academicJournals

Vol. 5(5), pp. 79-83, September, 2013
DOI 10.5897/JABSD2013.0204
ISSN 2141-2340 © 2013 Academic Journals
http://www.academicjournals.org/JABSD

Journal of Agricultural Biotechnology and Sustainable Development

Full Length Research Paper

Determination of some agronomic characters in different age groups of traditional rice cultivars in Sri Lanka under fertilized and non-fertilized conditions

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Accepted 26 August, 2013

Yields of traditional rice cultivars are typically low. The objective of this study was to understand the yield and agronomically important phenotypic traits of some traditional rice cultivars with different days to maturity at fertilized conditions. A field experiment was done at Faculty of Agriculture, University of Ruhuna, Mapalana, Kamburupitiya, Sri Lanka during *Maha* 2011 to 2012 and *Yala* seasons in 2012. The recommended fertilizer dose for improved rice cultivars was applied for the study. Effect of fertilizer on agronomic characters namely plant height (cm), number of tillers/plant and number of leaves/plant were measured during the experiment. Grain yield (g/plant) and harvest index were calculated at the end of the experiment. All the evaluated parameters were significantly higher at the fertilized conditions than those of at non fertilized conditions except the plant height in 161 to 165 days to maturity age group and number of leaves/plant in 110 to 115 days to maturity age group. At fertilized conditions the lowest significant plant height (97.5 cm) was recorded in the 161 to 165 age group while 151 to 155 age group recorded the significantly highest plant height (138.4 cm). The number of tillers/plant ranged from 6.0 to 9.8 while the highest significant number of tillers/plant (9.8) was recorded in 110 to 115 age group. However the highest grain yield/ plant (23.0 g) was recorded in the shortest days to maturity age group (110-115). Supporting this, the highest average yield/plant (10.1 g) at non fertilized conditions was also recorded in early maturing cultivars belong to 110 to 115 days to maturity age group.

Key words: Agronomic characters, traditional rice, fertilizer effect, days to maturity.

INTRODUCTION

The rice plant usually takes 3 to 6 months from germination to maturity, depending on the variety and the environment under which it is grown. The optimal growth duration for maximum yield of inbred *Indica* varieties in the tropics is about 120 days (Tanaka et al., 1976). There was a linear increase in total biomass as growth duration increased from 95 to 135 days whereas maximum grain yield of about 8 to 9 t/ha was constant in varieties of 110 to 130 days (Akita, 1989). Varieties of shorter growth duration usually give lower yields at typical hill spacing in transplanted rice due to insufficient vegetative growth for maximum yield levels (Yoshida, 1976).

Pandey et al. (2012) reported that late maturing and taller rice genotypes had high spikelet fertility contributing towards higher grain yield. The real situation of individual rice cultivars in traditional rice gene pool in Sri Lanka is no informative. Discovering factors such as yield potential, response of traditional rice cultivars to fertilizer,

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behavior of yield potential of the rice cultivars at fertilized condition must be depleted in systematic way in the process of utilization of none utilized or under-utilized rice cultivars for the improvement of rice cultivars by interrogation of favorable trait from traditional cultivars in to the modern rice cultivars.

Traditional rice cultivars in Sri Lanka were evaluated for some abiotic stress tolerance in systematic way (Ranawake et al., 2010, 2011; Rodrigo et al., 2012; Weragodavidana et al., 2012). The selected abiotic stress tolerance rice cultivars have a potential of direct introduction in to farmer fields (Djilianov et al., 2005; Xiang et al., 2007) or utilization of them in the breeding programs (Djilianov et al., 2005; Xiang et al., 2007; Ashfaq et al., 2012) of development of abiotic stress tolerance rice cultivars. In such a process, poor yield potential of traditional rice cultivars is a great problem to be overcome (Jennings, 1964; Saito et al., 2006; Amarasinghe et al., 2013). Some of the Sri Lankan traditional rice cultivars have also been evaluated in different fertilizer levels in Sri Lanka (Amarasinghe et al., 2012; Dharmasena 2012). Taking in to consideration of crop nutrition, nitrogen plays an important role in crop life. It is one of the most important nutrients needed in large quantities for the plant growth and development (Arif et al., 2010). The best level of fertilizer applications for the maximum benefit is among the most important strategies in rice crop management (Arif et al., 2010).

Plant height, number of tillers per plant, panicle length, flag leaf area, primary branches per panicle, days to heading, and days to maturity are more effective as compared to other traits in boosting yield performance of rice (Ashfaq et al., 2012; Osman et al., 2012). Among these characters plant height and days to maturity showed the highest variations among the genotypes in rice (Ashfaq et al., 2012). The degree of correlation among the characters is an important factor especially in economic and complex characters such as yield (Akinwale et al., 2011; Khan et al., 2009). Akinwale et al. (2011); and Panday et al. (2012) observed a positive and non significant correlation in between grain yield and days to maturity. Harvest index and days to maturity have also exhibited very high positive direct effect on grain yield (Panday et al., 2012).

In the present study rice cultivars with different days to maturity were analyzed to understand the fertilizer response of them at the field conditions. In the same time some of the agronomic characters were evaluated to see the contribution of them to yield increment under fertilized conditions.

METHODOLOGY

Fifty traditional rice cultivars (Table 1) were geminated and planted in nursery beds. Ten day old seedlings were transplanted in the field at Faculty of Agriculture, University of Ruhuna in rows with 15 × 20 cm spacing. Experiment was conducted as a randomized complete block design with four replicates. Each replicate consisted 3 rows of 20 rice plants. The recommended fertilizer dosage for modern rice cultivars (Basal Dressing: Urea 50 Kg/ha, TSP 62.5 Kg/ha, MOP 50 Kg/ha and Top Dressing**:** Urea 37.5 Kg/ha – 2 Weeks after planting and 8 Weeks after planting) was applied in recommended intervals. Control experiment was carried out without any fertilizer applications.

Plant height (cm) of individual rice cultivars was measured at reproductive stage in the middle row plants of the three-row-grown rice cultivars. Here, plant height was considered as the length in cm from the plant base to the tip of the highest leaf (or panicle, whichever was longer) (Ashfaq et al., 2012). Number of tillers/plant was counted at the age of 12 weeks of rice cultivars. Number of leaves/plant was counted at the vegetative stage before flowering, after second top dressing was applied in to the field. Grain yield (g/plant) was measured in individual rice cultivar after harvesting and removing unfilled grains. Harvest index was calculated according to Li et al. (2012) as follows:

$$\text{Harvest index } \alpha = \frac{\text{Grain yield (g)/plant}}{\text{Total biomass (g)/plant}}$$

Fifty traditional rice cultivars were categorized into seven age groups according to days to maturity; 110 to 115, 116 to 120, 121 to 125, 126 to 130, 131 to 135,151 to 155, 161 to 165. Days to maturity was decided according to the characterization catalogue on rice germplasm (Plant Genetic Resource Center, 1999).Data were statistically analyzed by ANOVA and mean separation were adjusted by DMRT using SAS statistical software (SAS Institute Inc., 2000)

RESULTS AND DISCUSSION

Harvest Index, yield/plant, and number of tillers/plant in traditional rice cultivars were significantly increased by inorganic fertilizers in all the age groups (Table 2). Plant height was significantly reduced by recommended fertilizers only in the longest age group. Only in the shortest age group number of leaves was significantly reduced by the recommended fertilizers. The days to maturity of the selected traditional rice cultivars spanned from 110 to 165. Plant height, number of tillers/plant, number of leaves/plant, average yield/plant and harvest index ranged from 97.5 to 138.4 cm, 6.0 to 9.8, 11.3 to 15.5, 5.0 to 23.0 g, 0.11 to 0.33 respectively, at fertilized conditions (Table 2) while at non fertilized conditions those parameters ranged from 106.5 to 133.3 cm, 3.9 to 5.3, 7.1 to 13.7, 2.1 to 10.1 g, 0.09 to 0.32. The significant lowest average plant height (97.5 cm) was recorded in the 161 to 165 days to maturity age group and the highest significant average plant height (138.4 cm) was recorded in the 151 to 155 days to maturity age group at the fertilized conditions. At non-fertilized conditions, the lowest significant average plant height (106.5 cm) was recorded in the 110 to 115 days to maturity age group and the highest significant average plant height (133.3 cm) was recorded in the 151 to 155 days to maturity age group.

According to Panday et al. (2012) late maturing and taller rice genotypes had higher spikelet fertility contributing towards the higher grain yield. Yoshida

Table 1. PGRC accession numbers and names of fifty traditional rice cultivars.

PGRC Acc No	Name	Days to maturity	PGRC Acc No	Name	Days to maturity
3423	*Giress*	122	3658	*Ingrisi wee*	124
3427	*Naudu wee*	127	3659	*Kotathavalu*	119
3434	*Kokuvellai*	125	3660	*Suduru*	119
3435	*Matara wee*	124	3661	*Polayal*	124
3438	*Murunga wee*	117	3664	*Tissa wee*	124
3440	*Kaharamana*	127	3665	*Sudu Karayal*	124
3445	*Yakada wee*	119	3666	*Podisayam*	125
3447	*Karabewa*	123	3668	*Ranruwan*	113
3451	*Halabewa*	123	3669	*Rajes*	119
3463	*Karayal*	115	3670	*Madoluwa*	127
3469	*Sudu wee*	121	3671	*Suduru Samba*	125
3477	*Sudu Goda wee*	110	3673	*Kaluhandiran*	126
3479	*Kiri Naran*	134	3674	*Kirikara*	119
3480	*Karayal*	122	3675	*Kotathavalu*	118
3482	*Akuramboda*	128	3676	*Dena wee*	117
3486	*Puwakmalata Samba*	163	3677	*Herath Banda*	117
3487	*Palasithari 601*	123	3678	*Hondarawala*	125
3489	*Murungakayan 3*	125	3679	*Kottakaram*	126
3490	*Murungakayan 101*	128	3681	*Dandumara*	127
3496	*Bala Ma wee*	122	3686	*Karayal*	124
3638	*Lumbini*	118	3687	*Dewaredderi*	125
3639	*Polayal*	111	3688	*Handiran*	118
3641	*Heendik wee*	128	3691	*Gunaratna*	155
3642	*Kahata Samba*	118	3659	*Kotathavalu*	119
3653	*Kalu Karayal*	125	3660	*Suduru*	119
3654	*Pokuru Samba*	125	3661	*Polayal*	124
3655	*Rata wee*	118	3664	*Tissa wee*	124

Table 2. Agronomic characters of traditional rice cultivars at non-fertilized conditions and at fertilized conditions.

Days to maturity	Plant height (cm)		Number of tillers		Number of leaves		Yield (g) /plant)		Harvest Index	
	No F.	RD	No F.	RD	No F.	RD	No F.	RD	No F.	RD
110-115	106.5^{b}	123.1^{a}	5.0^{b}	9.8^{a}	12.6^{a}	11.3^{b}	10.1^{b}	23.0c^{a}	0.24^{b}	0.3^{a}
116-120	115.3^{b}	122.4^{a}	4.9^{b}	6.0^{a}	13.2^{a}	13.2^{a}	7.1^{b}	12.5^{a}	0.27^{b}	0.33^{a}
121-125	121.4^{b}	128.0^{a}	5.3^{b}	6.8^{a}	11.4^{b}	13.0^{a}	9.6^{b}	14.1^{a}	0.28^{b}	0.33^{a}
126-130	114.0^{b}	118.7^{a}	4.6^{b}	6.3^{a}	10.8^{b}	12.6^{a}	9.7^{b}	13.7^{a}	0.32^{b}	0.35^{a}
131-135	126.3^{a}	125.9^{a}	4.5^{b}	7.2^{a}	10.8^{b}	15.5^{a}	7.4^{b}	13.4^{a}	0.28^{b}	0.32^{a}
151-155	133.3^{b}	138.4^{a}	5.3^{b}	6.3^{a}	13.7^{a}	13.8^{a}	9.1^{b}	11.3^{a}	0.29^{b}	0.3^{a}
161-165	119.0^{a}	97.5^{b}	3.9^{b}	7.7^{a}	7.1^{b}	11.8^{a}	2.1^{b}	5.0^{a}	0.09^{b}	0.11^{a}

Means with the same letter are not differ significantly; No F= No fertilizer; RD = Recommended fertilizer.

(1976) has revealed that varieties of shorter growth duration usually give lower yields at typical hill spacing in transplanted rice due to insufficient vegetative growth for maximum yield levels. However the earliest maturity group has responded in different way in the present study; the highest yield has been reported in the earliest maturing group (Table 2). Peng et al. (1994) has reported that rice cultivars those take 110 to 120 days to maturity were considered as medium growth duration varieties those can produce higher total yield. Finding of Peng et al. (1994) is aligned with the findings of the present study (Table 2).

Moreover, the lowest harvest index was recorded in the longest age group (Table 2) at fertilized (0.11) and at

non fertilized (0.09) conditions providing evidence on the effect of other factors rather than days to maturity on the yield determination of the studied rice cultivars. Under fertilized conditions the average number of tillers/plant ranged from 6.0 to 9.8 in the analyzed traditional rice cultivars. The highest average number of leaves/plant (15.5) was recorded in the 131-135 age group (Table 2). The highest grain yield/ plant (23.0 g) was recorded in the 110-115 age group, which included the cultivars with shortest days to maturity while the lowest grain yield/plant (5.0 g) was recorded in the 161-165 age group, which consisted of the cultivars with comparatively longer days to maturity. Further, the highest number of tillers/plant (9.8) was also recorded in the early maturing age group (110-115 days to maturity) while the lowest average number of tillers/plant (6.0) was recorded in 116-120 days to maturity age group (Table 2).

Harvest indices (HI) ranged from 0.11 to 0.35 in the cultivars used for the present study. This value in modern rice cultivars is more than 0.4 (Li et al., 2012) while it is varied from 0.4 to 0.6 in modern rice cultivars in Sri Lanka (De Costa et al., 2003; Wickramasinghe, 2011). The highest value of HI (0.35) in the present study was found in the 126-130 days to maturity age group. Panday et al. (2012) concluded that the harvest index, days to maturity and the effective tillers/plant as the major contributors for rice yield. So the rice cultivars with higher magnitude of these traits could be favorable for better yield in farmer field.

Under non fertilized conditions the average number of tillers/plant ranged from 3.9 to 5.3. The highest number of tillers/plant (5.3) was recorded in age groups; 121 to 125 and 151 to 155 while the lowest number of tillers/plant (3.9) was recorded in late maturing age group; 161 to 165 (Table 2). The highest number of leaves/plant (13.7) was recorded in the same 151 to 155 days to maturity age group which recorded the highest number of tillers/plant (Table 2). The highest grain yield/ plant (10.1 g) was recorded in the 110 to 115 early maturing age group, while the lowest grain yield/plant (2.1g) was recorded in the longest age group; 161 to 165. Harvest index (HI) ranged from 0.09 to 0.32 in the cultivars at non fertilized conditions. The HI values of the age groups with days to maturity 126 to 130 (0.35) was closer to the lower limit of the reference HI values of Sri Lankan modern rice cultivars (0.4 to 0.6) according to De Costa et al. (2003) and Wickramasinghe (2011). However the HI of age groups of 110 to 115 (0.3), 116 to 120 (0.33), 121 to 125 (0.33), 131 to 135 (0.32), 151 to 155 (0.3) and 161 to 165 (0.11) recorded the lower values than that of in modern rice cultivars in Sri Lanka.

Conclusion

All the evaluated parameters were significantly differed with the fertilized conditions than those of at non fertilized conditions except the plant height in 161 to 165 days to maturity age group and number of leaves in 116 to 120 days to maturity age group. The highest significant grain yield/plant can be obtained by planting cultivars in 110 to 115 days to maturity age group at fertilized conditions and at non-fertilized conditions as well. However for the highest harvest index, cultivars in relatively short days to maturity age group (126 to 130) are more suitable.

ACKNOWLEDGMENT

Authors would like to acknowledge, University of Ruhuna for financial support under research grant Transforming University of Ruhuna in to International standards (TURIS) and PGRC, Gannoruwa, Sri Lanka for providing planting materials of conserved traditional rice cultivars.

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