Int.J.Curr.Microbiol.App.Sci (2019) *8*(7): 1658-1667

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 8 Number 07 (2019)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2019.807.197

Effect of Plant Geometry, Fertility Level and Zinc Level on *Kharif* Baby Corn (*Zea mays* L.)

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Keywords

Plant geometry, Fertility, Zinc, Maize (*Zea mays* L.)

Article Info

Accepted:
12 June 2019
Available Online:
10 July 2019

A B S T R A C T

A Field experiments were carried out on sandy loam soil at Sabour during kharif season of 2018 to evaluate appropriate plant geometry, fertility levels and zinc lvel for baby corn (*Zea mays* L.). Experiment was laid out in split–plot design and replicated thrice with three plant geometry viz. P_1 (40X20 cm), P_2 (50X15 cm) and P_3 (paired row at 50+30 x20 cm) in main plot, three levels of fertility (kg NPK/ha) viz. F_1(120:60:60), F_2 (150:75:75) and F_3 (180:90:90) in sub plot whereas, two levels of zinc (kg/ha) viz., Z_1 (2.5) and Z_2 (5.0) in sub-sub plot. Significant increase in baby corn yield (14.34q ha^{-1}), green fodder yield (267.822q ha^{-1}) and net return (Rs 225774 ha^{-1}) and B: C ratio (5.12) in baby corn was recorded with paired row plant geometry. The baby corn yield (13.92q ha^{-1}), green fodder yield (278.91q ha^{-1}) and net return (Rs 219108 ha^{-1}) and B: C ratio (4.81) was significantly higher with fertility level 180: 90: 90 kg N P_2O_5 K_2O/ha. Higher level of zinc had improved baby corn yield (13.38q ha^{-1}), green fodder yield (277.7q ha^{-1}) and net return (Rs 211821 ha^{-1}) and B: C ratio (4.77) with successive increase in zinc level up to maximum level of fertility Zn_2 (5.0 kg ha^{-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. 2017-18) in India. The crispy nature of baby corn and its high nutritional value (86-89 % moisture, 8.2 g carbohydrate, 2 g protein, 0.2 g fat, 0.28 mg calcium, 0.86 mg phosphorus, 0.11 mg iron, 0.05 mg thiamin, 0.08 mg riboflavin, 11 mg ascorbic acid per 100 g of fresh baby corn) has made it of special choice among the elite group of people (Das *et al.*, 2009). 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. 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. The diara area of Bihar is generally flooded after second week of August every year, which may be utilized for *kharif* baby corn where short duration baby corn may be harvest before flood occurrence. Baby corn has prime place as a safe and quality vegetable. 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 and 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. 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, its 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). 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.

Materials 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. P_1 (40X20 cm), P_2 (50X15 cm) and P_3 (paired row at 50+30 x20 cm) in main plot, three levels of fertility (kg NPK/ha) viz. F_1 (120:60:60), F_2 (150:75:75) and F_3 (180:90:90) in sub plot whereas, two levels of zinc (kg/ha) viz., Z_1 (2.5) and Z_2 (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 earthing up 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.

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.

Results and Discussion

Effect of Plant geometry, fertility and zinc on growth characters

The different spacing treatments has been found to exert a significant difference on crop growth in terms of plant height and leaf area index plant height except during initial stage of growth. The data regarding plant height at harvest revealed that high plant density 50cm x 15 cm spacing had significantly higher plant height and LAI as compared to other spacing treatments. The higher plant height in closer spacing might be attributed to increase in competition for sunlight, nutrients, space and water by the plants which coupled with favourable climatic conditions especially temperature might have resulted in maximum plant height. The results are in conformity with the findings of Kunjir *et al.,* (2007) who also recorded higher plant height with closer spacing as compared over wider spacing. Higher leaf area index in closer spacing was observed due to increased plant density which accommodates more number of plants and can also be ascribed to lesser value of spacing (Wasnik *et al.,* 2012).

The crop sown under P_3 (paired row at 50+30 x20 cm) resulted significant values of no of leaves, dry matter accumulation. This might be due to the fact that lesser competition between the plants under paired row spacing which might have provided sufficient space to the crop for harnessing the solar energy and effective utilization of nutrients and moisture.

As regards to fertility level, F_3 (180:90:90 kg $N:P_2O_5:K_2O$ ha^{-1}) recorded significantly higher values of growth characters (plant height, no of leaves, LAI, dry matter accumulation and SPAD) but remained at par to preceding fertility level F_2 (150:75:75 kg $N:P_2O_5:K_2O$ ha^{-1}) at almost all the growth stages. This might be due to the more availability of nutrients in soil. These results are in line with Khadtare *et al.,* (2006) and Dadarwal *et al.,* (2009). Irrespective of variation in the level of fertility, balance application of N, P and K enables the crop to produce taller plants and more number of active leaves which ultimately caused more dry matter accumulation. The dry matter accumulation was initially slow because of slow growth during early stages (lag phase) primarily due to lower assimilating surface which rendered lower rate of photosynthesis and consequently less dry matter production during the initial stage of crop growth. Results obtained Sahoo and Mahapatra (2007), Singh and Choudhary (2008).

It is obvious from data that zinc supply caused significant effect on growth characters (plant height, no of leaves, LAI, dry matter accumulation).Tallest plant was noticed in Zn_2 (5.0 kg ha^{-1}). As Zinc fertilization has beneficial effect on physiological process, plant metabolism and plant growth. Similar observation was noticed by Kumar and Bohra (2014) with application of zinc in maize. Application of Z_2 (5 kg Zn ha^{-1}) exerted significant increase in LAI and dry matter accumulation over Z_1 (2.5 kg ha^{-1}) this happened due to zinc application which takes part in metabolism of plant as an activator of several enzymes and in turn may directly or indirectly affect the synthesis of carbohydrate and protein. These results are in conformity with the results Arya and Singh (2000). Nitrogen and zinc also helps in manufacturing more leaf area as a consequence more assimilates production. Similarly more vegetative development by nitrogen resulted in increased mutual shading and intermodal expansion was also reported by Asif *et al.,* (2013) (Table 1).

Table.1 Effect of plant geometry, fertility and zinc level on growth characters of baby corn at harvest

Treatments	Plant height (cm)	No of leaves plant^{-1}	LAI	Dry weight (g plant^{-1})
Plant geometry				
P_1 (40x20 cm)	203.67	10.39	3.75	101.29
P_2 (50X15 cm)	212.07	9.98	4.26	97.84
P_3 (Paired row)	205.63	10.63	4.12	103.35
S Em ±	1.59	0.12	0.08	1.04
CD (P=0.05)	6.26	0.48	0.30	4.09
Fertility level (N:P_2O_5 : K_2O kg ha^{-1})				
F_1 (120:60:60)	201.85	9.93	3.61	98.75
F_2 (150:75:75)	208.09	10.46	4.01	100.64
F_3 (180:90:90)	211.43	10.61	4.50	103.08
S Em ±	1.96	0.13	0.05	0.78
CD (P=0.05)	6.04	0.40	0.16	2.42
Zinc level (Zn kg ha^{-1})				
Z_1(2.5)	205.65	10.25	3.94	99.90
Z_2 (5.0)	208.59	10.42	4.14	101.75
S Em ±	1.59	0.10	0.02	0.40
CD (P=0.05)	NS	NS	0.06	1.19
Interaction				
P×F	NS	NS	S	NS
F×Z	NS	NS	NS	NS
P×Z	NS	NS	NS	S
P×F×Z	NS	NS	NS	NS

Table.1A Interaction effect of plant geometry and fertility level on leaf area index at harvest

Treatment	F_1	F_2	F_3	Mean
P_1	3.60	3.69	3.97	3.75
P_2	3.69	4.24	4.84	4.26
P_3	3.54	4.11	4.71	4.12
Mean	3.61	4.01	4.50	
SEm±	0.09			
C.D.	0.28			

Table.1b Interaction effect of plant geometry and zinc level on dry matter accumulation (g/plant) at harvest

Treatment	Z_1	Z_2	Mean
P_1	100.52	102.06	101.29
P_2	96.85	98.82	97.84
P_3	102.32	104.37	103.35
Mean	99.90	101.75	
SEm±	0.69		
C.D.	2.05		

Table.2 Effect of plant geometry, fertility and zinc level on yield attributes of baby corn

Treatments	Baby cob length (cm)	Baby corn length (cm)	Baby corn girth (cm)	Baby cob weight (g) plant^{-1}	Baby corn weight (g) plant^{-1}	Barren plant (ha^{-1})
Plant geometry						
P_1 (40x20 cm)	19.76	9.61	3.58	40.14	10.90	11642
P_2 (50X15 cm)	19.78	9.41	3.52	37.33	10.51	12988
P_3 (Paired row)	20.90	10.23	4.01	46.89	13.08	11357
S Em ±	0.25	0.15	0.04	1.19	0.36	87
CD (P=0.05)	0.97	0.57	0.18	4.66	1.41	342
Fertility level (N:P_2O_5 : K_2O kg ha^{-1})						
F_1 (120:60:60)	19.73	9.44	3.58	38.67	10.32	13122
F_2 (150:75:75)	20.16	9.81	3.75	40.81	11.02	12846
F_3 (180:90:90)	20.56	10.00	3.78	44.88	13.15	10020
S Em ±	0.15	0.14	0.04	0.74	0.24	119
CD (P=0.05)	0.47	0.44	0.13	2.29	0.74	366
Zinc level (Zn kg ha^{-1})						
Z_1(2.5)	19.76	9.63	3.64	40.28	11.18	12193
Z_2 (5.0)	20.54	9.87	3.77	42.62	11.82	11798
S Em ±	0.12	0.08	0.03	0.44	0.13	62
CD (P=0.05)	0.34	NS	0.08	1.30	0.38	185
Interaction						
P×F	NS	NS	NS	NS	NS	S
F×Z	NS	NS	NS	NS	NS	S
P×Z	NS	NS	NS	NS	NS	NS
P×F×Z	NS	NS	NS	NS	NS	NS

Table.3 Effect of plant geometry, fertility and zinc level on yield and economics of baby corn

Treatments	Baby cob yield (q ha^{-1})	Baby corn yield (q ha^{-1})	Green fodder yield (q ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B: C Ratio
Plant geometry						
P_1 (40x20 cm)	50.77	13.06	265.20	248949	204868	4.64
P_2 (50X15 cm)	46.90	12.09	284.24	238223	193782	4.35
P_3 (Paired row)	54.91	14.34	267.82	269855	225774	5.12
S Em ±	0.84	0.21	3.58	2944	2944	0.07
CD (P=0.05)	3.30	0.83	14.05	11560	11560	0.26
Fertility level (N:P_2O_5 : K_2O kg ha^{-1})						
F_1 (120:60:60)	46.87	12.05	266.10	235512	192642	4.49
F_2 (150:75:75)	52.04	13.52	272.25	256875	212673	4.81
F_3 (180:90:90)	53.66	13.92	278.91	264641	219108	4.81
S Em ±	0.59	0.12	1.34	2606	2606	0.06
CD (P=0.05)	1.81	0.37	4.14	8031	8031	0.18
Zinc level (Zn kg ha^{-1})						
Z_1(2.5)	50.11	12.95	267.14	248473	204461	4.64
Z_2 (5.0)	51.61	13.38	277.70	256212	211821	4.77
S Em ±	0.52	0.13	0.94	1999	1999	0.05
CD (P=0.05)	NS	NS	2.78	5939	5939	NS
Interaction						
P×F	S	S	NS	S	S	NS
F×Z	NS	NS	S	NS	NS	NS
P×Z	NS	NS	NS	NS	NS	NS
P×F×Z	S	NS	NS	S	S	NS

Effect of plant geometry, fertility and zinc on yield attributes and yield of baby corn

Yield attributes *i.e*, baby cob length, baby corn length, baby corn girth, baby corn weight (g) plant^{-1}, baby cob weight (g) plant^{-1}, total cob and baby corn yield q ha^{-1}, were significantly higher in P_3 (paired row). The crop under the wider spacing has utilized the available resources more efficiently and hence, producing more number of cobs plant$^{-1,}$ higher cob weight attributing to higher cob yield plant^{-1}. However, the crop under closer geometry P_2 level (50 cm ×15 cm) of plant geometry exhibited highest fodder yield as compared to the wider geometry though the values of yield attributes were poor with closer spacing. The fodder yield might have compensated these because of more number of plants ha^{-1}. The result is similar to the findings of Cho *et al.*, (2001) and in close conformity to those findings of Gosavi and Bhagat (2009), Mathukia *et al.*, (2014) and Singh *et al.*, (2015) (Table 2).

Fertility had improved yield attributes *i.e*, baby cob length, baby corn length, baby corn girth, baby corn weight (g) plant^{-1}, baby cob weight (g) plant^{-1}, total cob and baby corn yield q ha^{-1} and green fodder yield with successive increase in fertility level up to maximum level of fertility F_3 (180-90-90). That 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. Saha and Mondal (2006), Panwar and Munda (2006), Singh and Choudhary (2008), Sahoo and Mahapatra (2007) and Panwar (2008) further advocated similar effect of fertility as it has been observed in the present study.

Zinc had improved yield attributes *i.e.*, baby cob length, baby corn length, baby corn girth, baby corn weight (g) plant^{-1}, baby cob weight (g) plant^{-1}, and green fodder yield with successive increase in zinc level up to maximum level of fertility Zn_2 (5.0 kg ha^{-1}). However, total cob and baby corn yield q ha^{-1} could not vary significantly due to zinc level. Higher zinc level Z_2 (5 kg zinc ha^{-1}) also had significant effect on number of baby corn plant^{-1}, baby corn weight, cob as well as corn girth and green fodder yield.

The increase in yield attributes due to application of zinc was caused by higher chlorophyll contents, 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 of baby corn.

The results were in conformity with Meena *et al.*, (2013), Kumar and Bohra (2014) and Shivay and Prasad (2014). 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).

Effect of plant geometry, fertility and zinc on economics of baby corn

Perusal of Table 3 reveals that highest net returns (Rs 225774 ha-^{1}) and B: C ratio 5.12 had found in P_3 (paired row) plant geometry.

The planting geometry of P_3 paired row was attributed due to higher yield attributes *i.e*, baby cob length, baby corn length, baby corn girth, baby corn weight (g) plant^{-1}, baby cob weight (g) plant^{-1}, total cob and baby corn yield q ha^{-1}. The results collaborate with the findings of Kumar (2008).

Increase in fertility level upto F_3 (180-90-90) significantly fetched higher net returns (Rs 219108 ha-^{1}) and B: C ratio 4.81 in baby corn. This was attributed due to higher yield attributes *i.e.*, baby cob length, baby corn length, baby corn girth, baby corn weight (g) plant^{-1}, baby cob weight (g) plant^{-1}, total cob and baby corn yield q ha^{-1} and green fodder yield. Similar finding was repoted by Jeet *et al.*, (2014) reported highest net return and B: C ratio was recorded under 150 kg N ha^{-1}in QPM hybrids. In the same way, Kumar *et al.*, (2014) reported that yield of cob, corn and green fodder besides gross return, net return and benefit cost ratio increased significantly with application of 125% RDF (recommended dose of fertilizer) over 100% RDF.

Zinc level had improved gross return and net return with successive increase in zinc level up to maximum level of fertility Zn_2 (5.0 kg ha^{-1}). Higher gross return (Rs 256212) and net return (Rs 219108) was recorded with Zn_2 (5.0 kg ha^{-1}) application, this might be due to higher yield attributes and green fodder yield of baby corn.

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How to cite this article:

Alka Jyoti Sharma, M. K. Singh, Sanjay Kumar and Shweta Shambhavi. 2019. Effect of Plant Geometry, Fertility Level and Zinc Level on Kharif Baby Corn (*Zea mays* L.). *Int.J.Curr.Microbiol.App.Sci.* 8(07): 1658-1667. doi: https://doi.org/10.20546/ijcmas.2019.807.197