Japan Bilingual Publishing Co.

New Countryside

http://ojs.bilpub.com/index.php/nc

REVIEW

Evaluation of Morphological Variations in Exotic Rice (*Oryza Sativa* L.) Genetic Materials under Sri Lankan Field Conditions

W.D.P. Weerasinghe* **N.T. Prathapasinghe** **G.D.A. Priyantha**

Regional Rice Research and Development Center, Bombuwela, Sri Lanka

ARTICLE INFO

Article history
Received: 27 May 2022
Revised: 14 July 2022
Accepted: 15 August 2022
Published Online: 28 October 2022

Keywords:
Rice
Germplasm
Cluster analysis
Genetic diversity

ABSTRACT

To evaluate genetic diversity of 64 rice germplasms with five local check varieties, an experiment was conducted as the randomized complete block design with two replicates. It was conducted in experimental field of the Regional Rice Research and Development Center, Bombuwela, Sri Lanka. There were five morphological characters such as plant height, days to flowering, days to maturity, grain yield and the phenotypic acceptability of varieties were evaluated. As the results analysis of variance showed there is a significant difference among genotypes of all the tested characters. A total of four clusters were defined through cluster analysis and the distinct genetic variations were observed among the clusters. Cluster i consisted of six genotypes, cluster ii of 38, cluster iii of 19 and in cluster iv of one genotype were separated. Cluster groupings of local rice varieties into three main groups from three different rice breeding stations such as Bombuwela (Bw), Ambalantota (At) and Batalagoda (Bg) resemble their distance in genetic diversity as well as close genetic parental materials used in developing rice varieties within a cluster. Subsequent analysis of five tested variables confirms significant ($p < 0.01$) positive correlation ($r = 0.61$) between plant height and yield among the tested rice varieties. Depending on the breeding objectives the results of multivariate analysis can be applied for the rice varietal improvement program.

1. Introduction

Rice is the main staple food for more than half of the world population. Demand for rice is in increasing trend with the population growth. To meet the food security of growing population it is essential to increase the area under cultivation or the productivity per unit area. The cultivated land extends becoming shrinking with rapid population growth and industrialization, however, one way to increase the cultivated land area is to explore the possibilities of producing comparatively more rice from unutilized paddy fields due to some abiotic problems and rain fed lowlands with submergence conditions and flash floods. Therefore, there is a need to introduce rice varieties suitable to such a condition to increase the cultivation

*Corresponding Author:
W.D.P. Weerasinghe,
Regional Rice Research and Development Center, Bombuwela, Sri Lanka;
Email: deepika.weerasinghe@yahoo.com

DOI: https://doi.org/10.55121/nc.v1i2.32

extend and productivity in submerged areas resulting in an increase in national rice production. Development of rice varieties tolerant for such a situation appears to be the most suitable strategy to overcome this problem. Despite evaluation of germplasm resources is required for the continuous improvement of crop plants; Genetic diversity provides the raw material for breeding and plant improvement. Unexpected drought, salinity, submergence, temperature extremes and nutrient deficit soils are the major physical stresses, crops suffer from in general. Therefore, need to explore suitable germplasms as parental materials to develop suitable varieties for aforesaid situations. Natural tolerance gene sources available in crop gene pools have been identified and used to make crop varieties adapt to them and yield better.

Therefore, the main objective of this experiment was to explore suitable exotic rice germplasms for Sri Lankan field conditions and make use of those materials as the genetic sources for the researchers to use their crop improvement program for higher yield targets and selection of suitable quality breeding lines for observational yield trials followed by major yield trials to nominate national coordinated varietal testing program of the country.

2. Materials and Methods

The material used in this study was 64 rice germplasm lines (*Oryza sativa*. L.) having different maturity days. Among them fifty-nine were received from the International Network for Genetic Evaluation of Rice (INGER) is a multilateral rice germplasm exchange system as the International Rain fed Lowland Rice Observational Nursery (IRLON), five were local check varieties such as early maturity duration variety (Bg250), medium maturity duration variety (Bg300), late maturity duration variety (Bw372), blast resistant (Bg367) and bacterial blight resistant (At362) varieties. This germplasm evaluation was conducted at Regional Rice Research and Development Center, Bombuwela (RRRDC), Sri Lanka in *Yala* 2018, under rain fed lowland rice environments. Before establishment of the trial the soil testing was done in the location for the available phosphorus (P), exchangeable potassium (K), electrical conductivity (Ec) and texture.

During the experimental time seeds of all exotic entries and pure seeds of five local check varieties collected from the respective research stations were put in a prepared upland nursery beds with 3 m × 6 m size with the spacing 20 cm between two entries. Watering and fertilizer application to the nursery beds was done according to the Department of Agriculture (DOA) recommendations. Twenty-one days old seedlings were transplanted single plant per hill in prepared low land paddy field at the RRRDC, Bombuwela in *Yala* 2018. The evaluation was done with two replicates. Gap filling was executed for all of the plots at 10 days after transplanting by same aged seedlings. The plot size was 5 m × 1.4 m (7 m^2) and spacing between and within plants was 20 m × 20 cm. Chemical fertilizer and weedicides were applied according to the DOA recommendations. Pest and diseases were timely monitored and chemical protection against diseases and insects was applied as required. Data were collected at heading and harvesting stage of each variety. Plant height or the distance from the soil surface to the tip of the tallest panicle (awns excluded) was measured (cm) from five tiller samples in a plot when 80% of the plant population has reached maturity, maturity days after sowing at harvest was measured as the days from time of planting to time of maturity, number of days to 50% flowering was calculated based on the seeding date and the date when 50% of the main tillers in a plot have reached flowering stage, grain yield per plot was measured from the whole plot at harvest and converted to tons per hectare (t/ha) at approximately 14% moisture content, lodging incidence, pest and disease incidences and phenotypic acceptability of the varieties were measured based on the general reference for data collection is the "Standard Evaluation System for Rice" [1]. The number of days to grain ripening was calculated based on the seeding date and the date when 85% of grains on panicle of the whole plot are mature. Phenotypic acceptability was scored at maturity. The score reflects overall acceptability of the variety in the location where it was being grown. Scores of 1-3 are considered well-adapted, scores 4-6 as moderately adapted, and scores 7-9 as not adapted/suitable.

Data analysis was done to assess the variations among genotypes based on morphological traits using SAS 9.1 statistical computer program with ANOVA. In order to find relationship between the variables regression analysis was performed. Then 64 varieties were clustered using PROC CLUSTER of SAS, which grouped and scored closely related varieties into clusters. The relationship among the clusters was assessed by measuring the inter cluster distance using Mahalanobis distance.

3. Results and Discussion

3.1 Grain Yield of the Test Entries

Average grain yield of the tested exotic entries and local check varieties under the field of RRRDC, Bombuwela are presented in Figure 1. According to the results there was a significant yield different was observed among tested entries. Average grain yield of the local rice variety Bw372

(SVIN172) was significantly higher than the other tested lines and comparatively similar with the exotic lines SVIN 123 and SVIN 151. In addition to that, exotic lines SVIN 204, SVIN 120, SVIN 121 and SVIN 189 were also performed well under LCWZ condition by yielding more than 5 t/ha. Further, 25 tested exotic lines which were yielded more than 4 t/ha^{-1} under local conditions. Most interesting thing is local varieties Bg250 (SVIN 270), Bw367 (SVIN272) and Bg300 (SVIN274) yielded 1.35 t/ha^{-1}, 3.96 t/ha^{-1}, 2.9 t/ha^{-1} lower yields respectively. Normally in LCWZ area of Sri Lanka, average paddy yield is 3.3 t/ha^{-1} ~ 3.5 t/ha^{-1} but most of the selected exotic lines yielded more than the average expected rice yield. Yield is one of the most important and complex traits in rice. It is regulated by genes known as quantitative trait loci and influenced by external environmental factors [2-4]. The grain yield of the rice plant is a function of the three yie1d components such as number of panicles per plant or per unit area, the number of filled grains per panicle and the mean weight of individual grain. In addition to that grain yield of rice is basically determined by the genotype of the plant, climatic conditions and edaphic environment, and management practices [5,6]. Moreover, a number of studies demonstrated that agronomic traits such as panicle number, spikelet number per panicle, spikelet filling percentage, and grain weight are highly related to grain yield, for example, In rice, yield is determined by indirect traits like plant height, growth period, tillering ability, panicle length, seed length, seed setting rate, and grains per panicle as well as direct traits like panicle number per unit area or per plant, filled grains per panicle and 1000-grain-weight [7-9].

3.2 Days to 50% Flowering

Days to 50% flowering of the tested entries at RRRDC, Bombuwela, Sri Lanka is presented in Figure 2. According to the results almost all the accessions completed 50% flowering around 62 to 77 days after planting but short age local check variety Bg250 finished it's 50% flowering after 54 days of planting. Transition of apical bud in to floral bud demarcates the initiation of reproductive stage of rice in its growth cycle and number of days taken for this transition determines the heading date or days to flowering of any rice cultivar [10]. These all types of genes determine the crop duration, crop architecture and the final grain yield of rice. Among many agronomic characteristics, days to flowering, plant height and yield potential determine the economical production of any crop including rice [11]. Days to flowering in rice is determined by the length of basic vegetative growth phase and photo period sensitivity of the rice cultivar [12].

3.3 Average Maturity Days of the Varieties

Maturity days calculate based on the seedling date and the date when 85% of the panicles in a plot are getting yellow color plant population. Average maturity days of the tested exotic entries and local check varieties under the field of RRRDC, Bombuwela in *Yala* 2018 are presented in Figure 3. Average maturity days of the tested entries were varied in between 95 to 108 days. According to the rice varietal distribution of paddy extent by age group in 2018, in Sri Lanka, 69.8% of the varieties were under the 105 ±7 days (3 ½ months) and 19.8% under 3-month (90 days) age group [13]. Therefore, almost all tested exotic entries are majority cultivating age group of the country, and more preferable for the Sri Lankan situation.

3.4 Plant Height

Average plant height of the tested exotic entries and local check varieties under the field of RRRDC, Bombuwela are presented in Figure 4. According to the results a wide variation of the plant height across varieties can be observed. Plant height varied in between 120.6 cm to 68.85 cm. SVIN 123 is the tallest variety while SVIN 270 (Bg250) is the shortest variety and it matured around 85 days. The varieties SVIN 271, SVIN 154 and SVIN 123 were taller than 110 cm. In addition to that most of the tested entries were less than 100cm in height and resistant for lodging in the field condition. Plant height is the most important agronomical character for a variety. Semi-dwarf cultivars improve the harvest index and increase the grain yield by enhancing lodging resistance [14,15]. However, if the plants are too short, the yield potential will be negatively affected, suggested that increasing plant height is an effective way to increase grain yield. Therefore, in the absence of lodging, it is essential to increase plant height in order to increase grain yield [16].

3.5 Phenotypic Acceptability of Varieties (PAcp)

According to the Figure 5, Phenotypic Acceptability of varieties were observed based on the scale given by the IRRI. Most of the tested entries were fair to excellent in PAcp at maturity.

As the soil analysis data the pH value of the location is 5.8, electrical conductivity is (Ec) 0.25 ds/m, available phosphorus amount is 13.71 ppm, exchangeable potassium is 99.7 ppm, and the texture is silty loam. Normally for the rice cultivation the optimum soil conditions are as follow, pH value should be around 6.2-7.2, optimum Ec is < 0.14, phosphorus content is 5-10 ppm and exchangeable Potassium is 80-160 ppm. According to the data of soil analysis the soil condition of the location is favorable for rice cultivation.

3.6 Grouping of Tested Rice Varieties

The tested 64 rice varieties were grouped into four main clusters at a normalized distance of 2 as in Figure 6. The number of varieties with in a clusters varies, from one (Cluster iv) to 38 (Cluster ii). All the local tested check varieties SVIN 274 (Bg300), SVIN 273 (At362), SVIN 272 (Bw367), SVIN 271 (Bw372) and SVIN270 (Bg250) were grouped into three clusters (cluster i, iii and iv). Further, in cluster ii does not contain any local rice varieties. In addition to that at the normalized distance 3, local rice varieties were grouped into three clusters in which Bw372 and Bw367 grouped in cluster i, Bg300 and At362 into cluster iii and Bg250 grouped separately in cluster iv. The Cluster groupings of local rice varieties into three main groups (at the distance of 3) from three different rice breeding stations in Sri Lanka resembles their distance in genetic diversity as well as close genetic parental materials/resources used in developing rice varieties within a cluster. In the Cluster ii, at normalized distance 2, included 38 exotic rice lines and grouped separately from other clusters.

3.7 Statistical Analysis for the Correlation between Selected Characters

The subsequent analysis of five tested variables confirm significant ($p < 0.01$) positive correlation ($r = 0.61$) between plant height and yield among the tested rice varieties and explain its advantage of increasing plant height for rice yield within tested rice varieties.

There is a significant ($p < 0.01$) negative correlation ($r = -0.54$) between rice yield and the variable, phenotypic acceptance, which is considered to be a selective preference towards the quality of rice grain/panicle and plant architecture at the field level.The flowering character has moderate level of correlation ($r = 0.40$) against rice yield, implying that time taken to flower can have significant influence on its grain yield. Maturity of rice crop has lower significant ($p < 0.01$) correlation ($r = 0.19$) with rice yield and maturity range from 96.5 to 106 days indicating its less important in selecting maturity days within this maturity period under the tested rain fed conditions.

According to the results obtained all varieties were not subjected for lodging. The plant height also varied in range of 75 cm to 122 cm. Further, plant height around 90 cm to 100 cm is most suitable for mechanical harvesting as well as manual harvesting.

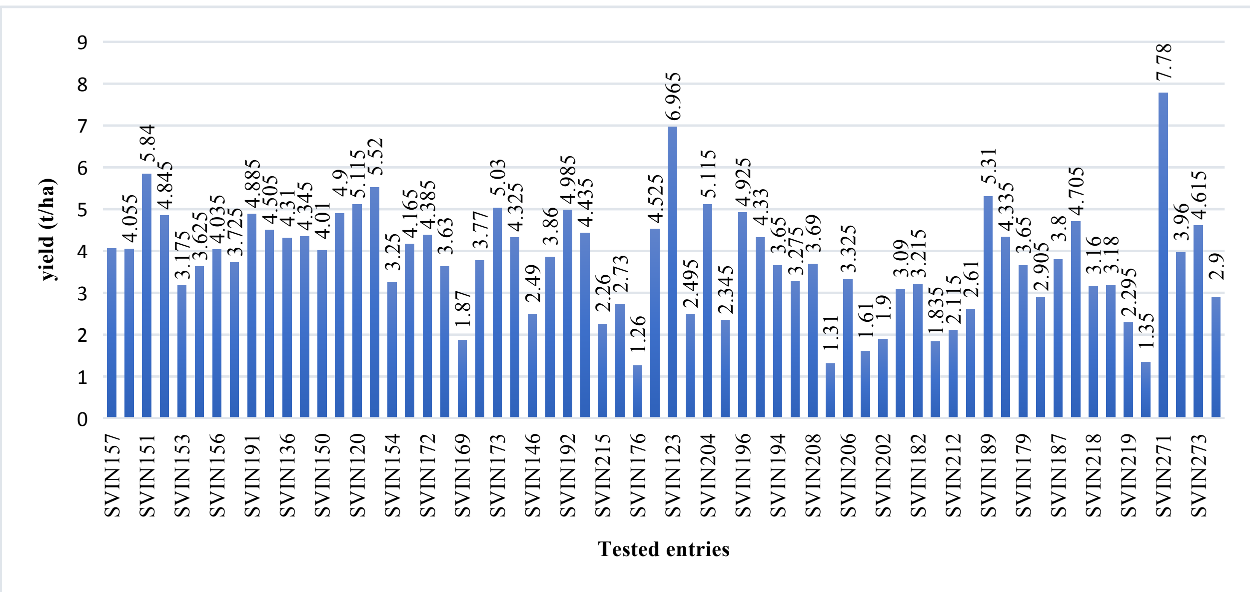

Figure 1. Average grain yield of the tested exotic entries and local check varieties under the field of RRRDC, Bombuwela

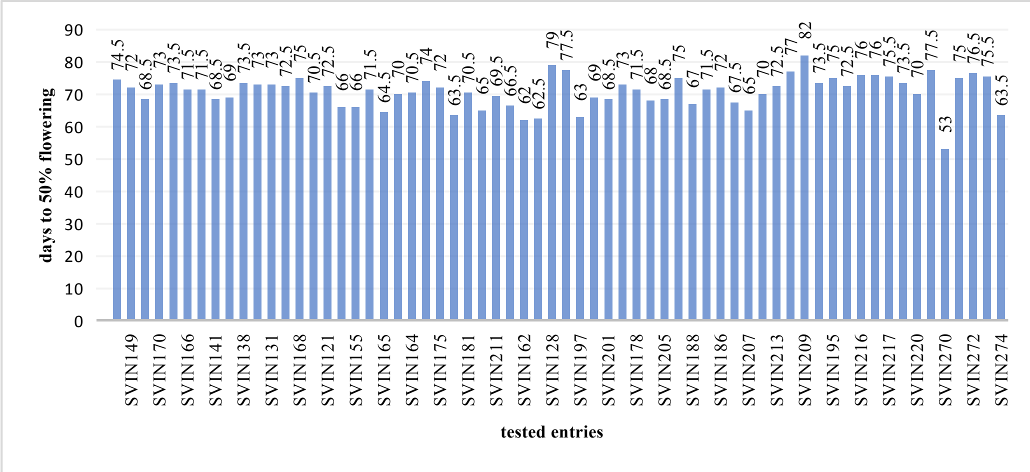

Figure 2. Days to 50% flowering of the tested entries at RRRDC, Bombuwela

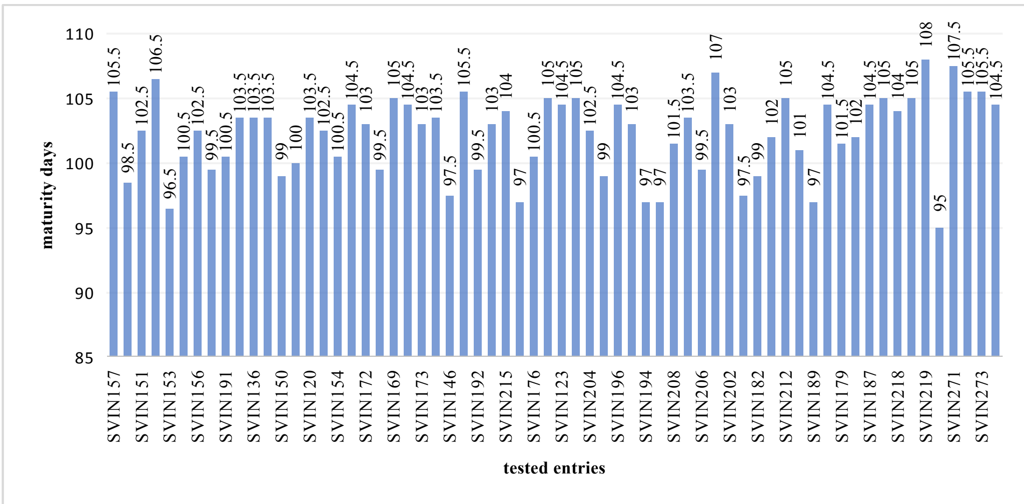

Figure 3. Average maturity days of the tested exotic entries and local check varieties under the field of RRRDC, Bombuwela

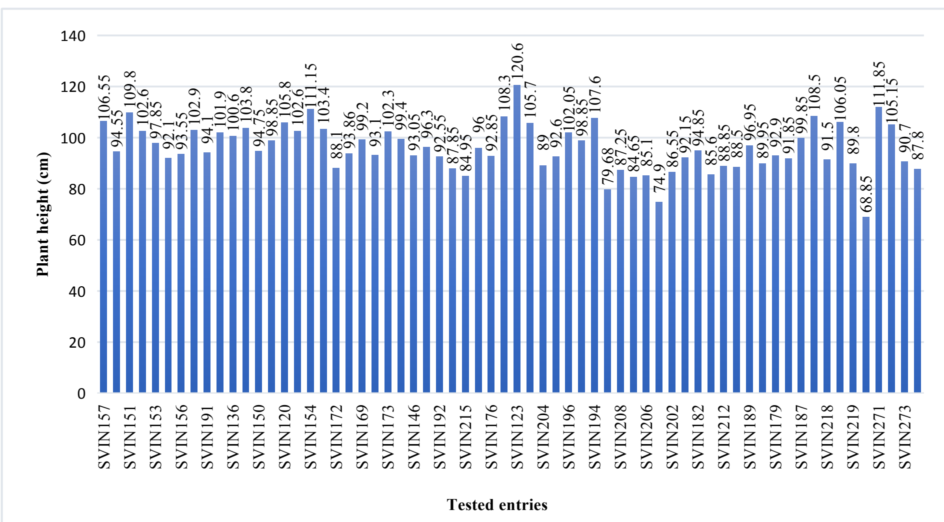

Figure 4. Average plant height of the tested exotic entries and local check varieties under the field of RRRDC, Bombuwela

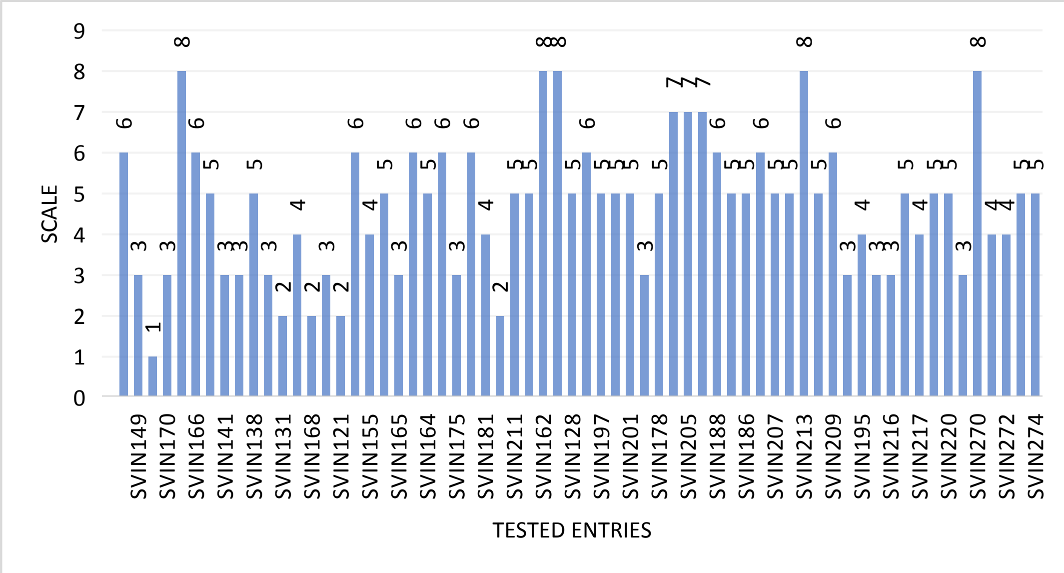

Figure 5. Phenotypic Acceptability of varieties under RRRDC, Bombuwela

(Scores 1-3 - well-adapted, 4-6 -moderately adapted, 7-9 not adapted/suitable.)

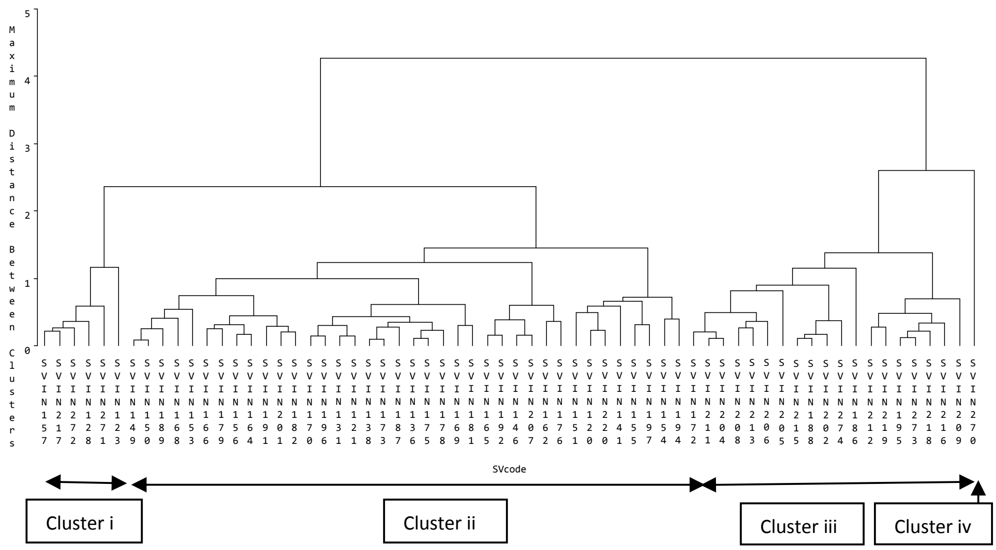

Figure 6. Dendrogram of rice varieties obtained through complete linkage cluster analysis based on five vegetative and reproductive characteristics

4. Conclusions

Most of the tested exotic rice lines performed well under the local field conditions in Sri Lanka and yielded comparatively similar yield as the local recommend rice varieties. Selection of parent with proper characters playing a vital role for a successful plant breeding program. Parents with more genetic distance can create higher variation which can increase of genetic grain in selection.

Conflict of Interest

There is no conflict of interest.

References

[1] IRRI, 2014. Standard Evaluation System for Rice. INGER, genetic resources center. International rice research institute, 1099, Manila, Philippines.

[2] Wang, S., Wu, K., Yuan, Q., et al., 2012. Control of grain size, shape and quality by OsSPL16 in rice. Nature Genetics. 44, 950-954.
DOI: https://doi.org/10.1038/ng.2327

[3] Zeng, D., Tian, Z., Rao, Y., et al., 2017. Rational design of high-yield and superior-quality rice. Nature Plants. 3, 17031.
DOI: https://doi.org/10.1038/nplants.2017.31

[4] Zhang, L., Yu, H., Ma, B., et al., 2017. A natural tandem array alleviates epigenetic repression of IPA1 and leads to superior yielding rice. Nature Communications. 8, 14789.
DOI: https://doi.org/10.1038/ncomms14789

[5] Slafer, G.A., 1994. Genetic Improvements of Field Crops. pp. 68. Marcel Dekker Inc., New York, USA.

[6] Richards, R.A., 2000. Selectable traits to increase crop 17. Photosynthesis and yield of grain crops. Journal of Experimental Botany. 51(1), 447-458.

[7] Moldenhauer, K., Nathan, S., 2004. 1-Rice growth and development. Slaton, N. (Ed.), Rice Production Handbook. Arkansas: University of Arkansas.

[8] Sakamoto, T., Matsuoka, M., 2008. Identifying and exploiting grain yield genes in rice. Current Opinion in Plant Biology. 11, 209-214.
DOI: https://doi.org/10.1016/j.pbi.2008.01.009

[9] Huang, R., Jiang, L., Zheng, J., et al., 2013. Genetic bases of rice grain shape: so many genes, so little known. Trends in Plant Science. 18, 218-226.
DOI: https://doi.org/10.1016/j.tplants.2012.11.001

[10] Yano, M., Kojima, S., Takahashi, Y., et al., 2001. Genetic control of flowering time in rice, a short-day plant. Plant Physiology. 127, 1425-1429.

[11] Xue, D., Qian, Q., Teng, S., 2014. Identification and Utilization of Elite Genes from Elite Germplasms for Yield Improvement. (Retrieved on 13.05.2014) http://cdn.intechopen.com/pdfs-wm/45539.pdf.
DOI: http://dx.doi.org/10.5772/56390

[12] Yano, M.Y., Harushima, Y., Nagamura, N., et al., 1997. Identification of quantitative trait loci controlling heading date of rice using a high-density linkage map. Theoretical and Applied Genetics. 95, 1025-1032.

[13] Agstat, 2018. Agricultural statistics, Socio Economics and Planning Center, Department of Agriculture, Peradaeniya, Sri Lanka. pp. 18.

[14] Spielmeyer, W., Ellis, M.H., Chandler, P.M., 2002. Semidwarf (sd-1), “green revolution” rice, contains a defective gibberellin 20-oxidase gene. Proceedings of the National Academy of Sciences of the United States of America. 99, 9043-9048.
DOI: https://doi.org/10.1073/pnas.132266399

[15] Kovi, M.R., Zhang, Y., Yu, S., et al., 2011. Candidacy of a chitin-inducible gibberellin-responsive gene for a major locus affecting plant height in rice that is closely linked to green revolution gene sd1. Theoretical and Applied Genetics.123, 705-714.
DOI: https://doi.org/10.1007/s00122-011-1620-x

[16] Zhang, Y., Yu, C., Lin, J., et al., 2017. OsMPH1 regulates plant height and improves grain yield in rice. PLoS One. 12, e0180825.
DOI: https://doi.org/10.1371/journal.pone.0180825