
RESEARCH ARTICLE

Agronomic characters of some traditional rice (*Oryza sativa* L.) cultivars in Sri Lanka

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Abstract: Grain yield in rice is a complex trait and highly dependent on the other agronomic characters. Agronomic characters and grain yield of twenty traditional rice cultivars were evaluated at Faculty of Agriculture, University of Ruhuna in *Maha-2010/2011* and in *Yala/2011*. The experiment was conducted according to the randomized complete block design with three replicates. Twenty plants from each cultivar were evaluated for the selected characters, Plant height, Leaf blade length, Leaf blade width, Number of tillers, Number of reproductive tillers, Panicle length, Number of spikelets per panicle, Number of fertile spikelets per panicle, Number of infertile spikelets per panicle, Seed length, Seed width, 100 seed weight and Yield per plant. Recommended modern rice cultivar Bg 379/2 was used as the reference. Deviations of each character in different traditional rice cultivars from those of recommended rice cultivar Bg 379/2 were recorded. The average plant height of the tallest rice cultivar, *Podihatatha* was 198 cm and that of the shortest rice cultivar, *Rathranwee* was 68 cm. The longest leaf blade and longest culm length were also belonged to *Podihatatha*. The highest number of tillers (9.6 tillers per plant) and the highest average number of reproductive tillers (9 per plant), were recorded by rice cultivar *Mahasudu wee*. The highest value of 100 seed weight was recorded by rice cultivar *Galpa wee*. However, the most important economical character, the highest yield per plant (28.52g/plant) was recorded by *Thanthiribalan* which was significantly higher than that of in the recommended rice cultivar Bg 379/2 (26.5 g/plant). Significant correlations were found between the yield per plant and the characters such as number of reproductive tillers ($r = 0.692$), panicle length ($r = 0.565$) and number of spikelets per panicle ($r = 0.761$). Agronomic data collected in the present study would be important to understand the suitability of an individual rice cultivar for the farmer field.

Keywords: Traditional rice, Agronomic characters, field experiment, Sri Lanka

Introduction

Improvement of rice grain yield is the main target of breeding program to develop rice varieties. Grain yield is a complex trait, controlled by many genes and highly affected by environment. In addition, grain yield is also related to other characters such as plant type, growth duration, and yield components (Yoshida 1981). Sri Lanka has a rich treasure of traditional rice cultivars and there are about 2000 conserved traditional rice varieties (Priyangani *et al.*, 2008). Many are very high in nutritional value and

have medicinal properties and most are resistant to extreme climatic conditions, soil conditions, diseases and pests. Conservation of genetic materials has been gaining importance as natural resources diminish (Yano & Sasaki, 1997; He *et al.*, 1999; Rabiei *et al.*, 2004). Reintroduction and improvement of traditional rice cultivars selected by mass selection method have been reported in different countries (Gravois & Mc New, 1993; Jannink *et al.*, 2000; Almekinders & Elings, 2001; Gyawali *et al.*, 2007).

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Some Sri Lankan traditional rice cultivars have been screened for abiotic stress tolerances such as submergence and salinity (Ranawake *et al.*, 2010a, some Ranawake *et al.*, 2010b; Ranawake *et al.*, 2011a, Ranawake *et al.*, 2011b). Tolerant rice cultivars for those stresses have been identified. Information on agronomic characteristics of these rice cultivars are needed for the further utilization of them in rice improvement programmes. Correlations between yield and other agronomic characters are important for the production of high yielding rice cultivars.

The objective of the present study was to investigate general phenotypic characters of selected traditional rice cultivars and to understand the correlations between agronomic characters and grain yield of these cultivars. Genetic variability of important traits and their association with grain yield in rice has also been studied previously (Silva, 2009).

Materials and Methods

Twenty Sri Lankan traditional rice cultivars were used for the experiment. Seeds were obtained from Plant Genetic Resource Center (PGRC) Gannoruwa. The accession numbers and names of the traditional rice cultivars used for the study are in given in Table 1. Seeds were kept at 50°C for 5 days to break dormancy and then they were dipped in 70% alcohol for 2 minutes and washed properly with distilled water. Seeds were then dipped in 2% Clorox for 30 minutes and were washed properly with distilled water. Seeds were kept in an incubator at 35°C for 7 days under dark condition and germinated seeds were planted in trays for two weeks. Two week old seedlings were then transplanted in the paddy field according to the randomized complete block design with three replicates and 20 plants per replicate with 15 cm X 20 cm spacing. Fertilizers were applied at rates of Urea 50 kg/ha, TSP 62.5kg/ha, MOP 50kg/ha at sowing time. Urea at a rate of 37.5 kg/ha was also applied as top dressing after 2 weeks of planting and 7 weeks of planting. The rice yield, yield components and other characteristics were determined according to the method of Standard Evaluation System for Rice (IRRI, 1988). The average results of the above measured parameters are given in table 3. Data were analyzed using statistical analysis software; SAS institute inc., (2000). Bg 379/2 was used as the reference recommended rice cultivar.

Table 1. PGRC Accession numbers and names of traditional rice cultivars (PGRC, 1999).

Accession number	Name	Accession number	Name
3710	<i>Sudhubalawee</i>	2203	<i>Dik wee</i>
3871	<i>Rathran wee</i>	3072	<i>Thanthiribalan</i>
3200	<i>Kaluheenati</i>	3164	<i>Heras</i>
3668	<i>Ran ruwan</i>	3203	<i>Kotanavalu</i>
3905	<i>Rathu wee</i>	3195	<i>Gallkatta</i>
3662	<i>Mahasudu wee</i>	3174	<i>Podihatatha</i>
3712	<i>Kahata wee</i>	3183	<i>Hathiel</i>
3735	<i>Welihandiran</i>	3341	<i>Galpa wee</i>
3664	<i>Tissa wee</i>	3190	<i>Mahakuru wee</i>
3908	<i>Rathkara wee</i>	3728	<i>Kalu wee</i>

Table 2. Evaluated parameters in the study

Plant height (cm)	Measured height from the base of the plant to the top of the latest spikelet on the panicle, excluding awn
Leaf blade length (cm)	Measured length from the leaf base to the leaf tip of the fully expanded leaves
Leaf blade width (cm)	measured at the widest point of the leaf
Number of tillers per plant	counted tillers at the maturity stage
Number of reproductive tillers per plant	counted number of tillers with panicles
Panicle length (cm)	measured from the base of the lowest spikelet to the tip of the latest spikelet on the panicle, excluding awn
Number of spikelets per panicle	counted total number of spikeletes in sampled panicles
Number of fertile spikelets per panicle	counted filled grains in sampled panicles
100 grain weight (g)	100 grains were counted from five plants of each replicate and weighed
Seed length (mm) and Seed width (mm):	measured using Venire caliper

*These parameters were evaluated in field conditions.

Results and discussion

Among the tested rice cultivars, 65% of the traditional rice cultivars had recorded plant heights between 60-100 cm while the tallest rice cultivar, *Podihitatha*, had a value of 198 cm for plant height. The shortest rice cultivar, *Rathranwee*, had a recorded value of 68 cm for plant height (Table 3). Leaf blade lengths ranged from 8.7- 94.2 cm (Figure 1). The highest value for the leaf blade length was recorded for *Podihatatha*. *Hathiel* had the lowest

value of leaf blade length (8.7 cm) and the reference, Bg 379/2 showed an average leaf blade length of about 39 cm. Leaf blade width of traditional rice cultivars ranged from 0.6 cm to 1.6 cm. Rice cultivar *Kotanavalu* had the broadest leaf blade whereas *Mahakuruwee* had the narrowest leaf blade Leaf blade width for Bg 379/2 was 1.3 cm leaf blade width.

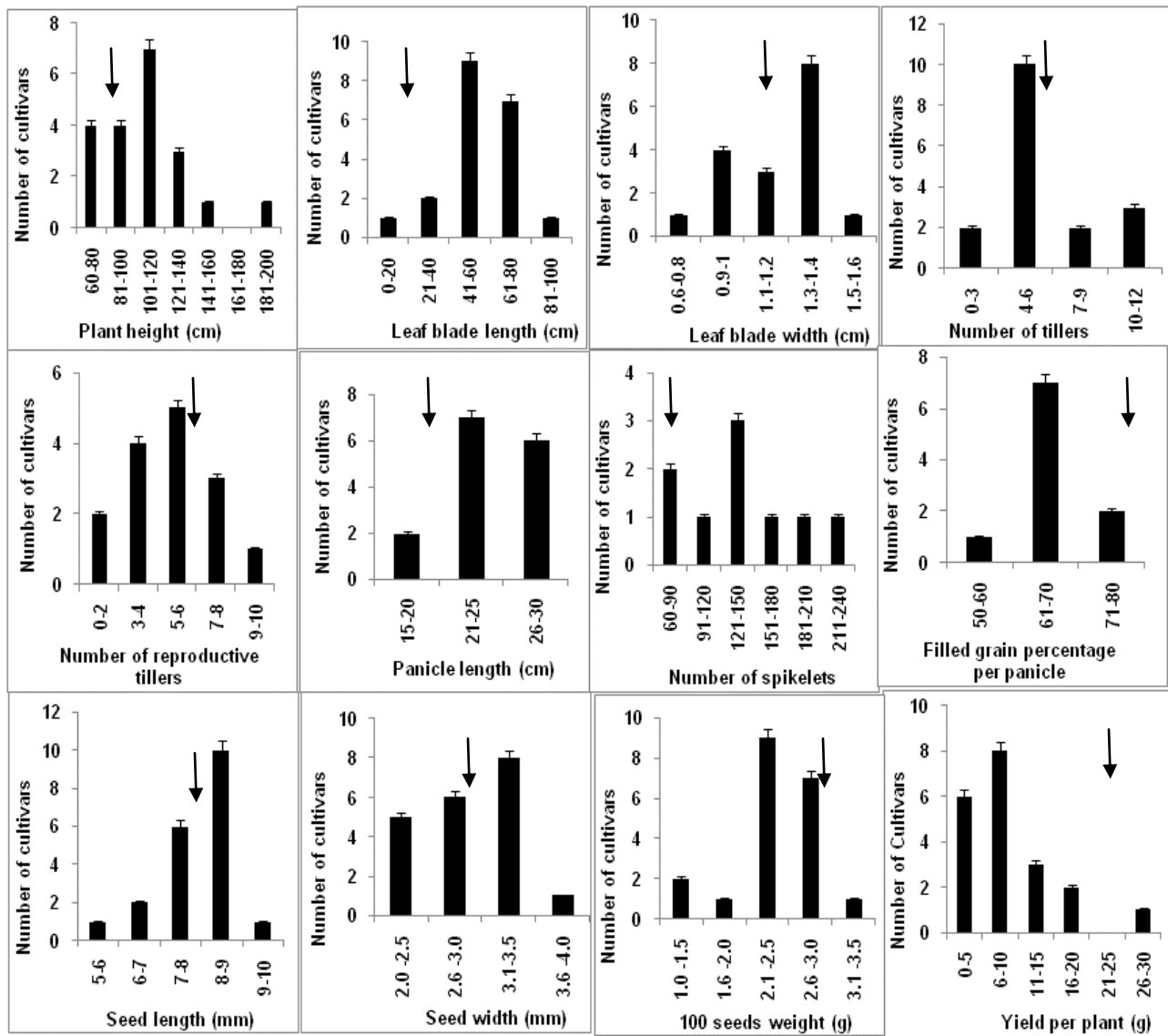


Figure 1: Agronomic trait distribution of traditional rice cultivars. Arrow indicates the trait value of the reference recommended rice cultivar Bg 379/2

Table 3. Average values of each trait of twenty traditional rice cultivars.

	Plant height (cm)	Leaf blade length (cm)	Leaf blade width (cm)	Number of tillers	Number of reproductive tillers	Panicle length (cm)	Number of spikelets per panicle	Filled grain percentage	Seed length (mm)	Seed width (mm)	100 seed weight (g)	Yield/ plant (g)
<i>Dik wee</i>	129.3	64.2	1.3	9.0	3.0	21.8	140.8	72.8	8.54	2.32	2.13	6.56 ^{gh}
<i>Thanthiribalan</i>	112.9	61.5	1.4	7.0	6.4	25.7	240.7	61.4	9.12	2.41	2.41	28.52 ^a
<i>Heras</i>	113.9	66.9	1.1	3.4	2.2	23.0	152.0	65.8	8.24	3.06	2.84	6.25 ^{gh}
<i>Podihatatha</i>	197.6	94.2	1.4	5.2	4.1	21.4	150.0	82.1	7.67	3.53	2.09	10.58 ^e
<i>Hathiel</i>	87.0	8.7	1.3	4.0	3.0	22.0	107.8	90.9	5.26	3.42	2.52	7.40 ^g
<i>Mahakuru wee</i>	71.8	43.0	0.6	2.5	2.5	22.0	155.0	81.0	7.23	3.35	2.10	6.58 ^{gh}
<i>Gallkatta</i>	95.4	53.0	1.2	4.6	1.7	28.0	153.3	70.0	6.50	3.17	2.74	4.90 ^{ij}
<i>Kaluheenati</i>	86.8	40.9	0.9	2.6	2.2	21.5	110.8	89.5	8.15	2.86	2.33	9.24 ^f
<i>Kotanavalu</i>	101.8	55.2	1.6	3.5	2.0	22.0	98.7	81.1	8.50	3.40	2.96	4.74 ^{ij}
<i>Galpa wee</i>	82.8	42.5	1.4	5.0	4.0	25.0	180.2	58.3	7.20	3.20	3.10	13.01 ^d
<i>Mahasudu wee</i>	106.4	35.6	1.2	9.6	9.5	16.4	65.7	66.0	7.44	2.56	1.25	5.43 ^{hi}
<i>Tissa wee</i>	79.7	42.7	1.0	8.3	3.0	23.0	104.0	81.7	8.55	2.37	2.64	6.74 ^g
<i>Ran ruwan</i>	103.3	49.3	0.9	9.2	5.0	22.8	80.3	73.9	7.36	2.83	1.45	4.29 ^{ij}
<i>Sudhubalawee</i>	76.3	42.0	0.9	3.2	2.0	23.0	103.2	82.4	8.10	2.59	2.40	4.08 ^{ij}
<i>Kahata wee</i>	140.9	74.3	1.3	9.3	8.0	29.0	202.3	65.2	8.11	2.47	2.27	23.94 ^c
<i>Kalu wee</i>	100.6	50.0	1.1	3.8	0.6	21.8	114.3	57.1	7.53	3.27	1.75	0.69 ^k
<i>Welihandiran</i>	103.5	78.5	1.3	5.0	4.0	24.0	100.0	74.0	8.29	2.58	2.22	6.57 ^{gh}
<i>Rathran wee</i>	66.7	28.5	1.1	5.0	2.7	15.1	88.0	85.2	6.07	2.26	2.35	4.76 ^{ij}
<i>Rathu wee</i>	120.4	63.0	1.3	7.1	6.6	27.7	143.3	76.5	8.50	3.26	2.70	23.69 ^c
<i>Rathkara wee</i>	125.3	64.6	1.2	7.4	4.7	25.7	121.0	55.9	8.49	2.90	2.77	8.74 ^f
<i>Bg 379/2</i>	98.8	32.0	1.4	8.3	7.0	22.2	106.3	90.6	8.2	3.3	3.20	26.50 ^b

DMRT groups of yield per plant are indicated in superscripts

About 55% of the evaluated traditional rice cultivars have produced less than 5 tillers per plant. The highest number of tillers was recorded by the rice cultivar *Mahasudu wee* which was around 9.6 tillers per plant in average. About 50% of the tested traditional rice cultivars recorded less than 5 reproductive tillers per plant on average and the value was 7 tillers per plant for the reference cultivar, Bg 379/2. A normal distribution of the trait can be seen for the leaf blade length, number of reproductive tillers and filled grain percentage per panicle in the tested traditional rice cultivars. The longest panicle length was recorded by *Kahata wee* which was 29 cm. According to Iddikut et al. (2010), a panicle length in one cultivar which was around 18.36 cm in one season had reported a range of 12-19 cm in another season. This change in panicle length in different seasons has been explained by Beser & Genctan, (1999) as an effect of plantation technique.

The number of spikelets per panicle was greatly varied from 65-240. The least number of spikelet per panicle was recorded in rice cultivar *Mahasudu wee* which was 65.7. The highest number of spikelets per panicle was recorded in rice cultivar *Thanthiribalan*. The greatest seed length (9.12 mm) was also observed in rice cultivar *Thanthiribalan* and the lowest (5.26 mm) was recorded for *Hathiel*. However, there was no correlation between spikelet length and seed length (Table 3). The lowest width of seeds was found in the rice cultivar *Rathran wee* (2.26 mm) and the highest was in the cultivar *Podihatatha*. The highest 100 seed weight (3.10g) was recorded for cultivar *Galpa wee* and that for the reference Bg 379/2 was 3.2g. The highest significant yield (28.52g) per plant was recorded for *Thanthiribalan*. Importantly, yield in reference rice cultivar Bg 379/2 was significantly lower (Table 3).

Table 4. Correlation coefficients between various plant characters of traditional rice cultivars

	Leaf blade length	Leaf blade width	Number of reproductive tillers	Number of spikelets per panicle	Seed length	Seed width	100 seeds weight	Yield per plant
Plant height	0.793*	0.505*	-	-	-	0.18*	-0.136*	0.347*
Leaf blade length	-	-	-	-	0.627*	-	-	-
Number of tillers	-	-	0.67*	-	-	-0.537*	-	-
Number of reproductive tillers	-	-	-	-	-	-	-	0.692*
Panicle length	-	-	-	0.631*	-	-	0.457*	0.565*
Number of spikelets per panicle	-	-	-	-	-	-	-	0.761*

*Significant at 5% probability level

Number of reproductive tillers and number of spikelets per panicle provide useful information for the rice breeders and those characters have direct effect on yield per plant (Sadeghi, 2011). In the present study, *Maha sudu wee* had the highest number of reproductive tillers/plant (9.5) but the grain yield per plant in *Maha sudu wee* was only 5.43g/plant. However, *Kahata wee* which produced 8 reproductive tillers/plant had a grain yield of 23.94g/plant. There was no significant difference between the yields of *Kahata wee* and *Rathu wee* according to DMRT grouping (Table 3). In the present research, plant height was positively correlated with leaf blade length ($r = 0.793$), leaf blade width ($r = 0.505$), seed width ($r = 0.18$) and yield per plant ($r = 0.347$) whereas it was negatively correlated with 100 seeds weight ($r = -0.316$) (Table 4). However, it has been reported that plant height was affected by many factors like plantation method, plant density and fertilizer application (Beser & Genctan, 1999; Aide & Beighly, 2006; Gozubenli, 1992).

There were strong positive correlations of panicle length with number of spikelets per panicle ($r = 0.631$), 100 seeds weight ($r = 0.457$) and yield per plant ($r = 0.565$) (Table 3). However, Ulger & Genc (1989), Beser & Genctan (2001), Surek (2002) and Ghosh *et al.*, (2004) reported that the tiller number and grain number per panicle were affected by the environmental and cultivation factors as well. Gozubenli (1992) reported that the grain weight per panicle was affected by the rate of fertilizer and plant

density. Yield per plant was significantly correlated with plant height ($r = 0.347$), number of reproductive tillers ($r = 0.692$), panicle length ($r = 0.565$) and number of spikelet per panicle ($r = 0.761$) (Table 3). Similar correlations were reported by Akram *et al.*, (1982). According to Surek & Beser (1996) and Manzoor *et al.*, (2006), 1000 g weight was affected by cultivation methods. However, Aidei & Beighly (2006) reported that cultivation methods didn't have such effect on 1000-grain weight.

Conclusion

Broad variations in agronomic characters have been found in tested traditional rice cultivars. Characters such as number of reproductive tillers, panicle length and number of spikelet per panicle are directly responsible for the final yield whereas characters such as plant height, leaf blade width and numbers of total tillers are not very important as yield determinants. However, all these characters are taken into consideration when the rice cultivars are selected for the commercial cultivation. The present study gives average values for each parameter. These primary data can be utilized when traditional rice cultivars are screened for future breeding programs.

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References

1. Aide, M., D. Beighley, 2006. Hyperspectral reflectance monitoring of rice varieties grown under different nitrogen regimes. Transactions of Missouri Academy of Science, 40: 6-11.
2. Akram, M., A. Rehman, A.A. Cheema, 1982. Correlation between yield and yield attributing characters in some induced dwarf mutants of rice (*Oryza Sativa* L.). Pakistan J. Agric. Res, 3(3):141 – 144.
3. Almekinders, C.J.M., A. Elings, 2001. Collaboration of farmers and breeders: participatory crop improvement in perspective. Euphytica, 122: 425-438.
4. Beser, N., T. Genctan, 1999. Effects of different plantation methods on some agricultural features and productivity in the rice (*Oryza sativa* L.). Turkey Third Field Crop Congress, 1:462-467.
5. Beser, N., T. Genctan, 2001. Effects of four irrigation methods on some quality features and productivity in the rice (*Oryza sativa*- L). Rural Services, Ataturk Research Institute Publications, Kırklareli, 125-132.
6. Characterization catalogue on rice (*Oryza sativa* L.) Germplasm, 1999. Plant Genetic Resource Centre, Sri Lanka.
7. Department of census and statistics, Annual report, 2011. Department of census and statistics, Sri Lanka.
8. Ghosh, M., B.K. Mandal, B.B.Mandal, S.B. Lodh, A.K. Dash, 2004. The effect of planting date and nitrogen management on yield and quality of aromatic rice (*Oryza sativa*). Journal of Agricultural Science, 142: 183-191.
9. Mithat, N., M.N. Gevrek, Ö. Tatar, B. Yagdmur, S. Ozaydine, 2009. The effects of clinoptilolite application on growth and nutrient ions content in rice grains. Turkish J. of field crops, 14(2): 79 – 88.
10. Gozubenli, H., 1992. The effects of nitrogen doses and seeding rates on yield and some yield components of rice (*Oryza sativa* L.). Cukuova University Institute of Natural and Applied Science, Journal of Science and Engineering, 6(1): 39-48.
11. Gravois, K. A., R.W. McNew, 1993. Genetic relationships among and selection for rice yield and yield components. Crop Science, 33: 249-252.
12. Gyawali, S., S. Sunwar, M. Subedi, M. Tripathi, K.D. Joshi, J.R. Witcombe, 2007. Collaborative breeding with farmers can be effective. Field Crop Research, 101: 88-95.
13. He, P., S.G. Li, Q. Qian, Y.Q. Ma, J.Z. Li, W.M. Wang, Y. Chen, L.H. Zhu, 1999. Genetic analysis of rice grain quality. Theoretical Applied Genetics, 98: 502-508.
14. Idikut, L., A. Akkaya, T. Dokuyucu, H. Bozok, 2010. Agronomic characters of landrace yellow-rice (*Oryza sativa* L.) selected according to plant height and panicle properties. Pak. J. Bot., 42(5): 3165-3171.
15. IRRI, 1988. Standard evaluation system for rice. The International rice testing program. 3rd Edition, The International Rice Research Institute, Los Banos, Philippines.
16. Jannink, J.L., J.H. Orf, N.R. Jordan, R.G. Shaw, 2000. Index selection for weed suppressive ability in soybean. Crop Science, 40: 1087-1094.
17. Manzoor, Z., R.I. Ali, T.H. Awan, N. Khalid, A. Mushtaq, 2006. Appropriate time of nitrogen application of fine rice *Oryza sativa*, Journal of Agricultural Research, 44 (4): 261-267.
18. Priyangani, E.G.D., N.S. Kottarachchi, D.P.S.T.G. Attanayaka, B.D. Pathinayake, 2008. Characterization of Suwandal and Heenati rice varieties for the fragrance gene using Polymerase Chain Reaction based molecular markers, Symposium 2008, Faculty of Agriculture and plantation management, Wayamba University of Sri Lanka.
19. Rabiei, B., M. Valizadeh, B. Ghareyazie, M. Moghaddam, 2004. Evaluation of selection indices for improving rice grain shape. Field Crops Research, 89: 359-367.
20. Ranawake, A.L., N. Dahanayake, D.D. Senadhipathi, 2010a. Evaluation of level of submergence tolerance in traditional rice cultivars at post-germination stage. 8th Academic session, University of Ruhuna, 203.
21. Ranawake, A.L., N. Dahanayake, R.D.G. Kumari, 2010b. Assessment of submergence tolerance of some traditional and modern rice cultivars in Sri Lanka. 8th Academic session, University of Ruhuna, 187.
22. Ranawake, A.L., U.G.S. Amarasingha, N. Dahanayaka, 2011a. Study on the submergence tolerance of some traditional rice cultivars in Sri Lanka under two different stress periods at seedling stage. International symposium on Agriculture and Environment (ISAE), 28.
23. Ranawake A.L., Dahanayake N., Rodrigo U.T.D., 2011b. Salinity tolerance in traditional rice cultivars. International Symposium on Agriculture and Environment (ISAE), 136.

24. Sadeghi, S.M., 2011. Heretability, Phenotypic correlation and path coefficient studies for some agronomic characters in Landrace rice varieties. *World Appled Sciences Journal*, 13(5): 1229-1233.
25. Samarahewa, K.N., A.L. Ranawake, S.G.J.N. Senanayake, 2010. Screening of some traditional rice cultivars for submergence tolerance. *International symposium on Agriculture and Environment (ISAE)*, 73.
26. SAS Institute Inc. 2000. *SAS Online Doco*, Version 8, Cary, NC: SAS Institute Inc.
27. Silva, NPS De, 2009. Genetic variability of important traits and their association with grain yield in rice, *Annals of the Sri Lanka Department of Agriculture*, 11;23-32.
28. Surek, H., 2002. *Rice Agriculture*, Harvest Publications Ltd. Co., Istanbul.
29. Surek, H., N. Beşer, 1996. A Research to Determine the Suitable Rice (*Oryza Sativa* L.) Harvesting Time. *Journal of Agriculture and Forestry*, 22: 391-394.
30. Ulger, A.C., I. Genç, 1989. Purification of grain productivity and herbal features of some domestic and strange rice (*Oryza sativa*- L.) species under the conditions of Cukurova. *C.U. Faculty of Agriculture*, 4 (2).
31. Yano, M., T. Sasaki, 1997. Genetic and molecular dissection of quantitative traits in rice. *Plant Mol. Biol.*, 35: 145-153.
32. Yoshida, S. 1981. *Fundamentals of Rice Crop Science*. IRRI, Los Banos, the Philippines. 269.