05)	1.59	2.04	0.95	3.56	3.41	2.94
Level of zinc sulpahate (kg ha^{-1})						
Zn_0: Control	15.52	17.20	16.43	28.30	31.79	30.05
Zn_{10}: 10 kg $ZnSO_4$	19.04	20.11	19.65	33.74	35.92	34.83
Zn_{20}: 20 kg $ZnSO_4$	21.23	21.41	21.39	38.64	39.18	38.91
Zn_{30}: 30 kg $ZnSO_4$	21.69	21.75	21.80	39.90	41.17	40.54
S.Em ±	0.61	0.43	0.36	0.89	1.08	0.73
CD (P=0.05)	1.78	1.26	1.07	2.39	3.16	2.14
Interaction	NS	NS	NS	NS	NS	NS

Economics

Data pertaining to economics (cost of cultivation, gross return, net return and B: C ratio) of fodder maize as influenced by phosphorus and zinc levels are presented Table 2.
The data clearly indicate that maximum mean cost of cultivation was recorded under combination of 90 kg P_2O_5 and 30 kg $ZnSO_4$ ha^{-1}(Rs. 48,192 ha^{-1}). The mean gross return of fodder maize cultivation was obtained maximum under combination of 90 kg P_2O_5 and 30 kg $ZnSO_4$ha^{-1} (Rs. 1, 60, 084 ha^{-1}) followed by 90 kg P_2O_5 and 20 kg $ZnSO_4$ ha^{-1} (Rs. 1,59,409 ha^{-1}), 60 kg P_2O_5 and 30 kg $ZnSO_4$ ha^{-1} (Rs. 1,59,157 ha^{-1}) and 60 kg P_2O_5 and 20 kg $ZnSO_4$ha^{-1} (Rs. 1,56,701 ha^{-1}). The mean net return of fodder maize was found maximum under the combined application of 60 kg P_2O_5 and 30 kg $ZnSO_4$ ha^{-1} (Rs. 1,12,596 ha^{-1}) followed by 90 kg P_2O_5 and 20 kg $ZnSO_4$ ha^{-1} (Rs. 1,12,317 ha^{-1}), 90 kg P_2O_5 and 30 kg $ZnSO_4$ha^{-1} (Rs. 1,11,893 ha^{-1}), 60 kg P_2O_5 and 20 kg $ZnSO_4$ha^{-1} (Rs. 1,11,240 ha^{-1}). Whereas, the maximum mean B:C ratio (2.45) was recorded under the combination of 60 kg P_2O_5 and 20 kg $ZnSO_4$ ha^{-1} followed by 60 kg P_2O_5 and 30 kg $ZnSO_4$ ha^{-1} (2.42) and 90 kg P_2O_5 and 20 kg $ZnSO_4$ ha^{-1}(2.39).
Increasing zinc level brought about an increase in B: C ratio. The highest B: C ratio was found in $P_{60}Zn_{20}$ combination and lowest under control plot. Similar results obtain by Thakur *et al*. (2020) [10].
Chandrakala *et al*. (2017) [5] found that application of 75% recommended P + recommended N and K recorded higher B: C ratio in both the crops and was the best and optimum P prescription for these crops as the P use efficiency was also higher. Application of higher dose of P fertilize has no beneficial effect in high and very high P fertility strips. Very low gradient with absolute control showed lower benefit cost ratio which indicates that application of sufficient amount of nutrients was very much essential in order to achieve better crop yields and income. There was an increased B:C ratio in absolute control with increased P fertility gradients there was increase in yield which shows the role and importance of phosphorus for crop production. Similar findings were reported by Singh *et al.* (1999) [9].

Table 2: Effect of phosphorus and zinc levels on cost of cultivation, gross return, net return and B: C ratio of fodder maize for seed purpose

Treatment	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B: C ratio
P_0Zn_0	40,000	52014	12,014	0.30
P_0Zn_{10}	41,100	71519	30,419	0.74
P_0Zn_{20}	42,200	84323	42,123	1.00
P_0Zn_{30}	43,300	90328	47,028	1.09
P30Zn0	41,631	90954	49,324	1.18
$P_{30}Zn_{10}$	42,731	118853	76,123	1.78
$P_{30}Zn_{20}$	43,831	128571	84,741	1.93
$P_{30}Zn_{30}$	44,931	129756	84,825	1.89
$P_{60}Zn_0$	43,261	124841	81,580	1.89
$P_{60}Zn_{10}$	44,361	145139	100,778	2.27
$P_{60}Zn_{20}$	45,461	156701	111,240	2.45
$P_{60}Zn_{30}$	46,561	159157	112,596	2.42

$P_{90}Zn_0$	44,892	138610	93,718	2.09
$P_{90}Zn_{10}$	45,992	149982	103,990	2.26
$P_{90}Zn_{20}$	47,092	159409	112,317	2.39
$P_{90}Zn_{30}$	48,192	160084	111,893	2.32

Conclusion

The present study's findings indicates that application of 90 kg P_2O_5 ha^{-1} and 30 kg $ZnSO_4$ ha^{-1} recorded significantly higher grain yield as well as Stover yield of fodder maize for seed purpose. However, it was comparable to 60 kg P_2O_5 ha^{-1} and 20 kg $ZnSO_4$ ha^{-1}, respectively. A combination of 60 kg P_2O_5 ha^{-1} and 20 kg $ZnSO_4$ ha^{-1} fodder maize was found profitable dose for fodder maize. The highest mean net return of fodder maize was found under the combined application of 60 kg P_2O_5 and 30 kg $ZnSO_4$ ha^{-1} (Rs.1,12596 ha^{-1}) followed by 90 kg P_2O_5 and 20 kg $ZnSO_4$ ha^{-1} (Rs. 1,12317 ha^{-1}), 90 kg P_2O_5 and 30 kg $ZnSO_4$ ha^{-1} (Rs. 1,11893 ha^{-1}), 60 kg P_2O_5 and 20 kg $ZnSO_4$ ha^{-1} (Rs. 1,11240 ha^{-1}). Whereas, the maximum mean B:C ratio (2.45) was recorded under the combination of 60 kg P_2O_5 and 20 kg $ZnSO_4$ ha^{-1} followed by 60 kg P_2O_5 and 30 kg $ZnSO_4$ ha^{-1} (2.42) and 90 kg P_2O_5 and 20 kg $ZnSO_4$ ha^{-1} (2.39).

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

1. Arya KC, Singh SN. Effect of different levels of phosphorus and zinc on yield nutrient uptake of maize (*Zea mays* L.) with and without irrigation. Indian Journal of Agronomy. 2000;45(4):717-721.
2. Ghodpage RM, Balpanda SS, Babhulka VP, Pongade S. Effect of phosphorus and zinc fertilization on nutrient content in root, yield and nutritional quality of maize. Journal of Soils Crop. 2008;18:458-461.
3. Gul S, Khan MH, Khanday BA, Nabi S. Effect of sowing methods and NPK levels on growth and yield of rainfed maize (*Zea mays* L.). Scientifica; c2015. p. 1- 6.
4. Jat RS, Ahlawat IPS. Direct and residual effect of vermicompost, bio fertilizers and phosphorus on soil nutrient dynamics and productivity of chickpea-fodder maize sequence. Journal of Sustainable Agriculture. 2006;28(1):41-54.
5. M Chandrakala, Srinivasamurthy CA, Kumar, Sanjeev, Naveen D. Effect of Application of Graded Level of Phosphorus to Finger Millet - Maize Cropping System in Soils of Different P Fertility. International Journal of Current Microbiology and Applied Sciences. 2017;6:265-280. DOI: 10.20546 ijcmas.2017.611.032.
6. Mehta YK, Shaktawat MS, Singh SM. Influence of sulphur, phosphorus and farmyard manure on yield attributes and yield of maize (*Zea mays* L.) in southern Rajasthan conditions. Indian Journal of Agronomy. 2005;50:203-205.
7. Ramachandrappa BK, Nanjappa HV, Soumya TM. Sensory parameters, nutrient content, yield and yield attributes of baby corn varieties as influenced by stage of harvest. Mysore Journal of Agricultural Science. 2007;41(1):01-07.
8. Saharan V, Sharma G, Yadav M, Choudhary MK, Sharma SS, Pal P. Synthesis and *in vitro* antifungal efficacy of Cu–chitosan nanoparticles against pathogenic fungi of tomato. International Journal of Biological Macromolecule. 2015;75:346-353.
9. Singh SC. Effect of plant population, fertility levels and date of sowing on the performance of maize inbred parental line (CM-III) in the Rabi season. Agronomy, Ph.D., thesis. B.H.U., Varanasi; c1999. p. 5.
10. Thakur PM, Dawson J, Thakur T. Effect of phosphorus, zinc and iron levels on growth and yield of kharif maize (*Zea mays* L.) International Journal of Current Microbiology and Applied Sciences. 2020;9(12):2312-2323.