Response of plant geometry, graded fertility and zinc level on yield and nutrients uptake by baby corn (Zea mays L.) and nutrients status of soil

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Abstract
A Field experiment was conducted on sandy loam soil at Sabour during kharif season of 2018 to evaluate optimum plant geometry, graded fertility level and zinc level for yield and nutrients uptake of baby corn (Zea mays L.). Experiment was laid out in split-plot design and replicated thrice with three plant geometry viz. P1 (40X20 cm), P2 (50X15 cm) and P3 (paired row at 50+30 x20 cm) in main plot, three levels of graded fertility (kg NPK ha⁻¹) viz. F1 (120:60:60), F2 (150:75:75) and F3 (180:90:90) in sub plot whereas, two levels of zinc (kg zinc ha⁻¹) viz. Z1 (2.5) and Z2 (5.0) in sub-sub plot. Significant increase in baby corn yield (14.34q ha⁻¹), nutrient uptake of baby corn, fodder and soil nutrient status were recorded with paired row plant geometry. The baby corn yield (13.92q ha⁻¹), green fodder yield (278.91q ha⁻¹), nitrogen, phosphorus and potash uptake of baby corn, fodder and soil nutrient status was higher with fertility level 180:90:90 kg N P₂O₅ K₂O ha⁻¹, Higher level of zinc (5.0kg ha⁻¹) had improved baby corn yield (13.38q ha⁻¹), green fodder yield (277.7q ha⁻¹) along with high uptake of nutrients and improved soil fertility status.

Keywords: Plant geometry, graded fertility, zinc, yield, nutrient uptake

1. Introduction
Maize (Zea mays L.) is grown on an area of 9.5 m ha, with production and productivity of 25.0 mt and 26.3 q ha⁻¹, respectively (Anon. 2018) in India. Maize assumes a special significance in Indian agriculture on account of its utilization as food, feed, fodder, silage and specialty corn besides several industrial uses. Baby corn ears in light yellow colour with regular row arrangement, 10 to 12 cm long and a diameter of 1.0 to 1.5 cm arrangement are preferred in the market. The crispy nature of baby corn and its high nutritional value has made it of special choice among the elite group of people. Its consumption is considered ecofriendly because it is free from the residue of pesticides by virtue of natural protection through many layers of husk. After harvesting of baby corn, quality palatable green fodder is used for cattle feed and for making good quality silage. At the same time it will also strengthen the cropping system (rice-wheat) and explore the possibilities of generating more income and employment for farming community of the region especially in periurban areas. There is good opportunity of baby corn production in rainfed region of South Bihar. The North Bihar including Diara region of Bihar is generally flooded after second week of August every year, which may be utilized for pre-kharif baby corn where short duration baby corn may be harvest before flood occurrence. Maize for baby corn may be grown as a best substitute for grain maize cultivation to get better economic returns because it is harvested in short time (within 65-75 days) which provides sweet, succulent and delicious green cobs and 3-4 crops of baby corn can be taken through staggered planting in a season with good quality of palatable green fodder. The short duration of the crop enables it to escape from many abiotic stresses expected to occur in the later part of the season. Baby corn has prime place as a safe and quality vegetable. It is emerging worldwide as one of the high value crops due to its high nutritive value, delicious taste, low calorie vegetable having higher fiber content without cholesterol and very large demand by the foreign tourists. Crop geometry vary widely in different parts of the world because great abundance of maize strains and their distribution all over the globe in different climatic
conditions. Crop geometry is one of the important factors for higher production as it determines the optimum plant population of a crop. Baby corn is heavy feeder of nutrients and productivity is largely dependent on nutrient management. Their application may assist in obtaining maximum production of baby corn; but the excessive use of chemical fertilizers has been associated with decline in soil physical and chemical properties and crop yield (Kumar et al., 2016) [6]. Zinc fertilization are used to increase micronutrient in edible parts to reduce the micro nutrient deficiency in human populations. For quality improvement of edible parts of crop, for enhancement of yield and zinc concentration in plants, Zn is extensively used. With successive increase of the graded fertility has not only enhanced the yield of baby corn and fodder in the significant manner and their availability status in the soil.

2. Material and Methods
A experiment was carried out at Research farm, Bihar Agricultural University, Sabour during kharif season of 2018. The farm is situated at 25°50’N latitude, 87°19’E longitude and at an altitude of 52.73 m above mean sea level. The sandy-loam soil of the experimental field was low in organic carbon (0.50%) and available N (182.3 kg/ha), medium in available P (37.7 kg/ha) and K (190.7 kg/ha) with pH 7.5. The experiment was laid out in split-plot design with three level of plant geometry viz. P1 (40X20 cm), P2 (50X15 cm) and P3 (paired row at 50+30 x 20 cm) in main plot, three levels of fertility (kg NPK/ha) viz. F1 (120:60:60), F2 (150:75:75) and F3 (180:90:90) in sub plot whereas, two levels of zinc (kg/ha) viz, Z1, (2.5) and Z2 (5.0) in sub-sub plot and replicated thrice. Crop was sown on 2nd June 2018 on levelled soil by opening 5 cm deep furrow at as per spacing of treatments. The different doses of fertilizers were applied as per the treatments. Full amount of phosphatic and potassic fertilizer, zinc and half amount of nitrogenous fertilizer were applied as uniformly as possible before sowing. The rest half of the nitrogenous fertilizer was applied as top dressing during the time of knee height stage and detasseling stage. The field was kept free from weeds. Harvesting of baby corn was done at 2-3 days of silk emergence stage by leaving border rows. These baby cobs were counted weighted and thereafter husked and silk was removed and baby corn yield was recorded. The fodder yield was measured after the last picking of baby corn and the dry fodder yield was calculated after drying the green fodder. The chemical analysis of baby corn, fodder and soil samples were carried out in the laboratory with their respective chemical analysis methods and the uptake of nitrogen, phosphorus, potassium and zinc was worked out for the baby corn and fodder samples. After harvest, soil sample were taken, processed then soil samples were analysed accordingly and their chemical parameter were worked out along with available nutrient status were find out.

2.1 Statistical analysis
The data on various observations were statistically analyzed by the procedure of analysis of variance for split-plot design (SPD) given by Panse and Sukhatma (1985). For significant ‘F’ test, critical difference (CD) was reported at 5 per cent probability level.

3. Results and Discussion
3.1 Effect of plant geometry, fertility and zinc on yield of baby corn and green fodder
Significantly higher baby corn yield (14.34 q ha⁻¹) were recorded with paired row planting. The crop under the wider inter row spacing has utilized the available resources more efficiently and hence, producing more yield attributes helped to higher baby corn yield. The crop under closer geometry at 50 cm x 15 cm of plant geometry exhibited highest green fodder yield (284.24 q ha⁻¹) and dry fodder yield (120.24 q ha⁻¹) as compared to the wider geometry. The fodder yield might have compensated these because of more number of plants ha⁻¹. The result is similar to the findings of Mathukia et al. (2014) [8] and Singh et al. (2015) [9].

Fertility had significant improved baby corn yield (13.92 q ha⁻¹), green fodder yield (278.91 q ha⁻¹) and dry fodder yield (118.44 q ha⁻¹) with application of F1 (180:90:90 kg N:P:O3:K:O ha⁻¹) however, bay corn yield was at par preceding level of fertility F2 (150:75:75 kgN:P:O3:K:O ha⁻¹). This might be due to better supply of nutrients which led to the better plant height, more number of green leaves, high value of LAI, increment in SPAD values and significant dry matter accumulation. All such improvement in growth parameter reflected profound growth and development and finely resulted significant increase in yield attributes of baby corn along with fodder yield. Saha and Mondal (2006) [13], Singh and Choudhary (2008) [18], Sahoo and Mahapatra (2007) [15] and Panwar (2008) [11] further advocated similar effect of fertility as it has been observed in the present study.

That might be due to better supply of nutrients, improved growth parameters and significant increase in yield attributes of baby corn.

Zinc significantly improved green fodder yield (277.7 q ha⁻¹) and dry fodder yield (118.28 q ha⁻¹) with successive increase in zinc level up to 5.0 kg Zn ha⁻¹. However, baby corn yield (13.38 q ha⁻¹) could not vary significantly with application of 5.0 kg Zn ha⁻¹. This might be due to zinc involved in various metabolic functions and enhances synthesis of growth hormones and protein. It is needed in the production of chlorophyll and metabolism of carbohydrate, may be resulted in higher chlorophyll contents and higher yield attributes, and this had apparently a positive effect on photosynthetic activity, synthesis of metabolites and growth-regulating substances, oxidation and metabolic activities and ultimately better growth and development of crop, which led to increase in yield attributes and yield of baby corn. The results were in conformity with Meena et al. (2013) [9], Shivay and Prasad (2014) [16]. Zinc fertilization has beneficial effect on physiological process, plant metabolism and plant growth, which leads to higher yield. Increase in cob and corn yield with application of zinc was also reported by Kumar and Bohra (2014) [4].

3.2 Effect of plant geometry, fertility and zinc on nutrient uptake by baby corn and fodder
Scanning of the data of table 1 and 2 reveals that significant removal of nutrients (kg ha⁻¹) viz, N,P, K and Zn are 178.08, 33.30, 228.52 kg ha⁻¹ and 352.52 g ha⁻¹ respectively by baby corn plant (baby corn and fodder) has been found in P3 (paired row) plant geometry. The planting geometry of P3, paired row was attributed due to higher yield attributes and baby corn yield q ha⁻¹. The results collaborate with the findings of Kumar (2008) [2]. The wider crop geometry had helped the individual plants to make better spatial utilization of available moisture, nutrients and higher interception of solar radiation with lesser competition which contributed towards more dry matter production per plant and ultimately enhancement of the uptake and utilization of nutrients.
Increase in fertility level up to F1(180:90:90 kgN:P2O5:K2O ha\(^{-1}\)) significantly resulted in the higher uptake and utilization of nitrogen (188.02 kg ha\(^{-1}\)), phosphorus (34.33 kg ha\(^{-1}\)), and potassium (237.87 kg ha\(^{-1}\)) while the significantly higher uptake of zinc (355.51 g ha\(^{-1}\)) by baby corn plant (baby corn and fodder) was observed at the lower fertility level. Higher dose of applied nutrients made luxury availability of nutrients to the plant which led to the better plant height, more number of green leaves, high value of LAI, increment in SPAD values and significant dry matter accumulation and more yield and nutrients content in plant ultimately influenced higher uptake by plants. Sahoo and Mahapatra (2007)\(^{(15)}\) and Panwar (2008)\(^{(11)}\) further advocated similar effect of fertility as it has been observed in the present study.

There was higher uptake of nitrogen (178.12 kg ha\(^{-1}\)), phosphorus (30.44 kg ha\(^{-1}\)), potassium (227.67 kg ha\(^{-1}\)) and zinc (345.77 g ha\(^{-1}\)) with successive increase in zinc level up to maximum level of fertility Zn2 (5.0 kg ha\(^{-1}\)) this might be due to takes part in metabolism of plant as an activator of several enzymes it lead to higher yield attributes, baby corn and green fodder yield of baby corn (Kumar and Bohra, 2014)\(^{(4)}\). The similar results were in conformity with Meena et al. (2013)\(^{(9)}\), Shivay and Prasad (2014)\(^{(10)}\).

### 3.3 Effect of plant geometry, fertility and zinc on nutrient status of soil

After harvest of the baby corn crop, paired row plant geometry had higher values of available nitrogen (178.04 kg ha\(^{-1}\)), phosphorus (36.40 kg ha\(^{-1}\)), potassium (228.28 kg ha\(^{-1}\)) and zinc (0.47 ppm). This might be due to less fodder yield and better soil environment and microbial activity over dense planting.

Increase in successive fertility level increased the available nutrients status in the soil after harvest of baby corn higher values of available nitrogen (188.97 kg ha\(^{-1}\)), phosphorus (39.39 kg ha\(^{-1}\)) and potassium (238.75 kg ha\(^{-1}\)) were found with F1(180:90:90 kgN:P2O5:K2O ha\(^{-1}\)) fertility levels. This might be due to higher added dose of fertiliser could not fully utilised by plants and remained in soil. Singh et al., (2010)\(^{(20)}\) found similar trend. Singh and Nepalia (2009) reported that application of 125% RDF (90 kg N+40 kg P2O5) favourably improved soil organic carbon, available N and K status over 100 RDF.

Application of Zinc 5.0 kg ha\(^{-1}\) recorded a little bit higher values of available nitrogen (178.60 kg ha\(^{-1}\)), phosphorus (31.49 kg ha\(^{-1}\)) and potassium (228.72 kg ha\(^{-1}\)) and Zinc (0.43 ppm) over lower level of zinc application.

### Table 1A: Interaction effect of fertility and zinc level on fodder yield (q ha\(^{-1}\)) after baby corn harvest

| Treatments | Z2(2.5 kg Zn ha\(^{-1}\)) | Z5(5.0 kg Zn ha\(^{-1}\)) | Mean | Z2(2.5 kg Zn ha\(^{-1}\)) | Z5(5.0 kg Zn ha\(^{-1}\)) | Mean |
|------------|------------------------|------------------------|------|------------------------|------------------------|------|
| F1 (120:60:60) | 267.80 | 269.40 | 268.10 | 110.81 | 112.29 | 111.55 |
| F2 (150:75:75) | 272.57 | 272.75 | 272.67 | 112.67 | 119.03 | 115.85 |
| F3 (180:90:90) | 278.91 | 281.54 | 280.23 | 117.35 | 119.54 | 118.44 |
| Mean | 267.14 | 277.70 | 272.42 | 113.61 | 118.28 |      |
| SEm± | 1.62 | 0.66 |      |      |      |      |
| C.D. | 4.82 | 1.98 |      |      |      |      |

### Table 1: Effect of plant geometry, graded fertility and zinc level on quality of baby corn and fodder

| Treatments | Yield (q ha\(^{-1}\)) | Nitrogen uptake (kg ha\(^{-1}\)) | Phosphorous uptake (kg ha\(^{-1}\)) | Potash uptake (kg ha\(^{-1}\)) |
|------------|----------------------|-------------------------------|----------------------------------|-------------------------------|
| Plant geometry | Baby corn | Green fodder | Dry fodder | Baby corn | Fodder | Total | Baby corn | Fodder | Total | Babycorn | Fodder | Total |
| P1 (40x20 cm) | 12.05 | 266.10 | 113.55 | 2.68 | 150.07 | 152.76 | 0.71 | 25.31 | 26.02 | 2.87 | 189.48 | 192.35 |
| P2 (50X15 cm) | 13.52 | 272.25 | 115.85 | 3.40 | 165.76 | 169.16 | 0.81 | 29.04 | 29.85 | 3.26 | 221.70 | 224.97 |
| P3 (Paired row) | 13.92 | 278.91 | 118.44 | 4.02 | 184.00 | 188.02 | 0.88 | 33.45 | 33.30 | 3.75 | 224.78 | 228.52 |
| S Em ± | 0.17 | 1.34 | 0.56 | 0.05 | 1.55 | 1.57 | 0.01 | 0.37 | 0.07 | 0.05 | 2.11 | 2.10 |
| C.D. (P=0.05) | 0.52 | 4.14 | 1.73 | 0.16 | 4.78 | 4.84 | 0.03 | 1.15 | 1.16 | 0.05 | 6.49 | 6.47 |

### Fertility level (N\(P_{2}O_{5}:K_{2}O\) kg ha\(^{-1}\))

| Treatments | Z2(2.5) | Z5(5.0) | S Em ± | C.D. (P=0.05) |
|------------|---------|---------|--------|---------------|
| F1 (120:60:60) | 12.95 | 267.14 | 113.61 | 0.13 | 0.94 |
| F2 (150:75:75) | 13.38 | 277.70 | 118.28 | 0.13 | 0.94 |
| F3 (180:90:90) | 13.38 | 277.70 | 118.28 | 0.13 | 0.94 |

### Zinc level (Zn kg ha\(^{-1}\))

| Zinc level | Z2(2.5) | Z5(5.0) | S Em ± | C.D. (P=0.05) |
|------------|---------|---------|--------|---------------|
| F1 (120:60:60) | 13.38 | 277.70 | 118.28 | 0.13 | 0.94 |
| F2 (150:75:75) | 13.38 | 277.70 | 118.28 | 0.13 | 0.94 |
| F3 (180:90:90) | 13.38 | 277.70 | 118.28 | 0.13 | 0.94 |

### Table 2: Effect of Plant geometry, fertility and zinc level on Zinc uptake (g ha\(^{-1}\)) and on nutrients status of soil

| Treatments | Zinc uptake (g ha\(^{-1}\)) | Soil parameters after harvest of baby corn |
|------------|-----------------------------|------------------------------------------|
| Baby corn | Fodder | Total | pH | EC (dSm\(^{-1}\)) | OC (%) | Available N (kg ha\(^{-1}\)) | Available P\(_{2}O_{5}\) (kg ha\(^{-1}\)) | Available K\(_{2}O\) (kg ha\(^{-1}\)) | Zn (ppm) |
| P1 (40x20 cm) | 38.51 | 292.86 | 331.38 | 7.65 | 0.12 | 0.46 | 162.97 | 32.27 | 213.17 | 0.40 |
| P2 (50X15 cm) | 29.92 | 262.97 | 292.89 | 7.66 | 0.12 | 0.43 | 169.93 | 25.56 | 220.05 | 0.38 |
| P3 (Paired row) | 44.59 | 307.92 | 352.52 | 7.66 | 0.12 | 0.45 | 178.04 | 36.40 | 228.28 | 0.47 |
| S Em ± | 1.93 | 6.36 | 8.03 | 0.10 | 5.43 | 3.58 | 3.96 | 0.64 | 2.24 | 0.01 |
| C.D. (P=0.05) | 7.56 | 24.98 | 31.51 | NS | NS | NS | NS | 2.51 | 8.78 | 0.03 |

### Fertility level (N\(P_{2}O_{5}:K_{2}O\) kg ha\(^{-1}\))
4. Conclusion
It may be concluded that paired row plant geometry with application of 180:90:90 kg N:P:K ha⁻¹ along with Zinc 5.0 kg ha⁻¹ may be recommended for higher, Yield of baby corn, fodder yield and soil nutrients status.

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