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Effect of spacing, nitrogen and growth regulators on yield and nutrient uptake by baby corn (*Zea mays* L.)

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ABSTRACT

A field experiment was conducted during kharif seasons, 2010 and 2011 at Instructional farm Rajasthan college of Agriculture Udaipur, to study the effect of crop spacing (45 × 20, 60 × 15 and 90cm × 10cm), nitrogen levels (60, 90 and 120 kg ha^{-1}) and plant growth regulators (control, NAA @) 40 ppm and Mepiquat chloride @ 200 ppm) on yield, nutrient content and uptake of nitrogen by baby corn. The results indicated that the crop spacing of 60cm × 15cm significantly influenced the yields and maximum green cob, baby corn and green fodder yields were recorded at 60cm × 15cm spacing which was 14.0, 24.0 and 9.0 %, higher over 90cm × 10 cm, respectively. In general, the maximum values of chlorophyll content in plants at various stages of growth were recorded with spacing of 60x15 cm. The content and uptake of N was not affected significantly with spacing's. Increasing nitrogen levels up to 90 kg ha^{-1} showed marked improvement in green cob and baby corn yield. But green fodder yield, nitrogen content and uptake by fodder were recorded significantly higher with 120 kg N ha^{-1}. The maximum values of chlorophyll in leaves at all the stages of growth studied were recorded with 120 kg N ha^{-1}. The crop sprayed with Mepiquat chloride @ 200ppm produced the highest green cob yield (5.90 t ha^{-1}), baby corn yield (2.08 t ha^{-1}) and this was comparable with application of NAA. But NAA @ 40 ppm produced significantly higher green fodder yield (26.88 t ha^{-1}) over Mepiquat chloride @ 200 ppm which produced lowest green fodder yield (22.13 t ha^{-1}). The relatively higher values of chlorophyll content and nitrogen uptake were recorded with 200 ppm mepiquat chloride and 40 ppm NAA, respectively.

Keywords: Spacing, nitrogen, PGR, baby corn, nutrient uptake.

INTRODUCTION

Baby corn is not a separate type of corn like sweet corn or pop corn. Baby corn is dehusked maize ear, harvested young especially when the silk have either not emerged or just emerged and no fertilization has taken place or the shank with unpollinated silk is baby corn. Baby corn ears in light yellow colour with regular row arrangement, 10-12 cm long and a diameter of 1.0 -1.5 cm arrangement, are preferred in the market (Muthukumar *et al.*, 2005). The economic product is harvested just after silk emergence (1-2 cm long). In India; recently baby corn has gained popularity as valuable vegetable in Delhi, Uttar Pradesh, Haryana, Maharashtra, Karnataka, Andhra Pradesh, Rajasthan and Meghalaya. In India, it is grown on 8.49 m ha with the production and productivity of 21.28 m t and 2507 kg ha^{-1}, respectively. Rajasthan state was first in respect of area, wherein this crop occupies 10.50 lakh ha area (12.93 per cent) with production of 19.54 lakh tonnes and productivity of 18.60 q ha^{-1}. Out of total production, 45 per cent is consumed as a staple food in various forms viz., bread, biscuits, cookies or transformed into corn flakes, soups, fresh-roasted sweets, boiled cobs and vegetables *etc.* It is highly nutritive. Its nutritive value per 100.0 g of edible portion is 89.10 % moisture, 8.20 g carbohydrates, 1.90 g protein, 28.0 mg calcium, 86.0 mg phosphorus, 0.10 mg iron, 0.50 mg thiamine, 0.08 mg riboflavin and 11.0 mg ascorbic acid (Muthukumar *et al.*, 2005). In order to achieve higher ear yields, maintenance of stand density is the most important factor. A spatial arrangement of 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 shoots and their activity. Maximum yield can be expected only when plant population allows individual plant to achieve their maximum inherent potential. Thus, there is need to work out optimum plant spacing by in relation to other agronomic factors. Thus, there is need to work out an optimum plant spacing by adjusting inter and intra row spacing in relation

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to other agronomic factors. Nitrogen is the key elements for higher productivity of maize. Among the inorganic nutrients, nitrogen plays an important role in the growth and development of crop plants. Maize is an exhaustive crop and requires high quantities of nitrogen for higher productivity. Nitrogen is indispensable for increasing crop production as a constituent of protoplasm and chlorophyll and is associated with the activity of every living cell. Plant growth regulators improve the effective partitioning and translocation of accumulates from source to sink in the field crops. NAA, being an auxin, promoted vegetative growth by active cell division, cell enlargement and cell elongation and thus helped in improving growth characteristics and in stimulating reproductive growth. NAA application significantly enhanced the fodder yield over other treatments (Muthukumar *et al.*, 2005). Increase in fodder yield due to NAA spray might be due to increase in plant height, leaf area index and total biomass, which might be due to increased cell division, cell enlargement and elongation. Growth regulators spray had positive influence on green cob yield of baby corn. The increase in yield due to Mepiquat chloride spray has been attributed to increased yield attributes, which in turn resulted from effective translocation of photosynthesis from source to sink due to the shortening of distance between source and sink. Since Mepiquat chloride is a growth retardant, resulted in reduced plant height and dry matter production and finally reduction in fodder yield. Cob yield increased due to increased mobilization of reserve food materials to developing sink through increase in hydrolyzing and oxidizing enzyme activities. Therefore, the present investigation was carried out to assess the effect of spacing, nitrogen levels and plant growth regulators on yield attributes and yield of Baby corn under sub humid condition in Rajasthan.

MATERIALS AND METHODS

A field experiment was conducted during *kharif* seasons of 2010 and 2011 on clay loam soil at Instructional farm of Agronomy, Rajasthan college of Agriculture, Udaipur, which is situated at 23°34' N latitude, 73°42' E longitude and at an altitude of 582.17 meters above the mean sea level. Soil test value indicated a slightly alkaline reaction (pH 7.8), available nitrogen (268 kg ha^{-1}) and available phosphorus (21 kg ha^{-1}) and available potassium (290 kg ha^{-1}). Precipitation differed markedly between 2010 and 2011 during growing seasons. The total precipitation during crop growing period was 637.4 mm in 2010 and 757.4 mm in 2011. Maximum and minimum temperature during baby corn crop growing period ranged between 35ºC and to 27.1ºC and 25.9ºC and 16.1ºC respectively during 2010.The corresponding fluctuations during second year were 35ºC to 23.7ºC and 29.1ºC to 20ºC. The experiment was laid out in split plot design with three replications. The treatments comprised combinations of three spacing (45 × 20, 60 × 15 and 90cm × 10cm), three nitrogen levels (60, 90 and 120 ka ha^{-1}) allocated in main plots and three plant growth regulators (control, NAA @) 40 ppm and Mepiquat chloride 200 ppm) in sub-plots, thereby making twenty seven treatment combinations., Half dose of nitrogen as per treatments and full dose of phosphorus was applied as basal dose before sowing in each plot. Remaining half dose of nitrogen was top dressed at knee high stage as per treatment. Plant growth regulators water spray as control, NAA (40 ppm) and mepiquat chloride (200 ppm).The sprays were given on 25 and 35 DAS. Green Baby corn variety HM-4 was sown manually on 24 July at varying row spacing as per treatment. Crop was harvested at just after silk emergence. Green cobs obtained from each plot without husk were weighed and used to compute baby corn yield. Soon after plucking of green cobs, the plants were harvested and bundled according to individual net plot and weighed to obtained final fodder yield. Fresh leaf samples collected at 30,45 and 60 DAS, were immediately washed with distilled water and dried with blotting paper. A sample of 100 mg was taken from each experimental unit in pestle and motor. The sample was ground well with 80 per cent acetone and filtered into a 25 ml volumetric flask. The volume was raised and recorded absorbance. The chlorophyll content was estimated as per following formula.

$$\text{Chlorophyll content} = \frac{20.2\,(A645)+8.02\,(A663)}{a \times 1000 \times W} \times V$$

Where, a = length of light path in cell (1 cm), V = volume of extract in ml,
W = fresh weight of leaf sample in g,
A = absorbance in nm

The fodder samples collected at harvest were oven dried at 70°C to a constant weight and ground in laboratory mill. The samples were subjected to chemical analysis for determination of nitrogen contents by modified Kjeldahl method. The uptake of nitrogen was computed from their content values with dry fodder yield.

RESULTS AND DISCUSSION

Effect of spacing

Yield: Significantly higher green cobs, baby corn and green fodder yields of baby corn were obtained under spacing of 60cm × 15cm over 90cm × 10cm but was observed at par with 45cm × 20 cm during both the years as well as pooled analysis (Table 1). Crop spacing of 60cm × 15cm, on pooled basis recorded highest green cob and baby corn yield of 5.76 and 2.07t ha^{-1} and green fodder yield 25.30 t ha^{-1}, respectively. The marked increases in baby corn yield may be due to an improvement in yield attributes which was brought about due to adoption of this crop spacing. This view is close conformity with the findings of Prodhan *et al.*, (2007) and Aravinth *et al.,* (2011),who recorded higher yields as a result of remarkable improvement in different growth and yield attributes when this crop was grown at spacing of 60 cm × 15 cm instead of other spacings.

Table 1: Effect of spacing, nitrogen and PGR on green cob, baby corn and green fodder yield

Treatments	Yield								
	Green cob yield (t ha^{-1})			Baby corn yield (t ha^{-1})			Green fodder yield (t ha^{-1})		
	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled
Spacing (cm)									
45 × 20	5.84	5.35	5.60	2.04	1.99	2.02	25.32	24.20	24.76
60 × 15	6.01	5.51	5.76	2.09	2.04	2.07	26.06	24.53	25.30
90 × 10	5.32	4.82	5.07	1.68	1.64	1.66	24.40	22.10	23.25
SEm ±	0.08	0.08	0.06	0.03	0.03	0.02	0.38	0.27	0.23
CD (P = 0.05)	0.25	0.26	0.17	0.09	0.09	0.06	1.14	0.81	0.67
Nitrogen (kg ha^{-1})									
60	5.02	4.52	4.77	1.67	1.60	1.64	21.37	19.38	20.32
90	5.99	5.50	5.75	2.03	2.01	2.02	26.64	25.52	26.08
120	6.15	5.65	5.90	2.12	2.06	2.09	27.76	26.04	26.90
SEm ±	0.08	0.08	0.06	0.03	0.03	0.02	0.38	0.27	0.
CD (P = 0.05)	0.25	0.26	0.17	0.09	0.09	0.06	1.14	0.81	0.67
PGR									
Control	5.00	4.50	4.75	1.63	1.57	1.60	24.71	23.88	24.30
NAA (40 ppm)	6.02	5.52	5.77	2.08	2.04	2.06	27.75	26.00	26.88
Mepiquat chloride (200 ppm)	6.15	5.65	5.90	2.11	2.05	2.08	23.31	20.95	22.13
SEm ±	0.05	0.05	0.03	0.02	0.02	0.01	0.24	0.31	0.20
CD (P = 0.05)	0.15	0.15	0.10	0.05	0.06	0.04	0.70	0.89	0.50

Chlorophyll content: Results (Table 2) indicated that crop spacing of 60cm × 15cm recorded significant increases in chlorophyll content in leaves at 45 and 60 DAS over 90cm × 10cm but was observed at par with 45cm × 20cm spacing during both years as well as in the pooled analysis. But at 30 DAS the effect was non significant. The pooled data show that spacing of 60cm × 15cm gave significantly higher chlorophyll content in plant at 45 and 60 DAS by 9.4 and 6.2 %, respectively over 90cm × 10cm. Crop spacing 60cm × 15cm appears to be best to increase the leaf chlorophyll content which might have helped directly or indirectly in maintain greater photosynthetic efficiency per unit leaf area.

Effect of nitrogen

Yield: Increasing levels of nitrogen up to 120 kg N ha^{-1} recorded significant increases in green cob and baby corn yield over 60 kg N ha^{-1} but was statistically at par with 90 kg N ha^{-1} during 2010 and 2011 as well as in the pooled analysis. The green cob yield and baby corn yield increased by 20.5 and 23.6 % with 90 kg N ha^{-1} respectively over 60 kg N ha^{-1}(Table 1). But significantly highest green fodder yield was

recorded with 120 kg N ha^{-1} as compared to 60 and 90 kg N ha^{-1}. The increased availability of photosynthates might have enhanced number of flowers and their fertilization resulting in higher yield attributes. Further, in most of cereals, greater assimilating surface at reproductive developments results in better green cob formation because of adequate production of metabolites and their translocation towards cob. The results of present investigation corroborate with the findings of Bindhani *et al.* (2007) and Gosavi and Bhagat, (2009). Application of nitrogen up to 90 kg ha^{-1} level significantly increased green cob and baby corn yield (Table 1). The higher green cob yield realization with application of higher nitrogen level could be ascribed to its profound influence on vegetative and reproductive growth of the crop.(Prodhan *et al.*, 2007; Bindhani *et al.,* 2008; Singh, 2017).

Table 2: Effect of spacing, nitrogen and PGR on Chlorophyll content in leaves

Treatments	Chlorophyll content (mg g^{-1} fresh leaf wt.)								
	30 DAS			45 DAS			60 DAS		
	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled
Spacing (cm)									
45 × 20	0.990	0.975	0.983	1.665	1.605	1.635	2.450	2.127	2.289
60 × 15	0.991	0.981	0.986	1.693	1.634	1.664	2.510	2.169	2.339
90 × 10	0.980	0.970	0.975	1.565	1.476	1.521	2.355	2.049	2.202
SEm ±	0.016	0.015	0.011	0.025	0.020	0.016	0.031	0.025	0.020
CD (P = 0.05)	NS	NS	NS	0.074	0.060	0.046	0.093	0.076	0.058
Nitrogen (kg ha^{-1})									
60	0.923	0.913	0.918	1.546	1.476	1.511	2.340	2.018	2.179
90	1.007	0.998	1.003	1.675	1.605	1.640	2.466	2.144	2.305
120	1.031	1.016	1.023	1.703	1.634	1.669	2.510	2.182	2.346
SEm ±	0.016	0.015	0.011	0.025	0.020	0.016	0.031	0.025	0.020
CD (P = 0.05)	0.047	0.046	0.032	0.074	0.060	0.046	0.093	0.076	0.058
PGR									
Control	0.921	0.911	0.916	1.531	1.461	1.496	2.334	1.993	2.163
NAA (40 ppm)	1.020	1.007	1.013	1.690	1.620	1.655	2.480	2.172	2.326
Mepiquat chloride (200 ppm)	1.021	1.009	1.015	1.702	1.633	1.668	2.501	2.179	2.340
SEm ±	0.015	0.014	0.010	0.020	0.020	0.014	0.031	0.025	0.020
CD (P = 0.05)	0.042	0.039	0.028	0.058	0.056	0.040	0.089	0.073	0.056

Chlorophyll content: The results revealed that the application of nitrogen up to 90 kg N ha^{-1} significantly increased chlorophyll content during both the years as well as pooled analysis (Table 2). In general, overall improvement in crop growth under optimum nitrogen level seems to be on account of their potential role in modifying soil and plant environment conducive for better development of morphological and biochemical constituent of plant growth . Nitrogen is considered to be essential for the synthesis of chlorophyll which is of great physiological significance in the plant system.Increased leaf chlorophyll content which might have helped directly or indirectly in maintaining greater photosynthetic efficiency per unit leaf area.

Nitrogen content and uptake: Application of 120 kg N ha^{-1} recorded significantly highest nitrogen concentration and uptake by fodder as compared to 60 and 90 kg N ha^{-1} (Table 3). The marked improvement in nitrogen concentration in crop seems to be on account of its greater availability in soil environment and enhanced translocation in plant system, thus ultimately uptake of nitrogen increased. The concentration of nitrogen is largely dependent in plant at its concentration in soil solution (Bindhani *et al.* 2007and Gosavi, Bhagat, 2009 Jaga *et al.* 2017).

Effect of plant growth regulators

Yield: The results revealed that the spray of Mepiquat chloride @ 200 ppm significantly increased green cob and baby corn yield as compared to control but was at par with NAA @ 40 ppm during both the years (Table 1). The crop sprayed with Mepiquat chloride produced the highest green cob yield (5.90 t ha^{-1}) and this

was comparable with application of NAA (5.77 t ha^{-1}).The increase in yield due to Mepiquat chloride spray might be due to increased attributes which in turn resulted from effective translocation of photosynthates from source to sink due to the shortening of distance between source to sink. Cob yield increased due to increased mobilization of reserve food materials to developing sink through increase in hydrolyzing and oxidizing enzyme activities. NAA, being an auxin, promoted vegetative growth by cell division, cell enlargement and cell elongation and thus helped improving growth characteristics and also in stimulating reproductive growth. The results of the present investigation indicating positive response of baby corn to plant growth regulators are alike to the findings of several researchers (Muthukumar *et al.* (2005), Rathika *et al.* (2009) and Mohamed *et al.* (2010).

Table 3: Effect of spacing, nitrogen and PGR on N content in plant and uptake by the fodder

Treatments	N content (%)			N uptake by fodder(kg ha^{-1})		
	2010	2011	Pooled	2010	2011	Pooled
Spacing (cm)						
45 × 20	0.90	0.80	0.84	66.97	57.52	62.25
60 × 15	0.96	0.81	0.85	67.82	57.21	62.51
90 × 10	0.90	0.80	0.85	67.50	55.43	61.47
SEm ±	0.01	0.01	0.01	1.20	0.66	0.69
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
Nitrogen (kg ha^{-1})						
60	0.78	0.68	0.73	48.83	38.64	43.74
90	0.95	0.84	0.90	73.08	63.70	68.39
120	0.97	0.87	0.92	80.38	67.82	74.10
SEm ±	0.01	0.01	0.01	1.20	0.66	0.69
CD (P = 0.05)	0.02	0.02	0.02	3.60	1.99	1.98
PGR						
Control	0.94	0.85	0.90	67.79	59.31	63.55
NAA (40 ppm)	0.97	0.87	0.92	81.16	68.27	74.71
Mepiquat chloride (200 ppm)	0.79	0.69	0.74	53.34	42.58	47.96
SEm ±	0.01	0.01	0.01	1.20	0.95	0.76
CD (P = 0.05)	0.03	0.02	0.02	3.43	2.72	2.15

Application of growth regulators exhibited significant influence on green fodder of baby corn, NAA @ 40 ppm produced significantly higher green fodder yield (26.88 t ha^{-1}). Application of Mepiquat chloride @ 200 ppm produced lowest green fodder yield (22.13 t ha^{-1}). Since Mepiquat chloride is a growth retardant, resulted in reduced plant height and dry matter production and finally reduction in fodder yield due to Mepiquat chloride application were also reported. NAA application significantly enhanced the fodder yield over other treatments. Increase in plant height, total bio mass which might be due to increased cell division, cell enlargement and elongation. Similar findings were also reported by Muthukumar *et al.*, 2005, Rathika *et al.*, 2009 and Mohamed *et al.*, 2010).

Chlorophyll content: The results revealed that spray of mepiquat chloride @ 200 ppm significantly increased chlorophyll content in leaves (at 30, 45 and 60 DAS) but was at par with NAA @ 40 ppm during both the years (Table 2). There have been significant increases in chlorophyll content in leaves spray with growth retardants. This finding is in conformity with that of Prashant *et al.*, (2009) who opined that growth retardants in addition to the inhibition of cell division caused induction of grana and initiated the development of chloroplast that ultimately increases the chlorophyll content in leaves.

Nitrogen concentration and uptake: NAA @ 40 ppm spray resulted in significantly higher N concentration and uptake by fodder during both the years (Table 3).This may be attributed to the higher vegetative growth and biomass production that resulted in concentration and accumulation of more N in their biomass, thus ultimately increases the uptake of nitrogen by

fodder. Mepiquat chloride @ 200 reduced the N uptake in plant due to reduction in plant height and dry fodder of the plants in turn, resulted in the vegetative structure. The increase in the N concentration of the plant with application of NAA might possibly be due to anti metabolic functions of growth regulators, which in turn resulted in changing the root permeability and cation exchange capacity of roots leading to higher concentration of nitrogen in plant, while in case of mepiquat chloride @ 200 reduced the N concentration in plant due to reduction in the vegetative structure in plant (Sivakumar, 2001).

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