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EFFECT OF SEEDLING AGE AND VARIETY ON THE YIELD AND YIELD ATTRIBUTES OF TRANSPLANTED MAIZE

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ABSTRACT

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The experiment was conducted at the Regional Agricultural Research Station, Bangladesh Agricultural Research Institute (BARI), Jmalpur during 2002-2003 to select variety as well as to ascertain suitable seedling age for higher grain yield with reduced field duration. The treatments included in the experiments were three varieties viz. BARI maize-6, Pacific-11 and BARI hybrid maize-3 (BHM-3) assigned and six ages of seedling viz. 0 (direct seeded)-, 14-, 21-, 28-, 35- and 42-day old assigned. Seedlings were raised through mud cake nursery. Results revealed that the highest grain yields were obtained from both the varieties BHM-3 (7.88 t ha^{-1}) and Pacific-11(8.17 t ha^{-1}) while the lowest from BARI maize-6 (5.78 t ha^{-1}). Direct-seeded crop, and 14- and 21-day old seedlings produced the highest grain yields and beyond 21-day old seedlings grain yield reduced significantly. Effects of interaction of variety and age of seedlings showed that grain yield reduced gradually beyond 21-day old seedling in all varieties. Pacific-11 with 14-day old seedling produced the highest grain yield. Pacific-11 with 0- and 21-day old seedling, and BHM-3 with 0-, 14- and 21-day old seedlings also produced statistically similar grain yields to Pacific-11 with 14-day old seedlings. The lowest grain yield was obtained from BARI maize-6 with 42-day old seedling which was statistically similar to BARI maize-6 with 35-day old seedling and Pacific-11 with 42-day old seedlings. Yield attributes like length of cob, number of cobs m^{-2} and grains cob^{-1} reduced gradually with the increment of age of seedlings which in turn produced significantly reduced grain yield in all varieties. Field duration reduced by 8-10 days with 14-day old seedlings while 13-15 days with 21-day old seedlings compared to direct seeded.

Key words: Seedling age, variety, yield, transplanted maize

INTRODUCTION

Maize (*Zea mays* L.) is the top most ranking cereal in terms of higher grain yield and holds third position in respect of total production following wheat and rice in the world. It is nutritionally superior to most other cereals as it contains 9.0% protein, 3.4% fat, 1.1% ash, 1.0% starch fibre, 0.30% thiamine, 0.08% riboflavin and 1.9% niacin (Paliwal, 2000). In Bangladesh, maize is primarily used as feed for livestock and poultry, and a considerable portion of grains and green cobs is used for human consumption. The demand of maize is thus rapidly increasing day by day in the Bangladesh and even world wide. It is expected to be increased further with the establishment of maize-based food industries, and poultry, dairy and fish farms. This may lead to an enormous increase in maize import, which may result in depleting the hard-earned foreign currency. Hence, special emphasis should be given for increasing the indigenous maize production in order to fulfill the present demand as well as of the future. *Rabi* season is reported to be the best time for maize cultivation with the optimum time of planting ranging from mid November to end November in Bangladesh (BARI, 1997). Maize is generally grown after harvest of transplant *aman* rice and consequently, planting time gets delayed. In the *char* lands, the potential maize growing areas of Bangladesh, the lands attain '*joe'* condition in late after recession of flood water and thus, maize planting time goes beyond the optimum time. Grain yield reduces due to late planting as the crop experiences high temperature with the advancement of growth which reduces the duration for grain filling and dry matter accumulation resulting in small grain size (Thompson, 1986). Porwal and Jain (1999) stated that grain yield of maize reduced due to early and delayed plantings to mid November by 3.9 to 66.4%. Mohamed and Shams (1991) reported that grain yield of hybrid maize was affected less by late sowing than the synthetic and open pollinated varieties. Hence, planting time and choice of variety should be important considerations for its cultivation. In addition to reduced grain yield the late sown crops may experience natural hazards at the later stage of growth due to nor'wester. Again sowing of the following crops like jute, aus rice, mungbean, blackgram etc. may be affected by the late maize harvest. So, the development of an appropriate early plant establishment technique through agronomic management is essential for maize cultivation under these situations. Basu *et al.* (2003) opined that transplanting of 21-day old seedlings gave identical grain yield with direct sown crop and matured 8-10 days earlier. Maize crop could also be established much earlier through transplanting technique which may produce higher yield (Dale and Drennan, 1997a). Badran (2001) stated that under late planting conditions, transplanting of maize may be a possible alternative to direct sowing. Therefore, transplanting of seedling may be an important area of study for maize cultivation considering the field duration and early plant establishment under Bangladesh conditions. The present study was, therefore, carried

out to evaluate the performance of transplanting different ages of seedling of maize varieties considering yield, yield attributes and field duration against direct planting of seed.

MATERIALS AND METHODS

The experiment was conducted at the regional agricultural Research Agricultural Station, Jamalpur, during Rabi 2002-03. There were three varieties viz. BARI maize-6, Pacific-11and BARI hybrid maize-3 and six ages of seedling viz. 0 (direct seeded)-, 14-, 21-, 28-, 35- and 42-day old in the experiment. A split plot design with three replications was used assigning variety in the main plot and age of seedling in the sub-plot. The variety BARI maize-6 was a composite while the others were hybrids. Unit plot size was 5.25m x 3.5m. Planting of seed and seedling was done on 3 December 2002. Seedlings were grown in mud cake nursery. Mud cakes were prepared following the method used in Viet Num (Uy, 1996). The top soil of the nursery bed was made level first and banana leaves were put on the bed. Then clay materials prepared from soil aside of the bed were spread on the banana leaves up to 4-5 cm depth. When the mud almost dried out on the surface, it was cut into square pieces like cake with a sickle to have sizes of 5cm in length and 5cm in width using a scale in order to grow 14-day old seedlings. Variable larger sized cakes were thus made for growing more than 14-day old seedlings e.g. 6cm x 6cm for 21-day old seedlings, 7cm x 7cm for 28-day old seedlings, 8cm x 8cm for 35- and 42-day old seedlings. Sprouted seeds were placed at the centre of each mud cake and gently pressed with fingers so that the individual seed was sunk to a depth of about 1 cm. It was then covered with pulverized soil. Frequent watering was done to maintain proper growth and development of seedling. Seeds were planted on 21 October, 28 October, 4 November, 11 November and 18 November to reach 42-, 35-, 28-, 21- and 14-day old seedlings, respectively on 3 December. Irrigation and fertilization were done for direct planting of seed as per Razzaque *et al.* (2000). For transplanted crop, the timing of irrigation and fertilizer application was followed such way that their applications may be concurrent with the greatest need of the crop as per age of seedling. However, irrigation schedule was as follows.

i. For direct planting of seed: Four irrigations were given in total in direct sown crop at 20-25 days after planting (DAP), 35-40 DAP, 60-65 DAP, and 80-85 DAP.
ii. For transplanted crop: This crop was irrigated 4 times at transplanting, 20-25 DAP, 35-40 DAP and 60-65 DAP. As the seedlings were raised in the nurseries, its may attain different growth stages earlier. Hence, irrigation scheduling is different than that of direct planting.

Flood irrigation was given at all times and after irrigation, excess water was drained out as soon as possible. Irrigation was applied in the respective plots cautiously so that the neighbor plots did not receive any water through overflow of the boundary.

Fertilizer rates were as follows:

i. For composite variety (BARI maize-6): Fertilizers at the rate of 140-97-86-27-6-1.5 kg ha^{-1} N-P_2O_5-K_2O-S-Zn & B were applied as suggested by Razzaque *et al.* (2000) through urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boron, respectively for both direct and transplanted crop.
ii. For hybrid variety (Pacific-11 and BARI hybrid maize-3): Fertilizers at the rate of 248-117-120-40-6-1.5 kg ha^{-1} N-P_2O_5-K_2O-S-Zn and B were applied as suggested by Razzaque *et al.* (2000) through urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boron, respectively for both direct and transplant crop.

Fertilizer application methods were as follows:

i. For direct planting of seed: One-third N and all other fertilizers were applied as basal dose during final land preparation. The rest N was top dressed in 2 equal splits at 1^{st} and at 2^{nd} irrigation i.e. at 20-25 DAP and at 35-40 DAP, respectively (Razzaque *et al*., 2000).
ii. For transplanted crop: One-half N and all other fertilizers were applied as basal during final land preparation. The rest N was top dressed at 1^{st} irrigation i.e. at 20-25 DAP. Transplanted crops may attain different growth stages earlier and with reduced crop duration than direct planting. Hence, to supply N at proper stage as per requirement, it was applied in two split application.

Crop maturity of cob was determined when base (attachment to the cob stalk) of the grain attained the black layer (Kumar and Singh, 1999). Twenty plants were selected from each plot at maturity to record data on yield components. Yield was calculated on the basis of 10.5 m^2 harvest area. Grains of each plot were dried in the sun. A moisture meter (Grain Moisture Meter, Model TD-5, Ogawa Seiki Co. Ltd.) was used to determine the moisture content of grains and finally grain yield and 1000-grain weight were adjusted at 14% moisture content. Stover yield

was calculated including the well sun dried plant, cob husk and cob stalk (rachis). Harvest index was calculated following Khan *et al.* (1999). Data regarding days to silking, days to tasseling and field duration were not analysed statistically and are presented as mean values. Other data were analysed statistically using a computer package program Mstat-C and means were separated as per Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Days to silking, tasseling and field duration

BARI hybrid maize-3 (BHM-3) with direct seeding took maximum days to tasseling, days to silking and field duration. These characters decreased progressively in the transplanted crops with the increase of seedling age compared to direct-seeded crops in all varieties (Table 1). Field durations were 137, 131, 129, 122 and 115 days for 14-, 21-, 28-, 35- and 42-day old seedlings, respectively while 145 days for direct-seeded in BARI maize-6. Pacific-11 took 139, 136, 131, 124, and 114 days for 14-, 21-, 28-, 35- and 42-day old seedlings, respectively while 149 days for direct-seeded as field duration. In BARI Hybrid Maize-3, field durations were 139, 134, 132, 125 and 116 days for 14-, 21-, 28-, 35- and 42-day old seedlings, respectively while 149 days for direct-seeded maize. On average, field duration reduced than direct-seeded crop by 8-10 days in 14-day old seedlings and 13-15 days in 21-day old seedlings. Sencar *et al*. (1997) opined that transplanting different ages of seedlings (5-20-day old) showed preponed flowering and harvesting date. Direct planted plots harvested late by 21 days when the crops grown from 30-day old seedlings (Wyatt and Mullins, 1988). Sudipta *et al*. (2003) stated that transplanting of 21-day old seedlings had poorer vegetative growth, earlier flowering and maturation (8-10 days) than direct-seeded crop.

Table 1. Mean values of days to tasseling, days to silking and field duration of maize during *rabi* 2002-03

Interaction		Days to 50% tasseling	Days to 50% silking	Field duration (days)
Variety x Age of seedling (days)				
BARI maize-6	0	91.3	96.0	145.0
	14	85.3	88.3	136.7
	21	82.3	86.7	131.0
	28	75.0	80.0	128.7
	35	67.3	73.0	121.7
	42	61.7	67.0	114.7
Pacific-11	0	95.0	99.0	148.7
	14	89.3	94.7	138.7
	21	86.0	89.7	135.7
	28	75.3	80.3	131.0
	35	65.0	70.0	123.7
	42	50.7	56.3	114.3
BARI hybrid maize-3	0	102.0	105.3	149.0
	14	97.0	101.0	139.3
	21	94.0	97.3	134.3
	28	90.0	96.0	131.7
	35	84.0	85.7	124.7
	42	63.7	68.7	116.3

'0' indicates direct-seeded

Yield and yield attributes

Yield and yield attributes differed significantly while harvest index (HI%) did not among the maize varieties (Table 2). The results revealed that BARI Hybrid Maize-3 produced the tallest plant as well as highest length of cob which was significantly different from the others. The shortest plant and lowest length of cob were recorded from BARI maize-6 and it was also different from the others two. Pacific-11 produced the highest number of cobs m^{-2} and the variety BARI maize-6 had the lowest which was statistically similar to BARI Hybrid Maize-3. BARI Hybrid Maize-3produced significantly highest number of grains cob^{-1} compared to rest two varieties. BARI maize-6 produced the lowest which was also statistically different from the others. The highest and statistically similar 1000-grain weight was obtained from both the varieties Pacific-11 and BARI Hybrid Maize-3. BARI maize-6 gave the lowest 1000-grain weight. Finally, BARI Hybrid Maize-3 produced the highest grain yield followed by Pacific-11 irrespective of seedling age. Higher number of cobs m^{-2}, grains cob^{-1} and 1000-weight possibly attributed to produce higher grain yield in both the varieties, BARI Hybrid Maize-3and Pacific-11. The lowest grain yield was obtained from BARI

maize-6 as it had the lowest number of cobs m^{-2}, grains cob^{-1} and 1000-grain weight. BARI Hybrid Maize-3 gave the highest stover yield and it was significantly different from the others while BARI maize-6 produced the lowest. Harvest index ranged from 50.07% in BARI maize-6 to 51.89% in Pacific-11.

The results revealed that yield and yield attributes including harvest index studied in the experiment differed significantly due to variation of age seedling (Table 3). The tallest plant was recorded from direct seeded and it decreased gradually as the age of seedling increased. The shortest plant stature was found in 42-day old seedlings. The highest lengths of cob were produced in direct seeded, 14- and 21-day old seedlings. The lowest length of cob was recorded in 42-day old seedlings. Length of cobs decreased in more than 10-day old seedlings (Nakano, 2001). Statistically similar number of cobs m^{-2} was obtained from the crops of direct seeded and 14-day old seedlings. The highest number of cobs m^{-2} was found in direct seeded crop. It was also decreased with the increment of age of seedling and thus the lowest was obtained from the maximum age of seedlings of 42-day old. The highest number of grains cob^{-1} was obtained from 14-day old seedlings due to its higher number of grain rows cob^{-1} as well grains row^{-1}. Number of grains cob^{-1} in direct-seeded maize was statistically at par with 14-day old seedlings. A dramatic reduction occurred beyond 14-day old seedlings in respect of number of grains cob^{-1} and finally the lowest number was obtained from 42-day old seedlings, a result also reported by Dale and Drennan, 1997a). Significantly the highest and statistically similar 1000-grain weight was obtained from 28-, 35- and 42-day old seedlings while the lowest was obtained from the direct seeded and 14-day old seedlings. The nursery period for raising seedlings provides advancement in thermal time (not estimated in this study) which can affect grain-filling in transplanted maize (Dale and Drennan, 1997b). The highest grain yield was obtained from 14-day old seedlings which was statistically similar to both direct seeded and 21-day old seedlings. Grain yield decreased significantly beyond 21-day old seedlings and the lowest grain yield was obtained from 42-day old seedlings. Higher number cobs m^{-2}, number of grains cob^{-1} and 1000-grain weight might be the causative factors for producing higher grain yield in 14- and 21-day old seedlings, and in direct seeded. Ibrahim and Gopalasamy (1989) obtained that transplanted maize gave 14.7 and 11.5% higher grain yields in *kharif* and *rabi* seasons, respectively compared to direct seeding. Transplanted crop produced about 15.44% higher grain yield than that of direct seeding and grain yield decreased with the increase of seedling age (Badran, 2001). Better performance was found in 17-day old seedlings considering the grain yield compared to direct seeding (Oswald *et al*., 2001). Sudipta *et al*. (2003) stated that there was non-significant yield reduction in transplanted crops compared to direct-seedd. The results obtained in this experiment did not accord with the findings of Wyatt and Mullins (1988). Direct seeded produced the highest stover yield that was at par with 14-day old seedlings. A significant reduction was found in and onwards 21-day old seedlings compared to direct seeding regarding stover yield. Harvest index increased significantly with increased age of seedling. Harvest index ranged from 48.13% in direct seeded-crop to 52.48% in 42-day old seedlings.

Interaction effects of variety and age of seedling was found significant in respect of yield attributes like length of cob, number of cobs m^{-2}, number of grains cob^{-1}, 1000-grain weight and grain yield. There were no significant differences in terms of plant height, stover yield and harvest index (Table 4). The results revealed that the longest cob was produced by BHM-3 with direct-seeded crop. Lengths of cob obtained from Pacific-11 with direct-seeded maize, 14- and 21-day old seedling and BARI Hybrid Maize-3 with 14-, 21-d and 28-day old seedlings were statistically similar to BARI Hybrid Maize-3 with direct-seeded crop. The shortest cob was obtained from BARI maize-6 with 42-day old seedlings. The highest number of cobs m^2 was found in Pacific-11 with direct seeding and it was statistically similar to 14-day old seedlings of the same variety. The results showed that both 35- and 42-day old seedlings failed to produce cob in each and every plant in BARI maize-6 but in case of Pacific-11 and BARI Hybrid Maize-3, only 42-day old seedlings failed. The highest number of grains cob^{-1} was found in BARI Hybrid Maize-3 with direct-seeded which was similar to 14-day old seedlings of the same variety. There was a general trend that 1000-grain weight increased gradually in 14- to 28-day old seedlings and direct-seeded crop had comparatively lower values for all varieties. It might be due to lower number of cobs as well as grains cob^{-1} which might help to translocate more photosynthates in individual grain in transplanted crops. Stover yield variation was not significant but in general, it was reduced with the increase of seedling age in all varieties. There were no significant differences among direct-seeded, 14- and 21-day old seedlings in terms of grain yield in the respective varieties. The highest grain yield was obtained from Pacific-11 with 14-day old seedlings that was statistically at par with Pacific-11 with direct-seeded and 21-day old seedlings and BHM-3 with direct-seeded, 14-d and 21-day old seedlings. Interestingly, Pacific-11 with 28-day old seedlings gave statistically similar grain yield to Pacific-11 with direct-seeded crop but not with 14- and 21-day old seedlings. Similar facts were observed in BARI maize-6 but not in BARI Hybrid Maize-3. In BARI Hybrid Maize-3, although 28-day old seedling failed to produce statistically similar grain yield to that of younger seedlings and direct-seeded crop but it was statistically at par with Pacific-11 with 28-day old seedlings. A drastic reduction of grain yield was also recorded from the crops grown from more than 28-day old seedlings in all

varieties although in BARI Hybrid Maize-3, grain yield reduction was not so much higher as in BARI maize-6 and Pacific-11. All varieties produced the minimum grain yield with 42-day old seedlings and the lowest grain yield was obtained from the BARI maize-6 with 42-day old seedlings.

Table 2. Yield and yield attributes of maize variety during *rabi* 2002-2003

Variety	Plant height at harvest (cm)	Length of cob (cm)	Number of cobs m^{-2}	Number of grains cob^{-1}	1000-grain weight (g)	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	HI (%)
BARI maize-6	177.67 c	13.11 c	5.478 b	363.24 c	310.06 b	5.78 b	5.90 c	50.07
Pacific-11	186.32 b	14.32 b	6.164 a	403.67 b	318.65 a	7.88 a	7.30 b	51.89
BARI hybrid maize-3	198.29 a	16.17 a	5.632 b	450.38 a	319.30 a	8.17 a	7.90 a	50.99
Level of significance	**	**	**	**	*	**	**	NS
CV (%)	4.12	5.44	4.69	7.09	2.55	11.29	6.80	3.88

Figures in a column having no or similar letter(s) do not differ significantly while those with different letters differ significantly at 5% level of probability; * and ** denote differ significantly at 5% and 1% levels of probability, respectively; NS - Not significant at 5% level.

Table 3. Effects of age of seedling on the yield and yield attributes of transplanted maize during *rabi* 2002-2003

Age of seedling (days)	Plant height at harvest (cm)	Length of cob (cm)	Number of cobs m^{-2}	Number of grains cob^{-1}	1000-grain weight (g)	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	HI(%)
0	237.06 a	16.03 a	6.216 a	485.33 a	295.96	8.58 a	9.00 a	48.73 c
14	221.37 b	16.15 a	6.084 ab	492.89 a	307.52	8.92 a	8.86 ab	50.03 bc
21	212.12 c	15.82 a	5.930 b	454.11 b	311.20	8.79 a	8.37 b	50.98 ab
28	189.16 d	15.02 b	5.744 c	394.81 c	333.62	7.86 b	7.11 c	52.45 a
35	142.78 e	12.99 c	5.326 d	329.22 d	324.66	5.39 c	5.13 d	51.23 ab
42	122.09 f	11.20 d	5.247 d	278.22 e	323.06	4.13 d	3.73 e	52.48 a
Level of significance	**	**	**	**	**	**	**	**
CV (%)	4.86	4.99	3.36	5.07	4.30	6.42	7.50	3.20

Table 4. Effects of interaction of variety and age of seedling on the yield and yield attributes of maize during *rabi* 2002-2003

Interaction		Plant height (cm) at harvest	Length of cob (cm)	Number of cobs m^{-2}	Number of grains cob^{-1}	1000 grain weight (g)	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	HI (%)
Variety × Seedling age (day)									
BARI maize-6	0	227.13	14.25de	5.810e-g	452.65de	284.16f	6.84 de	7.82	46.89
	14	214.67	14.78cd	5.661f-h	457.33de	300.60ef	7.23d	7.70	48.39
	21	200.53	14.13de	5.613f-i	438.33ef	296.76ef	6.96de	7.45	48.31
	28	173.90	13.82de	5.492g-j	337.45h	335.94ab	6.27e	5.72	52.14
	35	130.67	11.75f	5.146j	264.00i	308.00c-f	4.02g	3.74	51.66
	42	119.13	9.95h	5.144j	229.67j	334.88ab	3.38g	2.96	52.99
Pacific-11	0	231.77	16.24ab	6.812a	466.67c-e	309.89b-f	9.51ab	9.56	49.94
	14	222.17	16.48ab	6.658ab	498.67bc	316.94a-e	9.92a	9.19	51.90
	21	214.20	16.44ab	6.456bc	438.67ef	319.73a-e	9.85a	8.61	53.32
	28	193.10	14.84cd	6.287cd	404.67fg	336.05ab	8.83bc	7.74	53.30
	35	1353.53	11.55fg	5.497g-j	340.33h	327.79a-d	5.27f	5.11	50.83
	42	121.13	10.38gh	5.276ij	273.00i	301.52ef	3.89g	3.59	52.07
BARI hybrid maize-3	0	252.27	17.58a	6.025de	536.67a	293.83ef	9.38ab	9.62	49.35
	14	227.27	17.20a	5.933ef	522.67ab	305.02d-f	9.62ab	9.68	49.80
	21	221.63	16.88ab	5.722e-g	485.33cd	317.11a-e	9.55ab	9.07	51.31
	28	200.47	16.39ab	5.454g-j	442.31e	328.86a-d	8.48c	7.87	51.91
	35	162.13	15.67bc	5.334h-j	383.33g	338.19a	6.86de	6.54	51.19
	42	126.00	13.28e	5.322h-j	332.00h	332.79a-c	5.11f	4.63	52.38
Level of significance		NS	**	**	*	*	**	NS	NS
CV (%)		4.86	4.99	3.36	5.07	4.30	6.42	7.50	3.20

Figures in a column having no or similar letter(s) do not differ significantly while those with different letters differ significantly at 5% level of probability; * and ** denote differ significantly at 5% and 1% levels of probability, respectively; NS - Not significant at 5% level; '0' indicates direct-seeded.

CONCLUSION

Maize seedling raised in mud cake may be established earlier after late harvest of T. aman rice. Direct seeded and transplanting of 14- and 21-day old seedlings produced similar grain yields but transplanting crops may be harvested about 8-15 days earlier than the crops of direct seeded. Thus the crops may scape the damage from natural hazards like storms and rains. The farmers' income may also be increased due to higher market price of maize grain for early marketing.

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