__Original Research Article__

Effect of Row Spacing and Nitrogen Sources on Growth, Yield and Economics of Babycorn (*Zea mays* L.)

Abstract

A field experimented was conducted at Chamelti Agriculture Farm, MS Swaminathan School of Agriculture, Shoolini University of Biotechnology and Management Sciences, Solan during *kharif* season of 2022 to study the effect of row spacing and nitrogen sources on growth, yield and economics of babycorn. The results reveals that significantly higher growth and yield attributing characters were observed with wider spacing of (R_3) 60 cm and (N_4) nano urea. However, higher yield and economic returns were significantly higher with row spacing of (R_2) 45 cm along with (N_4) nano urea. On the basis of B: C ratio, row spacing of (R_2) 45 cm along with (N_4) nano urea was found to be remunerative for baby corn under Mid hills of Himachal Pradesh.

Keywords: Babycorn, Nano-urea, cobs, sulphur coated urea

1. Introduction

Maize (*Zea mays* L.) is an annual plant belongs to the family *Gramineae.* Among the cereals, maize ranks third in total world production of cereal after wheat and rice and it is principal staple food in many countries, particularly in the tropics and subtropics. Maize is considered as the “Queen of cereals”. Beside this maize have many types like normal yellow, white grain, sweet corn, baby corn, popcorn, waxy corn, high amylase corn, high oil corn, quality protein maize, etc. Among the types of maize, baby corn is the ear of maize plant harvested young, especially when the silk have either not been emerged or just emerged, and no fertilization has taken place, depending on the cultivar grown (Muthukumar *et al.,* 2007). It is generally harvested early, while the ears are very small and immature. It is a profitable crop that allows a diversification of production, aggregation of value, and increased income. It is a nutrient exhaustive crop (Kotru*et al.,* 2012) and due to high planting density, higher nitrogen application is important to retain productivity of the soil along with heavy returns.

Maximum yield can be expected only when plant population allows individual plant to achieve their maximum inherent potential. Thus, there is a need to work out an optimum population density by adjusting inter and intra row spacing in relation to other agronomic factors. Among the different commercial forms of mineral N fertilizers, Urea [$CO(NH_2)_2$] is the most widely used, mainly due to its high N content (46% N), in addition to its compatibility with other nutrients (Elemike*et al*., 2019). The high N loss coupled with its low use efficiency forced the farmers to increase the amounts of applied N fertilizers in order to achieve better crop production (Rathnayaka *et al*., 2018), which resulted in rising the costs of the farming practice, meanwhile, increasing the consequent environmental implications (Marchiol, 2019). Therefore, there is a pressing need to improve the N availability for plants, while reducing its harmful effects to the environment. In this regard, the utilization of nano fertilizers, especially nano particle urea (NPU) was proposed by several researchers (Chhowalla, 2017; Rathnayaka *et al*., 2018) to avoid the problems associated with the application of bulk Urea, while not depriving the plant from its benefits. As the nanostructured fertilizers are advantaged by the controlled release of nutrients, this will allow for the effective duration of nutrient supply to the plant which would secure optimum fulfillment to nutrient needs without any adverse environmental impacts (Kopittke*et al*., 2019). Hence, there is need to work out a suitable row spacing and nitrogen sources for babycorn and there is also a need to study the effect of row spacing and nitrogen sources on the growth and yield of babycorn. Since information on these aspects is lacking in the Mid Hills of Himachal Pradesh the current study will be aimed to determine the best row spacing andnitrogen sources.

2. Materials and methods

An experiment was conducted during *kharif* season of 2022 at Chamelti Agriculture Farm, MS Swaminathan School of Agriculture, Shoolini University of Biotechnology and Management Sciences, Solan(situated at 30^0 85'67.30 N latitude and 77^0 13'20.38 E longitude with an altitude of 1270 m above mean sea level). The soil of experimental field was sandy loam in texture, slightly alkaline in reaction (pH 6.95) with EC in safer range (0.24 dS m^{-1}), medium in organic carbon (0.55%), nitrogen (295.78 kg ha^{-1}), phosphorus (27.59 kg ha^{-1}) and high in available potassium (255.54 kg ha^{-1}). The experiment was laid out in Split Plot Design comprising of three row spacing *viz.* (R_1) 30 cm, (R_2) 45 cm and (R_3) 60 as first factor and four nitrogen sources *viz.* (N_1) Zinc coated urea, (N_2) Neem coated urea, (N_3) Sulphur coated urea and (N_4) nano urea as second factor. Thus a total of 12 treatment combinations were tested in the study and were replicated thrice. Recommended dose of nitrogen, phosphorous and potassium (100:50:50 kg ha^{-1}) through nitrogen sources, SSP and MOP, respectively were applied as basal and split doses of nitrogen. The total rainfall experienced during the crop growing season was 750.9 mm. CMVL baby corn 2 variety of baby corn was used for sowing. Row spacing and nitrogen sources were done as per treatment.

2.1 Statistical analysis and interpretation of data

Data recorded on various parameters of the experiment was subjected to analysis by using Fisher's method of analysis of variance (ANOVA) and interpreted as outlined by Gomez and Gomez (1984). The levels of significance used in 'F' and 't' test was p= 0.05. Critical difference values were calculated where F test was found significant.

3. Results and Discussions

The outcomes of the study (Table 1) showed that significantly higher plant height (32.15 cm) at 20 DAS was recorded with row spacing of(R_3) 60 cm over rest of the spacing. However, least plant height was noted under sowing on (R_1) 30 cm. Similar trend was also noted at 40 and 60 DAS. The tallest plant under row spacing of (R_3) 60 cm might be due to the phytochrome system of plants undergoes changes from red to far-red light ratios caused by shade as well as its proximity to neighbours to which plants respond with increased plant height.This might also be due to competition of light with closer plant-to-plant space for requirement of light, while wider row orientation had favours the better availability of resources. Further, wider space availability between the rows and closer intra-rows might have increased the root spread which eventually utilized the resources such as water, nutrients, CO_2 and light very effectively. The similar line of results was also reported by Dutta *et al*. (2015) wherein, they reported that crop geometry of 60 cm x 15 cm attained maximum plant height of 166.94 cm at harvest as compared to 45 cm x 20 cm and 30 cm x 30 cm crop geometries in maize. The results are in accordance with the results of Chavan *et al*. (2015); Biswas *et al*. (2014); Niveditha and Nagvani (2016); Scaria *et al*. (2016) and Singh *et al*. (2015).

Nitrogen sources also showed significant variation in plant height at periodic intervals. At 20 DAS, application of nano urea (N_4) was observed significantly higher plant height *i.e*. 31.35 cm over rest of the nitrogen sources. However, least plant height noted under (N_3) sulphur coated urea. Similar trend was observed at 40 and 60 DAS during course of study. Foliar application of Nano-Urea resulted in highest plant height which may be attributed due to enhanced absorption or assistance in transport of plant nutrients that increases the cell division capacity and cell protein content. Combined use of conventional fertilizers with nanobased fertilizers, stimulate the root and shoot development, which eventually reflect in enhanced plant height. Rathnayaka *et al*. (2018) also reported that nano-fertilizer application gave the highest plant height and least in control.

Dry matter accumulation (Table 2) varied significantly in response to row spacing and nitrogen sources at all stages. Crop accumulated dry matter at faster rate upto40 DAS and thereafter, slower rate was observed.Data at 20 DAS revealed that (R_3) 60 cm row spacing exerted significantly higher dry matter accumulation(9.57 g plant^{-1}) over rest of the row spacing. Similar trend was observed at 40 and 60 DAS during course of study. Higher dry matter production under 60 cm spacing could be attributed to increased plant height and higher leaf area maintained throughout the crop growth period resulting in enhanced carbohydrate synthesis (Kumar *et al.*,2006). Besides, optimum plant density at this geometry might have promoted better light interception by the leaves, enhanced photosynthesis and carbon dioxide assimilation leading to higher dry matter production as was noticed in the present study corroborates with earlier findings of Mahdi *et al*. (2010). These results are in corroborating with the findings of Niveditha and Nagvani (2016) wherein, they reported that plants of tallest stature, higher LAI and highest dry matter production were observed with a spacing of 60 cm x 15 cm and 30/90 x15 cm. These findings are in agreement with the results of Iptas and Acer (2006);Mathukia*et al*. (2014) and Singh *et al*. (2015).

Dry matter accumulation significantly affected by nitrogen sources. The highest dry matter accumulation (9.12 g plant^{-1}) was noted with application of (N_4) nano urea over rest of the nitrogen sources. However, least dry matter accumulation (7.11 g plant^{-1}) was noted under (N_3) Sulphur coated urea. Similar trend was observed at 40 and 60 DAS during course of experimentation. Suriyaprabha *et al.* (2012) also reported that foliar application of Nano-NPK increased nutrient availability to the growing plant through leaves via stomata that increased formation and content of chlorophyll, greater photosynthesis rate and maximum dry matter accumulation and thus, resulted in overall growth of the plant (Barkha *et al*., 2019).

Number of cobs plant^{-1} as affected by row spacing and nitrogen sources have been presented in Table 3. Maximum number of cobs plant^{-1} (2.48) was noted under wider spacing of (R_3) 60 cm followed by (R_2) 45 cm but the difference was found to be non-significant. Nano urea (N_4) recorded maximum number of cobs plant^{-1}(2.45) which was closely followed by (N_2) neem coated urea but the difference was found to be non-significant.

The data regarding cob length (Table 3) with respect to row spacing exhibited that cob length with husk (13.35 cm) and without husk (8.64 cm) were recorded under wider spacing of (R_3) 60 cm over rest of the spacing during course of study. Cob weight with husk (35.24 g) and without husk (22.81 g) were recorded under wider spacing of (R_3) 60 cm over rest of the spacing during course of study. The higher yield attributes under said treatment could be attributed to maximum exploitation of ground area and optimum availability of space and resources led to better translocation of photosynthates towards the sink in wider planting geometry which resulted in significantly higher cob length. These results are corroborates with the results of Nand (2015) who reported that geometry of 45 cm x 20 cm recorded significantly higher cob length (cm) and it was at par with geometry of 45 cm x 20 cm. Similar line of result was also observed by Kandil *et al.* (2017);Nwogboduhu (2016) and Singh *et al.* (2015).

Among the nitrogen sources, significantly higher cob length with husk (12.90 cm) and without husk (8.35 cm) along with cob weight with husk (33.92 g) and without husk (21.96 g) were recorded under (N_4) nano urea over rest of the nitrogen sources. The increase in yield attributes in treatments with Nano-Urea spray may be attributed that Nano-Urea promotes the overall plant growth and enhances nutrients uptake, improve photosynthesis rate and biological efficiency which reflected as improved yield contributing traits (Wu, 2013). Yield attributes increased with application of Nano-Urea. This might be due to sufficient amount of nitrogen Nano-Urea at critical stage which would have maintained continuous supply to nitrogen, led to meristematic cell activity, stimulation to cell elongation in crops and improve photosynthesis rate. These result findings were in close agreement with the findings of Jassim *et al*. (2019).

Significantly higher cob yield (61.45 q ha^{-1}), stover yield (175.67 q ha^{-1}) and biological yield (237.12 q ha^{-1}) of baby corn were recorded with row spacing of (R_2) 45 cm over rest of the row spacing (Table 4). Plants grown with wider spacing consume more nutrients and absorb more solar radiation for efficient photosynthesis and hence, perform better at individual basis. The reason for deviation of this linearity in case of cob yield because yield does not solely depend on the performance of individual plant but rather depend on yield contributing characters. The results are in close conformity with those obtained by Singh *et al.* (2008) they also found that geometries also influenced the grain yield of forage maize. These assumptions are confirmed by the findings of Katuwal*et al*. (2015)

they reported that maize grain yields were the highest at geometry of 45 cm x 25 cm. Similarly, Niveditha and Nagavani (2016) also noticed similar line of results in their study.

Nitrogen sources also significantly influenced the yield of baby corn. Significantly higher cob yield (58.42 q ha^{-1}), stover yield (162.92 q ha^{-1}) and biological yield (220.08 q ha^{-1}) were observed with (N_4) nano urea over rest of the nitrogen sources. However, significantly lower yield was observed with (N_3) Sulphur coated urea. Nano-Urea increased cob yield of baby corn. It is mainly due to increased growth of plant parts and metabolic process such as photosynthesis which lead to higher photosynthates accumulation and translocation to economic parts of the plant. Similar result were found by Kumar *et al*. (2020). Straw yield increase due to foliar spray of Nano-Urea might be due to quick absorption of Nano-Urea by the plant and easiness of translocation which aided in better photosynthesis and more dry matter production. Similar results were found by Sahu *et al.* (2022). The present findings are in line with the findings of Hafeez *et al*. (2015); Samui *et al.* (2022); Samanta *et al.* (2022) and Midde *et al*. (2022).

Row spacing and nitrogen sources failed to show any significant effect on harvest index.

A perusal of data presented in Table 5 indicates that maximum cost of cultivation (₹ 29217 ha^{-1}) was recorded under row spacing of (R_1) 30 cm and minimum under (R_3) 60 cm. Significantly higher gross returns (₹ 127309 ha^{-1}), net returns (₹ 100172 ha^{-1}) and B: C ratio (3.69) were noted under row spacing of (R_2) 45 cm. This might be due to higher yield and least cost of cultivation. Higher net return with BCR values were also observed by Mathukia*et al*. (2014) when maize crop sown at a spacing of 45 cm x 20 cm. The results are in the conformity with the results reported by Scaria *et al*. (2016) they observed higher net returns and benefit cost ratio was recorded under geometry of 45 cm x 20 cm.

In case of nitrogen sources, maximum and a similar cost of cultivation (₹ 27188 ha^{-1}) was recorded with (N_1) Zinc coated urea, (N_2) neem coated urea and (N_3) Sulphur coated urea. Among the nitrogen sources, (N_4) nano urea recorded significantly higher gross returns (₹ 122362 ha^{-1}), net returns (₹ 100172 ha^{-1}) and B:C ratio (3.53) over rest of the nitrogen sources. This might be due to higher cob and stover yield and less cost of cultivation. Our present findings are also supported by the work of Kumar *et al*. (2020) and Panda *et al*. (2020) who also reported that use of nano-fertilizers enhances the cob yield and stover yield, thus maximize the gross and net returns.

Conclusion

From data presented it might reasonably be argued that the significantly highergrowth and yield attributing characters were observed with spacing of (R_3) 60 cm and (N_4) nano urea.However, higher yield and economic returns were significantly higher with row spacing of (R_2) 45 cm along with (N_4) nano urea. On the basis of B: C ratio, row spacing of (R_2) 45 cm along with (N_4) nano urea was found to be remunerative for babycorn under Mid hills of Himachal Pradesh.

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Table 1: Plant height (cm) of baby corn as influenced by row spacing and nitrogen sources at periodic intervals

Treatments		Plant height (cm)		
		20 DAS	**40 DAS**	**60 DAS**
Main plot (Row spacing)				
R_1	30 cm	24.68	101.78	123.59
R_2	45 cm	28.57	117.82	143.07
R_3	60 cm	32.15	132.59	161.00
SEm±		0.85	3.75	4.82
LSD (*p*=0.05)		2.61	11.28	14.62
Sub plot (Nitrogen sources)				
N_1	Zinc coated urea	26.94	111.10	134.91
N_2	Neem coated urea	28.92	119.27	144.82
N_3	Sulphur coated urea	26.64	109.86	133.41
N_4	Nano urea	31.35	129.29	156.99
SEm±		0.64	2.86	3.43
LSD (*p*=0.05)		1.92	8.64	10.37
Interaction (R x N)		NS	NS	NS

Table 2: Dry matter accumulation plant^{-1} (g) of baby corn as influenced by row spacing and nitrogen sources at periodic intervals

Treatments		Dry matter accumulation plant^{-1} (g)		
		20 DAS	40 DAS	60 DAS
Main plot (Row spacing)				
R_1	30 cm	6.92	27.87	37.60
R_2	45 cm	7.69	31.62	42.64
R_3	60 cm	9.57	38.51	51.96
SEm±		0.24	1.03	1.39
LSD (p=0.05)		0.72	3.12	4.21
Sub plot (Nitrogen sources)				
N_1	Zinc coated urea	7.87	31.29	42.21
N_2	Neem coated urea	8.14	32.91	44.39
N_3	Sulphur coated urea	7.11	30.88	41.66
N_4	Nano urea	9.12	35.56	47.97
SEm±		0.19	0.73	1.06
LSD (p=0.05)		0.58	2.24	3.19
Interaction (R x N)		NS	NS	NS

Table 3: Yield attributes of baby corn as influenced by row spacing and nitrogen sources

Treatments		Yield attributes				
		Cobs plant^{-1}	Cob length (cm)		Cob weight (g)	
			With husk	Without husk	With husk	Without husk
Main plot (Row spacing)						
R_1	30 cm	2.31	9.84	6.37	23.61	15.28
R_2	45 cm	2.36	11.60	7.51	28.84	18.67
R_3	60 cm	2.48	13.35	8.64	35.24	22.81
SEm±		0.67	0.32	0.21	0.92	0.59
LSD (*p*=0.05)		NS	1.02	0.67	2.76	1.82
Sub plot (Nitrogen sources)						
N_1	Zinc coated urea	2.36	11.34	7.34	27.22	17.62
N_2	Neem coated urea	2.41	12.07	7.81	30.03	19.44
N_3	Sulphur coated urea	2.34	10.06	6.51	25.74	16.66
N_4	Nano urea	2.45	12.90	8.35	33.92	21.96
SEm±		0.41	0.26	0.16	0.63	0.41
LSD (*p*=0.05)		NS	0.81	0.52	1.91	1.23
Interaction (R x N)		NS	NS	NS	NS	NS

Table 4: Yield (q ha^{-1}) and harvest index (%) of baby corn as influenced by row spacing and nitrogen sources

Treatments		Yield (q ha^{-1})			Harvest index (%)
		Cob yield	Stover yield	Biological yield	
Main plot (Row spacing)					
R_1	30 cm	48.65	148.94	197.59	24.62
R_2	45 cm	61.45	175.67	237.12	25.92
R_3	60 cm	53.74	154.97	208.71	25.75
SEm±		1.78	5.09	6.37	0.87
LSD (p=0.05)		5.42	15.38	19.18	NS
159.86					
Sub plot (Nitrogen sources)					
N_1	Zinc coated urea	53.47	161.36	214.83	24.88
N_2	Neem coated urea	54.38	162.92	217.30	25.02
N_3	Sulphur coated urea	52.19	153.54	205.73	25.36
N_4	Nano urea	58.42	161.66	220.08	26.54
SEm±		1.05	3.40	4.54	0.72
LSD (p=0.05)		3.18	10.28	13.67	NS
Interaction (R x N)		NS	NS	NS	NS

Table 5: Economics (₹ ha^{-1}) of baby corn as influenced by row spacing and nitrogen sources

Treatments		Economics (₹ ha^{-1})			B:C ratio
		Cost of cultivation	Gross returns	Net returns	
Main plot (Row spacing)					
R_1	30 cm	29217	102763	73546	2.52
R_2	45 cm	27137	127309	100172	3.69
R_3	60 cm	25057	111604	86547	3.45
SEm±		-	3401	3401	0.06
LSD (p=0.05)		-	10217	10217	0.21
Sub plot (Nitrogen sources)					
N_1	Zinc coated urea	27188	111077	83889	3.09
N_2	Neem coated urea	27188	113954	86766	3.19
N_3	Sulphur coated urea	27188	108193	81005	2.98
N_4	Nano urea	26985	122362	95377	3.53
SEm±		-	2709	2709	0.04
LSD (p=0.05)		-	8147	8147	0.14
Interaction (R x N)		-	NS	NS	NS