Soil Nutrient Status after Harvest of Maize (*Zea mays* L.) as Influenced by Application of Different Levels of Nitrogen and Zinc in Rural and Peri-Urban of Southern Transect of Bengaluru

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ABSTRACT

Field experiments were conducted to assess the effect of different levels of nitrogen and zinc application on soil nutrient status, after harvestof maize in rural (Kaggalahalli) and peri-urban (Taralu) areas of southern transact of Bengaluru during *kharif* 2019. Ten different treatments with three replications each were carried out in randomized complete block design. Application of 200 kg N ha^{-1} + 4.2 kg Zn ha^{-1} + RDP and RDK + 10 t ha^{-1} FYM resulted in significantly higher soil available nitrogen (273.30 and 234.03 kg ha^{-1}), available phosphorus (43.98 and 38.67 kg ha^{-1}), available potassium (262.08 and 223.27 kg ha^{-1}), exchangeable calcium [4.75 and 3.81 c mol (p^+) kg^{-1}], available sulphur (32.58 24.71 ppm) and DTPA extractable zinc (0.50 and 0.42 ppm) in rural and peri-urban, respectively compared to absolute control. Whereas, exchangeable magnesium [2.71 c mol (p^+) kg^{-1}] was found significant only in rural (Kaggalahalli) soil. Hence, application of higher amount of deficient nutrient with recommended dose of fertilizer and organic manure (200 kg N ha^{-1} + 4.2 kg Zn ha^{-1} + RDP and RDK + 10 t ha^{-1} FYM) helps in improving the soil fertility and sustainability.

Keywords : Nitrogen, Zinc, Southern transact, Rural, Peri-Urban, Nutrient status

MAIZE is one of the globally important cereal crop next to wheat and paddy and it is called as 'Queen of cereal' due to its high productivity. Despite of its high productivity, the potential yield of maize is decreasing. Even though many biotic and abiotic factors can contribute to the big yield gaps, soil fertility depletion and poor nutrient management are among the major factors contributing to low productivity (Mourice *et al*., 2015). So, it is very important to correct nutrient deficiency in the soil to improve the yield.

Maize is an exhaustive cropand requires both macro and micro-nutrients in balanced quantity for optimum growth and development. The demand for nitrogen in maize is higher as compared to other nutrients (Eresh and Prakash, 2017). Hence, nitrogen (N) management in maize production system is greater concern since it is the very important and primary nutrient for growth and development of the crop (Leghari *et al*., 2016). But excess application of nitrogen result in leaching loss of nitrates from the soil and make it unavailable to the plants and also cause pollution. Hence, optimum application of nitrogen lead to efficient use. Nitrogen not only stimulates the root growth and crop development (Anas *et al*., 2020) but also has a synergistic effect on other nutrients as well. Due to this reason, it is the largest applied nutrient to most of annual crops and have substantial influence on growth and yield of maize crop.

Zinc is considered as one of the essential micronutrients for plant growth, but its supplementation has received less attention than major nutrients (Liu *et al*., 2020). In most of the cases, zinc requirement is met by organic manure application. However, nearly half of the cereal growing areas are deficit in zinc so external application of zinc through fertilizers containing zinc enhances soil fertility. It is the important constituent of several enzymes which regulate various metabolic reactions in the plants and also essential fox auxin and protein synthesis (Ramya and Subbarayappa, 2017). Zn decreases pollen viability and leads to pollen sterility in maize and then to low kernel numbers. Therefore, application of zinc fertilizer is required to improve soil fertility along with organic manures.

Material and Methods

Field experiments were conducted in nitrogen and zinc deficit soils of rural Kaggalahalli) and peri-urban (Taralu) of southern transact of Bengaluru, which falls under the Eastern Dry Zone of Karnataka. In Kaggalahalli village, total rainfall of 759.7 mm was observed with relative humidity of 81.95 per cent. The mean maximum temperature of 29.95 ºC and minimum of 20.52 ºC was recorded during the year 2019. Whereas, in Taralu total rainfall of 862.00 mm was observed with relative humidity of 82.45 per cent and mean maximum temperature of 30.97 ºC and minimum of 20.17 ºC. Soil samples were collected before initiation of the field experiment and after harvest of crop, analyzed for various parameters by following standard protocol (Table 1). Initial soil properties of the experimental site indicated that soils were acidic (6.8 and 5.8) and possess normal electrical conductivity (0.16 and 0.14 dS m^{-1}) with medium organic matter content (0.72 and 0.55 %). Soils have low available nitrogen (234.23 and 210.12 kg ha^{-1}), medium available phosphorus (25.52 and 22.23 kg ha^{-1}) and status of potassium (225.12 and 192.21 kg ha^{-1}) and soil was deficit in zinc (0.34 and 0.27 ppm) in rural and peri-urban, respectively (Table 1).

As the nitrogen and zinc were found low, the present study was conducted to assess the effect of different levels of nitrogen and zinc on soil nutrient status after harvest of maize crop in two selected farmers field in rural and peri-urban of southern transact of Bengaluru.

Field experiments were laid out in RCBD design consisting of ten treatments, replicated thrice *viz*., Absolute control (T_1), RDP + RDK + 10 t ha^{-1} FYM (T_2), 2.1 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM

Table 1

Analytical methods adopted for analysis of soil properties of rural and peri- urban experimental site

Soil property	Methods followed	Rural	Peri-urban
Sand (%)	International pipette method (Piper, 1966)	59.49	63.48
Silt (%)		6.81	9.81
Clay (%)		33.02	26.63
Textural class		Sandy clay	Sandy clay
pH (1:2.5)	Potentiometry (Jackson, 1973)	6.8	5.8
EC (1:2.5) (dS m^{-1})	Conductometry (Jackson, 1973)	0.16	0.14
OC (%)	Wet oxidation method (Jackson, 1973)	0.72	0.55
CEC [cmol (p^+) kg^{-1}]	Neutral 1N, ammonium acetate method (Jackson, 1973)	14.25	11.65
Available N (kg ha^{-1})	Alkaline permanganate method (Subbiah and Asija, 1956)	234.23	210.12
Available P_2O_5 (kg ha^{-1})	Bray's method (Bray and Kurtz, 1945)	25.52	22.26
Available K_2O (kg ha^{-1})	Neutral 1N NH_4OH extractant & flame photometry method (Jackson,1973)	225.12	192.21
Exch.Ca [c mol (p^+) kg^{-1}]	Versenate titration method (Jackson,1973)	4.20	3.07
Exch. Mg [c mol (p^+) kg^{-1}]	Versenate titration method (Jackson,1973)	2.32	2.12
Available S (kg ha^{-1})	Turbidometry method (Black, 1965)	23.02	19.15
Available Zn (ppm)	DTPA extraction, AAS method (Lindsay and Norvell, 1978)	0.34	0.27
Available Fe (ppm)		9.70	14.51
Available Mn (ppm)		7.14	11.56
Available Cu (ppm)		0.78	0.70

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(T_3), 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM (T_4), 150 kg N ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM (T_5), 150 kg N ha^{-1} + 2.1 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM (T_6), 150 kg N ha^{-1} + 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM (T_7), 200 kg N ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM (T_8), 200 kg N ha^{-1} + 2.1 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM (T_9), 200 kg N ha^{-1} + 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM (T_{10}). Nitrogen in the form of urea, phosphorous in the form of single super phosphate (SSP), potassium in the form of muriate of potash (MOP) andzinc in the form of zinc sulphate was applied. Full dose of phosphorus, potassium, zinc and 1/3 nitrogen were applied at sowing by drilling in the crop rows. The remaining dose of nitrogen was top dressed in two splits at knee high and tasseling stages depending upon the occurrence of rains.

The data on various characters studied during the course of investigation were statistically analyzed forrandomized block design. Whenever, F-test was significant for comparison amongst the treatment mean and appropriate value of critical difference (CD) was worked out. Otherwise, abbreviated NS (non-significant) was indicated against CD value.

Results and Discussion

Among different treatments application of 200 kg N ha^{-1} + 4.2 kg Zn ha^{-1} with recommended dose of phosphorus and potassium and 10 t ha^{-1} of FYM (T_{10}) resulted in significantly higher available nitrogen (273.30 and 234.03 kg ha^{-1}), available phosphorus (43.98 and 38.67 kg ha^{-1}) and available potassium (262.08 and 223.27 kg ha^{-1}), which was on par with

Table 2

Effect of different levels of nitrogen and zinc application on available N, P_2O_5 and K_2O in soil after the harvest of maize in rural and peri-urban

Treatments	Rural			Peri-urban		
	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})
T_1 : Absolute control	169.19	19.45	184.30	146.48	15.43	144.68
T_2 : RDP + RDK + 10 t ha^{-1} FYM	182.35	23.25	212.60	168.39	21.67	181.93
T_3 : 2.1 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	190.91	25.17	224.81	177.71	23.93	188.62
T_4 : 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	197.91	29.30	228.89	181.24	25.18	195.40
T_5 : 150 kg N ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	235.87	31.76	234.16	207.15	27.28	201.87
T_6 : 150 kg N ha^{-1} + 2.1 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	243.97	34.64	237.98	215.95	30.04	205.99
T_7 : 150 kg N ha^{-1} + 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	251.95	37.34	249.92	222.61	33.11	214.88
T_8 : 200 kg N ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	260.44	35.54	244.42	221.77	31.96	209.87
T_9 : 200 kg N ha^{-1} + 2.1 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	265.28	40.73	257.74	228.02	35.08	218.95
T_{10} : 200 kg N ha^{-1} + 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	273.30	43.98	262.08	234.03	38.67	223.27
S.Em. ±	9.15	2.39	7.33	6.61	2.46	6.54
CD @ 5 %	27.18	7.11	21.79	19.64	7.32	19.42

200 kg N ha^{-1} + 2.1 kg Zn ha^{-1}with recommended dose of phosphorus and potassium and 10 t ha^{-1} of FYM with available nitrogen (265.28 and 228.02 kg ha^{-1}), phosphorus (40.73 and 35.08 kg ha^{-1}) and potassium (257.74 and 218.95 kg ha^{-1}) in rural and peri-urban, respectively. The lowest available nitrogen (169.19 and 146.48 kg ha^{-1}), phosphorus (19.45 and 15.43 kg ha^{-1}) and potassium (184.30 and 144.68 kg ha^{-1}) were recorded in absolute control in rural and peri-urban, respectively (Table 2). Increased levels of nitrogen and zinc increased available major nutrients status in soil. The increase in available P content with increase in N levels may be due to increased crop growth (Anas *et al*., 2020), which might have led to more root exudates and ultimately solubilized more soil P, thus, registering increased available P. Such an increase in available K with nitrogen application might be due to the increase in the concentration of NH_4 ion in the soil solution which would have replaced K from the clay complexes.

The data pertaining to exchangeable calcium, magnesium and available sulphur as influenced by different levels of nitrogen and zinc in rural and peri-urban are presented in Table 3. Among treatments significantly, the highest values for exchangeable calcium (4.75 and 3.81 c mol (p$^+$) kg^{-1} soil) was recorded with application of 200 kg N ha^{-1} + 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM (T_{10}), which was on par with 200 kg N ha^{-1} + 2.1 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM [T_9: 4.66 and 3.78 c mol (p$^+$) kg^{-1} soil] and the lowest value in absolute control [3.01 and 2.00 c mol (p$^+$) kg^{-1} soil] in rural and peri-urban, respectively. Similar was the trend found in exchangeable magnesium in soil with application of different levels of nitrogen and zinc. Significantly the

TABLE 3

Effect of different levels of nitrogen and zinc application on exchangeable Ca, Mg and available S in soil after the harvest of maize in rural and peri-urban

Treatments	Rural			Peri-urban		
	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})
T_1 : Absolute control	3.01	1.87	19.53	2.00	1.85	16.87
T_2 : RDP + RDK + 10 t ha^{-1} FYM	4.12	2.36	22.89	3.01	2.09	18.98
T_3 : 2.1 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	4.20	2.42	24.07	3.15	2.15	19.10
T_4 : 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	4.25	2.48	24.79	3.24	2.21	20.65
T_5 : 150 kg N ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	4.32	2.53	26.93	3.41	2.26	21.35
T_6 : 150 kg N ha^{-1} +2.1 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	4.47	2.58	26.98	3.62	2.31	21.59
T_7 : 150 kg N ha^{-1} + 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	4.54	2.62	29.67	3.70	2.39	23.11
T_8 : 200 kg N ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	4.50	2.66	28.80	3.66	2.35	23.06
T_9 : 200 kg N ha^{-1} +2.1 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	4.66	2.69	30.45	3.78	2.42	23.92
T_{10} : 200 kg N ha^{-1} + 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	4.75	2.71	32.58	3.81	2.45	24.71
S.Em. ±	0.30	0.14	1.14	0.31	0.12	0.64
CD @ 5 %	0.90	0.41	3.39	0.94	NS	1.89

lowest exchangeable magnesium was recorded in absolute control [1.87 c mol (p^+) kg^{-1}] and the highest [2.71 c mol (p^+) kg^{-1}] in T_{10} (200 kg N ha^{-1} + 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM) in rural, while it was found non-significant in peri-urban.

Available sulphur (32.58 and 24.71 ppm) recorded significantly higher with application of 200 kg N ha^{-1} + 4.2 kg Zn ha^{-1} along with + RDP + RDK + 10 t ha^{-1} FYM (T_{10}) which was on par with application of 200 kg N ha^{-1} + 2.1 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM (T_9: 30.45 and 23.92 ppm) and least in absolute control (19.53 and 16.87 ppm) in rural and peri-urban, respectively. Higher calcium and sulphur due to application of phosphorus fertilizers could be due to addition of SSP which contains 18 per cent of Ca and 12 per cent S resulting in increased soil calcium and sulphur. Similarly, addition of FYM in these treatments has increased the secondary nutrient status of soil. Similar results were noticed by Santhosha (2013).

Release of nutrients during mineralization process and retention due to addition of organic matter might have also increased secondary nutrient content of soil. The data pertaining to DTPA extractable iron, manganese, zinc and copper as influenced by different levels of nitrogen and levels of zinc in rural and peri-urban are presented in Table 4. Application of different levels of nitrogen, zinc and their interaction recorded non-significant effect on available iron, manganese and copper in rural and peri-urban. Available zinc was found significant among the treatments. Significantly higher zinc (0.50 and 0.42 ppm) was noticed with application of 200 kg N ha^{-1} + 4.2 kg Zn ha^{-1} (T_{10}) and least in absolute control (0.30 and 0.24 ppm) in rural and peri-urban. Application of graded levels of N and

TABLE 4

Effect of different levels of nitrogen and zinc application on DTPA extractable Fe, Mn, Zn and Cu in soil after the harvest of maize in rural and peri-urban

Treatments	Rural				Peri-urban			
	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)
T_1 : Absolute control	9.26	7.10	0.30	0.67	14.47	11.23	0.24	0.67
T_2 : RDP + RDK + 10 t ha^{-1} FYM	9.87	7.21	0.37	0.79	14.64	11.64	0.31	0.77
T_3 : 2.1 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	9.92	7.31	0.41	0.81	14.82	11.72	0.32	0.79
T_4 : 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	10.16	7.36	0.43	0.83	15.12	11.79	0.34	0.80
T_5 : 150 kg N ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	10.30	7.39	0.42	0.84	15.33	11.87	0.33	0.81
T_6 : 150 kg N ha^{-1} + 2.1 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	10.38	7.41	0.44	0.85	15.53	11.92	0.36	0.82
T_7 : 150 kg N ha^{-1} + 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	10.42	7.49	0.48	0.86	15.87	12.01	0.38	0.83
T_8 : 200 kg N ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	10.40	7.46	0.43	0.87	15.67	11.97	0.35	0.82
T_9 : 200 kg N ha^{-1} + 2.1 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	10.47	7.52	0.47	0.88	16.01	12.08	0.37	0.83
T_{10} : 200 kg N ha^{-1} + 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	10.50	7.57	0.50	0.90	16.08	12.14	0.42	0.84
S.Em.±	0.29	0.14	0.03	0.05	0.50	0.21	0.02	0.04
CD @ 5 %	NS	NS	0.08	NS	NS	NS	0.06	NS

Zn significantly increased available Zn content in soil after harvest as compared to control. Availability of micronutrients greatly depend on pH and organic manure applied which increased availability of micronutrient through mineralization. As application of different levels of nitrogen and zinc along with FYM has increased microbial activity in soil and the consequent release of complex organic substances would have prevented micronutrients loss from soil. However, higher available iron and manganese was recorded in peri-urban due to acidic pH than rural. Similar was the result observed by Sharma *et al*., 2016.

Based on the findings of present study, it may be concluded that application of 200 kg N ha^{-1} + 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM proved effective in improving available nutrient status in nitrogen and zinc deficit soils of southern transact of Bengaluru.

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