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Effect of different levels of nitrogen and zinc application on growth, yield and quality of maize in rural and peri-urban gradients of southern transect of Bengaluru

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Abstract
The expansion of urbanization and industrialization has an adverse effect on the physical, chemical and biological properties of soils there by availability of nutrients and crop growth are getting affected with this the objective was framed to study the effect of different levels of nitrogen and zinc on growth, yield and quality of maize. Two field experiments were carried out in rural and peri-urban of southern transect of Bengaluru during 2019. The experiment was laid out in factorial RCBD with three replications. Three levels of nitrogen (0, 150 and 200 kg ha^{-1}) were applied as urea, in combination with three levels of zinc (0, 2.1 and 4.2 kg ha^{-1}) were applied as zinc sulphate. Experimental data showed that growth, yield and quality parameters of maize were significantly affected by both N and Zn. The application of 200 kg N ha^{-1} and 4.2 kg Zn ha^{-1} recorded significantly higher plant height (213.64 and 207.21 cm), no of leaves $plant^{-1}$ (12.28 and 11.62), chlorophyll content (30.38 and 27.48 mg g^{-1}), no. of grains cob^{-1} (638.86 and 604.60), grain weight cob^{-1} (202.35 and 187.66 g), cob diameter (4.80 and 4.50 cm), cob length (20.30 and 19.91 cm), cob yield (82.16 and 78.11 q ha^{-1}), straw yield (104.28 and 97.17 q ha^{-1}), protein content (9.11 and 8.67%) and oil content (3.99 and 3.81%) at harvest in rural. Similarly, in peri-urban, higher plant height (195.98 and 199.95 cm), no of leaves $plant^{-1}$ (11.79 and 11.12), chlorophyll content (26.16 and 23.92 mg g^{-1}), no. of grains cob^{-1} (622.59 and 590.69), grain weight cob^{-1} (189.40 and 173.09 g), cob diameter (4.46 and 4.21 cm), cob length (19.50 and 18.60 cm), cob yield (78.71 and 73.60 q ha^{-1}), straw yield (97.11 and 89.04 q ha^{-1}), protein content (8.60 and 8.15%) and oil content (3.96 and 3.73%) at harvest were recorded significantly by the application of 200 kg N ha^{-1} and 4.2 kg Zn ha^{-1}, respectively From the study, it was suggested that the combined application of 200 kg N ha^{-1} and 4.2 kg Zn ha^{-1} recorded to get better yield of maize.

Keywords: Maize, nitrogen, zinc, growth, yield, quality, rural-urban interface and southern transect of Bengaluru

Introduction
Urbanization often causes environmental degradation in developing countries and affects human health. It leads to the degradation of soil and water quality in the surrounding area through accumulation of heavy metals and pollutants in the soils as well as in the drinking water, acidification or alkalisation, salinity and change of land use, ultimately affecting the crop productivity. Usually in rural soils, farmers cultivate traditional crops with minimum inputs obtaining sustainable yields. However, the process of urbanization leads to shift in land use system, where farmers shifted from growing agriculture crops to commercial crops with injudicious use of fertilizers or dumping of fertilisers to get higher returns, in long run which lead to soil acidity and imbalance of nutrients and further lead to drastic reduction in the production of crops and soils become unsuitable for crop production.
Indiscriminate use of inorganic fertilizers leads to nutrient imbalance in soil causing ill effect on soil health and micro flora (Choudhary *et al.*, 2015) [11]. Unfortunately, continuous application of higher amount of fertilizer may pose deleterious effects which leads to decline in productivity, deteriorates the physical, chemical and biological properties of soil. Maize (*Zea mays* L.) is the most important cereal worldwide (Ashraf *et al*., 2016) [3]. Maize is an exhaustive crop and requires high quantities of nitrogen during the period of its growth. Being an essential element it plays an important role in crop development and yield. The deficiency of this element has been found as one of the major yield limiting factors for maize production. Applications of nitrogen at low rate adversely affect growth and grain yield of maize (Rajendra *et al*., 2017) [3].

Nitrogen is universally deficient in majority of Indian soil and experiment which are conducted at various places in different agro climatic zones of India indicated that nitrogen has beneficial effect on growth, yield attributing characters and yield of maize (Keteku *et al*., 2016) [18]. The inadequate management of nitrogen (N) is considered a major limiting factor for maize grain yield. N is important for the plant metabolism as it participates of proteins and chlorophyll biosynthesis, being necessary since the early phenological stages of the plant development (Basso and Ceretta, 2000) [6]. With the intensification of agriculture by use of high yielding short duration varieties and high analysis fertilizer, the deficiency of micronutrients, especially zinc has turned out to be a limiting factor in Indian agriculture (Rajendra *et al*., 2017) [3]. Zinc play important role in the correct functioning of many enzyme systems, the synthesis of nucleic acids and auxins (plant hormones) metabolisms, protein analysis and normal crop development and growth (Ananya *et al*., 2019) [2].

Material and Methods

Field experiments were conducted to study the response of nutrients to crop productivity in rural and peri-urban of southern transect of Bengaluru during *kharif*-2019 at Kaggalhalli (Rural) and Taralu (Peri-urban). The experiments were conducted in randomized complete block design (RCBD) with three replications. Three levels of nitrogen (0, 150 and 200 kg ha^{-1}) were applied in combination with three levels of zinc (0, 2.1 and 4.2 kg ha^{-1}) along with recommended dose of phosphorus, potassium and FYM.

The initial soil samples were collected from depth of 0-15 cm, then were combined as composite soil sampler. Collected soil samples were air dried, grinded using pestle and mortar and sieved using 2 mm sieve. Processed samples were analysed for physicochemical parameters by using standard analytical procedures and are presented in Table 1. The land was ploughed after application of recommended dose of FYM (10 t ha^{-1}) with mould board plough and cultivator was passed twice to get good tilth. Maize hybrid Hema was sown at seed rate of 15 kg ha^{-1} at inter row of 60 cm and plant to plant spacing of 30 cm. Recommended dose of fertilizer for maize crop is 150:75:40 kg N, P_2O_5, K_2O ha^{-1} which were applied according to the treatment details. Nitrogen in the form of urea, phosphorus in the form of single super phosphate (SSP), potassium in the form of muriate of potash (MOP) and zinc in the form of zinc sulphate were 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 rain.

Growth parameters

The growth parameters were recorded from randomly selected five plants in each plot and labelled. Periodical observations were taken in these plants at 30, 60, 90 DAS and at harvest. The plant height was measured from the ground level to the tip of the main stem. Whereas, total number of leaves in each plant was counted from five randomly selected plants and then mean value for each treatment was determined and chlorophyll content at different growth stages was recorded by SPAD-502 meter.

Yield and yield parameters

For post-harvest studied five randomly selected plants from each plot were harvested separately and then averaged from yield parameters such as number of cobs per plant, number of grains per cob, weight of grains per cob, 100-grain weight. Grain and stover yield per net plot were recorded and then calculated for hectare.

Table 1: Initial soil properties of the rural and peri-urban experimental site

Sl. No.	Soil property	Rural	Peri-urban	Method and reference
1	Sand (%)	59.49	63.48	International Pipette method (Piper, 1966) [23]
	Silt (%)	6.81	9.81	
	Clay (%)	33.02	26.63	
	Textural class	Sandy clay	Sandy clay	
2	pH (1:2.5)	6.8	5.8	Potentiometry (Jackson, 1973) [14]
3	EC (1:2.5) (dS m^{-1})	0.16	0.14	Conductometry (Jackson, 1973) [14]
4	OC (%)	0.72	0.55	Wet oxidation (Walkley and Black, 1934) [33]
5	Available N (kg ha^{-1})	234.23	210.12	Alkaline permanganate method (Subbaiah and Asija, 1956) [30]
6	Available P_2O_5 (kg ha^{-1})	25.52	22.26	Bray's extraction method (Bray and Kurtz, 1945) [9]
7	Available K_2O (kg ha^{-1})	225.12	192.21	Flame photometry (Jackson,1973) [14]
8	Exch.Ca [c mol (p$^+$) kg^{-1}]	4.20	3.07	Complexometric titration method (Jackson, 1973) [14]
9	Exch. Mg [c mol (p$^+$) kg^{-1}]	2.32	2.12	
10	Available. S (ppm)	23.02	19.15	$CaCl_2$ extractant method, Turbidometry (Black, 1965) [8]
11	Available. Zn (ppm)	0.34	0.27	Atomic absorption spectrophotometry (Lindsay and Norwell, 1978)
12	Available. Fe (ppm)	9.70	14.51	
13	Available. Mn (ppm)	7.14	11.56	
14	Available. Cu (ppm)	0.78	0.70	

Quality parameters

Crude protein content in the maize grain was calculated by multiplying the nitrogen content of grain with a factor 6.25 as proposed by Tsen and Martin (1971) [32]. It was expressed in terms of per cent protein content. The oil content of maize seeds was estimated by Soxhlet method.

Statistical Analysis

The observation recorded in these studies were analysed statistically for test of significance following the Fisher's method of analysis of variance (ANOVA) as outlined by Cochran and Cox (1965). The level of significance on 'F' test was tested at five percent. The results have been discussed based on critical difference at p=0.05. Wherever the treatment differences were found non-significant, it is denoted as 'NS'.

Result and Discussion
Growth parameters
Plant height
Plant height differed significantly at 30, 60, 90 DAS and at harvest with different treatments and it increased progressively with increase in age of the crop up to 90 days after sowing and thereafter increase was meagre (Table 2). Plant height is an important parameter related to growth and development of crop. In rural, significantly greater plant height (64.78, 177.61, 205.63 and 213.64 cm) was recorded with application of 200 kg N ha^{-1} (N_2) at 30, 60, 90 DAS and at harvest, respectively. Similar was the trend in peri-urban soil with application of 200 kg N ha^{-1} (N_2: 60.71, 172.11, 191.92 and 195.98 cm, respectively). Among different levels of zinc, application of 4.2 kg Zn ha^{-1} (Zn_2) resulted in taller in rural (61.02, 175.20, 201.99 and 207.21 cm) and peri-urban (58.88, 166.83, 186.55 and 191.95 cm) at 30, 60, 90 DAS and at harvest, respectively (Fig. 1 and 2).

Nutrient status of soil varied significantly along rural-urban interface of southern transect of Bangaluru and found lower in peri-urban compared to rural areas. Nitrogen and zinc help in maize plant growth, enzymes metabolism, faster cell divisions, cell elongation and ultimately increases plant height. It also helps in manufacturing more leaf area as a consequence more assimilates production and increases plant height. Similarly, increase in plant height due to more N may be attributed to more vegetative development that resulted in increased mutual shading and internodal extension (Iqbal *et al*., 2016; Ananya *et al*., 2019) [13, 2]. The results of the present investigation are in close conformity with Amin (2011) [1] who observed that the increase in plant height with nitrogen sources can be attributed to the fact that nitrogen promotes plant growth, increases the number and length of the internodes which results in progressive increase in plant height. Similar result was observed by Nirmal *et al*., 2016 [22].

Table 2: Effect of different levels of nitrogen and zinc application on plant height of maize at different growth stages in rural and peri-urban

	Rural				Peri-urban			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
Factor 1: Levels of Nitrogen								
N_0 - 0 kg ha^{-1}	44.18	153.59	175.66	177.16	43.83	140.74	159.55	162.82
N_1 - 150 kg ha^{-1}	57.01	165.03	190.79	195.93	52.90	158.79	177.03	179.90
N_2 - 200 kg ha^{-1}	64.78	177.61	205.63	213.64	60.71	172.11	191.92	195.98
S.Em.±	1.66	2.98	4.40	4.39	2.05	3.35	3.22	3.95
CD @ 5%	4.99	8.92	13.20	13.16	6.13	10.06	9.64	11.85
Factor 2: Levels of Zinc								
Zn_0 - 0 kg ha^{-1}	49.31	155.79	180.61	185.50	46.74	147.39	166.89	168.32
Zn_1 - 2.1 kg ha^{-1}	55.63	165.24	189.48	194.02	51.82	157.42	175.06	178.43
Zn_2 - 4.2 kg ha^{-1}	61.02	175.20	201.99	207.21	58.88	166.83	186.55	191.95
S.Em.±	1.66	2.98	4.40	4.39	2.05	3.35	3.22	3.95
CD @ 5%	4.99	8.92	13.20	13.16	6.13	10.06	9.64	11.85

Number of leaves per plant
Higher number of leaves per plant in rural (5.94, 14.30, 14.60 and 12.28) and peri-urban (5.72, 13.68, 14.12 and 11.79) at 30, 60, 90 DAS and at harvest, respectively were observed in plot where N applied @ 200 kg N ha^{-1} (Table 3), while least number of leaves per plant in rural (3.67, 10.38, 10.89 and 9.27) and peri-urban (3.43, 9.67, 10.43 and 8.77) was recorded with no application of nitrogen (N_0) at 30, 60, 90 DAS and at harvest, respectively. Although at zinc levels, application of 4.2 kg Zn ha^{-1} (Zn_2) resulted in higher number of leaves plants in rural (5.41, 13.63, 13.91 and 11.62) in rural and peri-urban at (5.20, 13.01, 13.32 and 11.12) at 30, 60, 90 DAS and at harvest, respectively.

In peri-urban soils availability of nutrients is poor compared to that of rural which resulted in higher plant growth in rural. Higher number of leaves per plant might be due to increase in plant height, number of internodes which result in progressive increase in the number of leaves. The increase in the number of leaves per plant could possibly be ascribed to the fact that nitrogen often increases plant growth and plant height and this resulted in more nodes and internodes and subsequently more production of leaves (Amin, 2011) [1]. Similarly, Jones *et al.* (1995) [15] found that nitrogen fertilization, significantly increased the number of leaves and they suggested that the increasing in number of leaves may be as a result of increasing number of nodes. This shows that higher nitrogen rates enhanced the vegetative growth and increased the source capacity of the plants as indicated by increase in number of leaves produced per plant (Kafle and Sharma, 2015) [16].

Table 3: Effect of different levels of nitrogen and zinc application on no. of leaves $plant^{-1}$ of maize at different growth stages in rural and peri-urban

	Rural				Peri-urban			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
Factor 1: Levels of Nitrogen								
N_0 - 0 kg ha^{-1}	3.67	10.38	10.89	9.27	3.43	9.67	10.43	8.77
N_1 - 150 kg ha^{-1}	5.24	12.61	12.90	10.94	5.05	11.89	12.09	10.44
N_2 - 200 kg ha^{-1}	5.94	14.30	14.60	12.28	5.72	13.68	14.12	11.79
S.Em.±	0.19	0.20	0.36	0.15	0.23	0.21	0.25	0.15
CD @ 5%	0.57	0.60	1.07	0.45	0.69	0.64	0.75	0.46
Factor 2: Levels of Zinc								
Zn_0 - 0 kg ha^{-1}	4.54	11.39	12.00	9.81	4.31	10.67	11.32	9.33
Zn_1 - 2.1 kg ha^{-1}	4.90	12.27	12.48	11.06	4.69	11.55	12.00	10.56
Zn_2 - 4.2 kg ha^{-1}	5.41	13.63	13.91	11.62	5.20	13.01	13.32	11.12

S.Em.±	0.19	0.20	0.36	0.15	0.23	0.21	0.25	0.15
CD @ 5%	0.57	0.60	1.07	0.45	0.69	0.64	0.75	0.46

Total chlorophyll content

Total chlorophyll content at different growth stages of maize was found significant in rural and peri-urban (Table 4). Significantly higher total chlorophyll content in rural (42.85, 44.59, 41.01 and 30.38) and peri-urban (38.20, 40.72, 37.45 and 26.16) was recorded with application of 200 kg N ha^{-1} (N_2) at 30, 60, 90 DAS and at harvest, respectively. Whereas, application of 4.2 kg Zn ha^{-1} (Zn_2) recorded significantly higher total chlorophyll content in rural (39.90, 42.24, 38.33 and 27.48) and peri-urban (36.14, 38.26, 34.88 and 23.92) at 30, 60, 90 DAS and at harvest, respectively in rural.

Chlorophyll concentration of the leaves influences the leaf biochemical properties and biochemical interactions are the result of molecular / atomic composition of the leaf. In turn they are responsible for colour changes resulting from differences in pigment concentration. The higher chlorophyll concertation of the leaves was observed in rural due to higher nitrogen availability for plant uptake compared to peri-urban. With the advancement of growth up to silk formation (30 to 60 DAS) of maize the chlorophyll concentration in the leaves was increased. Likewise, differences were found between the periods. Similar was the result cited by Kafle and Sharma, 2015 [16], they reported nitrogen is an integral part of chlorophyll, which converts light into chemical energy needed for photosynthesis, an adequate supply of nitrogen might result in high photosynthetic activity, vigorous vegetative growth and a dark green colour.

Table 4: Effect of different levels of nitrogen and zinc application on total chlorophyll content of maize at different growth stages in rural and peri-urban

	Rural				Peri-urban			
	30 DAS	**60 DAS**	**90 DAS**	**At harvest**	**30 DAS**	**60 DAS**	**90 DAS**	**At harvest**
Factor 1: Levels of Nitrogen								
N_0 - 0 kg ha^{-1}	31.69	33.06	28.38	17.74	28.82	30.19	25.70	15.19
N_1 - 150 kg ha^{-1}	38.51	40.03	36.01	24.38	34.75	36.27	32.78	21.38
N_2 - 200 kg ha^{-1}	42.85	44.59	41.01	30.38	38.20	40.72	37.45	26.16
S.Em.±	0.67	0.78	0.62	0.67	1.12	0.63	0.82	0.66
CD @ 5%	2.00	2.32	1.87	2.01	3.36	1.89	2.46	1.99
Factor 2: Levels of Zinc								
Zn_0 - 0 kg ha^{-1}	35.25	36.33	32.43	21.90	31.71	33.02	29.53	18.35
Zn_1 - 2.1 kg ha^{-1}	37.91	39.11	34.64	23.12	33.93	35.90	31.52	20.46
Zn_2 - 4.2 kg ha^{-1}	39.90	42.24	38.33	27.48	36.14	38.26	34.88	23.92
S.Em.±	0.67	0.78	0.62	0.67	1.12	0.63	0.82	0.66
CD @ 5%	2.00	2.32	1.87	2.01	3.36	1.89	2.46	1.99

Yield parameters

Grain weight per cob

Application of 200 kg N ha^{-1} (N_2) significantly increased grain weight per cob (202.35 and 189.40 g) compared to 150 kg N ha^{-1} (N_1: 169.89 and 159.91 g) and 0 kg N ha^{-1} (N_0: 142.31 and 136.71 g) in rural and peri urban, respectively. Among different levels of zinc, application of 4.2 kg Zn ha^{-1} (Zn_2) recorded higher grain weight per cob (187.66 and 176.09 g) and least in unapplied treatment (153.80 and 145.66 g) in rural and peri-urban soil, respectively (Table 5).

Number of grains per cob

Table 5 demonstrate that number of grains per cob was significantly affected with application of different levels of nitrogen and zinc. Among different levels of nitrogen fertilizers, application of 200 kg N ha^{-1} (N_2) resulted in higher grain per cob (638.86 and 622.59), followed by 150 kg N ha^{-1} (588.20 and 567.20) in rural and peri urban, respectively. Similarly, application of higher dose of zinc (4.2 kg ha^{-1}) resulted in significantly higher number of grains per cob (604.60 and 590.69), followed by application of 2.1 kg Zn ha^{-1} (586.47 and 567.85) in rural and peri-urban, respectively. Interaction of different levels of nitrogen and zinc showed on par result of number of grains per cob.

100 grain weight

Application of different levels of nitrogen and zinc recorded no significant effect of 100 grain weight. It ranged from 24.22 g to 33.22 g in rural and 21.20 g to 28.33 g in peri-urban with application of different levels of nitrogen. Whereas, application of 4.2 kg Zn ha^{-1} (Zn_2) showed higher test weight in rural (31.16 g) and peri-urban (26.58 g) maize crop.

Cob diameter

There was significant increase in cob diameter with application of different levels of nitrogen and followed order of 200 kg N ha^{-1} (N_2) > 150 kg N ha^{-1} (N_1) > 0 kg N ha^{-1} (N_0) which ranged from 3.58 to 4.80 cm in rural and 3.36 to 4.46 cm in peri-urban maize crop (Table 5). Similar was trend with application of zinc and it ranged from 3.88 to 4.50 cm in rural and 3.58 to 4.21 cm in peri-urban with application of 0 kg Zn ha^{-1} (Zn_0) and 4.2 kg Zn ha^{-1} (Zn_2), respectively.

Cob length

Application of 200 kg N ha^{-1} (N_2) resulted in significantly higher cob length (20.30 and 19.50 cm) of maize crop in rural and peri-urban, respectively. Similarly, application of higher level of zinc (4.2 kg Zn ha^{-1}) resulted in cob length of 19.91 cm in rural and 18.60 cm in peri-urban.

Application of nitrogen, zinc along with recommended dose of FYM might have promoted meristematic growth and physiological activities which promoted higher photosynthesis activity leading to the production of higher sink components like cob length, cob diameter, grain weight per cob, number of grains per cob and test weight of cob. Similar was the result found by Reddy *et al.* (2019) [26] who reported positive response of higher levels of nitrogen along with zinc on crop weight to be described as overall an improvement in crop growth that enabled the plant to absorbed more nutrients and moisture which empowered the plant to manufacture more quantity of photosynthesis and accumulating them in sink. Zinc is reported to enhance the absorption of native as well as added major nutrients, thereby increased yield attributes and production of maize

(Bhattacharaya *et al*., 2008) [7]. Shanti *et al*. (1997) [29] reported that the result emphasizes the importance of adequate N supply for the crop to obtaining large-size cobs having more grains, with heavier and bold seeds that contribute to higher harvest indices and in turn higher grain yield. However, higher yield parameter was recorded in rural over peri-urban due to good soil properties in rural than peri-urban.

Table 5: Effect of different levels of nitrogen and zinc application on yield parameters of maize in rural and peri-urban

	Rural					Peri-urban				
	Grain weight cob^{-1} (g)	No. of grains cob^{-1}	100 Grain weight (g)	Cob diameter (cm)	Cob length (cm)	Grain weight cob^{-1} (g)	No. of grains cob^{-1}	100 Grain weight (g)	Cob diameter (cm)	Cob length (cm)
Factor 1: Levels of Nitrogen										
N_0 - 0 kg ha^{-1}	142.31	519.94	24.22	3.58	17.59	136.71	502.83	21.20	3.36	16.21
N_1 - 150 kg ha^{-1}	169.89	588.20	30.16	4.26	19.21	159.91	567.20	25.02	3.92	17.91
N_2 - 200 kg ha^{-1}	202.35	638.86	33.22	4.80	20.30	189.40	622.59	28.33	4.46	19.50
S.Em.±	3.99	11.03	2.56	0.11	0.37	3.48	9.68	2.37	0.14	0.38
CD @ 5%	11.97	33.06	NS	0.34	1.12	10.45	29.02	NS	0.42	1.15
Factor 2: Levels of Zinc										
Zn_0 - 0 kg ha^{-1}	153.80	555.93	26.89	3.88	18.22	145.66	534.07	23.07	3.58	16.98
Zn_1 - 2.1 kg ha^{-1}	173.09	586.47	29.56	4.26	18.97	164.26	567.85	24.90	3.95	18.04
Zn_2 - 4.2 kg ha^{-1}	187.66	604.60	31.16	4.50	19.91	176.09	590.69	26.58	4.21	18.60
S.Em.±	3.99	11.03	2.56	0.11	0.37	3.48	9.68	2.37	0.14	0.38
CD @ 5%	11.97	33.06	NS	0.34	1.12	10.45	29.02	NS	0.42	1.15

Grain yield

There was significant increase in grain yield with application of levels of fertilizers (Table 6) and followed order of 200 kg N ha^{-1} (N_2) > 150 kg N ha^{-1} (N_1) > 0 kg N ha^{-1} (N_0) which ranged from 63.28 to 82.16 q ha^{-1} in rural and 57.65 to 78.71 q ha^{-1} in peri urban. Whereas, application of 4.2 kg Zn ha^{-1} (Zn_2) recorded higher grain yield (78.11 and 73.60 q ha^{-1}) in rural and peri-urban, respectively and lower grain yield with no application of zinc (68.09 and 63.47 q ha^{-1}).

Stover yield

Application of different levels of nitrogen and zinc varied the stover yield at harvest (Table 6). Among different levels of nitrogen, application of 200 kg N ha^{-1} (N_2) resulted in higher stover yield (104.28 and 97.11 q ha^{-1}), in rural and peri-urban maize crop, respectively. In case different levels of zinc, Zn_2 which received 4.2 kg Zn ha^{-1} recorded higher stover yield (97.17 and 89.04 q ha^{-1}) in rural and peri urban, respectively.

Table 6: Effect of different levels of nitrogen and zinc application on yield of maize in rural and peri-urban

	Rural		Peri-urban	
	Grain yield (q ha^{-1})	Stover yield (q ha^{-1})	Grain yield(q ha^{-1})	Stover yield (q ha^{-1})
Factor 1: Levels of Nitrogen				
N_0 - 0 kg ha^{-1}	63.28	73.85	57.65	65.78
N_1 - 150 kg ha^{-1}	74.88	92.00	69.60	81.76
N_2 - 200 kg ha^{-1}	82.16	104.28	78.71	97.11
S.Em.±	1.35	2.06	1.33	3.46
CD @ 5%	4.05	6.16	3.97	10.38
Factor 2: Levels of Zinc				
Zn_0 - 0 kg ha^{-1}	68.09	83.28	63.47	73.49
Zn_1 - 2.1 kg ha^{-1}	74.11	89.69	68.89	82.12
Zn_2 - 4.2 kg ha^{-1}	78.11	97.17	73.60	89.04
S.Em.±	1.35	2.06	1.33	3.46
CD @ 5%	4.05	6.16	3.97	10.38

The increase in grain yield was probably due to more number of rows per cob, number of grains per row, more thousand grains weight *etc*. The encouragement in photosynthesis, rapid growth and formation of heavy green foliage by nitrogen and zinc effectiveness which in turn produced more yield (Iqbal *et al*., 2016) [13]. Nitrogen store up in grain during grain filling and affect the carbohydrate metabolism (Bahrani and Mesgarbashi, 1993) [5]. Whereas, zinc is useful to store hydrocarbon in pollen and increasing viability of pollen and also lead to increasing grain number and high yield (Masoni *et al*., 1996) [21]. This increase in yield was probably due to effective utilization of applied nutrients, increased sink capacity and nutrient uptake by the crop. Since nitrogen is the major structural constitute of cells, as nitrogen level increased the rate of vegetative and reproductive growth also increased in plants due to increase in assimilating surface of plants as well as total photosynthesis.

The increase in yield could be attributed to the proper supply of Zn up to harvesting stages in soil and which might have led to increased photosynthetic activity for longer period and their beneficial effect on metabolism of plants thereby finally increased dry-matter accumulation (Reddy *et al*., 2019) [26]. The results are also supported by those of Asif *et al*. (2013) [4] who reported positive effect of combined use of nitrogen and zinc on yield and yield contributing parameters.

The increase in dry matter may be attributed to positive interaction between N and Zn supply to maize fodder, as result greater biomass yield produces more dry matter. This increase in yield might be due to its function as catalyst or stimulant in most of the physiological and metabolic processes and metal activator of enzymes, resulting in increased growth and development, which ultimately gave higher grain and straw yields (Chauhan *et al.*, 2014) [10]. However rural showed higher yield due to improved physicochemical properties of soil compared to peri-urban. One more important reason that in rural, farmers were practicing agricultural operations such as crop rotation, frequent application of organic manure and judicious application of fertilisers to get higher yields.

Quality parameters

Protein content

The result of field experiment conducted to study the effect of different levels of nitrogen and zinc on protein content and oil content in rural and peri-urban are presented in Table 8. Among different levels of nitrogen and zinc, application of 200 kg N ha^{-1} (9.11 and 8.60%) and 4.2 kg Zn ha^{-1} (8.67 and 8.15%) resulted in higher protein content compared to other levels of nitrogen and zinc in rural and peri-urban maize crops, respectively (Table 7).

Protein content continued to increase with increasing N levels indicating that nitrogen being a major constituent of proteins contributed towards increase in protein content. Whereas, zinc is vital for protein and amino acid synthesis (Logeragan *et al*., 1982) [20] 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) [31]. They expressed that the increase could be due to preferential deposition of zein over the other endosperm proteins. Besides, exclusion of N, in our 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) [28]. 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) [17].

Table 7: Effect of different levels of nitrogen and zinc application on quality parameters of maize in rural and peri-urban

	Rural		Peri-urban	
	Quality Parameters			
	Protein content (%)	Oil content (%)	Protein content (%)	Oil content (%)
	Factor 1: Levels of Nitrogen			
N_0 - 0 kg ha^{-1}	7.41	3.32	6.84	3.26
N_1 - 150 kg ha^{-1}	8.21	3.71	7.69	3.63
N_2 - 200 kg ha^{-1}	9.11	3.99	8.60	3.96
S.Em.±	0.22	0.06	0.19	0.07
CD @ 5%	0.65	0.18	0.57	0.22
	Factor 2: Levels of Zinc			
Zn_0 - 0 kg ha^{-1}	7.79	3.57	7.24	3.46
Zn_1 - 2.1 kg ha^{-1}	8.27	3.65	7.73	3.66
Zn_2 - 4.2 kg ha^{-1}	8.67	3.81	8.15	3.73
S.Em.±	0.22	0.06	0.19	0.07
CD @ 5%	0.65	0.18	0.57	0.22

Oil content

Application of 200 kg N ha^{-1} (3.99 and 3.96%) and 4.2 kg Zn ha^{-1} (3.80 and 3.73%) resulted in higher oil content compared to other levels of nitrogen and zinc in rural and peri-urban maize crops, respectively (Table 7). Higher 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) [34]. These results narrate the findings of Witt and Pasuquin (2007) [35]. while grain oil content continues to decrease in maize grain due to dilution (Ray *et al*., 2019) [25]. It was also earlier confirmed by Rehman *et al*. (2011) [27].

Conclusion

As the nitrogen and zinc status in soils of rural and peri-urban was low, application of higher level of nitrogen and zinc gradually increased growth and yield attributes of maize. Application of 200 kg N ha^{-1} and 4.2 kg Zn ha^{-1} recorded significantly higher growth and yield attributes in maize growth in rural and peri-urban soils. It also improved protein and oil content in maize grains. Thus combined application of 200 kg N ha^{-1} and 4.2 kg Zn ha^{-1} should be applied for better yield.

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