

## **GRAIN YIELD AND YIELD VARIABILITY OF RICE UNDER HIGH MANAGEMENT IN DIFFERENT AGRO-CLIMATIC ZONES IN SRI LANKA**

G.A.M. SHANTHA SIRI EMITIYAGODA<sup>1</sup>, D. SUMITH de Z.  
ABEYSIRIWARDENA<sup>2</sup> and NILUSHI SILVA<sup>1</sup>

<sup>1</sup> *Extension and Training Division, Department of Agriculture, Peradeniya, Sri Lanka*

<sup>2</sup> *CIC Agribusiness Center, Peiwehera, Dambulla, Sri Lanka*

### **ABSTRACT**

A study was undertaken to ascertain the highest possible rice yield that could be obtained and the yield variability under good crop management as influenced by the location, season, and variety and its age group, in two different agro-climatic zones of Sri Lanka. Data obtained from the "Maximum Yield Demonstration Programme" conducted by the extension officers were used. Based on the yield levels practically realized, the potential yield of the low country dry and intermediate zones (LCD&IZ) with currently cultivated varieties was estimated as 11.73 t/ha, which is the highest yield recorded to-date from inbred rice varieties available in the country. The maximum yield recorded in the low country wet zone (LCWZ) was 9.38 t/ha. The mode yield level in the LCD&IZ was 6 t/ha while that in the LCWZ was 5 t/ha. The location, season, and variety and its age group were found to be influencing the grain yield and yield variability in both agro-climatic zones while yield variability in the LCWZ was found to be the same as that in the LCD&IZ. Further yield improvements is possible through reducing the location differences by improving crop management and selecting the correct variety and the age group depending on the season and agro-climatic zone. Yield comparison among administrative districts could be misleading due to intra-district variations in climatic and soil conditions.

**KEYWORDS:** Age group, agro-climatic zone, grain yield, high management, rice

### **INTRODUCTION**

The agriculture sector in Sri Lanka contributed to 12.1% of the total gross domestic production (GDP) in 2008, while the rice sector alone contributed 14.8% to the agricultural GDP (Central Bank of Sri Lanka, 2008). The present annual value of the rice in Sri Lanka is about Rs. 99.8 billion, which has shown an increasing trend in the past, although, the relative contribution of the rice sector to the total GDP is diminishing. About 879,000 farm families comprising of 20% of the total population and 32% of the total labor force is directly engaged in the rice sector in Sri Lanka (Central Bank of Sri Lanka, 2008).

Sri Lanka has 730,000 ha of asweddumized rice lands. This is the maximum available extent for rice cultivation at present. Out of the above extent, at present about 600,000 ha are cultivated during *maha* season showing a seasonal cropping intensity of 82% and about 400,000 ha are cultivated in *yala* season showing a seasonal cropping intensity of 58.9% accounting for an

annual cropping intensity (CI) of 140.9%, which is an increase of the CI from around 120% recorded in the past decade. The stagnated rice production and average yield during the 1990s changed to an increasing production levels starting from the year 2000. The national average yield, which remained at 3.5 t/ha, increased up to 4.3 t/ha by the year 2007. The major contributory factors for this increase was the adoption of good management practices such as cultivation of high yielding varieties, use of proper crop establishment methods, timely cultivation, proper land preparation, application of recommended levels of fertilizers and organic manure to improve soil fertility, adoption of good pest management practices and use of proper post harvest technology.

With the enhanced demand for local consumption of rice due to gradual substitution of wheat flour and population growth, an increase in rice production by 30% was targeted by the end of 2010 under the domestic food production campaign conducted by the Ministry of Agriculture Development and Agrarian Services (MADAS, 2008). This expected production levels could be achieved by increasing the cultivated extent and/or improving productivity. According to the initial estimates, the extent that could be increased immediately by cultivating abandoned rice lands was about 20% (120,000 ha), which was already achieved in 2008. The national average yield targeted to be achieved by the end of 2010 is 5.4 t/ha.

Under the best environmental conditions, the theoretical yield potential of rice has been calculated to be 23.8 t/ha, if the length of the maturity phase is 40 days (Yoshida, 1981). However, based on the reports presently available, the highest yield recorded with inbred varieties in the subtropical and tropical environments are 15 t/ha and 11 t/ha, respectively. The highest recorded rice yield in the world to-date is 17.95 t/ha with a hybrid rice variety under a subtropical environment in China (Duwayri *et al.*, 1999). Yield potential is the maximum yield that a variety can reach under the best environment whereas potential yield is the maximum yield that can be realized by a variety  $\times$  environment combination. Most of the times environment appeared restricting the variety yield potential so that potential yield of the variety  $\times$  environment combination is the value mostly estimated practically.

Attaining the highest yield possible or the yield potential under a given environment is important to achieve expected productivity and improve farmer income. Grain yield is a function of genetic potential of the cultivar, the physical environment that includes climate and soil, the biological environment that includes insect pests, diseases and weeds, and the management practices adopted by the growers. The grower has no control in changing climatic factors that vary over zones and seasons, influencing the grain yield. The main variable factor that the grower can control is the management, which can influence soil and biological environments within

limits in addition to managing the crop itself mainly through selecting proper variety and the age group to fit into the climatic and soil environment where the crop is grown. Good crop management including adequate irrigation, soil fertility improvement and proper control of weeds, pests and diseases can increase yield.

The Extension and Training Division of the Department of Agriculture, Sri Lanka, has implemented various rice productivity improvement programs in the farmers' fields. The programmes implemented in the recent past were the National Agriculture Production Programme (NAPP), which was implemented from 1996 to 2004, and the Granary Area Programmes (GAP) implemented from 2004 to 2007 in high potential rice growing areas. The most recent program is *Api Wawamu Rata Nagamu* (AWRN), which is being implemented since 2008 to increase crop production including rice. Under these major programs, the Maximum Yield Demonstration (MYD) Programme is a sub-programme implemented by the extension officers attached to Provincial and Inter-Provincial Departments of Agriculture of the different administrative districts. The MYD program was done to demonstrate the recommended agricultural practices to obtain highest yields in different locations in the low country dry zone (LCD), low country intermediate zone (LCI), and the low country wet zone (LCWZ). Hardly any difference in rice yields between LCD and LCI zones has been reported in the past (Abeywardena, 2000; Abeywardena and Sandanayake, 2000; Emitiyagoda and Wirasinghe, 2000).

Abeywardena (2000) reported average potential rice yields for ten major rice-growing environments. Nissanka and Dayaratne (2002) reported the highest rice yield recorded in Sri Lanka (10 t/ha in *maha* season 2001/02) in the dry zone with the adoption of good soil improvement practices. However, no systematic study has been undertaken to ascertain the highest possible yield and yield variability with present day varieties under good management in different agro-climatic zones and cultivating seasons in Sri Lanka. Such studies are important to set target yields for different environments and to develop appropriate strategies to achieve them. The objective of the present study was to determine the highest rice yields achievable and the yield variability under good management as influenced by the location, age group of the variety and season in different climatic zones of Sri Lanka. District-wise yield comparison was also done as most of the development programs are made and implemented on district basis.

## MATERIALS AND METHOD

Data obtained from the Maximum Yield Demonstration (MYD) Programme of the National Agriculture Production Programmes (NAPP) and Granary Area Programme (GAP) was utilized as the primary data for this

study. The low country dry zone (LCD) and low country intermediate zone (LCI) were considered together as one zone (LCD&IZ) in the present study due to previous experience of similar rice yields. The plot size was 4000 m<sup>2</sup> in the LCD&IZ and 4000 or 2000 m<sup>2</sup> in the low country wet zone (LCWZ). These demonstrations were conducted in farmers' fields with the supervision of extension officers. Recommended amount of fertilizer (125 kg of Urea, 45 kg of Tripe Super Phosphate, 45 kg of Muriate of Potash, 2 kg of Zinc Sulphate and 10 kg of Kiesarite per 4000 m<sup>2</sup>) and cow dung (2 t/4000 m<sup>2</sup>) were supplied to the participating farmers. All the other practices including use of quality seed paddy, timely cultivation, proper land preparation, recommended weed control, integrated pest management, water management and recommended pre- and post-harvest operations were adopted by the farmers as their contribution to the programme. Varieties from all four age groups available namely 2½, 3, 3½ and 4 months, were used in the MYD. The number of varieties used within each age group varied depending on the number of high yielding varieties available. Only one variety (Bg 250) was available in the 2½ month age group and two (Bg 300 and Bg 305) were available in the 3 month age group. The number of varieties used in the 4 month age group (including varieties maturing around 4½ months) was 12 including the popular varieties such as Bg 379-2, Bg 403 and Bg 450 and in the 3½ month age group, 19 varieties were used including the popular varieties such as Bg 352, Bg 357, Bg 359, Bg 94-1, Bg 358, Bg 360, At 353, At 362, Bw 361, Bw 363 and Ld 356.

The number of demonstrations of all varieties covering both LCD&IZ and LCWZ conducted per season from 1999 *yala* season to 2005/06-maha season varied from 100 to 400 depending on the availability of financial and other resources, and the total number of demonstrations conducted over the above period was 2100. Yield estimations were done using the standard crop-cut methods (DCS, 2007) adopted by the extension officers in collaboration with the Department of Census and Statistics, Sri Lanka. The grain yield data were recorded at 14% grain moisture content, and summarized under different categories namely, agro-climatic zone, age group, variety, and season within agro-climatic zone using representative samples with varying sizes among categories. For example, grain yield data from sample sizes of 1540 and 196 combinations (variety × location × season) were available for the LCD&IZ and LCWZ, respectively. These samples adequately represented the zones as all the popular varieties and both cultivating seasons were used in the study while including adequate numbers of high, medium and low potential locations. As different categories with equal importance were compared, there was no control treatment as such in this study.

The average, mode, lowest and highest grain yield, and variance and coefficient of variation in grain yield within each category were estimated to characterize and compare among categories. Averages were compared using

confidence limits while variances were compared using F test for variance ratio. In a set of variances, the ratio of the highest to the lowest variance was first calculated and the F test was performed. If the result is not significant, all the variances in the set with similar sample sizes were considered not significantly different to each other. If the sample sizes were different, necessary variance ratios were further calculated and tested for significance. If the ratio of the highest to the lowest variance was found to be significant, then the ratio of the next highest to the lowest variance was calculated and tested for significance. This process was continued until all the non-significant variance groups were identified.

## RESULTS AND DISCUSSION

Although the rice yield data from 2100 demonstrations (100 to 400 demonstrations per season) of 4000 m<sup>2</sup> plots during the period from 1999 *yala* season to 2005/06 *maha* season were expected, data from only 1756 demonstrations were received. The number of demonstration plots conducted and those from which the data were received in different seasons under different development programmes are shown in Table 1.

**Table 1. Number of demonstration plots conducted and data were received in different seasons under different national development programmes in the rice sector**

<i>Rice Sector Development Programme</i>	<i>Season</i>	<i>Demonstrations</i>	
		<i>Number conducted</i>	<i>Number from which data received</i>
National Agriculture Production Programme	1999 <i>yala</i>	100	75
	1999/00 <i>maha</i>	225	198
	2000 <i>yala</i>	100	83
	2000/2001 <i>maha</i>	200	168
	2001 <i>yala</i>	250	228
	2001/2002 <i>maha</i>	400	337
Granary Area Programme	2004/05 <i>maha</i>	400	345
	2005 <i>yala</i>	175	140
	2005/06 <i>maha</i>	200	184
Total	09 Seasons	2100	1756

Data from 344 demonstrations were not received, as they had not been collected due to various reasons. Some of the demonstrations had not been properly managed by farmers, some had been severely damaged by pests, some had not been properly established due to poor seed germination, and some had been harvested without prior notification to the officer responsible. In addition, no demonstration could be conducted in 2002 and 2003 due to non-availability of financial resources. However, the available data provided

random samples to adequately represent LCD&IZ and LCWZ, different varieties and their age groups, and high, medium and low potential conditions in each agro-climatic zone.

### Grain yield and yield variability in different Agro-climatic Zones

The grain yield parameters of rice across the LCD&IZ and LCWZ of Sri Lanka are presented in table 2. The average grain yield in the LCD&IZ was higher than that in the LCWZ. Although the lowest yield obtained (3.13 t/ha) was the same in both agro-climatic zones, the frequency of occurrence was higher in the LCWZ (9.2%) than that in the LCD&IZ (0.9%). The highest yield recorded in the LCD&IZ (11.73 t/ha) was 25% higher than that in the LCWZ, under high management. They were the highest yields that have been reported in the LCD&IZ and LCWZ of Sri Lanka to-date. These yield levels could be considered as potential rice yields with present day cultivars in those zones. The previously recorded highest grain yield of rice (Nissanka and Dayaratne, 2002) in the Dry Zone is 14.7% lower than the highest yield recorded in the present study.

The within zone yield variability as measured by the yield variance was similar between two zones but the coefficient of variation was higher in the LCWZ than that in the LCD&IZ due to the relatively lower average yield recorded in the LCWZ. The within-zone yield variability may be attributed to yield differences resulting from the variations in location, season, variety and age group. This information is important to decide how the average rice yield could be increased in the respective zones by further improvements in management.

**Table 2. Grain yield parameters of rice in the Low Country Dry & Intermediate Zones (LCD&IZ) and Low Country Wet Zone (LCWZ) of Sri Lanka**

<i>Parameter and sample size</i>	<i>Agro-climatic zone</i>	
	<i>LCD&amp;IZ</i>	<i>LCWZ</i>
Sample size (No.)	1540	196
Highest Yield (t/ha)	11.73	9.38
Lowest Yield (t/ha)	3.13	3.13
Average Yield (t/ha)*	7.06 ± 0.06	5.83 ± 0.18
Mode Yield (t/ha)	6	5
Yield variance (t <sup>2</sup> /ha)**	1.39	1.61
CV (%)	17.4	22.7

\*Confidence limits at  $p=0.05$ . \*\*Within zone yield variances are not significantly different at  $p=0.05$ .

### Grain yield and yield variability as influenced by the age group

Table 3 shows the grain yield parameters of rice varieties grown in LCD&IZ and LCWZ.

**Table 3. Grain yield parameters of rice under different age groups in the low county dry and intermediate zones (LCD&IZ) and low country wet zone (LCWZ) of Sri Lanka**

Parameter & sample size	LCD&IZ				LCWZ		
	Age group				Age group		
	2½ m	3m	3½ m	4m	3m	3½ m	4m
Sample size (Number)	3	86	1197	249	4	121	70
Highest yield (t/ha)	7.30	11.21	11.73	10.95	6.36	9.49	9.49
Lowest yield (t/ha)	5.37	3.65	2.34	3.75	4.90	33.15	3.10
Average yield (t/ha)*	6.26	6.52	7.12	6.93	5.72	5.83	5.93
	± 2.57	± 0.27	± 0.07	± 0.14	± 1.18	± 0.19	± 0.36
Mode yield (t/ha)	NA	5	7	7	NA	5	6
Yield variance (t <sup>2</sup> /ha)**	0.57	1.59 a	1.56 a	1.35 a	0.73	1.12 a	2.32 a
CV (%)	12.6	19.4	18.4	12.6	15.5	19.0	26.7

- ± Confidence limits at p=0.05; NA - Data not available due to inadequate sample size.
- \*\* The yield variances of the 2½ month age group in the LCD&IZ and 3 month age group in the LCWZ were not compared with that of other age groups due to their low sample sizes. Variances followed by the same letter within a zone are not significantly different at p=0.05.

## LCD&IZ

The most popular rice age group in the LCD&IZ was the 3½ month as it represented 78% of the samples. The sample size (03) for the 2½ months varieties was inadequate to represent the age group (Table 3). This is because only one variety in this category has been recently released by the Department of Agriculture for cultivation particularly in drought and flood prone areas.

The average yields among 3, 3½ and 4 months age groups were not significantly different (p<0.05) in the LCD&IZ, although the 3½ month age group has given the highest and the lowest grain yields. The mode yield of 3½ and 4 month age groups (7 t/ha) was the highest. In overall ranking, the 3½ month age group was the best age group in terms of high grain yields in the LCD&IZ. Introducing varieties in 3 and 4 month age groups depending on the availability of water would not affect rice productivity and production in this agro-climatic zone. In addition, the ever-recorded highest yield of 11.73 t/ha may only be attained with the 3½ month age group in the LCD&IZ. It is also important to note that, although the maturity duration is ultra short in 2½ month age group, it could produce even up to 7.3 t/ha under good management in the LCD&IZ and this was the highest grain yield by this age group to-date in Sri Lanka. The yield variability of the 3, 3½ and 4 month age groups were not significantly different indicating that all three age groups were similar in adaptability across locations and seasons within the LCD&IZ. The yield

variability observed within each age group within a climatic zone may be attributed to variety, location and seasonal differences.

## LCWZ

No farmer was cultivating rice in the 2½ month age group at LCWZ. The highest and the lowest yields of 3½ and 4 month age groups were similar. Even the average yield of 3 month age group, though based on a small sample, was not significantly different ( $p>0.05$ ) from those of 3½ and 4 month age groups. However, the mode yield of 4 month age group was higher by 1 t/ha than that of 3½ month. The 4-month age group showed the highest yield variability indicating higher sensitivity of varieties in this age group to location and seasonal differences in the LCWZ, when compared with 3½ month varieties. Thus, when both the average yield and yield variability are considered, the 3½ month age group may be more suitable than the 4 month age group under good management in the LCWZ.

## Grain yield and yield variability as influenced by the season

The grain yield parameters of rice across seasons in the LCD&IZ and LCWZ of Sri Lanka are shown in Table 4.

**Table 4. Grain yield parameters of rice in *yala* and *maha* seasons in the low country dry and intermediate zone (LCD&IZ) and the low country wet zone (LCWZ) of Sri Lanka**

Parameter and sample size	LCD&IZ		LCWZ	
	<i>Yala</i>	<i>Maha</i>	<i>Yala</i>	<i>Maha</i>
Sample size (No.)	423	1117	87	109
Highest Yield (t/ha)	11.21	11.73	9.49	9.12
Lowest Yield (t/ha)	3.13	3.4	3.13	3.1
Average Yield (t/ha)*	6.88 ± 0.12	7.11 ± 0.07	6.05 ± 0.06	5.58 ± 0.2
Mode Yield (t/ha)	6	6	6	5
Yield variance (t <sup>2</sup> /ha)**	1.65 a	1.42 a	1.32 a	1.16 a
CV (%)	19.4	17.4	22.9	20.1

\* ± Confidence limits at  $p=0.05$ . \*\* Variances followed by the same letter within a zone are not significantly different at  $p=0.05$ .

## LCD&IZ

In the LCD&IZ, though the mode yields were similar, the average and the highest yields recorded in *maha* season were higher than that in *Yala* season. This indicates that *maha* season was more favorable for rice cultivation than *yala* probably due to low night temperatures during the

maturity period in the former. In addition, the highest grain yield (11.73 t/ha) was recorded in the *maha* season in the LCD&IZ (Table 4). These results indicate that the influence of seasonal differences on grain yield of rice is considerable in the LCD&IZ. The yield variability was similar in both seasons indicating that the factors influencing yield variability namely the location, variety and the age group of the variety have similar influence on rice yield in both seasons.

### LCWZ

In the LCWZ, however, the average, mode and highest yields in *yala* season were higher than that in *maha* season indicating that *yala* season was more favorable for rice cultivation in this zone. The reason for this is beyond the present study. The yield variability was similar in both seasons indicating that factors influencing yield variability namely the location, variety and the age group of the variety have similar influences on yield in both seasons as in both categories of agro-climatic zones.

### Grain yield and yield variability as influenced by the variety

As many popular varieties have been used in the LCD&IZ, the grain yield and variability as influenced by the variety was studied only in the LCD&IZ (Table 5). The most popular rice variety, as reflected by the sample size, was Bg 352 followed by Bg 358. The least popular variety was "*Pokuru samba*", which was not recommended by the Department of Agriculture (DOA) but a variety used by farmers. Among those recommended by the DOA, Bg 305 and At 402 were the least popular varieties, which may be due to the presence of some specific undesirable varietal characteristics such as early leaf senescence in both varieties, lodging in Bg 402 and long period of seed dormancy in Bg 305.

Significant variability among varieties in their yielding ability was observed. The varieties Bg 352, At 353 and At 361 recorded the highest yields of 11.73 t/ha in Sri Lanka. The variety At 361 was found to be the best with the highest yield and highest average yield while having a comparatively lower coefficient of variation in yield (Table 5). Although *Pokuru Samba* was one of the varieties with the lowest yield, but tested only in seven locations, it had the lowest variance and the lowest coefficient of variation in yield justifying its popularity among farmers. Although Bg 357 is a variety with high yield potential (Rajapakse *et al.*, 1999) recording its highest (11.47 t/ha) and average (7.14 t/ha) yields in this study, it showed a high variance and coefficient of variation in yield which has led to its low popularity among farmers. The variety Bg 94-1 recording an average yield of 7.5 t/ha and a moderately high mode yield and variance and low coefficient of variation in yield justifying its popularity especially among farmers in Ampara district.

still being the oldest variety in the list of recommended rice varieties in Sri Lanka.

The variance and coefficient of variation in yield could be used to measure the yield sensitivity of varieties across diverse environments. Yield sensitivity to environment varied considerably among varieties, ranging from *Pokuru samba* with the lowest sensitivity to Bg 357 with the highest sensitivity. Other varieties with relatively low sensitivity to environment were Bg 403, Bg 359, At 362 and At 402. Higher yield sensitivity of a variety to environment is critical as it would tend to reduce average yield of the variety in a given region and its acceptability by farmers.

**Table 5. Grain yield parameters different rice varieties popularly grown in the low country dry and intermediate zones (LCD&IZ) of Sri Lanka**

Variety	Sample size (no.)	Parameter				
		Maximum (t/ha)	Average* (t/ha)	Mode (t/ha)	Variance (t <sup>2</sup> /ha)**	CV %
Bg 352	480	11.73	6.99 ± 0.10	6	1.31 bcd	17.0
Bg 358	270	10.85	7.04 ± 0.12	6	1.05 cd	15.2
At 353	155	11.73	7.56 ± 0.29	6	1.86 bc	18.8
Bg 403	73	8.86	6.68 ± 0.21	6	0.83 de	14.2
Bg 300	73	11.21	6.47 ± 0.27	6	1.37 bcd	18.9
Bg 379/2	52	8.76	6.36 ± 0.25	6	0.86 cd	15.2
Bg 94-1	46	9.91	7.82 ± 0.34	7	1.37 bcd	15.6
Bg 357	42	11.47	7.14 ± 0.61	7	4.07 a	29.0
Bg 450	41	9.59	6.68 ± 0.33	6	1.17 bcd	16.9
Bg 359	39	9.49	7.15 ± 0.3	7	0.92 cd	14.1
At 362	36	11.73	7.46 ± 0.29	7	0.79 d	12.4
Bg 360	32	10.48	6.99 ± 0.42	6	1.35 bc	17.3
LD 355	20	9.39	6.52 ± 0.49	6	1.10 bcd	16.4
Bg 350	14	9.29	6.89 ± 0.58	6	1.04 cd	15.4
At 361	11	11.73	9.08 ± 0.85	8	1.66 bcd	14.8
At 402	9	8.86	7.62 ± 0.67	7	0.80 cd	12.2
Bg 305	7	9.65	7.72 ± 1.02	7	1.29 bcd	15.3
<i>Pokuru Samba</i>	7	7.40	6.42 ± 0.32	6	0.13 e	6.0

\*± Confidence limits at p=0.05. \*\* Variances followed by the same letter are not significantly different at p=0.05.

### Grain yield and yield variability as influenced by the location

As large number of locations (1756) were involved in the study, presenting data from all the locations is difficult. Hence, only the locations having information on soil type in the LCD&IZ with a grain yield of more than 10 t/ha were selected for the discussion. Locations were grouped within

variety for comparison purposes and the variety, locations within variety and their soil types and grain yields are presented in Table 6. This information would be of immense importance for rice breeders who are breeding for high yield potential.

**Table 6. Rice variety and locations with a grain yield of more than 10 t/ha and their soil types in the low country dry and intermediate zones (LCD&IZ) of Sri Lanka**

Variety	Location within variety	Soil Type*	Grain yield (t ha <sup>-1</sup> )**
At 362	Ambalantota 1	Alluvial	11.73
	Ambalantota 2	Alluvial	10.95
	Ambalantota 3	Alluvial	10.95
	Ambalantota 4	Alluvial	10.64
	Ambalantota 5	Alluvial	10.48
	Ambalantota 6	Alluvial	10.48
	Ambalantota 7	Alluvial	10.43
At 353	Ambalantota 1	Alluvial	11.73
	Ambalantota 2	Alluvial	11.21
	Ambalantota 3	Alluvial	10.69
	Ambalantota 4	Alluvial	10.69
Bg 352	Nikaweratiya 1	NCB	11.73
	Rajangana LB	NCB	11.21
	Nikaweratiya 2	NCB	10.69
	Monaragala	LHG	10.64
Bg 357	Mayadunne, Ampara	NCB	11.47
	Pallanoya, Ampara	NCB	10.95
	Udayapura, Ampara	NCB	10.82
	Mapakada, Badulla	LHG	10.74
Bg 94-1	Uhana1, Ampara	NCB	11.47
	Uhana2/Ampara	NCB	10.21
	Mayadunna, Ampara	NCB	10.48
Bg 358	Okkampitiya	RBE	10.85
	Rajangana RB	RBE	10.69

\* NCB = Non Calcic Brown, LHG = Low Humic Gley, RBE = Reddish Brown Earth. \*\* As the yields reported are not the averages but the yields at single locations, confidence limits are not given

Despite the restricted location variability within a variety, due to selecting locations giving yields more than 10 t/ha, the locations have shown a considerable influence on grain yield and yield variability in all varieties tested. The main factors that have contributed to the location variability of a variety may be the management of insect pests and weeds, as most of the locations where a variety has been cultivated had the same soil type. A larger variability could be expected if a variety was grown in locations with different

soil types. Thus, location would be a major factor that influences grain yields variability of a rice variety in a given region.

High yields of over 10 t/ha have mostly been obtained from Alluvial and Non Calcic Brown (NCB) soils, and in two locations each with Low Humic Gley (LHG) and Reddish Brown Earth (RBE) soils. Comparatively lower frequency of achieving grain yields over 10 t/ha in LHG soils is not in agreement with the findings of Panabokke (1998) who reported that LHG is the best soil with a comparatively higher potential to obtain high rice yields.

### Grain yields recorded in different administrative Districts

As most of the rice sector development plans are made and implemented on administrative district basis, the grain yield data were also recorded district- wise (Table 7).

**Table 7. Grain yield parameters of rice in different administrative districts in the low country dry and intermediate zones (LCD&IZ) and the low country wet zone (LCWZ) of Sri Lanka**

Zone and Administrative district	Sample Size	Yield (t/ha)		
		Highest	Average*	Mode
<b>LCD&amp;IZ</b>				
Hambantota	282	11.73	7.56±0.13	6
Kurunegala	316	11.73	6.83±0.12	6
Ampara	37	11.47	8.60±0.27	7
Monaragala	173	10.85	6.99±0.21	6
Anuradhapura	272	10.69	7.19±0.11	6
Batticaloa	30	9.91	6.78±0.34	6
Hasalaka	122	9.91	6.62±0.29	7
Puttalam	17	9.49	6.41±0.48	5
Mannar	25	8.76	8.08±0.31	7
Trincomalee	119	8.60	6.41±0.23	6
Polonnaruwa	95	8.34	6.78±0.21	6
<b>LCWZ</b>				
Ratnapura	71	9.49	5.89±0.25	5
Matale	12	9.38	6.62±0.42	6
Matara	48	8.60	5.99±0.43	6
Kegalla	28	7.56	5.79±0.47	5
Kandy	31	7.09	5.32±0.29	5
Galle	6	5.42	4.79±0.38	5

\* ± Confidence limits at p=0.05

The highest grain yield reported in the LCD&IZ (11.73 t/ha) was recorded in both Hambanthota and Kurunegala Districts, followed by in Ampara district. Monaragala and Anuradhapura districts also recorded higher grain yields. In the LCD&IZ, the highest average yield (8.6 t ha<sup>-1</sup>) was reported from Ampara district. The Mannar district reported the second highest average and the highest mode yield. Comparatively lower rice yields, still at good management levels, were reported from Polonnaruwa and Trincomalee districts, which may be due to the inherent low fertility of the soils of those districts as reported by Wickramasinghe *et al.* (2007).

In the LCWZ, Matale district recorded the highest yield. Ratnapura, Kandy, Matarā and Kegalla districts recorded considerably yields while Galle recorded the lowest yield. Although comparatively higher yielding districts have been identified as wet zone districts, some parts of the rice growing areas of those districts belong to dry and intermediate zones with a higher yield potential than that of the wet zone. This shows that district-wise yield comparison is misleading due to different climatic and soil conditions found within a district.

## CONCLUSIONS

The present study reported the highest rice grain yield recorded to-date, i.e. 11.73 t/ha, with locally bred rice varieties grown in Sri Lanka. As the yield potential of locally bred rice varieties is high, proper crop management with supplementary irrigation would help reach higher yield levels of more than 10 t ha<sup>-1</sup> in high potential areas as reported in the present study. Based on the yield levels practically realized, the potential yield of the LCD&IZ with present day varieties can be considered as 11.73 t/ha while that of the LCWZ as 9.38 t/ha. The mode yield level in the LCD&IZ was 6 t/ha while that in the LCWZ was 5 t/ha. Thus, in the countrywide development programmes, the present targets should be set to achieve these yield levels in the respective agro-climatic zones.

The location, season, variety and the age group of the variety were found to be influencing on the yield variability within the climatic zone, and was found to be similar between LCWZ and LCD&IZ. Further yield improvements to achieve the target yields is possible through reducing location differences by further improving crop management, including water and soil fertility management, and selecting the correct variety in the appropriate age group best suited to the season and agro-climatic zone.

District-wise yield comparison appeared not reliable as soil types, areas under different climatic zones, and others factors such as irrigation that influence grain yield of rice vary among districts. The crop-cut surveys implemented by the Department of Census and Statistics of Sri Lanka, to

estimate grain yield of rice, should be presented on the basis of agro-climatic zones in addition to the basis on administrative districts, for better utilization of the results.

## ACKNOWLEDGEMENTS

Authors wish to record their appreciation to the extension staff for conducting field trials and providing necessary data. Authors also acknowledge the support given by Dr. W.M.W. Weerakoon, Research Officer of the Rice Research and Development Institute (RRDI), Batalagoda, Sri Lanka, in reviewing this manuscript.

## REFERENCES

- Abey Siriwardena, D.S. de Z. 2000. Rice varietal improvement for future challenges. Rice Congress 2000. Department of Agriculture, Peradeniya, Sri Lanka. 87-99 p.
- Abey Siriwardena, D.S. de Z. and C.A. Sandanayake. 2000. Future rice research as directed by trends in cultivated extent and yield of rice during the recent past. Proceedings of the Annual Symposium of the Department of Agriculture, Sri Lanka. 2000:371-380.
- Central Bank of Sri Lanka. 2008. Annual Report. Central Bank of Sri Lanka, Colombo, Sri Lanka.
- DCS. 2007. Instructions for crop cut surveys. Department of Census and Statistics, Colombo, Sri Lanka.
- Emitiyagoda, S. and A.S.D.A. Wirasinghe. 2000. Rice productivity improvement in Sri Lanka, Yaya (tract) program. Annual Symposium of the Department of Agriculture, Peradeniya, Sri Lanka. 2000:395-408.
- Duwayri, M., D.V. Tran and V.N. Nguyen. 1999. Reflections on yield gaps in rice production. Int. Rice comm. newsletter. Food and Agriculture Organization of the United Nations. 49: 13-25 p.
- MADAS. 2008. Sri Lanka Paddy Cultivation - "Let us Cultivate and uplift the Nation". National Campaign to motivate Domestic Food Production 2008-2010, Ministry of Agriculture Development and Agrarian Services, Sri Lanka. 6-12 p.
- Nissanka, W.M.B.S. and P.M.N. Dayaratne. 2002. Competitiveness as a self motivation to increase productivity in rice: a new extension approach to *yaya* program. Annals of the Sri Lanka Department of Agriculture. 4:393-398.
- Panabokke C.R. 1998. Soils of Ceylon and Fertilizer Use. M. D. Gunasena Co. Ltd., Colombo, Sri Lanka. 119-120 p.
- Rajapakse R.M.T., B.D. Pathinayake and M.P. Dhanapala. 1999. Development of short duration rice varieties with high yield potential. Annual Symposium of the Department of Agriculture, Peradeniya, Sri Lanka. 1999:19-27.

- Wikramasinghe, D.B., D.N. Sirisena, W.M.U.K. Rathnayake, H.N.A.B. Herath, and M. Jinadarie. 2007. Use of GIS to assess the spatial variability of soil fertility characteristics of rice soil in the Parakrama Samudraya Scheme in Sri Lanka. Proc. 8<sup>th</sup> ESASS conf. 22-23 Oct 2007, Tsukuba, Ibaraki, Japan.
- Yoshida, S. 1981. Fundamentals of Rice Crop Science. International Rice Research Institute, Manila, Philippines, 90-92 p.