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

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Abstract

A discipline experiment became performed for the duration of Rabi season of 2020-21 and 2021-22 at Agricultural Farm of Krishi Vigyan Kendra, Pahanda (A), Durg, Chhattisgarh. To test the effect of phosphorus and zinc utility on increase and seed yield of fodder maize (*Zea mays* L.) in a *vertisol*. The test turn out to be specified in cut up plot format with three replications and 16 treatment mixtures. The primary plot made out of 4 phosphorus ranges (0, 30, 60 and ninety kg P₂O₅ ha⁻¹) and sub plot consisted four levels of ZnSO₄ (0, 10, 20 and 30 kg ZnSO₄ ha⁻¹). The consequences located out that the software program of ninety kg P₂O₅ ha⁻¹ and 30 kg ZnSO₄ ha⁻¹ recorded extensively higher plant pinnacle (212, 213 and 213 cm), quantity of grains cob⁻¹ (349, 356 and 352 grains cob⁻¹) and (337, 340 and 338 grains cob⁻¹), grain yield (24.13, 25.01 and 24.57 q ha⁻¹) and (21.69, 21.75 and 21.80) in addition to Stover yield (45.40, forty six. Ninety and forty six.16 q ha⁻¹) and (39.90, forty one.17 and 40.50 q ha⁻¹) of fodder maize for seed cause. But, it became much like 60 kg P₂O₅ ha⁻¹ and 20 kg ZnSO₄ ha⁻¹, respectively.

Keywords: Phosphorus, zinc, seed yield, fodder maize

Introduction

Creation

Maize (*Zea mays* L.) is a critical crop most of the cereals in India. It's far one of the essential meals, fodder business and desk purpose crop and fetches incredible price inside the marketplace. Maize is one of the most prominent forage plants no longer handiest in India however within the direction of the arena way to its higher increase price and yield, wider adaptability, higher digestibility, more palatability and lack of any potential anti-dietary component. It's far the most bendy crop with wider adaptability in varied agro-ecologies and has highest genetic yield ability a number of the forage vegetation. Due to the fact the call for maize is developing globally due to its multiple makes use of we need to deliver extra from equal or even a good deal less belongings.

The necessities of fertilizers in maize are essential for the early boom and preferred production of yield. Maize calls for heavy feeding for its potential manufacturing of yield. Indiscriminate use of inorganic fertilizers ends in nutrient imbalance in soil causing unwell effect on soil fitness and micro vegetation. Mineral nutrients are pillars of agriculture that make a contribution considerably to the established order of soil fertility. Phosphorus and zinc are vital nutrients which can be required for normal plant increase.

Phosphorus is 2d foremost nutrient after nitrogen for immoderate fodder crop yield specially for maize, due to the truth it's miles frequently bad for seed production of fodder maize and is needed thru crops in notably massive quantities. In flora, P is vital for photosynthesis, breathing, cellular characteristic, gene switch and reproduction. As soon as aware about the vital link among P and lifestyles itself, it turns into apparent that "without P, there may be no cellular, plant and grain and without ok P, there is lots of hunger". Lack of phosphorus is as critical as the lack of nitrogen restricting maize overall performance. It's miles a constituent of ADP and ATP which performs a key role in electricity transformation and additionally allows in assimilation of photosynthesis into other metabolites.

Zinc is one of the maximum important micronutrients. It's far required in a minute amount but positively have an effect on the yield, fruit set and fruit first-rate.

It is also involved in carbonic anhydrase activity, carbohydrate metabolism and preservation of membrane integrity, regulation of auxin and protein manufacturing and synthesis of pollen grains.

At present reputation of maize grain production Chhattisgarh is applicable, but maize has additionally the capacity to supply large portions of strength-wealthy forage for daily animal diets and its fodder can correctly be fed in any respect degrees of growth without any danger of oxalic acid and prussic acid. Accordingly, forage maize has end up an incredible constituent of ruminant rations in present day years, as its inclusion as dairy cow diets improves forage consumption, will increase animal overall performance and reduces manufacturing charges and superior relatively cheap repute of farmers.

Fabric and approach

The sphere test changed into achieved inside the route of Rabi season of 2021 and 2022 at Agricultural Farm, Krishi Vigyan Kendra, Pahanda (A), Durg (Chhattisgarh). Krishi Vigyan Kendra, Pahanda (A), Durg is located in critical a part of Chhattisgarh and lies at range, longitude of 21o20' N, 81o53' E, respectively and 291. Seventy nine meters above mean sea degree. In Chhattisgarh, this place falls below agroclimatic zone of C.G. Plains.

The general climatic situation of Durg is sub-humid to semi-arid. The average annual rainfall is 1144 mm, out of which eighty five % rainfall is received for the duration of rainy season (June to September) and the relaxation within the path of iciness and summer time (October to might also additionally). Might also is the most up to date and December is the coolest month of the year. The sample of rainfall particularly in the course of June to September months has exceptional variation from 12 months-to-year. The most temperature upward thrust as excessive as 40 four.8oC throughout summer season. The relative humidity is excessive from June to October and wind velocity is high from May additionally additionally to August with its top in June-July months. The test became laid out in cut up plot layout with 3 replications and 16 remedy combos. The primary plot constituted of four phosphorus stages (0, 30, 60 and ninety kg P2O5 ha⁻¹) and sub plot consisted four levels of ZnSO4 (zero, 10, 20 and 30 kg ZnSO4 ha⁻¹). The encouraged dose of Nitrogen changed into implemented form of urea @ 100 and twenty kg ha⁻¹ (forty six% N) in 3 identical splits (*viz.*, 1/3rd every at sowing, at 30 and 50 DAS). Encouraged dose of potassium @ 40 kg ha⁻¹ changed into performed via murate of potash (60% K2O) of the time of sowing. In treatment P0, P30, P60 and P90 phosphorus became implemented through SSP @ 0, 30, 60 and 90 kg P2O5 ha⁻¹, respectively at the time of sowing. In treatment Zn0, Zn30, Zn60 and Zn90 ZnSO4 ha⁻¹ Zinc changed into carried out via zinc sulphate @ 0, 10, 20, 30 kg ZnSO4 ha⁻¹, respectively, at the time of sowing.

Result and Discussion

The data pertaining to plant top at harvest diploma of crop boom as laid low with special remedies of P and Zn ranges are offered in desk 1. It is obvious from the statistics that outstanding phosphorus doses substantially affected the plant peak at harvest in the course of both the years and on propose foundation. As regards to software of zinc sulphate, top notch doses didn't provide vast effect on plant pinnacle of fodder maize throughout each the years and on suggest foundation.

A perusal of records indicated that 90 kg P2O5 ha⁻¹ suggests significantly taller plant at harvest in evaluation to 30 kg P2O5, however it have become statistically at par to 60 kg P2O5ha⁻¹ inside the direction of each the years and on imply basis. The tallest plant at harvest became 212, 213 and 213 cm with most dose (ninety kg P2O5 ha⁻¹) throughout 2020-21, 2021-22 and on advocate basis, respectively.

Growing degree of phosphorus as plenty as 90 kg P2O5 ha⁻¹ progressed the plant pinnacle at harvest of fodder maize. This is probably because of involvement of phosphorus in enhancing cellular department and cellular elongation which resulted and increase in stem elongation charge and in the long run plant pinnacle. Those consequences are settlement with the findings of Nimje and Seth (1988) ^[11], Casas *et al.* (1991) ^[2] and Patel *et al.* (2000) ^[13]. Phosphorus application at 30 percentage of recommended dose resulted growth in plant top as compared to plant top recorded in control plot (189, 177 and 183 cm) for the duration of each the years and on suggest foundation, respectively. With growth within the ranges of phosphorus morphological characters accelerated which is probably attributed to a stronger position of phosphorus in cell division, cell expansion, and expansion which in the long run added approximately the vegetative increase same end result turned into additionally stated by means of way of the Sabu *et al.* (2021) ^[16].

In any other have a take a look at it changed into referred to that the impact of increasing prices of software program of NPK kg ha⁻¹ on growth parameters of the crop became because of development in dietary surroundings of the plant life. The amazing enhancements in nutrient popularity of plant at harvest also advocate higher availability of vitamins for growth and development of plant. For that reason higher nutritional environment in plant underneath the impact of accelerated NPK appears to have promoted top of plant with the useful resource of manner of energetic cellular elongation. Those large upgrades in boom parameters of crop beneath the impact of NPK fertilizers are in near conformity with locating of Kumar and Bohra (2014) ^[7] and Kwadzo *et al.* (2016) ^[8], who had additionally located comparable results in maize with respect to plant height.

Facts referring to huge form of grains cob⁻¹ have been furnished in table 1. The findings indicated that the quantity of grains cob⁻¹ expanded notably with growth within the dose of phosphorus. Software of ninety kg P2O5 ha⁻¹ produced 352 grains cob⁻¹ which become determined significantly higher over 30 kg P2O5 ha⁻¹ (314) and control (272) grainscob⁻¹, however 60 kg P2O5ha⁻¹ was determined at par with 341 grains cob⁻¹ on recommend foundation. Those findings are in near conformity with the sooner findings of Thakur *et al.* (2020) ^[19].

The yield attributing person *viz.*, variety of grains cob⁻¹, multiplied considerably with the boom inside the dose of phosphorus as much as 90 kg P2O5 ha⁻¹ which became at par to 60 kg P2O5 ha⁻¹. This could be attributed to higher uptake of nutrients, increase and development of plant which in the long run caused better development of crop at better fertility degrees. The effects are in conformity with those of Negi *et al.* (1988) ^[10], Rammamurthy and Shivashankar (1996) ^[15], Patel *et al.* (2000) ^[13] and Sharar *et al.* (2003) ^[18].

The facts definitely indicates there has been a shocking reaction for implemented Zn when the Zn reputation end up beneath crucial restrict. Research have proven that software of 30 kg Zn through ZnSO4 to fodder maize (seed production)

recorded drastically higher (337, 340 and 338 grains cob^{-1}) in comparison to 10 kg $\text{ZnSO}_4 \text{ ha}^{-1}$ (317, 317 and 317 grains cob^{-1}) and manipulate (296, 290 and 293 number of grains cob^{-1}), however it became at par to 20 kg $\text{ZnSO}_4 \text{ ha}^{-1}$ with 329, 331 and 330 grains cob^{-1} during both the years and on mean basis, respectively. Balanced fertilization, wherein NPK fertilizer need to be completed alongside Zn in a Zn deficient soil, is essential for developing productiveness of maize and in turn to relieve Zn deficiency in soil, plant, animal and human continuum counseled via Panneerselvam and Palaniyandi (2017).

The exquisite reaction on yield additives of fodder maize seed production changed into because of the greater availability of zinc and metabolites for increase and improvement of reproductive shape which in the end delivered about recognition of better productiveness of individual plant. The accelerated availability of zinc and photosynthates may additionally have more amount of grain cob^{-1} . The findings of gift research are supported through Gupta *et al.* (2018) [5].

A perusal of facts provided in desk 2 found out that utility of phosphorus drastically affected grain yield of fodder maize for seed manufacturing. Considerably higher grain yield (24. Thirteen, 25.01 and 24. Fifty seven q ha^{-1}) have become obtained with software program of ninety kg $\text{P}_2\text{O}_5 \text{ ha}^{-1}$ in comparison to control and 30 kg $\text{P}_2\text{O}_5 \text{ ha}^{-1}$, but it changed into at par to 60 kg $\text{P}_2\text{O}_5 \text{ ha}^{-1}$ with seed yield of twenty-two. Eighty one, 23.96 and 23.68 q ha^{-1} throughout every the years and on imply basis, respectively. Software of zero kg $\text{P}_2\text{O}_5 \text{ ha}^{-1}$ (control) resulted lowest grain yield of eleven. Ninety nine, 12.15 and 12.07 q ha^{-1} in the course of 2020-21, 2021-2022 and on imply foundation, respectively.

In flora, P is essential for photosynthesis, respiration, mobile function, gene transfer and replica. As soon as aware about the essential hyperlink between P and life itself, it becomes obvious that “without P, there's no mobile, plant and grain and without ok P, there is a lot of starvation”. Lack of phosphorus is as essential as the dearth of nitrogen restricting maize normal overall performance (Gul *et al.*, 2015) [4].

The extensively maximum grain yield (21.69, 21.75 and 21.80 q ha^{-1}) become recorded with 30 kg $\text{ZnSO}_4 \text{ ha}^{-1}$ which registered 29.2 % higher seed yield over manipulate (15. Fifty two, 17.20 and 16.43 q ha^{-1}), however, 20 kg ha^{-1} ZnSO_4 recorded at par grain yield (21.23, 21. Forty one and 21.39 q ha^{-1}) at some point of 2020-21, 2021-22 and on imply basis, respectively. This growth in yields due to Zn application may be attributed to the truth that Zn is fundamental yield limiting plant nutrient in Zn poor soils. Implemented Zn is said to decorate the absorption of local in addition to delivered primary vitamins and there via improves common increase and development of plant and ultimately the yields.

The boom grain yield of maize is probably due to the improved availability of critical vitamins from the advanced degree of nutrients carried out to the crop. Those findings are in near conformity with the sooner findings of Ramachandrappa *et al.* (2007) [14].

Utility of P @ 30, 60 and 90 kg ha^{-1} led to extended grain yield of maize respectively over no want of phosphorus. This style suggests that balance use of N, P and okay encourages the premise formation, increase and improvement of maize plant. Mehta *et al.* (2005) [9] cautioned that 60 kg P ha^{-1} expanded substantially the grain yield of maize over 30 kg P ha^{-1} .

The grain yield relies upon on the synthesis and accumulation of photosynthates and their distribution among numerous plant additives. The synthesis, assembly, and translocation of photosynthates rely upon the efficient photosynthetic shape and the amount of translocation into the sink (grains) and plant increase and improvement at some degree in the early crop growth levels. The manufacturing and translocation of synthesized photosynthates rely on mineral nutrients via soil or foliar utility. Zn, among micronutrients, is fundamental for vegetation because it acts as a structural, catalytic and co-catalytic problem in many enzymes. It has thoughtfully been assumed that its rational use, mainly dose and time, can significantly make a contribution to boom and yield of vegetation (Saharan *et al.*, 2015) [17].

Software program of phosphorus to fodder maize significantly affected the Stover yield (desk 2). The extensively higher Stover yield (45. Forty, forty six. Ninety two and 46.16 q ha^{-1}) turned into recorded at 90 kg $\text{P}_2\text{O}_5 \text{ ha}^{-1}$ as in comparison to others, but at par with P level receiving 60 kg $\text{P}_2\text{O}_5 \text{ ha}^{-1}$ (41.88, forty five. 71, and forty three. Seventy nine q ha^{-1}) for the length of each the years and on suggest foundation, respectively. Software program of 30 kg $\text{P}_2\text{O}_5 \text{ ha}^{-1}$ recorded Stover yield of 31. Seventy seven, 34.05, and 32.91 q ha^{-1} , whereas, manage recorded Stover yield of 21. Fifty four, 21.38, and 21.46 q ha^{-1} during each the years and on mean basis, respectively).

As regards to Zn application, appreciably better Stover yield (39.90, forty one.17 and forty.54 q ha^{-1}) modified into recorded with 30 kg $\text{ZnSO}_4 \text{ ha}^{-1}$ as in comparison to govern and 10 kg $\text{ZnSO}_4 \text{ ha}^{-1}$, but it modified into at par to twenty kg $\text{ZnSO}_4 \text{ ha}^{-1}$ with Stover yield of 38. Sixty four, 39.18 and 38.91 q ha^{-1} during 2020-21, 2021-22 and on advocate foundation, respectively. The reaction of maize to extraordinary degrees of zinc software found that grain and Stover yield increased appreciably with developing degrees of zinc application as much as 30 kg $\text{ZnSO}_4 \text{ ha}^{-1}$ similar effects were additionally said by means of Arya and Singh (2000) [1].

The software program of phosphorus led to better grain and Stover yield of fodder maize. It might be due to the reality that local phosphorus in soil became low and the software of soluble phosphorus to the crop. The general development in crop increase and yield with P utility seems to be because of its pivotal feature in early root development. This might have progressed powerful usage of soil nutrient by way of the crop and extra nitrogen fixation through enhancement in nitrogenous interest. Phosphorus software extended nitrogen and phosphorus uptake through the device because of the fact applied phosphorus improved N and P content material in grain and straw by imparting a balanced nutritional environment within the plant and higher photosynthetic performance which preferred higher crop yield. The improved grain and Stover yields with better N and P content cloth together brought about extra uptake of vitamins. Those consequences are in specific settlement with the findings.

Software of phosphorus on the price of 90 kg ha^{-1} showed substantially most grain and Stover yields. Growth in grain yield of fodder maize might be because of the extended availability of important vitamins from the stepped forward level of vitamins carried out to the crop. The grain and Stover yields of fodder maize had been recorded significantly maximum under 30 kg $\text{ZnSO}_4 \text{ ha}^{-1}$ which become discovered at par with 20 kg $\text{ZnSO}_4 \text{ ha}^{-1}$.

Ghodpage *et al.* (2008) [3] assessed the response of maize to

distinct ranges of zinc (zero, 10 and 20 kg Zn ha⁻¹) and located that grain and fodder yield improved substantially with increasing levels of zinc software program up to twenty kg ha⁻¹.

End

Software of ninety kg P₂O₅ ha⁻¹ and 30 kg ZnSO₄ ha⁻¹ recorded substantially better grain yield (24.13, 25.01 and 24.57 q ha⁻¹) as compared to others, however it turned into at par to 60 kg P₂O₅ ha⁻¹ with seed yield of twenty-two. Eighty one, 23.96 and 23. Sixty eight q ha⁻¹ at some point of both the

years and on imply foundation, respectively. The substantially maximum grain yield (21.69, 21.75 and 21.80 q ha⁻¹) changed into recorded with 30 kg ZnSO₄ ha⁻¹, however, it was at par to twenty kg ha⁻¹ ZnSO₄ (21.23, 21.41 and 21.39q ha⁻¹) at some point of 2020-21, 2021-22 and on imply basis, respectively. The existing observer's findings shows that increasing tiers of phosphorus and zinc (desk 1 and a couple of) gave extensively increased plant increase, grain and Stover yield of fodder maize.

Table 1: Effect of phosphorus and zinc levels on plant height and number of grains cob⁻¹ of fodder maize for seed purpose

Treatment	Plant height at harvest (cm)			No. of grains cob ⁻¹		
	2020-21	2021-22	Mean	2020-21	2021-22	Mean
Level of phosphorus (kg ha⁻¹)						
P ₀ : Control	189	177	183	273	270	272
P ₃₀ : 30 kg P ₂ O ₅	194	195	195	319	310	314
P ₆₀ : 60 kg P ₂ O ₅	208	211	210	339	342	341
P ₉₀ : 90 kg P ₂ O ₅	212	213	213	349	356	352
SE m ±	2.9	4.7	3.19	5.03	6.71	5.77
CD (P=0.05)	10.10	16.30	11.06	17.43	23.24	19.98
Level of zinc sulphate (kg ha⁻¹)						
Zn ₀ : Control	197	195	196	296	290	293
Zn ₁₀ : 10 kg ZnSO ₄	201	199	200	317	317	317
Zn ₂₀ : 20 kg ZnSO ₄	202	201	201	329	331	330
Zn ₃₀ : 30 kg ZnSO ₄	203	202	202	337	340	338
SEm ±	2.98	3.07	2.5	5.77	4.91	5.0
CD (P=0.05)	NS	NS	NS	16.84	14.35	14.85
Interaction	NS	NS	NS	NS	NS	NS

Table 2: 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 ₂ O ₅	18.56	19.36	18.96	31.77	34.05	32.91
P ₆₀ : 60 kg P ₂ O ₅	22.81	23.96	23.68	41.88	45.71	43.79
P ₉₀ : 90 kg P ₂ O ₅	24.13	25.01	24.57	45.40	46.92	46.16
SE m ±	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 sulphate (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
SEm ±	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

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