INFLUENCE OF FERTILIZER AND SPACING ON THE YIELD PERFORMANCE OF BABY CORN

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DECEMBER, 2017

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By

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REGISTRATION NO. 16-07566

A Thesis
Submitted to the Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka,
In partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE
IN
AGRONOMY

SEMESTER: JULY- DECEMBER, 2017

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CERTIFICATE

This is to certify that thesis entitled, "***INFLUENCE OF FERTILIZER AND SPACING ON THE YIELD PERFORMANCE OF BABY CORN***" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS)** in **AGRONOMY**, embodies the result of a piece of bona fide research work carried out by **NURUN NAHAR** Registration No. **16-07566** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

…………………………..
Dated:
Place: Dhaka, Bangladesh

…………………………………
(Prof. Dr. Md. Jafar Ullah)
Supervisor

Dedicated To

My Beloved Parents

ACKNOWLEDGEMENT

Alhamdulillah, all praises are due to Almighty Allah for the best owing mercy upon me and for imbibing confidence on me to materialize the research work. It is a great gratification to articulate my gratitude to my respected parents, who had to pass through much hardship but always inspired for prosecuting my studies, which enabled me to reach at this stage of education.

I am greatly thankful to express my heartfelt gratitude and most sincere appreciations to my Supervisor ***Prof. Dr. Md. Jafar Ullah****, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for his valuable guidance, advice, immense help, encouragement and support throughout the study.*

I express my sincere appreciation to my Co-Supervisor ***Prof. Dr. H. M. M. Tariq Hossain****, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for his constant encouragement, cordial suggestions, constructive criticisms and valuable advice to complete the thesis.*

I would like to express my respectable and boundless gratitude to all the teachers of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, for their valuable teaching, sympathetic co-operation, and inspirations throughout the course of this study and research work.

I am also giving my special thanks to my class mates and friends Bibi Amena, Swapna Das, Tumpa Datta, Md. Enamul Hasan, Zamin Tani, Farzana Khan and Sayma Serine for their keen help as well as heartiest cooperation and encouragement during experimentation. Special thanks to all other friends for their support and encouragement to complete this study.

I am deeply indebted and grateful to my younger brothers Md. Abdullah Al Noman and Md. Sholiman Islam, relatives as well as my beloved husband Saiful Islam who continuously prayed for my success and without whose love, affection, inspiration and sacrifice this work would not have been completed.

Finally, I appreciates the assistance rendered by the staff members of the Department of Agronomy, Sher-e-Bangla Agricultural University Farm, Dhaka, who have helped me much during the period of study.

The Author

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ABSTRACT

An experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka during March to June 2017 to study the influence of fertilizer and spacing on the yield performance of baby corn. Four levels of fertilizer doses *viz*. F_1 = Recommended doses of fertilizer (RDF), F_2 = 20% less than RDF, F_3 = 40% less than RDF and F_4 = 20% higher than RDF and three levels of plant spacing *viz*. S_1 = 60 cm × 25 cm, S_2 = 50 cm × 25 cm and S_3 = 40 cm × 25 cm were the treatments for the experiment. The experiment was laid out in a split-plot design with three replications having fertilizer doses in the main plot and plant spacing in the sub-plot. The nutrients; N, P, K, S and Zn were applied from the sources of urea, TSP, MoP, gypsum and $ZnSO_4$ respectively at the rate of 300, 150, 100, 150 and 10 kg ha^{-1}, respectively which was considered as recommended doses of fertilizer (RDF). Hybrid baby corn was used as a test crop for the study. Results revealed that fertilizer treatment F_4 (20% higher than RDF) showed the highest fresh cob yield ha^{-1} (9.26 t) whereas, the lowest (6.52 tha^{-1}) was from F_3 (40% less than RDF). Again, plant spacing with S_3 (40 cm × 25 cm) produce the highest fresh cob yield ha^{-1} (9.01 t) while the S_1 (60 cm × 25 cm) produce the lowest (7.14 t). The interaction, F_4S_3 showed significantly the highest fresh cob yield (10.10 t ha^{-1}) which was attributed to the maximum number of cobs ha^{-1} (270.00 thousand) and it also produced the maximum stover yield ha^{-1} (11.12 t), biological yield ha^{-1} (21.22 t) and harvest index (47.60%). On the contrary, the minimum fresh cob yield was produced by the interaction, F_3S_1 (5.92 t ha^{-1}). For more precise results such trials need to be made in other agro climatic regions of Bangladesh. The highest gross return (Tk. 303000), net return (Tk. 137759) and BCR (1.83) were also obtained from the treatment combination of F_4S_3. But the lowest were obtained from the treatment combination of F_3S_1 (40% less than RDF with 40 cm × 25 cm plant spacing).

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
et al.,	=	And others
e.g.	=	exempli gratia (L), for example
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	Gram (s)
i.e.	=	that is
kg	=	Kilogram
LSD	=	Least Significant Difference
m^2	=	Meter squares
ml	=	Mililitre
M.S.	=	Master of Science
No.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
var.	=	Variety
^oC	=	Degree Celsius
%	=	Percentage
NaOH	=	Sodium hydroxide
GM	=	Geometric mean
mg	=	Milligram
P	=	Phosphorus
K	=	Potassium
Ca	=	Calcium
L	=	Litre
µg	=	Microgram
USA	=	United States of America
WHO	=	World Health Organization

CHAPTER I

INTRODUCTION

Maize (*Zea mays* L.) is the second most important cereal crop next to rice being used both as food and feed crop worldwide. It belongs to the family of grasses (Poaceae). It shows great adaptability to a wide range of agro-climatic regions and can be grown in all the three seasons *viz*., Pre-kharif, Kharif and Rabi. For diversification and value addition of maize as well as growing of food processing industries, an interesting development is of growing maize for vegetable purpose, which is known as 'baby corn'. It is not only a 'cash crop' but also a very good 'catch crop'. Thus, it is such a new crop which can improve the economic status of poor farmer. It is not only an important human food but a good source of nutrient and also a basic item of animal feed and raw material for manufacture of many industrial products. The products include corn starch, maltodextrins, corn oil, corn syrup and products of fermentation and distillation industries.

The production of maize in Bangladesh is popularizing for its multifarious use for food, feed and edible oil preparation (Azad, 2003). The cultivation of maize is increasing day by day due to its diversified use, where the total area coverage and productions were 3.17 lakh acres with a production of 7.29 lakh metric tons in 2008-2009 and 3.75 lakh acres with a production of 8.87 lakh metric tons during 2014-15 (BBS, 2016). The maize is richer in nutrition than rice and wheat, where it contains 11% protein including higher amount of essential amino acid, tryptophan and lysine. Besides, due to yellow color, it contains 90 mg carotene or Vitamin A in each 100g grains (Hossain *et al*., 2005).

The cultivation of maize as baby corn has been practicing in the countries like Thailand, Taiwan, China and Japan since long and in India, it is relatively new introduction. Baby corn has revolutionized the food habits by providing diversified food items over the world. The nutritional value of baby corn is at par or even superior to some vegetables. It is a rich source of fibres, protein, vitamins and iron and easy to digest. Baby corn is highly remunerative and farmers can get a high return in a short period of 45-60 days. Baby corn cultivation provides avenues for crop diversification, value addition and revenue generation as baby corn cultivation not only produces nutritious vegetables but also provides green fodder for the livestock.

It is an established fact that without application of the fertilizer elements in the soil, no crop can be grown successfully in terms of seed yield as these nutrient materials are deficient. Proper nutrient management is essential to get higher yield in any crop. Chemical fertilizer application and/or organic manure may leads to get maximum production of baby corn (Ranjan *et al*., 2013). Baby corn is quite popular worldwide but good agricultural management practices particularly nutrient management to maximize the production is the need of the day (Sobhana *et al*., 2012). Fertilizer management is an important window for sustainable crop production as it plays the most crucial role on growth and productivity of corn. Most of the works on fertility management are on corn production where the crop requires high doses of fertilizers application (Rakesh *et al*., 2015). Kotch *et al*. (1995) suggested that high doses of fertilizer application may not be essential as baby corn is harvested before ear maturation. Poor management of fertilizer has key role to play in obtaining low yield productivity, so in order to achieve optimum crop productivity management of nutrients through judicious application of micro and macro nutrients through fertilizer management are required Ghaffari *et al*. (2011). Furthermore, the fertilizer management is one of the most important factors that influence the growth and yield of maize crop. Maize is considered as most exhaustive crop after sugar cane and requires both micro and macro nutrients to obtain high growth and yield potentials. Nutrient management is a judicious use of organic and inorganic sources of nutrient to crop fields for sustaining and maintaining soil productivity. Judicious application of these combinations can sustain the soil fertility and productivity.

Maintaining proper plant spacing is an important agronomic management as this management changes the population density in the crop field which intern affects crop yield. Next to soil fertility another factor of equal importance is spacing. The yield of any crop depends to a greater extent on the number of plants per unit area. It plays an important role in influencing the productivity of any crop. It is essential to establish the optimum plant population for the yield concerned, because of non tillering habit, baby corn cannot compensate the loss of space unlike other tillering cereals like rice and wheat. Optimum plant density is required for obtaining high crop productivity. Baby corn needs to be planted at a spacing of 90 cm between rows and 10 cm between the plants within the row having a plant population of approximately 1,10,000 plant per hectare (Kotch *et al*., 1995). Researchers indicated a requirement of 70% extra population (1,10,000 ha^{-1}) for baby corn than normal maize (65000 ha^{-1}); required population can be obtained by adopting a spacing of either 45 × 20 or 60 × 15 cm. Sahoo and Mahapatra (2007) noted that 83,300 plants ha^{-1} produced 16.48 t ha^{-1} green cobs, which was 7.6% more than that of 66,700 plants ha^{-1} and it gave the maximum net profit.

Management in fertilizer application and plant spacing may be critical in having greater seed yields in baby corn. In one hand it may look that the same maize crop should require less nutrient since it is harvested much before grain maturity. On the other hand, when young cobs are harvested, the maize plant has the tendency to develop newer cob from the lower nodes. Hence, high nutrient supply may enhance this process. In view of the above the present study was conducted to find out the influence of fertilizer and spacing on the yield performance of baby corn with the following objectives:

1. To find out the suitable fertilizer dose of baby corn.
2. To find out the suitable spacing of baby corn for higher yield.
3. To find out the suitable combination of fertilizer dose and spacing for achieving higher yield of baby corn.

CHAPTER II

REVIEW OF LITERATURE

Fertilizer management and optimum plant spacing are considered to be one of the most important factors in baby corn cultivation. A number of research works have been done in different parts of the world to study the influence of fertilizer and spacing on the yield performance of baby corn. Some of the important and informative works and research findings related to the fertilizer management and plant spacing of maize done at home and abroad have been reviewed under the following sub headings:

2.1 Effect of fertilizer management

Fertilizer management is one of the most important factors that influence the growth and yield of maize crop. Maize is considered as most exhaustive crop after sugarcane and requires both micro and macro nutrients to obtain high growth and yield.

2.1.1 Growth characters

Patil (1997) conducted a field experiment and concluded that application of 120:40:20 kg NPK ha^{-1} had detectable variation in plant stand and plant height, leaf number and dry weight of baby corn over 90:40:20 kg ha^{-1}. Application of 80 kg N ha^{-1} increased plant height of maize (Raju *et al.*, 1997). Application of N from 0 to 100 kg ha^{-1} with each increment of 50 kg ha^{-1} significantly increment plant height, beyond which the increase in height was not significant while dry-matter accumulation $plant^{-1}$registered significant increase up to 150 kg N ha^{-1} (Thakur *et al.*, 1997).

Gawade (1998) conducted a field trial on medium black soils on sweet corn and reported that plant height, number of functional leaves and dry matter production were significantly higher under 100 kg N+50 kg P_2O_5 + 50 kg K_2O ha^{-1} than rest of the fertilizer levels and control.

Jat (1998) recorded 2.02 per cent increase in leaf area index with the application of 60 kg N and 30 kg P2O5 ha^1 as compared to control in sorghum. He also reported a significant increase in dry matter production by 2.22, 1.95 and 3.18 per cent with application of 60 kg N and 30 kg P_2O_5 ha^1 at 30 and 60 DAS and at harvest as compared to control, respectively. Similarly, Kulhari *et al.* (1998) from Udaipur observed 26.6 per cent increase in leaf area index of maize with the application of N @ 120 kg ha^1 over control (3.001) at 60 DAS. They further reported that application of 120 kg N ha^{-1} significantly improved dry matter production by 33.84, 16.21 and 10.60 per cent at 30 and 60 DAS and at harvest, respectively over control (32.50, 68.41, 106.53 g $plant^1$).

From New Delhi, Arya and Singh (2001) reported that application of phosphorus @ 39.6 kg P ha^{-1} produced significantly taller plants (172.83 and 166.23 cm), more LAI (3.78 and 3.82), decreased days to 50 percent silking (56.27 and 55.37) and maximum dry matter accumulation (216.10 and 174.29 g) than other levels of phosphorus (0, 13.2 and 26.4 kg P ha^{-1}) during both years experiment of 2000-2001 in maize. On clay loam soils of Coimbatore (Tamil Nadu), increasing nitrogen levels up to 60 kg ha^{-1} significantly increased plant height, leaf area index and dry matter production of winter maize (Vadivel *et al.,* 2001).

A field trial conducted by Wagh (2002) at College of Agriculture, Pune, Maharashtra on sweet corn and concluded that LA, LAI and AGR were found significantly more with application of 100 per cent RDF (225:50:50 kg N, P_2O_5, K_2O ha^{-1}, respectively).

Kalpana and Krishnarajan (2002) reported that significantly highest values of plant height (237.1 cm), leaf area index (4.16) and dry matter production (13.61 t ha^{-1}) of baby corn were obtained with the application of 50 kg K ha^{-1} in 3 splits over other treatments.

A field trial conducted by Grazia *et al.* (2003) on sweet corn opined that total leaf number, height, leaf width and length, leaf area, plant height, stem diameter and shoot dry matter content were significantly higher under the combination of 200 kg N ha^{-1} along with 80 kg P_2O_5 ha^{-1} than rest of the treatment combinations.

Gosavi *et al*. (2006) conducted a field trial during *rabi* on medium black soil in sweet corn and reported that mean plant height at all the stages, number of functional leaves at 60 DAS and harvest and dry matter production at all the growth stages were influenced significantly due to application of recommended dose of fertilizer than control treatment.

Chillar and Kumar (2006) found that increasing levels of nitrogen from 0-120 kg ha^1 significantly increased plant height, LAI and dry weight $plant^{-1}$ of sweet corn. At Udaipur, maximum plant height and leaf area index of maize were recorded with the application of 150 per cent NPK (Verma *et al.,* 2006).

Zende (2006) observed that the plant height, number of functional leaves and dry matter of sweet corn increased significantly with the increase in the fertilizer levels at all crop growth stages during both the years and in the mean of two years. Therefore, 150% RDF was significantly superior over the lower fertilizer levels in respect of all the above referred observations.

Arun *et al.* (2007) conducted an experiment during *kharif,* 2002 at Main Agricultural Research Station, Agriculture College, Dharwad on vertisols of zone- 8 of Karnataka and found the growth parameters of sweet corn *viz.,* LAI and total drymatter production were influenced favourably with increasing levels of fertilizers (100%, 75% and 75% RDN and 100%, 75% RDP and 75%, 100% and 125% RDK) application.

Pinjari (2007) undertaken the field experiment during 2055-06 and 2006-07 to find out the effect integrated nutrient management on sweet corn and revealed that the plant height increased significantly with the application of 75 % RDN + 25 % N through PM as compared to all the remaining nutrient sources during 2005-06, 2006-07 and in the mean of two years at all the crop growth stages. The number of leaves was significantly superior with 100% RDN over rest of the nutrient sources except 75 % RDN + 25 % N as PM at all the crop growth stages during both the years and in the mean of two years. The total dry matter accumulation (plant^{-1}) at 30 DAS, the dry matter accumulation (plant^{-1}) in leaves, stem and total dry matter at 60 DAS, in the leaves, stem, cob and total dry matter (plant^{-1}) at 90 DAS and in the leaves, stem, grains, cob sheath, cob axis and total dry matter (plant^{-1}) at harvest were significantly higher with the application of 75 % RDN + 25 % N as PM during both the years of study and in the mean of two years than the remaining nutrient sources.

Bindhani *et al.* (2007) observed that application of 120 N ha^{-1} resulted in tallest plants with maximum dry matter and leaf area index of baby corn which were significantly higher than those at remaining N levels (40 and 80 N ha^{-1}). Successive increase in nitrogen levels from 0 to 120 kg ha^{-1} significantly improved leaf area index and dry weight plant^{-1} at 40 to 60 days after planting and maturity stages of baby corn over other treatments (Sepat and Kumar, 2007).

Shobhana *et al.* (2012) noticed that increasing NPK level from control to $N_{187\cdot5}$ $P_{26\cdot2}$ $K_{62\cdot5}$ recorded taller plants and dry weight plant^{-1} from a field experiment conducted at the Indian Agricultural Research Institute, New Delhi.

Keerthi *et al*. (2013) conducted a field experiment with different fertility levels of 180-75-60 kg N P K ha^{-1} + vermiwashat 20, 35 and 50 DAS recorded the highest growth parameters, and highest plant height, number of leaves plant^{-1}, and dry weight plant^{-1} was found from 180-75-60 kg N P K ha^{-1} + vermicompost.

Roy *et al.* (2015) conducted a field experiment to study the effect of irrigation and nutrient management on growth, yield attributes, yield, quality and WUE of baby corn (cv. Super 36) during summer. Application of nutrient management markedly influenced growth parameters and produced maximum plant height and dry weight per plant with the application of N_3 treatment (75% RDF along with FYM - 6.0 t ha^{-1}). Among the treatment variables, least performance exhibited under rain-fed situation, which received 75% RDF alone.

Kaur *et al*. (2016) conducted a field experiment to study Integrated Nutrient Management for increasing growth with sustainability of baby Corn. Significant increase in all growth parameters of baby corn was observed with integrated nutrient management over control. Moreover, among nutrient management treatments, the integration of 5 tonne of FYM with 100 kg of inorganic N ha^{-1} came out to be the best for all growth characters *viz*. plant height, number of leaves per plant, leaf area index and dry matter accumulation.

Auwal and Amit (2017) conducted a field experiment during the winter season to study the influence of integrated nutrient management on growth and yield parameters of maize (*Zea mays* L.). The growth parameters (plant height and leaf area) were found to be highest under poultry manure (PM) or farm yard manure (FYM) + recommended dose of fertilizers (RDF) which are statistically on par but comparatively higher than T_1 (100% RDF

Subedi *et al*. (2018) conducted a field experiment on baby corn to identify effect of different combination of organic and inorganic fertilizers on yield and yield attributes of baby corn. Result revealed that the highest plant height, number of leaves per plant, dry weight per plant and root length were found significantly superior in treatment with 75% vermicompost and 25% inorganic fertilizers.

2.1.2 Effect on yield attributes and yield

Chen *et al*. (1993) studied the effect of N, P_2O_5 and K_2O with respect to their application rate and ratios on the yield of sweet corn. They found that the commercial fresh cob yield of sweet corn was significantly higher (9.6 t ha^{-1}) with the application of 273 kg N + 94.5 kg P_2O_5 + 270 kg K_2O ha^{-1} than the lower levels.

Khairi *et al.* (1994) reported that when sweet corn was treated with five permutations of 0 or 150 kg N ha^{-1} and 0 or 65 kg of each of phosphorus and potassium, application of 150:65:65 kg ha^{-1} N, P_2O_5 and K_2O produced the higher grain yield of 11.3 t ha^{-1} compared with the control yield of 7.3 t ha^{-1}.

Patil (1997) from a field experiment reported that application of 120:40:20 kg NPK ha^{-1} was beneficial to baby corn as number of cobs ha^{-1} and green fodder yield with or without husk were significantly improved as compared to 80:40:20 kg NPK ha^{-1}. Sahoo and Panda (1997) also obtained the highest baby corn yield (1634 and 1491 kg ha^{-1} in the winter and wet seasons, respectively) when fertilized with 120 kg N + 26.2 kg P + 50 kg K ha^{-1}.

Cant *et al.* (1998) studied the effects of N, P and K with respect to their application rates and ratios on yield and quality of sweet corn. The commercial fresh ear yield of sweet corn was 9.6 t ha^{-1} with application of 250 kg N + 94.5 kg P_2O_5+270 kg K_2O ha^{-1}.

Gawade (1998) conducted a field trial at ASPEE Foundation, Tansa farm (Thane) on sweet corn reported that the length and girth of cob, average weight of cob, number of grain row per cob, number of grains per cob, weight of grains per cob, 100 grain weight, green cob yield, biomass yield and total biomass yield were significantly higher under 100 kg N + 50 kg P_2O_5 + 50 kg K_2O ha^{-1} than rest of the fertilizer levels and control.

Thakur and Sharma (1999) carried out an experiment at Bajaura (Himachal Pradesh) with three levels of nitrogen *viz.* 100, 150 and 200 kg N ha^{1} and found that yield of baby corn increased significantly with up to 150 kg N ha^{-1}, whereas cob yield with husk and fodder yield increased significantly up to 200 kg N ha^{-1}.

Roongtanakiat *et al*. (2000) reported that super sweet corn hybrid gave maximum grain yield and stover yield when fertilizer with 75:75:75 kg N P_2O_5 and K_2O ha^{-1}, which was significantly higher than the lower levels of the combination.

Arya and Singh (2001) observed that application of phosphorus @ 39.6 kg P ha^{-1} gave significantly higher grain (5.84 and 4.24 t ha^{-1}) and stover (6.95 and 5.74 t ha^{-1}) yields of maize compared with the other levels of phosphorus (0,13.2 and 26.4 kg P ha^{1}) during 1994 and 1995, respectively. It was noticed from a field experiment conducted at Hyderabad that successive increase in nitrogen levels (0-120 kg N ha^{-1}) significantly increased the number of primes, yield attributes, green ear and kernel yield of super sweet corn (Raja, 2001).

Sahoo and Panda (2001) reported that increasing P levels from 8.7 to 35 kg P_2O_5 ha^{1} increased number of baby corns $plant^{-1}$ from 2.1 to 2.6 during 1997-1998 and from 2.2 to 2.7 during 1998-1999. The treatment comprising 210:90:150 kg NPK ha^{1}resulted in higher grain yields of maize with an additional increase of 33.0 percent over the state recommendations of 100:60:40 kg NPK ha^{1}.

Gaur (2002) from Udaipur (Rajasthan) reported that application of 150 kg N ha^{1} significantly enhanced baby corn and green fodder yield by 16.22 and 52.31 per cent over 120 kg N ha^{1} and 36.39 and 61.71 per cent over 90 kg N ha^{1}, respectively.

Raja (2001) reported that all the yield attributing characters like ear weight and yield of green kernel of super sweet corn were significantly superior with 120 kg N ha^{-1} over 80, 40 kg N ha^{-1} and control.

Grazia *et al.* (2003) reported after conducting a field trial at Catede Horticulture and Agriculture Institute, Argentina on sweet corn that cob diameter, weight of cob with or without husk were significantly higher under combination of 200 kg N ha^{-1} along with 80 kg P_2O_5 ha^{-1} than rest of the treatment combinations. Yield with and without husk, total biomass production, stover yield and harvest index were also significantly higher under the combination of 200 kg N ha^{-1} along with 80 kg P_2O5 ha^{-1} than rest of the treatment combinations.

Kalpana and Anbumani (2003) observed that application of 50 kg K ha^{-1} applied in 3 splits (basal, 15 and 30 DAS) to baby corn significantly improved the cobs plant^{1}, cob length, cob width, cob and stover yields as compared to rest of the treatments.

Kunjir (2004) had conducted a field trial at College of Agriculture, Dapolion sweet corn and opined that weight of cob, number of grains per cob and weight of grains per cob were significantly higher under 225 kg N ha^{-1} than rest of the nitrogen treatments.

Paradkar (2004) reported that application of 180 kg N ha^{1} significantly increased baby corn plant^{1} and baby corn yield by 6.09 and 19.03 per cent over 120 kg N ha^{1} and 19.12 and 44.13 per cent over 60 kg N ha^{1}, respectively.

AICMIP (All India Coordinated Maize Improvement Project) (2005) noticed a significantly higher pop corn grain and stover yields with the application of 90:45 kg N and P_2O_5 ha^{-1}. Mehta *et al.* (2005) also observed similar results and found that application of 40 kg P_2O_5 ha^{1} significantly improved cobs plant^{1}, number of rows cob^{1}, cob weight, grain weight cob^{1}, seed index, seed and stover yields over 20 kg P_2O_5 ha^{1} in maize.

Gosavi *et al*. (2006) after conducting a field trial at ASPEE foundation, Thane in *rabi,* 2005-06 on medium black soil in sweet corn and revealed that weight of cob with and without husk, length of cob, number of kernel rows per cob, number of kernels per cob, number of cobs per plant, kernels weight per cob, green cobs number and yield per ha, stover yield and total biomass yield of sweet corn were significantly higher under application of 225 N, 60 P_2O_5 and 60 K_2O kg ha^{-1} (RDF) than control.

Kar *et al.* (2006) reported that application of 80 kg N ha^{-1} significantly increased number of prime cobs, length and girth of green cobs and green fodder yields. Consequently the highest green cob yield was obtained which was 220, 160, 48 and 21 per cent higher than that of the control, 20, 40 and 60 kg N ha^{-1}.

Rajanna *et al.* (2006) carried out a field experiment and showed that application of 150:75:40 kg NPK ha^{1} resulted in significant improvement in husked (10.56 t ha^{1}), dehusked (2.58 t ha^{1}) and green fodder yields (21.18 t ha^{1}) compared to 100:50:27 kg NPK ha^{-1} treatment in baby corn. Verma *et al.* (2006) also observed similar results and found that application of 150 per cent NPK resulted in highest grain and straw yields in maize.

Zende, (2006) carried out two years experiment during 2004-05 and found that different yield attributes *viz.,* cob length, cob girth, number of grains per cob, weight of grains per cob and number of cobs per plant in the mean of two years significantly superior with 150% RDF over rest of the fertilizer levels. Number of cobs per hectare, straw yield, harvest index, cob yield and biological yield were also significantly superior with 150% RDF over rest of the fertilizer levels including control.

Khadtare *et al*. (2006) carried out a research during rabi season of 2005-06 and reported that significantly higher values were recorded in respect of cob girth, cob length and green cob weight in treatment T_{10} (RDF 150:50:0 $NPKha^{-1}$) followed by T_4 (75 % RDN + 25 % N through VC) and T_6 (21.7 %) (75 % RDN + 25 % N through VC). Significantly higher values were also recorded in respect of green cob yield and green fodder yield in treatment T_{10} (112.5 qha^{-1} and 246.3 qha^{-1}, respectively) (RDF 150:50:0 $NPKha^{-1}$) followed by T_4 (108.1 and 235.6 qha^{-1}, respectively) and T_6 (107.3 and 229.6 qha^{-1}, respectively).

Bindhani *et al.* (2007) conducted a field experiment and revealed that application of 120 kg ha^{-1} significantly increased baby corn length, girth, baby corn yield and green fodder yields over lower levels. The improvement in baby corn yield due to 120 kg ha^{-1} was 28.6, 52.2 and 178.7 per cent over 80, 40 kg N ha $^{-1}$ and control, respectively.

Sahoo and Mahapatra (2007) conducted a field experiment and observed that number of cobs ha^{1}, cobs $plant^{1}$, cob weight, grains cob^{1}, kernel weight, green cob yield, green fodder yield and fresh kernel yield of sweet corn were significantly higher under 120:26.5:50 N, P_2O_5 and K_2O kg ha^{-1} than control and rest of fertilizer levels from a field experiment conducted at Orissa University of Agriculture and Technology, Jashinpur in red sandy loam soil.

Arun *et al.* (2007) conducted experiment on sweet corn at Main Agricultural Research Station, Agriculture College, Dharwad, in vertisols and found that number of cobs plant^{-1}, cob length, number of grains cob^{-1} and fresh cob weight were highest with 100% RDN, 100% RDP and 125% RDK compared to different fertilizer levels.

Pinjari (2007) undertaken the field experiment during 2005-06 and 2006-07 to find out the effect of integrated nutrient management on sweet corn and observed that the cob length, cob girth, number of grain rows per cob, number of grain per cob were significantly superior with the application of 75 % RDN + 25 % N as PM over rest of the nutrient sources during both the years of study and in the mean of two years. The number of cobs per hectare, cob yield, straw yield and biological yield during both the years were also significantly superior with the application of 75 % RDN + 25 % N as PM over rest of the nutrient sources. While harvest index was higher with the application of 50 % RDN + 50 % N as PM over rest of the nutrient sources.

Thakur *et al.* (2010) conducted a field experiment during *kharif* season and observed that application of 100:50:50 kg NPK ha^{-1} (T_3) recorded significantly more length of cob, diameter of cob than FYM alone and FYM+ *Azospirillium* application.

Aravinth *et al*. (2011) found that application of recommended dose of fertilizer (150:60:40 kg of N, P_2O_5 and K_2O ha^{-1}) + vermicompsot @ 5 tons ha^{-1} on baby corn in kharif and summer seasons recorded the highest number of cobs plant^{-1} (2.60 and 2.39), higher cob length (23.18 and 22.04 cm), highest cob width (2.69 and 2.57 cm), cob weight (33.31 and 28.69 g) and higher baby corn yield (7195 and 5477 kg ha^{-1}) than recommended dose of fertilizer alone.

Singh *et al.* (2012) found that application of 120 kg N ha^{-1} being on par with 250 kg N ha^{-1} significantly improved all yield attributes, *viz.* number of cobs ha^{-1}, weight of green cob, number of kernel cob^{-1} and 1,000 kernel fresh weight over preceded levels from experiment at Wadura, Sapore, Jammu and Kashmir on well drained silty clay loam.

Sunitha and Reddy (2012) conducted an experiment during *rabi* season of 2005 and 2006 on sandy loam soils and revealed that the highest green cob (15.91 t ha^{-1}) and fodder yield (20.34 t ha^{-1}) of sweet corn with good quality of produce could be realized with the supply of NPK @ 150:70:50 kg ha^{-1}

Keerthi *et al.* (2013) conducted a field experiment on sandy loam soil during rabi, 2012-13. Among the fertility levels tried, application of 180-75-60 kg N P K ha^{-1} + vermicompost 20, 35 and 50 DAS recorded the highest yield attributes and cob yield which was however, found parity with 180-75-60 kg N P K ha^{-1} + vermicompost. Integrated nutrient management treatments exhibited their superiority at the highest levels of fertilization over the same levels under chemical sources in enhancing green cob yield. The lowest cob yield was associated with non-supply of fertilizers.

Ajaz *et al*. (2013) conducted an experiment and found that the application of farm yard manure (FYM) at 6 Tha^{-1} in combination with 150% recommended dose of fertilizer (225 N: 90 P_2O_5: 60 K_2O $kgha^{-1}$) reveled maximum cob yield (without husk) of 20.60 qha^{-1} associated with maximum number of cobs/plot (326). However application of FYM at 6 tha^{-1} in combination with state recommended dose of Nitrogen: Phosphorus: Pottasium (N:P:K) at 90: 60: 40 $kgha^{-1}$ was statistically at par with the best treatment and gave a cob yield of 19.85 qha^{-1}. Application of 150% of Recommended Dose of Fertilizer (RDF) without FYM reveled increased cob length (10.90 cm), whereas, 125% of RDF resulted in maximum cob girth without husk (18.30 mm). Similar trend of enhanced green fodder yield (26.39 Tha^{-1}) was observed with application of 6 Tha^{-1} FYM + 150% of RDF).

Mathukia *et al.* (2014) conducted a field experiment During *rabi,* 2010 and observed that significantly enhanced yield attributes *viz*., number of cobs/plant, cob length, cob girth , fresh weight of cob, number of kernels/cob and fresh weight of 100-kernels was recorded from application of 120-60 kg N- P_2O_5 ha^{-1} over application of 90-30 kg N-P_2O_5 ha^{-1} and control. The highest green cob yield (80 q ha^{-1}) and green fodder yield (366.6 q ha^{-1}) was also recorded on application of 120-60 kg N-P_2O_5 ha^{-1}.

Priyanka *et al.* (2014) conducted an experiment in clay loam soils during *kharif*season 2013 to investigate the yield of baby corn with different fertilizer management. Results revealed that application of 90 kg N+40 kg P_2O_5 ha^{-1} gave significantly higher green cob and fodder yield when compared to other treatments.

Roy *et al*. (2015) conducted a field experiment to study the effect of irrigation and nutrient management on growth, yield attributes, yield, quality and WUE of baby corn (cv. Super 36) during summer. Integrated nutrient management markedly influenced yield components and yield and these were (both corn as well as fodder) produced maximum with the application of N_3 treatment (75% RDF along with FYM - 6.0 t ha^{-1}). N_3 treatment also produced maximum cobs $plant^{-1}$, Cob length (cm) and number of rows cob^{-1}. Among the treatment variables, least performance exhibited under rain-fed situation, which received 75% RDF alone.

Kaur *et al*. (2016) conducted a field experiment to study Integrated Nutrient Management for increasing Growth with Sustainability of Baby Corn. The experiment having seven treatments i.e. T_1= Control, T_2= 100 percent recommended dose of N, T_3 = 5 tons of FYM + 100 kg inorganic N ha^{-1}, T_4= 10 tonne of FYM + 75 kg inorganic N ha^{-1}, T_5= 15 ton of FYM + 50 kg inorganic N ha^{-1}, T_6= 20 ton of FYM + 25 kg inorganic N ha^{-1}, T_7= 25 ton of FYM ha^{-1}. Significant increase in yield parameters of baby corn was observed with 5 ton of FYM with 100 kg of inorganic N ha^{-1} over control.

Jinjala *et al.* (2016) conducted a field experiment during rabi season to study the effect of integrated nutrient management on growth and yield of baby corn. The cob and fodder yields significantly differed with different integrated nutrient management treatment. Significantly the higher growth and yield attributes yield and fodder yield were recorded with the application of 100% RDF from chemical fertilizer with bio-fertilizer. Application of 100% RDN from chemical fertilizer with biofertilizer was recorded higher net returns over 100% RDN from vermicompost (Rs. 220775ha^{-1}) and BCR (12.54).

Auwal *et al*. (2017) conducted a field experiment during the winter season to study the influence of integrated nutrient management on growth and yield parameters of maize (*Zea mays* L.). The yield parameters (number of grains per cob, cobs weight per plant, Test weight and stover yield) were significantly higher under INM compared to T_1 (100% RDF). Therefore, the integration of 50% RDF along with either 5 tha^{-1} FYM or PM or both resulted in maximum maize productivity on par compared with sole used of 100% RDF. It was also observed that 100% RDF with additional nutrient supply resulted higher yield contributing parameters (cobs plant^{-1}, cob length and diameter, cob number for unit area and harvest index) of maize.

Kumar *et al*. (2018) conducted a field experiment on baby corn (*Zea mays* L.) in sandy loam soil to assess the effect of balanced fertilization (NPKS and Zn) on productivity, quality, energetics and soil health of baby corn. Results revealed that application of 125% RDF (187.5, 93.75, 75.0 kg NPK ha^{-1}) produced significantly higher yields of total baby cob yield with husk (9.55 tons ha^{-1}) and total baby corn yield without husk (2.15 tons ha^{-1}). Among different levels of S and Zn, application of 50 kg S and 10 kg Zn ha^{-1} produced significantly higher yields of total baby cob with husk (9.38 and 9.24 tons ha^{-1}) and total baby corn without husk (2.15 and 2.10 tons ha^{-1}), respectively.

Subedi *et al*. (2018) conducted a field experiment on baby corn to identify effect of different combination of organic and inorganic fertilizers on yield and yield attributes of baby corn during kharif season of 2017. The treatments are different combination of vermicompost, farm yard manure and chemical fertilizers. Result revealed that yield and yield attributes are statistically different among treatments. Yield and yield attributing character *viz*. length and weight of baby corn with and without husk in first three harvest of baby corn were found significantly superior in treatment with 75% vermi-compost and 25% inorganic fertilizers.

2.2 Effect of plant spacing

Planting density vary widely in different parts of the world because great abundance of maize strains and their distribution over different climatic conditions. An increase or decrease in the plant density has been found to effect the growth of the crop and a number of experiments all over the world have been carried out to determine the optimum plant density for maximum production.

2.2.1 Growth characters

Dalvi (1984) conducted a field experiment during *rabi*season and reported that number of functional leaves and dry matter accumulation were significantly higher at 60 cm × 30 cm spacings during all the growth stages as compared to 30 cm × 30 cm and 45 cm × 30 cm spacing.

Sahoo (1995) observed no influence of different populations on days taken to harvest initiation. Whereas, plant spacing of 45 cm × 15 cm produced significantly taller baby corn plants both at grand growth stage and harvest compared to 45 × 30 and 60 × 15 cm spacing. However, leaf area and dry matter yield plant^{-1} at above stages remained significantly higher at 45 × 80 cm spacing (Sukanya*et al.*, 1999).

Sukanya *et al.* (2000) studied the effect of spacing on growth, development and yield of baby corn varieties during summer season under irrigated condition. It was found that the spacings of 45 cm × 15 cm recorded the maximum plant height of 181.8 cm, which was significantly superior to wider row spacings of 60 cm × 15 cm. Similarly, the 45 cm × 30 cm spacings produced significantly higher dry matter of 223.25 g plant^{-1} over other spacing. The lowest drymatter of 166.47 g palnt^{-1} was recorded in 60 cm × 15 cm spacings.

Thakur *et al.* (2000) conducted a field trial to study the effect of planting geometry on baby corn. They reported maximum plant height with wider spacings (60 cm × 30 cm) than closer spacing (40 cm × 40 cm, 50 cm × 30 cm, 40 cm × 35 cm, 50 cm × 25 cm and 45 cm × 25 cm).

Pandey *et al.* (2002) reported that with increase in plant population from 111 K (lacs ha^{-1}) to 166 K plants ha^{-1} barrenness per cent increased significantly; however, the plant height remained unaffected under different plant densities. They also reported that with increase in plant population from 111 K (lacs ha^{-1}) to 166 K plants ha^{-1} days to harvest initiation showed significant delay, however, there was no effect on the plant height under different plant densities. However, increase in the plant density from 111 K to 166 K plants ha^{-1}, barrenness per cent and harvest initiation days increased significantly, however, duration reduced by two days.

Chougule (2003) conducted a field experiment on sweet corn at Rahuri and reported that plant height, number of functional leaves, leaf area and total dry matter production per plant were significantly higher with 60 cm × 20 cm spacings than the closer spacing *viz.* 45 cm × 15 cm, 45 cm × 20 cm and 60 cm × 15 cm.

Planting of two plants $hill^{-1}$ at a spacing 50 cm × 20 cm was found optimum for baby corn cultivation (Sahu *et al,* 2005). The trend of response to thicker stand was not similar in other plant characteristics viz. dry matter accumulation, stem diameter, leaf area, number of functional leaves and number of cobs $plants^{-1}$.

Zarapkar (2006) conducted a field experiment to study the effect of spacings on growth and development of baby corn and revealed that plant height was significantly higher under the closer spacings of 30 cm × 20 cm than other spacing (40 cm × 20 cm and 60 cm × 20 cm). Whereas, number of functional leaves and dry matter accumulation per plant was higher in case of wider spacings (60 cm × 20 cm) as compared to closer spacings.

Kunjir *et al.* (2007) conducted a field trial to study the effect of spacings on the growth and development of maize (sweet corn). Results revealed that stated that the spacings of 45 cm × 20 cm produced significantly higher plant height of maize (sweet corn) than 60 cm × 20 cm and 75 cm × 20 cm spacings.

Shafi *et al*. (2012) conducted this present study to investigate the effect of planting density on plant growth and yield of maize varieties. The experiment consist of four maize varieties *viz*., Azam, Pahari, Jalal-2003 and Sarhad white with three plant densities of 45000, 55000 and 65000 plants ha^{-1}. Planting density had a significant ($p<0.05$) effect on leaf area index and plant height. Maximum leaf area index and plant height was recorded from planting density of 65000 plants ha^{-1}.

Kheibari *et al*. (2012) conducted an experiment to investigate the "effects of variety and plant density on yield and yield component of corn varieties. Three plant densities (75,000 115,000 and 155,000 plantsha^{-1}) and 3 corn varieties (KSC403su, KSC600 and KSC704) were evaluated. The data on growth attributing characters like plant height, number of leaves, leaf area, leaf area index, dry matter accumulation in leaf, stem, husked baby corn and total dry matter, stem girth, average growth and crop growth rate in baby corn in per plant basis influenced by plant density and highest was from plant density of 75,000 plantsha^{-1}.

Sarjamei *et al*. (2014) conducted an experiment to investigate the effect of planting method and plant density, on morpho-phenological traits of baby corn (*ZeamIays* L.) variety KSC 704. Three levels of plant density (D_1: 90,000; D_2: 120,000 and D_3: 150,000 plant/ha) were initiated. Ear number per plant, ear height, leaves number, leaves number above ear, ear leaf diameter, ear length, ear diameter, stalk fresh weight and husked ear yield affected by plant density. The highest ear per plant (2.3 ear/plant) produced by D_2 treatment. Leaves number above ear, ear leaf length and diameter, fresh stalk weight and diameter affected by interaction between plant density and planting method respectively.

Bairagi *et al*. (2015) conducted this experiment to study the effect of crop geometry impacts on growth and yield of baby corn (Var. G-5414). Three levels of plant population *viz*. 45 × 30 cm (S_1), 45 × 20 cm (S_2) and 45 × 10 cm (S_3) were assigned. Plant height was higher when baby corn planted in wider spacing of 45 × 30 cm. whereas, closer spacing of 45 × 10 cm resulted in shorter plant. Days to 50% flowering did not vary among the spacing.

Chamroy *et al*. (2017) carried out an experiment entitled "Growth and yield response of baby corn (*Zea mays* L.) to geometry". Four levels of sowing periods (i.e. Last week of Aug., Sept., Oct. and Nov.) and five different crop geometry (30cm × 30cm, 45cm × 15cm, 45cm × 30cm, 60cm × 15cm and 60cm × 30cm) were used. Among the plant spacings, it was observed that S_3 (45 × 30 cm) exhibited highest number of leaves plant^{-1} (13.63), leaf area (512.62 cm^2) and LAI (3.62). Whereas S_2 (45 × 15 cm) gives highest plant height (205.47 cm).

2.2.2 Yield attributes and yield

Dalvi (1984) conducted a field experiment during *rabi* season and revealed that spacings of 60 cm × 30 cm recorded significantly higher length of cob, girth of cob, number of grains per cob, weight of grains per cob and 1000 grain weight than other narrow spacings of 45 cm × 30 cm and 30 cm × 30 cm.

Carlos (1990) reported that 'super sweet' corn can be grown for young cobs at a population density of 60, 000 plants ha^{-1}, the population, however, can be increased up to 1, 80, 000 plants ha^{-1}.

Thakur *et al.* (1995) evaluated the performance of maize cultivar early composite for baby corn production under different spacing regimes *viz.,* 40 cm and 60 cm of inter-row spacing and 10 cm and 20 cm of intra-row spacing. They found 40 cm × 20 cm and 40 cm × 10 cm spacings as optimum for baby corn and baby corn + green fodder productions, respectively. Significantly higher yield of baby corn (1737 kg ha^{-1}) was recorded by planting the crop at 40 × 20 cm spacings than the other spacing of 60 ×10 cm (1561 kg ha^{-1}), 40 ×10 cm (1588 kg ha^{-1}) and 60 × 20 cm (1555 kg ha^{-1}).

Experiments on three plant populations, at densities of 106666, 160000 and 213333 plants ha^{-1} resulting from the row spacing of 75 cm and 25 cm between hills with 2, 3 and 4 plants hill^{-1}, respectively showed that there was significant difference in husked and unhusked young cob weights and husk weights at different densities (Soonsuwon *et al*., 1996).

Thakur *et al.* (1997) conducted a field experiment on baby corn and indicated that the wider spacings of 60 cm × 20 cm increased significantly all the yield attributing character *viz.* cob per plant, cob number per unit area, cob weight with and without husk of baby corn as compared to other spacing of 40 cm × 20 cm, 60 cm × 10 cm and 40 cm × 10 cm. But the spacings of 40 × 20 cm recorded significantly more baby corn yield of 17.37 q ha^{-1} as compared to 40 × 10 cm (15.88 q ha^{-1}) and 60 × 20 cm (13.55 q ha^{-1}) spacing.

Thakur *et al.* (1998) reported that cob yield with husk and baby corn yield was significantly higher under plant spacing of 40 cm × 20 cm compared to 60 cm × 20 cm and 60 cm × 10 cm, whereas green fodder yield was significantly higher under spacing 40 cm × 10 cm compared to other plant spacings.

Sahoo and Panda (1999) reported that plant spacing of 40 cm × 20 cm, being at par with 40 cm × 15 cm recorded significantly higher baby corn yield in wet season compared to 40 cm × 25 cm spacing, whereas green fodder yield during winter season was significantly higher under 40 cm × 15 cm spacing compared to other spacings.

Sukanya *et al.* (1999) found that the green fodder yield of baby corn increased significantly with reduction in plant spacing compared to other spacings.

Thakur and Sharma (2000) conducted a field experiment on baby corn and showed significantly higher length of cob with husk and cobs per plant under wider spacings of 60 cm × 30 cm and 40 cm × 40 cm as compared to other closer spacing.

Raja (2001) conducted a field experiment and reported that green ear weight/ha and green kernel weight/ha of super sweet corn was significantly higher at the population density of 88,888 pants/ha (108.05 q ha^{-1} and 83.15 q ha^{-1}) than the other plant populations *viz.* 66,666 and 53,333 plants/ha.

Pandey *et al.* (2002) conducted a field experiment and reported that the lower plant density (1,11,000 plants ha^{-1}) of baby corn recorded significantly higher weight of green cob and baby corn/plant than 1,33,000 and 1660 plants per ha. It was also reported that the baby corn yield and fodder yield obtained respectively at plant density of 1660 plants ha^{-1}. (1,148 kg ha^{-1} and 24.5 t ha^{-1}) and 1,33,000 plants ha^{-1} (1,0536 kg ha^{-1} and 23.4 t ha^{-1}) were on par and significantly superior to that of 1,11,000 plants ha^{-1} (900 kg ha^{-1} and 20.3 t ha^{-1}).

Ramchandrappa *et al.* (2004) carried a field study and observed that the length and girth of baby corn was adversely affected with the increase in plant densities and the differences were not significant. The wider spacings of 45 × 30 cm recorded higher number of baby ears per plant, husked baby corn length, girth and weight. Wider spacings of 45 cm × 30 cm also recorded significantly higher baby corn yield than other spacings (45 cm × 20 cm and 30 cm × 30 cm).

Sahoo and Mahapatra (2004) conducted a field trial on sweet corn and reported that higher plant population (83,333 plants per ha) with spacings of 60 cm × 20 cm produced maximum number of ears. But green cob weight and length of dehusked cob were maximum under lower plant population (55,555 plants per ha) which was at par with 66,666 plant population per ha. It was also reported, significantly higher green cob yield and fresh grain yield when sweet corn was sown with a spacings of 60 cm × 25 cm than that of 60 cm × 20 cm and 60 cm × 30 cm spacings.

Ochapong (2005) reported no significant difference in baby corn yield among plant densities. The results suggested that planting of 2 plants hill^{-1} at the recommended plant density especially when field practices and cost of seed were also taken into consideration and application of nitrogen 40 kg ra^{-1} yielded the highest baby corn production.

Kar *et al.* (2006) conducted a field experiment and reported that the spacings of 60 x 20 cm significantly increased the number of prime cobs, green cob yield, highest net return and benefit : cost ratio over the 45 × 30, 45 × 20 and 60 × 30 cm spacing.

Zarapkar (2006) observed from a field study that the yield attributing characters of baby corn such as length of baby corn, number of baby corn per plant, baby corn weight with husk and baby corn weight without husk were significantly higher under wider spacings of 60 cm × 20 cm as compared to closer spacings of 30 cm × 20 cm. It was also found that baby corn yield was significantly higher under the closer spacings of 45 cm×× 20 cm than remaining spacing viz. 30 cm × 20 cm and 60 cm × 20 cm. However, green fodder yield and total biomass yield per hectare were significantly higher under spacings of 30 cm × 20 cm than other spacing.

Prodhan *et al.* (2007) reported that the plant density of 1, 33,000 plants ha^{-1} gave significantly higher husked, dehusked yield and standard yield of baby corn compared to plant densities of 66, 000 and 2,08,000 plant ha^{-1} whereas barrenness per cent was significantly higher in plant density of 66,000 plants ha^{-1} and fodder yield was significantly higher under density 1, 33, 000 compared to 2, 08, 000 plants ha^{-1}.

Kunjir *et al*. (2007) conducted a field experiment on sweet corn and observed that length of cob, rows per cob, girth of cob, weight of cob, weight of grains per cob, number of grain rows per cob, weight of grains per cob and 1000 grains weight increased significantly with wider spacing (75 cm × 20 cm) as compared to narrower spacing (45 cm × 20 cm and 60 cm × 20 cm). The experiment also showed that the close spacings of 45 cm × 20 cm reported significantly higher cob yield (114.99 q per ha), stover yield (73.79 q ha^{-1}) and total biomass yield (188.78 q ha^{-1}) than the remaining broader spacing (60 × 20 cm and 75 × 20 cm).

The results of a study on light interception and productivity of baby corn as influenced by crop geometry, intercropping and integrated nutrient management practices revealed that barring at 25 DAS, plant spacing of 60 ×

19 cm registered higher green cob yield and baby corn equivalent yield compared to 45 × 25 cm spacing (Thavaprakaash and Velayudham, 2008).

Long *et al*. (2009) carried out the study on effects of plant density on hybrid baby corn production. Four plant densities (two plants/hill): D_1 (114,000 plants/ha), D_2 (133,000 plantsha^{-1}), D_3 (143,000 plants ha^{-1}) and D_4 (167,000 plantsha^{-1}) and 3 baby corn varieties: RL1, RL4 and LVN23 (check) were assigned. At plant density D_4 (167000 plantsha^{-1}), total yield, green fodder yield and marketable yield of three hybrids were higher than other densities at significant level of P>95% while remaining at short growth duration and ensured to obtain exportation standard size. RL1 had highest yield (2.37) in plant density D_4, higher than LVN23 (1.98) respectively at P>95%.

Shafi *et al*. (2012) conducted this present study to investigate the effect of planting density on plant growth and yield of maize varieties. The experiment consist of four maize varieties *viz*., Azam, Pahari, Jalal-2003 and Sarhad white with three plant densities of 45000, 55000 and 65000 plants ha^{-1}. Data indicated that planting density had a significant effect on ear length, number of grains ear^{-1}, grain weight ear^{-1}, 1000 grain weight, biological yield, stover yield, grain yield and harvest index. Maximum biological yield, stover yield, grain yield and harvest index was recorded from planting density of 65000 plants ha^{-1}. The combined effect of Sarhad white with planting density of 65000 plants ha^{-1} produced highest grain weight cob^{-1}, biological yield, stover yield, grain yield and harvest index.

Kheibari *et al*. (2012) conducted an experiment to investigate the "effects of variety and plant density on yield and yield component of corn varieties. Three plant densities (75,000 115,000 and 155,000 plantsha^{-1}) and 3 corn varieties (KSC403su, KSC600 and KSC704) were evaluated. The data on yield parameters influenced significantly by plant density. Plant density of 155,000 plantsha^{-1} with variety KSC403su showed highest yield ha^{-1}.

Golada *et al*. (2013) conducted a field experiment to study the effect of crop spacing (45 × 20, 60 × 15 and 90 × 10 cm) on yield attributes, yield and economics of baby corn. The crop spacing 60 × 15 cm significantly influenced yield attributes. Maximum green cob yield, baby corn yield and green fodder yield was recorded at 60 × 15 cm spacing which was higher (14.0, 24.3 and 8.8%, respectively) over 90 × 10 cm.

Sarjamei *et al*. (2014) conducted an experiment to investigate the effect of planting method and plant density, on morpho-phenological traits of baby corn (*Zea mays* L.) variety KSC 704. Three levels of plant density (D_1: 90,000; D_2: 120,000 and D_3: 150,000 plantha^{-1}) were initiated. The highest and lowest ear yield belonged to D_2 and D_1 plant density by 9987 and 8780 kg ha^{-1} ear production respectively. D_3 produced the highest de husked ear yield by mean of 1969 kg ha^{-1}.

Bairagi *et al*. (2015) conducted this experiment to study the effect of crop geometry impacts on growth and yield of baby corn (Var. G-5414). Three levels of plant population *viz*. 45 × 30 cm (S_1), 45 × 20 cm (S_2) and 45 × 10 cm (S_3) were assigned. Corn yield and fodder yield were higher when baby corn planted in wider spacing of 45 × 30 cm. whereas, closer spacing of 45 × 10 cm resulted in reduction of both corn and fodder yield per plant. The yield parameters of baby corn were clearly indicative that they were thermo-sensitive and baby corn cobs and fodder yield are higher at closer spacing.

Singh *et al*. (2015) conducted a field experiment to study the effect of two varieties (VL Baby Corn-1 and HM 4), two spacings (45×25 cm and 60×25 cm) and three sowing dates (1st October, 30th October and 29th November) on performance of baby corn (*Zea mays* L.). The results indicated that the maximum corn yield (32.55%) and fodder yield (26.21%) was found to be higher from 45×25 cm spacing over 60×25 cm spacing.

Chamroy *et al*. (2017) carried out an experiment entitled “Growth and yield response of baby corn (*Zea mays* L.) to geometry”. Four levels of sowing periods (i.e. Last week of Aug., Sept., Oct. and Nov.) and five different crop geometry (30cm × 30cm, 45cm × 15cm, 45cm × 30cm, 60cm × 15cm and 60cm × 30cm) were used. It was observed that the yield attributing characters such as, number of cobs plant^{-1}(3.43), cob weight (9.87 g) and cob yield plant^{-1} without husk (31.64 g) were found highest in S_5 (60 × 30 cm). However, S_2 (45 × 15 cm) exhibited the highest yield hectare^{-1} (81.10 q).

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the research field of Sher-e-Bangla Agricultural University, Dhaka-1207 during the Kharif season from March to June, 2017 to study the influence of fertilizer dose and spacing on the yield performance of baby corn. The materials used and methodology followed in the investigation have been presented details in this chapter.

3.1 Description of the experimental site

3.1.1 Geographical location

The experimental area was situated at $23^{0}77'$ N latitude and $90^{0}33'$ E longitude at an altitude of 9 meter above the sea level.

3.1.2 Agro-ecological region

The experimental field belongs to the Agro-ecological zone of "The Modhupur Tract", AEZ-28 (Anon., 1988a). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain (Anon., 1988b). The experimental site was shown in the map of AEZ of Bangladesh in Appendix I.

3.1.3 Soil

The soil of the experimental site belongs to the general soil type, shallow red brown terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH ranged from 5.6-6.5 and had organic matter 1.10-1.99%. The experimental area was flat having available irrigation and drainage system and above flood level. The physico-chemical properties of soil is presented in Appendix II.

3.1.4 Climate

The area has subtropical climate, characterized by high temperature, high relative humidity and heavy rainfall with occasional gusty winds in Kharif season (April- September) and scanty rainfall associated with moderately low temperature during the Rabi season (October-March). Climatic parameters of the experimental site is presented in Appendix III.

3.2 Experimental details

3.2.1 Treatments

Factor A: Fertilizer – four levels

1. F_1 = Recommended doses of fertilizer (RDF)
2. F_2 = 20% less than RDF
3. F_3 = 40% less than RDF
4. F_4 = 20% higher than RDF

Factor B: Spacing – three levels

1. S_1 = 60 cm × 25 cm
2. S_2 = 50 cm × 25 cm
3. S_3 = 40 cm × 25 cm

As such there were 12 treatment combinations or interaction Treatments as follows:

F_1S_1, F_1S_2, F_1S_3, F_2S_1, F_2S_2, F_2S_3, F_3S_1, F_3S_2, F_3S_3, F_4S_1, F_4S_2, F_4S_3

3.2.2 Layout of the experiment

The experiment was laid out into Split-plot design with three replications having fertilizer doses in the main plot considered as Factor-A and plant spacing in the sub-plot considered as Factor-B. Each replication had 12 unit plots to which the treatment combinations were assigned randomly. The total numbers of unit plots were 36. The size of unit plot was 6.16 m^2 (2.8 m × 2.2 m). The distances between replication to replication and plot to plot were 0.75 m and 0.50 m, respectively.

3.2.3 Planting materials

In this research work, "Hybrid baby corn-1" variety was used as plant materials and the seeds were collected from Kustia seed store, Mirpur, Dhaka.

3.3 Preparation of the experimental field

The land was opened with the help of a tractor drawn disc harrow on March 12,2017, and then ploughed with rotary plough twice followed by laddering to achieve a medium tilth required for the crop under consideration. All weeds and other plant residues of previous crop were removed from the field. Immediately after final land preparation, the field layout was made on March 14, 2017 according to experimental specification. Individual plots were cleaned and finally prepared the plot.

3.4 Fertilizer application

During final land preparation, the land was fertilized as per treatment. Four levels of fertilizer treatments were used under the present study based on recommended doses of fertilizers. The recommended doses of nutrients through fertilizers were as below:

Plant nutrients	Name of fertilizer	Fertilizer Rate (ha^{-1})
N	Urea	300 kg
P	TSP	150 kg
K	MOP	100kg
S	Gypsum	150 kg
Zn	$ZnSO_4$	10 kg

Source: BARI, 2014 (Krisi Projukti Hat Boi, P. 54)

The total amount of nitrogen in the form of urea was divided into three equal portions; one third was applied during final land preparation. The rest two portions were applied as split doses at 25 DAS and 45 DAS, respectively. Whole amount of P, K, S and Zn through TSP, MoP, Gypsum and $ZnSO_4$, respectively were applied at the time of final land preparation.

3.5 Seed sowing

The baby corn seeds were sown in lines maintaining plant to plant and row to row distance as per treatments having 2 seeds $hole^{-1}$ under direct sowing (dibbling) in the well prepared plot on 20 March, 2017.

3.6 Intercultural operations

3.6.1 Thinning and gap filling

The plots were thinned out and gap filled on 15 days after sowing having single plant $hill^{-1}$ to maintain a uniform plant stand.

3.6.2 Weeding

The crop field was infested with some weeds during the early stage of crop establishment. Two hand weedings were done; first weeding was done at 25 days after sowing followed by second weeding at 45 days after sowing.

3.6.3 Earthen up

Earthen up is a major intercultural operation for better establishment and anchorage of crown root of baby corn. It was done two times, 1^{st} one at 25 days after sowing, 2^{nd} one at 45 days after sowing.

3.6.4 Irrigation and drainage

Irrigation water was added to each plot as and when necessary. Drainage channels were properly prepared to easy and quick drained out of excess water.

3.6.5 Plant protection measures

The crops were infested by insects. Ripcord 10 EC @500 ml in 20 L water was sprayed at 46 days after sowing.

3.7 Harvesting and post-harvest operations

At 20 June, 2017, the cobs of five randomly selected plants of each plot were separately harvested for recording yield attributes and other data. The five cobs were harvested for recording cob yield and other data.

3.8 Recording of data

Experimental data were collected at the time of harvest. Five plants were randomly selected and fixed in each plot from the inner row of the plot for recording data. Dry weight of plants were collected by harvesting five plants at different specific dates from the inner rows leaving border plants and harvest area for cob of baby corn.

The following data were recorded:

3.8.1 Growth parameters

1. Plant height (cm)
2. Number of leaves plant^{-1}
3. Dry weight plant^{-1} (g)

3.8.2 Yield contributing parameters

1. Number of cobs plant^{-1}
2. Number of rows cob^{-1}
3. Cob length (cm)
4. Cob weight plant^{-1} with husk (g)
5. Cob weight plant^{-1} without husk (g)
6. Base diameter of cob(cm)
7. Top diameter of cob(cm)

3.8.3 Yield parameters

1. Number of cobs ha^{-1}
2. Fresh cob yield ha^{-1}
3. Stover yield ha^{-1}
4. Biological yield ha^{-1}
5. Harvest Index

3.9 Procedures of recording data

A brief outline of the data recording procedure followed during the study are given below:

3.9.1 Growth characters

Plant height (cm)

The height of plant was recorded in centimeter (cm) at harvest. Data were recorded as the average of 5 plants selected from the inner rows of each plot. The height was measured from the ground level to the tip of the plant.

Number of leaves plant^{-1}

The number of leaves plant^{-1} was count at the time of harvest from the top to bottom of the five selected plants from the inner rows of each plot and the average data were recorded.

Dry weight plant^{-1}

Dry weight plant^{-1} was collected at harvest. Five plants from each plot were collected for each recording data. The plant parts were packed in paper packets then kept in the oven at 80°C for 72 hours to reach a constant weight. Then the dry weights were taken with an electric balance. The mean values were determined.

3.9.2 Yield contributing parameters

Number of cobs plant^{-1}

Cob number of five randomly selected plants plot^{-1} were counted and finally averaged.

Number of rows cob^{-1}

Row number of five randomly selected cobs from the five selected plants plot^{-1} were counted and finally averaged.

Cob length (cm)

Cob length was measured in centimeter from the base to the tip of the ear of 5 baby corn from the five selected plants in each plot with the help of a centimeter scale then average data were recorded.

Cob weight plant^{-1} with husk (g)

Cob weight with husk of five randomly selected cobs from the five selected plants in each plot was taken and the average weight was recorded in gram.

Cob weight plant^{-1} without husk (g)

Cob weight without husk of five randomly selected cobs from the five selected plants in each plot was taken and the average weight was recorded in gram.

Base diameter of cob (cm)

The base diameter of five randomly selected cobs from the five selected plants in each plot was measured in centimeter at the base of the ear and averaged.

Top diameter of cob (cm)

The top diameter of five randomly selected cobs from the five selected plants in each plot was measured in centimeter at the top of the ear and averaged.

3.9.3 Yield parameters

Number of cobs ha^{-1}

Cob number of 1 m^2 plants in each plot were counted and finally converted into ha and data were recorded in thousand unit basis.

Cob yield ha^{-1}(t)

Weight of cobs collected from each plot was taken after final completion of cob harvest and converted into hectare and were expressed in t ha^{-1}.

Stover yield ha^{-1}(t)

Weight cleaned and well dried stover were collected from each plot were taken and converted into hectare and were expressed in t ha^{-1}.

Biological yield ha^{-1}(t)

Cob (dehusked) yield and stover yield were all together regarded as biological yield. Biological yield was calculated with the following formula:

$$\text{Biological yield (t ha}^{-1}) = \text{Cob yield (t ha}^{-1}) + \text{Stover yield (t ha}^{-1})$$

Harvest index (%)

It denotes the ratio of economic yield to biological yield and was calculated with following formula (Donald, 1963; Gardner *et al.,* 1985).

$$\text{Harvest Index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

3.10 Statistical analysis

The data obtained for different characters were statistically analyzed using MSTATC software to find out yield potential of baby corn as influenced by different levels of fertilizer and plant density. The mean values of all the characters were evaluated and analysis of variance was performing by the 'F' test. The significance of the difference among the treatments means was estimated by the Least Significant Difference Test (LSD) at 5% level of probability (Gomez and Gomez, 1984).

3.11 Economic analysis

Economic analysis was done to find out the cost effectiveness of different treatments like different levels of fertilizer and bending process in cost and return were done in details according to the procedure of Alam *et al*. (1989).

3.11.1 Analysis for total cost of production of baby corn

All the material and non-material input cost, interest on fixed capital of land and miscellaneous cost were considered for calculating the total cost of production. Total cost of production (input cost, overhead cost), gross return, net return and BCR are presented in Appendix VIII.

3.11.2 Gross income

Gross income was calculated on the basis of sale of mature bulb. The price of cob was assumed to be Tk. 30/kg basis of current market value of Kawran Bazar, Dhaka at the time of harvesting.

3.11.3 Net return

Net return was calculated by deducting the total production cost from gross income for each treatment combination.

3.11.4 Benefit cost ratio (BCR)

The economic indicator BCR was calculated by the following formula for each treatment combination.

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross income per hectare}}{\text{Total cost of production per hectare}}$$

CHAPTER IV

RESULTS AND DISCUSSION

The study was conducted to determine the influence of fertilizer and spacing on the yield performance of baby corn. Data on different growth, yield contributing characters and yield were recorded to find out of the optimum level of fertilizer and spacing for successful baby corn production. Results obtained from the study have been presented and discussed in this chapter.

4.1 Growth parameters

4.1.1 Plant height

Effect of fertilizer

There was a significant variation on plant height of baby corn influenced by different fertilizer levels (Fig. 1 and Appendix IV). Results revealed that the highest plant height (120.72 cm) was found from the treatment F_4 (20% higher than RDF) which was statistically identical with the treatment F_1 (RDF). Likewise, the lowest plant height (101.84 cm) was recorded from the treatment F_3 (40% less than RDF) followed by F_2 (20% less than RDF). Similar result on plant height was also observed by Pinjari (2007), Chillar and Kumar (2006), Gawade (1998) and Patil (1997).

Effect of spacing

Plant height was significantly influenced by different plant spacing of baby corn (Fig. 2 and Appendix IV). Results indicated that the highest plant height (118.79 cm) was found from the plant spacing S_3 (40 cm × 25 cm) followed by S_2 (50 cm × 25 cm). The lowest plant height (105.41 cm) was obtained from the plant spacing S_1 (60 cm × 25 cm). Zarapkar (2006) also found that plant height was significantly higher under the closer spacings. Similar result was also observed by Chamroy *et al*. (2017).

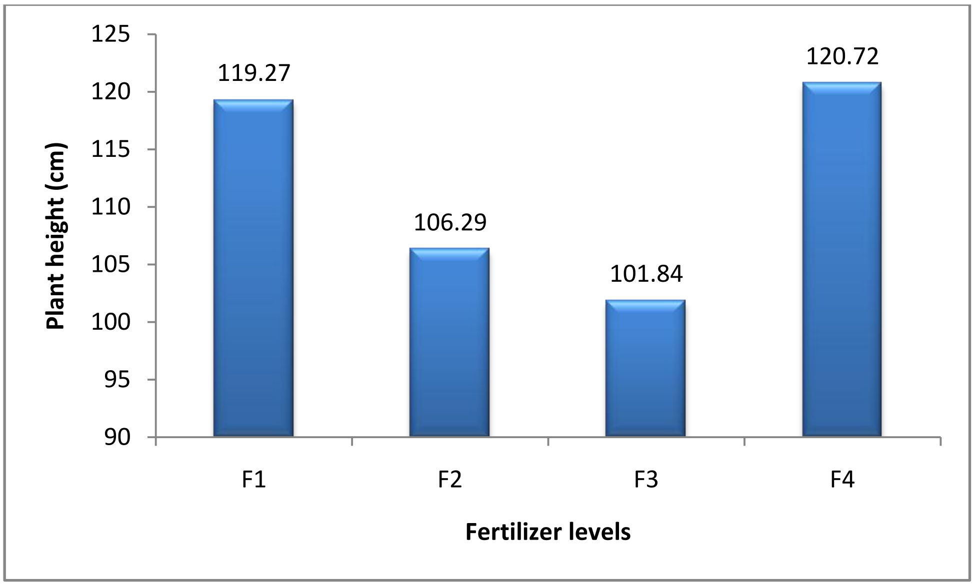

Figure 1. Plant height influenced by different fertilizer levels ($LSD_{0.05}$ = 2.044)

F_1 = Recommended doses of fertilizer (RDF), F_2 = 20% less than RDF, F_3 = 40% less than RDF, F_4 = 20% higher than RDF

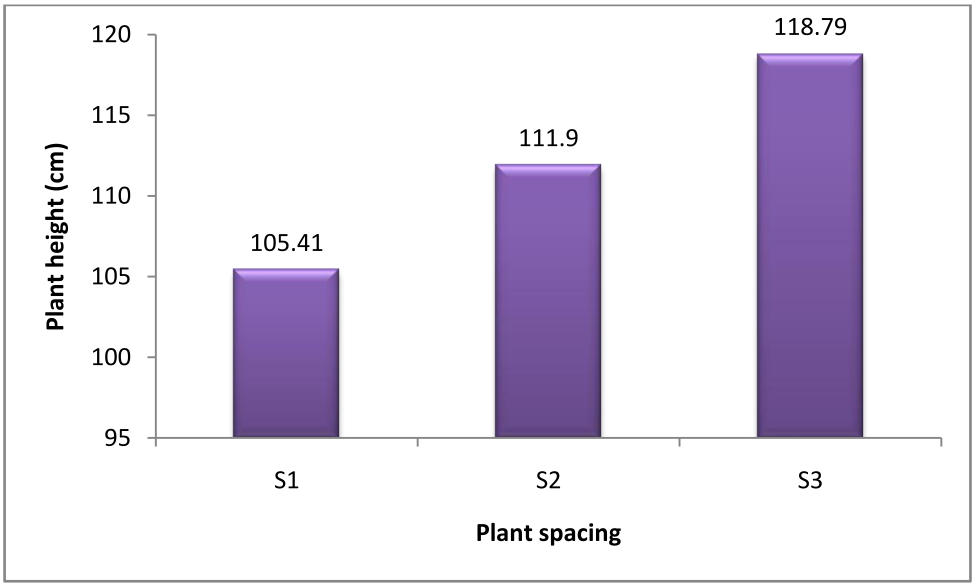

Figure 2. Plant heightinfluenced by different plant spacing ($LSD_{0.05}$ = 2.836**)**

S_1 = 60 cm × 25 cm, S_2 = 50 cm × 25 cm, S_3 = 40 cm × 25 cm

Combined effect of fertilizer and spacing

Significant variation was observed on plant height of baby corn influenced by combined effect of fertilizer and spacing (Table 1 and Appendix IV). It was observed that the highest plant height (126.60 cm) was found from the treatment combination of F_4S_3 which was statistically similar with the treatment combination of F_1S_3 followed by F_1S_2 and F_4S_2. The lowest plant height (95.28 cm) was obtained from the treatment combination of F_3S_1 which was statistically identical with F_2S_1 followed by F_3S_2.

4.1.2 Number of leaves plant^{-1}

Effect of fertilizer

Remarkable variation was observed on number of leaves plant^{-1} influenced by different fertilizer levels (Fig. 3 and Appendix IV). Results indicated that the highest number of leaves plant^{-1} (13.93) was found from the treatment F_4 (20% higher than RDF) which was statistically identical with the treatment F_1 (RDF). The lowest number of leaves plant^{-1} (11.44) was recorded from the treatment F_3 (40% less than RDF) which was statistically identical with F_2 (20% less than RDF). The result obtained from the present study was similar with the findings of Pinjari (2007), Gawade (1998) and Patil (1997).

Effect of spacing

Significant influence was noted on number of leaves plant^{-1} affected by different plant spacing (Fig. 4 and Appendix IV). Results showed that the highest number of leaves plant^{-1} (13.31) was found from the plant spacing S_1 (60 cm × 25 cm) followed by S_2 (50 cm × 25 cm). The lowest number of leaves plant^{-1} (11.99) was obtained from the plant spacing S_3 (40 cm × 25 cm). Number of functional leaves per plant was higher in case of wider spacings compared to closer spacings (Zarapkar, 2006). Bairagi *et al*. (2015) and Chamroy *et al*. (2017) also supported the present findings.

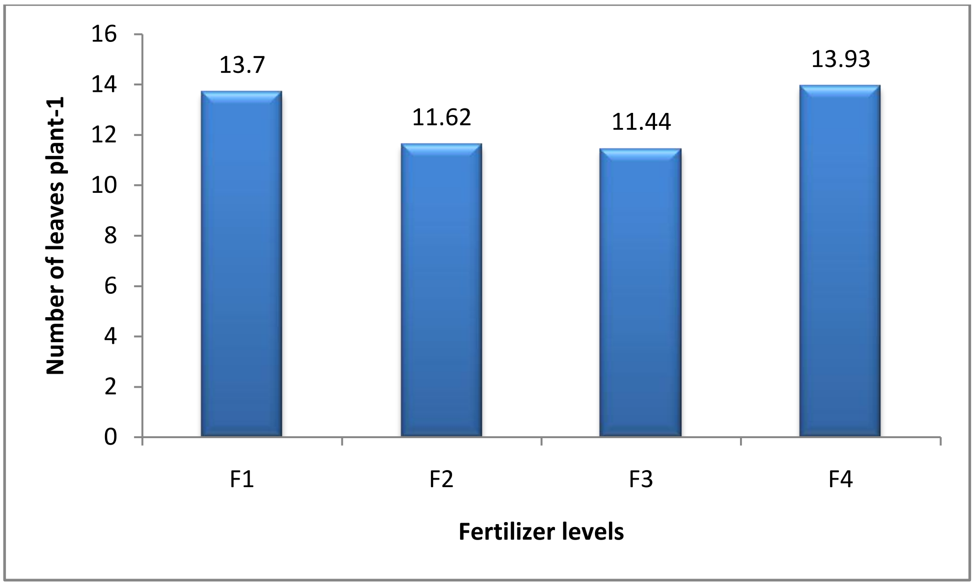

Figure 3. Number of leaves plant^{-1} influenced by different fertilizer levels ($LSD_{0.05}$ = 0.634)

F_1 = Recommended doses of fertilizer (RDF), F_2 = 20% less than RDF, F_3 = 40% less than RDF, F_4 = 20% higher than RDF

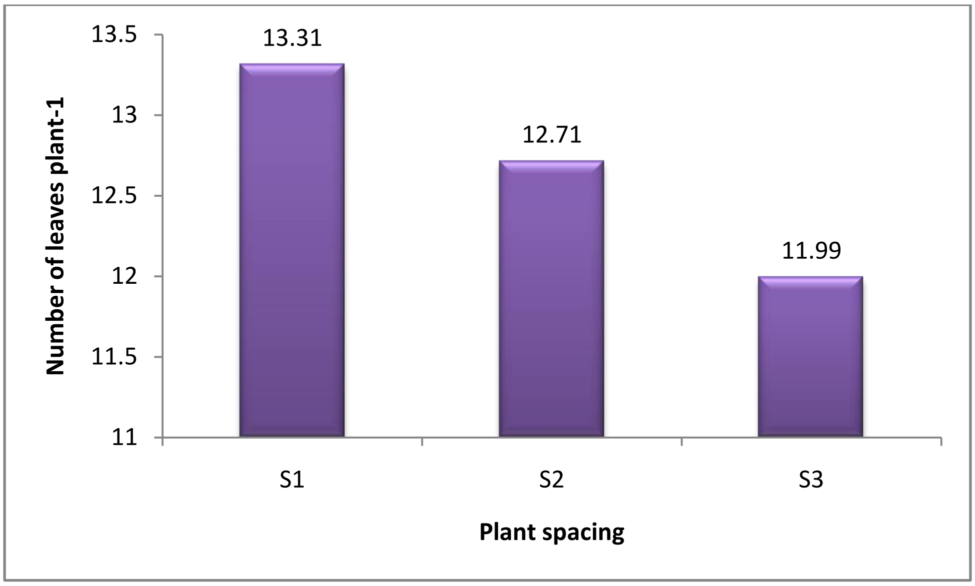

Figure 4. Number of leaves plant^{-1} influenced by different plant spacing ($LSD_{0.05}$ = 0.542)

S_1 = 60 cm × 25 cm, S_2 = 50 cm × 25 cm, S_3 = 40 cm × 25 cm

Combined effect of fertilizer and spacing

Significant variation was noticed on number of leaves plant^{-1} due to the combined effect of fertilizer and spacing (Table 1 and Appendix IV). It was found that the highest number of leaves plant^{-1} (14.48) was found from the treatment combination of F_4S_1 which was statistically similar with the treatment combination of F_1S_3. The lowest number of leaves plant^{-1} (10.67) was obtained from the treatment combination of F_3S_3 which was statistically identical with F_2S_1 followed by F_3S_2 and F_2S_2.

4.1.3 Dry weight plant^{-1} at harvest

Effect of fertilizer

Dry weight plant^{-1} was found as significant among the treatments with the application of different fertilizer doses (Fig. 5 and Appendix IV). Results indicated that the highest dry weight plant^{-1} (66.88 g) was found from the treatment F_4 (20% higher than RDF) which was statistically identical with the treatment F_1 (RDF). The lowest dry weight plant^{-1} (49.26 g) was recorded from the treatment F_3 (40% less than RDF) followed by the treatment F_2 (20% less than RDF). The result on dry weight plant^{-1} obtained from the present study was similar with the findings of Pinjari (2007), Gawade (1998) and Patil (1997).

Effect of spacing

Significant variation on dry weight plant^{-1} among the spacings was noted (Fig. 6 and Appendix IV). It was observed that the highest dry weight plant^{-1} (65.51 g) was found from the plant spacing S_1 (60 cm × 25 cm) followed by S_2 (50 cm × 25 cm). The lowest dry weight plant^{-1} (51.12 g) was obtained from the plant spacing S_3 (40 cm × 25 cm). Zarapkar (2006) also found that dry matter accumulation per plant was higher in case of wider spacings compared to closer spacings. Similar results was also observed by Bairagi *et al*. (2015) and Chamroy *et al*. (2017).

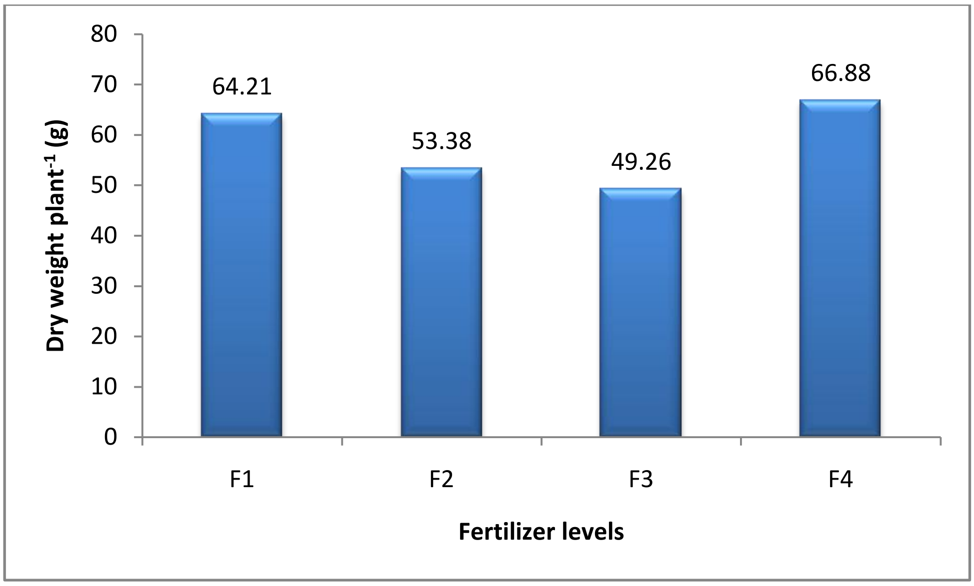

Figure 5. Dry weight plant^{-1} influenced by different fertilizer levels ($LSD_{0.05}$ = 2.046)

F_1 = Recommended doses of fertilizer (RDF), F_2 = 20% less than RDF, F_3 = 40% less than RDF, F_4 = 20% higher than RDF

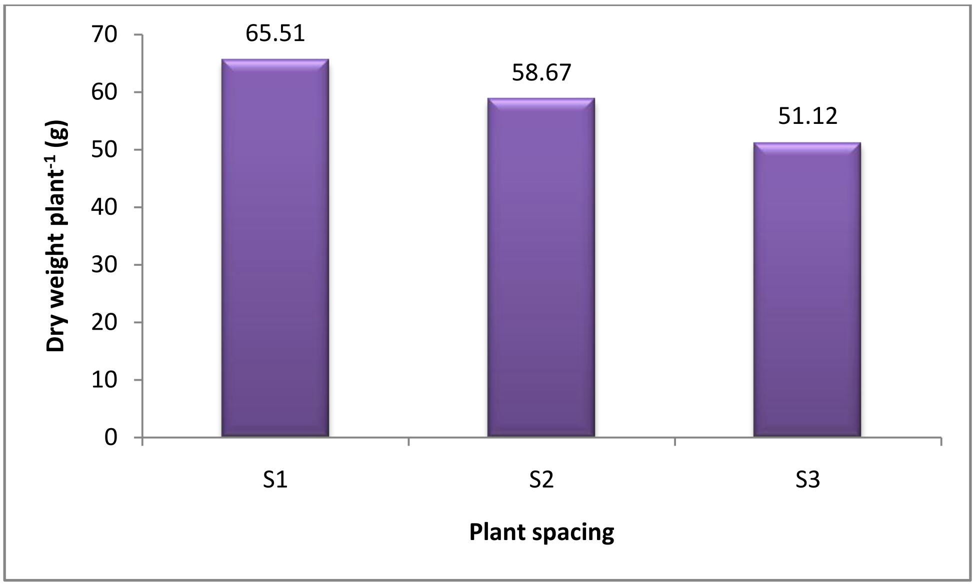

Figure 6. Dry weight plant^{-1} influenced by different plant spacing ($LSD_{0.05}$ = 3.727)

S_1 = 60 cm × 25 cm, S_2 = 50 cm × 25 cm, S_3 = 40 cm × 25 cm

Combined effect of fertilizer and spacing

Significant variation was remarked on dry weight plant^{-1} as influenced by combined effect of fertilizer and spacing (Table 1 and Appendix IV). It was found that the highest dry weight plant^{-1} (72.80 g) was achieved from the treatment combination of F_4S_1 which was statistically identical with the treatment combination of F_1S_1. The treatment combination of F_4S_1 and F_4S_2 also showed higher dry weight plant^{-1} but significantly different to others. The lowest dry weight plant^{-1} (43.66 g) was obtained from the treatment combination of F_3S_3 followed by the treatment combination of F_2S_3 and F_3S_2.

Table 1: Growth parameters of baby corn (plant height, number of leaves plant^{-1} and dry weight plant^{-1}) as influenced by combination of different fertilizer rates and spacing

Treatments	Growth parameters at harvest		
	Plant height (cm)	Number of leaves plant^{-1}	Dry weight plant^{-1} (g)
F_1S_1	114.30 d	13.15 d	71.92 a
F_1S_2	119.80 bc	13.75 bc	66.48 b
F_1S_3	123.60 ab	14.20 ab	54.24 de
F_2S_1	96.66 g	10.75 g	61.60 c
F_2S_2	105.80 e	11.80 ef	51.33 ef
F_2S_3	116.50 cd	12.30 e	47.20 g
F_3S_1	95.25 g	12.25 e	55.72 d
F_3S_2	101.80 f	11.40 f	48.40 fg
F_3S_3	108.50 e	10.67 g	43.66 h
F_4S_1	115.40 d	14.48 a	72.80 a
F_4S_2	120.20 bc	13.90 bc	68.47 b
F_4S_3	126.60 a	13.40 cd	59.36 c
$LSD_{0.05}$	3.8730	0.4908	3.047
CV(%)	11.562	5.823	8.914

F_1 = Recommended doses of fertilizer (RDF), F_2 = 20% less than RDF, F_3 = 40% less than RDF, F_4 = 20% higher than RDF

S_1 = 60 cm × 25 cm, S_2 = 50 cm × 25 cm, S_3 = 40 cm × 25 cm

4.2 Yield contributing parameters

4.2.1 Number of cobs plant^{-1}

Effect of fertilizer

The recorded data on number of cobs plant^{-1} was significantly influenced by the application of different fertilizer levels (Fig. 7 and Appendix V). Results revealed that the highest number of cobs plant^{-1} (2.69) was found from the treatment F_4 (20% higher than RDF) which was statistically identical with the treatment F_1 (RDF). Similarly, the lowest number of cobs plant^{-1} (2.45) was recorded from the treatment F_3 (40% less than RDF) which was statistically identical with F_2 (20% less than RDF). Roy *et al.* (2015) and Auwal and Amit (2017) also found similar result of the present study.

Effect of spacing

Number of cobs plant^{-1} was influenced significantly by different plant spacing of baby corn (Fig. 8 and Appendix V). Results indicated that the highest number of cobs plant^{-1} (2.65) was found from the plant spacing S_1 (60 cm × 25 cm) followed by S_2 (50 cm × 25 cm). The lowest number of cobs plant^{-1} (2.48) was obtained from the plant spacing S_3 (40 cm × 25 cm). Similar result on number of cobs plant^{-1} also observed by Ramchandrappa *et al.* (2004), Bairagi *et al*. (2015) and Chamroy *et al*. (2017).

Combined effect of fertilizer and spacing

Combined effect of fertilizer and spacing showed significant variation on number of cobs plant^{-1} (Table 2 and Appendix V). It was observed that the highest number of cobs plant^{-1} (2.76) was found from the treatment combination of F_4S_1 which was statistically similar with the treatment combination of F_1S_1 which was statistically similar with the treatment combination of F_1S_1 and F_4S_1. The lowest number of cobs plant^{-1} (2.36) was obtained from the treatment combination of F_3S_3 which was statistically identical with F_2S_3 and closely followed by F_2S_2 and F_3S_2.

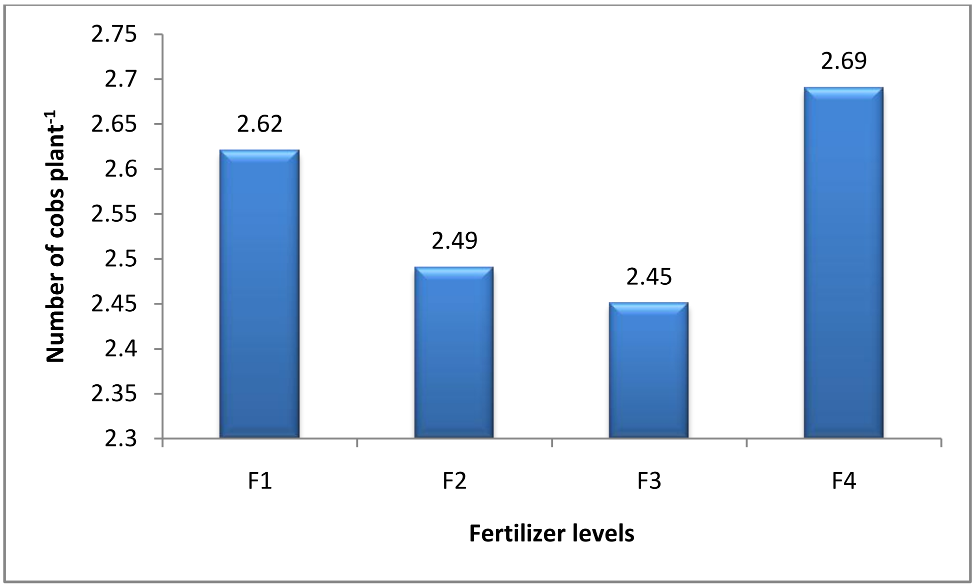

Figure 7. Number of cobs plant^{-1} as influenced by different fertilizer levels ($LSD_{0.05}$ = 0.104)

F_1 = Recommended doses of fertilizer (RDF), F_2 = 20% less than RDF, F_3 = 40% less than RDF, F_4 = 20% higher than RDF

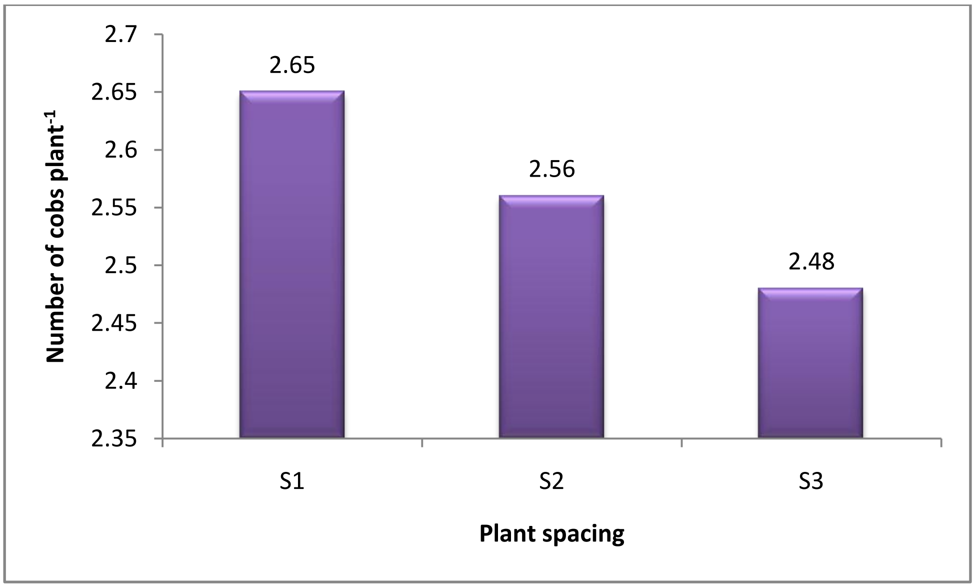

Figure 8. Number of cobs plant^{-1} as influenced by different plant spacing ($LSD_{0.05}$ = 0.078)

S_1 = 60 cm × 25 cm, S_2 = 50 cm × 25 cm, S_3 = 40 cm × 25 cm

4.2.2 Number of rows cob^{-1}

Effect of fertilizer

Remarkable variation was observed on number of rows cob^{-1} due to different fertilizer levels (Fig. 9 and Appendix V). Results indicated that the maximum number of rows cob^{-1} (13.78) was found from the treatment F_4 (20% higher than RDF) which was statistically identical with the treatment F_1 (RDF). The least number of rows cob^{-1} (12.52) was recorded from the treatment F_3 (40% less than RDF) which was also statistically identical with F_2 (20% less than RDF). Roy *et al.* (2015) also found similar result which supported the present finding.

Effect of spacing

Significant influence was noted on number of rows cob^{-1} affected by different plant spacing (Fig. 10 and Appendix V). Results showed that the maximum number of rows cob^{-1} (13.74) was found from the plant spacing S_1 (60 cm × 25 cm) followed by S_2 (50 cm × 25 cm). The least number of rows cob^{-1} (12.63) was obtained from the plant spacing S_3 (40 cm × 25 cm). Kunjir *et al*. (2007) found similar result on number of rows cob^{-1}.

Combined effect of fertilizer and spacing

Number of rows cob^{-1} was found significant influenced by the treatment combination of fertilizer and spacing (Table 2 and Appendix V). It was found that the maximum number of rows cob^{-1} (14.40) was found from the treatment combination of F_4S_1 which was statistically identical with the treatment combination of F_1S_1. Comparatively higher number of rows cob^{-1} was also obtained from the treatment combination of $F_1S_2$and F_4S_2 but significantly different to others. The least number of rows cob^{-1} (12.25) was obtained from the treatment combination of F_3S_3 which was statistically identical with F_2S_3 and statistically similar with by F_2S_2 and F_3S_2.

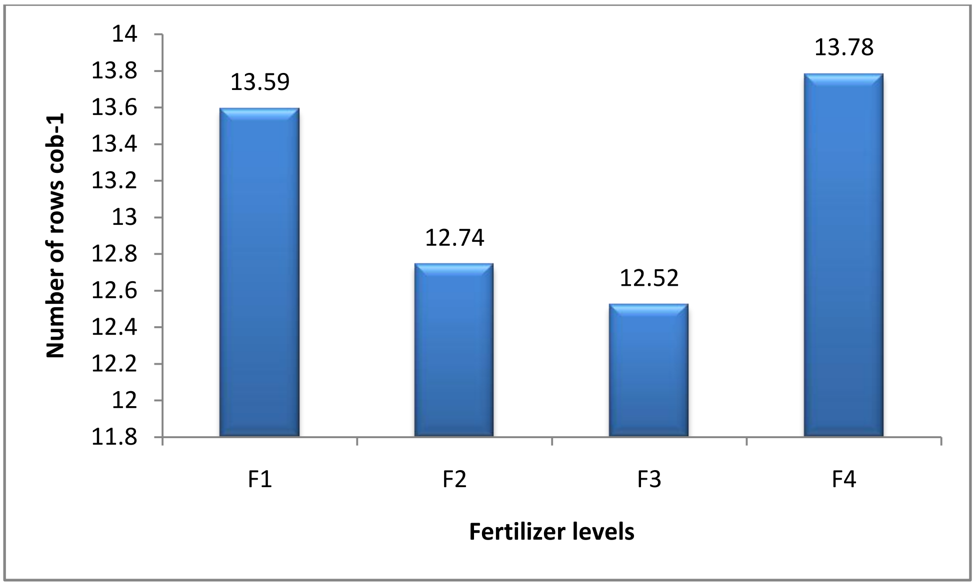

Figure 9. Number of rows cob^{-1} as influenced by different fertilizer levels ($LSD_{0.05}$ = 0.415)

F_1 = Recommended doses of fertilizer (RDF), F_2 = 20% less than RDF, F_3 = 40% less than RDF, F_4 = 20% higher than RDF

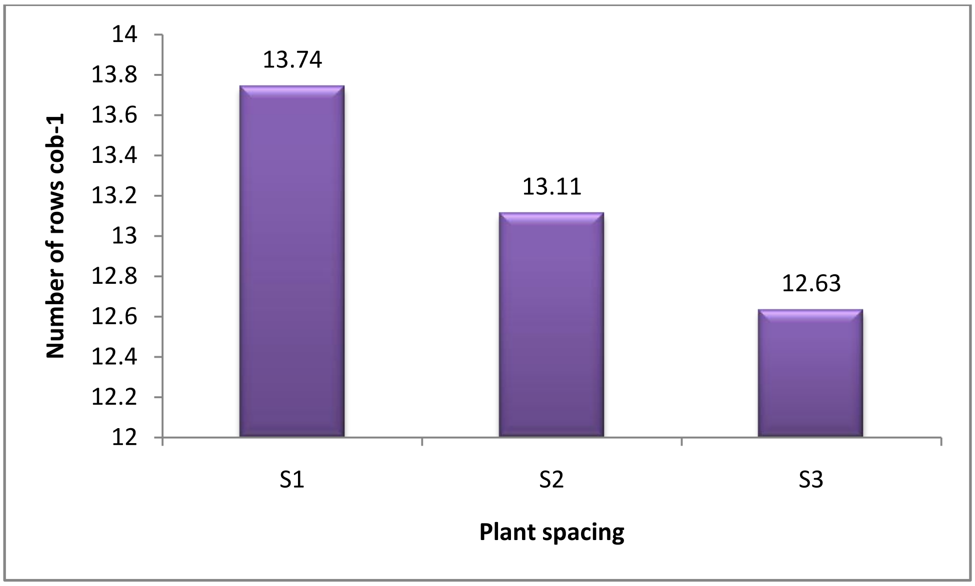

Figure 10. Number of rows cob^{-1} as influenced by different plant spacing ($LSD_{0.05}$ = 0.311)

S_1 = 60 cm × 25 cm, S_2 = 50 cm × 25 cm, S_3 = 40 cm × 25 cm

4.2.3 Cob length

Effect of fertilizer

Significant variation was achieved on cob length influenced by different fertilizer levels (Fig. 11 and Appendix V). Results signified that the highest cob length (17.76 cm) was found from the treatment F_4 (20% higher than RDF) which was statistically identical with the treatment F_1 (RDF). The lowest cob length (15.93 cm) was recorded from the treatment F_3 (40% less than RDF) which was statistically identical with F_2 (20% less than RDF). Supporting findings was also observed by Roy *et al.* (2015) and Auwal and Amit (2017).

Effect of spacing

Cob length was significantly varied due to different plant spacing of baby corn (Fig. 12 and Appendix V). Results showed that the highest cob length (17.60 cm) was found from the plant spacing S_1 (60 cm × 25 cm) whereas the lowest cob length (16.20 cm) was obtained from the plant spacing S_3 (40 cm × 25 cm) which was statistically identical with S_2 (50 cm × 25 cm). Ramchandrappa *et al.* (2004), Kunjir *et al.* (2007), Bairagi *et al.* (2015) and Chamroy *et al.* (2017) found similar result which supported the present study.

Combined effect of fertilizer and spacing

Combined effect of fertilizer and spacing showed significant influence on cob length of baby corn (Table 2 and Appendix V). It was found that the highest cob length (18.36 cm) was found from the treatment combination of F_4S_1 which was statistically similar with the treatment combination of F_1S_1. Comparatively higher cob length was also obtained from the treatment combination of F_1S_2 and F_4S_2 but significantly different from other treatment combinations. The lowest cob length (15.40 cm) was obtained from the treatment combination of F_3S_3 which was statistically identical with the treatment combination of F_2S_2, F_2S_3 and F_3S_2.

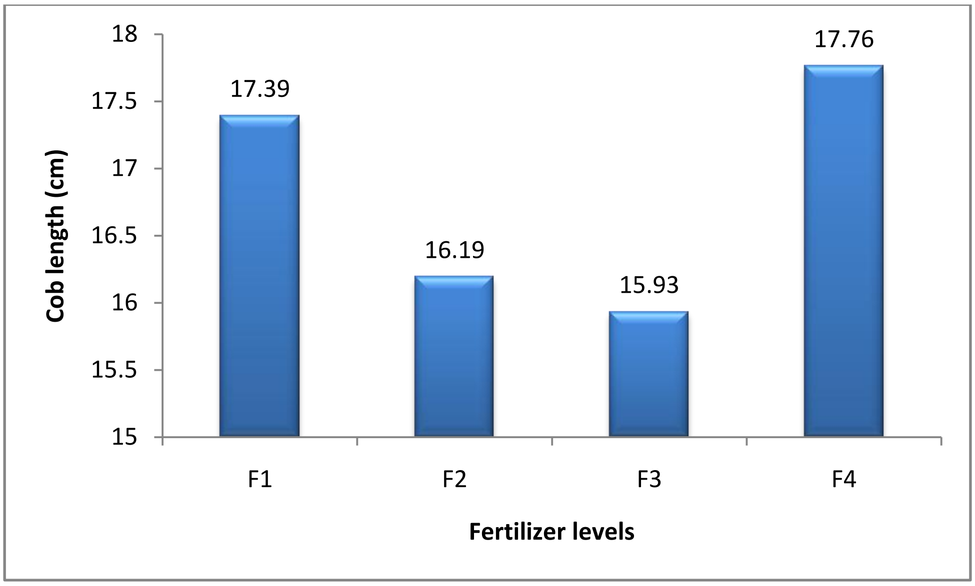

Figure 11. Cob length influenced by different fertilizer levels ($LSD_{0.05}$ = 0.548)

F_1 = Recommended doses of fertilizer (RDF), F_2 = 20% less than RDF, F_3 = 40% less than RDF, F_4 = 20% higher than RDF

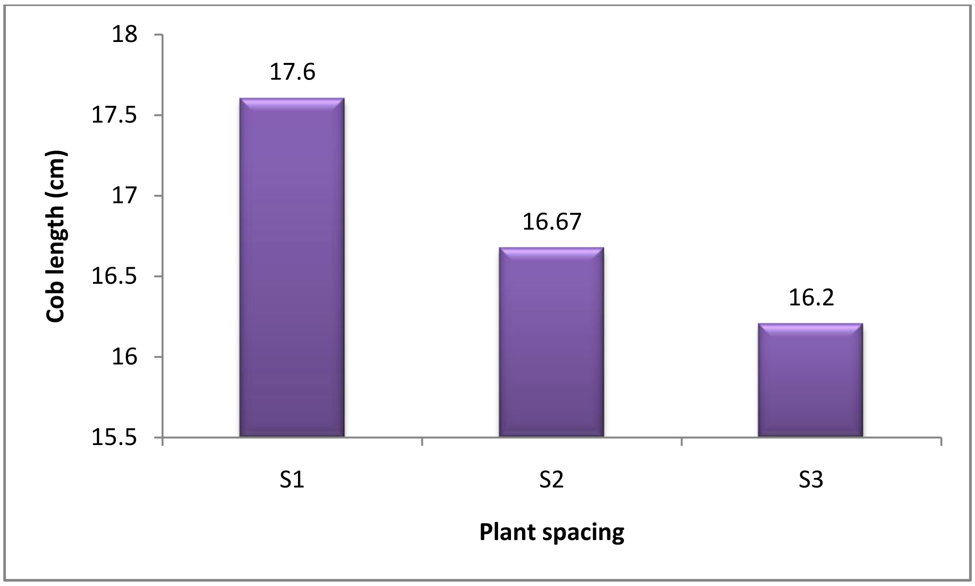

Figure 12. Cob length influenced by different plant spacing ($LSD_{0.05}$ = 0.583)

S_1 = 60 cm × 25 cm, S_2 = 50 cm × 25 cm, S_3 = 40 cm × 25 cm

Table 2: Interaction effect of fertilizer levels and spacing on number of cobs plant^{-1}, number of rows cob^{-1} and cob length

Treatments	Yield contributing parameters		
	Number of cobs plant^{-1}	Number of rows cob^{-1}	Cob length (cm)
F_1S_1	2.70 ab	14.25 a	18.10 ab
F_1S_2	2.65 bc	13.72 bc	17.48 cd
F_1S_3	2.52 de	12.80 ef	16.60 e
F_2S_1	2.60 bcd	13.40 cd	17.20 d
F_2S_2	2.46 ef	12.45 fg	15.80 f
F_2S_3	2.40 f	12.36 g	15.58 f
F_3S_1	2.55 cde	12.92 e	16.72 e
F_3S_2	2.45 ef	12.40 fg	15.66 f
F_3S_3	2.36 f	12.25 g	15.40 f
F_4S_1	2.76 a	14.40 a	18.36 a
F_4S_2	2.67 ab	13.85 b	17.75 bc
F_4S_3	2.64 bc	13.10 de	17.18 d
$LSD_{0.05}$	0.09275	0.3935	0.435
CV(%)	4.215	6.389	9.527

F_1 = Recommended doses of fertilizer (RDF), F_2 = 20% less than RDF, F_3 = 40% less than RDF, F_4 = 20% higher than RDF

S_1 = 60 cm × 25 cm, S_2 = 50 cm × 25 cm, S_3 = 40 cm × 25 cm

4.2.4 Cob weight plant^{-1} with husk

Effect of fertilizer

Significant variation was noticed on cob weight plant^{-1} with huskinfluenced by different fertilizer levels (Fig. 13 and Appendix VI). Results signified that the highest cob weight plant^{-1} with husk (106.85 g) was found from the treatment F_1 (RDF) which was statistically identical with the treatment F_4 (20% higher than RDF). The lowest cob weight plant^{-1} with husk (74.90 g) was recorded from the treatment F_3 (40% less than RDF) followed by F_2 (20% less than RDF). Gosavi (2006), Thakur and Sharma (1999) and Patil (1997) found similar results with the present study.

Effect of spacing

Cob weight plant^{-1} with husk was significantly varied due to different plant spacing of baby corn (Fig. 14 and Appendix VI). Results showed that the highest cob weight plant^{-1} with husk (97.77 g) was found from the plant spacing S_1 (60 cm × 25 cm) whereas the lowest cob weight plant^{-1} with husk (16.20 cm) was obtained from the plant spacing S_3 (40 cm × 25 cm). The plant spacingS_2 (50 cm × 25 cm) showed intermediate result compared to other spacings. Ramchandrappa *et al.* (2004) found similar result on cob weight plant^{-1} with husk.

Combined effect of fertilizer and spacing

Combined effect of fertilizer and spacing showed significant influence on cob weight plant^{-1} with husk of baby corn (Table 3 and Appendix VI). It was found that the highest cob weight plant^{-1} with husk (117.00 g) was found from the treatment combination of F_1S_1 followed by the treatment combination of F_1S_2, F_4S_1 and F_4S_2. The lowest cob weight plant^{-1} with husk (71.57 g) was obtained from the treatment combination of F_3S_3 which was statistically identical with the treatment combination of F_3S_2.

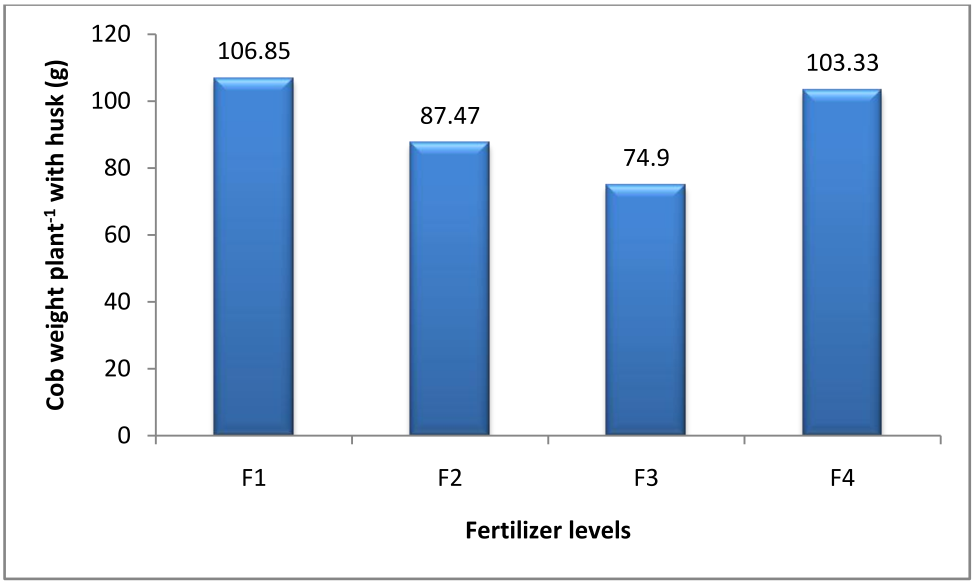

Figure 13. Cob weight plant^{-1} with husk influenced by different fertilizer levels ($LSD_{0.05}$ = 4.117)

F_1 = Recommended doses of fertilizer (RDF), F_2 = 20% less than RDF, F_3 = 40% less than RDF, F_4 = 20% higher than RDF

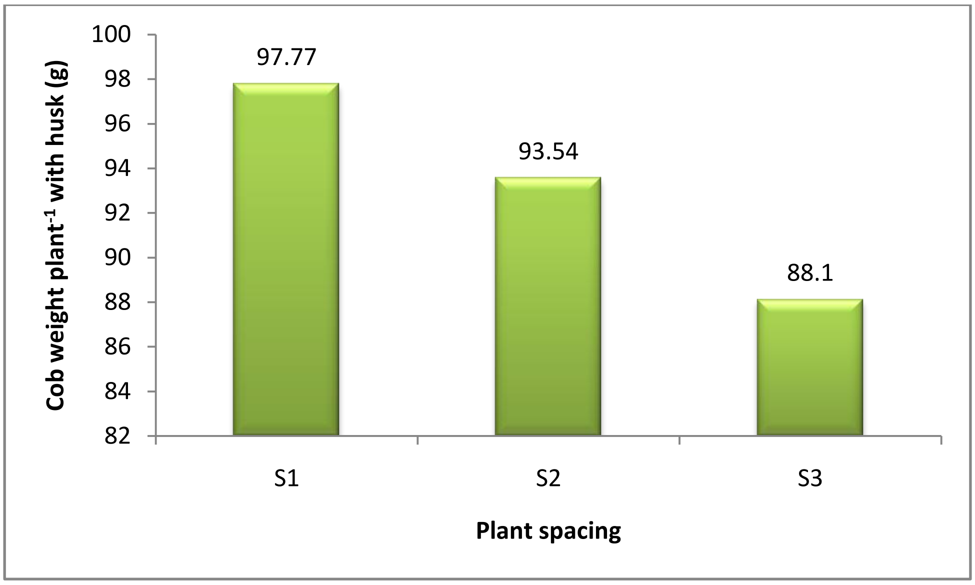

Figure 14. Cob fresh weight plant^{-1} with husk influenced by different plant spacing ($LSD_{0.05}$ = 3.589)

S_1 = 60 cm × 25 cm, S_2 = 50 cm × 25 cm, S_3 = 40 cm × 25 cm

4.2.5 Cob weight plant^{-1} without husk

Effect of fertilizer

Cob weight plant^{-1} without huskwas significant varied due to different fertilizer levels (Fig. 15 and Appendix VI). Results showed that the highest cob weight plant^{-1} without husk (62.98 g) was found from the treatment F_1 (RDF) followed by F_4 (20% higher than RDF). The lowest cob weight plant^{-1} without husk (39.99 g) was recorded from the treatment F_3 (40% less than RDF) followed by the treatment F_2 (20% less than RDF). The result obtained from the present study was similar with the findings of Ajaz *et al*. (2013), Gosavi (2006), Thakur and Sharma (1999) and Patil (1997).

Effect of spacing

Cob weight plant^{-1} without huskwas significantly influenced by different plant spacing of baby corn (Fig. 16 and Appendix VI). It was observed that the highest cob weight plant^{-1} without husk(55.34 g) was found from the plant spacing S_1 (60 cm × 25 cm) whereas the lowest cob weight plant^{-1} without husk (47.75 g) was obtained from the plant spacing S_3 (40 cm × 25 cm) followed by the spacing S_2 (50 cm × 25 cm). Similar result on cob weight plant^{-1} without husk was observed by Chamroy *et al*. (2017).

Combined effect of fertilizer and spacing

Combined effect of fertilizer and spacing showed significant influence on cob weight plant^{-1} without husk of baby corn (Table 3 and Appendix VI). It was noted that the highest cob weight plant^{-1} without husk (71.50 g) was found from the treatment combination of F_1S_1 which was significantly different from other treatment combinations followed by the treatment combination of F_1S_2. The lowest cob weight plant^{-1} without husk (37.55 g) was obtained from the treatment combination of F_3S_3 which was statistically identical with the treatment combination of F_3S_2.

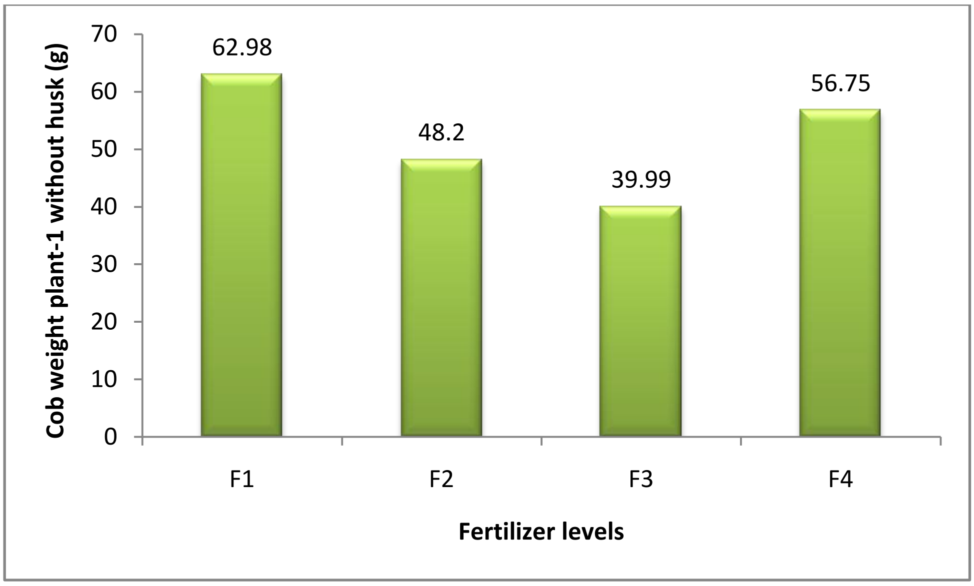

Figure 15. Cob weight plant^{-1} without husk influenced by different fertilizer levels ($LSD_{0.05}$ = 3.714)

F_1 = Recommended doses of fertilizer (RDF), F_2 = 20% less than RDF, F_3 = 40% less than RDF, F_4 = 20% higher than RDF

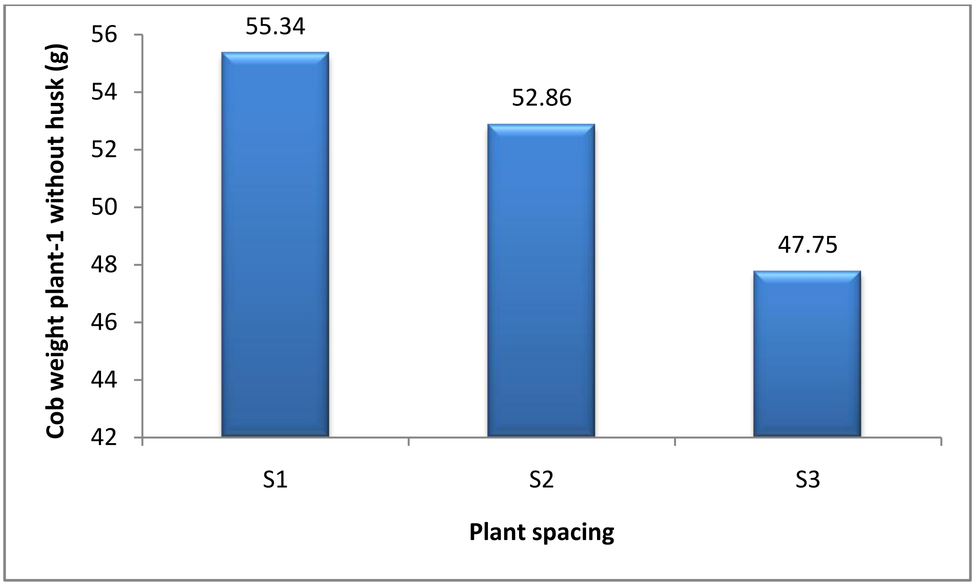

Figure 16. Cob weight plant^{-1} without husk influenced by different plant spacing ($LSD_{0.05}$ = 2.865)

S_1 = 60 cm × 25 cm, S_2 = 50 cm × 25 cm, S_3 = 40 cm × 25 cm

4.2.6 Base diameter of cob

Effect of fertilizer

Significant influence was found on base diameteramong the treatments influenced by different fertilizer levels (Fig. 17 and Appendix VI). Results signified that the maximum base diameter (4.60 cm) of cob was found from the treatment F_4 (20% higher than RDF) which was statistically identical with the treatment F_1 (RDF). The lowest base diameter (4.11 cm) was recorded from the treatment F_3 (40% less than RDF) which was also statistically identical with F_2 (20% less than RDF). Auwal and Amit (2017) found similar result with the present study.

Effect of spacing

Base diameter was significantly varied due to different plant spacing of baby corn (Fig. 18 and Appendix VI). Results showed that the maximum base diameter (4.58 cm) of cob was found from the plant spacing S_1 (60 cm × 25 cm) whereas the lowest base diameter (4.20 cm) was obtained from the plant spacing S_3 (40 cm × 25 cm) followed by S_2 (50 cm × 25 cm). Ramchandrappa *et al.* (2004) and Kunjir (2007) found similar results on diameter of cob.

Combined effect of fertilizer and spacing

Combined effect of fertilizer and spacing had significant variation on base diameter of baby corn (Table 3 and Appendix VI). It was observed that the maximum base diameter (4.80 cm) of cob was found from the treatment combination of F_4S_1 which was statistically similar with the treatment combination of F_1S_1. The lowest base diameter (3.92 cm) was obtained from the treatment combination of F_3S_3 which was significantly different from other treatment combinations.

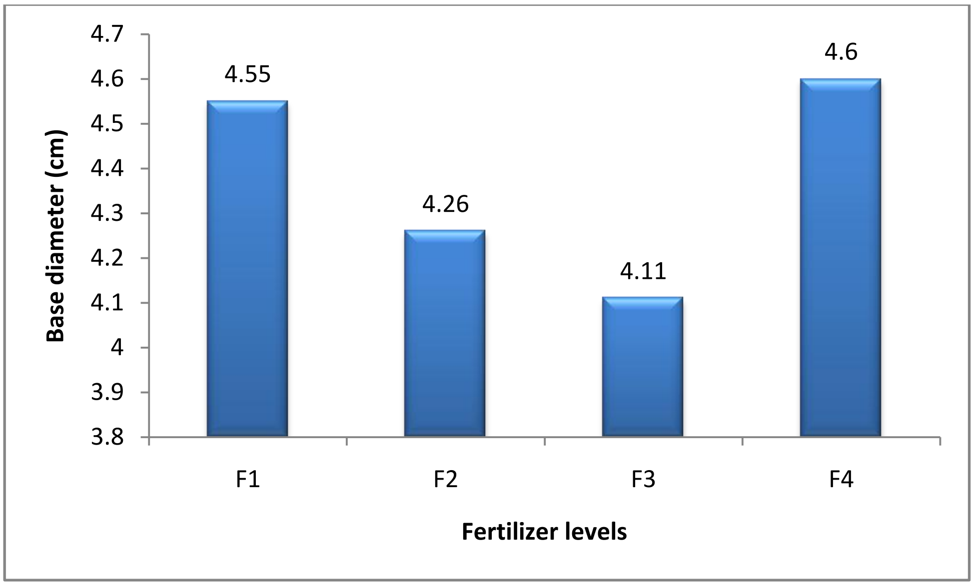

Fig. 17. Base diameter of cob influenced by different fertilizer levels ($LSD_{0.05}$ = 0.256)

F_1 = Recommended doses of fertilizer (RDF), F_2 = 20% less than RDF, F_3 = 40% less than RDF, F_4 = 20% higher than RDF

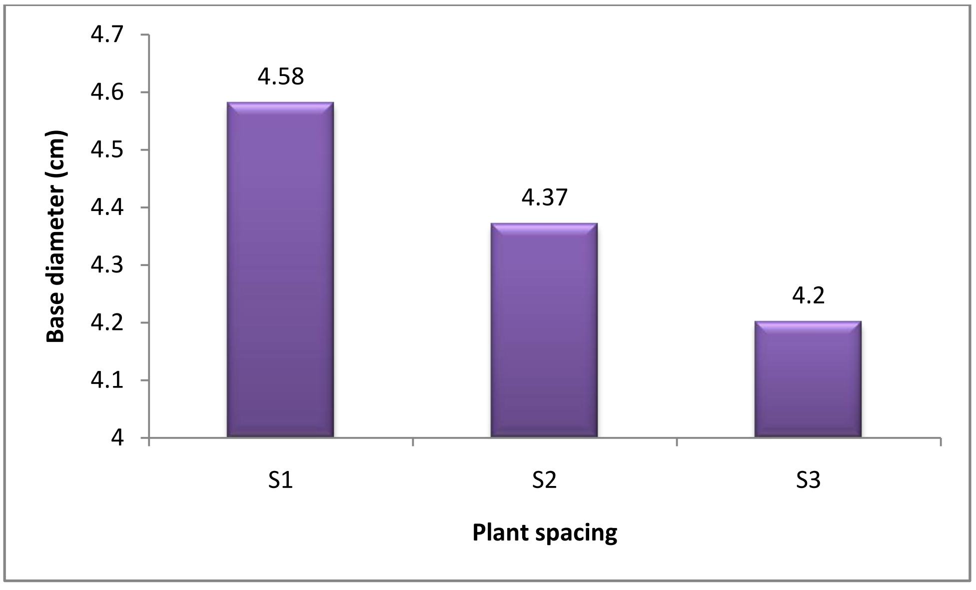

Figure 18. Base diameter of cob influenced by different plant spacing ($LSD_{0.05}$ = 0.117)

S_1 = 60 cm × 25 cm, S_2 = 50 cm × 25 cm, S_3 = 40 cm × 25 cm

4.2.7 Top diameter of cob

Effect of fertilizer

Significant variation was achieved on top diameter influenced by different fertilizer levels (Fig. 19 and Appendix VI). Results signified that the highest top diameter (2.25 cm) of cob was found from the treatment F_4 (20% higher than RDF) which was statistically identical with the treatment F_1 (RDF). The lowest top diameter (2.07 cm) was recorded from the treatment F_3 (40% less than RDF) which was also statistically identical with F_2 (20% less than RDF). Similar result was observed by Auwal and Amit (2017) which supported the present study.

Effect of spacing

Top diameterwas significantly varied due to different plant spacing of baby corn (Fig. 20 and Appendix VI). Results showed that the highest top diameter (2.23 cm) of cob was found from the plant spacing S_1 (60 cm × 25 cm) which was statistically identical with S_2 (50 cm × 25 cm) whereas the lowest top diameter (2.11 cm) was obtained from the plant spacing S_3 (40 cm × 25 cm). Ramchandrappa *et al.* (2004) and Kunjir (2007) found similar results on diameter of cob.

Combined effect of fertilizer and spacing

Combined effect of fertilizer and spacing showed significant influence on top diameter of baby corn (Table 3 and Appendix VI). It was found that the highest top diameter (2.30 cm) of cob was found from the treatment combination of F_4S_1 which was statistically identical with the treatment combination of F_1S_1. The lowest top diameter (2.03 cm) was obtained from the treatment combination of F_3S_3 which was statistically identical with the treatment combination of F_2S_3.

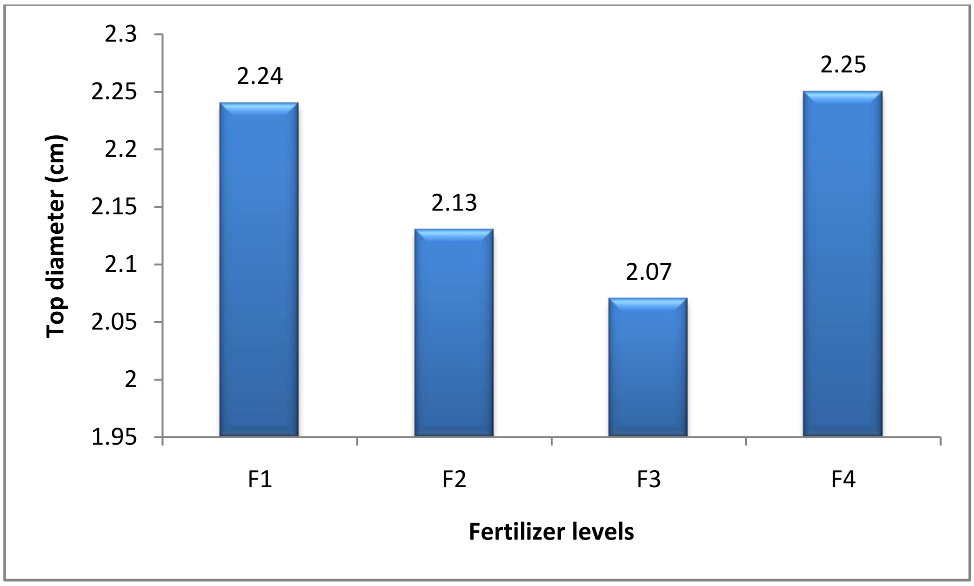

Figure 19. Top diameter of cob influenced by different fertilizer levels ($LSD_{0.05}$ = 0.106)

F_1 = Recommended doses of fertilizer (RDF), F_2 = 20% less than RDF, F_3 = 40% less than RDF, F_4 = 20% higher than RDF

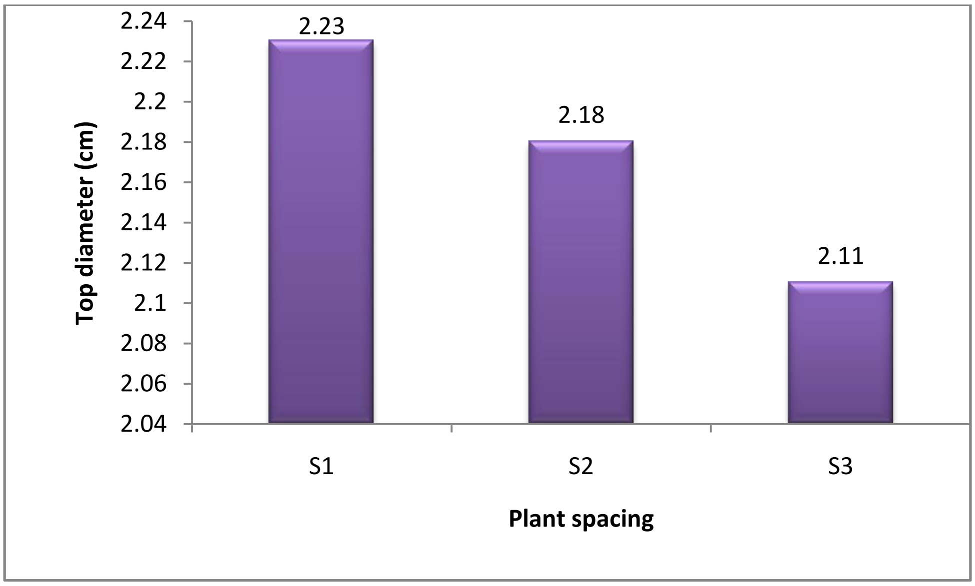

Figure 20. Top diameter of cob influenced by different plant spacing ($LSD_{0.05}$ = 0.052)

S_1 = 60 cm × 25 cm, S_2 = 50 cm × 25 cm, S_3 = 40 cm × 25 cm

Table 3: Yield contributing parameters as cob weight plant^{-1} with husk, cob weight plant^{-1} without huskand diameter of cob influenced by combination of different fertilizer rates and spacing

Treatments	Yield contributing parameters			
	Cob weight plant^{-1} with husk (g)	Cob weight plant^{-1} without husk (g)	Base diameter of cob (cm)	Top diameter of cob (cm)
F_1S_1	117.00 a	71.50 a	4.74 ab	2.32 a
F_1S_2	107.70 b	64.62 b	4.55 c	2.24 b
F_1S_3	95.82 c	52.82 ef	4.30 d	2.15 d
F_2S_1	87.61 d	48.80 fg	4.48 c	2.20 c
F_2S_2	88.75 d	49.75 fg	4.20 de	2.14 d
F_2S_3	86.04 d	46.04 gh	4.10 e	2.05 f
F_3S_1	81.04 e	44.12 h	4.28 d	2.10 e
F_3S_2	72.09 f	38.30 i	4.14 de	2.08 e
F_3S_3	71.57 f	37.55 i	3.92 f	2.03 f
F_4S_1	105.40 b	56.92 cd	4.80 a	2.30 a
F_4S_2	105.60 b	58.75 c	4.58 bc	2.25 b
F_4S_3	98.95 c	54.58 de	4.47 c	2.19 c
$LSD_{0.05}$	4.660	3.842	0.161	0.029
CV(%)	10.539	8.752	5.588	3.214

F_1 = Recommended doses of fertilizer (RDF), F_2 = 20% less than RDF, F_3 = 40% less than RDF, F_4 = 20% higher than RDF

S_1 = 60 cm × 25 cm, S_2 = 50 cm × 25 cm, S_3 = 40 cm × 25 cm

4.3 Yield parameters

4.3.1 Number of cobs ha^{-1}

Effect of fertilizer

Different fertilizer levels showed significant variation among the treatments on number of cobs ha^{-1} (Table 4 and Appendix VII). Results revealed that the highest number of cobs ha^{-1} (235.23 thousand) was found from the treatment F_4 (20% higher than RDF) followed by the treatment F_1 (RDF). The lowest number of cobs ha^{-1} (214.14 thousand) was recorded from the treatment F_3 (40% less than RDF) which were also statistically identical with F_2 (20% less than RDF). Similar result was observed by Gosavi (2006) and Auwal *et al*. (2017).

Effect of spacing

Number of cobs ha^{-1} was significantly affected due to different plant spacing of baby corn (Table 4 and Appendix VII). The highest number of cobs ha^{-1} (253.64 thousand) was found from the plant spacing S_3 (40 cm × 25 cm) followed by S_2 (50 cm × 25 cm) whereas the lowest number of cobs ha^{-1} (193.77 thousand) was obtained from the plant spacing S_1 (60 cm × 25 cm). The result obtained from the present study was similar with the findings of Thakur *et al.* (1997).

Combined effect of fertilizer and spacing

Combined effect of fertilizer and spacing represented significant influence on number of cobs ha^{-1} of baby corn (Table 4 and Appendix VII). It was found that the highest number of cobs ha^{-1} (270.00 thousand) was found from the treatment combination of F_4S_3 followed by the treatment combination of F_1S_3 and F_2S_3. The lowest number of cobs ha^{-1} (186.30 thousand) was obtained from the treatment combination of F_3S_1 which was statistically similar with the treatment combination of F_2S_1.

4.3.2 Fresh cob yield ha^{-1}

Effect of fertilizer

Significant influence was observed on fresh cob yield ha^{-1} due to different fertilizer levels (Table 4 and Appendix VII). Results revealed that the maximum fresh cob yield ha^{-1} (9.26 t) was found from the treatment F_4 (20% higher than RDF) which was statistically identical with the treatment F_1 (RDF). The least fresh cob yield ha^{-1} (6.52 t) was recorded from the treatment F_3 (40% less than RDF) followed by F_2 (20% less than RDF). The results on fresh cob yield ha^{-1} achieved from the present study was conformity with the findings of Khadtare *et al*. (2006), Gosavi (2006), Aravinth *et al*. (2011) and Auwal *et al*. (2017).

Effect of spacing

Fresh cob yield ha^{-1} was significantly affected due to different plant spacing of baby corn (Table 4 and Appendix VII). The maximum fresh cob yield ha^{-1} (9.01 t) was found from the plant spacing S_3 (40 cm × 25 cm) followed by S_2 (50 cm × 25 cm) whereas the least fresh cob yield ha^{-1} (7.14 t) was obtained from the plant spacing S_1 (60 cm × 25 cm). The result obtained from the present study was similar with the findings of Kunjir (2007), Golada *et al*. (2013) and Bairagi *et al*. (2015).

Combined effect of fertilizer and spacing

Combined effect of fertilizer and spacing showed significant variation on fresh cob yield ha^{-1} of baby corn (Table 4 and Appendix VII). It was observed that the maximum fresh cob yield ha^{-1} (10.10 t) was found from the treatment combination of F_4S_3 which was statistically similar with the treatment combination of F_1S_3. The least fresh cob yield ha^{-1} (5.92 t) was obtained from the treatment combination of F_3S_1 which was statistically similar with the treatment combination of F_2S_2.

4.3.3 Stover yield ha^{-1}

Effect of fertilizer

Different fertilizer levels showed significant variation among the treatments on stover yield ha^{-1} (Table 4 and Appendix VII). Results signified that the maximum stover yield ha^{-1} (10.46 t) was found from the treatment F_4 (20% higher than RDF) which was statistically identical with the treatment F_1 (RDF). The lowest stover yield ha^{-1} (8.37 t) was recorded from the treatment F_3 (40% less than RDF) followed by F_2 (20% less than RDF). Similar result was observed by Gosavi (2006), Khadtare *et al*. (2006) and Auwal *et al*. (2017).

Effect of spacing

Stover yield ha^{-1} was significantly affected due to different plant spacing of baby corn (Table 4 and Appendix VII). Results showed that the highest stover yield ha^{-1} (10.37 t) was found from the plant spacing S_3 (40 cm × 25 cm) followed by S_2 (50 cm × 25 cm) whereas the lowest stover yield ha^{-1} (9.02 t) was obtained from the plant spacing S_1 (60 cm × 25 cm). Similar findings was achieved by Kunjir (2007), Golada *et al*. (2013) and Bairagi *et al*. (2015).

Combined effect of fertilizer and spacing

Combined effect of fertilizer and spacing gave significant influence on stover yield $ha^{-1}$of baby corn (Table 4 and Appendix VII). It was found that the highest stover yield ha^{-1} (11.12 t) was found from the treatment combination of F_4S_3 which was statistically identical with F_1S_3 and statistically similar with F_1S_2. The lowest stover yield ha^{-1} (7.88 t) was obtained from the treatment combination of F_3S_1 followed by the treatment combination of F_2S_1 and F_3S_2.

4.3.4 Biological yield ha^{-1}

Effect of fertilizer

Different fertilizer levels showed significant variation among the treatments on biological yield ha^{-1} (Table 4 and Appendix VII). Results revealed that the highest biological yield ha^{-1} (19.90 t) was found from the treatment F_4 (20% higher than RDF) which was statistically identical with the treatment F_1 (RDF). The lowest Biological yield ha^{-1} (14.89 t) was recorded from the treatment F_3 (40% less than RDF) followed by F_2 (20% less than RDF). The result obtained from the present study was similar with the findings of Gawade (1998) and Gosavi (2006).

Effect of spacing

Biological yield ha^{-1} was significantly affected due to different plant spacing of baby corn (Table 4 and Appendix VII). The highest biological yield ha^{-1} (19.37 t) was found from the plant spacing S_3 (40 cm × 25 cm) followed by S_2 (50 cm × 25 cm) whereas the lowest biological yield ha^{-1} (16.15 t) was obtained from the plant spacing S_1 (60 cm × 25 cm). The result achieved from the present study was similar with the findings of Kunjir *et al*. (2007) and Zarapkar (2006).

Combined effect of fertilizer and spacing

Combined effect of fertilizer and spacing showed significant influence on biological yield ha^{-1} of baby corn (Table 4 and Appendix VII). It was found that the highest biological yield ha^{-1} (21.22 t) was obtained from the treatment combination of F_4S_3 which was statistically similar with the treatment combination of F_1S_3. The lowest biological yield ha^{-1} (13.80 t) was obtained from the treatment combination of F_3S_1 which was significantly different from other treatment combinations followed by F_2S_1 and F_3S_2.

4.3.5 Harvest index

Effect of fertilizer

Harvest index was significantly varied among the treatments due to different fertilizer levels (Table 4 and Appendix VII). Results indicated that the maximum harvest index (46.53%) was found from the treatment F_4 (20% higher than RDF) which was statistically identical with F_1 (RDF). The least harvest index (43.79%) was recorded from the treatment F_3 (40% less than

RDF) which was also statistically identical with F_2 (20% less than RDF). Zende (2006), Pinjari (2007) and Auwal *et al*. (2017) found similar result which supported the present study.

Effect of spacing

Harvest index was significantly affected by different plant spacing of baby corn (Table 4 and Appendix VII). Results showed that the maximum harvest index (46.38%) was found from the plant spacing S_3 (40 cm × 25 cm) followed by S_2 (50 cm × 25 cm) whereas the least harvest index (44.10%) was obtained from the plant spacing S_1 (60 cm × 25 cm). Shafi *et al*. (2012) found similar result which supported the present study.

Combined effect of fertilizer and spacing

Regarding combined effect of fertilizer and spacing, harvest index was significantly affected (Table 4 and Appendix VII). It was found that the maximum harvest index (47.60%) was found from the treatment combination of F_4S_3 which was statistically identical with F_1S_3 followed by the treatment combination of F_1S_2 and F_4S_2. The least harvest index (42.90%) was obtained from the treatment combination of F_3S_1 which was statistically identical with the treatment combination of F_2S_1 and F_3S_2.

Table 4: Number of cobs, fresh cob yield, stover yield, biological yield and harvest index as influenced by fertilizer rates and spacing

Treatments	Yield parameters				
	Number of cobs ('000' ha^{-1})	Fresh cob yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Effect of fertilizer					
F_1	229.09 b	9.03 a	10.45 a	19.47 a	46.38 a
F_2	217.01 c	7.66 b	9.49 b	17.15 b	44.66 b
F_3	214.14 c	6.52 c	8.37 c	14.89 c	43.79 b
F_4	235.23 a	9.26 a	10.64 a	19.90 a	46.53 a
$LSD_{0.05}$	4.752	0.524	0.542	1.023	1.114
CV(%)	12.053	7.288	9.314	10.542	8.786
Effect of spacing					
S_1	193.77 c	7.14 c	9.02 c	16.15 c	44.10 c
S_2	224.20 b	8.20 b	9.84 b	18.04 b	45.28 b
S_3	253.64 a	9.01 a	10.37 a	19.37 a	46.38 a
$LSD_{0.05}$	6.817	0.612	0.473	1.314	0.611
CV(%)	12.053	7.288	9.314	10.542	8.786
Combined effect of fertilizer and spacing					
F_1S_1	197.20 gh	8.55 d	10.24 c	18.79 d	45.50 c
F_1S_2	232.30 e	9.44 bc	10.72 ab	20.16 b	46.83 b
F_1S_3	257.70 b	9.80 ab	10.95 a	20.75 ab	47.23 a
F_2S_1	189.90 hi	6.40 f	8.40 f	14.80 g	43.24 e
F_2S_2	215.60 f	7.78 e	9.64 d	17.42 e	44.66 d
F_2S_3	245.40 c	8.80 d	10.44 bc	19.24 c	45.74 c
F_3S_1	186.30 i	5.92 g	7.88 g	13.80 h	42.90 e
F_3S_2	214.80 f	6.32 fg	8.36 f	14.68 g	43.05 e
F_3S_3	241.40 cd	7.32 e	8.96 e	16.28 f	44.96 d
F_4S_1	201.60 g	7.70 e	9.60 d	17.30 e	44.51 d
F_4S_2	234.10 de	9.26 c	10.62 b	19.88 bc	46.58 b
F_4S_3	270.00 a	10.10 a	11.12 a	21.22 a	47.60 a
$LSD_{0.05}$	8.557	0.4544	0.411	0.473	0.518
CV(%)	12.053	7.288	9.314	10.542	8.786

F_1 = Recommended doses of fertilizer (RDF), F_2 = 20% less than RDF, F_3 = 40% less than RDF, F_4 = 20% higher than RDF

S_1 = 60 cm × 25 cm, S_2 = 50 cm × 25 cm, S_3 = 40 cm × 25 cm

4.4 Economic analysis

Cost of production include materials and non-material input cost like land preparation, onion seed cost, fertilizers, irrigation, labour, interest on fixed capital of land (Leased land by ban loan basis) and miscellaneous cost. It was calculated from planting of seeds seed to harvesting of baby corn and was recorded per unit plot basis and converted it into cost per hectare (Table 5 and Appendix VIII). Price of baby corn was considered at market rate. The economic analysis is presented under the following headlines:

4.4.1 Gross income

The combination of different fertilizer and spacing showed variation on gross return (Table 5). Gross income was calculated on the basis of sale of baby corn's cob. The highest gross return (Tk. 303000) was obtained from F_4S_3 (20% higher than RDF with plant spacing of 40 cm × 25 cm) treatment combination followed by F_1S_3 and the lowest gross return (Tk. 177600) obtained from F_3S_1 (40% less than RDF with plant spacing of 60 cm × 25 cm) treatment combination followed by F_3S_2 and F_2S_1.

4.4.2 Net return

Net return was found different among the treatments influenced by treatment combination of different fertilizer and spacing (Table 5). The highest net return (Tk. 137759) was found from F_4S_3 (20% higher than RDF with plant spacing of 40 cm × 25 cm) treatment combination followed by F_1S_3 and lowest net return (Tk. 15419) obtained from F_3S_1 (40% less than RDF with plant spacing of 60 cm × 25 cm) followed by F_3S_2 and F_2S_1.

4.4.3 Benefit cost ratio (BCR)

Different BCR was obtained from the different treatment combinations of fertilizer and spacing (Table 5). It was found that the benefit cost ratio (BCR) was highest (1.83) from the treatment combination of F_4S_3 (20% higher than RDF with plant spacing of 40 cm × 25 cm) followed by F_1S_3 and F_1S_2. The lowest BCR (1.10) was obtained from F_3S_1 (40% less than RDF with plant spacing of 60 cm × 25 cm) followed by F_3S_2 and F_2S_1. From economic point of view, from the above results, it was evident the combination of F_4S_3 (20% higher than RDF with plant spacing of 40 cm × 25 cm) was more profitable than rest of the treatment combinations.

Table 5. Cost and return analysis of baby corn production

Treatments	Total cost of production (Tk. ha^{-1})	Cob yield (t ha^{-1})	Gross return (Tk. ha^{-1})	Net return (Tk. ha^{-1})	BCR
F_1S_1	162819	8.55	256500	93682	1.58
F_1S_2	163871	9.44	283200	119330	1.73
F_1S_3	164923	9.80	294000	129078	1.78
F_2S_1	162500	6.40	192000	29500	1.18
F_2S_2	163552	7.78	233400	69848	1.43
F_2S_3	164604	8.80	264000	99396	1.60
F_3S_1	162182	5.92	177600	15419	1.10
F_3S_2	163234	6.32	189600	26367	1.16
F_3S_3	164286	7.32	219600	55315	1.34
F_4S_1	165137	7.70	231000	65863	1.40
F_4S_2	165189	9.26	277800	112611	1.68
F_4S_3	165241	10.10	303000	137759	1.83

F_1 = Recommended doses of fertilizer (RDF), F_2 = 20% less than RDF, F_3 = 40% less than RDF, F_4 = 20% higher than RDF

S_1 = 60 cm × 25 cm, S_2 = 50 cm × 25 cm, S_3 = 40 cm × 25 cm

CHAPTER V

SUMMARY AND CONCLUSION AND RECOMMENDATIONS

Summary

The experiment was conducted at Agronomy research farm of Sher-e-Bangla Agricultural University located in Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh. The experiment was executed during the period of March to June, 2017. The objective of the experiment was to determine the influence of fertilizer and spacing on the yield performance of baby corn. Hybrid baby corn was used as a test crop for the study. The experiment was consisted of two factors: Factor A - four levels of fertilizer doses *viz*. F_1 = Recommended doses of fertilizer (RDF), F_2 = 20% less than RDF, F_3 = 40% less than RDF and F_4 = 20% higher than RDF and Factor B - three levels of plant spacing *viz*. S_1 = 60 cm × 25 cm, S_2 = 50 cm × 25 cm and S_3 = 40 cm × 25 cm. The experiment was laid out in a split-plot design with three replications having fertilizer doses in the main plot considered as Factor-A and plant spacing in the sub-plot considered as Factor-B.

Fertilizer doses effect had significant influence on different growth, yield and yield contributing parameters. Considering growth parameters, the highest plant height (120.72 cm), number of leaves plant^{-1} (13.93) and dry weight plant^{-1} (66.88 g) were found in the treatment F_4 (20% higher than RDF). Regarding yield and yield contributing parameters, the highest number of cobs plant^{-1} (2.69), number of rows cob^{-1} (13.78), cob length (17.76 cm), base diameter of cob (4.60 cm), top diameter of cob (2.25 cm), number of cobs ha^{-1} (235.23 thousand), fresh cob yield ha^{-1} (9.26 t), stover yield ha^{-1} (10.46 t), biological yield ha^{-1} (19.90 t) and harvest index (46.53%) were obtained from the treatment F_4 (20% higher than RDF). But the highest cob weight plant^{-1} with husk (106.85 g) and cob weight plant^{-1} without husk (62.98 g) were found from the treatment F_1 (RDF). Again, the lowest plant height (101.84 cm), number of leaves plant^{-1} (11.44) and dry weight plant^{-1} (49.26 g) were recorded from the treatment F_3 (40% less than RDF). The lowest number of cobs plant^{-1} (2.45), number of rows cob^{-1} (12.52), cob length (15.93 cm), cob weight plant^{-1} with husk (74.90 g), cob weight plant^{-1} without husk (39.99 g), base diameter of cob (4.11 cm), top diameter of cob (2.07 cm), number of cobs ha^{-1} (214.14 thousand), fresh cob yield ha^{-1} (6.52 t), stover yield ha^{-1} (8.37 t), Biological yield ha^{-1} (14.89 t) and harvest index (43.79%) were also recorded from the treatment F_3 (40% less than RDF).

Different plant spacing had significant influence on different growth, yield and yield contributing parameters of baby corn. Regarding growth parameters, the highest plant height (118.79 cm) was found from the plant spacing S_3 (40 cm × 25 cm) but the highest number of leaves plant^{-1} (13.31) and dry weight plant^{-1} (65.51 g) were found from the plant spacing S_1 (60 cm × 25 cm). In case of yield contributing parameters, the highest number of cobs plant^{-1} (2.65), number of rows cob^{-1} (13.74), cob length (17.60 cm), cob weight plant^{-1} with husk (97.77 g), cob weight plant^{-1} without husk (55.34 g), base diameter of cob (4.58 cm) and top diameter of cob (2.23 cm) were also found from the plant spacing S_1 (60 cm × 25 cm). But the highest number of cobs ha^{-1} (253.64 thousand), fresh cob yield ha^{-1} (9.01 t), stover yield ha^{-1} (10.37 t), biological yield ha^{-1} (19.37 t) and harvest index (46.38%) were obtained from the plant spacing S_3 (40 cm × 25 cm). Conversely, the lowest plant height (105.41 cm) was obtained from the plant spacing S_1 (60 cm × 25 cm) but the lowest number of leaves plant^{-1} (11.99) and dry weight plant^{-1} (51.12 g) were obtained from the plant spacing S_3 (40 cm × 25 cm). The lowest number of cobs plant^{-1} (2.48), number of rows cob^{-1} (12.63), cob length (16.20 cm), cob weight plant^{-1} with husk (16.20 cm), cob weight plant^{-1} without husk (47.75 g), base diameter of cob (4.20 cm) and top diameter of cob (2.11 cm) were also obtained from the plant spacing S_3 (40 cm × 25 cm). But the lowest number of cobs ha^{-1} (193.77 thousand), fresh cob yield ha^{-1} (7.14 t), stover yield ha^{-1} (9.02 t), biological yield ha^{-1} (16.15 t) and harvest index (44.10%) were obtained from the plant spacing S_1 (60 cm × 25 cm).

Combined effect of fertilizer and spacing showed significant influence on all the studied parameters. Regarding growth parameters, the highest plant height (126.60 cm) was found from the treatment combination of F_4S_3 but the highest number of leaves plant^{-1} (14.48) was found from the treatment combination of F_4S_1 and highest dry weight plant^{-1} (72.80 g) were achieved from the treatment combination of F_4S_1.Considering yield contributing parameters and yield, the highest number of cobs plant^{-1} (2.76), number of rows cob^{-1} (14.40), cob length (18.36 cm), the base diameter of cob (4.80 cm) and top diameter of cob (2.30 cm) were achieved from the treatment combination of F_4S_1. But the highest cob weight plant^{-1} with husk (117.00 g) and cob weight plant^{-1} without husk (71.50 g) were obtained from the treatment combination of F_1S_1. Again, the highest number of cobs ha^{-1} (270.00 thousand), fresh cob yield ha^{-1} (10.10 t), stover yield ha^{-1} (11.12 t), biological yield ha^{-1} (21.22 t) and harvest index (47.60%) were found from the treatment combination of F_4S_3. The lowest plant height (95.28 cm) was obtained from the treatment combination of F_3S_1 where the lowest number of leaves plant^{-1} (10.67) and dry weight plant^{-1} (43.66 g) were obtained from the treatment combination of F_3S_3. The lowest number of cobs plant^{-1} (2.36), number of rows cob^{-1} (12.25), cob length (15.40 cm), cob weight plant^{-1} with husk (71.57 g), cob weight plant^{-1} without husk (37.55 g), base diameter of cob (3.92 cm) and top diameter of cob (2.03 cm) were also obtained from the treatment combination of F_3S_3. But the lowest number of cobs ha^{-1} (186.30 thousand), fresh cob yield ha^{-1} (5.92 t), stover yield ha^{-1} (7.88 t), biological yield ha^{-1} (13.80 t) and harvest index (42.90%) were obtained from the treatment combination of F_3S_1.

Considering economic analysis, it was found that the highest gross return (Tk. 303000), net return (Tk. 137759) and BCR (1.83) were obtained from the treatment combination of F_4S_3 (20% higher than RDF with plant spacing of 40 cm × 25 cm) where the lowest gross return (Tk. 177600), net return (Tk. 15419) and BCR (1.10) were obtained from the treatment combination of F_3S_1.

Conclusion:

Based on the results of the present study, the following conclusions may be drawn-

1. The fertilizer dose F_4 (20% higher than RDF) showed maximum yield and yield parameters of baby corn compared to other fertilizer doses treatments.
2. The plant spacing, S_3 (40 cm × 25 cm) showed best yield returns compared to other studied plant spacing treatments
3. The treatment combination of F_4 (20% higher than RDF) and S_3 (40 cm × 25 cm) i.e. F_4S_3 performed the best results in terms of fresh cob yield of baby corn compared to other treatment combinations. Gross return and BCR also found the highest with the same treatment combination.

So, the treatment combination of F_4 (20% higher than RDF) and S_3 (40 cm × 25 cm) can be considered as the superior treatment combination compared to other treatment combinations under the present study.

Recommendations

The experiment was conducted only one growing season. So, considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performances
2. More doses of fertilizer may be included in the future program
3. Some other plant spacings may be included in the further program.

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APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location

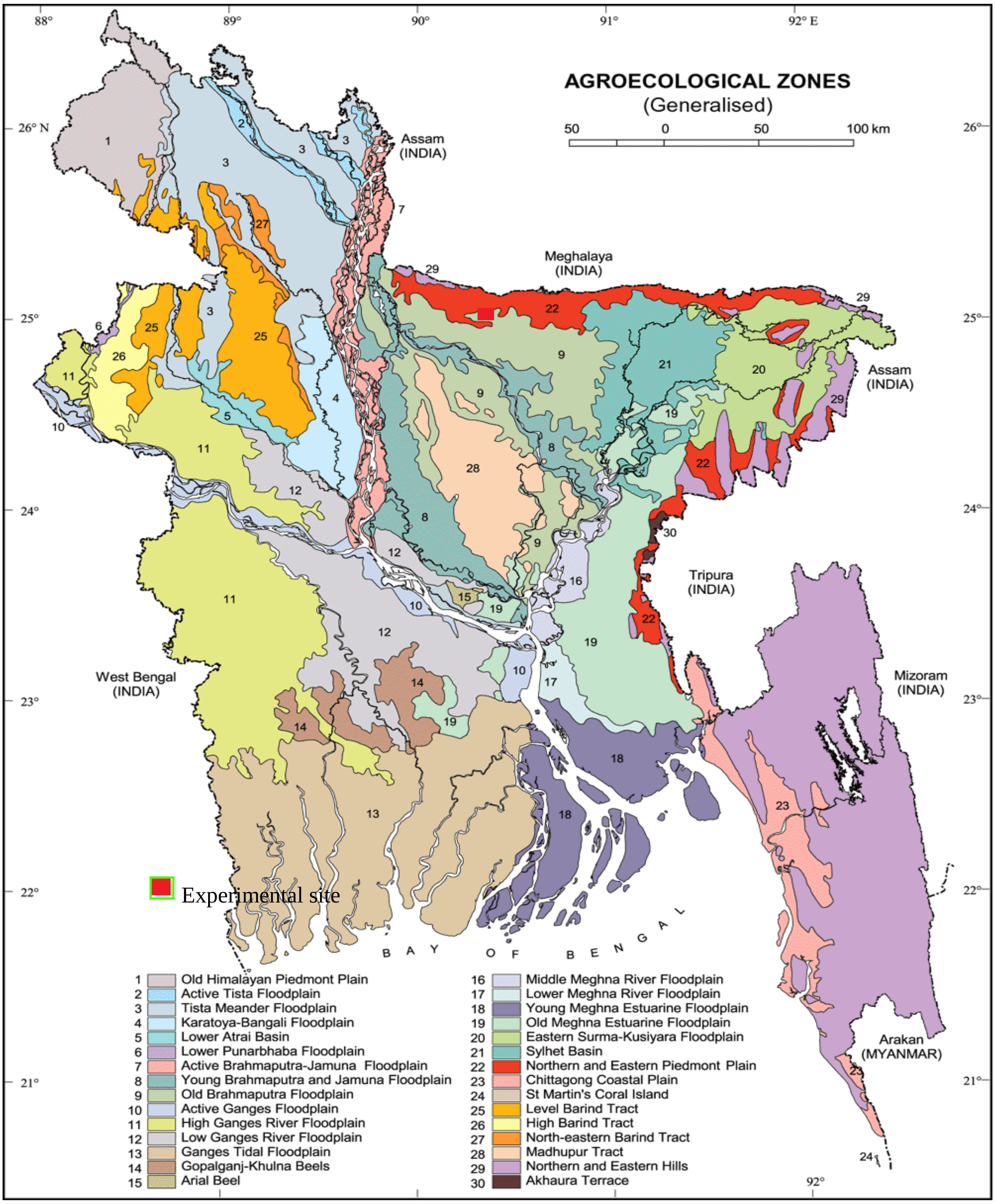

Fig. 21. Experimental site

Appendix II. Monthly records of air temperature, relative humidity, rainfall and sunshine hours during the period from March to June 2017

Month and year	RH (%)	Air temperature (C)			Rainfall	Sunshine
		Max.	*Min.*	*Mean*	(mm)	(Hours)
March, 2017	72.70	33.60	29.50	31.55	3.00	227.00
April, 2017	68.50	33.50	25.90	29.70	1.00	194.10
May, 2017	61.00	34.90	27.00	30.95	2.00	221.50
June, 2017	72.65	35.60	29.30	32.45	2.50	229.40

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix III. Characteristics of experimental field soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Agronomy Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not Applicable

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

Characteristics	**Value**
Partical size analysis % Sand	27
%Silt	43
% Clay	30
Textural class	Silty Clay Loam (ISSS)
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.1
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix IV: Growth paarameters as plant height, number of leaves plant^{-1} and dry weight plant^{-1} influenced by different fertilizer rates and spacing

Source of variation	Degrees of freedom	Mean square of growth parameters at harvest		
		Plant height (cm)	Number of leaves plant^{-1}	Dry weight plant^{-1} (g)
Replication	2	3.051	0.596	1.592
Factor A	3	28.614*	12.389	16.217
Error	6	7.652	3.189	4.516
Factor B	2	17.736*	16.514*	18.633*
AB	6	48.381*	14.162*	22.148*
Error	16	6.536	2.025	3.068

Appendix V: Yield contributing parameters as number of cobs plant^{-1}, number of rows cob^{-1} and cob lengthinfluenced by different fertilizer rates and spacing

Source of variation	Degrees of freedom	Mean square of yield contributing parameters		
		Number of cobs plant^{-1}	Number of rows cob^{-1}	Cob length (cm)
Replication	2	0.003	0.424	0.649
Factor A	3	1.362**	4.568*	8.163*
Error	6	0.368	1.852	3.687
Factor B	2	2.032*	8.338**	10.646**
AB	6	1.354*	6.715*	10.384*
Error	16	0.017	1.267	2.016

Appendix VI: Yield contributing parameters as cob weight plant^{-1} with husk, cob weight plant^{-1} without huskand diameter of cob influenced by different fertilizer rates and spacing

Source of variation	Degrees of freedom	Mean square of yield contributing parameters			
		Cob weight plant^{-1} with husk (g)	Cob weight plant^{-1} without husk (g)	Base diameter of cob (cm)	Top diameter of cob (cm)
Replication	2	3.028	2.314	0.003	0.001
Factor A	3	24.345*	16.221*	1.136*	1.012**
Error	6	10.476	9.109	0.147	0.131
Factor B	2	28.83*	31.647*	2.019*	1.082*
AB	6	45.742*	28.533**	0.589**	0.458**
Error	16	11.061	13.022	0.012	0.008

Appendix VII: Yield parameters as number of cobs ha^{-1} and fresh cob yield ha^{-1} influenced by different fertilizer rates and spacing

Source of variation	Degrees of freedom	Mean square of yield parameters				
		Number of cobs ('000' ha^{-1})	Fresh cob yield ^{1} (t ha^{-})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Replication	2	4.092	0.107	0.203	1.024	0.704
Factor A	3	114.38*	4.345*	6.275*	6.885*	3.613*
Error	6	14.891	1.476	1.883	2.013	2.636
Factor B	2	182.93*	6.83*	7.796*	6.754**	9.384*
AB	6	305.38*	5.742*	9.238*	10.832*	7.938*
Error	16	10.361	0.461	1.426	1.577	1.063

Appendix VIII: Cost of production of baby corn per hectare

A. Input cost (Tk. ha^{-1})

Treatment	Cultivation of land with power tiller	Baby corn seed	Pesticides	Irrigation	Urea	Fertilizer				No. of labour for			Cost of seed sowing, intercultural operation and harvesting @ Tk. 400/ day/lobor	Subtotal (A)
						TSP	MP	Gypsum	$ZnSO_4$	Seed sowing	Intercultural operation	Harvesting and threshing		
F_1S_1	7000	2200	4000	3000	4800	3750	1600	1800	300	14	6	10	12000	40450
F_1S_2	7000	2600	4000	3000	4800	3750	1600	1800	300	14	6	10	12000	40850
F_1S_3	7000	3000	4000	3000	4800	3750	1600	1800	300	14	6	10	12000	41250
F_2S_1	7000	2200	4000	3000	3840	3000	1280	1440	240	14	6	10	12000	38000
F_2S_2	7000	2600	4000	3000	3840	3000	1280	1440	240	14	6	10	12000	38400
F_2S_3	7000	3000	4000	3000	3840	3000	1280	1440	240	14	6	10	12000	38800
F_3S_1	7000	2200	4000	3000	2880	2250	960	1080	180	14	6	10	12000	35550
F_3S_2	7000	2600	4000	3000	2880	2250	960	1080	180	14	6	10	12000	35950
F_3S_3	7000	3000	4000	3000	2880	2250	960	1080	180	14	6	10	12000	36350
F_4S_1	7000	2200	4000	3000	5760	4500	1920	2160	360	14	6	10	12000	42900
F_4S_2	7000	2600	4000	3000	5760	4500	1920	2160	360	14	6	10	12000	43300
F_4S_3	7000	3000	4000	3000	5760	4500	1920	2160	360	14	6	10	12000	43700

F_1 = Recommended doses of fertilizer (RDF), F_2 = 20% less than RDF, F_3 = 40% less than RDF, F_4 = 20% higher than RDF

S_1 = 60 cm × 25 cm, S_2 = 50 cm × 25 cm, S_3 = 40 cm × 25 cm

B. Overhead cost (Tk. ha^{-1}), Cost of production (Tk. ha^{-1}), Gross return (Tk. ha^{-1}), Net return (Tk. ha^{-1}) and BCR

Treatments	Overhead cost (Tk. ha^{-1})				Subtotal (A)	Total cost of production (A+B)	Cob yield ha^{-1} (ton)	Gross return (Tk. ha^{-1})	Net return (Tk. ha^{-1})	BCR
	Cost of leased land for 6 months (8% of value of land Tk. 10,00,000/-	Miscellaneous cost (Tk. 5% of the input cost)	Interest on running capital for 6 month (8% of cost year-1)	Subtotal (B)						
F_1S_1	40000	2022.5	3236	45258.5	117560	162819	8.55	256500	93682	1.58
F_1S_2	40000	2042.5	3268	45310.5	118560	163871	9.44	283200	119330	1.73
F_1S_3	40000	2062.5	3300	45362.5	119560	164923	9.8	294000	129078	1.78
F_2S_1	40000	1900	3040	44940	117560	162500	6.4	192000	29500	1.18
F_2S_2	40000	1920	3072	44992	118560	163552	7.78	233400	69848	1.43
F_2S_3	40000	1940	3104	45044	119560	164604	8.8	264000	99396	1.60
F_3S_1	40000	1777.5	2844	44621.5	117560	162182	5.92	177600	15419	1.10
F_3S_2	40000	1797.5	2876	44673.5	118560	163234	6.32	189600	26367	1.16
F_3S_3	40000	1817.5	2908	44725.5	119560	164286	7.32	219600	55315	1.34
F_4S_1	40000	2145	3432	45577	119560	165137	7.7	231000	65863	1.40
F_4S_2	40000	2165	3464	45629	119560	165189	9.26	277800	112611	1.68
F_4S_3	40000	2185	3496	45681	119560	165241	10.1	303000	137759	1.83

Cost of baby corn per kg = Tk. 30.00

F_1 = Recommended doses of fertilizer (RDF), F_2 = 20% less than RDF, F_3 = 40% less than RDF, F_4 = 20% higher than RDF

S_1 = 60 cm × 25 cm, S_2 = 50 cm × 25 cm, S_3 = 40 cm × 25 cm