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EFFECT OF SEASONAL AND ENVIRONMENTAL VARIATION ON YIELD AND YIELD COMPONENTS OF HYBRID MAIZE

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Abstract

The experiment was conducted during kharif II in 2006 & 07, rabi in 2006-07 & 07-08 and kharif I in 2007 and 2008 at ARS, Burirhat, Rangpur in RCB design to understand the influence of season and location specific environment effect on growth and yield of hybrid maize and selected suitable variety(s). Four hybrid maize varieties V_1=BARI hybrid Maize (BHM)-2, V_2=BHM-3, V_3= BHM-5 and V_4= Pacific-984 (as check) were tested during kharif II in 2006 while seven varieties V_1= BHM-2, V_2= BHM-3, V_3= BHM-5 and V_4= Pacific-984, V_5= Pacific-60, V_6= Pacific-11 and V_7= Prolin were during the other seasons except rabi, 07-08, where variety Pacific-555 was used in V_7 instead of Prolin. Seeds were sown on August 30 and August 11 for kharif II of 2006 and 2007, respectively, November 28 and 17 for rabi 2006-2007 and 2007-08 and March 08 and 12 for for kharif I 2007 and 2008. The crops were harvested on January 25, 2007 and January 12, 2008 in the two consecutive kharif II seasons; May 10 and April 29 in rabi 2006-07 and 2007-08, and July 01 and 05 in kharif I 2007 and 2008, respectively. Yield parameters were mostly varied significantly. The highest yield was obtained from BHM-5 (9.03 t ha^{-1}), which was followed by Pacific-984 (8.89 t ha^{-1}), BHM-3 (8.81 t ha^{-1}) and BHM-2 (8.58 t ha^{-1}) in kharif II, 2006 while in kharif II, 2007 the highest significant yield was noted in Pacific-984 (9.22 t ha^{-1}). In rabi, 2006-07, significant highest grain yield was obtained from Pacific-60 (11.03 t ha^{-1}), which was statistically identical with Prolin (10.20 t ha^{-1}). The yield of Prolin was also statistically identical with Pacific-11 (10.01 t ha^{-1}), BHM-5 (10.00 t ha^{-1}), BHM-3 (9.92 t ha^{-1}) and BHM-2 (9.51 t ha^{-1}). Comparatively lower temperature during ear initiation (mean 29.6^{o}C in rabi and 31^{o}C in kharif II) and silking (mean 18.2^{o}C in rabi and 20.2^{o}C in kharif II) contributed much for higher trend of yield in rabi over kharif. In kharif I, 2007, the highest yield (9.55 t ha^{-1}) was recorded from Pacific-60, which was identical to Pacific-984 (9.25 t ha^{-1}), BHM-5 (9.11 t ha^{-1}) and BHM-3 (8.89 t ha^{-1}). All the BARI hybrid maize varieties were suitable to grown in kharif I, kharif II and rabi season although BHM-3, BHM-5, Pacific-60 and Pacific-984 were better in Kharif I and Pacific-60, BHM-5, Prolin and Pacific-555 were found better in Rabi season.

Keywords: Season, Environment, Yield, Maize

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Introduction

Among the cereals maize ranks 3rd position after rice and wheat. Maize can be grown throughout the year. High yield per hectare, high food value and multipurpose use as well as its high demand expanding maize cultivation day by day. There is a demand of 1.2 million tons of maize only to feed the poultry industries of Bangladesh (BARI, 2001). Again, for starch industries, other industries and for human consumption maize has a great demand. The yield of hybrid maize is about 20-30% higher than that of open pollination composite ones, which encouraged the farmers to prefer hybrid maize. Now, 87% of the total maize area is under hybrid maize. Recently BARI has developed 5 hybrid maize varieties. High quality protein maize (QPM) rich in tryptophen and lycin associated with recently evolved BARI hybrid maize-5 and other predominant BARI hybrid maize varieties along with other commercial hybrid maize varieties, the performance of the same across the seasons as well as across the locations is yet to be studied.

The environmental scientist working with maize have concluded from long term weather data that higher mean seasonal temperature was negatively correlated with grain yield and final grain yield was dependent on the rate and duration of grain growth and dry matter accumulation (BARI, 2001; Law and Brander, 1999). Increase in temperature decreased net photosynthesis and

optimum temperature ranged from 28^{0}C to 37.5^{0}C for higher photosynthesis (Brandner and Salvucci, 2002). Physiological parameter like NAR depends on temperature due to enzyme activity rubisco and at 28^{0}C rubisco oxygenase activity was 100% (Edwards *et al.*, 2001). However, the relationship among physiological parameters with the yield and yield components in three contrasting season has not been worked out in detail. The present investigation was carried out to understand the influence of season and location specific environment effect on growth and yield of hybrid maize and selected suitable variety (s) adaptive for specific areas.

Materials and Methods

The experiment was conducted during kharif II season of 2006 & 07, rabi in 2006-07 & 07-08, kharif I in 2007 at sandy loam soils of ARS, Burirhat, Rangpur following RCB design with 3 replications. The treatments included 4 hybrid maize varieties namely: V_1=BARI hybrid maize (BHM)-2, V_2=BHM-3, V_3= BHM-5 and V_4 = Pacific-984 (as check) in kharif II, 2006 and seven varieties viz. V_1= BHM-2, V_2= BHM-3, V_3= BHM-5 and V_4= Pacific-984, V_5= Pacific-60, V_6= Pacific-11 and V_7= Prolin in other seasons except rabi, 07-08 where variety Pacific-555 was used in V_7 instead of Prolin. Seeds were treated with Vitavex 200 @ 5 g kg^{-1} seed for 10 minutes in airtight bag then kept open. Blanket application of cow dung @ 10 t ha^{-1} was made 7 days before sowing. The field was fertilized with 200-60-110-45-5-2 kg NPKSZn and B/ha, respectively. One-third amount of N as Urea and rest full amount of all other fertilizer were applied in experimental unit plot one day before sowing. Seeds of different hybrids maize varieties were accommodated in 4.5 m × 6.0 m sized plot. Two seeds/hill were sown on August 30 and August 11 for kharif II, 2006 and 2007, respectively, November 28 and 17 for rabi 2006-07 and 07-08, and March 08 and 12 for kharif I, 2007 and 2008, at spacing 75 cm × 20 cm. Necessary gap filling were made by re-sowing within 8 days of sowing (DAS). Rest 2/3rd Urea in equal splits was top dressed (TD) at 30 and 60 DAS. Weeding and mulching were done properly; final earthling up was made after 2nd TD, which was followed by irrigation. Futher irrigation was made at 75 and 90 DAS. Despite that plant received about 405 mm and 554 mm of precipitation in kharif II 2006 and 2007 respectively. In rabi, the crop was irrigated 4 times at 60, 90, 110 and 120 DAS. The crop also received rainfall at 2nd decades of December and February, slight in the month of March and 3rd decade of April in rabi, 2006-07. The crop in kharif I was irrigated 4 times at 10 days interval starting form 25 DAE. The crop also received a total of around 880 mm rainfall in Kharif I, 2007. Diazinon 60 EC @ 2 ml L^{-1} of water was sprayed at 72 DAS. Guard was placed to avert bird (crow, parrot etc) damage. Minor variation about the maturity among the hybrid maize varieties was observed. The crops were harvested on January 25, 2007 and January 12, 2008 respectively for the two consecutive kharif II seasons of 2006 and 2007, May 10 and April 29 for rabi 2006-07 and 07-08, and July 01 and 05 for kharif I, 2007 and 2008.

Data on yield and yield components were taken properly, analyzed statistically and presented in tables 1 and 2.

Results and Discussion

Traditionally hybrid maize is sown either rabi or kharif I season. Here the hybrid maize varieties were grown during kharif II season. In lieu of sowing in August 30 if the crop could be sown on mid July. The crop could be received about 600 mm rainfall and also assumed to be harvested within November 2006. Dowswell *et al*. (1996) also opined that, in most tropical environments, maize requires 600-700 mm of moisture well distributed over the growing season. Forty five per cent of total maize area in the developing tropical countries of the world covers 36.7 million hectares. The environment is characterized by a high mean temperature (around 28^{0}C) during the growing season (FAO, 1988). They have a high mean maximum temperature (around 32^{0}C) and a high mean minimum temperature (around 22^{0}C). At Rangpur region of Bangladesh there prevailed mean high temperature (around 33^{0}C) and high mean minimum temperature (around 26^{0}c) during growing season of maize. Sultan (2006) opined that the temperature 24^0 to 30^{0}C is suitable for maize production. He also opined that fluctuation of the temperature results in fluctuation in field duration of maize.

Table 1.a . Performance of hybrid maize varieties during kharif II season of 2006 season at ARS, Burirhat, Rangpur

Treatments	Plant height (cm)	No. of leaves/ plant	Days to 50% tasseling	Days to 50% silking	Ear height (cm)	Cob length (cm)	No. of cobs/ plant	No. of seeds/ cob	1000 grain wt. (g)	Yield (t ha^{-1})
V_1=BHM-2	211a	14	62a	65a	101a	20.3a	1.20a	442b	325a	8.58
V_2=BHM-3	216a	13	61a	64a	96a	19.7a	1.10b	487ab	318a	8.81b
V_3=BHM-5	196ab	12	55b	61ab	80b	16.6b	1.29a	474b	298ab	9.03a
V_4=Pacific 984	186b	13	53b	57b	78b	19.7a	1.02b	540a	285b	8.89b
CV (%)	5.15	4.60	1.98	2.18	4.27	2.81	2.70	5.76	3.05	6.32

Means in a column having similar or no letter did not differ significant at 5% level of significance

Table 1.b. Performance of different hybrid maize during rabi season of 20006-07 at ARS, Burirhat, Rangpur

Treatment	Plant height (cm)	No. of leaves/ plant	Days to 50% tasseling	Days to 50% silking	Ear height (cm)	No. of cob/ plant	Cob length (cm)		No. of grain/cob		1000 grain wt. (g)		Yield (t ha^{-1})
							Pri.	Sec.	Pri.	Sec.	Pri.	Sec.	
T_1=BHM-2	252a	16.7a	109a	112a	145a	1.29ab	16.7ab	10.5	384d	209c	381ab	331b	9.51b
T_2=BHM-3	255a	15.3b	112a	114a	148/a	1.09cd	16.6ab	9.2	430c	218c	397a	322bc	9.92b
T_3=BHM-5	223b	14.9b	110a	112a	130b	1.32a	16.2b	10.5	441bc	258ab	348b	285c	10.00b
T_4=Pacific-984	211b	13.5cd	111a	113a	104d	1.03d	16.8ab	10.0	474ab	253b	360ab	290bc	9.67b
T_5=Pacific-60	250a	14.7bc	104b	107b	136b	1.13cd	17.9a	10.7	491a	266ab	375ab	372a	11.03a
T_6=Pacific-11	224b	14.7b	105b	107b	134b	1.21bc	16.8ab	10.3	417cd	280a	390a	303bc	10.01b
T_7=Prolin	225b	13.3d	104b	106b	113c	1.03d	15.5b	8.0	501a	198c	365ab	293bc	10.20ab
CV (%)	3.55	3.27	1.3	.88	3.13	3.98	3.15	11.09	2.93	5.78	3.66	7.16	4.92

Means in a column having similar or no letter did not differ significant at 5% level of significance

Table 1.c. Performance of different hybrid maize during kharif I season of 2007 at ARS, Burirhat, Rangpur

Treatment	Plant height (cm)	No. of leaves/ plant	Days to 50% tasseling	Days to 50% silking	Ear height (cm)	No. of cobs/ Plant	Cob length (cm)	No. of seeds/ cob	1000 seeds wt. (g)	Yield (t ha^{-1})
V_1=BHM-2	245.07a	15.80a	56.67a	58.67a	130.40a	1.08ab	17.66	396d	328.00a	8.47b
V_2= BHM-3	237.20a	13.87b	55.67ab	58.00ab	107.80b	1.08ab	18.84	430bcd	308.70ab	8.89ab
V_3= BHM-5	200.87b	12.47bc	54.33bcd	56.67abc	84.00bc	1.09a	17.36	460bc	294.00b	9.11ab
V_4=Pacific-984	213.93b	12.73bc	53.33cd	55.00c	85.73bc	1.05ab	16.93	531a	295.00b	9.25ab
V_5=Pacific-60	212.27b	12.87bc	54.00bcd	56.00bc	90.60bc	1.08ab	16.88	476b	322.20a	9.55a
V_6=Pacific-11	193.00b	12.80bc	53.00d	55.33c	92.33b	1.07ab	16.25	419cd	315.90ab	8.54b
V_7=Prolin	167.07c	11.80c	55.33abc	58.00ab	66.67c	1.02b	16.97	425bcd	306.90ab	8.49b
CV (%)	4.06	5.05	2.19	2.39	9.62	2.16	8.07	4.49	3.95	4.64

Means in a column having similar or no letter did not differ significant at 5% level of significance

All the parameters varied significantly in kharif II season except number of leaves/plant and yield in 2006-07 and days to 50% silking in 2007-08. The highest grain yield (9.03 t ha^{-1}) was associated with BARI hybrid maize-5 in 2006-07 while in 2007-08, the highest significant yield was noted in Pacific-984 (9.22 t ha^{-1}), which was statistically similar with other varieties except BHM-2 and Prolin (Table 1.a & 2.a). Yields by BHM-3 (8.30 t ha^{-1}), Pacific-11 (8.04 t ha^{-1}), Prolin (7.57 t ha^{-1}) and BHM-2 (7.47 t ha^{-1}) were also identical. Higher number of cob/plant, seeds/cob and 1000-grain wt. contributed to the higher yields.

Table 2.a. Performance of different hybrid maize during kharif II season of 2007 at ARS, Burirhat, Rangpur

Treatment	Plant height (cm)	No. of leaves/ plant	Days to 50% tasseling	Days to 50% silking	Ear height (cm)	No. of cobs/ Plant	Cob length (cm)	No. of seeds/ cob	1000 seeds wt. (g)	Yield (t ha^{-1})
V_1=BHM-2	248.80a	15.87a	60.33abc	62.33	126.93a	1.08ab	18.60a	421.00c	321.67a	7.47b
V_2= BHM-3	249.60a	14.33bc	61.67ab	63.67	134.00a	1.11a	18.44a	450.67bc	323.00a	8.30ab
V_3= BHM-5	238.47ab	14.80b	62.67a	63.67	129.73c	1.10ab	17.95ab	440.67c	310.00ab	9.01a
V_4=Pacific-984	215.20b	13.20de	60.00abc	62.33	101.73c	1.02c	18.63a	531.33a	311.00ab	9.22a
V_5=Pacific-60	234.33ab	14.00bcd	58.00c	61.00	123.07ab	1.04bc	16.29bc	476.00b	312.00ab	9.08a
V_6=Pacific-11	217.80b	13.53cde	57.33c	60.00	124.40ab	1.05bc	16.22bc	419.33c	300.00b	8.04ab
V_7=Prolin	216.77b	12.80e	59.00bc	61.67	107.67bc	1.01c	14.60c	427.00c	298.00b	7.57b
CV (%)	3.85	2.98	3.03	3.60	5.66	3.50	4.27	2.70	3.09	6.02

Means in a column having similar or no letter did not differ significant at 5% level of significance

Table 2.b. Performance of different hybrid maize during rabi season of 2007-08 at ARS, Burirhat, Rangpur

Treatment	Plant height (cm)	No. of leaves/ plant	Days to 50% tasseling	Days to 50% silking	Ear height (cm)	No. of cobs/ Plant	Cob length (cm)	No. of seeds/ cob	1000 seeds wt. (g)	Yield (t ha^{-1})
T_1 = BHM-2	203.33	14.57	106.00	108.00	104.53	1.13	16.78ab	423.00a	370.00ab	9.53b
T_2 = BHM-3	218.00	14.87	104.00	106.00	113.33	1.17	16.20bc	415.00a	343.33c	9.70b
T_3 = BHM-5	186.80	14.30	104.00	106.00	99.07	1.10	17.72a	414.33a	371.67ab	11.08a
T_4= Pacific-984	205.53	14.57	103.33	105.33	102.93	1.20	16.15bc	363.33b	351.67bc	9.72b
T_5 = Pacific-60	212.80	14.60	103.33	106.00	107.80	1.30	16.02bc	386.00ab	380.00a	11.10a
T_6 = Pacific-11	204.73	15.20	104.33	106.33	107.67	1.13	15.54c	356.67b	370.00ab	9.88b
T_7 = Prolin	219.07	15.03	103.67	106.00	115.60	1.13	16.11bc	391.67ab	360.00abc	10.00ab
CV (%)	5.18	3.84	2.12	3.14	9.50	8.57	3.45	4.52	3.60	6.03

Means in a column having similar or no letter did not differ significant at 5% level of significance

Table 2.c. Performance of different hybrid maize during kharif I season of 2008 at ARS, Burirhat, Rangpur

Treatment	Plant height (cm)	No. of leaves/ plant	Days to 50% tasseling	Days to 50% silking	Ear height (cm)	No. of cobs/ Plant	Cob length (cm)	No. of seeds/ cob	1000 seeds wt. (g)	Yield (t ha^{-1})
T_1 = BHM-2	230 a	14.93 a	56.16a	58.30ab	120a	1.12a	16.5	370b	330a	7.8b
T_2 = BHM-3	229 a	14.75 a	55.9a	59.03a	110ab	1.04b	17.0	375a	310b	8.6ab
T_3 = BHM-5	220 ab	14.30 bc	55.2b	57.10b	101b	1.08ab	16.8	415a	305b	9.0a
T_4= Pacific-984	225 a	14.70 ab	55.3ab	57.06bc	95b	1.10a	16.7	400ab	320ab	8.7ab
T_5 = Pacific-60	210 b	14.50 b	53.05c	55.48c	92b	1.09ab	16.7	398ab	340a	9.4a
T_6 = Pacific-11	217 b	13.86 c	56.52a	58.75a	125a	1.03b	16.4	372b	308b	8.3ab
T_7 = Pacific-555	215 b	14.60 b	53.80c	55.67bc	98b	1.10a	17.1	380ab	320ab	9.1a
LSD (0.05)	10.88	18.41	2.23	0.56	12.85	-	-	-	-	-
CV (%)	2.77	3.8	2.36	3.05	6.4	3.18	4.62	5.03	3.70	4.8

Means in a column having similar or no letter did not differ significant at 5% level of significance

Table 1.b revealed that, in rabi 2006-07, the yield and all the yield-contributing characters except secondary cob length were significantly varied. Significant highest cob length (17.9 cm) along with significant highest number of grains/primary cob (491), higher number of grains/secondary cob (266), significant higher 1000 grain wt. of primary cob (375 g) and highest weight (372 g) of secondary cob contributed much to pacific-60 for giving significantly highest yield (11.03 t ha^{-1}) which was statically identical to Prolin (10.20 t ha^{-1}). The yield of Prolin was also statistically identical with other hybrid maize. In rabi, 2007-08, cob length, number of seeds/cob, 1000 seed weight and yield were varied significantly (Table 2.b). Pacific-60 was also highest yielder (11.10 t ha^{-1}), which was identically followed by BHM-5 (11.08 t ha^{-1}) and Pacific-555 (10.00 t ha^{-1}) but significantly higher than the other varieties. Cumulative favourable effects of higher number of seeds/cob 386, 414.33 & 391.67 and higher 1000 seed weight 380, 371.67 & 360, respectively contributed much for higher yields in Pacific-60, BHM-5 and Pacific-555. The yield trend with hybrid maize during rabi season was comparatively higher than that of kharif II maize. This might be due to (about 40 cm) taller plant stand associated with rabi maize. Again, average 2 more number of leaves/plant was observed in rabi maize than kharif II. Longer period taken for days to 50% tasseling (around 108 days) and days to 50 % silking (around 111 days) in rabi, 2006-07 over kharif II maize (around 58 and 62 days, respectively). Comparatively lower temperature during ear initiation and silking of rabi maize (mean maximum around 29.6^{o}C and mean minimum around 18.2^{o}C) over kharif II maize (mean maximum 31^{o}C and mean minimum 20.2^{o}C) contributed much for higher trend of yield in rabi, 2006-07 over kharif II, 2007. Similar trend was also observed in the kharif II, 2008. BARI (2001) opined that increase in temperature decreased spikelet fertility and grain number was found to be dependent to temperature and radiation regimes during the period from ear initiation to silking.

In kharif I, all the parameters varied significantly except cob length in 2008. The highest yield in 2007 (9.55 t ha^{-1}) was recorded from Pacific-60, which was identical to Pacific-984 (9.25 t ha^{-1}), BHM-5 (9.11 t ha^{-1}) and BHM-3 (8.89 t ha^{-1}) but significantly higher than the rest varieties (Table-1.c). Except Pacific-60, all other varieties produced identical yield. Significantly, higher number of cobs/plant (1.08) and 1000 grain weight (322.20g) attributed to highest yield in Pacific-60. Similar trend was also observed in Pacific-984, BHM-5 and BHM-3 where either number of cobs per plant or number of seeds per plant alone or along with 1000-grain weight favoured the higher yield. Similar trend was observed in kharif I, 2008 where the highest yield (9.4 t ha^{-1}) was recorded from Pacific 60 identically followed by Pacific 555 (9.1 t ha^{-1}), BHM 5 (9 t ha^{-1}) BHM 3 (8.6 t ha^{-1}) and Pacific 11 (8.3 t ha^{-1}). BHM 2 produced significantly the lowest yield (7.8 t ha^{-1}).

Conclusion

All the BARI hybrid maize varieties including check (Pacific-984) can be grown in kharif I and kharif II season although BHM-3, BHM-5, Pacific-60 and Pacific-984 are better in Kharif I. Again, considering the performance during rabi season, all the varieties can be grown as their yields were either higher or identical to the check variety Pacific-984 although Pacific-60, BHM-5, Prolin and Pacific-555 were found better.

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