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Response to different levels of spacing, nitrogen and plant growth regulators

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ABSTRACT

An experiment was conducted during *kharif* season, 2010 and 2011 at Rajasthan College of Agriculture Udaipur, to study the effect of crop spacing (45cm × 20cm, 60cm × 15cm 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 baby corn. The higher green cob yield, baby corn yield and green fodder yield was significantly recorded at 60cm × 15cm spacing over 90cm × 10cm. Increasing nitrogen levels up to 90 kg ha^{-1} showed marked improvement in green cob yield and baby corn yield, but in case of green fodder yield, nitrogen concentration and uptake by fodder recorded significantly highest with 120 kg ha^{-1}. The crop sprayed with Mepiquat chloride @ 200ppm produced the highest green cob yield (5903.03 kg ha^{-1}), baby corn yield (2082.64 kg ha^{-1}) and this was comparable with application of NAA, in case of green fodder yield 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}).

Key words: Baby corn, Green fodder yield, Nutrient content, Uptake.

INTRODUCTION

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. Baby corn ears are light yellow in colour with regular row arrangement of 10-12 cm long and a diameter of 1.0 -1.5 cm , are preferred in the market (Muthukumar *et al*., 2005). The economic product is harvested just after silk emergence (1-2 cm long). Baby corn is an important crop of Thailand, Taiwan and in India. Recently baby corn has gained popularity as 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 (Govt. of India, 2011). Rajasthan stands first in area, where in this crop occupies 10.50 lakh ha area with production of 19.54 lakh tones and productivity of 18.60 q ha^{-1} (Govt. of Rajasthan 2010). 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*.

In order to achieve high ear yields, maintenance of plant 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, proliferation 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 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 to other agronomic factors. Nitrogen is the key element for getting higher productivity of maize. Among the inorganic nutrients, nitrogen play an important role in the growth and development of crop plants. Baby Corn is an exhaustive crop and requires high quantities of nitrogen for higher productivity. 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

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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

The present experimentation was conducted during 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 were indicated a slightly alkaline pH (7.85), medium in available nitrogen (268.40 kg ha^{-1}), available phosphorus (20.80 kg ha^{-1}) and high in available potassium (290.50 kg ha^{-1}). Precipitation differed markedly between 2010 and 2011 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 to 27.1ºC and 25.9ºC to 16.1ºC, respectively during 2010.The corresponding fluctuations during 2011 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 of three spacings (45cm × 20cm, 60cm × 15cm and 90cm × 10cm), three nitrogen levels (60, 90 and 120 ka ha^{-1}) allocated in main plots and three plant growth regulator levels (control, NAA @) 40 ppm and Mepiquat chloride 200 ppm) in sub-plots, thereby making twenty seven treatment combinations, Half dose of nitrogen and full dose of phosphorus were applied as basal 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 24th July at varying row spacing as per treatment. Crop was harvested at just after silk emergence. Green cobs obtained from each plot than after without husk were weighed and used to compute baby corn yield and expressed as kg. Soon after plucking of green cobs, the plants were harvested and bundled according to individual net plot and weighed to obtained final fodder yield and expressed as t ha^{-1}. Fresh leaf samples were collected at 30,45 and 60 DAS, these were immediately taken to lab, washed with distill 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 standard procedure (Arnon, 1949).

The fodder samples were collected at harvest from produce of each experimental unit 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 standard methods Nasseler's reagent calorimetric method (Snell and Snell, 1949). The uptake of nitrogen was computed from their content in dry fodder yield

RESULTS AND DISCUSSION

EFFECT OF SPACING

Yield: Significantly higher green cobs, baby corn and green fodder yields were obtained under spacing with 60cm × 15cm above it on at par with 45cm × 20 cm during both the years (Table 1). Crop spacing of 60cm × 15cm, on pooled analysis recorded the highest green cob and baby corn yield of 5759.20 and 2065.13 kg ha^{-1} and green fodder yield of 27.89 t ha^{-1}.This mighting include to the resultant of remarkable improvement in different yield attributes which was brought about by the adoption of this crop spacing. This seems is close conformity with the findings of Sarkar *et al.,* (1996), Prodhan *et al*., (2007) and Aravinth *et al.,* (2011).

Chlorophyll content: The Results (Table 2) reveled that crop spacing 60cm × 15cm recorded significant 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 in case of 30 DAS was non significant. The pooled data show that spacing of 60cm × 15cm gave significantly higher chlorophyll content in plant at 45 and 60 DAS were 9.40 and 6.22 per cent, respectively over 90cm × 10cm. Crop spacing 60cm × 15cm appeared to be a result of increased leaf chlorophyll content which might have helped directly or indirectly in maintain greater photosynthetic efficiency per unit leaf area.

EFFECT OF NITROGEN

Yield: Application of increasing levels of nitrogen up to 120 kg N ha^{-1} recorded the significant increase in green cob yield and baby corn yield kg ha^{-1}over 60 kg N ha^{-1} but it was found statistically on par with 90 kg N ha^{-1} during 2010 and 2011. The pooled analysis showed that green cob yield and baby corn yield increased with application of 90 kg N ha^{-1} in tune of 20.46 and 23.58 per cent, respectively over 60 kg N ha^{-1} (Table 1). In case of green fodder yield the significantly highest green fodder yield was recorded with the application of 120 kg N ha^{-1} as compared to 60 and 90 kg N ha^{-1} levels. The results indicated that application of increasing levels of nitrogen up to 90 kg ha^{-1} a rapid growth under the influence of higher level of nitrogen fertilization might have played a significant role in reducing competition for photosynthates and nutrients with other plants resulting in healthy plants. The increased availability of photosynthates might have enhanced number of flowers and their fertilization resulting in higher number of yield attributes. Further, in most of cereals, greater assimilating surface at reproductive

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

Treatments	Yield								
	Green cob yield (kg ha^{-1})			Baby corn yield (kg ha^{-1})			Green fodder yield (t ha^{-1})		
	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled
Spacing									
45 cm × 20 cm	5844.33	5348.38	5596.35	2044.72	1986.68	2015.70	25.32	24.20	24.76
60 cm × 15cm	6007.17	5511.22	5759.20	2092.30	2037.96	2065.13	26.06	24.53	25.30
90 cm × 10 cm	5316.26	4816.53	5066.39	1681.71	1640.16	1660.93	24.40	22.10	23.25
SEm ±	86.185	86.803	61.161	32.181	32.862	22.997	0.38	0.27	0.23
CD (P = 0.05)	258.382	260.234	176.183	96.478	98.521	66.248	1.14	0.81	0.67
Nitrogen Levels (kg ha^{-1})									
60	5018.58	4522.63	4770.60	1672.17	1597.94	1635.05	21.37	19.38	20.32
90	5994.95	5499.00	5746.98	2030.39	2010.93	2020.66	26.64	25.52	26.08
120	6154.23	5654.50	5904.36	2116.18	2055.92	2086.05	27.76	26.04	26.90
SEm ±	86.185	86.803	61.161	32.181	32.862	22.997	0.38	0.27	0.23
CD (P = 0.05)	258.382	260.234	176.183	96.478	98.521	66.248	1.14	0.81	0.67
PGR									
Control	4998.72	4503.81	4751.27	1626.30	1573.14	1599.72	24.71	23.88	24.30
NAA (40 ppm)	6015.62	5519.67	5767.64	2080.28	2038.50	2059.39	27.75	26.00	26.88
Mepiquat chloride (200 ppm)	6153.42	5652.65	5903.03	2112.14	2053.14	2082.64	23.31	20.95	22.13
SEm ±	54.179	54.442	38.404	20.520	20.820	14.616	0.24	0.31	0.20
CD (P = 0.05)	155.395	156.148	108.267	58.853	59.715	41.205	0.70	0.89	0.50

Table 2: Effect of spacing, nitrogen levels 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									
45cm × 20cm	0.99	0.98	0.98	1.67	1.61	1.64	2.45	2.13	2.29
60cm × 15cm	0.99	0.98	0.99	1.69	1.63	1.66	2.51	2.17	2.34
90cm × 10cm	0.98	0.97	0.98	1.57	1.48	1.52	2.36	2.05	2.20
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 Levels (kg ha^{-1})									
60	0.92	0.91	0.92	1.55	1.48	1.51	2.34	2.02	2.18
90	1.01	0.99	1.0	1.66	1.61	1.64	2.47	2.14	2.31
120	1.03	1.02	1.02	1.70	1.63	1.67	2.51	2.18	2.35
SEm ±	0.02	0.02	0.01	0.03	0.02	0.02	0.03	0.03	0.02
CD (P = 0.05)	0.047	0.046	0.032	0.074	0.060	0.046	0.093	0.076	0.058
PGR									
Control	0.92	0.91	0.92	1.53	1.46	1.50	2.33	1.99	2.16
NAA (40 ppm)	1.02	1.01	1.01	1.69	1.62	1.66	2.48	2.17	2.36
Mepiquat chloride (200 ppm)	1.02	1.01	1.02	1.70	1.63	1.67	2.50	2.18	2.34
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

developments results in better green cob formation because of adequate production of metabolites and their translocation towards cob. The results of present investigation indicating positive response of various yield attributes to higher nitrogen fertilization corroborate findings of several researchers (Chillar and Kumar, 2006; Bindhani *et al.* 2007; Gosavi and Bhagat, 2009). The results revealed that application of nitrogen up to 90 kg ha^{-1} significantly increased green cob and baby corn and (Table 3). The higher green cob yield realization with application of higher nitrogen level of plant nutrition could be ascribed to its profound influence on vegetative and reproductive growth of the crop. The results of the present investigation indicating positive response of baby corn to nitrogen fertilization are alike to the findings of several researchers (Raja, 2001, Thakur and Sharma, 1999; Prodhan *et al*., 2007; Bindhani *et al.*, 2008) was in close conformity with the findings of Sahoo and Mahapatra, (2007); Gosavi and Bhagat, (2009); Gulabrao, (2010).

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

Treatments	N content and uptake					
	N content (per cent)			N uptake by fodder(kg ha^{-1})		
	2010	2011	Pooled	2010	2011	Pooled
Spacing						
45 cm × 20 cm	0.90	0.79	0.84	66.97	57.52	62.25
60 cm × 15cm	0.96	0.81	0.85	67.82	57.21	62.51
90 cm × 10 cm	0.89	0.79	0.85	67.49	55.43	61.47
SEm ±	0.009	0.006	0.006	1.200	0.664	0.686
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
Nitrogen Levels (kg ha^{-1})						
60	0.78	0.68	0.73	48.83	38.64	43.74
90	0.95	0.84	0.89	73.08	63.69	68.39
120	0.97	0.87	0.92	80.37	67.82	74.10
SEm ±	0.009	0.006	0.006	1.200	0.664	0.686
CD (P = 0.05)	0.018	0.019	0.016	3.599	1.992	1.976
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 ±	0.010	0.006	0.006	1.196	0.950	0.764
CD (P = 0.05)	0.027	0.018	0.016	3.430	2.724	2.153

Chlorophyll content: The results revealed that 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.

Nutrient content and uptake: Application of nitrogen 120 kg ha^{-1} recorded significantly highest nitrogen concentration and uptake by fodder as comparison to 60 and 90 kg N ha^{-1} levels (Table 3). The marked improvement in nitrogen concentration in crop seems to be on account of their greater availability in soil environment and enhanced translocation in plant system, thus ultimately uptake of nitrogen increased. Moreover, increase in shoot growth was noticed as evident from higher dry matter accumulation under the influence of increasing levels of nitrogen up to 120 kg ha^{-1}. Further, it has been reported that shoot and root growth mutually inherent for the efficiency of plants, as evident from higher fodder yield which might have supplied adequate metabolites for root growth and its functional activity (Bodake *et al.*, 2006). The concentration of nitrogen is largely dependent in plant at cellular level. The same was in conformance with the findings of Thakur *et al.*, (1999), Bindhani *et al.*(2007) and Gosavi and Bhagat,(2009).

EFFECT OF PLANT GROWTH REGULATORS

Yield: Growth regulators spray had positive influence on yield of baby corn. The results revealed that spray of Mepiquat chloride @ 200 ppm significantly increased green cob and corn yield of baby corn as comparison to control but was on par with NAA @ 40 ppm during both the years (Table 1). The crop sprayed with Mepiquat chloride produced the highest green cob yield (5903.03 kg ha^{-1}) and this was comparable with application of NAA (5767.64 kg ha^{-1}).The increase in yield 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. The results of the present investigation indicating positive response of baby corn to plant growth regulators were alike to the findings of Muthukumar *et al*., (2005), Rathika *et al*., (2009) and Mohamed *et al*., (2010).

Application of NAA @ 40 ppm produced significantly higher green fodder yield (26.88 t ha^{-1}), where as the 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 and\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).

Table 4: Interaction effect of plant growth regulators and nitrogen levels on green cob yield (kg ha^{-1}).

	Plant growth regulators								
	2010			2011			Pooled		
Nitrogen levels (Kg ha^{-1})	**Control**	**NAA (40 ppm)**	**Mepiquat chloride (200ppm)**	**Control**	**NAA (40 ppm)**	**Mepiquat chloride (200ppm)**	**Control**	**NAA (40 ppm)**	**Mepiquat chloride (200ppm)**
60	4613.66	5094.59	5347.47	4117.71	4598.64	4851.52	4365.68	4846.61	5099.49
90	5055.16	6433.85	6495.83	4559.21	5937.90	5999.88	4807.19	6185.87	6247.86
120	5327.33	6518.40	6616.94	4834.50	6022.45	6106.54	5080.92	6270.42	6361.74
SEm±	93.84*	127.413**		94.296*	128.166**		66.517*	90.361**	
CD (P=0.05)	269.15*	365.440**		270.456*	367.599**		187.523*	254.744**	

*CD for Nitrogen level mean at same level of plant growth regulators mean.
** CD for Plant growth regulators mean at same Nitrogen level.

Table 5: Interaction effect of nitrogen levels and plant growth regulators on green fodder yield (t ha^{-1}).

	Plant growth regulators								
	2010			2011			Pooled		
Nitrogen levels (Kg ha^{-1})	**Control**	**NAA (40 ppm)**	**Mepiquat chloride (200ppm)**	**Control**	**NAA (40ppm)**	**Mepiquat chloride (200ppm)**	**Control**	**NAA (40ppm)**	**Mepiquat chloride (200ppm)**
60	22.687	24.651	17.779	20.005	22.203	15.620	21.346	23.427	16.700
90	24.164	29.405	26.345	25.638	27.447	23.480	24.901	28.426	24.912
120	26.272	31.205	25.817	26.003	28.362	23.753	26.138	29.783	24.785
SEm±	0.420*	0.565**		0.535*	0.599**		0.340*	0.412**	
CD (P=0.05)	1.206*	1.634**		1.534*	1.720**		0.959*	1.162**	

*CD for Nitrogen level mean at same level of plant growth regulators mean.
** CD for Plant growth regulators mean at same Nitrogen level.

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 it was on 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. Prashant *et al*., (2009) 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: With respect to growth regulators tested, NAA @ 40 ppm spray resulted in significantly higher N concentration and uptake by fodder during both the years (Table 3).The reason might 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 (Sivakumar, 2001).

Interaction effects of PGR x N levels on green cob yield: The pooled analysis (Table 4) showed that irrespective of nitrogen levels, spray of plant growth regulators NAA @ 40 ppm and mepiquat chloride @ 200 ppm were observed on par and both these PGR recorded significant increases in green cob yield over control. However, under application of nitrogen at 90 and 120 kg, spray with NAA and mepiquat chloride recorded significant increases in green cob yield over 60 kg N levels.

Interaction effects of PGR x N levels on green fodder yield: The results indicated that spray of plant growth regulators NAA @ 40 ppm recorded significant increases in green fodder yield over control and mepiquat chloride @ 200 ppm. However, the application of nitrogen at 90 and 120 kg, spray with NAA recorded significant increases in green fodder yield over 60 kg N levels.

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