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Effect of Transplanting Dates on Cooking, Milling and Eating Quality Parameters of Some Fine and Coarse Grain Rice Lines

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Abstract

In order to elucidate the effects of transplanting date on milling, cooking and eating quality traits of nine coarse grain and ten fine grain *indica* rice lines under four sowing date treatments were studied. Results suggest that very early transplanting is more damaging to milling and cooking of both, fine as well as coarse grain rice lines as compared to delayed transplanting. Likewise, much delayed transplanting is more destructive for milling and cooking characters in case of fine grain rice lines as compared to coarse grain type rice lines. In case of studied fine grain rice genotypes, head rice recovery was observed maximum when translated at 18th of June. Similarly, cooked grain length was improved significantly in case of fine rice lines with delay in transplanting. Results suggest fine grain rice varieties to be transplanted before onset of July in order to have least broken rice in milled rice. Delayed sowing date, milling quality, total and head rice recovery, cooked grain length and bursting percentages showed different trend with respect to the rice lines. KSK 133 and Basmati 515 showed maximum head rice recovery among coarse and fine grain rice lines respectively. Likewise, PK 8785-1-1 and PK 8671-24-4-1-20 showed maximum cooked grain length among coarse and fine grain rice lines respectively.

Keywords: Milling; Cooking; Quality traits; Fine grain; Coarse grain; Rice lines

Introduction

Rice is an important food crop of world and feeds almost half of the world's population. Rice in Pakistan holds an extremely important position in agriculture and the national economy. Pakistan is the world's 11th largest producer of rice, after China, India, Indonesia, Bangladesh, Vietnam, Thailand, Burma, Philippines, Brazil and Japan. Rice is the second largest staple food crop and is also an exportable item. It accounts for 3.2% in the value added in agriculture and 0.7% of GDP. During July-March 2014-15, rice export earned foreign exchange of 1.53 billion USD. During 2014-15, rice was sown on an area of 2891 thousand hectares showing an increase of 3.6% over last year's area of 2789 thousand hectares. Rice recorded highest ever production at 7005 thousand tonnes, showing a growth of 3.0% over corresponding period of last year's production which was 6798 thousand tonnes (Economic Survey of Pakistan 2014-15). Rice is grown in all five provinces of Pakistan, its mainland is plain areas of Province Punjab. Pakistan stands among the leading exporters of rice in the world, and is known for its cooking quality i.e., longer grain length special taste and aroma, which can be produced nowhere else but in "Kallar Track" of Pakistan.

Kallar Track in an area in Punjab which includes District Sialkot, Narowal, Gujaranwala, Hafizabad, Shiekhupura and some part of District Lahore. Due to the presence of heavy clay soil enriched with calcium carbonate the trait of aroma can only be expressed in this soil. Pakistani basmati rice is a source of foreign exchange earning More than 1.36 million tonnes of rice worth 507 million USD were exported in the 2014-15 fiscal year (Ministry of Commerce Pakistan). Being an agrarian based economy, Pakistan's economic growth depends upon progress in agricultural research. In rice sector, there is only one known public sector rice research institution in Pakistan: Rice Research Institute, Kala Shah Kaku. While conducting research on rice many management practices are adopted to check the effect on its quality and production.

Transplanting date is a key factor which affects quality of basmati and coarse grain rice cultivars. To acquire higher paddy yield of better quality, coarse grain varieties may be transplanted from mid-June to early July. Pakistani farmers are demanding superior rice grain quality varieties for different reasons [1-3]. The of rice grain quality parameters includes many components such as appearance, cooking, milling and eating qualities. Among these, consumers often pay more consideration to appearance after cooking [4]. Genetic and environmental factors both confer great effect on rice grain quality, especially photo-periodism and temperature at the heading and doughing stage. There are increase chances of occurrence of chalky grain and reduction of the head rice ratio because of high temperature during the heading stage [5,6]. The optimum temperature to produce superior quality rice is about to be 25°C at the filling stage [7]. The reason for deterioration of rice quality is because of the high temperatures at grain filling and doughing stage adversely affect kernel development and reduce the carbohydrates in the plant, leading to a decrease in the head rice recovery as well as cooking traits [8-10].

The grain dimensions of both paddy and milled rice was affected by sowing and transplanting date. Bran percentage was significantly increased with late transplanting dates, however decrease in amylose content occur. Late transplanting dates affect the cooking time as it decrease the cooking time but increased the solid losses in gruel. Similarly late transplanting deteriorated the organoleptic features of cooked rice and had higher values for clearing and spreading [11]. Different rice varieties showed Significant variation in rice quality

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characters (head rice and brokens) tested under different transplanting dates [12]. For this reason, it is necessary to evaluate the performance and quality characteristics of rice cultivars/promising lines at different transplanting dates in order to measure the effect of high temperature and photo-sensitive during the ripening stage.

Material and Methods

Research study was carried out in Rice Technology section of Rice Research Institute, Kala Shah Kaku where grain shape, appearance, cooking, milling and eating quality traits of rice breeding material comprising of nine coarse grain and ten fine grain *indica* rice lines transplanted under four transplanting date treatments were studied. Physical characteristics include milling recovery (Brown Rice, Total Milled Rice and Head Rice percentages) and cooking quality (Cooked Grain Length and percentage of grains bursting upon cooking).

The objective of this experiment is to ascertain the optimum time (date) of transplanting for obtaining higher milling recovery and best cooking quality in advanced coarse grain rice lines. There were eight advance coarse grain lines and nine fine grain lines including two check varieties from each group of grain type transplanted at four different dates by the Agronomy Section of this institute. Transplanting dates were kept in the main plots while varieties/lines in sub plots. After harvesting from the field, paddy samples were cleaned, dried to 10% moisture content and milled in the Rice Technology Laboratory. The data on milling recovery and cooking quality of these lines were determined and compared with standard check variety of KSK 133 (coarse grain type) and Basmati 515 (fine grain type).

Results and Discussion

The main results showed that the effects sowing date and cultivars on the grain qualities were highly significant (Tables 1 and 2). Delayed sowing date, milling quality, total and head rice recovery, cooked grain length and bursting percentages showed different trend with respect to the rice lines (Figures 1-4). However, as depicted in Figure 1, in case of coarse grain rice lines, changing the translating dates had not significant effects on brown rice % and total milling recovery. However, head rice recovery was affected significantly due to different transplanting dates. As depicted in Figure 1, average HR% of all the studied coarse genotypes increased from 48.8% to 55.4%, 59.4% and 62.8% from D1, D2, D3 and D4 respectively. In case of fine grain type genotypes, the trend was same for BR and TMR as depicted in Figure 2. For HR%, average HR% increased up to D3 i.e., 54.3% at its maximum, and then decreased after further delaying translating to D4 as depicted in Figure 2. This trend shows that much delay in transplanting after 18th of June, fine grain type rice genotypes may result in more broken grains in final product after milling [13-25].

	BR (%)	TMR (%)	HR (%)	CGL (mm)	B (%)
D1	78.9	70.3	48.8	11.3	7.6
D2	79.7	71.2	55.4	11.6	4
D3	80.3	71.3	59.4	11.5	3.7
D4	79.9	72	62.8	11.6	4.4
S.D. (Mean)	± 0.589	± 0.698	± 6.016	± 0.141	± 1.806
Average	79.7	71.2	56.6*	11.5	4.925*
D1: 5th May; D2: 27th May; D3: 18th June; D4: 10th July					

Table 1: Averaged values of cooking, milling and eating quality parameters of some coarse grain rice lines as influenced by different transplanting dates.

	BR (%)	TMR (%)	HR (%)	CGL (mm)	B (%)
D1	78.8	68.7	41.3	12.4	15.5
D2	78.8	69.1	46.6	13.8	14.7
D3	79.9	70.6	54.3	13.9	6.1
D4	80	70.7	52.5	14.8	2.6
S.D. (Mean)	± 0.665	± 1.024	± 5.915	± 0.991	± 6.377
Average	79.4	69.8	48.7*	13.7	9.7**
D1 = 5th May; D2 = 27th May; D3 = 18th June; D4 = 10th July					

Table 2: Averaged values of cooking, milling and eating quality parameters of some fine grain rice lines as influenced by different transplanting dates.

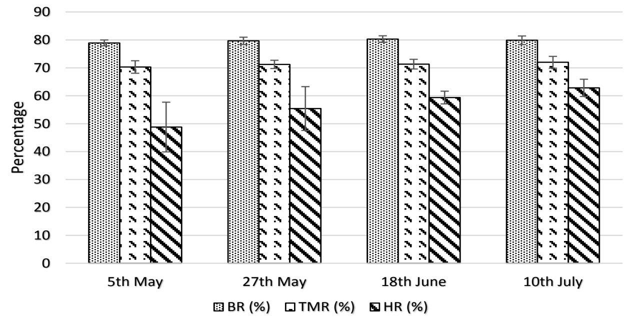

Figure 1: Changes in average brown rice, total milling recovery and head rice recovery percentages of coarse grain rice lines due to changing transplanting dates.

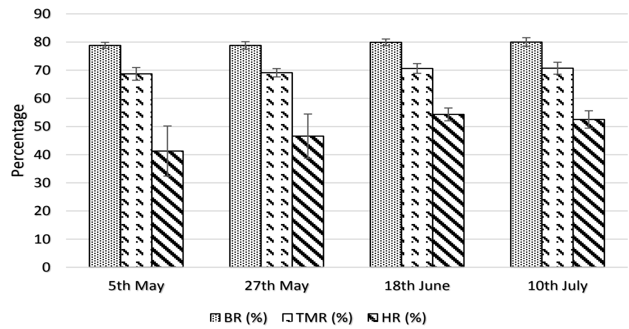

Figure 2: Changes in average brown rice, total milling recovery and head rice recovery percentages of fine grain rice lines due to changing transplanting dates.

As depicted in Figure 3, cooked grain length in coarse type rice lines remained nearly stable at all the dates. Cooked grain length increased whereas bursting percentage decreased in fine grain lines with delaying sowing date as depicted in Figure 4. However, in coarse type, bursting percentage decreased drastically and became stable after second date of transplanting. Brown rice percentage and total milling recovery were significantly different among different sowing dates with significant change.

The results in Table 3 shows that on average with respects to date, maximum brown rice (80.3%) was recorded at transplanting date of 18th August 2013 followed by date 10th August 2013 with 79.9% BR. Similarly, maximum TMR (71.3%) was observed transplanting date of 18th August 2013, followed by transplanting date of 27th May 2013. Maximum head rice of 62.8% was observed on transplanting date of 10th July 2013 followed by transplanting date of 18th August 2013 with 59.4% HR. With respect to average data of lines, maximum TMR% of 72.0% was observed for line KSK 469 followed by line PK 7688-1-1-2-2 with 71.9% TMR. Similarly, maximum HR% of 59.8% was observed for line KSK 474 followed by line PK 8785-1-1 with 58.2% HR which is below the HR% of standard check variety of KSK 133 with 62.0% HR.

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Date	5th May 2013			27th May 2013			18th June 2013			10th July 2013			Average		
Line/Variety	BR (%)	TMR (%)	HR (%)	BR (%)	TMR (%)	HR (%)	BR (%)	TMR (%)	HR (%)	BR (%)	TMR (%)	HR (%)	BR (%)	TMR (%)	HR (%)
PK 8785-1-1	78.5	72.5	59	78	69.5	56.7	81	72	58	81	73	59	79.6	71.8	58.2
KSK 474	78	71	52.6	78	70.5	63	81	73	62	77	68	61.5	78.5	70.6	59.8
PK 7688-1-1-2-2	77.4	68.2	46.3	80.1	71.8	51.3	81	73.6	60.5	81	74	65	79.9	71.9	55.8
KSK 469	80	70	33.7	81	73	64.5	80	71	59	81	73	68	80.5	71.8	56.3
KSK 133 (check)	80	73	63	81	73	60	81	72	61.5	81	73	65	80.8	72.8	62.4
KSK 434	80	72	48	80	73	62	78	69	61	81	74	65	79.8	72	59
KSK 462	78	66	42	78	70.7	45.1	80	71	60	79	72	59	78.8	69.9	51.5
KSK 463	80	71	51	80.9	69.6	42.8	79	72	55	80	72	61	80	71.2	52.5
KSK 464	78.3	69	43.5	80	70	53.3	81.7	68.3	57.3	78	69	62	79.5	69.1	54
S.D. (Mean)	± 1.07	± 2.25	± 8.90	± 1.31	± 1.48	± 7.85	± 1.17	± 1.73	± 2.26	± 1.53	± 2.12	± 3.08	-	-	-
Average	78.9	70.3	48.8**	79.7	71.2	55.4**	80.3	71.3	59.4*	79.9	72	62.8*	-	-	-

BR: Brown Rice; TMR: Total Milled Rice; HR = Head Rice

Table 3: Brown rice, total milling and head rice recovery of different coarse grain rice lines.

Date	1st June 2013			23rd June 2013			14th July 2013			5th August 2013			Average		
Line/Variety	BR (%)	TMR (%)	HR (%)	BR (%)	TMR (%)	HR (%)	BR (%)	TMR (%)	HR (%)	BR (%)	TMR (%)	HR (%)	BR (%)	TMR (%)	HR (%)
PK 8660-13-3-1	80	67.5	42	78	68.5	50.5	80	71	51	81	71	52	79.8	69.5	48.9
PK 8662-12-2	78	68	44	79	71.5	55.5	81	74	57	80	70	64.5	79.5	70.9	55.3
Basmati 515	80	72	62	81	74	65	81	68	64	81	74.5	63	80.8	72.1	63.5
PK 8662-20-1-1-1-1	80	71	55.5	78	69	58	81	73	61	81.5	74.5	63.5	80.1	71.9	59.5
PK 8971-24-3-1-19	78	68	35.5	78	68.5	35	81	74	57	80	70	55	79.3	70.1	45.6
PK 8671-24-4-1-20	78.5	68	32.5	80	68	43	80	71	50	79.5	68	38	79.5	68.8	40.9
PK 9118-2-3-1-18	78	68	38	78.5	68	38	79	69.5	47	79	70	48	78.6	68.9	42.8
PK 10052-1	78.5	68	29	78	67	44.5	79	68	50	79	69	35	78.6	68	39.6
EF-1-20-52-04	78.5	68	34	79	68	35	79	69	50	79	71.5	61	78.9	69.1	45
EF-1-30-39-04	78	68	40	78	68.5	41	78	68	56	80	68	45	78.5	68.1	45.5
S.D. (Mean)	± 0.89	± 1.52	± 10.36	± 1.03	± 2.07	± 10.30	± 1.10	± 2.43	± 5.53	± 0.91	± 2.32	± 10.78	-	-	-
Average	78.8	68.7	41.3**	78.8	69.1	46.6**	79.9	70.6	54.3*	80	70.7	52.5**	-	-	-

BR: Brown Rice; TMR: Total Milled Rice; HR: Head Rice

Table 4: Brown rice, total milling and head rice recovery of different fine grain rice lines.a

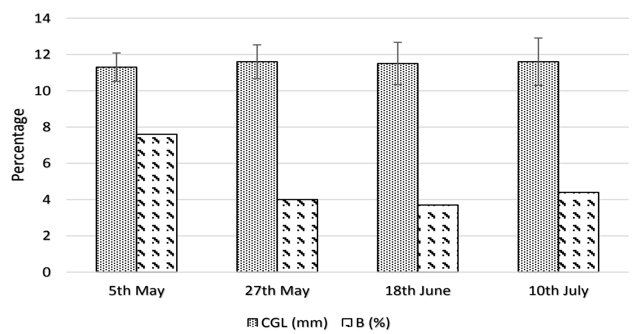

Figure 3: Changes in average cooked grain length and bursting percentages of coarse grain rice lines due to changing transplanting dates.

However, overall line KSK 474 give better result in milling recovery as discussed above.

The Table 4 shows that on average with respect to date of transplanting, maximum brown rice (80.0%) and maximum total milled rice (70.7%) were recorded at transplanting date of 5th August 2013 followed by date 14th July 2013 with 79.9% BR, 70.6% TMR. In similar way, maximum Head Rice (54.3%) was recorded at transplanting date of 14th July 2013 followed by 5th August 2013 with 52.5% HR. Taking average data with respect to lines, maximum TMR (71.9%) was observed for line PK 8662-20-1-1-1-1 followed by line PK 8971-24-3-1-19 with 70.1% TMR. Similarly on average, maximum HR% of 59.5% was observed for line PK 8662-20-1-1-1-1 followed by line PK 8662-12-2 with 55.3% HR. However, this HR% was less than that of our check variety Basmati 515 with 64.5% HR. Individually, maximum HR% of 64.5% was observed for line PK 8662-12-2 on 5th August 2013 followed by line PK 8662-20-1-1-1-1 with 63.5% HR at the same transplanting date. Overall, best milling recovery was observed at transplanting date of 14th July followed by 5th August. None of the under-experiment lines exceeded the check variety of Basmati 515 in terms of milling recovery; however lines PK 8662-12-2 and PK 8662-20-1-1-1-1 gave better results in milling recovery as discussed above [26-30].

The Table 5 shows that on average with respect to date of transplanting, maximum cooked grain length of 11.6 mm with minimum bursting percentage of 4.0% was recorded for transplanting date 27th May 2013 followed by transplanting date 10th July 2013 with 11.6 mm CGL and 4.4% bursting. On average data with respect to lines/variety, maximum CGL of 12.9 mm was observed for line PK 8785-1-1 with 5.0% bursting followed by line PK 7688-1-1-2-2 with 12.8 mm CGL and with 1.5% bursting which is also a minimum. Individually, maximum CGL of 13.6 mm with 5.0% bursting was recorded for line

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Date	5th May 2013		27th May 2013		18th June 2013		10th July 2013		Average	
Line/Variety	CGL (mm)	B (%)	CGL (mm)	B (%)	CGL (mm)	B (%)	CGL (mm)	B (%)	CGL (mm)	B (%)
PK 8785-1-1	12.5	10	13	3	12.8	2	13.4	5	12.9	5
KSK 474	10.2	4	10.5	2	10.4	5	10.2	6	10.3	4.3
PK 7688-1-1-2-2	12	4	12.6	0	13.2	0	13.2	2	12.8	1.5
KSK 469	11	6	11.4	2	10.6	6	12	4	11.3	4.5
KSK 133 (check)	12.2	8	12.5	2	12.8	4	12.7	6	12.6	5
KSK 434	11.2	6	11.5	7	11.8	5	11.7	5	11.6	5.8
KSK 462	11.2	12	11.3	7	11.3	5	11.2	8	11.3	8
KSK 463	11.1	13	10.8	6	10.6	4	10.7	1	10.8	6
KSK 464	10.4	5	10.5	7	10.2	2	9.7	3	10.2	4.3
S.D. (Mean)	± 0.783	± 3.395	± 0.933	± 2.739	± 1.168	± 1.936	± 1.309	± 2.186	-	-
Average	11.3*	7.6**	11.6*	4.0**	11.5*	3.7**	11.6*	4.4**	-	-

CGL: Cooked Grain Length; B: Bursting Upon Cooking

Table 5: Cooked grain length and bursting parameters of different coarse grain rice lines.

Date	1st June 2013		23rd June 2013		14th July 2013		5th August 2013		Average	
Line	CGL (mm)	B (%)	CGL (mm)	B (%)	CGL (mm)	B (%)	CGL (mm)	B (%)	CGL (mm)	B (%)
PK 8660-13-3-1	12.3	3	14.2	2	14.8	2	15.3	1	14.2	2
PK 8662-12-2	11.6	9	13.8	8	13.6	8	14.2	4	13.3	7.3
Basmati 515	12.2	8	14.6	7	15	4	15	5	14.2	6
PK 8662-20-1-1-1-1	12	10	13.4	13	13	12	15.5	0	13.5	8.8
PK 8971-24-3-1-19	12.7	9	14	10	14	4	14.6	4	13.8	6.8
PK 8671-24-4-1-20	13.2	3	15	3	15	0	16.7	0	15	1.5
PK 9118-2-3-1-18	12.5	1	13.5	8	14.3	7	15	4	13.8	5
PK 10052-1	12.6	7	13.1	6	13.8	4	14.5	1	13.5	4.5
EF-1-20-52-04	12.3	60	13	50	12.7	14	13.5	3	12.9	31.8
EF-1-30-39-04	12.5	45	13.8	40	13	6	13.5	4	13.2	23.8
S.D. (Mean)	± 0.428	± 20.04	± 0.636	± 16.446	± 0.853	± 4.332	± 0.960	± 1.897	-	-
Average	12.4	15.5	13.8	14.7	13.9	6.1	14.8	2.6	-	-

CGL: Cooked Grain Length; B: Bursting upon cooking

Table 6: Cooked grain length and bursting parameters of different fine grain rice lines.

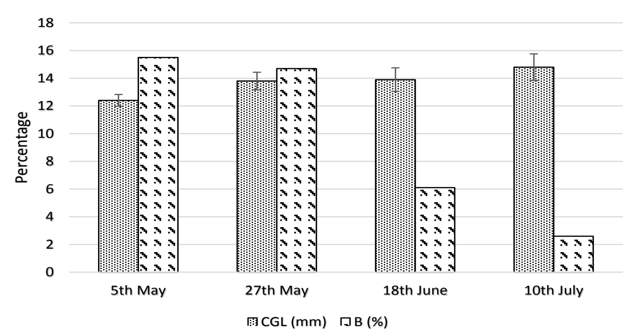

Figure 4: Changes in average cooked grain length and bursting percentages of fine grain rice lines due to changing transplanting dates.

PK 8785-1-1 on 10th July 2013 followed by line PK 7688-1-1-2-2 with 13.2 mm CGL with 0.0% bursting on 27th May 2013. In all, best cooking quality was recorded at 27th May and 10th July and by the lines PK 7688-1-1-2-2 and PK 8785-1-1 performing well as discussed above.

The Table 6 shows that on average with respect to date of transplanting, maximum cooked grain length (CGL) of 14.8 mm with minimum bursting percentage of 2.6% was recorded for transplanting date 5th August 2013 followed by transplanting date 14th July 2013 with 13.9 mm CGL and 6.1% bursting percentage. With respect to average data of lines, maximum CGL of 15.0 mm was observed for line PK 8671-24-4-1-20 with 1.5% bursting which is minimum bursting; followed by line PK 8660-13-3-1 with 14.2 mm CGL and 2.0% whereas check variety Basmati 515 recorded 14.2 mm CGL and 6.0% bursting. As for individual performance, maximum CGL of 16.7 mm was recorded for line PK 8671-24-4-1-20 with 0.0% bursting at transplanting date of 5th August followed by line PK 8660-13-3-1 with 15.3 mm CGL and 1.0% bursting at the same transplanting date. Over all, better cooking quality was recorded at transplanting date of 5th August followed by 14th July. Lines PK 8671-24-4-1-20 and PK 8660-13-3-1 performed well by exceeding the check variety of Basmati 515 in terms of cooking quality parameters as discussed above.

Conclusion

The results showed that the effects sowing date and cultivars on the grain milling and cooking qualities were highly significant. Delayed sowing date, milling quality, total and head rice recovery, cooked grain length and bursting percentages showed different trend with respect to the rice lines. Results suggest that very early transplanting is more damaging to milling and cooking of both, fine as well as coarse grain rice lines as compared to delayed transplanting. Likewise, much delayed transplanting is more destructive for milling and cooking characters in case of fine grain rice lines as compared to coarse grain type rice lines. In case of studied fine grain rice genotypes, head rice recovery was observed maximum when translated at 18th of June. Similarly, cooked grain length was improved significantly in case of fine rice lines with delay in transplanting. Results suggest fine grain rice varieties to be transplanted before onset of July in order to have least broken rice in milled rice. Delayed sowing date, milling quality, total and head rice recovery, cooked grain length and bursting percentages showed different trend with respect to the rice lines. KSK 133 and Basmati 515 showed maximum head rice recovery among coarse and fine grain rice lines respectively. Likewise, PK 8785-1-1 and PK 8671-24-4-1-20 showed maximum cooked grain length among coarse and fine grain rice lines respectively.

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