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Tillering Dynamics in Aromatic Rice Genotypes

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ABSTARCT

An experiment was conducted with thirty aromatic rice genotypes to evaluate the tillering patterns and to explore its relationship with grain yield. Much variation was observed in tillering dynamics among the genotypes. Nineteen genotypes reached to peak population around 40 days after transplantation (DAT), when after tiller numbers started to reduce; 10 of them showed tillering climax at 50 DAT and only Kalijira Tapl-73 at 60 DAT. Maximum number of tillers varied from 136 (Khazar) to 455/m^2 (Chinigura). The highest rate of tiller mortality was found 49.29% in Chinigura and lowest in Jesso balam (10.10%). Sakkor khora produced highest number of panicles (277), whereas Khazar proved its worst performance with 90 panilces/m^2. Among the aromatic rice genotypes in the current study, Elai produced higest grain yield (3.35 t/ha). The lowest yield was harvested 1.42 t/ha from Khazar. The number of panicles was positively correlated with maximum number of tillers (r = 0.76) and grain yield (r = 0.62). Total number of tillers at harvest had the biggest direct effect on grain yield. Number of panicles had insignificant direct effect on yield; however it created a large indirect effect through the total number of tillers. Number of tillers at all stages imposed considerable indirect effects through number of panicles.

Key Words: Aromatic rice; Rice tillering; Tiller mortality; Grain yield; Path analysis

INTRODUCTION

The geographical distribution of rice growing areas in different parts of the world reveals that rice is cultivated from 50° North to 35° South, from low-lying basin to hill top over 2000 m. The crop is cultivated under extremely wet condition however, it is also grown in desert climate (Swaminathan, 1999). Therefore, it is obvious that rice world has a vast diversity in its album. Through the centuries of cultivation and selection, thousands of rice cultivars have been evolved, which are well adapted to the local environments. Many of those also possess good taste and qualities and are preferred by the people. A group of such rices is known as aromatic rices. This rice, by its name, is characterized by the presence of aroma in it and often slender in shape (Singh *et al*., 2000a). In the consideration of consumption, aromatic rices constitute a small special group that is regarded as best in quality. Aromatic rice varieties are low yielding because of its traditional plant type associated with lodging and low 1000-grain weight.

Rice tillering is a major determinant for panicle production (Miller *et al*., 1991) and as a consequence affects total yield (Gallagher & Biscoe, 1978). The substantial variability observed in responses of rice varieties to tillering is closely related to plasticity with respect to environmental conditions (Yoshida, 1981). It plays a key role as tiller number per plant as high as 40 and tiller senescence rate as high as 50% can be observed (Peng *et al.*, 1994). Tillering of rice depends on the genotypes and on resources available for growth; tillering beyond a sustainable number it is corrected by senescence (Dingkuhn & Kropff, 1996). For achieving high yield, plant architecture must be changed to make an ideotype with only 3-4 tillers bearing large number of grains in the panicle (Peng *et al*., 1999). A low-tillering new plant type bears the advantage of higher nitrogen use efficiency compared to a high-tillering rice cultivar, when both of them are grown with high N supply (Peng *et al*., 1994). Conversely, excessive tillering leads to high tiller abortion, poor grain setting, small panicle size and further reduced grain yield (Peng *et al*., 1994; Ahmad *et al*., 2005). Therefore, excessive branching is often considered expensive (Dun *et al*., 2006), as formation of low-productive tillers becomes investment loss for a plant.

Study of tillering pattern of rice genotypes is a crucial need for better selection and improvement. Morpho and physiological aspects of tillering dynamics in modern rices (inbred & hybrid cultivars) were investigated by several workers (Lafarge *et al*., 2004; Rashid & Khan, 2006). However, aromatic rices are yet not properly addressed in this avenue. The objective of the present research was the detail investigation of tillering patterns of thirty aromatic rice genotypes and to explore relationship with yield and yield components.

MATERIALS AND METHODS

Crop management. The experiment was conducted in 2005 at the farm of Bangladesh Rice Research Institute (BRRI), Gazipur, situated at 24.00°N, 90.25°E with an

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elevation of 8.4 m from sea level. The cropping season started in hot-humid weather with heavy shower and ended in dryness with low temperature (Table I). A total of thirty aromatic rice germplasm composed of 27 local and three exotic cultivars were selected for the study (Table II). Among the exotic genotypes Basmati PNR346 was from Pakistan and Khazar and Neimat were from Iran. The rest materials are representing their distribution throughout Bangladesh. Thirty rice genotypes formed the treatment variables and were assigned randomly to each unit plot of 5 m × 2 m dimension. Thirty days-old seedlings were transplanted on August 15, 2005 following randomized complete block design (RCBD) with three replications. Transplanting was done at the spacing of 20 cm × 20 cm. A fertilizer rate of 25, 35, 10, 3 kg ha^{-1} of P, K, S, Zn in the form of triple super phosphate, muriate of potash, gypsum and zinc sulphate, respectively was applied as basal dose at final land preparation. Because of wide genotypic variation in phenological development, entries differed enormously in attaining panicle initiation (PI) stage and in the requirement of nutrient elements. For this reason, nitrogen was top-dressed as urea in 2-3 splits to the contrary of a common dose with fixed time routine. The amount of urea and time of application were determined with the help of a leaf colour chart (Ladha *et al*., 1998; Hossain *et al*., 2008).

Observations. Data collection was started at 20 days after transplanting (DAT) and continued with a 10 days interval up to harvesting (4^{th} September to 18^{th} December, 2005). One square meter area (5 plants × 5 plants) was selected and marked in each plot for tiller count. Tillering trend was closely observed. Daily tiller emergence (tiller growth rate) was determined after Radford (1967).

$$\text{Tiller emergence rate (No.m}^{-2}\text{ day}^{-1}) = \frac{N_2 - N_1}{t_2 - t_1}$$

Where, t_1 = day of starting, t_2 = day of final record.

N_1 = number of tillers at t_1, N_2 = number of tillers at t_2.

Counting was accomplished at every alternate day during pick period to determine ceiling number of tillers for each genotype. Tiller mortality was calculated using the formula as follows:

$$\text{Tiller mortality (\%)} = \frac{\text{Number of panicles}}{\text{Maximum number of tillers}} \times 100$$

Plants were harvested at crop maturity. All the plants of a 5 m^2 sample area were cut at base. After threshing and cleaning, the fresh weight of grains was recorded and adjusted to 14% moisture content as follows:

$$\text{Grain yield} = \frac{\text{FW}(100-\text{MC})}{100-14}$$

Where, FW = fresh weight of the grains.

MC = % moisture in the fresh grains.

Statistical analysis. Data were analysed statistically by analysis of variance technique by IRRISTAT Windows 4.01. Genotypic and phenotypic co-efficients of variation were estimated according to Burton (1952) as follows:

$$\text{Genotypic co-efficients of variation (GCV)} = \frac{\sqrt{\sigma_g^2}}{\bar{x}}$$

$$\text{Phenotypic co-efficients of variation (PCV)} = \frac{\sqrt{\sigma_p^2}}{\bar{x}}$$

Simple correlation was estimated from average data using the following formula:

$$\text{Correlation co-efficient (r)} = \frac{COV_{xy}}{\sqrt{\sigma_x^2 \times \sigma_y^2}}$$

Path co-efficient analysis was performed according to Singh (2000).

RESULTS AND DISCUSSION

Tillering patterns of 30 aromatic rice genotypes are presented in Table II. Rice genotypes varied to a great extent for growth and number of tillers all through the life span. Khazar, an exotic cultivar possessed lowest 46 tillers/m^2 at 20 DAT. In each and every tiller count it maintained its lowest position up to maturity and also for number of panicles. Saibail exhibited the largest number (92 tillers/m^2) followed by Basmati Tapl-90 (91 tillers/m^2) at 20 DAT. However, Saibail could not hold its top position in latter stages. At 30 DAT, tiller numbers rangrd from 81 (Khazar) to 239/m^2 (Chinigura). The genotype, Chinigura had been capturing its top position at 40, 50 and 60 DAT with tiller numbers 430, 455 and 387, respectively. At these stages, Bhog ganjia was the closest follower having tiller numbers 426, 415 and 361 at 40, 50 and 60 DAT, respectively. After this event, Bhog ganjia uplifted its level by containing 348 and 310 tillers/m^2 at 70 and 80 DAT, respectively, which was immediately followed by Sakkor khora for 329 and 308 tillers/m^2. Bhog ganjia and Sakkor khora maintained this trend up to maturity. Declining trend in tiller numbers was also found to vary among the genotypes. Nineteen genotypes reached to peak population around 40 DAT, when after tiller numbers started to reduce. Ten of them required around 50 DAT for attaining ceiling number of tillers. In our list, Kalijira Tapl-73 was an exception, whose tillering climax was observed around 60 DAT. Production of excessive tillers, specially at later stages is an useless effort and just wastage of energy for a genotype.

Grain yield along with yield components and tiller mortality behaviour are presented in Table III. Maximum number of tillers of a rice plant is achieved at a certain moment in its life cycle, which disappears soon after achievement. The ceiling number of tillers varied from 136 (Khazar) to 455 tillers/m^2 (Chinigura). Lafarge *et al.* (2004) reported that the genotype, which stopped emergence of new tillers earlier it increased the partition of newly gained

Table I. Meteorological data recorded at the site of experiment during the study period

Month	Average temperature (°C)		Rainfall (mm)	Evaporation (mm)	Relative humidity (%)		Sunshine (h day^{-1})
	Max.	Min.			9 a.m.	2 p.m.	
July	31.6	25.9	459.2	74.4	86.5	80.6	1.63
Aug.	31.9	26.2	452.4	106.6	83.5	73.5	4.25
Sept.	33.0	26.1	125.4	117.6	77.5	65.2	5.56
Oct.	32.0	23.4	51.4	98.3	75.3	60.7	6.97
Nov.	29.5	18.9	201.2	83.1	75.9	59.8	7.01
Dec.	26.5	14.4	0.0	75.3	80.2	54.7	6.57

Table II. Tiller number per square meter at different ages of rice plants

Name of genotype	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT	70 DAT	80 DAT
Badsha bhog	64	154	309	300	281	262	254
Baoi jhak	71	188	361	333	304	293	286
Basmati Tapl-90	91	231	396	392	327	285	273
Basmati PNR 346	63	164	329	355	307	299	281
Begun bichi	71	183	367	355	299	276	269
Bhog ganjia	63	194	426	415	361	348	310
Chinigura	88	239	430	455	387	286	263
Chinikani	62	141	296	277	262	232	226
Darshal	47	106	248	260	233	222	208
Doiar guro	72	163	311	293	256	244	240
Elai	75	200	345	344	329	299	276
Hatisail	66	169	334	347	305	299	292
Jamai sohagi	67	173	345	357	302	284	260
Jata katari	70	175	346	339	293	271	250
Jesso balam	59	128	258	259	253	250	249
Jira katari	70	171	302	292	261	243	237
Kalijira Tapl-73	53	138	277	288	309	286	282
Kalomai	66	159	304	304	286	264	242
Kamini soru	76	184	263	283	259	250	243
Kataribhog	60	130	305	300	282	269	261
Khazar	46	81	117	136	134	116	113
Niemat	73	179	331	332	328	308	284
Philippine katari	74	190	361	360	304	280	272
Premful	66	161	287	282	266	258	252
Radhuni pagal	79	172	281	275	265	238	233
Rajbhog	61	146	284	291	256	239	229
Sai bail	92	228	335	323	308	293	282
Sakkor khora	61	163	352	366	358	329	308
Tilkapur	76	215	363	327	296	268	260
Ukni madhu	74	207	359	343	296	285	268
CGV	15.90	20.68	18.53	17.90	15.74	15.08	14.08
PCV	19.54	25.57	22.45	20.99	17.78	17.28	16.01
SE	1.72	5.59	9.40	9.04	7.22	6.42	5.72
F (probability)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

assimilate to existing tillers hence out yielded over other. Final number of tillers at harvesting time is a vital determinant of grain yield. The highest number of tillers was recorded 288 for Bhog ganjia and the lowest was 104 for Khazar. The trend of panicle number among the genotypes differed slightly with the trend of final tiller number as because of some un-productive tillers were still in the hill without bearing panicles. Number of panicles per unit area is the most important component of rice yield. It accounts for 89% of the variation of grain yield (Yoshida *et al*., 1972; Miller *et al*., 1991). Sakkor khora produced highest number of panicles (277) followed by Bhog ganjia (269) and Kalijira Tapl-73 (264). Khazar proved its worst performance with 90 panilces/m^2. The highest rate of tiller mortality was found 49.29% in Chinigura follwed by Jamai sohagi (43.78%) and Bhog ganjia (36.88%). The genotype Jesso balam exhibited lowest mortality rate (10.10%) followed by Kalijira Tapl-73 (14.32%) and Premful (20.35%). Among the aromatic rice genotypes in the current study, Elai produced higest grain yield (3.35 t/ha). The lowest yield was harvested 1.42 t/ha from Khazar, an exotic cultivar from Iran. Inferior performance of the cultivar in a new environment might be due to lack of wider adaptability. Grain yield is the important consideration for a producer of a crop. Aromatic rice is considered as the best in quality. So, its lower yield could be accepted for the sack of consumer's demand (Singh *et al*., 2000b).

The genotypic and phenotypic co-efficients of variations for each and every characters were also showed the Tables I and II. Highest genotypic co-efficient of

Table III. Tiller mortality rate, number of panicles and grain yield of different rice genotypes at harvest

Name of genotype	Max. number of tillers (m^{-2})	Total tillers (m^{-2})	Unproductive Tillers (m^{-2})	Tiller mortality (%)	No. of panicles (m^{-2})	Grain yield (t ha^{-1})
Badsha bhog	309	246	15	25.24	231	2.86
Baoi jhak	361	280	19	27.66	261	2.88
Basmati Tapl-90	396	264	11	36.19	253	3.23
Basmati PNR 346	355	263	19	31.35	244	3.24
Begun bichi	367	262	8	30.68	254	2.90
Bhog ganjia	426	288	19	36.88	269	2.56
Chinigura	455	243	12	49.29	231	2.83
Chinikani	296	210	16	34.39	194	2.88
Darshal	260	199	6	25.98	193	2.99
Doiar guro	311	235	10	27.52	225	2.91
Elai	345	246	16	33.37	230	3.35
Hatisail	347	272	10	24.50	262	2.93
Jamai sohagi	357	216	16	43.78	200	2.49
Jata katari	346	245	17	34.03	228	2.98
Jesso balam	259	242	9	10.10	233	2.91
Jira katari	302	233	20	29.40	213	2.94
Kalijira Tapl-73	309	276	12	14.32	264	2.29
Kalomai	304	233	8	25.98	225	3.01
Kamini soru	283	232	20	24.99	212	3.14
Kataribhog	305	241	10	24.37	231	2.84
Khazar	136	104	14	34.17	90	1.42
Niemat	331	266	22	26.13	244	2.98
Philippine katari	361	261	15	31.70	246	3.01
Premful	287	241	12	20.35	229	2.96
Radhuni pagal	281	214	10	27.29	204	2.42
Rajbhog	291	221	7	26.28	214	2.74
Sai bail	335	263	12	24.89	251	3.14
Sakkor khora	366	287	10	24.28	277	3.10
Tilkapur	363	256	6	31.21	250	2.81
Ukni madhu	359	261	11	30.33	250	3.13
CGV	17.75	14.28	34.69	26.23	15.01	12.59
PCV	22.86	15.48	40.75	30.69	16.55	12.97
SE	9.17	5.49	0.72	1.20	5.46	0.06
F (probability)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table IV. Matrix for correlation coefficients showing the simple linear relationship among grain yield and tillering dynamics at harvest (n=30, **significant at 1% level & *significant at 5% level)

Characters Detail	Character No.	2	3	4	5	6	7	8	9	10
No. of tillers (m^{-2}) at 50 DAT	1.	0.94**								
No. of tillers (m^{-2}) at 60 DAT	2.	0.85**	0.93**							
No. of tillers (m^{-2}) at 70 DAT	3.	0.80**	0.89**	0.98**						
No. of tillers (m^{-2}) at 80 DAT	4.	0.99**	0.93**	0.85**	0.81**					
Maximum no. of tillers (m^{-2})	5.	0.74**	0.83**	0.93**	0.97**	0.77**				
Total no. of tillers (m^{-2}) per plant	6.	0.13	0.15	0.20	0.16	0.12	0.11			
Unproductive tillers (m^{-2}) per plant	7.	0.49	0.29	0.06	-0.06	0.47	-0.16	0.25		
Tiller mortality per plant	8.	0.73**	0.81**	0.91**	0.95**	0.76**	0.99**	-0.02	-0.20	
No. of panicles (m^{-2})	9.	0.52	0.51	0.58*	0.60*	0.50	0.63*	0.05	-0.08	0.62*

variation (GCV) was recorded 35% for the number of unproductive tillers followed by tiller mortality rate (26%) and the number of tillers at 30 DAT (21%). Lowest value of GCV was observed for grain yield (13%) followed the number of tillers at 80 DAT (14%) and the number of tillers/m^2 at harvest (14%). The rest of the characters hold GCV in the range of 15 - 19%. Higher GCV in a character gives the better opportunity for a cross combination to get wider variation. The majority of the characters showed little differences between PCV and GCV, which indicated negligible influence of environment on the expressions of these characters. However, spikelet sterility showed slightly higher differences between GCV and PCV indicating comparatively higher influence of environments on the expression of the characters. Low GCV and PCV were for plant height and panicle length were reported by Das and Rahman (1984). Amin *et al.* (1992) observed closeness of PCV and GCV for a few characters and much difference between PCV and GCV for others.

Correlation co-efficient analysis measures the linear relationships between characters and determines the selection of component characters for plant improvement

Table V. Direct effects and indirect effects of different characters on grain yield of aromatic rice varieties

Characters	01	02	03	04	05	06	Correlation with GY
01. No. of tillers at 70 DAT	-0.11	-0.07	0.14	0.98	0.00	-0.35	0.58
02. No. of tillers at 80 DAT	-0.11	-0.07	0.14	1.02	0.00	-0.37	0.60
03. Max. no. of tillers	-0.09	-0.06	0.17	0.81	-0.03	-0.30	0.50
04. Total no. of tillers	-0.10	-0.07	0.13	1.05	0.01	-0.39	0.63
05. Tiller mortality rate (%)	-0.01	0.00	0.08	-0.17	-0.06	0.08	-0.08
06. No. of panicles	-0.10	-0.07	0.13	0.84	0.01	-0.19	0.62

Residual effect = 0.49

(Singh, 2000). Relationships among the different grades of spikelets and yield related parameters were determined through simple correlation co-efficient (r). A total of 10 characters were subjected to correlation matrix (Table IV). Among the 45 correlation co-efficient values, 25 had positive 'r' values at significant level ($p<0.05$). The highest 'r' value was recorded 0.99 between the number of tillers at 50 DAT and the maximum number of tillers. This indicated that ceiling number of tillers mostly determined at around 50 DAT. The number of panicles was positively correlated with maximum number of tillers ($r = 0.76$) and grain yield ($r= 0.62$). In the correlation matrix, it was observed that neither the number of un-productive tillers nor the rate of tiller mortality had significant influence on any other characters. Grain yield had significant positive relationship also with total number of tillers at harvest ($r = 0.63$) and the number of tillers at 80 DAT ($r = 0.60$). Several researchers made effort on the analyses of grain yield and related components of modern, lowland and winter rice varieties. And they reported different levels of correlation among the traits (Mamin, 2003). Six parameters were subjected to path analysis, where correlation coefficients were partitioned. Direct effects and indirect effects were quantified and presented in Table V. Results showed that all characters, but had exerted negligible direct effect on grain yield. Total number of tillers at harvest had the biggest direct effect on grain yield. Number of panicles had insignificant direct effect on yield, however it created a large indirect effect through the total number of tillers. In addition, it is also notable that number of tillers at all stages imposed considerable indirect effects through number of panicles. It is well known that grain yield is a resultant character and very complicated trait. In this analysis it is observed that a considerable portion of effects were un-explained and remained as residual effect (0.49).. Huan *et al*. (1999) performed path co-efficient analysis in an experiment with direct seeded rice in dry and wet seasons. Although direct effect of panicles/m^2 was negligible in both seasons it exhibited indirect effect through other components.

CONCLUSION

Tillering patterns in aromatic rice genotypes exhibited wide range of variations without showing any major influence on grain yield. Number of panicles had significant positive correlation with grain yield, however in path co-efficient analysis it exhibited considerable indirect effect through other traits rather than direct effect.

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