EFFECT OF PLANTING ARRANGEMENTS ON THE PERFORMANCE OF WINTER MAIZE VARIETIES

A THESIS

BY

MD. MONIRUL ISLAM
EXAMINATION ROLL NO. MS 050812

A thesis submitted to Agrotechnology Discipline in partial fulfillment of the requirements for the Degree of Master of Science in Agronomy

AGROTECHNOLOGY DISCIPLINE
KHULNA UNIVERSITY
KHULNA, BANGLADESH

MARCH, 2008

EFFECT OF PLANTING ARRANGEMENTS ON THE PERFORMANCE OF WINTER MAIZE VARIETIES

A THESIS

BY

EXAMINATION ROLL NO. MS 050812

Approved as to style and content

By

....

Dr. Md. Abdul Mannan (Supervisor)

Dr. Md. Yasin Ali (Co-supervisor)

....

Prof. Dr. Md. Yasin Ali
Chairman
Examination Committee
and
Head,
Agrotechnology Discipline
Khulna University
Khulna,

DEDICATED TO MY

SUPERVISORS

ACKNOWLEDGEMENT

All praise, gratitude and thanks are due to the Supreme ruler of the Universe the "Almighty Allah" who allowed the author to complete the research work and the thesis.

The author wishes to express his unfettered gratification, sincere appreciation and indebtedness to his honorable research supervisor Dr. Md. Abdul Mannan, Associate Professor, Agrotechnology Discipline, Khulna University, Khulna, for his scholastic supervision, valuable suggestions and inspiration, constructive criticism, helpful comments and continuous supervision throughout the study.

The author also takes the opportunity to express his deepest sense of gratitude and cordial esteem to his co-supervisor Dr. Md. Yasin Ali, Professor and Head, Agrotechnology Discipline, Khulna University, Khulna, for his constant and untiring help and technical suggestion throughout the study period.

The author also gives his special thanks to Dr. Sanjoy Kumar Adhikary, Professor, Agrotechnology Discipline, Khulna University, Khulna for his criticism and constructive advice. Cordial thanks are also due to all the teachers of Agrotechnology Discipline, Khulna University, Khulna for their help and co-operation.

The author expresses his sincere appreciation, indebtedness and gratitude to Mr. Md. Minul Islam, Scientific Officer, Pathology Division, Bangladesh Agriculture Research Institute (BARI), Joydebpur, Gazipur, for his co-ordination for completion of the research work. Thanks are also due to Md.

Farukur Rahman, M.S. student, Agrotechnology Discipline, Khulna University Khulna, and Himu, Student of Agriculture Economic, Bangladesh Agricultural University, Mymensingh.

Finally, the author wants to express his gratefulness to his dearest parents, sisters and friends specially Sweety Acharja, Mehedi Hasan, Limu and all of his classmates and all the students of Agrotechnology Discipline, Khulna University, Khulna, for their blessing and logistic supports during the entire period of the study.

March, 2008 **The author**

ABSTRACT

An experiment was conducted at the Agrotechnology Field Laboratory, Khulna University, Khulna, during the period from November 2006 to April 2007 to study the effect of variety and planting arrangements on the performance of winter maize varieties. The study included four maize varieties, namely BARI maize3, BARI maize5, Shuvra and Barnali, and three planting arrangements viz; one plant hill^{-1}(20 cm apart), two plants hill^{-1} (40 cm apart) and three plants hill^{-1}(60 cm apart). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Results showed that both variety and planting arrangement exerted significant influence on most of the plant characters studied. The highest grain yield (7.92 t ha^{-1}), the maximum cobs plant^{-1} (1.09), fertile cobs plot^{-1} (52.24) and grains cob^{-1} (393.16) was produced by BARI maize5. On the other hand, the lowest grain yield (4.71 t ha^{-1}), minimum cobs plant^{-1} (1.02) and grains cob^{-1} (355.15) was obtained from Barnali. The present study revealed that one plant hill^{-1} showed the better performance. The highest grain yield (6.68 t ha^{-1}), circumference of cob (14.47 cm), maximum rows of grains cob-^{1}(12.96), heaviest cob (209.46 g), maximum cobs plant^{-1} (1.07), fertile cobs plot^{-1} (51.94) and grains cob^{-1} (386.50) was produced by one plant hill^{-1}. Poor performance was showed by three plants hill^{-1}, which produced the lowest grain yield (5.94 t ha^{-1}), circumference of cob (13.89 cm), minimum rows of grains cob^{-1}(12.77), lightest cob (198.94 g), minimum cobs plant^{-1} (1.03), fertile cobs plot^{-1} (49.23) and grains cob^{-1} (361.33). Three plants hill^{-1} gave the highest plant height (241.64 cm), whereas lowest plant height (234.85 cm) was produced by the one plant hill^{-1}. BARI maize5 with one plant hill^{-1} showed the better performance, which gave the highest grain yield (8.39 t ha^{-1}), circumference of cob (14.67 cm), heaviest cob (230.50 g), maximum cobs plant^{-1} (1.13), cobs plot^{-1} (54.20) and grains cob^{-1} (416.66). Poor performance showed by Barnali with three pants hill^{-1}, which produced the lowest grain yield (4.33 t ha^{-1}), lowest circumference of cob (13.27 cm), lightest cob (181.77 g), minimum cobs plant^{-1} (1.00), lowest cobs plot^{-1} (48.43) and grains cob^{-1} (350.07). It was observed from the results that BARImaize5 with one plant hill^{-1} found to be the best combination for the maximum growth and yield.

CONTENTS

		Page
	ACKNOWLEDGEMENT	i
	ABSTRACT	iii
	LIST OF TABLES	vii
	LIST OF FIGURES	viii
	LIST OF APPENDICES	ix
Chapter		
1	**INTRODUCTION**	1
2	**REVIEW OF LITERATURE**	4
	2.1 Effect of variety	4
	2.1.1 Effect on plant characters	4
	2.1.2 Effect on grain yield	7
	2.2 Effect of planting arrangement	10
	2.2.1 Effect on plant characters	10
	2.2.2 Effect on grain yield	13
3	**MATERIALS AND METHODS**	18
	3.1 Experimental site	18
	3.2 Climate	18
	3.3 Experimental materials	18
	3.4 Experimental treatments	19
	3.5 Design of the experiment	20
	3.6 Layout of the experiment	20

CONTENTS (Continued)

Chapter		Page
	3.7 Soil sampling	20
	3.8 Land preparation	21
	3.9 Manuring and fertilization	21
	3.10 Seed sowing	21
	3.11 Thinning and gap filling	22
	3.12 Weeding	22
	3.13 Irrigation	22
	3.14 Earthing up	22
	3.15 Crop protection	22
	3.16 General observation	23
	3.17 Harvesting and processing	23
	3.18 Parameters studied	23
	3.19 Methods of data collection	24
	3.20 Statistical analysis	25
4	**RESULTS AND DISCUSSION**	26
	4.1 Plant height	26
	4.2 Length of cob	27
	4.3 Circumference of cob	28
	4.4 Rows of grains cob^{-1}	29
	4.5 Weight of individual cob	30
	4.6 Number of cobs plant^{-1}	31
	4.7 Number of cobs plot^{-1}	32
	4.8 Number of fertile cobs plot^{-1}	32
	4.9 Number of grains cob^{-1}	33

CONTENTS (Continued) **Page**

Chapter

4.10 Weight of 100-grains 34

4.11 Grain yield 35

4.12 Stalk yield 36

4.13 Biological yield 37

4.14 Harvest index 38

4.15 Functional relationship between grain yield and yield contributing characters

5 SUMMARY AND CONCLUSION 47

REFERENCES 50

APPENDICES 63

LIST OF TABLES

Table		Page
1	Effect of variety on growth characters of maize	39
2	Effect of planting arrangement on growth characters of maize	40
3	Interaction effect of variety and planting arrangement on growth characters of maize	41
4	Effect of variety on yield contributing characters and yield of maize	42
5	Effect of planting arrangement on yield contributing characters and yield of maize	43
6	Interaction effect of variety and planting arrangement on yield contributing characters and yield of maize	44

LIST OF FIGURES

Figure		Page
1	Functional relationship between grain yield (t ha^{-1}) and cobs $plant^{-1}$ in maize	45
2	Functional relationship between grain yield (t ha^{-1}) and grains cob^{-1} in maize	46
3	Functional relationship between grain yield (t ha^{-1}) and weight of 100 grains in maize	47
4	Functional relationship between grain yield (t ha^{-1}) and biological yield (t ha^{-1}) in maize	48

LIST OF APPENDICES

Appendix		Page
I	Physical and chemical characteristics of soil of the experimental plot (0- 15 cm depth)	63
II	Monthly total rainfall, temperature and relative humidity during the growing period of maize from November 2006 to March 2007	64
		65
III	Analysis of variance of the data on growth characters of maize	66
IV	Analysis of variance of the data on yield and yield contributing characters of maize	67
V	Layout of the experiment	68

CHAPTER 1
INTRODUCTION

CHAPTER 1

INTRODUCTION

Bangladesh is a densely populated country; the food demand will continue to rise with the ever-increasing expansion of human population. Although the agriculture of Bangladesh is crop- based, the crop production is not sufficient to meet up the food demand. To meet up the present food demand, efforts should be taken to increase total food production by bringing more area under cultivation and by increasing the yield per unit area. Since the cultivable land area is limited, horizontal expansion of cropping is not possible. Therefore, yield per unit area is to be increased through the adoption of crops having high yielding potentials as well as by following appropriate cultural practices.

Maize (*Zea mays* L.) is a multipurpose crop. Every part of the plant and its products are used in many forms. Its grains have high nutritive value containing 66.2% starch, 11.1% protein, 7-12% oil and 1.5% minerals. Besides, it contains 90 mg carotene, 1.8 mg niacin, 0.8 mg thiamin and 0.1 mg riboflavin per 100 g grains (Chowdhury and Islam, 1993). As food, it can be consumed directly as green cob, roasted cob or popped grain and flour satu. It is also used for manufacturing starch, corn flakes, alcohol, salad, oil, soap, varnishes, paints and similar products (Thakur, 1980). Starch is used in making pudding and in the manufacture of candies. Cake made of corn flour is the main food in Mexico, Chili, Equador and Guatemala (Chowdhury and Islam, 1993). The by-product obtained after oil extraction is a cake which is valued highly as livestock feed. Sheaths of cobs are used to make the paper of improved quality cigarettes (Chowdhury and Islam, 1993). In addition to all these uses, it is one of the main fodder crops for live stock.

Maize is one of the most efficient crops which can give high biological yield as well as grain yield in relatively short period of time due to its unique photosynthetic mechanism (Hatch and Slack, 1966). The position of this crop within the cereals of the world is after wheat and rice considering total area and production, but quantitatively, it occupies the first position for its yield. The average yield of maize in the world is 4.18 t ha^{-1} as compared to 3.8 and 2.7 t ha^{-1} for rice and wheat, respectively (FAO, 1997).

In recent years, the cultivation of maize has been emphasized in Bangladesh. It is now becoming an important cereal crop for its high productivity and diversified uses (Islam and Kaul, 1986). Maize is grown as grains as well as fodder crop in many parts of Bangladesh. In 2000-2001 maize was grown on about 130000 acres of land which produced 316000 metric tons of grains in Bangladesh (BBS, 2002).

With fast population growth food production and supply must be increased as a top priority. Expansion of maize cultivation can solve the problem to a great extent because of its higher productivity per unit area than wheat and rice (Elias *et al.,* 1986). Maize can be grown in our country throughout the year because of suitable climate for its growth and development.

Bangladesh Agricultural Research Institute (BARI) released some varieties of maize, namely, Barnali, Khoibhutta, Mohor and Shuvra by the year 1991. In the recent years BARI released three varieties viz; BARI maize2, BARI maize3, and BARI maize5. These varieties are cultivating in our country by the farmers. But the productions of all of these varieties are not same. In Bangladesh, little work has so far been done to find out the performance of these varieties in different situations and locations in spite of the fact that the government is aiming to popularize maize as a grain crop to attain selfsufficiency in grain production. So, it is very important to study the varieties in different locations of the country to evaluate their performance.

In Khulna region of Bangladesh, maize cultivation is not popular. But the climatic condition and soil of the region are favorable for cultivation of this crop successfully. So it is very important to popularize it in this region.

Crop yield depends on many factors such as light, water and nutrients and soil properties. The availability of these inputs for the plant may be influenced by variety, planting arrangement and cultural practices. Hence, adjustment of planting arrangement in the field for maize varieties is therefore, more important to ensure maximum maize production. According to BARI (1989), there are two ways of planting arrangement of maize – (1) 50 cm apart with 2 plants $hill^{-1}$, and (2) 25 cm apart with 1 plant $hill^{-1}$. Although plant population from these two arrangements will be the same, it is not clear whether yield will also be the same from these arrangements because the former is likely to suffer from intra hill competition, but not the later. Keeping all this in view an experiment was carried out to study the effect of variety and planting arrangements on the performance of winter maize varieties in Khulna Region. The present study has been undertaken with the following objectives:

I) to study the performance of winter maize varieties and

II) to identify the suitable or appropriate planting arrangement for higher yield of the varieties under study.

CHAPETR 2
REVIEW OF LITERATURE

CHAPTER 2

REVIEW OF LITERATURE

Maize is one of the most important crops next to wheat and rice in the world. It drew much attention to the researchers for its high yielding potentiality and multipurpose uses. Although this is well adapted under the agro climatic conditions of Bangladesh but this crop is not widely cultivated. To meet up the present food demand of ever increasing human population this crop may be provide a partial solution as production per unit area is high enough compared to rice and wheat.

Works done by various investigators at home and abroad included the effect of variety, spacing, plant population and other agronomic and cultural practices on grain yield and so on which are the result of many morphological and physiological events. Variety and planting arrangement are two important factors which have received attention from researchers as they may influence grain yield in maize. A brief review of the literatures related to the present study has been presented here with the view that it may provide useful information.

2.1 Effect of variety

2.1.1 Effect on plant characters

Variety may have variable effect on different plant character of maize. Chowdhury and Islam (1993) reported that plant heights of varieties Barnali, Khoibhutta, Mohor and Shuvra are 200, 160, 210 and 175 cm, respectively. In another report, heights of Barnali, Mohor and Shuvra were found to be 201, 205, and 180 cm in rabi season, respectively (SCA, 1992). Barnali produced significantly taller plants than Khoibhutta as reported by Annonyumous (1988). Alam and Quasem (1987) found that plant height of some exotic varieties ranged from 135 to 150 cm as compared to local check

Barnali. Onn (1988) observed that plant height to be significantly correlated with cultivar.

Akhtar and Mitra (1990) conducted an experiment with CIMMYT entries and one local check and found that plant height was significantly different among the entries. The exotic entry Rattary Arnold(1)8149 was the shortest (111 cm) among al the entries including local check Barnali (168 cm). In another experiment with 6 selected exotic composites and the same check variety Barnali, Chowdhury *et al.* (1989) observed that all the composites were shorter than Barnali (193 cm).

Singh *et al.* (1991) conducted an experiment with varieties Ganga5 and HLL and found that Ganga5 was significantly superior to HLL with regard to growth and yield which was due to cob length. In an experiment with 5 maize cultivars (R2, Ganga5, Ganga11, HH216 and D765), Paradkar and Sharma (1993) found that Ganga11 gave more cob length followed by Ganga5 and D765.

Weight cob^{-1} may also be influenced by variety. Kamal *et al.* (1994) reported that higher yielding varieties had higher weight cob^{-1}. Average cob weight of Barnali was found to be heavier (133.6 g) than that of Khoibhutta (101.8 g) (Annonymous, 1988).

Effect of variety on cob plant^{-1}, number of rows of grains cob^{-1}, number of grains row^{-1} and number of grains cob^{-1} were studied by different workers. BARI (1990) reported that cv. Barnali gave more cobs plant^{-1} than Khoibhutta. Paradkar and Sharma (1993) observed that out of 5 maize varieties (R2, Ganga5, Ganga11, HH216 and D765), Ganga11 gave increased grains rows^{-1} cob^{-1}. Kamen (1983) observed that early maturity hybrids had fewer grain rows^{-1} cob^{-1} than late maturity hybrids. Grains row^{-1} may differ among the varieties. Singh *et al*. (1991) observed more grains row^{-1} in Ganga5 than in HLL.

In an experiment with 5 different cultivars, Quayyum and Raquibullah (1986) observed that the number of grains cob^{-1} differed among the varieties and the variety Pozarica 7728 and Alajuela 7725 produced increased number of grains cob^{-1}. Khoibhutta produced significantly higher (432.5) number of grains cob^{-1} than Barnali (343.5) as reported by Annonymous (1988). On the other hand, Khoibhutta produced the highest number of grains cob^{-1} when compared with variety Pirsabak8146, Lamaquina7827 and Guaira8045 (Annonymous 1987).

Variety may have variable effect on weight of grains cob^{-1} plant^{-1} and Weight of 100-grains. BARI (1990) reported that Barnali produced increased weight of grains cob^{-1} and 100 grain weight. Singh *et al.* (1991) reported that Ganga5 was significantly superior to HLL with regard to 100 grain weight. Quayyum and Raquibullah (1986) conducted an experiment with 5 maize cultivars and found that the weight of 100 grains differed among the varieties and Pozarica7728 and Alajuela7725 produced increased 100-grain weight and also reported that the variety which produced higher yield had also higher 100-seed weight.

Pande *et al.* (1971) observed that 100 seed weight was positively correlated with grain yield. Krisnamurthy *et al*. (1977) found highest 100 seed weight in Vikram (28.8 g) and lowest in Vijoy (23.2 g). SCA (1992) reported that 100-seed weight of Barnali, Khoibhutta and Mohor were 27.6, 14.4 and 29.0 g, respectively. Chowdhury and Islam (1993) also reported the similar results.

2.1.2 Effect on grain yield

Bangladesh Agricultural Research Institute (BARI) developed some varieties of maize for cultivation in Bangladesh. These varieties were recommended during 1986 to 1991 (SCA 1992, Chowdhury and Islam, 1993). They possessed various desirable characteristics like high yield and resistant to disease and insects. Grain yield varied with variety as reported by many investigators.

Different workers studied the effect of variety on grain yield of maize. Shah *et al.* (1981) observed that Savar1 produced highest grain yield (5.83 t ha^{-1}) which was closely followed by JC1 and Opaque2 but the yield was lowest in Sadaf. Begum and Roy (1987) reported that yield variations among the varieties were due to varietal characteristics. Guaria8045 gave significantly higher grain yield (5.15 t ha^{-1}), whereas Pirsabak8146, Lamaquina and Khoibhutta produced grain yields of 4.50, 5.07 and 4.00 t ha^{-1}, respectively (Annonymous, 1987). SCA and BARC (1992) reported that on an average maize varieties Barnali, Khoibhutta, Mohor and Shuvra yielded 5.0, 4.2, 6.0 and 5.6 t ha^{-1} grains, respectively in rabi season, and 4.0, 3.4, 5.0 and 4.5 t ha^{-1} grains, respectively in the kharif season. Kamal *et al.* (1994) reported that grain yields of four maize varieties studied ranged from 4.52 to 5.96 t ha^{-1}. The highest yield obtained from Shuvra followed by Mohor (5.55 t ha^{-1}) and the lowest from Khoibhutta.

Quayyum and Rquibullah (1986) found with 5 varieties that grain yield and yield components were affected significantly by variety and spacing. They also found that cv. Pozarica7728 and Alajuela7725 produced higher grain yield. Singh *et al.* (1991) reported that Ganga5 was found significantly superior to HLL with regard to growth and yield attributes. On the other hand, Singh *et al.* (1980) found that the maize varieties Basi, Ganga5, Vijay, Vikram and local did not differ significantly for yield. However, composite Vikram produced marginally higher yield than the other varieties.

Paradkar and Sharma (1993) also found the difference in grain yield among 5 cultivars. The variety Ganga11 gave significantly higher grain yield and responses were generally lower in D765 than the other varieties. Pestean (1988) found that the grain yields were 14.4, 14.3 and 15.0 t ha^{-1} in hybrids Tundra199, Tundra213 and Pioneer3901, respectively. Mannio *et al.* (1987) reported that yields of Logos and XL72A (11.5 and 11.1 t ha^{-1}, respectively) were significantly higher than that of Super (10.4 t ha^{-1}).

In a trial with 13 entries including 2 checks, the exotic entries were found to produce 10 % to 47% increased yield over the check and the highest yield of 6395 kg ha^{-1} was recorded in Pirasabak(1)7642 as reported by BARI (1981). Chowdhury *et al.* (1989) conducted an experiment with 3 promising composites and a local variety Barnali and found Pirasabak8146 was lowest in grain yield (3.97 t ha^{-1}), Guira8045 was medium (4.83 t ha^{-1}), and La Maquina7827 was higher (5.84 t ha^{-1}) than Barnali (5.11 t ha^{-1}). In another experiment with 6 exotic composites and the same check Barnali, Chowdhury *et al.* (1989) found that Across7845 RE gave the highest grain yield (7.14 t ha^{-1}) followed by Ludhiana8445 (6.99 t ha^{-1}) across location. BARI (1990) observed in an advanced trial of maize with six CIMMYT entries and one local check that grain yield did not significantly differ among the entries. The entry Sids(1)8244 gave the highest yield (5.4 t ha^{-1}) followed by Rattary Arnold(1)8149 (4.7 t ha^{-1}), local check Barnali (4.6 t ha^{-1}) and Across149 (4.15 t ha^{-1}). In Malaysia, Onn (1988) found that the yields of cv. Suwan1 and Cayil CI were 5.78-7.13 and 5.75-6.45 t ha^{-1}, respectively. Haque (1989) obtained the highest grain yield from Barnali (3.70 t ha^{-1}) and the lowest from composite BZM-9 (2.86 t ha^{-1}).

Dhaif (1984) observed significant differences in grain yield and other characters among the genotype as well as among plant spacing treatments. The early hybrid EY23 XF-44 gave the highest grain yield at 75 cm x 15 cm spacing, while the early synthetic variety C-4 and the late cross hybrid C 103 x W- 17 gave the highest grain yield at 75 cm x 20 cm spacing.

Berzsenyi (1988) reported that grain yield response to plant density differed between hybrids, the highest grain yield of 7.2 t ha^{-1} was obtained in FAO maturity group 300 at 80,000 plants ha^{-1}. On the other hand, Sarvari (1982) reported that in the 500 group and maximum yields at 100,000 plants ha^{-1}.

In an experiment comprising 12 treatment combinations of 3 varieties (Ganga5, Ganga, Safed2 and Sathi) and 4 fertility levels, Mishra (1993) found that the variety Ganga5 gave significantly higher grain yield than Ganga Safed2 and Sathi.

Under irrigated conditions, the late maturity hybrid Pioneer3183 gave the highest grain yield of 14.90 t ha^{-1} followed by H-708 with 14.32 t ha^{-1}. Among medium late hybrids, Knezha530 gave the highest yield of 12.01 t ha^{-1} as reported by Tashkov and Delchev (1988).

Desiderio *et al.* (1989) found that highest yields among the cultivars tested in 1981 occurred in cv. AS x 58 (10.9 t ha^{-1}) and Victor (10.8 t ha^{-1}) at Rome and cv. First (10.71 t ha^{-1}) at Policoro, in 1982 in cv. Solar (10.5 t ha^{-1}) at Rome, and in 1983 in cv. First (12.1 t ha^{-1}) at Policoro.

Babu and Mitra (1989) obtained highest grain yield from Ganga compared with Sadaf2 and Kshan. Singh *et al.* (1992) reported that Ganga2, Novjot and Kiran produced 3.43 and 2.75 t ha^{-1} grain yields, respectively. SCA

(1992) and Chowdhury and Islam (1993) reported that Barnali and Khoibhutta produced grain yields of 4-5 and 3-4 t ha^{-1}, respectively. They also reported that grain yields of Mohor and Shuvra ranged from 4-5.5 t ha^{-1} in rabi season.

2.2 Effect of planting arrangement

2.2.1 Effect on plant characters

Plant characters may be influenced by different spacing and planting arrangements. Vipawon and Anothai (1985) reported that plant height was increased with increased pants per hill. On the other hand, Pissaio *et al.* (1995) reported that spacing had no effect on plant height.

In India, Rathore *et al.* (1976) found that there was no significant difference in plant height in low plant populations. However, Tetio-Kagho and Gardner (1988) observed that plant density influenced the plant height of maize significantly. Tano *et al.* (1987) found that increasing plant density increased plant height. Ogunlela *et al.* (1988) also found that increasing plant density from 25,000 to 75,000 plants ha^{-1} increased plant height.

Islam (1981) obtained slightly taller plants from single plant $hill^{-1}$ where double pants $hill^{-1}$ produced shorter stature. Plant height was found to be highest at a spacing of 75 cm x 25 cm (Anonymous, 1987). On the other hand, Onn (1988) observed highest plant height at a spacing of 75 cm x 15 cm.

Number of cobs may be influenced by planting arrangement and spacing. Vipawon and Anothai (1985) found that increased number of plants $hill^{-1}$ decreased cob number $plant^{-1}$. Pissaio *et al.* (1995) reported that spacing had no effect on cob number $plant^{-1}$. But Kayode and Agboola (1981) found that spacing significantly influenced number of cobs plant^{-1}. Bangarwa *et al.* (1988) found that number of cobs plant^{-1} decreased with increasing plant density. Gutierrez and Pedro (1992) also reported similar result. Sharma and Adamu (1984) found the highest number of cobs plant^{-1} at the lowest plant population (25,000 plants ha^{-1}). Similar results were also reported by Rathore *et al.* (1976). Islam found no significant difference in number of cobs plant^{-1} due to one or two plants hill^{-1}.

Vipawon and Anothai (1985) reported that increased number of plants hill^{-1} decreased cob length. BARI (1990) reported that large cobs were obtained from 75 cm and 60 cm row spacing during 1985. Again, Osorio (1976) found that cob length was reduced with an increase in plant density. Loesch *et al.* (1976) found that length of cob was improved significantly by reducing plant density. Rathore *et al.* (1976) found that length of cob decreased with increased plant population. Wilson and Allison (1978) also reported the similar results. Islam (1981) reported that cob length was not significantly affected by number of plants hill^{-1}. On the other hand, cob length was slightly greater at a spacing of 75 cm x 50 cm as reported by Annonymous (1987).

Loesch *et al.* (1976) found that cob diameter was improved significantly by reducing plant density. Wilson and Allison (1978) reported that circumference of the rachies decreased with an increase in plant population.

Weight of cob is an important character that is related to grain yield. Rathore (1976) found highest cob weight at lower plant densities. Sharma and Adamu (1984) also found the similar results. Wilson and Allison (1978) reported that the size and weight of cob were decreased with an increase in plant population. Baenziger and Glovar (1980) obtained increased cob weight and grain number by reducing plant population densities.

Vipawon and Anothai (1985) reported that increased number of plants hill^{-1} increased the weight of cob. Cobb weight differed under different plant densities and decreased when plant density increased as reported by Hsu and Huang (1984). Vipawon and Anothai (1985) found that cob weight was increased with increasing plant hill^{-1}. Rogers and Lomman (1988) reported that maximum cob weight occurred at lower density. Similarly, Loesch *et al.* (1976) reported that weight of cobs was improved significantly by reducing plant density.

Babu and Mitra (1989) found that the number of grains row^{-1} was the greatest with 33,333 plants ha^{-1} and decreased with increasing plant densities.

Dong and Cheng (1995) reported that increasing plant density decreased grain number cob^{-1}. Bangarwa *et al.* (1988) also found similar result. Hsu and Huang (1984) reported that grain number cob^{-1} differed under different plant densities and decreased as plant density increased. Tano *et al.* (1987) also found similar result. In India, Rathore *et al.* (1976) found that number grains cob^{-1} decreased with increasing plant population. Wilson and Allison (1978) found similar result. Kernel number pant^{-1} was also decreased with increasing plant population as reported by Kholany and Abdel Aziz (1986).

Grains cob^{-1} were highest at a spacing 75 cm x 25 cm. But regardless of spacing 2 plants hill^{-1} produced maximum grains cob^{-1} (Annonymous 1987). On the contrary, Islam (1981) obtained maximum grains cob^{-1} from single plant hill^{-1}. Mannino *et al.* (1987) reported that number of grains cob^{-1} decreased with an increase in plants hill^{-1}.

Lapcevic (1985) reported that plant density did not influence grain size. On the other hand, Wilson and Allison (1978) found decreased grain size with increased population.

Grain weight cob^{-1} or plant^{-1} and 100 grain weight may be influenced by planting arrangement and spacing. Vipawon and Anothai (1985) reported that grain weight decreased with increasing plants hill^{-1}. Hsu and Huang (1984) found that grain weight cob^{-1} differed under different plant densities. Tano *et al.* (1987) found the similar result. However, Sharma and Adamu (1984) found highest grain weight pant^{-1} at lowest plant population.

Vipawon and Anothai (1985) reported that 100-grain weight was decreased with increasing number of plants hill^{-1}. Lapcevic (1985) observed that plant density influenced 100-grain weight notably.The 100-grain weight decreased with increasing plant density was also reported by Bangarwa *et al.* (1988).

Islam (1981) obtained slightly higher 100-seed weight from one plant hill^{-1} arrangement. A spacing of 75 cm x 25 cm with one plant hill^{-1} produced maximum 100-seed weight (Annonymous 1987). Weight seed^{-1} was higher at lower plant population densities as observed by Al-Younis (1989).

2.2.2 Effect on grain yield

Spacing and planting arrangement may have effect on grain yield. Lima and Lodi (1982) reported that the highest grain yields were produced by 1 or 2 plants hill^{-1} at 33 cm between hills (4.23 and 4.03 t ha^{-1}, respectively). At 25 cm and 33 cm between hills, grain yield was reduced as plant number hill^{-1}

increased. BARI (1990) reported that maize with 75 cm x 25 cm spacing gave different yields at different locations. One plant hill^{-1} produced the highest at Joydebpur against 2 plants hill^{-1} at Jamalpur and Hathazari and 3 plants hill^{-1} at Ishurdi.

Al-Younis (1989) observed highest grain yield from one plant hill^{-1} arrangement. Nadar (1984) obtained highest grain yield at a spacing of 75 cm x 30 cm. Khan and Haque (1989) obtained highest grain yield at a spacing of 60 cm x 20 cm. However, Khot and Umrani (1992) obtained significantly highest seed yield at a spacing of 75 cm x 30 cm. Rizzardi *et al.* (1994) reported that grain yield and yield components did not differ between spacing patterns or row spacing.

Araujo *et al.* (1983) reported that maize with .02, 0.50, 0.75 or 1.00 m between hills with 1, 2, 3, or 4 plants hill^{-1} giving a population of 40,000 ha^{-1} did not give significant yield difference. Srivastava and Singh (1975) also found similar yields when both pants in a hill were allowed to mature or one of them was removed 30 days after sowing. Garcia-Soloria and Ruiz-Vega (1993) reported that an extra 474 kg ha^{-1} of grain was produced under the two plants hill^{-1} system. Oppong (1988) found the highest grain yield from 2 plants stand^{-1} out of four densities namely, 1, 2, 3 and 4 plants stand^{-1}.

Shah *et al.* (1989) observed that plant spacing and number of plants hill^{-1} had significant effect on yield, and the highest yield was obtained from 75 cm x 25 cm plant spacing with 3 pants hill^{-}.

BARI (1990) reported that there was no significant yield difference due to difference in row spacing in maize. The highest yield was obtained with 75 cm row spacing and significantly the highest grain yield (3.39 t ha^{-1}) was obtained from 25 cm hill spacing followed by 30 cm (3.26 t ha^{-1}) and 20 cm (3.04 t ha^{-1}). Again, yield and yield attributes were affected significantly by spacing and cultivar at Joydebpur but not at Hathazari (BARI, 1990). Similarly, Quayyum and Raquibullah (1986) reported that the highest yield (4.11 t ha^{-1}) was obtained from 75 cm row spacing which was identical with that obtained from 30 cm row spacing (4.01 t ha^{-1}).

Sawhney *et al.* (1989) reported that spacing influenced grain yield significantly. Closer spacing of 50 cm x 16 cm or 40 cm x 20 cm resulted in the highest grain yield. Again, Hoque (1982) reported that closer spacing between rows were better because these spacing gave higher yield. Kolcar and Vdenovic (1988) also reported that closer spacing gave the highest yield (8.67 t ha^{-1}) for early sowing. Bertic *et al.* (1987) also found similar result.

Podolak (1984) reported that irrigation, hybrid, sowing density and year had grater influence on yield than row width. Rows 60 cm apart were recommended. Truksa and Zaborsky (1983) did not find consistent yield difference between row widths of 70 and 40 cm.

Barthakur *et al.* (1975) found that higher yields (4.53 t ha^{-1}) were obtained in rows 50 cm apart than in rows 75 cm (4.16 t ha^{-1}) or 100 cm apart (3.49 t ha^{-1}) in summer season. But yield in winter was the highest (6.24 t ha^{-1}) in rows 75 cm apart. Quayyum and Raquibullah (1986) observed that the variety Pozarica produced the grain yield (4.42 t ha^{-1}) at row spacing of 60 cm followed by variety Sadaf (4.35 t ha^{-1}) at 75 cm row spacing. Ekka *et al.* (1977) did not find significant difference among row spacing but 60 cm between rows produced the highest grain yield.

Khan and Haque (1989) found maximum yield at 60 cm x 20 cm spacing. Nagy (1982) reported that the highest yields were obtained from 80,000 plants ha^{-1} with 50 cm and 25 cm row and hill spacing, respectively. Wahua (1983) found 5.08 and 3.28 t ha^{-1}grain yields at 40 cm x 30 cm and 40 cm x 20 cm spacing, respectively. BARI (1981) reported that spacing had considerable effect on grain yield of maize and maximum yield was recorded at the row spacing of 45 cm.

Hsu and Huang (1984) found that yield differed significantly with plant densities. Vasic *et al.* (1988) reported that grain yield increased with an increase in number of plants $unit^{-1}$ surface regardless of sowing time. Senait and Dejene (1992) also reported similar results. Simeonov and Tsankova (1990) reported similar result which was limited from 45,000 to 55,000 plants ha^{-1} but not to 65,000 plants ha^{-1}. On the other hand, Pestean (1988) found mean grain yields of 13.8-15.1 t ha^{-1} with an increase in plant density from 70,000 to 1, 00,000 plants ha^{-1}. However, Chrzanowska (1990) observed that a density of 8 plants m^{-2} proved more effective because the obtained yield was 6.97 t $ha^{-1}$and with lower density it was 6.15t ha^{-1}.

Variable effects of plant density on grain yield were also reported. Desiderio *et al.* (1989) observed that increasing plant density increased grain yield except at Papiano where trends were not clear. Vivas *et al.* (1988) reported that plant density was not a critical factor in determining maize yield. On the contrary, Borowiecki (1986) reported that optimum plant density depended on cultivar. Row spacing did not affect yield. Narayanaswamy *et al.* (1994) found that pant density did not affect the mean yield in 1988-89 but yield was higher at the higher density in 1989-90 (1.98 vs. 1.75 t ha^{-1}).

Different studies revealed that yield was reduced with increasing plant density. Amoruw *et al.* (1987) reported that increasing plant density reduced grain yield but increased stalk yield. Tano *et al.* (1987) also found the similar result. Elsahockie (1977) reported that grain yields of 11 maize hybrids tended to decrease as plant density increased from 75,000 to 90,000 ha^{-1}. Tashkov and Delchev (1988) reported that Pionner3183, Pioneer 3707 and Knzha530 hybrids gave highest yield at a density of 70,000 plants ha^{-1}.

Salontai *et al.* (1985) found that yield of the early hybrid Turda100 was mainly affected by plant density and average weight cob^{-1} that of the semi-early Turda228 was influenced by plant density and number of cobs plant^{-1}. Tano (1986) reported that grain yield of maize cv. Iperon were significantly increased at 2 sites when row spacing was reduced from 70 cm to 50 cm and plant density was increased from 5.5 to 8.5 plants m^{-2}. Vukadinovic *et al.* (1984) found highest grain yield from NSSK606 growing at intermediate density (50,000 plants ha^{-1}).

Sarvari (1982) observed that hybrids in the 500 group had maximum yields at 100,000 plants ha^{-1}. Again, Kamen (1983) found the highest grain yields of early maturity hybrids at 72,000 plants ha^{-1}. Alessi and Power (1976) obtained the highest yield of maize with 30,000 plants ha^{-1}. On the other hand, Ignatova (1974) found highest economically justified grain yields at 50,000 to 60,000 plants ha^{-1}.

Sufian and Abedin (1985) obtained highest grain yield from growing maize at a population of 1,00,000 plants ha^{-1} and minimum at 40,000 plants ha^{-1}. Jones (1986) reported that grain yield was widely affected by population densities but row spacing had no significant effect.

CHAPTER 3
MATERIALS AND METHODS

CHAPTER 3

MATERIALS AND METHODS

This chapter deals with the materials used and methodology followed in conducting the experiment. The location of the study area and its climate, materials used, methods followed in different operations during the experiment (November 2006 to April, 2007) as well as in data collection has been described here under the following sub-headings.

3.1 Experimental site

The study was conducted at the Agrotechnology Field Laboratory, Khulna University, Khulna. Experimental site is located at the latitude of 22°47′ N and longitude of 89°34′ E. It belongs to the Agroecological Zone of Gangas Tidal Flood Plain (AEZ-13a) with and elevation of 4m from the mean sea level.

3.3 Climate

The region is situated in the sub-tropics where rainfall is maximum during the Kharif season (April- September) and scanty in association with moderately low temperature and plenty of sunshine in the Rabi season (October-March). The meteorological data have been presented in Appendix I.

3.4 Experimental materials

The main experimental materials were seeds of four winter maize varieties collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur 1701.

The maize varieties used in the experiment were:

1) BARI maize3, 2) BARI maize5, 3) Shuvra and 4) Barnali

The followings are the characteristics of the varieties used in the experiment (SCA and BARC, 1992; BARI 2005):

Shuvra: The grains of this variety are large and white in color. Grains are semi-flint. It is resistant to insects and diseases.

Barnali: Its cobs are large in size and narrow at apex covered with hard sheaths. Grains are semi-flint and yellow in color. It is resistant to insects and diseases.

BARI maize3: The cobs of this variety are large in size and its apex is covered with sheaths hardly. Grain color is light yellow and grains are not flint type.

BARI maize5: Cobs of this variety are large in size and its apex covered with sheaths hardly. Grain color is orange yellow and grains are not flint type.

3.4 Experimental treatments

The treatments of the experiment were four varieties of maize and three planting arrangements. Thus the experiment included two factors, which were as follows:

Factor A: Varieties of maize -4

1) V_1= BARI maize3

2) V_2= BARI maize 5

3) V_3= Shuvra

4) V_4= Barnali

Factor B: Planting arrangements-3

A_1= One plant hill^{-1} (20 cm apart)

A_2= Two plants hill^{-1} (40 cm apart)

A_3= Three plants hill^{-1} (60 cm apart)

3.8 Land preparation

The experimental land was first opened early November 2006 with a power tiller. Later on, the land was ploughed and cross-ploughed 4 times followed by breaking clods and laddering to obtain the desirable tilth. The corners of the land were trimmed with a spade and all the weeds and stubbles were removed from the field. Finally, the land was leveled and divided into blocks and plots maintaining the recommended distances.

3.9 Manuring and fertilization

The experimental plots were fertilized with cow dung, Urea, TSP, MP, Gypsum, Zinc sulphate and Boric acid as per following rate (BARI, 1989):

Manures/Fertilizers	Doses/ha	Quantity/plot (3m x 2.5m)
Cow dung	5 tons	3.75kg
Urea	220 kg	165 g
TSP	110kg	82.5 g
MP	50kg	37.5 g
Gypsum	125 kg	93.75 g
Zinc sulphate	10 kg	7.5 g
Boric acid	6.5 kg	48.75 g

The total amount of well decomposed cow dung, TSP, MP, Gypsum, Zinc sulphate and Boric acid and one-third of urea were broadcasted and incorporated to the soil of the plots at the time of final land preparation. The rest part of urea (two-third) were top dressed in 2 installments one at 30 days after sowing (DAS) and the rest at 60 DAS.

3.10 Seed sowing

The seeds were sown in rows made by hand plough on 27 November 2006 at a distance of 75 cm apart. Two seeds, four seeds and six seeds were sown 20 cm, 40 cm and 60 cm apart within a row at a depth of 4-5 cm from the surface for the treatments of 1 plant hill^{-1} (20 cm apart), 2 plants hill^{-1} (40 cm apart) and 3 plants hill^{-1} (60 cm apart), respectively. After sowing, the seeds were covered with soil.

3.11 Thinning and gap filling

The crop was thinned to one plant hill^{-1}, two plants hill^{-1} and three plants hill^{-1} as per requirement of the experimental treatments. Necessary gap filling was done at 23 days after sowing. 48 plants were in each plot.

3.12 Weeding

The first weeding was done on 18th day after sowing and the second after 40 days of first weeding.

3.13 Irrigation

The crop was irrigated two times by flooding. The first irrigation was done after 30 days and the second after 95 days of sowing.

3.14 Earthing up

Earthing up was done in two times – First after 65 days of sowing and the other after 87 days of sowing. The operation was carried out by raising soil to the base of the crop plants along the rows.

3.15 Crop protection

No pesticides were used in the experimental plots as there was no notable incidence of diseases and insects was observed.

3.16 General observation

The field was under constant observation. Crop condition was satisfactory throughout the experiment.

3.17 Harvesting and processing

The experimental crop was harvested plot wise at maturity in the second half of April 2007. Five hills were randomly selected from each plot prior to harvest for collection of data on plant characteristics, grain yield and its components. The harvested plants of each plot were bundled separately, tagged and taken to the threshing floor. These were dried in bright sunshine. Threshing was done by corn sheller after separating cobs from the plant and drying the cobs. The grains were cleaned properly. Grains and stalks were thoroughly dried before their weights were recoded.

3.18 Parameters studied

Data on the following plant characteristics and yield components were collected from selected sample plants of each plot:

a) Plant height (cm)

b) Number of cobs plant^{-1}

c) Number of cobs plot^{-1}

d) Number of fertile cobs plot^{-1}

e) Length of cob (cm)

f) Weight of individual cob (g)

g) Circumference of cob (cm)

h) Number of rows of grains cob^{-1}

i) Number of grains cob^{-1}

j) 100-grain weight (g)

k) Grain yield (t ha^{-1})

l) Stalk yield (t ha^{-1})

m) Biological yield (t ha^{-1})

n) Harvest index (%)

3.19 Methods of data collection

i) Plant height: Before harvesting, the heights of selected plants were measured from the base of the plants to the tip of the tassel.

ii) Number of cobs $plant^{-1}$: The number of cobs was counted one day before harvesting. Total numbers of cobs from selected plants of each plot were counted and recorded $plant^{-1}$ basis.

iii) Number of cobs $plot^{-1}$: Total numbers of cobs from selected plants of each plot were counted one day before harvesting.

iv) Number of fertile cobs $plot^{-1}$: Fertile cobs $plot^{-1}$ were counted after separating the cobs from the stalk plot by plot.

v) Length of cob: It was measured from the cobs of selected sample plants of each plot.

vi) Weight of individual cob: It was measured from the cobs of selected sample plants of each plot after through sun drying.

vii) Circumference of the cob: Circumference of selected cobs was measured at the lower and upper ends and in the middle and then averaged.

viii) Number of rows of grains cob^{-1}: It was counted from selected cobs $plot^{-1}$.

ix) Number of grains cob^{-1}: From selected cobs $plot^{-1}$ the number of grains cob^{-1} was counted.

x) 100-grain weight: Weight of 100 gains was recoded from the dried grains of selected cobs $plot^{-1}$.

xi) Grain yield: After shelling and thorough sun drying total grain weight from each plot was taken in kilograms and then converted to metric ton per hectare.

xii) Stalk yield: After separating the cobs from the plants and drying the plants in the sun, the total stalk weight of each plot was taken in kilograms and then converted in to metric tons per hectare.

xiii) Biological yield (ton/ha): Biological yield was calculated by the following formula:

Biological yield = Grain yield + Stalk yield

xiv) Harvest index (%): Harvest index was calculated at final harvest by the following formula proposed by Donald and Hamblin (1976):

$$HI\ (\%) = \frac{\text{Economic yield (i. e. grain yield)}}{\text{Biological yield}} \times 100$$

3.20 Statistical analysis

The collected data were statistically analyzed to find out the significance of differences between the treatments and treatment combinations. The means of all the treatments were calculated and the analysis of variances (ANOVA) for all the characters was performed by F-test. The significant differences of the means of treatments were compared by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

CHAPETR 4
RESULTS AND DISCUSSION

CHAPTER 4

RESULTS AND DISCUSSION

Results of the analysis of variance in respect of all parameters obtained from the present investigation have been presented and discussed in this chapter. The data have been presented in table (s) for ease of discussion, comprehensions and understanding. The result of each parameter has discussed and possible interpretations have been given whenever necessary.

4.1 Plant height

It was evident from the result of the experiment that plant height significantly varied with variety (Appendix III). The tallest plant was recorded from BARI maize3 (258.26 cm) followed by BARI maize5 (250.36 cm), and the shortest plant was obtained from Shuvra (211.65 cm) proceeded by Barnali (231.11 cm) (Table 1). Varieties of maize differ for plant height might be due to their genetic characters. Variation in plant heights of maize varieties is also supported by SCA (1992), Chowdhury and Islam (1993), Chowdhury *et al.* (1989) and Akhtar and Mitra (1989).

Effect of planting arrangement on plant height was significantly varied (Appendix III). The highest plant height (241.64 cm) was recorded from three plants hill^{-1} and the lowest plant height (234.84 cm) was obtained from one plant hill^{-1} (Table 2).This might be due to plant density, because plant density influences the plant height. Competition among three plants hill^{-1} for light and nutrients was more, which influenced the plant height. Plant height differed due to the influence of planting arrangement as reported by Annonymous (1987).

Table 1. Effect of variety on growth characters of maize

Variety	Plant height (cm)	Cob length (cm)	Circumference of cob (cm)	Rows of grains cob^{-1} (no.)	Weight cob^{-1} (g)
BARI maize3	258.26a	16.41a	14.02c	12.34c	216.61b
BARI maize5	250.36b	16.01b	14.33b	12.88b	221.03a
Shuvra	211.65d	15.56c	14.63a	13.90a	190.10c
Barnali	231.11c	15.82bc	13.61d	12.23d	184.61d
Level of significance	0.01	0.01	0.01	0.01	0.01
CV (%)	0.44	1.58	1.58	0.46	0.38

In a column figures having similar letter (s) do not differ significantly whereas figures with dissimilar letter (s) differ significantly as per DMRT.

Table 2. Effect of planting arrangement on growth characters of maize

Planting arrangement	Plant height (cm)	Cob length (cm)	Circumference of cob (cm)	Rows of grains cob^{-1} (no.)	Weight cob^{-1} (g)
One plant $hill^{-1}$	234.84c	16.02	14.47a	12.96a	209.46a
Two plants $hill^{-1}$	237.06b	15.90	14.09b	12.78b	200.87b
Three plans $hill^{-1}$	241.64a	15.93	13.89b	12.77b	198.94c
Level of significance	0.01	NS	0.01	0.01	0.01
CV (%)	0.44	1.58	1.58	0.46	0.38

In a column figures having similar letter (s) do not differ significantly whereas figures with dissimilar letter (s) differ significantly as per DMRT.

The combined effect of variety and planting arrangement showed significant variation (Table 3). From the observation the tallest plant was recorded from BARI maize3 with three plants hill^{-1} (2593.66 cm) followed by two plants hill^{-1} (257.98 cm) and one plant hill^{-1} (257.15 cm) in the same variety. But the shortest plant (207.17 cm) was observed from Shuvra with one plant hill^{-1} followed by two plants hill^{-1} (210.65 cm) and three plants hill^{-1} (217.12 cm) in the same variety could be due to no interplant competition in one plant. Plant height of BARI maize3 is genetically higher than Shuvra.

4.2 Length of cob

Length of cob varied significantly with variety (Appendix III). The longest cob was observed in BARI maize3 (16.41 cm) followed by BARI maize5 (16.01 cm) which was superior to that of Shuvra and Barnali (Table 1). The shortest cob was found in Shuvra (15.56 cm) which was statistically identical to Barnali (15.82 cm). This result is in agreement with that of Rashid (1997) who found shorter cob in Shuvra (15.69 cm) and taller in Khoibhutta (17.51 cm).

It is revealed from the result of the study that there was no significant variation in cob length among the planting arrangements (Appendix III). However, numerically the longest cob (16.02 cm) was found in the plots having one plant hill^{-1} and that was the lowest (15.90 cm) in two plants hill^{-1} preceded by three plants hill^{-1} (15.93 cm) (Table 2). This result was supported by Annonymous (1987) and Islam (1981) who reported that cob length was not significantly affected by number of plants hill^{-1}. On the other hand, Islam also reported that cob length was slightly greater at a spacing of 75 cm x 50 cm.

Table 3. Interaction effect of variety and planting arrangement on growth characters of maize

Treatment combinations	Plant height (cm)	Cob length (cm)	Circumference of cob (cm)	Rows of grains cob^{-1} (no.)	Weight cob^{-1} (g)
V_1A_1	257.15a	16.37ab	14.57ab	12.63c	218.53b
V_1A_2	257.98a	16.17bc	13.47de	12.17e	215.93c
V_1A_3	259.66a	16.70a	14.03bc	12.23e	215.37c
V_2A_1	247.29c	15.93bcd	14.67a	12.87b	230.50a
V_2A_2	249.61c	16.17bc	14.60a	12.90b	216.70c
V_2A_3	254.19b	15.93bcd	13.73cde	12.86b	215.90c
V_3A_1	207.17h	15.63d	14.73a	13.95a	202.10d
V_3A_2	210.65g	15.47d	14.63a	13.90a	185.47e
V_3A_3	217.12f	15.57d	14.53ab	13.86a	182.73f
V_4A_1	227.76e	16.13bc	13.90cd	12.38d	186.70e
V_4A_2	229.99e	15.80cd	13.67cde	12.16e	185.37e
V_4A_3	235.58d	15.53d	13.27e	12.14e	181.77f
Level of significance	0.01	0.05	0.01	0.01	0.01
CV (%)	0.44	1.58	1.58	0.46	0.38

In a column figures having similar letter (s) do not differ significantly whereas figures with dissimilar letter (s) differ significantly as per DMRT.

V_1: BARI maize3
V_2: BARI maize5
V_3: Shuvra
V_4: Barnali

A_1 : One plant $hill^{-1}$
A_2 : Two plant $hill^{-1}$
A_3 : Three plant $hill^{-1}$

Cob length was significantly varied due to the combined effect of variety and planting arrangement (Appendix III). The longer cobs were found in BARI maize3 with three plants hill^{-1} (16.70 cm), one plant hill^{-1} (16.37 cm) and two plants hill^{-1} (16.17 cm), respectively in the same variety. Whereas, shorter cobs were found in the treatment combination of the variety Shuvra (15.47 cm) with two plants hill^{-1} preceded by Barnali (15.53 cm) with three plants hill^{-1}, Shuvra (15.57 cm) with three plants hill^{-1} and Shuvra (15.63 cm) with one plant hill^{-1} and these were statistically identical with Shuvra with three plants hill^{-1} (Table 3). Osorio (1976) found that cob length was reduced with an increase in plant density which is similar to the present result. It is also supported by Losech *et al.* (1976). They reported that length of cob was improved significantly by reducing plant density.

4.3 Circumference of cob

Significant differences were observed among the varieties in respect of circumference of cob (Appendix III). Shuvra showed the highest circumference (14.63 cm) which was followed by BARI maize5 (14.33 cm) and BARI maize3 (14.02 cm) (Table 1). The lowest circumference of cob was found in Barnali (13.61 cm). This result is supported by Rashid (1997) having the similar result.

There was a significant difference among the planting arrangements in regard to circumference of cob (Appendix III). One plant hill^{-1} gave the highest circumference (14.47 cm) which was followed by two plants hill^{-1} (14.09 cm) (Table 2). The lowest circumference of cob (13.89 cm) was found in three plants hill^{-1} which was statistically identical with two plants hill^{-1}. Highest circumference of cob may be produced due to more nutrient uptake by the individual plant without competition in case of one plant hill^{-1}. On the other hand, lowest circumference due to more competition among the plants for nutrients in three plant hill^{-1} where they got lesser nutrients than one plant hill^{-1}. Rahman (1996) reported that one plant hill^{-1} gave higher cob circumference than two plants hill^{-1}, which was similar to the obtained result of the present study.

Combined effect of variety and planting arrangement on circumference of cob was found statistically significant (Appendix III). The highest circumference of cob (14.67 cm) was found in one plant hill^{-1} and two plants hill^{-1} (14.60 cm) from BARI maize5 preceded by Shuvra with one plant hill^{-1} (14.73 cm) and two plants hill^{-1} (14.63 cm), respectively (Table 3). But the lowest circumference of cob was obtained from Barnali (13.27 cm) with three plants hill^{-1} (Table 3). Rahman (1996) reported that Barnali gave the lowest circumference with three plants hill^{-1}.

4.4 Rows of grains cob^{-1}

There were significant differences among the varieties in respect of number of rows of grains cob^{-1} (Appendix III). Number of rows of grains cob^{-1} ranged from 13.90 to 12.23 (Table 1). The highest number of rows of grains was found in Shuvra (13.90) followed by BARI maize5 (12.88) and BARI maize3 (12.34). The lowest number of rows of grains was observed in Barnali (12.23). A different effect of cultivars on number of rows of grains cob^{-1} was reported by Paradkar and Sharma (1991).

There were significant differences among the planting arrangement in regard to number of rows of grains cob^{-1} (Table 2). Number of rows of grains cob^{-1} ranged from 12.96 to 12.77. Maximum number of rows of grains cob^{-1} (12.96) was recorded from one plant hill^{-1} and minimum number of rows of grains cob^{-1} (12.77) was found in the plots having three plants hill^{-1}.

It was revealed from the result of the present study that there was a significant combined effect of variety and planting arrangement on rows of grains cob^{-1} (Appendix III). The highest rows of grains cob^{-1} was obtained from the treatment combination of the variety Shuvra with one plant $hill^{-1}$ (13.95) followed by two plants $hill^{-1}$ (13.90) and three plants $hill^{-1}$ (13.86) in the same variety (Table 3). On the other hand, the lowest rows of grains cob^{-1} was obtained from the treatment combination of the variety BARI maize5 with one plant $hill^{-1}$ (12.87) preceded by two plants $hill^{-1}$ (12.90) and three plants $hill^{-1}$ (12.86) in the same variety (BARI maize5).

4.5 Weight of individual cob

It was observed from the result of the present study that varieties differ significantly in respect of weight of individual cob (Table 1). Among the varieties BARI maize5 gave the heaviest cob (221.03 g) which was followed by BARI maize3 (216.61 g). The cob of Barnali was the lightest (184.61 g). Variation in weight of individual cob in respect of variety was also supported by Annonymous (1987), who reported that Barnali and shuvra produced the lighter cob than Mohor and Khoibhutta.

The study also revealed that planting arrangement differs significantly in regard to weight of cob (Appendix III). Among the planting arrangements one plant $hill^{-1}$ produced the heaviest cob (209.46 g). The cob of three plants $hill^{-1}$ was the lightest (198.94 g) (Table 2). This result is supported by Rathere (1976), who found highest cob weight at lower plant densities. Sharma and Adamu (1984) also found the similar results.

There was significant combined effect of variety and planting arrangement on individual cob weight (Appendix III). From the study it was found that, the heaviest cob (230.50 g) was obtained from the treatment combination of

BARI maize5 with one plant hill^{-1} followed by BARI maize3 (218.53 g) with one plant hill^{-1}(Table 3). On the other hand, the lightest cob was obtained from Barnali (181.77 g) with three plants hill^{-1} preceded by the treatment combination of the variety Shuvra (182.73 g) with three plants hill^{-1}.

4.6 Number of cobs plant^{-1}

There was significant variation in producing cobs plant^{-1} among the varieties (Appendix IV). The variety BARI maize5 produced the highest number of cobs plant^{-1} (1.09) followed by BARI maize3 (1.06). Whereas, Barnali produced the lowest number of cob plant^{-1} (1.02). The variety Shuvra gave statistically identical results with BARI maize3 and Barnali in respect of number of cobs plant^{-1} (Table 4).

Planting arrangement had significant effect in producing cobs plant^{-1} (Appendix IV). The highest number of cobs plant^{-1} (1.07) was found in one plant hill^{-1} followed by two plants hill^{-1} (1.05). Whereas, three plants hill^{-1} produced the lowest number of cobs (1.03) plant^{-1} (Table 5). This result is supported by that of Vipawon and Anothai (1985). They reported that increased number of plants hill^{-1} decreased cob number plant^{-1}. This result was also supported by Bangarwa *et al.* (1988).

Significant variation was also found in respect of number of cobs plant^{-1} of maize due to combined effect of variety and planting arrangement (Appendix IV). The highest number of cobs plant^{-1} was obtained from the treatment combination of BARI maize5 with one plant hill^{-1} (1.13) followed by two plants hill^{-1} from the same variety BARI maize5 (1.09) (Table 6). But the lowest numbers of cobs plant^{-1} (1.00) was obtained from the treatment combination of the variety Barnali with three plants hill^{-1} preceded by two plants hill^{-1} (1.02) and one plant hill^{-1}(1.03).

4.7 Number of cobs plot^{-1}

There was significant effect of varieties on number of cobs plot^{-1} (Appendix IV). It was found that the highest number of cobs plot^{-1} was recorded in BARI maize5 (52.43) followed by BARI maize3 (51.67), whereas the lowest number of cobs plot^{-1} was recorded in Barnali (50.01) (Table 4).

In the present study, number of cobs plot^{-1} was affected significantly by planting arrangement (Appendix III). The highest number of cobs plot^{-1} was obtained from one plant hill^{-1} (52.53) which was followed by two plants hill^{-1} (51.51). The lowest cobs plot^{-1} (49.44) was found in three plants hill^{-1}(Table 5).

The present study revealed that there was a significant combined effect of variety and planting arrangement on number of cobs plot^{-1} (Appendix IV). The highest number of cobs plot^{-1} was found from BARI maize3 (54.23) and BARI maize5 (54.20) with the similar arrangement (one plant hill^{-1}) followed by BARI maize5 (52.40) with two plants hill^{-1}. Whereas, the lowest number of cobs plot^{-1} was obtained from Shuvra (48.57) with three plants hill^{-1} and Barnali (48.43) with the same arrangement (three plants hill^{-1}) (Table 6)

4.8 Number of fertile cobs plot^{-1}

Varieties of maize have significant effect on numbers of fertile cobs plot^{-1} (Appendix IV). BARI maize5 produced the highest fertile cobs plot^{-1} (52.24) followed by BARI maize3 (51.46). On the other hand, the lowest fertile cobs plot^{-1} was produced by Shuvra (49.84) proceeded by Barnali (49.20) (Table 4). Though, BARI maize5 produced the maximum cobs plot^{-1} so, it produced the maximum fertile cobs plot^{-1}.

Table 4. Effect of variety on yield contributing characters and yield of maize

Variety	Cobs $plant^{-1}$ (no.)	Cobs $plot^{-1}$ (no.)	Fertile cobs $plot^{-1}$ (no.)	Grains cob^{-1} (no.)	Weight of 100-grain (g)	Grain yield (t ha^{-1})	Stalk yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
BARI maize3	1.06b	51.67b	51.46b	383.70b	28.32b	7.73b	8.01a	15.74a	49.10b
BARI maize5	1.09a	52.43a	52.24a	393.16a	28.89a	7.92a	7.82b	15.74a	50.34ab
Shuvra	1.04bc	50.04c	49.84c	359.58c	24.21c	4.96c	4.72d	9.69b	51.22a
Barnali	1.02c	50.01c	49.20d	355.15d	23.91c	4.71d	4.91c	9.62b	48.96b
Level of significance	0.01	0.01	0.05	0.01	0.01	0.01	0.01	0.01	0.01
CV (%)	1.64	1.11	3.83	0.17	1.91	2.15	2.03	0.93	2.07

In a column figures having similar letter (s) do not differ significantly whereas figures with dissimilar letter (s) differ significantly as per DMRT.

Table 5. Effect of planting arrangement on yield contributing characters and yield of maize

Planting arrangement	Cobs $plant^{-1}$ (no.)	Cobs $plot^{-1}$ (no.)	Fertile cobs $plot^{-1}$ (no.)	Grains cob^{-1} (no.)	Weight of 100-grain (g)	Grain yield ($t\ ha^{-1}$)	Stalk yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest index (%)
One plant $hill^{-1}$	1.07a	52.53a	51.94a	386.50a	26.94a	6.68a	6.75a	13.43a	49.77
Two plants $hill^{-1}$	1.05a	51.51a	50.54b	370.86b	26.23b	6.38b	6.35b	12.72b	50.22
Three plants $hill^{-1}$	1.03b	49.44c	49.23b	361.33c	25.83c	5.94c	6.00c	11.94c	49.72
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	NS
CV (%)	1.64	1.11	3.83	0.17	1.91	2.15	2.03	0.93	2.07

In a column figures having similar letter (s) do not differ significantly whereas figures with dissimilar letter (s) differ significantly as per DMRT.

Table 6. Interaction effect of variety and planting arrangement on yield contributing characters and yield of maize

Treatment combination	Cobs $plant^{-1}$ (no.)	Cobs $plot^{-1}$ (no.)	Fertile cobs $plot^{-1}$	Grains cob^{-1} (no.)	Weight of 100-grains (g)	Grain yield ($t\ ha^{-1}$)	Stalk yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest index (%)
V_1A_1	1.05cd	54.23a	52.73	403.47b	28.83	8.19b	8.50a	16.69a	49.09
V_1A_2	1.07bc	51.67c	50.70	383.59d	28.20	7.67d	7.91b	15.54b	49.07
V_1A_3	1.05cd	50.07cd	50.00	364.06f	27.93	7.37e	7.62cd	14.99c	49.14
V_2A_1	1.13a	54.20a	53.93	416.66a	29.63	8.39a	8.28a	16.67a	50.35
V_2A_2	1.09b	52.43b	52.40	385.90c	28.70	7.82c	7.72bc	15.55b	50.32
V_2A_3	1.06bcd	50.70c	50.37	376.91e	28.33	7.55de	7.45d	15.00c	50.35
V_3A_1	1.07bc	51.30bc	51.10	365.09f	24.77	5.26f	4.91f	10.17d	51.71
V_3A_2	1.04cd	50.27c	50.07	359.37g	24.10	5.14f	4.86f	10.00de	51.39
V_3A_3	1.01e	48.57e	48.37	354.27h	23.77	4.49h	4.39g	8.89f	50.56
V_4A_1	1.03de	50.37c	50.00	360.79g	24.53	4.88g	5.30e	10.18d	47.93
V_4A_2	1.02de	51.87bc	48.80	354.59h	23.90	4.91g	4.89f	9.81e	50.10
V_4A_3	1.00e	48.43e	48.17	350.07i	23.30	4.33h	4.54g	8.87f	48.84
Level of significance	0.01	0.05	NS	0.01	NS	0.01	0.05	0.01	NS
CV (%)	1.64	1.11	3.83	0.17	1.91	2.15	2.03	0.93	2.07

In a column figures having similar letter (s) do not differ significantly whereas figures with dissimilar letter (s) differ significantly as per DMRT.

V_1 : BARI maize3 — A_1 : One plant $hill^{-1}$
V_2 : BARI maize5 — A_2 : Two plants $hill^{-1}$
V_3 : Shuvra — A_3 : Three plants $hill^{-1}$
V_4: Barnali

The effect of planting arrangement on numbers of fertile cobs plot^{-1} was varied significantly (Appendix IV). Fertile cobs plot^{-1} was found the highest (51.94) in the treatment of one plant hill^{-1} . The lowest fertile cobs plot^{-1} was produced in the treatment of three plants hill^{-1} (49.23) (Table 5).

There was no significant combined effect of variety and planting arrangement on fertile cobs plot^{-1} (Appendix IV). However, numerically the highest fertile cobs plot^{-1} was found from BARI maize5 (53.93) with one plant hill^{-1} followed by BARI maize3 (52.73) with the similar planting arrangement (one plant hill^{-1}) and the lowest fertile cobs plot^{-1} was obtained from Barnali (48.17) with three plants hill^{-1} preceded by Shuvra (48.37) with the same arrangement (three plants hill^{-1}) (Table 6).

4.9 Number of grains cob^{-1}

Grains per cob varied significantly with variety (Appendix IV). BARI maize5 produced the highest number of grains cob^{-1} (393.16) and Barnali gave the lowest number of grains cob^{-1} (355.15) proceeded by Shuvra (359.58) (Table 4). Similar result was also reported by Annonymous (1988), He reported that Barnali produced lower number of grains cob^{-1} than other maize varieties.

Planting arrangement had significant influence on grains cob^{-1} (Appendix IV). The highest numbers of grains cob^{-1} (386.50) was found in one plant hill^{-1} followed by two plants hill^{-1} (370.86) (Table 5). On the other hand, the lowest numbers of grains cob^{-1} (361.33) was obtained from three plants hill^{-1}. Islam (1981) reported that number of grains per cob decreased with the increase in number of plants hill^{-1}.

The combined effect of variety and planting arrangement on grains cob^{-1} was statistically significant (Appendix IV). BARI maize5 produced the highest grains cob^{-1} (416.66) with one plant hill^{-1} followed by BARI maize3 (403.4) with one plant hill^{-1}. On the other hand, Barnali produced the lowest grains cob^{-1} (350.07) with three plants hill^{-1} preceded by Shuvra (354.27) with three plants hill^{-1} and Barnali with two plants hill^{-1} (354.59) (Table 6).

4.10 Weight of 100-grains

Significant differences were observed among the varieties in respect of 100-grain weight (Appendix IV). It was found that BARI maize5 produced the highest 100-grains weight (28.89 g) followed by BARI maize3 (28.32 g) (Table 4). The lowest 100-grains weight was produced by Barnali (23.91 g) which was statistically identical with Shuvra (24.21 g). SCA (1992) reported that highest 100-grain weight was obtained from Mohor and the lowest from Barnali. Similar result was also reported by Chowdhury and Islam (1993) which supported the results of the present study.

Statistically significant differences were observed among the planting arrangements in regard to 100-grain weight (Appendix IV). It was found that one plant hill^{-1} produced the highest 100-grains weight (26.94 g) followed by two plants hill^{-1} (26.23 g) (Table 5). The lowest 100-grains weight was produced by three plants hill^{-1} (25.83 g). This was supported by Vpawon and Anothai (1985). They reported that 100-grain weight decreased with increasing number of plants hill^{-1}. This is also supported by Sharma and Adamu (1984).

Weight of 100-grains was not significantly varied due to the interaction effect of variety and planting arrangement (Appendix IV). However, numerically the highest 100-grains weight was found from BARI maize5 (29.63 g) with one plant hill^{-1} followed by BARI maize3 (28.83) with the similar planting arrangement (one plant hill^{-1}) and the lowest 100- grains weight was obtained from Barnali (23.30 g) with three plants hill^{-1} preceded by shuvra (23.77 g) with the same planting arrangement (Table 6).

4.11 Grain yield

Grain yields of maize significantly varied among the varieties (Appendix IV). The highest grain yield (7.92 t ha^{-1}) was obtained from BARI maize 5 followed by BARI maize 3 (7.73 t ha^{-1}) and that of the lowest (4.71 t ha^{-1}) in the variety Barnali (Table 4). These varietal performances for grain yield were in conformity with those of SCA (1992) and Chowdhury and Islam (1993).

Various yield components as well as grain yield was strongly influenced by planning arrangement significantly (Appendix IV). In the study it was found that one plant hill^{-1} produced the highest grain yield (6.68 t ha^{-1}) statistically followed by two plants hill^{-1} (6.38 t ha^{-1}) (Table 5). The superior effect of one plant hill^{-1} might be attributable to reduce intra-hill competition of plants compared to two plants hill^{-1} and three plants hill^{-1}. Three plants hill^{-1} ranked the lowest for grain yield (5.94 t ha^{-1}) might be due to higher competition among the plants. This result however, does not support the idea of two plants and three plants hill^{-1} as reported by BARI (1989), but suggested that one plant hill^{-1} is a better planting arrangement for higher grain yield.

Interaction effect of different variety and planting arrangement on grain yield was statistically significant (Appendix IV). BARI maize5 produced the highest grain yield (8.39 t ha^{-1}) with one plant $hill^{-1}$ followed by BARI maize3 (8.19 t ha^{-1}) with the same arrangement (one plant $hill^{-1}$). On the other hand, Barnali produced the lowest grain yield (4.33 t ha^{-1}) followed by Shuvra (4.49 t ha^{-1}) with three plants $hill^{-1}$ (Table 6).

4.12 Stalk yield

The present study revealed the significant differences due to variety for stalk yield (Appendix IV). BARI maize3 produced the highest stalk yield (8.01 t ha^{-1}) followed by BARI maize5 (7.82 t ha^{-1}) (Table 4). Among the varieties the lowest stalk yield was produced by Shuvra (4.72 t ha^{-1}) preceded by Barnali (4.91 t ha^{-1}).

In the present study stalk yield was affected significantly by planting arrangements (Appendix IV). One plant $hill^{-1}$ produced the highest stalk yield (6.75 t ha^{-1}) followed by two plants $hill^{-1}$ (6.35 t ha^{-1}). Among the planting arrangement the lowest stalk yield was produced by three plants $hill^{-1}$ (6.00 t ha^{-1}) (Table 5).

Significant variation in the stalk yield was found in case of combined effect of variety and planting arrangement (Appendix IV). The highest stalk yield was found from BARI maize3 (8.50 t ha^{-1}) followed by BARI maize5 (8.28 t/ha) with one plant $hill^{-1}$. In contrast, the lowest stalk yield was obtained from Barnali (4.54 t ha^{-1}) preceeded by Shuvra (4.39 t ha^{-1}) with three plants $hill^{-1}$ (Table 6).

4.13 Biological yield

Biological yield of maize varieties was differed significantly (Appendix IV). It was observed from the present study that the highest biological yield was produced by BARI maize3 and BARI maize5 (15.74 t ha^{-1}) because grain yield and stalk yield of them are more. The lowest biological yield was produced by Barnali (9.62 t ha^{-1}) preceded by Shuvra (9.69 t ha^{-1}) (Table 4).

Planting arrangement had significant influence on biological yield of maize (Appendix IV). One plant $hill^{-1}$ produced the highest biological yield (13.43 t ha^{-1}) followed by two plants $hill^{-1}$ (12.72 t ha^{-1}), whereas, the lowest biological yield was produced by three plants $hill^{-1}$ (11.94 t ha^{-1}) (Table 5).

Significant variation in the biological yield was also found in case of combined effect of variety and planting arrangement (Appendix IV). The highest biological yield was found from BARI maize3 (16.69 t ha^{-1}) followed by BARI maize5 (16.67 t ha^{-1}) with one plant $hill^{-1}$ (Table 6). By contrast, the lowest biological yield was obtained from Barnali (8.87 t ha^{-1}) preceded by Shuvra (8.89 t ha^{-1}) with three plants $hill^{-1}$.

4.14 Harvest index

It is evident from the results of the present study that there was significant effect of varieties on harvest index of maize (Appendix IV). The highest harvest index was found in Shuvra (51.22 %) and the lowest in Barnali (48.96 %). BARI maize3 and BARI maize5 produced the statistically identical harvest index with the variety Barnali (Table 4).

Result showed that there was no significant variation in percentage of harvest index of maize due to the effect of planting arrangement (Appendix

IV). However, numerically the highest harvest index was found in two plant hill^{-1} (50.22 %) and the lowest harvest index was recorded from three plants hill^{-1} (49.72 %) (Table 5).

The combined effect of variety and planting arrangement showed no significant variation in respect of harvest index (Appendix IV). However, numerically the highest harvest index was obtained from Shuvra (51.71%) with one plant hill^{-1} statistically followed by two plant hill^{-1} (51.39%) in the same variety. On the other hand, the lowest percentage of harvest index was obtained from Barnali (47.93%) with one plant hill^{-1} preceded by three plants hill^{-1} in the same variety (Table 6).

4.15 Functional relationship between grain yield and yield contributing characters

4.15.1 Functional relationship between grain yield and cobs plant^{-1}

Regression analysis between grain yield and cobs plant^{-1} showed that grain yield had a positive relation with cobs plant^{-1}. Over 60% of the variation in grain yield could be explained by the variation in cobs plant^{-1} (Fig. 1).

4.15.2 Functional relationship between grain yield and grains cob^{-1}

Regression analysis between grain yield and grains cob^{-1} revealed that grain yield is highly dependent on grains cob^{-1} and over 76% (R^2 = 0.7696) of the variation in grain yield could be explained by the variation in grains cob^{-1} (Fig. 2).

4.15.3 Functional relationship between grain yield and weight of 100 grains

Plotting grain yield against weight of 100 grains yielded straight lines. This indicates that grain yield increased with the increment of weight of 100 grains. The value of R^2 (0.9898) revealed that over 98% of the variation in grain yield could be explained by the variation in weight of 100 grains (Fig. 3).

4.15.4 Functional relationship between grain yield and biological yield

Regression analysis taking biological yield as independent variable and grain yield as dependent variable showed a linear and positive relationship. This result indicates that over 99% of the variation in grain yield could be explained by the variation in biological yield (Fig. 4).

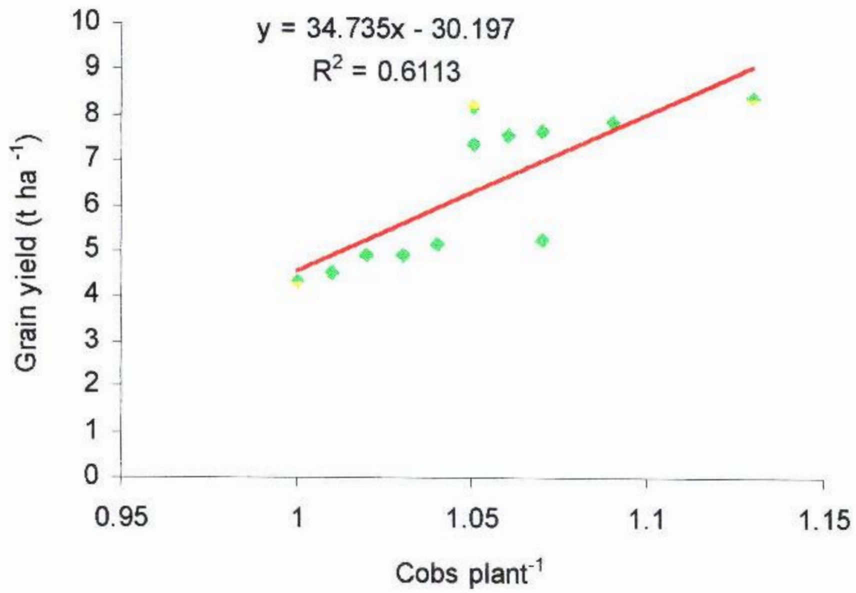

Fig. 1. Relationship between grain yield (t ha^{-1}) and cobs $plant^{-1}$

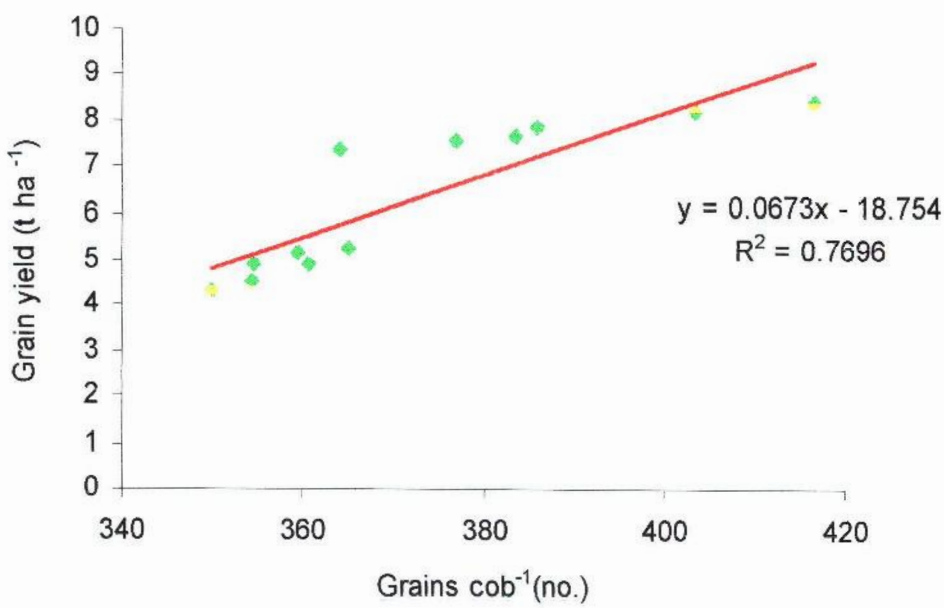

Fig. 2. Relationship between grain yield (t ha^{-1}) and grains cob^{-1}(no.)

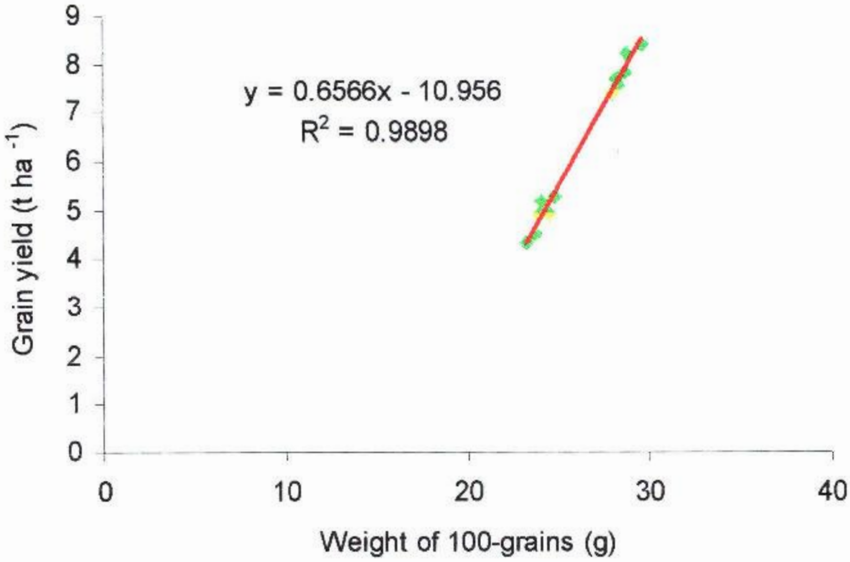

Fig. 3. Relationship between grain yield (t ha^{-1}) and weight of 100 grains (g)

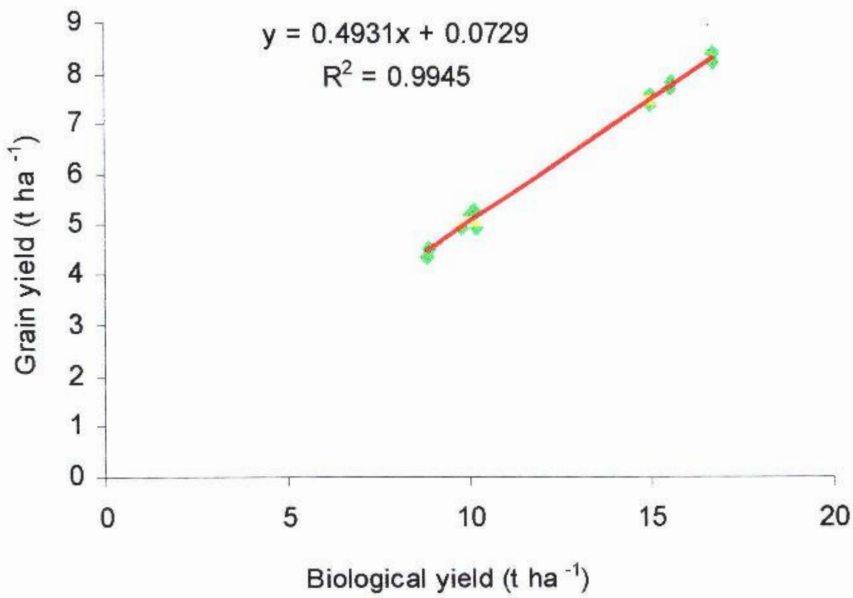

Fig. 4. Relationship between grain yield (t ha^{-1}) and biological yield (t ha^{-1})

CHAPTER 5

SUMMARY AND CONCLUSION

An experiment on the performance of winter maize varieties under different planting arrangements was conducted at the Agrotechnology Field Laboratory, Khulna University, Khulna, during the period from November 2006 to April, 2007. The study included four maize varieties viz. BARI maize3, BARI maize5, Shuvra and Barnali and three planting arrangements viz. one plant hill^{-1} (20 cm apart), two plants hill^{-1} (40 cm apart) and three plants hill^{-1} (60 cm apart) where row spacing was kept constant to 75 cm and block to block distance was 1.0 m. The individual plot size was 7.5 m^2. Two factors experiment was laid out in the Randomized Complete Block Deign (RCBD) with three replications. Land preparation and seeding were done in early November 2006 and fertilizers were applied as per BARI (1989) recommendations. Agronomic management practices were applied as and when necessary. The crop was harvested at maturity in April 2007.

It was evident from the study that variety, planting arrangements and treatment combinations exerted significant influence on plant height, length of cob, circumference of cob, rows of grains cob^{-1}, weight cob^{-1}, cobs plant^{-1}, grains cob^{-1}, 100-grain weight, grain yield, stalk yield, biological yield and harvest index.

The highest grain yield (7.92 t ha^{-1}), the maximum cobs plant^{-1} (1.09), fertile cobs plot^{-1} (52.24) and grains cob^{-1} (393.16) was produced by BARI maize5. On the other hand, lowest grain yield (4.71 t ha^{-1}), minimum cobs plant^{-1} (1.02) and grains cob^{-1} (355.15) was obtained from Barnali.

REFERENCES

Akhtar, M. I. and Mitra, B. N. 1990. Advanced yield trial on maize. Proc. 14th Ann. Bangladesh Sci. Conf., Bangladesh Assoc. Advt. Sci., Dhaka. p. 45.

Alam, M. F. and Qusem, A. 1987. Performance of some exotic white grain maize strains. Proc. 12th Ann. Bangladesh Sci. Conf. 1. p. 65.

Alessi, J. and Power, J. F. 1976. Response of an early maturity corn hybrid to planting date and population in the northern plains. Agron. J., 67 (6): 762-765.

Al-Younis, A. H. 1989. Effect of plant population and planting date on performance and yield of corn (*Zea mays* L.). Mesopotemia J. Agric., 21 (1): 7-17. (Cited from Maize Abst. 6(1): 28. 1990).

Amoruwa, G. M., Ogunlela, V. B. and Ologunde, O. O. 1987. Agronomic performance and nutrient concentration of maize as influenced by nitrogen fertilization and plant density. J. Agron. Crop Sci., 159 (4): 226-231.

Annonymous. 1987. Annual Reprot. Plant Breeding Division, Maize Section, Bangladesh Agril. Res. Inst., Joydebpur, Gazipur. p. 24.

Annonymous. 1988. Annual Reprot. Plant Breeding Division, Maize Section, Bangladesh Agril. Res. Inst., Joydebpur, Gazipur. p. 56.

Araujo, G. A., Silva, C. C., Vieira, C. and Chagas, T. M. 1983. Efeect of spacing between maize hills. Revista Ceres, 30(171): 394-397.

Babu, K. S. and Mitra, S. K. 1989. Effect of plant density on grain yield of maize during rabi season. Madras Agril. J., 75 (5): 290-292.

Baenziger, P. S. and Glover, D. V. 1980. Effect of reducing plant population on yield and kernel characteristics of Sugary-2 and normal maize. Crop Sci., 20: 444-447.

Bangarwa, A. S., Kairon, M. S. and Singh, K. P. 1988. Effect of plant density and, level and proportion of nitrogen fertilization on growth, yield and yield components of winter maize. Indian J. Agri. Sci., 58 (11):854-856.

BARI 1981. Ann. Rep. for 1977-78. Bangaldesh Agril. Res. Inst., Gazipur. p. 6.

BARI. 1989. Maize Cultivation. (In Bengali). Bangladesh Agri. Res. Inst., Gazipur. p. 14.

BARI. 1990. A Decade of Agronomic Research (1978-88). Div. Agron., Bangladesh Agril. Res. Inst., Gazipur. pp. 29-34.

BARI. 2005. BARI Hybrid MAize-3 and BARI Hybrid-5 Characteristics and Production System (In Bengali). Bangladesh Agril. Res. Inst., Joydebpur, Gazipur.

Barthakur, B. C., Nath, S. and Purkayastha, P. K. 1975. Effect of dates of sowing, rates of nitrogen and planting densities on grain yield of hybrid maize 'Ganga 11'. Indian J. Agron., 20 (3): 257-259.

BBS. 2002. Monthly Statistical Bulletin, Bangladesh Bureau of Statistics. March 2002. p. 48.

Begum, S. N. and Roy, A. K. 1987. Proc. 12th Bangladesh Sci. Conf. Sec. 1. p.58.

Bertic, B., Seput, M., Vukadinovic, V., Trogrlic, V. and Teklic, T. 1987. Response of maize hybrids to plant density. (In Serbo-Crotian). Agro-hemija. Pub. no. 4. pp. 243-250.

Berzsenyi, Z. 1988. Changes in the harvest index of maize (*Zea mays* L.) in relation to N fertilizer application, plant density and growing season. Nevenytermeles, 37(3): 229-238.

Borowiecki, J. 1986. Yield and quality of maize grown for single in relation to plant density and other agronomic factors. (In Polish). Pamietnik-Pulawaski. Pub. no. 87. pp. 195-202.

Chowdhury, U. R., Hossain, S. A., Jalal Uddin, M., Parh, D. K. Mitra, B., and Alam, M. S. 1989. A variety trial on promising composites of maize. Proc.11th Ann. Bangladesh Sci. Conf. Bangladesh Assoc. Advt. Sci, Dhaka. p. 100.

Chowdhury, M.K. and Islam, M. A. 1993. Production and uses of Maize. (In Bengali). Published On-Farm Research Division, Bangladesh Agricultural Research Institute, Joydebpur. pp. 1-189.

Chrzanowska, B. 1990. Cultivation of maize for grain corn in crop rotation on light soils. (In Polish). Zesyty-Naukowe-Akademii-Rolniczej-we-Wroclawiu-Rolnictwo, 199 (52): 31-42. Cited from Computer Search Service. BAU Lib. Mymensingh.

Desiderio, E., Cuocolo, L., Mariani, G. and Monotti, M. 1989. Effects of sowing date and plant density on yield of maize of different maturity groups, (In Italian). Infirmator- Agrario., 45 (14): 57-69.

Dhaif, A. 1984. Effect of plant population on some characters of different maturity of hybrids and synthetic of maize. J. Agric. And Water Resources (Iraq), 3(1): 37-46.

Donald, C. M. and Hamblin, J. 1976. the biological yield and harvest index of cereals as agronomic and plant breeding criteria. Adv. Agron., 28: 361-405.

Dong, P. Y. and Cheng, Y. N. 1995. A study on the factorial relationship between density and yield of maize. Beijing Agril. Sci., 13 (1): 23-25. (Cited from Maize Abst. 12 (3): 148. 1996).

Ekka, D., Shahni, M. N. and Srivastava, V. C. 1977. Effect of nitrogen levels, intra and inter row spacing on the yield of composite maize. Indian J. Agron., 22 (3): 196-201.

Elias, S. M., Ahmed, J. and Sikder, F. S. 1986. A prospective of winter maize in Bangladesh. An agro economic analysis. Bangladesh Agricultural Research Institute. Joydebpur, Gazipur. p. 26.

Elsahockie, M. M. 1977. Density, draught and depth effects on some agronomic trials of corn. Mexico Agril. Sci., Cited from Field Crop Abst., 31 (10): 629. 1978.

FAO. 1997. Production Yearbook. Food and Agriculture Organization, Rome, 51: 71-72.

Garcia-Solorio, M. and Ruiz-Vega, J. 1993. Evaluation of three maize varieties associated with beans under rain fed conditions in the central valleys of Oaxacal. Terra (Mexico), 11 (1): 100-105.

Gomez, K. A. and Gomez. A. A. 1984. Statistical Procedures for Agricultural Research. (2nd ed.). John Willy and Sons, New York. pp. 272-279.

Gutierrez, C. and Pedro. 1992. Evaluation of maize and sweet corn cultivars in response to variations of plant density in San Clements. Santiago (Chile).p. 119.

Hatch, M. D. and Slack, C. R. 1966. Photosynthesis by sugarcane leaves. A new carboxylation reaction and the pathway of sugar formation. Biochemistry Journal, 101 (7): 103.

Hoque, M. E. 1982. Effect of plant and row spacing on the yield of maize (In Bangladesh). Proc. 6th and 7th Bangladesh Sci. Conf. Bangladesh Assoc. Advt. Sci., Dhaka. p. 3.

Hoque, M. M. 1989. Farmers field trial of some advance composites of maize. Proc. 14th Ann. Bangladesh Sci. Conf. Sec. 1., p. 87.

Hsu, A. N. and Huang, S. C. 1984. Effects of plant density on yoeld and agronomic characteristics of maize in spring and autumn cropping seasons. Bull. Taichung District Agril. Improvement Sta. Pub. no. 9. pp. 13-21. Collected from Computer Search Service. BARC Lib. Dhaka.

Ignatova, A. 1974. The effects of plant density, fertilizers and irrigation on yields of maize grown on calcareous chernozem soil. New york Agril J. Cited from Field Crop Abst., 29 (6): 403. 1976.

Islam, S. 1981. Effect of plant density and planting arrangement on the yield and yield contributing characters of maize. M. Sc. (Ag) thesis. Department of Agronomy, Bangladesh Agricultural University. pp.29.

Islam, T. M. T. and Kaul, A. K. 1986. Prospects of maize in Bangladesh. FAO/UNDP Publication, Dhaka. pp. 13.

Jones, M. J. 1986. Maize population densities and spacing in Botswana. Tropical Agriculture (Trinidad and Tobago), 63 (1): 25-29.

Kamal, A. M. A., Chowdhury, B. L. D. and Islam, M. R. 1994. Studies on cereal yield, quality and soil productivity improvement. I. Yield, quality soil nutrient status and nutrient uptake. BAU Res. Prog., 8: 1-9.

Kamen, J. T. 1983. Plant density, maturity and prolificacy effects on maize production. Dissertation Abst., 44 (2): 3798.

Kayoed, G. O. and Agboola, A. A. 1981. Effect of different nitrogen levels, plant population and soil nutrient status on yield and yield components of maize (*Zea mays* L.) in different ecological zones of Nigeria. Fert. Res. (Netherlands), 2 (3): 177-191.

Khan, M. R. and Haque, M. M. 1989. Effect of spacing (population) and rates of nitrogen on the yield of maize under rainfed condition. Proc. 14th Ann. Bangladesh Sci, Conf. Bangladesh Assoc. Advt. Sci. Dhaka. p. 140.

Kholany, A. A. and Abdel-Aziz, M. 1986. Effect of plant population, nitrogen levels and harvesting time on grain yield and dry matter distribution in maize kernels. Bull. Faculty Agroc. Cairo-Univ. (Egypt), 37 (2): 613-624.

Khot, R. B. and Umrani, N. K. 1992. Seed and quality of African tall maize as influenced by spacing and level of nitrogen. Indian J. Agron., 37 (1) 183-184.

Kolkar, F. and Videnovic, Z. 1988. Effect of time of planting and plant density on the grain yield of some ZP hybrid of maize FAO maturity group 200. AhivZa-Poljopri-vredne-nauke (Yugoslavia), 49 (176): 309-320. Collected from_Computer Search Service. BAU Lib. Mymensingh.

Krisnamurthy, K., Bommegowda, A., Venugopal, N., Jagannath, M. K. and Prasad, T. V. R. 1977. Analysis of yield in composite maize. Current Research, 6 (9): 161.

Lapcevic, R. 1985. The influence of plant density and harvest time on quality and biological properties of maize hybrid seed. Novi sad (Yugoslavia). pp. 217-223.

Lima, T. and Lodi, N. V. 1982. Spacing and plant density per hill for maize in Acre (In Portuguese). Comunicado-Tecnico,-Unidade-de-Execucao-de-Pesquisa-de-Ambito-Estadual, Rio-Branco. No. 27. p. 3. Collected from Computer Search Service. BARC Lib. Dhaka.

Loesch, P. J. J., Stark, C. F. and Zuber, M. S. 1976. Effects of plant density on the quality of cobs used for corn cobs pipes. Crop Sci., 16 (5): 706-709.

Mannino, M. R., Tano, F. and Andreuceetti, U. 1987. Row spacing plant density of grain in maize. (In Italian), Part three. Information-Agrrio,43 (28): 93-95.

Mishra, C. M. 1993. Performance of maize (*Zea mays* L.) varieties of fertility levels under rainfed conditions of Madhya Prodesh. Indian J. Agron., 38 (3): 483-484.

Nadar, H. M. 1984. Maize yield response to row spacing and population densities under different environmental conditions. East African Agri. and Forestry J., 44: 157-165.

Nagy, M. 1982. Relationship between plot shape, plant density, leaf area index and yield in various maize hybrids. (In Hugarian), Debreceni-Agratudomanyi-Egytem-Tudomanyos-Kozlemenyei, 23:259-274.

Narayanswamy, M. R.,Veerabadran, V., Joyanthi, C. and Chinnuswammy, C. 1994. Plant density and nutrient management for rainfed maize in red soil. Madras Agril. J., 81 (5): 248-251.

Ogunlela, V. B., Amoruwa, G. M. and Ologunde, O. O. 1988> Growth, yield components and micro nutrient of field grown maize (*Zea mays* L.) as affected by nitrogen fertilization and plant density. Fert. Res., 17(2): 189-196.

Onn, L.C. 1988. Maximum yield research towards predicting high yields of maize in Malaysia. Proc. Symposium on maximum yield research, Nov. 16-18. 1988, New Delhi. India. (Cited from_Field Crop Abst. 43 (4): 305.1990).

Oppong, J. 1988. Effect of stand density on growth and yield of maize (*Zea mays* L.). Kumasi (Ghana). p. 45.

Osorio, F. O. 1976. Population effects on yield and other characteristic of maize in the E-1 Zamorano Valley, Honduras, Agril. J. (Cited from Field Crop Abst. 33 (2): 126. 1980).

Pande, R. C., Rajput, U. S., Tawari, R. C. 1971. Studies on the yield and yield componenets in different hybrids, composites and local variety of maize (*Zea mays* L.). Mysore J. Agri. Sci., 5 (2): 181-186.

Paradkar, V. K. and Sharma, R.K. 1993. Response of improved maize (*Zea mays* L.) varieties to nitrogen during the winter season. Indian J. Agron., 38 (4): 650-652.

Pestean, V. 1988. Influence of plant density and irrigation on the yield of severa maize hybrids under the condition of Moldavian plain. (In Romanian) Ceretari. Agronomice in Moldova, 21(3): 53-56.

Pissaio, A., Scholz, G. A., Yorinori, N. A., Possamal, E. and Daros, E. 1995. Grain yield of a maize hybrid grown at different densities. Mexican Agril Sci., (Cited from Field Crop Abst. 12 (3): 29. 1996).

Podolak, M. 1984. Effect of row spacing and other factors on silage maize cob yields. Pol'nohospodarstvo, 30 (12): 1077-1084.

Quayyum, M. A. and Raquibullah, S. M. 1986. Effect of plant spacing on growth and yield of five maize varieties. Abstract of papers of Bangladesh Soc. Agron. Ann. Conf. BARI. pp. 9-10.

Rahman. M. F. 1996. Effect of variety and planting arrangement on grain yield and protein content of maize. MS Thesis. p. 28.

Rashid, M. H. 1997. A study on grain yield and nutrient uptake in maize. MS Thesis. p. 25.

Rathore, D. M., Singh, K. and Singh, B. P. 1976. Effect of nitrogen and plant population on the yield attributes of maize. Indian J. Agric. Res., 10 (2): 79-82.

Rizzardi, M. L., Boller, W. and Dalloglio, R. 1994. Spacing of maize plants within row and its effects on yield component. Pesquisa Agropecua'ria Brailev'ra, 29 (8): 1231-1236. (Cited from_Field Crop Abst. 48 (6): 500.1995).

Rogers, I. S. and Lomman, G. J. 1988. Effect of plant spacing on yield, size and kernel fill of sweet corn (cultivars). Aust. J. Exptl. Agric., 26 (6):787-792.

Salontai, A., Muntean, L., Morar, G., Cernea, S., Carean, V., Petrusa, D. and Cotirla, V. 1985. Studies on the inter relationships between hybrids, plant density and fertilizer application in non-irrigated maize. (In Rumanian. Bul. Inst. Agron. Clu. Napoca, Agric. No. 39. pp. 33-38.

Sarvari, M. 1982. Relationship between optimum plant density and yield in maize hybrids on meadow soils. (In Hungarian). Debreceni-Agrartudomanyi-Eyetem-Tudomanyo-Kozlemenyei. No. 23. pp. 109-126.

Sawhney, J. S., Bhinder, S. S., Sidhu, M. S. and Narang, R. S. 1989. Agronomic practices for higher productivity in winter maize. Indian J. Agron., 34 (1): 24-26.

SCA and BARC. 1992. Characteristics of Crop Varieties Recommended by National Seed board. (In Bengali). Pub. by Seed Certification Agency (SCA) and Bangladesh Agril. Res. Council (BARC), Dhaka. No. 2. pp. 28-35.

Seed Certification Agency (SCA). 1992. Characteristics of crop varieties recommended by National Seed Board (In Bangla). Pub. by Seed Certification Agency (SCA) and BARC, Dhaka. No. 2. pp.24-36.

Senait and Dejene. 1992. Leaf removal and planting density effects on grain yield anmd yield components of maize (*Zea mays* L.). Ethiopian J. Agril. Sci., 13 (1-2): 1-8.

Shah, M. A. R., Islam, M. N. and Aziz, M. A. 1989. Effect of plant spacing and number of plant per hill on the yield of maize. Proc. 11^{th} –Ann. Bangladesh Sci. Conf. Bangladesh Assoc. Advt. Sci., Dhaka. p. 123.

Shah, W. A., Talukdar, M. A. H. and Abedin, M. Z. 1981. Performance of eight varieties of maize in Dinajpur districts. North-West Research Index, 2: 14-15. Bangladesh Agril. Bib., p. 17. 1983-1984.

Sharma, T. R. and Adamu, I. M. 1984. The effect of plant population on the yield and yield attributing characters in maize. New Delhi (India) Agril. J. (Cited from Maize Abst. 1 (4): 214. 1985).

Simenov, N. and Tsankova, G. 1990. Effect of fertilizers and plant density on yield of maize hybrids with two years. (In Bulgarian). Resteniev'dni-Nauki, 27 (8): 14-18.

Singh, D., Jain G. L. and Gupta, M. L. 1991. Effect of tracontanol based growth substances on production of rabi maize. Indian J. Agron., 36 (2): 267-272.

Singh, S. P., Gaur, B. L. and Shekhawat, A. S. 1992. Effect of cultivar, spacing and nitrogen fertilization on yield and nutrient uptake by maize (*Zea mays* L.). Ann. Agril. Res., 13 (3): 277-279.

Singh, S.N., Dayanand, R. N., Sharma, R. N. and Patil, R. R. 1980. Nitrogen requirement of maize under rainfed condition. Indian J. Agron., 25 (2): 2-7.

Srivastava, S. P. and Singh, A. P. 1975. Note on effect of two maize plants per hill and subsequently one plant on grain yield. Sci. and Cul., 41 (7): 316-317.

Sufian, M. A. and Abedin, M. Z. 1985. Effect of plant population and plants per hill on the growth and yield of sweet corn. Bangladesh J. Agric., 10 (2): 17-22.

Tano, F. 1986. Row spacing and plant density for grain maize, (In Italian). Informatorre- Agario, 42 (7): 147-149.

Tano, F., Mannino, M. R. and Aiello, F. 1987. Row spacing and plant density of grain maize (Part two), (In Italian). Infirmatore-Agrario, 43 (26): 59-61.

Tashkov, G. and Delchev, L. 1988. Studies on plant density of some maize hybrids grown in the upper Thracian plain. (In Bulgarian). Rasteniev'dni-Nauki, 25 (1): 13-17.

Tetio-Kagho, F. and Gardner, F. P. 1988. Response of maize to plant population density. I. Canopy development, light relationships and vegetative growth. Agron J., 80 (6): 930-935.

Thakur, C. 1980. Scientific Crop Production. Vol. I. Food. Crops. Metropolitan Book Co., New Delhi. pp. 145-185.

Truksa, J. and Zaborsky, J. 1983. Effect of spacing between rows on grain yield in selected hybrids of unirrigated and irrigated maize. (In Sluvakian). Rostlnna-Vyrova. 29 (8) : 865-874.

Vasic, G., Krzic, M. and Budimirovic, D. 1988. Effect of late planting on maize yield under irrigation. Savremena-Poljoprivreda (Yugoslavia), 36 (11-12): 509-516.

Vipawon and Anothai. 1985. Effects of plant density on yield and quality of sweet corn seeds. Res. Rep. 1985. Kasetsart Univ., Bangkok (Thailand). pp. 41-42.

Vivas, H., Moresco, R. and Gambaudo, S. 1988. Effect of nitrogen and plant density on maize production in eastern Argentina. Turrialba, 38 (2): 127-131.

Vukainovic, V., Seput, M., Bosnic, J. and Trogrlic, V. 1984. Hybrid and plant density as factors in the yield and chemical composition of maize grain (In Serbo-croatian), Znanost-i- Praksa-u- Poljoprivredi-i-. Prehrambenj-Tehnobgiji, 14 (3/4): 391-405.

Wahua, T. A. T. 1983. Nutrient uptake by intercropped maize and cowpeas and a concept of nutrient supplementation index (NSI). Expt. Agric., 19(3): 263-275.

Wilson, J. H. and Allison, J. C. S. 1978. Production and distribution of dry matter in maize following changes in plant population after flowering. Ann. App. Biol., 90 (1): 127-132.

APPENDICES

Appendix I: Physical and chemical characteristics of the experimental plot (0- 15 cm depth)

Sl. no.	Soil characteristics	Analytical data	Comment
1.	Textural class		
2.	P^H	6.2	Light acidity
3.	Salinity (ds m^{-1})	4.6	Slight
4.	Organic matter (%)	4.32	High
5.	Potassium (me / 100g soil)	0.46	Very high
6.	Total Nitrogen (%)	0.250	Medium
7.	Phosphorus (μg / g soil)	2.78	Very low
8.	Sulphur (μg / g soil)	251.03	Very high

Source: Soil sample analyzed from Soil Resource Development Institute, Regional Research Centre, Doulatpur, Khulna.

Appendix II: Monthly total rainfall, temperature and relative humidity during the growing period of maize from November 2006 to March 2007

Month	Temperature (°C) Monthly average		Rainfall (mm) Monthly total	Humidity (%)
	Maximum	Minimum		
November 2006	29.6	20.1	4	79.67
December 2006	26.9	15.0	Nil	79.33
January 2007	24.9	12.3	Nil	78.67
February 2007	27.6	16.9	54	77.67
March 2007	30.2	19.9	14	70.67

Source: Weather Department, Regional observation Centre, Gallamari, Khulna.

Appendix III. Analysis of variance of the data on growth characters of maize

Source of variation	Degree of freedom (df)	Mean square values				
		Plant height (cm)	Cob length (cm)	Circumference of cob (cm)	Rows of grains cob^{-1} (no.)	Weight cob^{-1} (g)
Variety (A)	3	3915.99**	1.16**	1.72**	5.26**	3044.97**
Planting arrangement (B)	2	144.03**	0.04	1.02**	0.13**	376.24**
A x B	6	7.62**	0.17*	0.34**	0.04**	61.19**
Error	22	1.10	0.06	0.05	0.00	0.58

** Significance at 1% level
* Significance at 5% level

Appendix IV. Analysis of variance of the data on yield contributing characters and yield of maize

Source of variation	Degree of freedom (df)	Mean square values			
		Cobs $plant^{-1}$ (no.)	Cobs $plot^{-1}$ (no.)	Fertile cobs $plot^{-1}$ (no.)	Weight of 100 grain (g)
Variety (A)	3	0.008**	19.64**	12.07*	62.57**
Planting arrangement (B)	2	0.005**	29.29**	25.53**	3.79**
A x B	6	0.001*	1.30**	1.91	0.039
Error	22	0.0003	0.32	3.80	0.25

** Significance at 1% level
* Significance at 5% level

Appendix IV. Continued

Source of variation	Degree of freedom (df)	Mean square values			
		Grain yield (t ha^{-1})	Stalk yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Variety (A)	3	26.95**	28.87**	111.08**	10.38**
Planting arrangement (B)	2	1.69**	1.67**	6.68**	0.91
A x B	6	0.078**	0.046*	0.194**	1.23
Error	22	0.019	0.017	0.014	1.06

** Significance at 1% level
 * Significance at 5% level