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Effect of Phosphorus and Zinc Fertilization on Production Potential and Physico-chemical Properties of Soil under Pearlmillet in Semi-arid Eastern Plain Zone of India

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Abstract

A field experiment was carried out at the Agricultural Farm of Rajiv Gandhi South Campus, Banaras Hindu University, Barkachha, Mirzapur to study the effect of phosphorus and zinc fertilization on production potential and physico-chemical properties of soil under pearlmillet in semi-arid eastern plain zone of India. On experimental data basis significant improvements were recorded in physic-chemical properties of and production potential of pearl millet. The pH and EC of the post harvest soil varied from 4.94 to 5.36 and 0.03 to 0.06. The highest soil pH and EC were observed in treatment $P_{20}Z_{10}$. The lowest pH and EC value was recorded in treatment $P_{10}Z_{30}$. The available nitrogen, phosphorus and potassium content in the post harvest soil of pearl millet ranged between 160.93 to 220.7, 8.14 to 25 and 169.0 to 197.3 kg ha^{-1}, respectively. The highest N and K content in post harvest soil were recorded in the treatment $P_{10}Z_{10}$. The maximum P content in soil (25 kg ha^{-1}) was recorded in the treatment where a combination of 30 kg ha-1 P and Zn was applied ($P_{30}Z_{30}$). The DTPA extractable Zn content in soil increased significantly from 1.22 to 4.51 mg kg^{-1}, maximum DTPA extractable Zn content (4.51 mg kg^{-1}) was recorded in the treatment $P_{30}Z_{30}$, however, minimum (1.22 mg kg^{-1}) was recorded in control.

Keywords: Physico-chemical soil properties, Pearl millet, Production potential, Phosphorus and Zinc.

Introduction

Pearl millet (*Pennisetum glaucum* L.) is one of the most important among the millets or nutritious coarse grain cereals crops. Pearl millet is the most drought and heat tolerant among cereals or millets and it has the highest water use efficiency under drought stress. It is the only major crop that has high levels of tolerance to both acid and saline soils. It can be cultivated even in the most sandy infertile soils and droughty environments where no other cereal crop can survive. Among all rainfed, high temperature and drought tolerant crops, pearl millet has gained highest productivity growth. Among coarse cereals it occupies maximum area with highest production. India is the largest producer of pearl millet in the world occupying an area of 9.07 million ha, production of 10.05 MT per year and average productivity of 1.1 ton/ha. Several varieties/hybrids of pearl millet have been evolved which are tolerant to drought, high temperature and low fertility due to natural and induced adaptations. It is a well known safety factor against droughts and high temperature related vulnerabilities. There are hybrids of pearl millet which mature in relatively short duration of 80-85 days and have given very high productivity of 4-5 ton per ha under irrigated conditions in parts of Rajasthan, Gujarat and Uttar Pradesh.

Adequate phosphorus nutrition enhances many aspects of plant development including flowering, fruiting and root growth. P uptake in plants is often constrained by the very low solubility of P in the soil. In agricultural systems, phosphorus in the harvested crops is removed from the system, resulting in P deprived soils if no P is supplemented as fertilizer (Raghothama, 1999) [25]. The main functions of zinc is tendency to make up tetragonal complexes with nitrogen, oxygen and sulphur, thus zinc have a catalytic, building and activating role in the enzymes (Alloway, 2008) [2]. Zinc is essential element for crop production and optimal size of fruit, also it required in the carbonic enzyme which present in all photosynthetic tissues, and required for chlorophyll biosynthesis (Ali *et al*., 2008; Graham *et al*., 2000) [1, 10].

Phosphorus and zinc interaction affects the availability and utilization of both the nutrients and imbalance of any in soil matrix affects the dynamics (Nayak and Gupta, 1995) [19].

Material and methods

The present investigation entitled "effect of phosphorus and zinc fertilization on production potential and physico-chemical properties of soil under pearlmillet in semi-arid eastern plain zone of India" was carried out during *kharif* season, 2012 at the Agronomy farm of Rajiv Gandhi South Campus, Banaras Hindu University, Barkachha, Mirzapur, which is situated in *Vindhyan* region of district Mirzapur (25º 10' latitude, 82º 37' longitude and altitude of 427 meters above mean sea level). The soil was sandy loam, acidic (pH 5.6), low in initial organic carbon (0.29%), available N (188.2 kg/ha) and P_2O_5 (9.66 kg/ha) and medium in available K_2O (186.4 kg/ha), with EC 0.44 dS/m (table-1). The experiment comprising 10 treatment with different combinations of phosphorus levels (10, 20 and 30 kg P_2O_5/ha) and zinc levels (10, 20 and 30 kg Zn/ha) and control as without application of phosphorus and zinc was laid out in randomized block design with thrice replications. Pearlmillet *cultivar* Kaveri Super Boss – A recommended variety for cultivation in *Kharif* season matures in 80-85 days. The fertilizer N and K was uniformly applied @ 80 and 30 kg ha^{-1} respectively. Half of the recommended dose of nitrogen and full of potassium were applied at the time of sowing. Remaining half dose of N was applied one month after sowing. The phosphorus and zinc was applied as per treatments at the time of sowing. The source of phosphorus and zinc was single super phosphate (SSP) and Zink Sulphate. All the agronomic practices except those under study were kept normal and uniform for all the treatments. Initial soil samples were collected from surface soil (0-15 cm depth) and analyzed for physicochemical properties (Table 1). Random soil samples were collected plot wise after harvesting of crop and brought to laboratory. Air dried soil samples were ground to pass through 2 mm mesh sieve. The data gathered in each observation were statistically analyzed using analysis of variance technique and significant differences among treatments mean were tested using least significant difference (LSD) test at 5% probability (Panse and Sukhatme 1985) [21].

3. Result and Discussion

Production potential (kg ha^{-1})

Fertilization of P and Zn in Pearlmillet crop, when the grain, straw and biological yield significantly increased and varied from 1599 to 2066, 3256 to 4443 and 4856 to 6510 kg ha^{-1}, Respectively (table 2). The maximum grain yield (2066, 4443 and 6510 kg ha^{-1}, respectively) was recorded with the application of 30 kg P ha^{-1} + 20 kg Zn ha^{-1} followed by 30 kg P ha^{-1} + 10 kg Zn ha$^{-1,}$ which were statistically at par. However, minimum (1599, 3256 and 4856 kg ha^{-1}, respectively) was recorded in control. Treatment 30 kg P ha^{-1} + 20 kg Zn ha^{-1} have shown 15, 6 and 23 % increase over $P_{10}Z_{20,}$ $P_{20}Z_{20}$ and control, respectively. The treatments $P_{10}Z_{30}$ and $P_{20}Z_{10}$, were found statistically at par, also treatments $P_{20}Z_{30}$ and $P_{30}Z_{30}$ had similar relation. The increase in the yield components might be connected with the release of essential nutrient elements. The increase in the yield attributes might also be due to role of zinc in biosynthesis of indole acetic acid (IAA) and especially due to its role in initiation of primordia for reproductive parts and partitioning of photosynthates towards them (Wear and Hagler, 1968) [32], which might have been resulted in better flowering and fruiting. A positive correlation between grain yield and available soil Zn and P was also observed by Keram *et al*., (2012) [15] and Habib (2012) [11].

Physico-chemical properties of soil

Soil pH and EC

pH significantly varied with the application of phosphorus and zinc. The pH of the post harvest soil varied from 4.94 to 5.36.The highest soil pH was observed with application of 20 kg P ha^{-1} + 10 kg Zn ha^{-1}. The lowest pH value was recorded in treatment 10 kg P ha^{-1} + 30 kg Zn ha^{-1} (Table 2). The soil pH is mainly determined by the minerals present in soil or type of soil but it is also affected by nature of added fertilizer and amendments. Most of the early studies have shown that the soil reaction (pH) is normally unaffected by application of organic, inorganic and biological amendments. But integrated application of bio-organics and fertilizers in long-term experiments (6-18 years) a decrease in the pH by 1.0-2.0 pH-units in the topsoil (0-5 cm) (Ekeberg and Riley, 1997) [7]. Overall effect of treatments was statistically non-significant at harvest. Therefore, the possible reason for lowering soil pH might be the excretion of organic acids by the plant roots and increased activity of microbes in the decomposition of sloughed off roots and thus producing different organic acids in the root zone (Subba rao, 1997) [29]. Decrease in soil pH due to bio-organics application has been reported by Ramanathan *et al.* (1977) [26] and Frequez *et al.* (1990) [8]. The data showed that there was less variation in EC of samples. The EC of the post harvest soil varied from 0.03 to 0.06 the highest EC was observed in control treatment. The lowest EC value was recorded with application of 30 kg P ha^{-1} + 10 kg Zn ha^{-1}. Mineralization of nutrients results in the formation of ionic compounds which in the fixation process replaces other soil cations such as Ca^{++}, Mg^{++}, Na^{+} and H^{+} in the expanded lattice of clay minerals (Subba Rao, 1977) [28]. Thus, an increment in total soluble salts in the solution is expected. Similar result was have been by Campitelli *et al*. (2008) [5].

Organic carbon

The organic carbon content in the post harvest soil of pearl millet ranged between 2.91 to 3.94 g kg^{-1}. The highest organic carbon content (3.94 g kg^{-1}) in soil was recorded in the treatment 30 kg P ha^{-1} + 30 kg Zn ha^{-1} followed by $P_{10}Z_{30,}$ $P_{20}Z_{10}$, $P_{20}Z_{20,}$ $P_{20}Z_{30}$, $P_{30}Z_{10}$ and $P_{30}Z_{20.}$ However minimum was recorded in P_0Z_0. This could be attributed not only to addition of organic materials but also to better root growth and plant residue addition by the growing crop at harvest. Improvement of organic carbon content in soil with the use of inorganic fertilizer as crop requirement for dry matter production could be emphasized to proper decomposition of organic material to the carbon stock of the soil (Dang and Verma, 1996) [6]. The fertilization of inorganic may change the quality of the total organic carbon (Pascual *et al.*, 1999) [22]. Similar results were also found by Pinheiro *et al*. (2007) [23].

Available nitrogen

Available nitrogen, content in the post harvest soil of pearl millet ranged between 160.9 to 220.7 kg ha^{-1}. The highest N content in soil was recorded in the treatment 30 kg P ha^{-1} + 30 kg Zn ha^{-1} followed by $P_{10}Z_{30,}$ $P_{20}Z_{10}$, $P_{20}Z_{20,}$ $P_{20}Z_{30}$, $P_{30}Z_{10}$ and $P_{30}Z_{20.}$ However minimum was recorded in P_0Z_0. The treatment 30 kg P ha^{-1} + 30 kg Zn ha^{-1} has shown 27.0, 26.2 and 22.0 % increase over control, $P_{10}Z_{10}$ and $P_{10}Z_{20}$, respectively and statistically at par with rest of the treatments. Increase in availability of soil nutrients might be due to the inorganic fertilization process to soil and mineralization and solubilization of available nutrients through direct and indirect mechanism of nutrients in soil and transport of nutrients to plant (Bhatti *et al.*, 2011) [4]. The increment in available nutrients might be due to, in general application of inorganic fertilizer along with microbial cultures and humic acid increase the available soil N. This may probably be due to mineralization of organic compounds. Significant increase in soil available N due to direct fertilization of mineral fertilizers was also reported earlier by Singh *et al.* (2010) [27].

Available phosphorus

The perusal of data contained in Table 2 showed that the available p content in the post harvest soil varied significantly due to application of phosphorus and zinc levels. The available phosphorus content of the experimental field ranged between 8.14 to 25 kg ha^{-1}, minimum being in the control. The maximum P content in soil (25 kg ha^{-1}) was recorded in the treatment where a combination of 30 kg ha^{-1} P and Zn was applied ($P_{30}Z_{30}$), it has shown about 67% increase over control. The increase in the available phosphorus due to increasing level of zinc and phosphorus could be ascribed to the established fact that phosphorus has antagonistic relationship with Zn and P which might have worked in the present case. Research works of Gour (1994) [9] and Naga (2005) [18] also support the experimental findings under the present study.

Available potassium

The data pertaining to the neutral normal ammonium acetate extractable potassium ranged from 169.00 to 197.33 kg ha^{-1}. The maximum potassium content (197.33 kg ha^{-1}) was recorded with the application of 10 kg P ha^{-1} + 10 kg Zn ha^{-1}, which was 11% higher than control. However, minimum was recorded in the treatment 30 kg P ha^{-1} + 30 kg Zn ha^{-1}. The treatment 10 kg P ha^{-1} + 10 kg Zn ha^{-1} application was found to be significantly different with all other treatments, however, rest other treatment were statistically at par with each other. The application of Zn and P significantly increased the nitrogen and potassium content in after harvest of crop. It might be due to effect of Zn and P on microbial nitrogen fixation in soil which was also indicated by Jat *at el.* (2013) [14].

DTPA extractable Zn

DTPA extractable Zn content in post harvest soil of pearl millet increased significantly from 1.22 to 4.51 ppm due to application of phosphorus and zinc. The maximum DTPA extractable Zn content (4.51 ppm) was recorded in the treatment of 30 kg P ha^{-1} + 30 kg Zn ha^{-1}, however, minimum (1.22 ppm,) was recorded in control. The treatment 30 kg P ha^{-1} + 30 kg Zn ha^{-1} have shown 73, 51 and 14 % increase in DTPA extractable Zn content over control, $P_{30}Z_{10}$ and $P_{30}Z_{20}$, respectively. Application of Zn increased the DTPA extractable zinc significantly over the control. The Zn significantly increased the DTPA extractable Zn in soil at harvest. This ia due to increase in Zn concentration in the soil by application of Zn in the experimental field which was deficiet in Zn. The results were conformity to those reported by Badiyala and Chopra (2011) [3] and Jat at el., (2015) [13].

Table 1: Physico-chemical properties the soil of experimental plot

Soil properties	Unit	Value	Method employed
A. Physical			
Course sand	(%)	7.14	Piper, 1967 [24]
Fine sand	(%)	50.41	
Silt	(%)	19.45	
Clay	(%)	23.00	
Textural class	Sandy clay loam		
Bulk density	(Mg/m3)	1.46	
Particle density	(Mg/m3)	2.65	
B. Chemical			
pH $_{(1:2)}$	-	5.6	Jackson (1973) [12]
EC$_{(1:2)}$	(dSm-1)	0.44	
Organic carbon	(%)	0.29	Walkley and Black, 1934 [31]
Available N	(kg/ha)	188.2	Subbiah and Asija, 1956 [30]
Available P	(kg/ha)	9.66	Olsen *et al.*, 1954 [20]
Available K	(kg/ha)	186.4	Metson (1956) [17]
DTPA extractable Zn	mg ka^{-1}	1.02	Lindsay and Norvell (1978) [16]

Table 2: Effect of phosphorus and zinc level on physic-chemical properties of soil and production potential of pearlmillet.

Treatments	pH	EC (dS m^{-1})	Organic carbon (g kg^{-1})	Available nutrients				Production potential of peralmillet (kg ha^{-1})		
				N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	Zn (mg kg^{-1})	Grain yield	Straw yield	Biological yield
T_1- 0 kg P_2O_5 + 0 kg Zn ha^{-1}	5.24	0.06	2.87	160.9	8.14	180.12	1.22	1599	3257	4856
T_2- 10 kg P_2O_5 + 10 kg Zn ha^{-1}	5.14	0.05	2.91	162.9	9.47	197.33	2.28	1670	3357	5027
T_3- 10 kg P_2O_5 + 20 kg Zn ha^{-1}	5.05	0.04	2.95	165.2	15.00	180.67	3.30	1747	3512	5259
T_4- 10 kg P_2O_5 + 30 kg Zn ha^{-1}	4.94	0.04	3.09	172.9	20.00	170.00	4.27	1835	3611	5447
T_5-20 kg P_2O_5 + 10 kg Zn ha^{-1}	5.36	0.05	3.10	173.6	11.40	178.00	2.17	1858	3897	5755
T_6-20 kg P_2O_5 + 20 kg Zn ha^{-1}	5.20	0.04	3.04	170.3	16.33	175.00	3.20	1929	3986	5915
T_7-20 kg P_2O_5 + 30 kg Zn ha^{-1}	5.32	0.04	3.23	181.1	19.00	180.00	4.11	2010	4051	6061
T_8-30 kg P_2O_5 + 10 kg Zn ha^{-1}	5.26	0.03	3.35	187.7	15.00	175.00	2.23	2050	4184	6234
T_9-30 kg P_2O_5 + 20 kg Zn ha^{-1}	5.23	0.03	3.78	211.4	19.00	170.00	3.86	2067	4443	6510
T_{10}-30 kg P_2O_5 + 30 kg Zn ha^{-1}	5.06	0.05	3.94	220.7	25.00	169.00	4.51	2010	4214	6224
SEm±	0.116	0.006	0.14	7.91	0.79	2.57	0.612	11.25	44.34	55.59
CD (p=0.05)	NS	0.017	0.42	23.50	1.81	7.63	1.81	33.45	131.74	165.19

Conclusion

On the basis of the findings of the present investigation, it can be concluded that the levels of phosphorus (30 kg ha^{-1}) and zinc (20 kg ha^{-1}) was found most suitable levels of phosphorus and zinc, among all the levels of phosphorus and zinc under rain fed condition. Application of phosphorus and zinc was significantly improved the physic-chemical properties of soil. Production potential of pearlmillet was increased with increasing doses of phosphorus and Zinc.

References

1. Ali S, Riaz KA, Mairaj GM, Arif M, Fida S, Bibi. Assessment of different crop nutrient management practices for yield improvement. Australian Journal of Crop Science. 2008; 2(3):150-157.
2. Alloway BJ. Zinc in soil and crop nutrition. 2nd edition published by International Zinc Association and International fertilizer Association, Belgium and Pairs, France. 2008, 223-25.
3. Badiyala D, Chopra P. Effect of Zn and FYM on productivity and nutrient availability of maize- linseed cropping sequence. Indian Journal of Agronomy. 2011; 56:88-91.
4. Bhatti MB, Rajpar I, Hassan ZU, Shah AN, Tunio SD. Humic acid improves growth, yield and oil content of Brassica Compestris L., Pak. J. Agri. 2011; 27(2):125-133.
5. Campitelli PS, Velasco MI, Ceppi SB. Chemical and physicochemical characteristics of humic acids extracted from compost, soil and amended soil. Talanta. 2008; 69:1234-1239.
6. Dang YP, Verma KS. Direct and residual effect of press mud cakes in rice-wheat cropping system. J. Indian Soc. Soil Sci. 1996; 44:448-450.
7. Ekeberg E, Riley HCF. Tillage intensity effects on soil properties and crop yields in a long-term trial on morainic loam soil in south-east Norway. Soil Tillage Resh. 1997; 42(4):277-293.
8. Frequez K, Kobayashi M, Takahashi E. Changes in the soil micro flora and in their metabolic activity. Changes during the decomposition of plant residues. J Sci. Soil Manure Jap. 1990; 43:155-159.
9. Gour SL. Study of zinc and iron effect on growth and yield of fennel crop. *M.Sc. (Ag.) Thesis*, Rajasthan Agricultural University, Bikaner (Rajasthan), 1994.
10. Graham RD, Welch RM, Bouis HE. Addressing micronutrient nutrition through enhancing the nutritional quality of staple foods. Advances in Agronomy. 2000; 70:77-161.
11. Habib M. Effect of supplementary nutrition with Fe, Zn chelates and urea on wheat quality and quantity. African Journal of Biotechnology. 2012; 11(11):2661-65.
12. Jackson ML. Soil Chemical Analysis, Prentice Hall, Pvt. Ltd. New Delhi, 1973, 239-241.
13. Jat G, Sharma KK, Jat NL. Effect of FYM and mineral nutrients on physic-chemical properties of soil under mustard in western arid zone of India. Annals of Plant and Soil research. 2015; 14:167-170.
14. Jat SR, Patel BJ, Shivran AC, Kuri BR, Jat G. Effect of phosphorus and sulphur levels on growth and yield of cowpea under rainfed conditions. Annals of Plant and Soil Research. 2013; 15(2):114-117.
15. Keram KS, Sharma BL, Sawarkar SD. Impact of Zn application on yield, quality, nutrients uptake and soil fertility in a medium deep black soil (vertisol). International Journal of Science, Environment and Technology. 2012; 5(1):563-571.
16. Lindsay WL, Norvell WA. Development of DTPA soil test for Zn, Fe, Mn and Cu. Soil Science Society of American Journal. 1978; 42:421-428.
17. Metson AI. Methods of chemical analysis for survey samples Bulletin No. 2, Department of Science Mediterranean Research Soil Bureau, 1956, 12.
18. Naga SR. Response of wheat to zinc and iron fertilization under irrigation with different RSC water. *Ph.D. Thesis*, Rajasthan Agricultural University, Bikaner, 2005.
19. Nayak AK, Gupta ML. Phosphorus, zinc and organic matter interaction in relation to uptake, tissue concentration and absorption rate of phosphorus in wheat. J of the Ind. Soc. of Soil Sci. 1995; 43(4):633-636.
20. Olsen SR, Cole RV, Watanabe FS, Lean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. Circular, United States Department of Agriculture 1954; 11:540-545.
21. Panse VG, Sukhatme PV. Statistical Methods for Agricultural Workers. ICAR, New Delhi, 1985.
22. Pascual JA, Garcia C, Hernandez T. Comparison of fresh and composted organic waste in their efficacy for the improvement arid soil quality. Bioresource Technology (in press), 1999.
23. Pinheiro JP, Domingos R, Lopez R, Brayner R, Fievet F, Wilkinson K. Determination of diffusion coefficients of nanoparticles and humic substances using scanning stripping chronopotentiometry (SSCP). Colloids Surf. 2007; 295:200-208.
24. Piper CS. Soil and Plant analysis. Inter science publisher Inc., New York, 1967.
25. Raghothama KG. Phosphate acquisition. Ann. Rev. Plant Physiol. Plant Mol. Bio. 1999; 50:665-693.
26. Ramanathan A, Bharathi R, Vivekananthan R, Harish S, Samiyappan R. Rhizobacteria-based bio-formulations for the management of fruit rot infection in chillies, Crop Prot. 1977; 23:835-843.
27. Singh BK, Sharma SR, Singh B. Variation in mineral concentrations among cultivars and germplasms of cabbage. J of Plant Nutr. 2010; 33(1):95-104.
28. Subba Rao NS. Microbial interactions in agriculture and forestry, Science Publishers, Inc, U.S.A. 1977, 278.
29. Subba Rao NS. Soil Microorgainisms and Plant Growth. Oxford I.B.H. Pub. Co., New Delhi, 1997, 165.
30. Subbiah BV, Asija GL. A rapid procedure for the estimation of available N in soils. Current Science 1956; 25:259.
31. Walkley A, Black IA. Estimation of soil organic carbon by the chromic acid titration method. Soil Science. 1934; 37:29-38.
32. Wear JI, Hagler TB. Plant food review. Spring, 1968.