Bangladesh Agron. J. 2023, 26(1): 96-103

EFFECTS OF PLANTING GEOMETRY AND FERTILIZER MANAGEMENT ON LIGHT INTERCEPTION, CHLOROPHYLL CONTENT AND PRODUCTIVITY IN BABY CORN CULTIVATION

S.S. Kakon*, J.A. Chowdhury, M.Z. Ali, M.R. Karim and D.A. Chowdhury

Agronomy Division, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur 1701, Bangladesh
*Corresponding author, Email: kakonbari@gmail.com

(Received: 28 August 2023, **Accepted:** 20 September 2023**)**

Keywords: Light Interception, Chlorophyll Content and Productivity, Baby Corn

Abstract

A field experiment was conducted during during *rabi* seasons (December to March) of 2019-20 and 2020-21 to find out optimum plant spacing and fertilizer levels on yield of baby corn. Three plant spacing viz, S_1=40 cm × 20 cm (1,25000 plants ha^{-1}), S_2=50 cm × 20 cm (100000 plants ha^{-1}) and S_3 =60 cm × 20 cm (83333 plants ha^{-1}) and three fertilizer doses viz, F_1 = 150- 30- 50- 25-3. 5- 1.5 kg ha^{-1}of NPKSZnB (Recommended fertilizer dose for baby corn), F_2 = F_1 + 25% NPK and F_3 = F_1 + 50% NPK, were used as treatments. Results revealed that, planting geometry and fertilizer levels showed great influence on leaf area index (LAI), light interception, dry matter production and yield of babycorn. LAI was found the highest with the population of 125000 plants ha^{-1} receiving N_{225} P_{45} K_{75} kg ha^{-1}.Light absorption was maximum at densely plant population with $N_{225}P_{45}K_{75}$ kg ha^{-1}. Response of soil-plant-analysis development (SPAD) value to planting geometry and fertilizer level was found significant. Plants grown with 40 cm × 20 cm spacing (125000 plants ha^{-1}) with recommended ferltilizer dose + 50% N- P- K of RF gave the highest dehusked cob yield over the years (3.42 and 3.73 t ha^{-1}) which was followed by 40cm × 20 cm (1,25,000 plants ha^{-1}) with recommended fertilizer dose + 25% N-P-K of RF. Though S_1F_3 combination gave the highest gross return (Tk.333140 ha^{-1} in 2019-20 and Tk. 378900 ha^{-1} in 2020-21) but the highest benefit cost ratio over the years (3.64 and 3.83) was recorded in S1F2 treatment. The overall results indicated that 40 cm × 20 cm (1,25,000 plants ha-1) with fertilizer dose of RFD + 25% NPK (N187.5 P37.5K62.5 S25Zn3. 5B1.5 kg ha-1) might be economically profitable for baby corn production.

Introduction

Babycorn (*Zea mays* L.) is an immatured, dehusked and unfertilized maize ear, harvested within two days of silk emergence but prior to fertilization (Ramchandrappa *et al.*, 2004). Change in food habit from non-vegetarian to vegetarian aggravated the consumption of vegetables especially babycorn. Babycorn ends its life cycle within 75 days and enters its reproductive phase during 50-55 DAS. Nitrogen is the most important nutrient for maize production and application of varied levels had significant influence on growth and yield of babycorn (Thakur *et al.*,1997). It is a low calorie vegetable having higher fibre content without cholesterol. Besides nutritive advantage, it is also free from residual effect of pesticides as it is harvested within a week of tassel emergence and the young cob is wrapped up tightly with husk and well protected from insects and pests Recently it is becoming popular very rapidly as vegetables, salad, pasta, soup, pakora, chutney, cutlets chat, dry vegetable. To sustain the heavy cattle population, baby corn can provide a valuable supplementary source of green fodder. Optimum crop geometry is one of the important factors for higher production leading to efficient utilization of resources and also harvesting as much as solar radiation and in turn better photosynthesis. The yield of baby corn of our country is 0.99-1.1 t ha^{-1} (BARI, 2008). But its potentiality is 5 t ha^{-1} (BARI, 2004). Nevertheless, it is not cultivated all over the country due to the lack of appropriate production technology. Growth of baby corn are affected by cultural management practices especially fertilizer application. The application of 150:75:40 kg ha^{-1} NPK + 10 t FYM was found to be optimal for obtaining high baby corn and fodder yields with good quality (Ramchandrappa *et al.*, 2004). Though the spacing requirements of grain and fodder maize are well defined, such information is meager in baby corn. The duration of crop being short, the need for nutrient management and other package of practices may also differ from the grain or fodder crop of maize. Therefore, the experiment was undertaken to find out optimum plant spacing and fertilizer levels on yield of babycorn.

Materials and Methods

The experiment was conducted at the Research Field of Agronomy Division BARI, Gazipur, Bangladesh during *rabi* season (December to March) of 2019-2020 and 2020-2021. The soil was clay loam with pH 6.1. Soils of the experimental plots were collected and analyzed. The average maximum (30.5°C) temperature was found in the month of December at early stage of crop establishment and minimum (7.5°C) in the month of February during the crop growing season (Figure 1). The physical and chemical properties of soil are presented in Table 1.

Table 1. Physical and chemical properties of experimental soil at Gazipur, Bangladesh

pH	OM (%)	Total N (%)	Exchangeable K (meq 100g $soil^{-1}$)	Available P (g ml^{-1})	Available S (g ml^{-1})	Available Zn (g ml^{-1})	Available B (g ml^{-1})
6.23	1.29	0.112	0.098	15.23	24.94	0.654	0.168
	VL	VL	VL	O	O	L	VL
Critical Levels		-	0.12	7.0	10.00	0.60	0.20

L= Low, VL= Very low

Three plant spacing viz., S_1= 40 cm × 20 cm (1,25000plants ha^{-1}), S_2= 50 cm × 20 cm (100000 plants ha^{-1}) and S_3 = 60 cm × 20 cm (83333plants ha^{-1}) and three fertilizer doses viz., F_1 = 150- 30- 50- 25-3. 5- 1.5 kg ha^{-1} NPKSZnB (Recommended fertilizer dose), F_2 = F_1 + 25% NPK and F_3 = F_1 + 50% NPK, were used. The experiment was laid out in a randomized complete block design with three replications. The unit plot size was 4 m × 3.6 m. Seeds of BARI Baby corn-1 were sown on 12 December 2019 and on 3 December 2020. Fertilizers were applied as per treatments. One-third of nitrogen and full amount of Triple super phosphate (TSP), Muriate of potash (MoP), Zinc sulphate and Boric acid were applied at the time of final land preparation. The remaining N (urea) was top dressed in two equal splits at 25 DAS and 45 DAS, respectively and mixed thoroughly with the soil as soon as possible for better utilization. A light irrigation was given after sowing of seeds for uniform germination. Two irrigations were done at 30 and 45 DAS. Thinning's were done at 10 DAS and weeding at 15 and 25 DAS. Leaf area was measured by an automatic leaf Area Meter (L13200 C, LICOR, USA). For dry matter estimation, 5 plants were sampled started from 20 DAE at 15 days interval up to maturity. Dry weight of the samples was taken after drying at 80°C in an oven for 72 h. CGR (g m^{-2} day^{-1}), was calculated using equation as suggested by Yellam as follows.

Light interception (LI) by the crop was recorded at five times, for example, 25, 45, 60 DAS and at harvest at around 11:30 am to 13:00 pm of baby corn by Sunfleck Ceptometer (Model Decagon, Pulman, Washington, USA). Four readings each of PARinc and PARt were recorded at different spots of each plot. The proportion of intercepted PAR (PARint) was calculated using the following equation and expressed in percentage:

$$\text{Light interception \{PARint (\%)\}} = \frac{\text{PARinc} - \text{PARt}}{\text{PARinc}} \times 100$$

where, PARinc = Incident PAR, PARt = Transmitted PAR, PARint = Intercepted PAR

Soil-Plant-Analysis Development (SPAD) Value. Leaf chlorophyll content may be used as an indirect indicator of crop N status. Chlorophyll meter values (SPAD) were taken using a portable SPAD meter (Model SPAD-502, Minolta crop., Ramsey, NJ) starting from 35 DAS with 15-day interval.

BARI Babycorn-1 was harvested on 04 March 2020 (85 days after sowing) and on 08 March 2021. The yield component data was taken from 5 randomly selected plants from each plot. At harvest, the yield data was recorded plot wise. The collected data were analyzed statistically and means were adjudged by LSD test at 5% level of significance using MSTAT-C package.

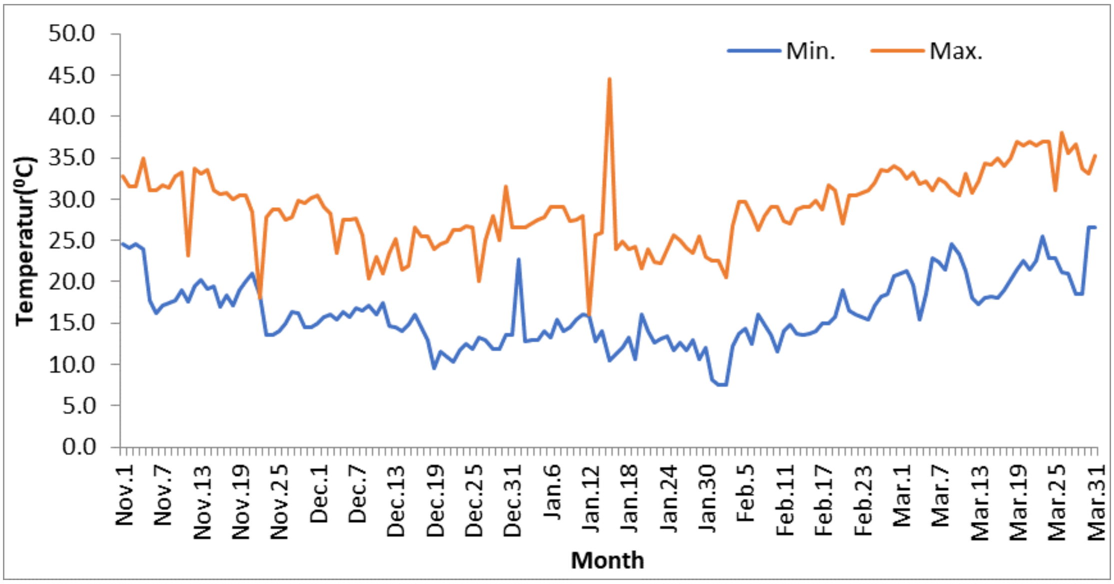


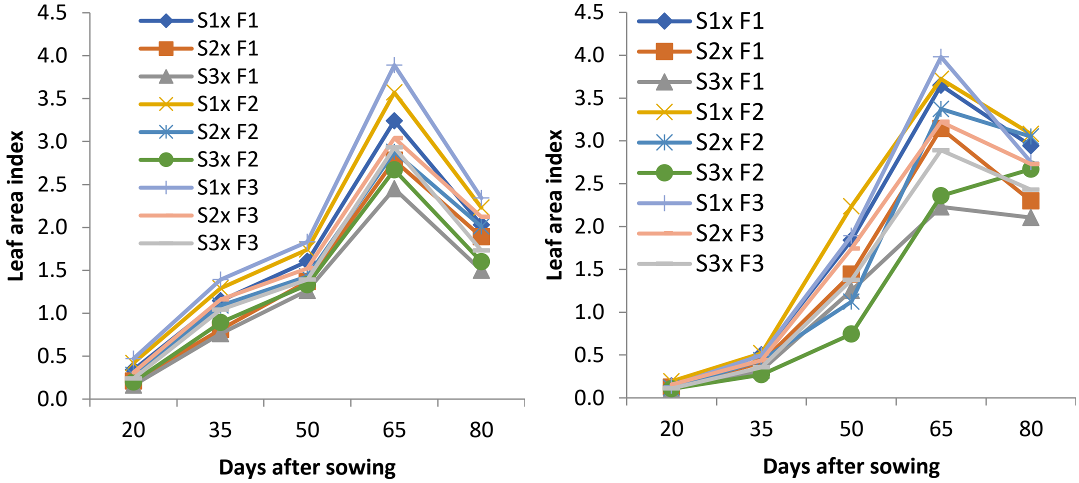
Fig. 1. Mean temperature prevailed during baby corn growing periods.

Results and Discussion

Growth analysis

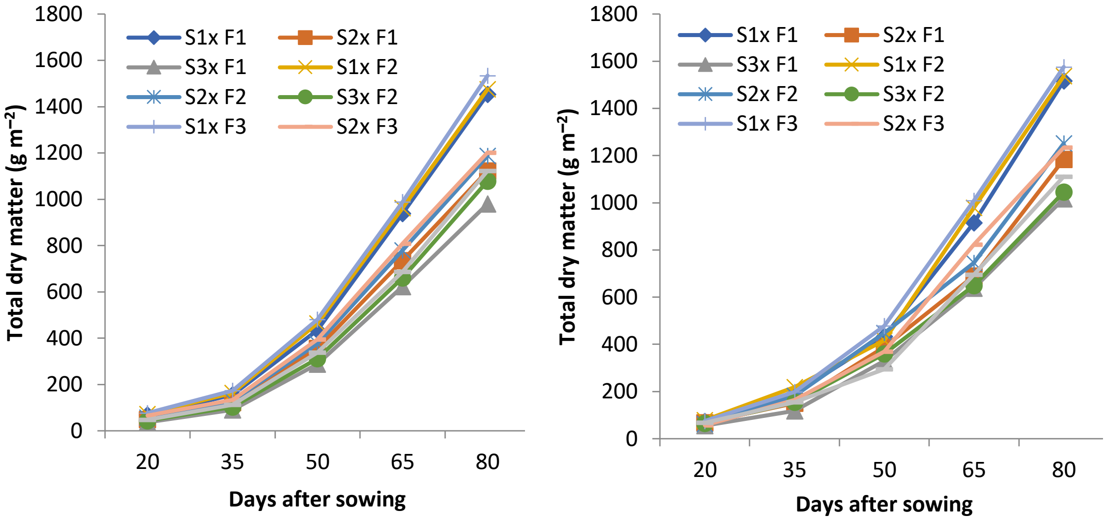
Leaf area index (LAI) varied at different plant spacing and fertilizer level. LAI increased up to 60 DAS and thereafter decreased in all treatments (Fig. 2). Maximum LAI (3.89 in 2019-20 and 3.98 in 2020-21) was recorded at 65 DAS in S_1F_3 (125000 plants ha^{-1} × N $_{225}$P$_{45}$K$_{75}$kg ha^{-1}) treatment followed by S_1F_2 (100000 plants ha^{-1} × N$_{187.5}$ P$_{37.5}$K$_{62.5}$kg ha^{-1}) treatment. Higher LAI indicates better leaf area expansion, which might help in solar radiation interception for more dry matter production. The lowest leaf area index (1.5 in 2019-20 and 2.10 in 2020-21) was found in $S_3 \times F_1$followed by $S_2 \times F_1$ treatment. 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). Total dry matter (TDM) production increased gradually with the advancement of plant growth in both the plant spacing and different fertilizer doses (Figure 3). TDM of baby corn was higherinS_1F_3 (125000 plants ha^{-1} × N$_{225}$P$_{45}$K$_{75}$kg ha^{-1}) followed by S_1F_2 treatment.

The lowest TDM was observed from $S_2 \times F_1$ treatment. Total dry matter reduced in plant spacing S_3 (60cm × 20 cm) under all fertilizer treatments. It might be due to lower population (83,333plants ha^{-1}) and leaf senescence caused by might reduce the photosynthetic efficiency and ultimately reduced the dry matter accumulation (Figure 2). The treatments which gave the higher value in leaf area index (LAI) were performed better in total dry matter production. Similar findings were also observed with Tollenaar *et al.* (1997).



a) 2019-2020 b) 2020-2021

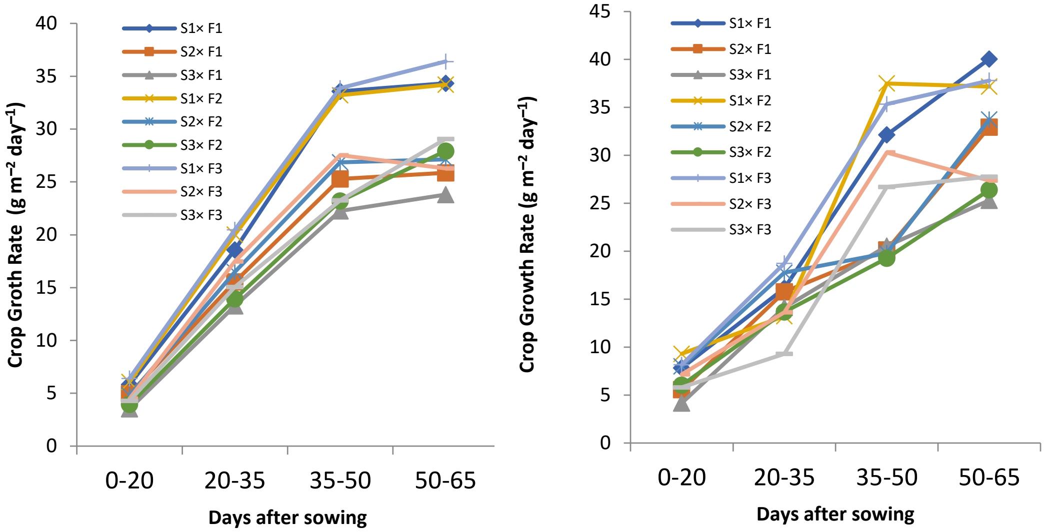
Fig. 2. Leaf Area Index of baby corn plant as influenced by planting density and fertility level.



a) 2019-2020 b) 2020-2021

Fig. 3. Total dry matter of baby corn plant as influenced by planting density and fertilizer levels.

Significant effect on CGR value at all growth periods was found in both the plant spacing and different fertilizer doses (Figure 4). CGR values were increased with the progress of the growth and development of the crop. CGR of baby corn was higher in S_1F_3(125000 plants ha^{-1} × $N_{225}P_{45}K_{75}$kg ha^{-1}) followed by S_1F_2 treatment. The lowest CGR was observed from S_2 × F_1 treatment. CGR reduced in plant spacing S_3 (60cm × 20 cm) under all fertilizer treatments.

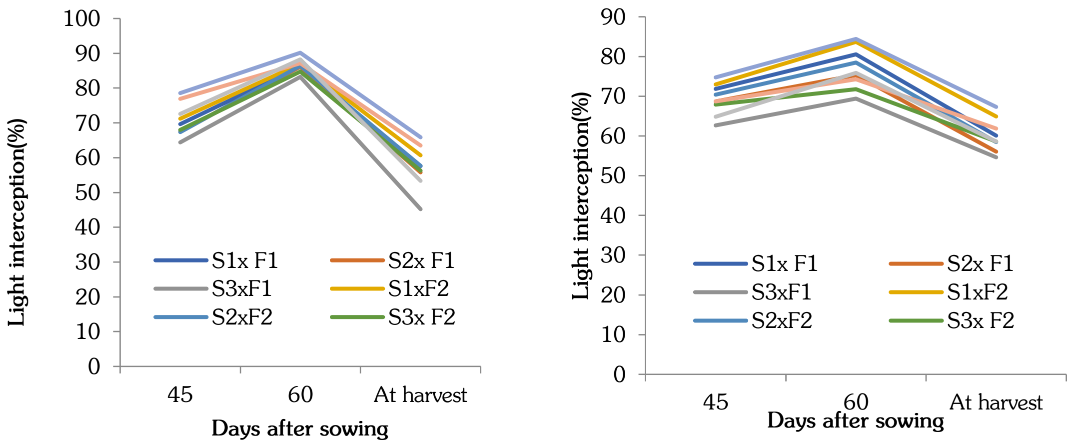


a) 2019-2020 b) 2020-2021

Fig. 4. Crop Growth Rate of baby corn plant as influenced by planting geometry and fertilizer levels.

Light Interception

Light interception steadily increased up to 60 DAS and decreased at harvest. Light Interception varied at different plant spacing and fertilizer doses (Figure 5).



a) 2019-2020 b) 2020-2021

Fig. 5. Light interception by baby corn canopy as influenced by planting density and fertilizer levels.

Combination of S_1F_3 (125000 plants ha^{-1} × N $_{225}$P$_{45}$K$_{75}$ kg ha^{-1}) was favorable for light penetration to the upper of the canopy, which resulted better LI and the lowest LI was found in S_3F_1 (83,000 plants × 150- 30- 50- 25-3. 5- 1.5 kg ha^{-1}NPKSZnB). Higher light absorption by the plants of treatment S_1F_3 is presumably because of larger leaf surface availability for photosynthesis as evident by higher leaf dry- weight. This indicates that population is the main factor influencing the net radiation absorbed by the plants.

Higher penetration of radiation below the canopy indicates lower interception of solar radiation at the canopy. The maximum light was intercepted at 60 DAS corresponded to higher LAI. These results indicated that the more the LAI, the greater the light interception. These results are in conformity with the findings of several earlier researchers Amanullah *et al.,* (2010).

SPAD value

SPAD value was influenced by planting geometry and fertilizer level (Figure 5). SPAD meter measure the leaf greenness which indicated the leaf chlorophyll content. Regardless of treatment, SPAD values decreased with the plant age (Figure 6). Maximum SPAD values were observed at 65 DAS which declined progressively reaching the lowest at 80 DAS. The higher SPAD values of baby corn leaves at 65 DAS were probably due to the less sink demand for N from the source (leaf). SPAD value increases with the increase of fertilizer (especially nitrogen).

Conversely, lower SPAD values at 80 DAS and afterwards might have been due to remobilization of N from leaves to reproductive organs as grain formation was started after 60 DAS. SPAD values increased with the increase of fertilizers levels irrespective of population density. The highest SPAD value was found in S_1F_3 (125000 plants ha^{-1} × $N_{225}P_{45}K_{75}$ kg ha^{-1}).

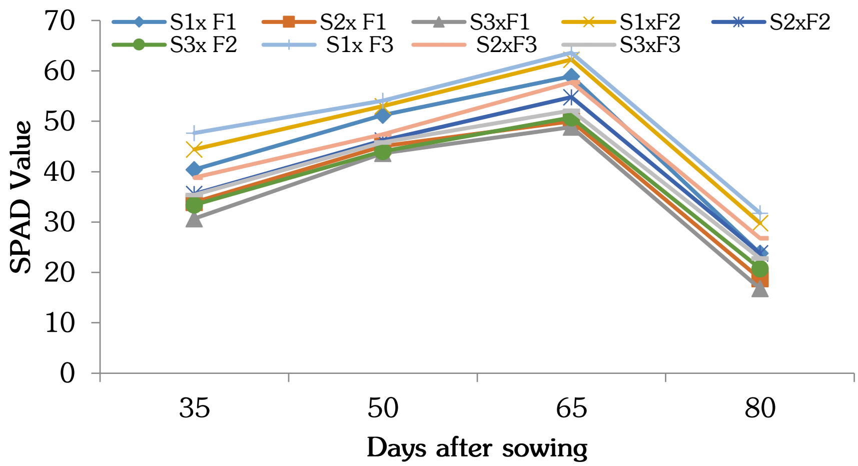


Fig. 6. SPAD value on baby corn plant as influenced planting geometry and fertility levels.

Yield component and yield

Plant population, yield components and yield of baby corn were significantly affected by plant spacing and fertilizer doses (Table 2) in both the years.

Number of cob per plant, cob wt. with husk, dehusked cob weight, dehusked cob yield and fodder yield varied significantly due to variation of treatments. Maximum plants were recorded in S_1F_1, S_1F_2 and S_1F_3 treatments and minimum plants were recorded in S_3F_1, $S_3F_2S_3F_3$ treatments. Significantly the highest number of cob per plant (2.80 in 2019-20 and 3.00 in 2020-21), dehusked cob weight/ plant (69.04g in 2019-20 and 58.67g in 2020-21) were obtained from S_3F_3 treatment followed by, S_2F_3 treatment. Higher dehusked cob yield (3.42t ha^{-1} in 2019-20 and 3.73 t ha^{-1} in 2020-21) was recorded from S_1F_3 treatment followed by S_1F_2 treatment.It might be due to higher number of plants. The result coincides with the findings of Kunjir *et al.*, (2007). The lowest green cob yield average over the years (2.32 and 2.36 t ha^{-1}) were obtained from S_3F_1 treatment which was statistically similar with S_2F_1 treatment.

Table 2. Plant population, yield attribute and yield of baby corn as influenced by plant spacing and fertilizer levels (2019-20 and 2020-21)

Treatment	Plant m^{-2} (no.)		Cob wt. with husk (g $plant^{-1}$)		Cob wt. dehusked (g $plant^{-1}$)		Cob $plant^{-1}$ (No.)	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
$S_1\times F_1$	10.00	10.34	97.64	116.33	30.94	31.30	2.53	2.51
$S_2\times F_1$	8.00	8.10	109.80	119.59	34.13	34.03	2.59	2.67
$S_3\times F_1$	6.33	6.74	118.50	131.33	38.38	42.07	2.68	2.73
$S_1\times F_2$	9.67	9.87	103.40	121.33	48.51	41.78	2.57	2.67
$S_2\times F_2$	7.67	7.74	113.25	127.00	53.58	48.67	2.64	2.70
$S_3\times F_2$	6.67	6.77	121.93	144.00	59.02	54.00	2.72	2.78
$S_1\times F_3$	9.67	9.59	109.80	126.90	56.57	49.63	2.61	2.60
$S_2\times F_3$	7.00	7.63	118.65	131.33	62.17	54.00	2.70	2.70
$S_3\times F_3$	6.67	6.62	127.20	147.33	69.04	58.67	2.80	3.00
$LSD_{(0.05)}$	2.65	0.20	11.23	1.17	3.31	1.12	0.21	0.055
CV (%)	4.30	3.44	3.63	3.56	4.65	4.41	5.05	4.03

Treatment	Yield dehusked (t ha^{-1})		Yield withhusk (t ha^{-1})		Fodder yield (t ha^{-1})	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
$S_1\times F_1$	2.65	2.83	11.45	12.08	28.26	29.63
$S_2\times F_1$	2.49	2.62	9.42	10.84	26.01	25.93
$S_3\times F_1$	2.32	2.36	8.86	9.80	24.02	24.07
$S_1\times F_2$	3.30	3.57	13.50	13.33	31.18	32.10
$S_2\times F_2$	2.71	3.12	11.89	12.00	29.64	29.32
$S_3\times F_2$	2.50	2.71	10.06	11.02	26.94	26.85
$S_1\times F_3$	3.42	3.73	14.02	14.15	32.98	33.33
$S_2\times F_3$	3.01	3.24	12.50	12.90	31.01	32.10
$S_3\times F_3$	2.70	2.81	11.03	11.57	28.05	27.47
$LSD_{(0.05)}$	0.13	0.08	3.05	0.14	4.20	0.92
CV (%)	4.73	3.29	6.01	5.68	5.61	5.83

Significantly the highest green fodder yield was recorded in S_1F_3 (32.98 t ha^{-1}in 2019-20 and 33.33 t ha^{-1} in 2020-21) treatment. Hussain (2014) reported that higher dose of fertilizer application resulted the increased fodder yield. The lowest fodder yield was obtained from S_3F_1 treatment in both the years. Yield attributes increased with increased rates of N might be due to the fact that application of nitrogen to the maize plants maintained greenness of leaves for longer period which in turn helped in greater dry matter accumulation and this might have contributed much as a major source for the development of sink and thereby improved the yield attributes. Significantly the highest fodder yield was recorded in closer spacing with higher level of NPK indicating a faster growth under influence of higher level of NPK fertilization might have played a significant role in reducing competition for photosynthates and nutrients with other plants resulting in healthy plants.

Cost benefit Analysis

Cost and return analysis is an important tool to evaluate the economic feasibility of crop production. Benefit cost analysis of baby corn production has been presented in Table 3. Gross return and BCR depends on grain yield. Among the treatments, the highest gross return (Tk. 333140 ha^{-1}in 2019-20 and Tk.378900 ha^{-1} in 2020-21) was obtained from S_1F_3 treatment and the lowest gross return (Tk. 226477 ha^{-1} in 2019-20 and Tk.267350 ha^{-1}in 2020-21) was found in S_3F_1 treatment. The highest gross margin (Tk. 239685 ha^{-1} in 2019-20 and Tk.278949 ha^{-1} in 2020-21) was obtained from S_1F_3 treatment. The highest benefit cost ratio (3.64 in 2019-20 and 3.80 in 2020-21) was also obtained from S_1F_2 treatment (Table 3) which was followed by S_1F_3 and S_2F_3.

Table 3. Cost benefit analysis of babycorn as influenced by planting geometry and fertilizer level

Spacing fertilizer	Gross return (Tk. ha^{-1})		Cost of production (Tk. ha^{-1})		Gross margin (Tk. ha^{-1})		BCR	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
$S_1\times F_1$	278683	329350	84560	92752	194123	236598	3.30	3.55
$S_2\times F_1$	243073	292250	81820	88552	161253	203698	2.97	3.30
$S_3\times F_1$	226477	267350	77450	85352	149027	181998	2.92	3.13
$S_1\times F_2$	317917	360450	87280	94231	230637	266220	3.64	3.83
$S_2\times F_2$	290897	326600	83020	90649	207877	235952	3.50	3.60
$S_3\times F_2$	255380	299550	79350	87449	176030	212102	3.22	3.43
$S_1\times F_3$	333140	378900	93455	99951	239685	278949	3.56	3.79
$S_2\times F_3$	305033	354000	87850	94745	217183	259255	3.47	3.74
$S_3\times F_3$	272610	310900	81665	89545	190945	221355	3.34	3.47

Price (Tk.kg^{-1}): Baby corn (with husk) = 12 in 2019-20 and 15 in 2019-20; Fodder = 5

Conclusion

Results reveled that fertilizer dose 187.5- 37.5- 62.5- 25- 3.5- 1.5 kg ha^{-1} of NPKSZnB (RFD + 25% NPK) with plant spacing 40 cm × 20 cm would be optimum for getting higher yield and better economic return at Joydebpur.

References

Amanullah, A., M. Asif and K. Nawab. 2010. Impact of planting density and P-fertilizer source on the growth analysis of maize. Pak. J. Bot. 42(4): 2349–2357.

BARI. 2008. BARI Annual Research Report. 2007- 08. Effect of season and population density on growth, fodder production and yield of baby corn at different locations. Agronomy division, BARI, RARS, Hathazari, Chittagong, Bangladesh.

BARI. Production technology of baby corn (in Bengali). Agronomy Division, BARI, Joydebpur, Gazipur, Bangladesh.

Hussain, A. 2014. Effect of different combinations of organic and inorganic nutrients on productivity and profitability of baby corn varieties in Kashmir Valley. Ph.D. thesis, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Division of Agronomy, Shalimar Campus, Srinagar–190025.

Kunjir, S.S., S.A. Chavan, S.B. Bhagat and N.B. Zende. 2007. Effect of planting geometry, nitrogen levels and micronutrients on the growth and yield of sweet corn. Crop Prot. Prod. 2: 25- 27.

Ramachandrappa, B.K., I.I.V. Nanjappa and I.I.K. Shivakumar. 2004. Yield and quality of baby corn (*Zea mays* L.) as influenced by spacing and fertilization levels. Acta Agron. Hung. 52: 237-243.

Thakur, D.R., O.M. Prakash, P.C. Kharwara and S.K. Bhalla. 1997. Effect of nitrogen and plant spacing on growth, yield and economics of baby corn (*Zea mays*). Indian. J. Agron. 42(3): 479-483.

Tollenaar, M., A. Aguilera and S.P. Nissanka. 1997. Grain yield is reduced more by weed interference in an old than in a new maize hybrid. Agron. J. 89: 239-246.

Wasnik, V.K., A.P.K. Reddy and S.S. Kasbe. 2012. Performance of winter maize under different rates of nitrogen and plant population in Southern Telangana region. Crop Res. 44(3): 269-273.