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Performance of Phosphorus and Zinc to the Yield, Yield Attributes, and Economics of Maize *(Zia mays L)*

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Abstract

*At present diversification in agricultural activities, maximization in output, economic viability, social acceptability, and sustainability are important aspects. Maize can be grown over a range of agro-climatic zones and this quality makes it a versatile crop. Maize is suitable to be grown in diverse environmental conditions which is not possible for any other crop.It is well known that maize is a heavy feeder crop and it well responded to fertilization, especially where soils are generally low in native fertility.Phosphorus is present abundantly in the growing and storage organs such as fruits and seeds. It promotes healthy root growth and fruit ripening by helping translocation of carbohydrates. Zinc is the micronutrient that most commonly limits maize yield. Zinc is commonly applied to maize crops in physical blends with phosphorus (P) or potassium (K) fertilizers. A research experiment was conducted during the Kharif season of 20019 at the Research Farm, School of Agriculture, ITM University, Gwalior (M.P.). The VNR Hybrid Corn 4226variety of maize was sown in the 60x20 cm spacing @25 kg ha^{-1}in a randomized block design having a factorial concept with a total of twelve treatment combinations consisting of four levels of phosphorus (**P_0:** 0 kg P_2O_5/ ha,**P_1:** 20 kg P_2O_5/ ha,**P_2:** 40 kg P_2O_5/ ha and **P_3**: 60 kg P_2O_5/ha) and three levels of zinc (**Zn_0**: 0 kg Zn / ha, **Zn_1**: 5 kg Zn / ha and **Zn_2**: 10 kg Zn / ha) replicated thrice was employed in this study.The grain yield q / ha increased significantly from 33.05to 53.63 q/ha with increasing levels of phosphorus from 0 to 60 kg/ha. The high estgrain yield per hectare (53.63q/ha) was observed in the application of phosphorus @ 60 kg/ha which was found significantly superior to other treatments in this study and closely followed by 49.39q/ha with the application of phosphorus @ 40 kg/ha. The application of zinc also influenced the grain yield q/ha significantly. The maximum grain yield (48.21q/ha) was found under the application of zinc @ 10 kg/ha followed by the application of zinc @ 5 kg/ha (46.54q/ha).The treatment combination consisting of the application of phosphorus @ 60 kg/ha with a combined application of zinc @ 10 kg/ ha gave a significantly highest net monetary return (Rs. 75696.77 Rs/ha) followed by the application of phosphorus @ 60 kg/ha with without zinc application @ 0 kg/ ha (Rs.74003.40 Rs/ha) as compared to all the remaining treatment combinations.*

Keywords: Maize, Phosphorus, Zinc, Yield, economics.

Introduction

At present diversification in agricultural activities, maximization in output, economic viability, social acceptability, and sustainability are important aspects. Maize in this context seems a vital and alternative crop that bridges the noted productivity gap of the rice-wheat system. Maize (*Zea mays* L.) is the third most important cereal, next to wheat and rice in the world as well as in India[18]. Maize can be grown over a range of agro-climatic zones and this quality makes it a versatile crop. Maize is suitable to be grown in diverse environmental conditions which is not possible for any other crop. It is grown from 58°N to 40°S, from below sea level to altitudes higher than 3000 m, and in areas with 250 mm to more than 5000 mm of rainfall per year and with a growing cycle ranging from 3 to 13 months[14].

Globally maize is cultivated in an area of 170.39 Million ha with a production of 883.46 Million tones and 5.18 Million tones /ha productivity. Maize is the driver of US food safety with the highest productivity (>10 t/ha) which is double the global productivity (5.1 t/ha). Whereas, the productivity of India is just half of the world's productivity[4]. In India, important maize cultivating states are Gujarat, Rajasthan, Punjab, Haryana, Madhya Pradesh, Uttar Pradesh, Himachal Pradesh, and Bihar. Maize is grown in an area of 8.69 million hectares, with a production of 21.8 million tonnes and a productivity of 2509 kg /ha (Annual Progress Report Kharif Maize, IIMR, 2016). In Madhya Pradesh, it covers an area of 1098 thousand ha with a production of 2580.3 thousantonneses at average productivity of 2350 kg/ha. Area covered under maize crop in Gwalior district of 200 ha, production of 300 tones with the productivity of 1830 kg/ha[2].

Nowadays it is gaining immense importance on account of its potential uses in the manufacture of starch, plastic, rayon, dye, resins, boot polish, syrups ethanol, etc. Maize grain contains about 70% carbohydrate, 10% protein, 4% oil, 2.3% crude fibre, 10% aluminizes, 1.4% ash. The productivity of maize is very high because of its C_4 nature of plants and it is very efficient in converting solar energy into the production of dry matter. Maize is emerging as an important world cereal crop after wheat and rice, which is the

Materials and Methods

"Queen of Cereals", due to the high productiveness, ease to process, and low cost of other cereals[10], provides nutrients for humans and animals, serves as basic raw materials for production of starch, oil, protein, alcoholic beverages, food sweetness and more recently fuel[21].

It is well known that maize is a heavy feeder crop and it well responded to fertilization, especially where soils are generally low in native fertility. It is generally observed that maize fails to produce worthwhile grain yield in plots without fertilizer application[11]. In addition to the above constraints, in Madhya Pradesh, lower yields are recorded due to a lack of adoption of approved technology, particularly in optimal use of fertilizer at farmer levels and poor economic conditions of the farmers. Phosphorus is the second most essential nutrient required for high growth and yield of maize, next to nitrogen. Therefore, deficiency of phosphorus is as crucial as the deficiency of nitrogen restricting maize performance[6]. Phosphorus is present abundantly in the growing and storage organs such as fruits and seeds. It promotes healthy root growth and fruit ripening by helping translocation of carbohydrates. An increased concentration of carbohydrates is also reported.

Zinc is the micronutrient that most commonly limits maize yield. Zinc is commonly applied to maize crops in physical blends with phosphorus (P) or potassium (K) fertilizers. Zinc sulphate is the most commonly used zinc source[1]. Zinc plays an important role in the correct functioning of many enzymatic activities, the synthesis of nucleic acids and auxins (plant hormones), protein metabolism, and normal crop development and growth.

A research experiment was conducted during the Kharif season of 20019 at the Research Farm, School of Agriculture, ITM University, Gwalior (M.P.). The VNR Hybrid Corn 4226variety of maize was sown in the 60x20 cm spacing@25 kg ha^{-1}in a randomized block design having a factorial concept with a total of twelve treatment combinations consisting of four levels of phosphorus (**P_0:** 0 kg P_2O_5/ ha,**P_1:** 20 kg P_2O_5/ ha,**P_2:** 40 kg P_2O_5/ ha and **P_3**: 60 kg P_2O_5/ha) and three levels of zinc (**Zn_0**: 0 kg Zn / ha, **Zn_1**: 5 kg Zn / haand **Zn_2**: 10 kg Zn / ha) replicated thrice was employed in this study.

After field preparation, the seedbeds of 6.0 m x 5.0 m size were prepared as per the plan of the layout. Seeds were sown on the furrow onAugust, 5^{th} 2019 after being treated with Bavistin to control the seed-borne disease.

The experimental plots were fertilizers as per treatments. Urea, Single Super Phosphate (SSP), and muriate (MOP) were used as a source of nitrogen, phosphorous, and potassium, respectively. One-third amount of the nitrogen at the rate of 120 kg/ha was applied as basal during land preparation and the remaining amount of nitrogen was top dressed in two equal splits viz., 1/3 at knee high stage (30 DAS) and the remaining 1/3 at the tasseling stage for growing maize crop.

In addition to rainfall received during the crop season, one irrigation was given through a sprinkler system during dry spells to ensure optimum growth, development, and yield of the crop.

Nutrients, phosphorus, and zinc were applied, as basal dressing during land preparation in the experimental plot as per the treatments. Zinc was applied as per treatment through zinc sulphate ($ZnSO_4.7H_2O$) containing 21% zinc and 10% S at the time of sowing as basal dose.MOP was applied during the final land preparation, @ 40 kg K_2O/ ha. Fertilizers were applied by placement i.e., 5 cm away from the seed row and 5 cm below the seed zone.

In order to minimize weed competition, weed control practices were applied. In order to minimize weed competition, pre-emergence application of atrazine @ 0.5 kg/ha followed by one hoeing and earthing up at the knee height stage was carried out. Herbicides were applied with the help of battery- operated knapsack sprayer with a single flat fan nozzle using 400 liters of water per hectare.In order to prevent the attack of white grubs and termites, phorate 10 G at 10 kg/ha was drilled at the time of sowing. Further Imidacloprid 17.8 SL (0.03%) was sprayed to prevent the attack of crop pests.

The crop was harvested at the physiological maturity stage which was determined by the formation of the black layer in the placental region of maize grain. After the maturity of the crop, harvesting was followed by removing the cobs from the plant subsequently the plant was harvested by sickle from each plot. Randomly selected five plants from each net plot were harvested first for recording biometric observation and the produce of these plants was added to the product of the respective net plot. Maize was harvested at aproximate120 DAS on 5^{th} November 2019. The observations were recorded for each parameter as per methodology.

Results and Discussion

Number of cobs plant^{-1}

The result (Table 1) shows that the number of cobs per plant was influenced significantly due to different levels of phosphorus. The average number of cobs per plant significantly increased from 1.27to 1.91withan increasing dose of phosphorus from 0 to 60 kg/ha. The application of zinc also significantly influenced to the number of cobs per plant.

Number of grains cob^{-1}

The average number of grains per cob significantly increased from 201.78to 308.27withincreasing the phosphorus level from 0 to 60 kg/ha. The maximum number of grains per cob (308.27) was observed in the application of phosphorus @ 60 kg/ha and found significantly superior over other treatments and closely followed by 252.69with the application of phosphorus @ 40 kg/ha). Whereas the minimum number of grains per cob (201.78) was noted without application of phosphorus @ 0 kg/ha. The zinc also significantly influenced the number of grains per cob. The maximum number of grains per cob (262.63) was found under the application of zinc @ 10 kg/ha followed by the application of zinc @ 5 kg/ha (258.25), while, the minimum number of grains per cob (229.37) was recorded in the crop without zinc application.

Table 1 Yield Attributing Characters of Maize as Influenced by the Application of Phosphorus and Zinc

Treatment combination	Number of cobs plant^{-1}	Number of grains cob^{-1}	Length of cob (cm)	Girth of cob (cm)	Weight of cob (g)
P@ 0 kg/ha + Zn@ 0 kg/ha	1.13	192.80	11.13	5.88	94.02
P@ 0 kg/ha + Zn@ 5 kg/ha	1.40	223.80	17.11	8.30	100.96
P@ 0 kg/ha + Zn@ 10 kg/ha	1.53	249.20	17.81	8.65	113.73
P@ 20 kg/ha + Zn@ 0 kg/ha	1.73	279.00	18.06	9.27	118.46
P@ 20 kg/ha + Zn@ 5 kg/ha	1.33	219.07	12.13	8.27	99.81
P@ 20 kg/ha + Zn@ 10 kg/ha	1.47	241.93	17.49	8.45	111.46
P@ 40 kg/ha + Zn@ 0 kg/ha	1.60	251.93	17.89	8.75	115.49
P@ 40 kg/ha + Zn@ 5 kg/ha	1.87	320.87	18.48	9.34	118.48
P@ 40 kg/ha + Zn@ 10 kg/ha	1.40	226.80	17.16	8.37	111.43
P@ 60 kg/ha + Zn@ 0 kg/ha	1.53	244.07	17.57	8.57	112.38
P@ 60 kg/ha + Zn@ 5 kg/ha	1.73	257.73	18.01	9.13	117.13
P@ 60 kg/ha + Zn@ 10 kg/ha	2.13	324.93	19.38	10.46	123.68
SE(m)±	0.10	10.52	0.89	0.39	2.03
C.D.	0.31	30.85	2.62	1.14	5.96

Length of cob (cm)

The result shows that the length of cob was influenced significantly due to different levels of phosphorus. The average length of cob was significantly increased from 13.46 to 18.64 cm with increasing the phosphorus level from 0 to 60 kg/ha. The data presented in Table 1 revealed that the highest length of cob (18.64 cm) was observed with the application of phosphorus @ 60 kg/ha found significantly superior over other treatments and closely followed by 17.90 cm with the application of phosphorus @ 40 kg/ha (P_2). Whereas the lowest length of cob (13.46 cm) was noted under without the application of phosphorus @ 0 kg/ha. The application of zinc also influenced the length of cob significantly. The highest length of cob (18.02 cm) was found under the application of zinc @ 10 kg/ha, while, the lowest length of cob (16.04 cm) was recorded in crop fertilized without zinc application @ 0 kg/ha.

Girth of cob (cm)

The average girth of cob was significantly increased from 7.48to 9.69 cm with increasing levels of phosphorus from 0 to 60 kg/ha. The maximum girth of cob (9.69 cm) was observed with the application of phosphorus @ 60 kg/ha and found significantly superior over other treatments and closely followed by 8.84 cm with the application of phosphorus @ 40 kg/ha. The application of zinc also significantly influenced the girth of cob (cm). The highest girth of cob (9.12 cm) was found under the application of zinc @ 10 kg/ha followed by the application of zinc @ 5 kg/ha (8.70 cm).

Weight of cob (g)

The weight of the cob was influenced significantly due to the application of different doses of phosphorus. The average weight of cob was significantly increased from 94.93to 120.21 g with the increasing level of phosphorus from 0 to 60 kg/ha. The heaviestcob (120.21 g) was recorded with the application of phosphorus @ 60 kg/ha and was found significantly superior to other treatments in the experiment and closely followed by 115.45 g with the application of phosphorus @ 40 kg/ha.The application of zinc significantly influenced the weight of cob (g). the heaviest cob (113.54 g) was found under the application of zinc @ 10 kg/ha followed by the application of zinc @ 5 kg/ha (111.31 g).

The greater availability of photosynthates, metabolites, and nutrients to develop reproductive structures seems to have resulted in increased productive plants, number of grains per cob, number of rows per cob, number of cobs per plant, cob length, and cob girth with the phosphorus levels[2,5,10].

An increase in the number of grains per cob, cob girth, cob weight, and test weight in maize might be due to the utilization of rhizobacteria which promoted plant growth through the production of phytohormone (Yazdani et al., 2009) and balanced supply of nutrients, throughout the growing period and readily available P through chemical fertilizers. Furthermore, the positive increase associated with phosphorus management on the yield components and improved availability of residual soil phosphorus. The enhanced grain and stover yield due to phosphorus application may be attributed to the activation of metabolic processes, where its role in building phospholipids and nucleic acid is known. The stimulation effects of P on growth and yield attributes and enhanced nitrogen activity in plants which in turn reflected positively on the economic yield of the crop. The improved fertility status of the plots, which received a higher amount of phosphorus in maize, might have improved the plant growth and yield attributes.

The increase in yield parameters may beattributed to better uptake of nutrients, growth, and development of source i.e. increase in leaf area index which ultimately resulted in better development of sink i.e. yield attributing characters at higher fertility levels. Phosphorus application increased the shelling percentage significantly upto the highest level of phosphorus. This may be attributed toproportionally better development of grains i.e. test weight with an increase in the dose of phosphorus in comparison to total cob development. It was also reported an increase in shelling percentage with an increase in the dose of phosphorus application. The heaviest grain weight with a higher P level probably may be due to the higher P translocation into the fruiting areas which resulted in highest grain weight.

Stover yield (q/ha)

The average Stover yield per hectare was significantly increased from 42.26to 58.89 q/ha with increasing the phosphorus level from 0 to 60 kg/ha (table 2). The highest Stover yield (58.89q/ha) was observed in the application of phosphorus @ 60 kg/ha and was found significantly superior over other treatments and closely followed by 54.92q/hawith the application of phosphorus @ 40 kg/ha. There was a significant increase in Stover yield per hectare, recorded with the higher dose of zinc. The highest Stover yield (53.83q/ha) was recorded under the application of zinc @ 10 kg/ha followed by the application of zinc @ 5 kg/ha (52.46q/ha).

Table-2: Yield and economics of maize as influenced by the application of phosphorus and zinc

Treatments combination	Stover yield (q\ha)	Grain yield (q/ha)	Biological yield (q/ha)	Harvest Index (%)
P@ 0 kg/ha + Zn@ 0 kg/ha	33.72	20.01	53.73	37.13
P@ 0 kg/ha + Zn@ 5 kg/ha	47.80	42.34	90.14	46.97
P@ 0 kg/ha + Zn@ 10 kg/ha	52.01	46.49	98.50	47.20
P@ 20 kg/ha + Zn@ 0 kg/ha	58.05	52.49	110.54	47.48
P@ 20 kg/ha + Zn@ 5 kg/ha	42.25	39.82	85.07	46.81
P@ 20 kg/ha + Zn@ 10 kg/ha	49.89	44.42	94.31	47.07
P@ 40 kg/ha + Zn@ 0 kg/ha	56.10	50.57	106.67	47.41
P@ 40 kg/ha + Zn@ 5 kg/ha	58.60	53.02	111.61	47.49
P@ 40 kg/ha + Zn@ 10 kg/ha	49.83	44.36	94.19	47.09
P@ 60 kg/ha + Zn@ 0 kg/ha	50.83	45.34	96.17	47.13
P@ 60 kg/ha + Zn@ 5 kg/ha	56.66	51.12	107.78	47.43
P@ 60 kg/ha + Zn@ 10 kg/ha	60.01	54.37	114.38	47.51
SE(m)±	1.79	1.81	3.58	0.39
CD at 5%	5.24	5.30	10.51	1.15

Grain yield (q/ha)

The grain yield q / ha increased significantly from 33.05to 53.63 q/ha with increasing levels of phosphorus from 0 to 60 kg/ha. The highest grain yield per hectare (53.63q/ha) was observed in the application of phosphorus @ 60 kg/ha which was found significantly superior to other treatments in this study and closely followed by 49.39q/hawith the application of phosphorus @ 40 kg/ha. The application of zinc also influenced the grain yield q/ha significantly. The maximum grain yield (48.21q/ha) was found under the application of zinc @ 10 kg/ha followed by the application of zinc @ 5 kg/ha (46.54q/ha).

Biological yield (q/ha)

The biological yield is the sum of grain yield and stover yield. The data presented in table 2 clearly shows that the biological yield was significantly influenced by the application of phosphorus and zinc. The application of phosphorus increased the biological yield significantly from 80.79 q/ha to 106.11 q/ha. The higher biological yield (106.11 q/ha) was obtained with the application of phosphorus @60 kg/ha closely followed by 104.16 q/ha with the application of phosphorus @40 kg/ha. The application of zinc also enhanced the biological yield of maize significantly. The maximum biological yield (103.13 q/ha) was obtained with the application of zinc @10 kg /ha.

Harvest index (%)

The result shows that the harvest index was influenced significantly due to different levels of phosphorus. The average harvest index was significantly increased from 42.99to 47.64 % with the increasing phosphorus level from 0 to 60 kg/ha. The data presented in Table 2 revealed that the highest harvest index (47.64 %) was observed in the application of phosphorus @ 60 kg/ha which was found significantly superior to other treatments and closely followed by 47.35 % with the application of phosphorus @ 40 kg/ha. The zinc also significantly influenced the harvest index. The highest harvest index (47.16 %) was found under the application of zinc @ 10 kg/ha followed by the application of zinc @ 5 kg/ha (46.92 %). There was a significant increase in harvest index, recorded with the higher dose of zinc in this study.

Since, the yield of the crop is a function of several yield components which are dependent on complementary interaction between vegetative and reproductive growth of the crop. As the growth and yield attribute improved evidently if resulted in higher yields under higher phosphorus levels. A significant increase in grain yield, straw yield, and biological yield under phosphorus levels appear to be on account of their influence on dry matter production and indirectly via an increase in plant height, number of leaves, leaf area index, stem thickness and possibly a result of higher uptake of nutrients[8, 17]. The increase in maize yield at higher phosphorus levels probably may be ascribed to the increase in cob number, the number of grains row, and the number of grains/cob as well as the heaviest grain weight. A good and optimum supply of phosphorus is associated with increased root growth due to which the plants explore more soil nutrients and water. Increasing phosphorus level enhance maize yield[3, 15, 16]. The beneficial effect of zinc fertilizer could be attributed to its vital role in the activity and function of enzymes for the biological processes in plants which leads to an increase in yield components. In the present study, soil application of 10 kg Zn/ha (Zn_3) recorded significantly higher yield and yield attributes. The increase in yield attributes might be dueto the involvement of zinc in various enzymatic processes which helps in catalyzing reactions for growth finally leading to the development of superior yield attributing characters[9]. The increase in yield could be attributed to the proper supply of Zn up to harvesting stages in plots, which might have led to increased photosynthetic activity for a longer duration and its beneficial effect on the metabolism of plants thereby finally increasing dry matter accumulation[7].

Economics

It is necessary to work out the economics of the treatments for the sound recommendation. Sometimes, the most effective treatment may become uneconomical due to high production and input costs. The average economics of maize as influenced by different phosphorus and zinc levels treatments are furnished in table 3. The result shows that cost of cultivation was influenced significantly due to different levels of phosphorus and zinc. The treatment combination consisting of the application of phosphorus @ 60 kg/ha with a combined application of zinc @ 10 kg/ ha charged the significantly highest cost of cultivation (Rs.27755.43 Rs/ha) followed by the application of phosphorus @ 40 kg/ha with combined application of zinc @ 10 kg/ ha (Rs. 26849.43 Rs/ha) as compared to all the remaining treatment combinations. The lowest cost of cultivation (Rs. 21465.00 Rs/ha) was noticed in crop fertilized without application of phosphorus and zinc i.e. @ 0 kg/ha with zinc @ 0 kg/ ha. The treatment combination consisting of the application of phosphorus @ 60 kg/ha with a combined application of zinc @ 10 kg/ ha produced significantly highest gross monetary return (Rs.103452.20 Rs./ha) followed by the application of phosphorus @ 60 kg/ha with combined application of zinc @ 5 kg/ ha (Rs.99175.20 Rs/ha) as compared to all the remaining treatment combinations. The lowest gross monetary return (Rs. 38589.60 Rs/ha) was noticed in crop from controlled plots i.e. phosphorus @ 0 kg/ha with zinc @ 0 kg/ ha. The net returns are the difference between gross returns and the cost of cultivation. The treatment combination consisting of the application of phosphorus @ 60 kg/ha with a combined application of zinc @ 10 kg/ ha gave a significantly highest net monetary return (Rs.75696.77 Rs/ha) followed by the application of phosphorus @ 60 kg/ha with without zinc application @ 0 kg/ ha (Rs.74003.40Rs/ha) as compared to all the remaining treatment combinations. The lowest net monetary return (Rs.17124.60 Rs/ha) was noticed in crop control plots i.e. phosphorus @ 0 kg/ha with zinc @ 0 kg/ ha.

Table 3 Economics of various treatments

Treatments combination	Cost of cultivation (Rs\ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B: C ratio
P@ 0 kg/ha + Zn@ 0 kg/ha	21465.00	38589.60	17124.60	0.80
P@ 0 kg/ha + Zn@ 5 kg/ha	23250.70	71669.00	48418.30	2.08
P@ 0 kg/ha + Zn@ 10 kg/ha	25036.40	76940.00	51903.60	2.07
P@ 20 kg/ha + Zn@ 0 kg/ha	22371.00	83056.60	60685.60	2.71
P@ 20 kg/ha + Zn@ 5 kg/ha	24156.70	83168.20	59011.50	2.44
P@ 20 kg/ha + Zn@ 10 kg/ha	25942.00	84881.40	58939.00	2.27
P@ 40 kg/ha + Zn@ 0 kg/ha	23278.00	87023.40	63745.40	2.74
P@ 40 kg/ha + Zn@ 5 kg/ha	25063.70	94613.20	69549.50	2.77
P@ 40 kg/ha + Zn@ 10 kg/ha	26849.40	95637.20	68787.80	2.56
P@ 60 kg/ha + Zn@ 0 kg/ha	24184.00	98187.40	74003.40	3.06
P@ 60 kg/ha + Zn@ 5 kg/ha	25969.70	99175.20	73205.50	2.82
P@ 60 kg/ha + Zn@ 10 kg/ha	27755.40	103452.00	75696.80	2.73

Phosphorus levels significantly influenced economics *viz.*, cost of cultivation, gross monetary return (GMR),net monetary return (NMR), and benefit-cost ratio (B:C ratio). The data on economics clearly indicated that the highest net realization of Rs.74301.89/ha was accrued with the application of 60 kg phosphorus per ha. The results of the present investigation are in accordance with the findings of Meena *et al*., (2011) and Tetarawal *et al*., (2011) in maize. The effect of Phosphorus on GMR and NMR in maize was significant with all P rates. It might be due to the beneficial effect of P on improving growth characters, yield attributes, grain yield, and Stover yield of maize[12, 13, 22].

Conclusion

Based on the results of this experiment, it can be concluded that the application of 60 kg/ha P_2O_5 /ha with a combined application of zinc @ 10 kg/ha can be used as a remunerative strategy for the maximum and significantly higher grain yield 55.37 q/ha and net returns (Rs.75696.77/ha).

References

1. Alloway, B.J. (2009). Soil factors associated with zinc deficiency in crops and humans. *Environmental Geochemistry and Health*, 31: 538-548.
2. Anonymous, (2015-16). Commissioner land records, M.P. Gwalior.
3. Choudhary, M., Verma, A. and Singh, H. (2012). Productivity and economics of maize as influenced by phosphorus management in south Rajasthan. *Annals of Agricultural Research*. 33 (1 &2): 88-90.
4. DMR. (2012). “Maize Biology: An Introduction”. Directorate of Maize Research, ICAR, New Delhi.
5. Dibaba, D. H., Hunshal, C. S., Hiremath, S. M., Awaknavar, J. S., Wali, M. C., Nadagouda, B. T. and Chandrashekar, C. P. (2013). Performance of maize (Zea mays L.) hybrids as influenced by different levels of nitrogen, phosphorus, potassium and sulphur application. *Karnataka Journal Agricultural Sciences*. 26 (2): 194-199
6. Gul, S., Khan, M. H., Khanday, B. A and Nabi, S. (2015). Effect of sowing methods and NPK levels on growth and yield of rainfed maize (*Zea mays* L.). *Hindawi Publishing Corporation, Scientific*, 1-6.
7. Hussain, F. and Yasin, M. (2004). Soil Fertility Monitoring and Management in Rice- Wheat System, Annual Report: 1–33. LRRP, NARC.
8. Jena, N., Vani, K.P., Rao, P., Srinivas, A. and Sankar, S. (2013). Performance of quality protein maize (QPM) on quality, yield and yield components as influenced by nutrient management. *Journal of Progressive Agriculture*, 4(2): 72-74.
9. Jakhar, S. R., Singh, M. and Balap, C.M. (2006). Effect of farmyard manure, phosphorus zinc levels on growth, yield, quality and economics of pearl millet. (*Pennisetum glaucum*). *Indian Journal Agricultural Sciences*, 76 (1): 58-61.
10. Jaliya, M.M., Falaki, A.M., Mahmud, M., Abubakar, I.U and Sani, Y.A. (2008). Response of Quality Protein Maize (QPM) (Zea Mays L.) to sowing date and NPK fertilizer rate on yield & yield components of Quality Protein Maize. Savannah Journal of Agriculture. 3: 24-35.
11. Kumar, V. (1993). Crop production in the West Africa dry land. In: Dry land farming in Africa, J. R J. Rowland (ed.) Mac Millan Press Ltd., London, Pp. 109-141.
12. Manimaran, M. and Poonkodi, P. (2009). Yield and yield attributes of maize as influenced by graded levels of phosphorus fertilization in salt affected soils. *Ann. Agri. Res. New Series.* 30 (1&2): 26-28.
13. Meena, K. N., Kumar, A., Rana, D. S. and Meena, M. C. (2011). Productivity and nutrient uptake of maize (*Zea mays* L.) - Wheat (*Triticum aestivum*) cropping system under different bio-sources and nitrogen levels. *Indian Journal of Agronomy*. 56(3): 182-188.
14. Murdia L. K., Wadhwani R., Wadhawan N., Bajpai P., Shekhawat S. (2016) Maize Utilization in India: An Overview,

American Journal of Food and NutritionVol. 4, (6): 169-176.

15. Nath, K., Nepalia, V. and Singh, D. (2009). Effect of integrated nutrient management on growth and yield of sweet com (*Zea mays* L. SSP. SACCHARATA). *Ann. Agri. Res*. New Series. 30 (1&2): 73-76.
16. Nsanzabaganwa, E., Das, T.K., Rana, D.S and Kumar, S.N. (2014). Nitrogen and phosphorous effects on winter maize in an irrigated agro eco system in western Indo Gangetic plains of India. Maydica- Electronic Publication.
17. Om, H., Singh, S. P., Singh, J. K., Singh, R. N., Ansari, M. A., Meena, R.L. and Yadav, B. (2014). Productivity, nitrogen balance and economics of winter maize (*Zea mays* L.) as influenced by QPM cultivars and nitrogen levels. *Indian Journal of Agricultural Sciences*. 84 (2): 306–8.
18. Paramasivam, M., Kumaresan, K.R., Malarvizhi, P., Mahimairaja, S. and Velayudham, K. (2010). Effect of different levels of NPK and Zn on yield and nutrient uptake of hybrid maize (COHM 5) (*Zea mays* L.) in Madhukkur (Mdk) series of soils of Tamil Nadu. *Asian Journal of Soil Science*, 5: 236- 240.
19. Singh, G., Sharma, G. L. and Golada, S. L. (2011). Integrated nutrient management in quality protein maize (*Zea mays* L.). *Journal of Progressive Agriculture*, 2 (3): 65- 67.
20. Singh, S., Sati, A. and Mishra, P. (2010). Soil test based integrated N, P and K prescriptions for yield targets of maize in Mollisols of Uttarakhand. *Panthngar Journal of Research*, 2: 248- 250.
21. Singh, S., Singh, V. and Mishra, P. (2017). Effect of NPK, boron, and Zinc on productivity and profitability of late sown kharif maize (*Zea mays* L.) in western Uttar Pradesh, India. *Annals of Agricultural New Series*, 38 (3): 310-313.
22. Tetarwal, J. P., Ram, B. and Meena, D. S. (2011). Effect of integrated nutrient management on productivity, profitability, nutrient uptake and soil fertility in rain fed maize. *Indian Journal of Agronomy*. 56 (4): 373-376.