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GROWTH AND YIELD OF ADVANCED BREEDING LINES OF MEDIUM GRAIN RICE AS INFLUENCED BY DIFFERENT TRANSPLANTING DATES

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ABSTRACT

Rice plant was considered sensitive to heat stress especially during reproductive growth phase. Eight medium grain rice accessions: 999421, KSK 401, KSK 402, PK 7797-1-2-1, KSK 301, KSK 418, KSK 406 and KS 282 were sown on five different sowing dates: 16th April, 1st May, 16 May, 1st June and 16th June during summer seasons of three successive years from 2004 to 2006 to access their growth and yield performance under earlier, mid and late sown conditions. Experiment was laid out in split plot design. Accession × sowing date interaction remained significantly different for all traits studied. The differential yield response of accessions to various sowing dates was found to be due to their differential tolerance against high temperature stress at vegetative and reproductive growth phases. On an average, 12% and 9% reduction in paddy yield was obtained in sowing dates where heat stress coincided with reproductive and seedling growth, respectively. Paddy yield and number of grains panicle^{-1} increased with delay in sowing time up to 16th May whereas days to 100 % flowering, tillers hill^{-1} and plant height decreased with delayed sowing. Among yield components number of grains panicle^{-1} showed positive linear relationship (R^2=0.40) with paddy yield which means yield gains were attributed to higher number of grains panicle^{-1} rather than higher number of tillers hill^{-1}. Maximum number of grains panicle^{-1} and paddy yield of almost all rice accessions under mid sown conditions (16th May) seem to be associated with non-coincidence of their reproductive growth periods with heat stress as occurred in early sown conditions (16th April, 1st May).

Key words. Accession, Paddy, Reproductive, sowing dates, yield performance.

INTRODUCTION

In Pakistan, rice is the second most important cereal after wheat and a major source of foreign exchange earnings in recent years (GOP, 2011). However, yield per unit area of rice in Pakistan is much low compared to other nations as regarding yield per unit area, it occupies 30th position among 61 rice producing nations. Therefore, improvement in its yield while maintaining high quality is a long term goal in Pakistan. Choosing optimum date of plantation occupies an important part of high production package. Sowing dates have been shown to provide differential growth conditions such as temperature, precipitation and growth periods. Different author(s) reported the benefits of choosing optimum planting dates in rice (Habibullah *et al.,* 2007; Safdar *et al*., 2008) and in most of the cases, neither too early nor too late sowing proved to give better yield response by offering prolonged growth period while eliminating chances of heat stress during reproductive growth (Hassan *et al.,* 2003; Baloch *et al.,* 2006; Laborte *et al*., 2012).

Although sowing dates affect paddy yield by providing various environmental conditions, yet temperature is the key factor to be affected by sowing dates in medium grain rice. This is because, growth and yield of non-basmati rice is little or not affected by the other weather factors especially day length due to its non-photosensitive nature in contrast to basmati rice (Akhter *et al.* 2007). Different authors used different sowing dates to check contrasting temperature regimes in various summer crops including rice (Basal *et al.* 2009; Rauf *et al.* 2007; Rahman *et al.* 2004; Rahman *et al.* 2007; Safdar *et al*., 2008). They concluded that early sowing dates coincided with reproductive phase heat stress while late sowing helps to escape from heat stress. Therefore, early sowing is considered as the vector to reduce the growth and yield.

On the basis of these grounds, the present studies were planned to investigate the growth and yield response of various medium grain advanced breeding lines of rice to different sowing dates.

MATERIALS AND METHODS

Three years field study was conducted at Rice Research Institute, Kala Shah Kaku, Lahore, Pakistan during summer seasons of three successive years from 2004 to 2006. During each year, eight medium grain rice accessions viz. M_1 (99421), M_2 (KSK 401), M_3 (KSK

402), M_4 (PK 7797-1-2-1), M_5 (KSK 301), M_6 (KSK 418), M_7 (KSK 406), and M_8 (KS 282) were sown on five different sowing dates viz. D_1 (16th April), D_2 (1st May), D_3 (16th May), D_4 (1st June), and D_5 (16th June). Seed bed for nursery and field preparation both were prepared by conventional puddling method. Thirty days old seedlings nursery of all accessions was transplanted in field manually by different sowing dates.

According to design, sowing dates were kept in the main plots whereas accessions in the sub-plots. Each block was replicated thrice in a randomized complete block design (RCBD) with split plot arrangement. The net plot size was maintained as 2.25 x 6.75 m^2. While transplanting in field, row to row and plant to plant distance was kept 22.5 cm constantly.

During each year, the recommended doses of fertilizers, N, P_2O_5 and K_2O were applied @ 170, 100 and 62 kg ha^{-1}, respectively. Half dose of nitrogen with full doses of phosphorus and Potash were applied at the time of seed bed preparation while the other half of nitrogen were applied 30 days after nursery transplanting. $ZnSO_4$ (35%) was applied @ 12.5 kg ha^{-1} at 12 Days after Transplanting. The pre-emergence herbicide Machete 60EC @ 2 L ha^{-1} was applied just after fifth day of transplanting, however later appeared weeds were controlled manually.

Flowering data were recorded by visiting the field daily while yield and yield related parameters were recorded at maturity stage of each respective sowing date. They were then subjected to analyses using Fisher's analysis of variance technique and means were compared at 5 % significance level (Steel *et al*., 1997).

RESULTS

Data regarding all parameters taken during three successive years showed a similar trend; therefore we pooled them to get 3 year averages. Mean sum of square for yield and yield contributing traits are presented in table 2. Both factors; sowing dates and accessions were found significant ($P \leq 0.01$) for all traits. Variation due to accessions was the highest for traits like days to 100% flowering, 1000-grain weight, total panicle per plant and plant height while variation due to sowing date was the highest for paddy yield and grains per spike. Sowing dates × accessions was significant ($P \leq 0.05$) for all traits.

Days to 100% flowering which is an indicator of maturity time was found having decreasing trend in all accessions in case of delayed sowing, however when this trait was averaged across eight accessions seem to decline consistently from D_1 to D_5 (Figure 1). Accession M_7 took maximum number of days (99.1) whereas M_4 reached in to reproductive phase in shortest duration as its attained 100% flowering in 67.4 days only. The overall trend in plant height of almost all accessions seems to be downward as their sowing times were delayed (Figure 2). Rice accession M_4 gained maximum plant height in D_1 whereas M_2 produced smallest plants in D_5.

Data regarding tillers per hill are presented in figure 3. An overview of data revealed that most of the accessions decreased their tillers per hill with delayed sowing. However, M_6 reached up to its maximum tillering potential in D_4 sowing date. Among all accessions, M_2 achieved the highest number of tillers in D_1 whereas M_4 produced the lowest number of tillers in D_4 (Figure 3). Generally accessions showed increasing trends for grains per panicle (Figure 4) with delayed sowing reaching the maximum at D_4 thereafter declined. Accession M_7 showed the highest value for grains per panicle at D_3 whereas accession M_2 produced lowest number of grains when sown at D_1.

Variable response of rice accessions due to sowing dates was observed for 1000-grain weight (Figure 5). Accessions such as M_5, M_6, M_7 and M_8 showed increasing trend with delay in sowing until the highest peak was achieved at D_3. Contrastingly accessions M_1, M_2, M_3 and M_4 showed a consistent decline in 1000-grain weight in case of delayed sowing. Among all accessions, M_4 showed the highest 1000-grain weight at D_4 whereas M_6, the lowest 1000 grain weight at D_5.

Response of rice accessions to the sowing dates for paddy yield is presented in figure (6). Paddy yield means across eight accessions increased with the delay in sowing date until peak was achieved at D3. Individually, all the accessions responded differently to different sowing dates. This variation was the highest (3.7-5.4 t ha^{-1}) at sowing date D_3 whereas the lowest (3.7-4.5 t ha^{-1}) at sowing date D5. Accession M_1 showed the highest yield performance at D_1 and D_2 whereas lowest at D_5. The accessions M_2, M_3, M_4, M_5 and M_6 gave higher paddy

Table 1. Mean minimum and maximum temperature during various growth stages of rice over three years.

Growth Stage	15-Apr	1-May	15-May	1-Jun	15-Jun
	D1	D2	D3	D4	D5
Sowing – Transplanting	21-32°C	23-33°C	24-33°C	29-43°C	29-44°C
Transplanting - Spike initiation	28-40°C	29-40°C	27-40°C	28-40°C	28-39°C
Vegetative Phase	26-39°C	27-39°C	28-34°C	28-40°C	28-39°C
Reproductive phase	28-43°C	27-45°C	24-34°C	24-34°C	20-34°C

Table 2. Analyses of variance for paddy yield tones per hectare (PY) and yield contributing traits i.e. 100% flowering (100%F), 1000-grain weight (1000-GWT), grain per panicle (GPP), tiller per plants (TPP) and plant height (PH)

S.O.V.	d.f.	Mean Sum of Square					
		PY	100% F	1000-GWT	GPP	TPP	PH
Replication	2	2.15^{**}	46.25^{NS}	34.84^{**}	1552.68^{**}	9.75^{*}	442.47^{**}
Sowing date (S)	4	8.26^{**}	4641.44^{**}	10.80^{**}	4087.75^{**}	64.81^{**}	4422.90^{**}
$Error_a$	8	0.24	28.31	3.22	195.53	2.51	51.96
Accessions (A)	7	2.20^{**}	8119.08^{**}	163.44^{**}	3539.06^{**}	81.70^{**}	6062.49^{**}
S × A	28	1.32^{**}	109.91^{*}	10.80^{**}	1820.05^{**}	109.16^{**}	102.51^{**}
$Error_b$	71	0.12	24.77	2.48	96.53	2.53	37.04

Significant (P≤0.05); highly significant (P ≤ 0.01)

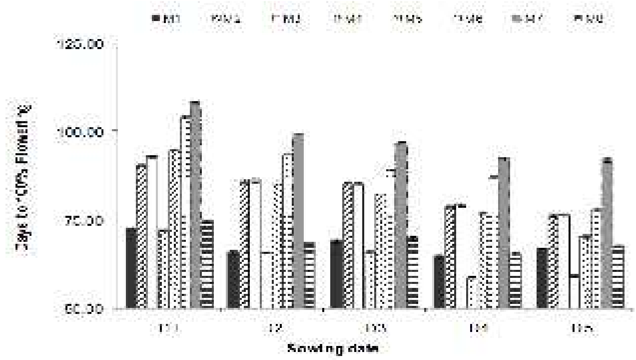

Fig 1. Effect of sowing dates on days to 100% flowering in various accessions of rice.

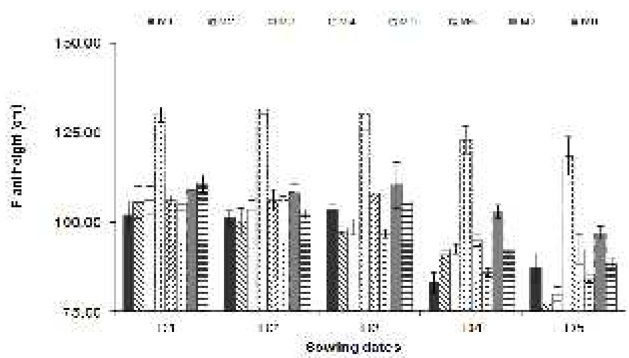

Fig 2. Effect of sowing dates on plant height (cm) in various accessions of rice.

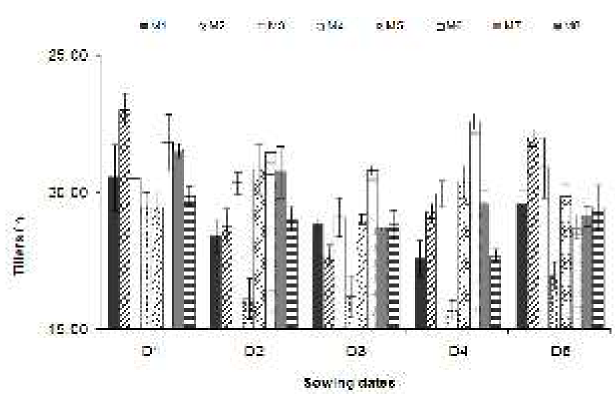

Fig 3. Effect of sowing dates on tillers per hill in various accessions of rice.

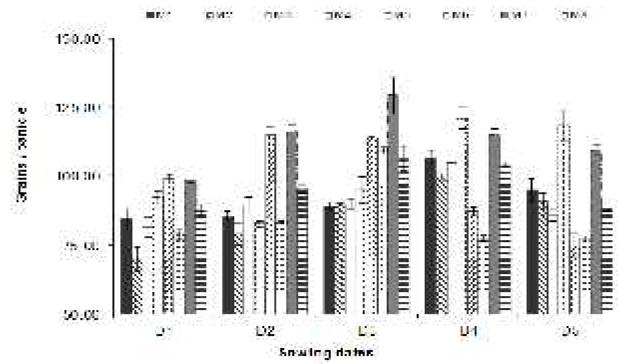

Fig 4. Effect of sowing dates on grains per panicle in various accessions of rice.

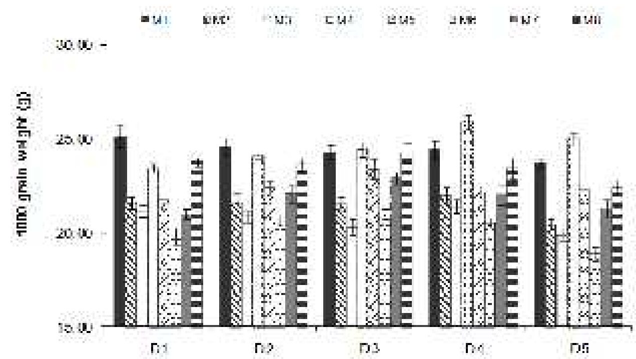

Fig 5. Effect of sowing dates on 1000-Grain weight (g) in various accessions of rice.

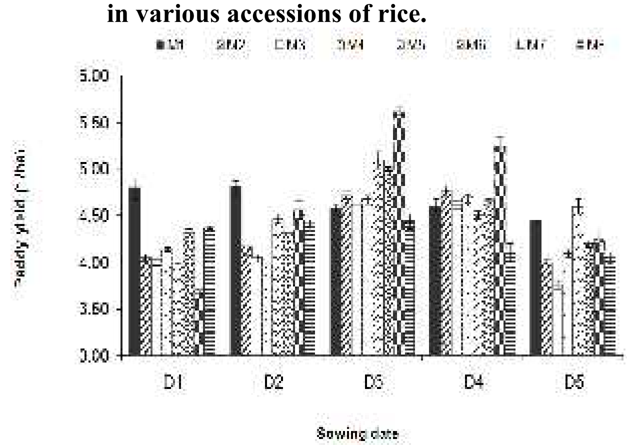

Fig 6. Effect of sowing dates on paddy yield in various accessions of rice.

yields at sowing dates D_3 and D_4. However these breeding lines fail to show good performance when sown on D_5. Accession M_7 achieved the highest paddy yield in D_3 sowing date whereas the lowest paddy yields at D_1 sowing date. However accession M_8 showed a consistent yield performance over sowing dates D_1 to D_3 sowing dates thereafter presented a declining trend.

DISCUSSION

Three year means of minimum and maximum temperature during various phonological stages are given in table 1. Mean minimum and maximum temperature prevailing during seedling stage increased with delay in sowing. Therefore, rice accessions sown earlier i.e. D_1 to D_3 completed their earlier growth cycle (germination to transplanting) under relatively lower temperature regime as compared to that experienced by later sown (D_4 and D_5) rice accessions. Contrastingly mean minimum and maximum temperature prevailing during reproductive phase increased with delay in sowing. That is why, first two sowing dates (D_1 and D_2) had relatively higher temperature during reproductive phase (anthesis to physiological maturity) compared with three later sowing dates i.e. D_3 to D_5 which had relatively lower temperature during reproductive phase. The result was that, accessions in sowing dates (D_1 and D_2) remained stress free during seedling stage but had to face heat stress during reproductive phase. On the other hand accessions kept under late sown conditions especially in D_4 and D_5 had heat stressed seedling stage but stress free reproductive phase. Accessions in sowing date D_3 enjoyed a favorable optimum temperature regime throughout growth period i.e. remained stress free during both vegetative as well as reproductive growth phases.

Sowing date showed significant interaction with accessions for all traits. It means that their growth and yield performance varied among different sowing dates. Several authors have shown significant interaction and benefits of choosing optimum date of sowing in rice (Gangwar & Sharma, 1997; Safdar *et al*., 2008; Khalifa, 2009). The differential response of accessions to sowing dates may be due to their differential tolerance for heat stress. For instance accessions M_1 and M_2 showed the highest paddy yield in earlier sowing dates (D_1 & D_2) where their reproductive stages faced heat stress whereas accession M_7 produced higher paddy yield in later sowing dates (D_3 and D_4) which remained free from reproductive heat stress. On an average 12% and 9% reduction in yield was obtained in sowing dates coinciding with reproductive and vegetative heat stress, respectively. Provision of heat stress at different growth stages through sowing a rice genotype at various dates is a valid technique to determine heat tolerance behavior in it (Rafiq *et al*., 2005; Ahmad *et al.,* 2006; Safdar *et al*., 2008).

Out of all yield contributing parameters, grains per panicle of almost all accessions showed a similar response to sowing date as shown by the paddy yield i.e. this yield component increased until D_3 or D_4 and then declined while days to 100% flowering, tillers per hill and plant height decreased with the delay in sowing. Days to 100% flowering represents vegetative growth duration of crop. Obviously rice, a photoperiod sensitive plant had to shift form vegetative into reproductive growth phase when entered into specific day length. That is why, late sown rice accessions reduced their growth duration. In the same manner, the other vegetative growth characters such as plant height and number of tillers per hill also declined with delayed sowing. On the other side, the reproductive growth characteristics such as grains per panicle was adversely affected by heat stress at reproductive phase therefore remained low in D_1 and D_2, the early sowing dates.

Therefore it may be concluded that paddy yield is more dependent upon number of grains per panicle rather than number of tillers per plant. This has been further confirmed by the highest positive linear relationship (R^2=0.40) of this trait with paddy yield as shown by regression analyses. Zahid *et al*., (2006), Awan *et al*., (2007), Noorka *et al.,* (2009) and Akhtar *et al.*, (2011) also attributed higher paddy yield in rice to more productive panicles rather than more tillers per plant. Similar results have been reported by Pal *et al.,* (1999), Hassan *et al.,* (2003) and Baloch *et al.,* (2006) who revealed that time of transplanting and number of seedlings hill^{-1} influenced most of the growth and yield related traits. Moreover, among transplanting dates, crop planted on during June gave higher paddy yield.

These findings lead us to the conclusion that sowing date of a rice accession should be adjusted such that its reproductive growth phase dose not coincide with high temperature stress as it results in lower number of grains per panicle and lower grain weight resulting in lower grain yield. Furthermore, these traits should be kept at priority while breeding for high yielder rice genotypes.

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