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Effect of Plant Densities and Fertilizer Levels on Growth, Yield Attributing Characters and Yield of Baby Corn

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ABSTRACT

A field experiment was conducted at the Agricultural Research Station, Garikapadu, to study the effect of plant densities and fertilizer levels on growth, yield attributing characters and yield of baby corn. The highest plant height (177.7 cm), drymatter accumulation (8722.1 kg ha^{-1}), days to 50% tasseling (51.1), days to 50% silking (54.0) and green fodder yield (25.9 t ha^{-1}) were recorded with the planting density of 3,33,333 plants ha^{-1}. The highest number of ears per plant (2.1), ear length (12.3cm), ear weight with husk and without husk (92.5 g & 24.8 g) and ear yield (92.4 q ha^{-1}) were recorded with the planting density of 1,11,111 plants ha^{-1}. Application of 125% RDF gave the highest plant height (168.1 cm), drymatter accumulation (9308.3 kg ha^{-1}), number of ears per plant (1.8), ear length (13.0 cm), ear weight with husk and without husk (95.3 g & 27.2 g), ear yield (105.4 q ha^{-1}) and green fodder yield (25.9 t ha^{-1}).

Key words: Baby corn, Fertilizer levels, Growth, Plant densities, Yield.

Baby corn is the dehusked corn ear, harvested within 2-3 days of silk emergence but prior to fertilization (Pandey *et al*., 2000). It may be eaten raw as salad or used as an ingredient in various preparations *viz*., soup, pakora, vegetables, pickles etc. Further, baby corn is an added advantage in dairy farms since its husk, green nutritive leaves and stem after picking ears may be used as fodder for cattle. One hundred grams of baby corn is found to be rich in 89.1% moisture, 1.9 g of protein, 0.2 g fat, 0.06 g ash, 8.2 mg of carbohydrate, 28 mg calcium, 86 mg phosphorus and 11 mg ascorbic acid. It is rich in phosphorus content (86 mg/100 g edible portion in comparison to 21 to 57 mg phosphorus content in other commonly used vegetables).

In order to popularize its cultivation among the farming community, it is essential to standardize its agro-techniques not only for its potential yield and green fodder but also for its quality young ears. Among different agronomic practices, optimum plant density and nutrient requirement are the most important factors affecting the productivity, yield and quality of baby corn. In order to achieve higher ear yield, maintenance of plant density is the most important factor. Plant density is unique in baby corn production in order to obtain the maximum number of ears per unit area. Spatial arrangement of a plant governs the shape and size of the leaf area per plant, which in turn influences efficient interception of radiant energy and proliferation and growth of shoot and their activity. Maximum yield can be expected only when the population allows individual plant to achieve it's maximum inherent potential.

Crop nutrition is an important aspect to achieve the higher yield of baby corn. Singh *et al.* (2010) reported good response of baby corn to higher doses of NPK. Nitrogen is an essential element and important determinant of plant growth and development. Phosphorus plays a key role in energy transfer and is essential for photosynthesis and other chemico-physiological processes in plants. Potassium is one of the most crucial plant nutrient involved in many physiological processes. Potassium's impact on water relations, photosynthesis, assimilate transport and enzyme activation was reported by many works. Balanced use of N, P and K fertilizers play a pivotal role in increasing the yields of cereals.

MATERIAL AND METHODS

The experiment was laid out in field No.3, in "B" block of Agricultural Research Station, Garikapadu, on a sandy loam in texture, very low in available nitrogen (180 kg ha^{-1}), medium in phosphorus (25 kg ha^{-1}), high in potassium (270 kg ha^{-1}), medium in organic carbon (0.74%) and slightly neutral in reaction (pH 6.7).

The treatments consisted of a combination of four population levels S_1 : 30 cm x 10 cm (3,33,333 plants ha^{-1}), S_2 : 30 cm x 15 cm (2,22,222 plants ha^{-1}), S_3 : 45 cm x 10 cm (2,22,222 plants ha^{-1}), S_4 : 45 cm x 20 cm (1,11,111 plants ha^{-1}) and four fertilizer levels F_1 : Control (0:0:0 kg NPK ha^{-1}), F_2 : 75% RDF (90:45:30 kg NPK ha^{-1}), F_3 : 100% RDF (120:60:40 kg NPK ha^{-1}) and F_4 : 125% RDF (150:75:50 kg NPK ha^{-1}) in Factor – A and Factor – B respectively. The experiment was laid out in Randomized Block Design with factorial concept and the treatments were replicated thrice. A sturdy and vigorously growing baby corn hybrid G-5414 was sown on 10 th August, 2015 as per treatment combinations. Nitrogen and Phosphorus were applied in the form of Urea, SSP and Potash in the form of MOP. SSP and MOP were applied as per the treatments in basal dose. Urea was applied 1/3rd as basal, 1/3rd at 20 days after sowing and the remaining 1/3rd at 40 days after sowing. Statistical analysis for the data recorded *viz.,* pre-harvest and post harvest observations of baby corn was done following the analysis of variance technique for Randomized Block Design as suggested by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

At harvest, significantly taller plants (177.7 cm) were recorded with a plant density of 3,33,333 plants ha^{-1} and the least plant height (129.7 cm) was registered with 1,11,111 plants ha^{-1}. Taller plants in the plots with high population levels might be due to over crowded plant densities and the interplant competition that could result in more cell division, cell elongation in search of light and other natural resources. The stem with its apical meristem usually remain embryonic and capable of growth over long periods. For the rapid division and elongation of this apical meristem, where the light involvement is there, in search of light, plants might have increased their height. At low plant densities, in the absence of interplant competition and sufficiency of light availability might have not encouraged the plants to grow taller. Hence, the plants are dwarfer when compared to plants at high population levels. Similar findings were reported by Moosavi *et al.* (2012) and Dar *et al.* (2014). During harvest 125% RDF resulted in the tallest plants with 168.1 cm and was on par with 100% RDF with 154.2 cm and significantly superior to control with 115.2 cm and 75% RDF with 132.3 cm. The maximum plant height recorded at higher levels of fertilizer might be due to balanced supply of sufficient nutrients in suitable proportion and in sufficient quantities during the crop growth and development. This sufficiency of nutrients might have resulted in better cell division and cell elongation. This better creation of chlorophyll at higher fertilizer levels could have lead for higher rates of photosynthesis that ultimately produced more taller plants. Rapid division and elongation of cells with increasing fertility level particularly N and greater availability of nitrogen at higher fertilizer doses which improved photosynthesis as well as protein synthesis ultimately led to vigorous plant growth. Marwan *et al.* (2015) also reported similar effects of higher fertilization on baby corn.

At harvest, the maximum drymatter accumulation (8722.1 kg ha^{-1}) was recorded with a plant density of 3,33,333 plants ha^{-1} (Table 1). This was significantly superior to other three levels of plant density *viz.,* 30 cm x 15 cm (2,22,222 plants ha^{-1}) with 6451.4 kg ha^{-1}, 45 cm x 10 cm (2,22,222 plants ha^{-1}) with 6637.7 kg ha^{-1} and 45 cm x 20 cm (1,11,111 plants ha^{-1}) with 5443.2 kg ha^{-1}. At lower plant densities, due to more availability of space, light, moisture and nutrients, per plant, the drymatter increased but total drymatter yield was lower due to lower number of plants per unit area. However, at higher plant densities, even though the drymatter $plant^{-1}$ was lower due to interplant competition, higher densities resulted in higher total drymatter in unit area. Similar observations of higher drymatter at higher planting densities compared to lower planting densities was also reported by Arvadiya *et al.* (2012). At harvest the application of 125% RDF resulted in the maximum drymatter production of 9308.3 kg ha^{-1}, However, it was significantly superior to control, 75% RDF and on par with 100% RDF. Increased drymatter with increased fertilizer level might be due to the adequate supply of N, P and K that might have helped the baby corn plant to enhance their plant growth through production of more number of leaves per plant and higher leaf area which inturn put forth

Table 1. Growth components of baby corn as influenced by plant densities and fertilizer levels.

Treatment	Plant height at harvest (cm)	Drymatter accumulation at harvest (kg ha^{-1})	50% tasseling	50% silking
Plant densities (plants ha^{-1})				
S_1 - 3,33,333	177.7	8722.1	51.1	54.0
S_2 - 2,22,222	158.2	6451.4	49.5	52.4
S_3 - 2,22,222	151.4	6637.7	49.3	51.7
S_4 - 1,11,111	129.7	5443.2	48.2	50.9
S.Em±	5.44	326.6	0.50	0.48
CD (P = 0.05)	15.9	958	1.5	1.4
Fertilizer levels				
F_1 - Control	115.2	2689.2	51.7	53.9
F_2 – 75% RDF	132.3	5255.6	51.0	52.7
F_3 – 100% RDF	154.2	8358.1	49.4	51.8
F_4 – 125% RDF	168.1	9308.3	48.2	50.1
S.Em±	5.4	326.6	0.50	0.48
CD (P = 0.05)	15.9	958	1.5	1.4
Interaction (S X F)				
S.Em±	7.7	461.9	0.71	0.69
CD (P = 0.05)	NS	NS	NS	NS
CV (%)	8.0	11.3	2.5	2.3

more photosynthates, thus contributing for higher drymatter production. These results are in close conformity with the findings of Singh *et al*. (2010), Sobhana *et al*. (2012), Rakesh kumar *et al*. (2015) and Marwan *et al*. (2015) in baby corn.

Significantly higher number of days for 50% tasseling (51.1) was recorded with 3,33,333 plants ha^{-1} while the lowest number of days (48.2) was observed with 1,11,111 population. This might be due to more competition between plants for moisture and nutrients at high plant densities and that might have slowed down the physiological development and ultimately delayed the emergence of tassel. A plant must absorb light before it can begin to respond to that light. The absorption of light by the plant causes activation, thus initiating a sequence of chemical reactions that lead ultimately to a general plant response. Under high densities there was an inter-plant competition for light where as at low plant populations, such inter-plant competition was low. This better availability and absorption of light at low plant populations might have encouraged better transformation of sugars to the meristem leading to differentiation into flower buds. Hence, early flowering at low population levels and vice versa. Similar results were reported earlier by Dawadi and Sah (2012). The treatment which received the highest dose of fertilizer *i.e.,* 125% RDF took the lowest number of days 48.2 for 50 % tasseling and was followed by 100% RDF and these two treatments were statistically comparable. Maximum number of days (51.7) were required in the control treatment. This direct involvement of nitrogen, phosphorus and potassium in the enzymatic activity, and continuous and better supply of these nutrients to the plants might have caused early flowering in baby corn. Similar findings were reported by More *et al.* (2014).

Plant density of 1,11,111 plants ha^{-1} registered the lowest of 50.9 days to 50 % silking,

Table 2. Yield attributes, cob yield and fodder yield of baby corn as influenced by plant densities and fertilizer levels.

Treatment	Number of ears plant^{-1}	Ear length (cm)	Ear weight with husk(g)	Ear weight without husk(g)	Ear yield (q ha^{-1})	Green fodder yield (t ha^{-1})
Plant densities (plants ha^{-1})						
S_1 - 3,33,333	1.0	10.5	64.3	19.1	67.7	25.9
S_2 - 2,22,222	1.4	11.7	76.8	21.8	80.3	23.5
S_3 - 2,22,222	1.5	11.9	78.5	22.2	80.5	23.1
S_4 - 1,11,111	2.1	12.3	92.5	24.8	92.4	19.5
S.Em±	0.07	0.5	4.28	0.83	4.05	0.74
CD (P = 0.05)	0.2	1.5	12.5	2.45	11.96	2.18
Fertilizer levels						
F_1 - Control	1.1	10.4	55.2	18.4	43.4	18.5
F_2 – 75% RDF	1.4	12.3	70.4	21.9	72.6	23.8
F_3 – 100% RDF	1.7	12.6	84.5	25.4	94.5	26.8
F_4 – 125% RDF	1.8	13.0	95.3	27.2	105.4	27.5
S.Em±	0.07	0.5	4.28	0.83	4.05	0.74
CD (P = 0.05)	0.2	1.5	12.5	2.45	11.96	2.18
Interaction (S X F)						
S.Em±	0.1	0.73	6.05	1.18	5.72	1.05
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
CV (%)	11.3	10.6	12.6	8.5	11.9	7.5

whereas, the highest plant density with 3,33,333 plants ha^{-1} took the highest number of days (54.0). With more denser plant populations, baby corn plants are taller and thinner with few leaves exposed to bright sunshine. This more absorption of light by plant at lower densities might have played a role to develop flower initiating hormones and caused early flowering. In addition, more drymatter accumulation which is the indication of better performance of the individual baby corn plant might be the reason for their early silking. Similar results were also reported by Arvadiya *et al*. (2012). Fertilizer levels significantly influenced the days to 50% silking. Treatment which received the highest dose of fertilizer level (125% RDF) recorded significantly the lowest number of days for silking *i.e.,* 50.1 days compared to 75% RDF (52.7) and 100% RDF (51.8). Mineral nutrients have a strong influence on both synthesis and degradation, either directly or indirectly via altering the membrane structure and thus, compartmentation of the phytohormone balance, which is particularly true for nitrogen. More often nitrogen is the limiting nutrient in plant growth as it is a constituent of chlorophyll, plant proteins and nucleic acid. Hence, the high availability of nitrogen, phosphorus and potash might have resulted in early silking. Earliness in silking with application of fertilizers at higher levels was also reported by Dawadi and Sah (2012).

The highest and significant number of ears (2.1) were recorded at the lowest plant density *i.e.,* 1,11,111 plants ha^{-1} where as the lowest (1.0 ears plant^{-1}) number was registered with 3,33,333 plants ha^{-1}. The plants at low plant densities were more sturdy and stronger While the higher competition and low individual drymatter accumulation might be the reason for the poor performance at high plant densities. Similar findings were also reported by Aravinth *et al*. (2011).

Number of ears increased significantly with increase in fertilizer levels from control to 100% RDF (Table 2). Application of 100% RDF (1.7 ears plant^{-1}) and 125% RDF (1.8 ears plant^{-1}) did not differ significantly from one another. . The increased levels of NPK nutrients might have resulted in balanced nutrition with ease and greater availability of NPK to the plants, which was evident by taller plants and more drymatter accumulation in baby corn. The more growth at higher fertilizer levels might have resulted in rapid leaf expansion and for obtaining high LAI. High LAI could have resulted in production of more photosynthates and translocation of these photosynthates to sink and consequently improved yield attributes of baby corn. Supplying ample amounts of nitrogen, phosphorus and potassium during the critical phases of plant growth is quite effective in the production of yield attributes. That is why, the number of ears plant^{-1} were lower at low level of fertilizer. Sobhana *et al.* (2012) also reported similar effects of higher fertilization on baby corn.

The highest ear length (12.3 cm) was found with a plant density of 1,11,111 plants ha^{-1}, which was significantly superior to 10.5 cm of 3,33,333 plants ha^{-1} and was on par with 11.7 cm of 30 cm x 15 cm (2,22,222 plants ha^{-1}) and 11.9 cm of 45 cm x 10 cm (2,22,222 plants ha^{-1}). The reduction in ear length under higher plant density could be attributed to higher inter-plant competition for light, moisture and nutrients that was reflected in low drymatter accumulation per plant. Similar findings were also reported by Lal shankar *et al.* (2013).The highest ear length (13.0 cm) was recorded with the application of 125% RDF and it was significantly superior to 10.4 cm of control and was on par with 12.3 cm of 75% RDF and 12.6 cm of 100% RDF. This might be due to increased total chlorophyll, at higher fertilizer levels leading to higher photosynthetic rate and accumulation of more assimilates which in turn increased the sink size.

Significantly the highest ear weight with husk (92.5 g) was registered by 1,11,111 plant ha^{-1} while significantly the lowest weight (64.3 g) was observed in 3,33,333 plants ha^{-1}. This might be due to the reason that under low plant density, although single-plant production increased due to sufficient availability of metabolites for reproductive structures, which resulted in higher ear weight with husk. Similar findings were also reported by Aravinth *et al.* (2011) and Dar *et al.* (2014). Individual ear weight with husk increased significantly with increase in fertilizer level up to 100% RDF and further increment in fertilizer level showed a non significant increment in ear weight. The highest ear weight (95.3 g) was recorded with 125% RDF which was significantly superior to 55.2 g of control and 70.4 g of 75% RDF and was on par with 84.5 g of 100% RDF. This might be attributed to the fact that increased NPK levels increased the growth and yield attributing factors such as plant height, drymatter due to more availability of nutrients. In addition, higher source-sink relationship which resulted in enhanced supply of photosynthates for formation of more robust (length, girth and weight) babies in baby corn. Similar findings were also reported by Sahoo and Mahapatra (2007).

Individual ear weight without husk was significantly higher at low plant densities 1,11,111 plants ha^{-1} (24.8 g) and the lowest ear weight was observed at the highest plant density 3,33,333 plants ha^{-1} (19.1 g). This might be due to the reason that under low plant density single-plant production increased due to sufficient availability of metabolites for reproductive structures. Similar findings were also reported by Aravinth *et al.* (2011) and Dar *et al.* (2014). The highest ear weight was recorded with 125% RDF (27.2 g) which was significantly superior over 18.4 g of control and 21.9 g of 75% RDF and was on par with 25.4 g of 100% RDF. This might be due to taller plants, more drymatter accumulation, increased ear length and increased ear weight at higher levels of fertilization which could have increased the individual ear weight without husk. Similar findings were also reported by Singh *et al.* (2012).

The highest ear yield (92.4 q ha^{-1}) was recorded with a plant population of 1,11,111 plants ha^{-1} and significantly the lowest ear yield of 67.7 q ha^{-1} was registered with 3,33,333 plants ha^{-1}. Increase in ear yield might be due to improvement in length, weight and number of ears plant^{-1} and also higher photosynthesis and higher drymatter accumulation, that could have lead to adequate supply of metabolites for development of reproductive structures. Similar results were reported by Sobhana *et al.* (2012), Lal shankar *et al.* (2013).

Application of 125% RDF recorded significantly higher ear yield 105.4 q ha^{-1} over control with 43.4 q ha^{-1} and 75% RDF with 72.6 q ha^{-1} and was on par with 100% RDF with 94.5 q ha^{-1}. The increase in yields might be attributed to the fact that increased NPK levels increased the growth and yield attributing factors due to more availability of nutrients and consequently enhanced the yield levels. Taller plants, more drymatter, higher number of ears plant^{-1} (table 2) and more ear weight might have contributed for higher yields. Similar results were reported by Singh *et al.* (2010), Sobhana *et al.* (2012) and Marwan *et al.* (2015).

The highest green fodder yield (25.9 t ha^{-1}) was recorded with a plant population of 3,33,333 plants ha^{-1} and the lowest (19.5 t ha^{-1}) green fodder was registered with 1,11,111 plant ha^{-1}. This might be due to higher plant population at closer spacing, taller plants, more drymatter per unit area at higher plant populations might be the reasons for the higher green fodder yield at higher populations. Similar findings were also reported by Lal shankar *et al.* (2013) and Marwan *et al.* (2015). Application of 125% RDF recorded 27.5 t ha^{-1} fodder yield, which was significantly superior to control and 75% RDF with 18.5 and 23.8 t ha^{-1}, respectively. Where as 125% RDF and 100% RDF were on par. This was mainly due to higher vegetative growth in terms of plant height, number of leaves, leaf area index and drymatter plant^{-1} with higher levels of NPK application. These findings are in conformity with those of Singh *et al.* (2010) and Sobhana *et al.* (2012).

Interaction between intercrops and nitrogen was not significant with regard to all the data presented.

CONCLUSION

Baby corn at 3,33,333 plants ha^{-1} registered better growth parameters. However, yield attributes and yield were higher at 1,11,111 plants ha^{-1}. Applying 125% RDF to baby corn resulted in better growth, more yield attributes and higher yields

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