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Effect of Different Levels of Nitrogen and Zinc on Quality and Nutrient Content of Maize in Rural and Peri-Urban Southern Transact of Bengaluru

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ABSTRACT

Field experiments were conducted in farmers field's in rural and peri-urban southern transact of Bengaluru during *kharif* 2019 to assess the effect of different levels of nitrogen and zinc on quality of maize grain, nutrient content and uptake by maize. Experiment was conducted in a factorial randomized complete block design with ten treatments and three replications. Three levels of nitrogen (0, 150 and 200 kg ha^{-1}) and three levels of zinc (0, 2.1 and 4.2 kg ha^{-1}) was applied in combination with recommended dose of phosphorus, potassium along with FYM. Application of 200 kg N ha^{-1} + 4.2 kg Zn ha^{-1} + RDP and K + 10 t ha^{-1} FYM recorded significantly higher oil content (4.07 and 4.04 %) and protein content (9.52 and 9.03 %) in grains of maize grown in rural and peri-urban, respectively. Significantly higher content of nitrogen (1.40 and 0.80 %), phosphorus (0.29 and 0.22 %), potassium (0.57 and 1.13 %) and zinc (30.50 and 21.80 ppm) in grain and strover of maize in rural with application of 200 kg N ha^{-1} + 4.2 kg Zn ha^{-1} along with RDP and K + 10 t ha^{-1} FYM. Same treatment recorded significantly higher total content of nitrogen (1.23 and 0.75 %), phosphorus (0.26 and 0.21 %), potassium (0.46 and 0.89 %) and zinc (25.57 and 11.67 ppm) in grain and stover of peri-urban grown maize. Hence, judicious application of nutrients to correct deficiency can increase nutrient content and finally productivity of the crop.

Keywords : Nutrient uptake, Nitrogen, Zinc, Oil content, Protein

MAIZE (*Zea mays* L.) is one of the important stable food crops grown all over the world under diversified climatic conditions. Maize is called the queen of cereals because of its greater production potential compared to other cereals. Besides being a potential source of food for human being, it is also used for feeding cattle, poultry and industries for production of starch, syrup, alcohol, acetic acid etc. (Kiran and Chennakeshava, 2017). Hence, nutrient content is very much important. However, there are a number of factors which are responsible for the low nutrient content, quality, production and productivity of maize. Among these factors, inappropriate crop nutrition management and poor soil fertility are the most important factors responsible for low yield of maize (Shah *et al*., 2009 and Kumar *et al*., 2020). Nutrient deficiency is one of the major problems constraining the development of an economically successful agriculture.

Nitrogen has long been considered the most influential macronutrient for maize grain yields. It is a key component of enzymes and other proteins essential to all growth functions. Zinc is considered as a fourth most important yield limiting nutrient after major nutrients. It is an essential micronutrient for plant and animals. Higher plants generally absorb zinc as divalent cation, which acts either as the metal components of enzymes or as a functional, structural or a regulatory co-factor of a large number of enzymes and helps in increasing plant growth and yield (Harish and Rame Gowda, 2017).

MATERIAL AND METHODS

The experiment was conducted in farmers' fields of Kaggalahalli and Taralu of rural and peri-urban areas of southern transact of Bengaluru. The total rainfall during 2019 at Kaggalahalli (Rural) was759.7 mm with maximum rainfall during October (368.2 mm) and minimum during December (4.0 mm). Whereas, in Taralu higher rainfall was recorded in September (275.5 mm) and least in December (2.0 mm) with total rainfall of 862.0 mm. The maximum temperature was

29.95 ºC and 30.97 ºC, while minimum temperature was 20.52 ºC and 20.42 ºC in rural and peri-urban, respectively.

Soil samples were collected before initiation of the field experiment and after theharvest of crop, analysed for various parameters by following standard protocol. Initial soil properties of the experimental site indicated that soils were acidic6.8 and 5.8 (Jackson, 1973), normal electrical conductivity of 0.16 and 0.14 dSm^{-1} (Jackson, 1973) with medium organic matter content of 0.72 and 0.55 per cent (Jackson, 1973), low available nitrogen of 234.23 and 210.12 kg ha^{-1} (Subbiah and Asija, 1956), medium available phosphorus of 25.52 and 22.23 kg ha^{-1} (Bray and Kurtz, 1945) and medium available potassium of 225.12 and 192.21 kg ha^{-1} (Jackson, 1973) and deficit in zinc with 0.34 and 0.27 ppm (Lindsay and Norwell, 1978) in soils of rural and peri-urban, respectively. As the nitrogen and zinc was found low, present study was conducted to assess the effect of different levels of nitrogen and zinc on maize grain quality and nutrient content of plant in two selected farmers field in rural and peri-urban of southern transact of Bengaluru.

Field experiment was laid out in a factorial randomized complete block design with three replications and ten treatment combinations *viz*., T_1: Absolute control, T_2: RDP + RDK + 10 t ha^{-1} FYM, T_3: 2.1 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM, T_4: 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM, T_5: 150 kg N ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM, T_6: 150 kg N ha^{-1} + 2.1 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM, T_7:150 kg N ha^{-1} + 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM, T_8: 200 kg N ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM, T_9: 200 kg N ha^{-1} + 2.1 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM and T_{10}: 200 kg N ha^{-1} + 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM. 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.Nitrogen in the form of urea, phosphorous in the form of SSP, potassium in the form of muriate of potash (MOP) and zinc in the form of zinc sulphate.

Results and Discussion

In nitrogen and zinc deficit soils, application of higher levels of nitrogen and zinc resulted in improving quality of maize grains. Application of 200 kg N ha^{-1} + 4.2 kg Zn ha^{-1} (T_{10}) resulted in significantly higher protein content in maize (9.52 and 9.03 %) followed by 200 kg N ha^{-1} + 2.1 kg Zn ha^{-1} + RDP and K + FYM (9.42 and 8.90 %) compared to absolute control (4.33 and 3.82 %) in rural and peri-urban, respectively. Protein content continued to increase with increasing N levels indicating that nitrogen being a major constituent of proteins contributed towards increase in protein content (Asif *et al*., 2013). Whereas, zinc is vital for protein and amino acid synthesis (Logeragan *et al*., 1982) in leaves and this leads to accumulation in seeds. The increase in protein concentration of maize grain with nitrogen supply was earlier confirmed by Tsai *et al*. (1992). They expressed that the increase could be due to preferential deposition of zeinover the other endosperm proteins. Besides, exclusion of N, in the experiment, resulted in lower protein content, corroborating with previous finding that nitrogen application is essential for maize plant to synthesize amino acids (Seebauer *et al*., 2004). Nitrogen, being the principle constituent of protein might have substantially increased the protein content of kernel due to increased uptake of nitrogen under higher nutrient level (Keerthi *et al*., 2013).

Significantly higher oil content in maize in rural (4.07 %) and peri-urban (4.04 %) was observed with application of 200 kg N ha^{-1} + 4.2 kg Zn ha^{-1} with RDP and RDK and 10 t ha^{-1} of FYM (T_{10}) compared to absolute control (2.47 and 2.17 %, respectively). Low grain oil content might be due to availability of nitrogen to plant at proper time and in proper proportion because if protein content is more, then oil content is decreases (Waseem *et al*., 2012). These results narrate the findings of Witt and Pasuquin (2007).while grain oil content continues to decrease in maize grain due to dilution (Ray *et al*., 2019). It was also earlier confirmed by Rehman *et al*. (2011).

TABLE 1

Effect of different levels of nitrogen and zinc application on quality parameters of maize in rural and peri-urban

Treatments	Rural		Peri-urban	
	Protein content (%)	Oil content (%)	Protein content (%)	Oil content (%)
T_1 : Absolute control	4.33	2.47	3.82	2.17
T_2 : RDP + RDK + 10 t ha^{-1} FYM	7.32	3.15	6.70	3.08
T_3 : 2.1 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	7.44	3.38	6.87	3.36
T_4 : 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	7.48	3.42	6.94	3.34
T_5 : 150 kg N ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	7.68	3.69	7.16	3.45
T_6 : 150 kg N ha^{-1}+ 2.1 kg Zn ha^{-1} + RDP+ RDK + 10 t ha^{-1} FYM	7.93	3.50	7.41	3.63
T_7 : 150 kg N ha^{-1}+ 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	9.01	3.93	8.49	3.80
T_8 : 200 kg N ha^{-1} + RDP+ RDK + 10 t ha^{-1} FYM	8.38	3.86	7.86	3.85
T_9 : 200 kg N ha^{-1} + 2 .1 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	9.42	4.05	8.90	3.99
T_{10} : 200 kg N ha^{-1} + 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	9.52	4.07	9.03	4.04
S.Em.±	0.36	0.13	0.36	0.15
CD @ 5 %	1.06	0.39	1.06	0.45

The data pertaining to nitrogen, phosphorus, potassium and zinc concentrations as influenced by different levels of nitrogen and zinc in grain and stover are presented in Table 2.

T_{10} treatment which received 200 kg N ha^{-1} + 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM recorded higher nitrogen concentration in grain (1.40 and 1.23 %) and stover (0.80 and 0.75 %) of maize grown in rural and peri-urban, respectively and least concentration in grain (1.02 and 0.84 %) and stover (0.61 and 0.48 %) was recorded in absolute control (T_1).

Similar was the trend in phosphorus content, application of 200 kg N ha^{-1} + 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM (T_{10}) resulted in higher grain (0.29 and 0.26 %) and stover (0.22 and 0.21 %) concentration, followed by application of 200 kg N ha^{-1} + 2.1 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM (T_9) in rural and peri-urban, respectively. Least content in grain (0.10 and 0.10 %) and stover (0.06 and 0.03 %) was recorded in absolute control (T_1).

The significantly higher concentration of potassium in grain (0.57 and 0.46 %) and stover (1.13 and 0.89 %) 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}), followed by T_9 (200 kg N ha^{-1} + 2.1 kg Zn ha^{-1} RDP + RDK + 10 t ha^{-1} FYM) over absolute control (T_1) in rural and peri-urban, respectively. Increased application of nitrogen and zinc along with recommended dose of FYM, phosphorus and potassium had resulted in increased availability of nutrients to maize crop and enhance the process of mineralization of nutrients by microorganisms thereby the concentrations of major nutrients in grain and straw has increased. Application of nitrogen significantly affected its concentration of nutrients in plants of maize. This substantial increase can be due to increased N availability enabling plants to take up more nitrogen. Secondly, N application might have increased the root growth which favoured more removal of nitrogen by maize plants. This increase in nitrogen concentration might be attributed to better plant growth

TABLE 2

Effect of different levels of nitrogen and zinc application on N, P, K and Zn content of maize in rural of southern transact of Bengaluru

Treatments	Rural							
	Nitrogen (%)		Phosphorus (%)		Potassium (%)		Zinc (ppm)	
	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover
T_1 : Absolute control	1.02	0.61	0.10	0.06	0.32	0.85	15.25	9.98
T_2 : RDP + RDK + 10 t ha^{-1} FYM	1.16	0.63	0.15	0.10	0.39	0.90	17.05	11.05
T_3 : 2.1 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	1.20	0.65	0.17	0.12	0.42	0.93	21.06	13.55
T_4 : 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	1.21	0.67	0.18	0.14	0.43	0.95	24.01	14.43
T_5 : 150 kg N ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	1.24	0.68	0.19	0.14	0.45	0.97	23.26	13.12
T_6 : 150 kg N ha^{-1} + 2.1 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	1.27	0.72	0.21	0.16	0.47	1.03	24.66	14.95
T_7 : 150 kg N ha^{-1} + 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	1.34	0.74	0.23	0.20	0.50	1.08	26.16	17.20
T_8 : 200 kg N ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	1.30	0.72	0.22	0.18	0.49	1.03	23.82	15.04
T_9 : 200 kg N ha^{-1} + 2.1 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	1.36	0.76	0.25	0.21	0.53	1.10	28.05	18.09
T_{10} : 200 kg N ha^{-1} + 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	1.40	0.80	0.29	0.22	0.57	1.13	30.50	21.80
S.Em.± 0.04	0.03	0.02	0.01	0.02	0.03	1.68	1.44	
CD @ 5 %	0.11	0.08	0.05	0.03	0.06	0.08	5.00	4.29

TABLE 3

Effect of different levels of nitrogen and zinc application on N, P, K and Zn content of maize in peri-urban of southern transact of Bengaluru

Treatments	Peri - urban							
	Nitrogen (%)		Phosphorus (%)		Potassium (%)		Zinc (ppm)	
	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover
T_1 : Absolute control	0.84	0.48	0.10	0.03	0.26	0.59	9.75	4.99
T_2 : RDP + RDK + 10 t ha^{-1} FYM	0.88	0.50	0.13	0.06	0.30	0.67	13.24	6.61
T_3 : 2.1 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	0.96	0.59	0.14	0.08	0.31	0.70	16.42	7.83
T_4 : 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	0.99	0.62	0.16	0.11	0.33	0.72	20.01	8.14
T_5 : 150 kg N ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	1.06	0.64	0.18	0.14	0.36	0.74	18.59	6.43
T_6 : 150 kg N ha^{-1} + 2.1 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	1.10	0.66	0.20	0.15	0.37	0.78	20.10	8.45
T_7 : 150 kg N ha^{-1} + 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	1.18	0.71	0.22	0.18	0.40	0.85	21.85	9.26
T_8 : 200 kg N ha^{-1} + RDP + RDK+ 10 t ha^{-1} FYM	1.14	0.67	0.21	0.16	0.38	0.82	19.05	8.17
T_9 : 200 kg N ha^{-1} + 2.1 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	1.20	0.72	0.23	0.19	0.43	0.87	23.44	10.95
T_{10} : 200 kg N ha^{-1} + 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	1.23	0.75	0.26	0.21	0.46	0.89	25.57	11.67
S.Em.±	0.04	0.04	0.02	0.01	0.02	0.03	2.02	0.64
CD @ 5 %	0.12	0.12	0.05	0.03	0.07	0.08	6.01	1.91

TABLE 4

Effect of different levels of nitrogen and zinc application on Ca, Mg and S content of maize in rural and peri-urban of southern transact of Bengaluru

Treatments	Rural						Peri - urban					
	Calcium (%)		Magnesium (%)		Sulphur (%)		Calcium (%)		Magnesium (%)		Sulphur (%)	
	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover
T_1 : Absolute control	0.23	0.51	0.10	0.20	0.04	0.06	0.13	0.43	0.06	0.14	0.03	0.06
T_2 : RDP + RDK + 10 t ha^{-1} FYM	0.26	0.61	0.13	0.23	0.09	0.11	0.18	0.48	0.08	0.17	0.06	0.10
T_3 : 2.1 kg Zn ha^{-1} + RDP+ RDK + 10 t ha^{-1} FYM	0.30	0.65	0.15	0.27	0.12	0.15	0.20	0.52	0.10	0.19	0.09	0.13
T_4 : 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	0.32	0.70	0.16	0.28	0.11	0.14	0.22	0.54	0.10	0.24	0.08	0.12
T_5 : 150 kg N ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	0.35	0.73	0.18	0.31	0.10	0.13	0.25	0.56	0.12	0.26	0.07	0.11
T_6 : 150 kg N ha^{-1} + 2.1 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	0.36	0.75	0.19	0.32	0.12	0.15	0.27	0.58	0.13	0.27	0.09	0.13
T_7 : 150 kg N ha^{-1} + 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	0.39	0.76	0.20	0.34	0.16	0.18	0.28	0.60	0.14	0.30	0.12	0.14
T_8 : 200 kg N ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	0.38	0.76	0.19	0.32	0.11	0.14	0.27	0.59	0.13	0.27	0.08	0.13
T_9 : 200 kg N ha^{-1} + 2.1 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	0.40	0.78	0.21	0.37	0.13	0.16	0.29	0.62	0.14	0.31	0.10	0.15
T_{10} : 200 kg N ha^{-1} + 4.2 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM	0.42	0.80	0.23	0.39	0.16	0.20	0.33	0.64	0.15	0.35	0.14	0.18
S.Em.± 0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.03	0.01	0.04	0.01	0.01	
CD @ 5 %	0.05	0.07	0.05	0.05	0.04	0.04	0.04	0.08	0.02	0.11	0.04	0.04

as zinc helps in nitrogen absorption due to synergistic relationship between nitrogen and zinc. Similar findings were obtained by Abel-Hady (2007).

Concentration of zinc was found higher with application of higher zinc and nitrogen along with RDP and K in grain (30.50 and 25.57 ppm) and stover (21.80 and 11.67 ppm) of rural and peri-urban grown maize, respectively. It was found to be on par with the treatment T_9 (200 kg N ha^{-1} + 2.1 kg Zn ha^{-1} + RDP + RDK + 10 t ha^{-1} FYM) and least concentration of zinc in grain (15.25 and 9.75 ppm) and stover (9.98 and 4.99 ppm) was recorded in absolute control. The increase in Zn concentration might be due to synergistic effect between nitrogen and zinc as adequate supply of N enhanced the translocation of Zn from roots to other parts of plants. Further better root and shoot growth with the application of N might have led to better utilization of the zinc and other cations from the soil solution. Similar results were reported by Lin *et al*., 2007.

The data pertaining to calcium, magnesium and sulphur concentration as influenced by different levels of nitrogen and zinc in grain and stover are presented in Table 4.

Among treatments, significantly higher concentration in grain (0.42 and 0.33 %) and stover (0.80 and 0.64 %) in rural and peri-urban maize, respectively 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) over control (T_1). Similarly, significantly higher magnesium concentration in grain (0.23 and 0.15 %) and stover (0.39 and 0.35 %) was observed in T_{10} (200 kg N ha^{-1} + 4.2 kg Zn ha^{-1} RDP + RDK + 10 t ha^{-1} FYM) over absolute control (T_1).

Significantly higher concentration of sulphur in grain (0.16 and 0.14 %) and stover (0.20 and 0.18 %) 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}), followed by 200 kg N ha^{-1} + 2.1 kg Zn ha^{-1} RDP + RDK + 10 t ha^{-1} FYM (T_9) over control (T_1) in rural and peri-urban, respectively. The application of higher level of nitrogen and zinc along with recommended dose of phosphorus, potassium and FYM (10 t ha^{-1}) had significantly increased content of secondary nutrients in maize crop, this may be due to synergetic effect of nitrogen and zinc with secondary nutrients.

From the above results it can be concluded that, rural maize crop recorded higher nutrient content compared to peri-urban, due to judicious use of chemical fertilisers and organic manure applications that maintained optimum soil pH and thereby governing the availability of nutrients.

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