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TRADITIONAL RICE VARIETIES WITH HIGH ADAPTABILITY AND STABILITY FOR ORGANIC FARMING IN THE WET ZONE OF SRI LANKA

A. P. BENTOTA[1], S. M. WEJESUNDARA[2], U.K.D.N.N. RANATHUNGA[3] AND G.D. NELUMSHEELI[1]

[1]Regional Rice Research and Development Centre, Bombuwela, Sri Lanka, [2]Regional Agriculture Research & Development Centre, Bandarawela, Sri Lanka, [3]Office of the Deputy Director of Agriculture (Inter Provincial Office), Polonnaruwa, Sri Lanka

ABSTRACT

Twenty one traditional varieties presently available in the wet zone of Sri Lanka were managed organically and evaluated for grain yield along with three improved rice varieties, especially bred for Low Country Wet Zone. The trial was in two locations in Randomized Complete Block Design with two replicates during 2006 *yala* and 2006/07 *maha* seasons at Regional Rice Research and Development Centre, Bombuwela in Sri Lanka. Mean deviation parameters (D) and interaction variances (S^2) for each genotype were estimated to identify widely adaptable and stable varieties for locations and seasons. Traditional varieties such as Kahatawee, Molligoda, Dickwee, Madathawalu and Beath Heenati showed significantly high positive deviations and non significant lower interaction variations in yield for both locations and seasons. Hence those varieties are more adaptable and stable across the locations and seasons. Similarly the three improved varieties tested, Bw267-3, Bw272-6b and Bw364 performed well over both locations and seasons. Sulai, Herath Banda, and Hondarawala performed well in loamy soils than in sandy soils in both seasons. Godaheenati performed well in both locations during *yala* season. Dahanala, Kottayar, Suduheenati, Suwadal, and Manchelalergy were poor yielders with fairly acceptable stabilities. The variety Devaraddiri, a poor yielder was the highly stable variety next to Molligoda.

KEYWORDS: Adaptability, Organic farming, Stability, Traditional rice varieties

INTRODUCTION

Paddy cultivation in Sri Lanka has a documented history of more than 2300 years (Buddhaputhra Thero, 1236-1270). Pre historic existence of rice in the form of wild species and existence of large number of land races in Sri Lanka during early periods and use of ancient irrigation systems indicated that

prominence was given to rice cultivation in the past (Rajapksha *et al.*, 2000). There are evidences to show that the Great Kings of Sri Lanka had extended their patronage for uplifting paddy cultivation (Ellawala, 1964). During that period Sri Lanka was known as granary of the East due to its self sufficient economic pattern obtained through paddy cultivation. As there was no evidence in usage of inorganic fertilizer or pesticide during that period, we believe the production was obtained solely from organic farming methods. In recent history rice yield fluctuations have been observed in the country. During 1940's the rice production was 0.26mMT. Since the quantity was not sufficient to feed the nation, county imported 60% of the rice requirement at that time. According to Department of Census and Statistics, at present country produces 3.87m MT and import less than 1%. From late 1950s, to realize high yielding healthy rice crop, the Department of Agriculture produced fertilizer responsive high yielding rice varieties and secured the staple food, rice in the country. By 1980s traditional rice varieties were replaced almost completely by high fertilizer responsive improved rice varieties. These varieties are of semi dwarf nature in plant type with erect leaves. Therefore, less weed competitive ability was shown. Hence chemical weed control over a long period of time becomes a practice in rice cultivation. Intensive rice cultivation with 10-15 improved varieties has increased the pest population especially Brown Plant Hopper (BPH) and Gall Midge (GM) in the resent past. Similarly Blast and the Sheath Blight disease incidences were higher and use of chemicals for pest and disease control were increased, though it has reduced with the cultivation of rice varieties resistant to major pests and diseases. Therefore, present intensive input system of rice cultivation has paved way to pollute ground water, reduce the natural soil fertility and create soil erosion and health hazards to human beings.

The demand for traditional rice varieties grown organically however, is increasing. Therefore, it is important to identify widely adaptable and stable high yielding traditional rice varieties for the Low Country Wet Zone (LCWZ) of Sri Lanka, an area with a potential for organic cultivation with minimal influence on the national rice production.

No systematic varietal evaluation has been reported under organic condition, in LCWZ of the country. The production potential of some traditional and improved rice varieties under organic rice culture was reported recently by Bandara, *et al.* (2007) and found that traditional rice varieties such as Gonabaru, Godawee, Herath banda and Dickwee can successfully be cultivated under organic

farming conditions. Therefore, presently available traditional rice cultivars in the LCWZ of Sri Lanka were evaluated for their performances particularly for grain yield adaptability and stability in two locations having significantly different soil types (sandy and loamy) in two distinctly different cultivation seasons in Sri Lanka.

METHODOLOGY

Twenty three traditional rice varieties presently available in the wet zone were selected for this study and were evaluated along with three improved rice varieties especially bred for the Low Country Wet Zone (LCWZ) of Sri Lanka for grain yield in two locations over two seasons namely '*yala*' and '*maha*' in Randomized Complete Block Design with two replications. Each variety was evaluated on a plot of 3x4 m^2 and yield was estimated after removing a border of 30 cm around the plot. In the wet zone '*yala*' is the season with comparatively higher rain fall starting from March and ending in August and '*maha*' is the season with comparatively low rain fall starting in September and ending in February in the following year. Minimum temperature during *yala* was lower than that of *maha* season. Five agronomically important characters namely Culm length, Panicle length, Tiller number, Days to heading and Days to maturity were also recorded in each variety in each replicate to characterize varieties under different seasons and locations. The trial was managed organically in the two locations during 2006 *yala* and 2006/07 *maha* seasons at the Regional Rice Research and Development Centre, Bombuwela in Sri Lanka. The tested varieties are listed in Table 1. Soil characteristics of the two experimental locations are presented in Table 2.

Table 1. List of varieties tested

Dahanala	Devaraddari	Manchelalergy
Molligoda	Goda Heenati	Dick Wee
Kottyar	Kalu Heenati	Masuran
Sudu Heenati	Kahata Wee	Bw 267-3*
Rath Suwadal	Murungakayan	Rathu Heenati
Beath Heenati	Suwadal	Hondarawala
Sulai	Bw 272-6b*	Gonabaru
Bw 364*	Herath Banda	Madathawalu

* Improved rice varieties by conventional method of breeding at Regional Rice Research & Development Centre, Sri Lanka

Table 2. Soil Characteristics of two experimental locations

Soil parameter *	Sandy Location	Loamy Location
pH	4.7	5.2
EC (ds/m)	0.018	0.054
Texture (by feel)	Loamy sand	Loamy
P (ppm)	1.7	2.00
K (ppm)	06	43
OM %	3.18	21.62
Fe (ppm)	1.8	281

EC- Electric Conductivity P- Initial Phosphorus content

K- Initial Potassium content OM- Initial Organic Matter content

Fe- Initial Iron content

*Data from Soil Science Laboratory at Regional Rice Research Development Centre, Bombuwela, Sri Lanka.

Analysis of variance on the plot deviations from mean yield in each season and location was performed. When the interactions were present they were analyzed by a method proposed by Abeysiriwardena *et al.* (1991). In this method mean deviation parameters (D) provide the average effect of each genotype separately, hence provide an opportunity to select significantly high and positive deviations over all environments. Further interaction variances (s^2) provide to identify non significant interaction variances corresponding to each genotype over locations and over seasons and provide stable varieties over seasons and over locations.

RESULTS AND DISCUSSION

Mean grain yield of all the tested varieties in the loamy location was 1.24 t/ha while that of sandy location was 0.84 t/ha. Similarly mean grain yield in 2006/07 *maha* season was 1.38 t/ha and that of 2006 *yala* season was 0.71 t/ ha. Results implied that the adequate locational and seasonal differences were achieved to evaluate variety adaptability across diverse environments. Results further revealed that loamy location and 2006/07 *maha* season was the most favorable experimental environment for the rice production. According to soil characteristics of two experimental locations given in table 2 the loamy location is the most fertile location and this location as expected was favorable for rice cultivation than the sandy location. Plant response indicates that the *maha* season is the better yielding season in the wet zone (DOA, 2009).

In order to increase the productivity across all environments it is important to identify widely adaptable varieties across all environments or specific varieties for specific environment. Hence, analysis of genotype x environment (GE) interaction in an agronomically sound way was adopted. This means any disproportionate yield variability has been considered to measure yield stability. Varieties were selected for adaptability using mean deviation (D) across environments and stability parameter derived by partitioning GE interaction variance into components, one corresponding to each variety (s^2).

Combined analysis of variance for plot yield deviations of varieties over locations and seasons is presented in Table 3. Three way interaction effect of variety x location x season was found to be not significant. However, two way interaction effects of variety x location and variety x season were found to be significant at 0.05 and 0.01 probability levels, respectively. Hence mean deviations of yield across environments (D) were calculated and Duncan New Multiple Range Test (DNMRT) was performed for separation of mean deviations. Similarly, stability parameter (s^2) corresponding to each variety was estimated over locations and over seasons separately. Mean yield of each variety along with all the corresponding D and s^2 values are presented in Table 4. Mean deviation of yield, D includes only the average effect of variety while mean yield of variety includes overall mean (a constant) in addition to the average effect of variety. Both parameters showed perfect co-relation (r = 1) as expected. Positive and high D values are useful to select highly adaptable varieties regardless of s^2 values. Hence, D values have an advantage over mean yield data in evaluating varieties.

Table 3. Combined analysis of variance for plot yield deviations (t/ha) of 24 varieties grown in two locations during two seasons

Source	DF	MS
Block(Location)	2	4.65***
Varieties	23	0.84***
Season	1	9.10×10^{-7}
Location	1	1.7×10^{-7}
Season x Varieties	23	0.51**
Location x Varieties	23	0.40*
Season x Location	1	1.9×10^{-8}
Season x Location x Varieties	23	0.26
Error	94	0.23
Total	191	

*, **, *** significant at the 0.05, 0.01 and 0.001 probability levels, respectively

Table 4. Yield, adaptability and stability parameters of D and s^2 for 24 varieties grown in two locations over two seasons

Variety	Grian yield t/ha	D t/ha x 10^{-2}	s^2 x 10^{-2}	
			Seasons	Locations
Dahanala	0.53^{cd}	-51.93^{cd}	59.50	36.90
Molligoda	1.13^{ab}	8.70^{ab}	1.50	0.30
Kottayar	0.55^{cd}	-49.30^{cd}	42.00	10.90
Sudu Heenati	0.33^{d}	-71.05	31.70	6.30
Rath Suwadal	0.95^{abc}	-09.30^{dbc}	31.70	6.30
Beath Heenati	1.16^{ab}	11.58^{ab}	46.90	6.10
Sulai	1.43^{a}	38.08^{a}	10.50	222.80**
Bw 364	1.30^{ab}	25.08^{a}	9.70	75.50
Devaraddari	0.71^{bcd}	-33.05^{bcd}	2.70	3.80
Goda Heenati	1.24^{ab}	19.08^{ab}	305.30**	3.40
Kalu Heenati	1.01^{abc}	-3.93^{abc}	16.80	7.60
Kahata Wee	1.44^{a}	39.70^{a}	17.10	11.20
Murungakayan	1.03^{abc}	-2.05^{abc}	150.70**	10.90
Suwadal	0.88^{abcd}	-16.68^{abc}	16.80	8.40
Bw 272-6b	1.22^{ab}	17.45^{ab}	32.50	3.20
Herath Banda	1.44^{a}	39.08^{a}	31.10	103.50**
Manchelalergy	0.49^{dc}	-55.80^{dc}	16.60	25.50
Dick Wee	1.18	13.95^{ab}	30.70	35.80
Masuran	0.96^{abc}	-08.30^{abc}	157.40**	10.40
Bw 267-3	1.41^{a}	36.58^{a}	46.90	2.00
Rathu Heenati	1.02^{abc}	-02.05^{abc}	40.00	45.50
Hondarawala	1.35^{a}	30.70^{a}	17.60	211.40**
Gonabaru	0.99^{abc}	-5.93^{abc}	34.40	11.50
Madathawalu	1.34^{a}	29.33^{a}	15.70	55.20

** Significant at 0.01 probability level.

'D's with the same letter are not significantly different based on the 0.05 probability level (DNMR Test)

High and positive D values were observed in nine traditional varieties namely Kahatawee, Herath banda, Sulai, Hondarawala , Madathawalu, Goda Heeneti, Dikwee, Beath Heenati and Molligoda. Among those adaptable 9 traditional varieties Kahatawee, Madathawalu, Dikwee, Beath Heenati and Molligoda had non significant lower interaction variation in yield for both locations and seasons. Similar pattern was observed from three improved varieties, Bw 267-3, Bw 364 and Bw 272-6b. Hence it is reasonable to state that those five traditional varieties and 3 improved varieties were more adaptable and stable across locations and seasons. Sulai, Herath Banda and Hondarawala showed significantly high location interaction at 0.01 probability level indicating that they performed well in loamy location than sandy location in both seasons. Goda heenati had a significantly higher seasonal interaction and performed well in both locations during 2006 *yala* season. Dahanala, Kottayar, Sudu Heenati, Suwadel

and Manchelalergy were poor yielders with lower s^2 values. Hence these varieties had acceptable stabilities in all environments.

Table 5. Agronomic characters of the varieties used in the study

Variety	Agronomic Character *				
	Culm Length (cm)	Panicle Length (cm)	Tiller Number	Days to 50% Flowering +	Days to Maturity +
Dahanala	86.86^{lk}	19.64^{jk}	4.4^{bcde}	68.9^{hi}	99.9^{k}
Molligoda	138.74^{bc}	26.56^{bcd}	3.1^{h}	101.4^{ab}	137.5^{ab}
Kottyar	113.13^{ef}	24.30^{cdefg}	3.0^{h}	82.9^{fg}	126.3^{def}
Sudu Heenati	113.33^{ef}	23.59^{efgh}	3.4^{gh}	81.6^{fg}	116.5^{ghi}
Rath Suwadal	102.51^{hij}	18.88^{k}	4.5^{bcde}	68.0^{i}	108.5^{ij}
Beath Heenati	106.50^{fhi}	22.90^{fghi}	6.0^{a}	89.9^{cdef}	121.0^{fgh}
Sulai	142.34^{ab}	26.40^{bcd}	3.3^{h}	101.6^{ab}	136.9^{abc}
Bw 364	78.79^{l}	21.51^{hij}	3.8^{efgh}	77.8^{gh}	111.6^{ij}
Devaraddari	130.05^{d}	24.58^{bcdefg}	3.5^{fgh}	85.1^{efg}	122.5^{efg}
Goda Heenati	128.99^{d}	24.96^{bcdefg}	3.8^{efgh}	83.9^{fg}	120.9^{fgh}
Kalu Heenati	112.21^{efg}	22.85^{fghi}	4.5^{bcde}	82.3^{fg}	111.9^{ij}
Kahata Wee	135.38^{bcd}	27.18^{b}	3.4^{gh}	101.4^{ab}	138.8^{a}
Murungakayan	130.95^{cd}	26.84^{bc}	3.3^{h}	99.1^{abc}	133.1^{abcd}
Suwadal	103.76^{ghij}	26.23^{bcd}	4.8^{bc}	83.6^{fg}	110.6^{ij}
Bw 272-6b	82.40^{kl}	24.29^{cdefg}	4.8^{bc}	69.8^{hi}	115.4^{jk}
Herath Banda	117.58^{e}	20.64^{ijk}	3.0^{h}	81.1^{fg}	114.1^{lhi}
Manchelalergy	88.31^{k}	22.51^{ghi}	4.1^{cdefg}	61.5^{i}	91.3^{l}
Dick Wee	110.46^{efgh}	25.91^{bcde}	4.4^{bcde}	95.6^{abcd}	134.9^{abc}
Masuran	109.89^{efgh}	25.06^{bcdefg}	5.1^{b}	94.1^{bcde}	140.5^{a}
Bw 267-3	97.56^{j}	25.19^{bcdef}	4.6^{bcd}	88.1^{def}	116.5^{ghi}
Rathu Heenati	100.76^{ij}	23.41^{efgh}	4.3^{cdef}	87.3^{defg}	128.9^{cdef}
Hondarawala	111.94^{efg}	24.75^{bcdefg}	4.1^{cdefg}	95.5^{abcd}	134.4^{abcd}
Gonabaru	147.01^{a}	29.64^{a}	3.9^{defgh}	105.4^{a}	138.5^{a}
Madathawalu	114.74^{ef}	23.94^{defgh}	3.3^{h}	100.5^{ab}	129.4^{bcde}
CV% **	6.99	9.20	18.40	9.95	5.93

* Values with same letter within columns are not significantly different at 0.05 probability level; ** CV – Coefficient of Variation; + Days after dry sowing

The variety Devaraddiri and Molligoda had the lowest stability parameters in all environments though they are poor yielders. The culm length, panicle length, tiller number, days to 50% flowering and days to maturity of the tested varieties are given in Table 5.

The Culm length of the varieties varied from 78.79cm to 147.01cm while panicle length varied from 18.88cm to 29.64cm. Most of the traditional varieties with taller culms were lodged. Therefore, precautions should be taken to avoid contamination of panicles with mud. Most of the varieties had 3-5 tillers whereas Beath Heenati had the highest number of tillers of 6. Days to 50% flowering of the tested materials varied from 61 to 105 days. Days to maturity varied from 91 days to 140 days. As the different ecosystems of rice growing environments of LCWZ of Sri Lanka demands different varieties with varying age, the tested material will provide an opportunity to select the best varieties that would match to their ecosystems.

CONCLUSION

Kahatawee, Molligoda, Dickwee, Madathawalu and Beath Heenati were more adaptable and stable traditional varieties to be grown under organic condition across the locations and seasons. The similar observations were made from three improved varieties tested. Sulai, Herath Banda, and Hondarawala performed well in loamy soils than in sandy soils in both seasons. Godaheenati performed well in both locations during *yala* season. Dahanala, Kottayar, Suduheenati, Suwadal, and Manchelalergy were poor yielders with fairly acceptable stability. The variety Devaraddiri, a poor yielder, was a highly stable variety next to Molligoda.

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