I J T A
© Serials Publications
National Academy of Agricultural Science (NAAS) Rating : 3. 03

Geographic Variation of Wild Rice; *Oryza nivara* (S.D. Sharma and Shastry) populations in Sri Lanka

Disna Ratnasekera[1*] and APT Subhashi[1]

ABSTRACT: *Wild relatives of rice are considered as an invaluable resource for crop improvement through restoring genetic diversity and incorporating useful traits back in to modern cultivars. In this context, phenotypic diversity of Oryza nivarapopulations exist in Sri Lanka were studied based on thirteen quantitative morphological traits. The results revealed high phenotypic diversity among O.nivara populations tested. Among the vegetative traits studied, a huge variability was observed for the plant height (138.70 ± 6.1 - 93.00 ± 3.0), leaf length (66.00 ± 3.4 - 28.10 ± 0.9) and seedling height (55.50 ± 3.8 - 27.10 ± 1.8). Among the reproductive traits observed, panicle length (31.5 ± 0.3-12.2 ± 0.3), panicle-bearing tillers/ plant (25.3 ± 1.2- 11.7 ± 2.5), number of spikelets/ panicle (123 ± 5.3 - 47 ± 3.6), filled grains/panicle(98.7 ± 3.1 - 16.3 ± 1.5) and shattered seeds/panicle (105.33 ± 7.6 - 44 ± 1.7) showed remarkable variability among populations.The highest genetic identity was observed in between population -4 (P-4) from Matale district and P-7from Baticaloa district (0.9182) while the lowest genetic identity value (0) was observed in between P-3 from Vavuniya district and P-10 from Matara district indicating the highest genetic distance among them. This study highlights the phenotypic diversity of O.nivara populations existing in Sri Lanka across the geographic locations and the potential of using them in rice improvement program in future.*

Keywords: *morphological divergence, quantitative morphological traits, wild relatives of rice.*

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important crops being cultivated in the world, particularly in Asia. Enhanced interest on development of high yielding cultivars with the green revolution has narrow down the genetic diversity of cultivated rice. Hence, wild species of rice have been considered as a very important resource for rice improvement. Wild rice species have been identified as potential sources of genes contributing resistance to pests and diseases [7,4,8], tolerance to abiotic stresses [15,11] and improved useful traits such as nutrient content [13]. Although overall global rice germplasm has been characterized, analysis of country's specific germplasms including wild relatives is utmost important and therefore having greatest research interest [14].

Wild relatives are considered as the ancestors of the cultivated rice species,*O. sativa* (Asian rice) and *O. glaberrima* (African rice), which include 22 species[1].From these 22, five species are reported in Sri Lanka; *O. nivara*, *O. rufipogon*, *O. eichingeri*, *O. rhyzomatis* (endemic to Sri Lanka) and *O. granulate* which indicative of the wealth of biodiversity in Sri Lanka, which is mainly unexploited.

Oryza nivara is the most common and widely distributed wild rice species found in Sri Lanka[5]. It possesses AA genome and the ploidy level is $2n = 24$[2] which is similar to the cultivated rice and therefore, having greatest potential to be used in rice variety improvement programs.

Since there is no habitat-wise information of morphological and genetic diversity among *O. nivara* accessions collected from Sri Lanka, morphological characterization is timely needed as base line data to predict the potential use of them in rice variety improvement programs. Morphological traits of plants are generally influenced by genotype, environment and management[12]. Therefore, assessment of morpho-logical diversity of them under favorable environment with best management practices is important.

[1] Department of Agricultural Biology, Faculty of Agriculture, University of Ruhuna, Mapalana, Kamburupitiya, Sri Lanka.
* Corresponding author.

In the present study 13 vegetative and reproductive quantitative characteristics of *O.nivara* accessions were investigated in common garden to determine the extent and pattern of variation in 10 *O.nivara*populations and to identify groups of populations having similar quantitative morphological traits.

MATERIALS AND METHODS

Plant Materials

Ten *O. nivara* populations collected from different locations in Sri Lankaand maintained by the Department of Agricultural Biology were used for the study (Table 1).

Study Site and Experimental Design

The study was carried out in the Department of Agricultural Biology, Faculty of Agriculture, University of Ruhuna, Sri Lanka (latitude 6° 08' N and longitude 80° 56' E) during the Maha, 2014/2015 cropping season. Dormancy broken (50°C, 5 days) hull removed *O. nivara* seeds were allowed to germinate on wetted tissue papers at 35°C. Germinated seeds were planted in 16' × 16' × 18' cm cement pots. The pots were arranged in a randomized complete block design (RCBD) with three replicates. Incorporation of fertilizer and pest and disease management were done according to the recommendations of Department of Agriculture, Sri Lanka.

Estimation of Morphological Variation

Quantitative traits; seedling height, leaf length, leaf width, ligule length, plant height,panicle length, grain bearing tillers per plant, non bearing tillers per plant, number of spikelets per panicle, unfilled grains per panicle, filled grains per panicle, shattered seeds per panicle, 100 grain weight were recorded based on descriptors of rice developed by the International Rice Research Institute (IRRI), 1980. As time of planting being same for all the populations, measurements were done at different time periods parallel to their maturity.

Table 1
***O. nivara* accessions used for the study with collected locations**

Population No.	*District*	*Longitude(N)*	*Latitude(E)*
P1	Anuradhapura	08^0 07′ 44.95″	80^0 33′ 46.87″
P2	Polonnaruwa	08^0 02′ 15.5″	80^0 45′ 48.36″
P3	Vavuniya	$08^0$51′ 06.0″	$80^0$29′ 06.04″
P4	Matale	07^0 33′ 24.88″	$80^0$29′ 41.96″
P5	Kilinochchi	$09^0$25′ 55.2″	$80^0$29′ 56.5″
P6	Mannar	$08^0$54′ 36.4″	$79^0$57′ 42.3″
P7	Baticaloa	$07^0$30′ 33.1″	$81^0$43′ 55.1″
P8	Badulla	$06^0$53′ 22.8″	$81^0$41′ 33.5″
P9	Hambantota	06^0 09′ 18.64″	$80^0$46′02.83″
P10	Matara	$06^0$00′ 01.60″	$80^0$33′ 43.90″

RESULTS AND DISCUSSION

Variability of quantitative morphological traits among *O nivara* populations

A Considerable variation of characteristics was found among populations for most of the traits measured. The mean and variability exhibited by the vegetative and reproductive quantitative traits through standard deviation (SD) are presented in Table 2and3 respectively. The tallest plants at seedling stage were observed in P-1 (55.50 ± 3.8) from Anuradhapura district while shorted were found in P-6 (27.10 ± 1.8) in Mannar district.At the maturity stage, the highest plants were recorded in P-10 (138.70 ± 6.1) from Matara district while shortest were recorded in P-8 (93.00 ± 3.0) from Badulla district. In general morphological characterization based on quantitative traits showed the tested populations were mostly tall with vigorous growth

Table 2
Means of different vegetative characteristics of *O. Nivara* accessions

Population	*SH (± SD)(cm)*	*LL (± SD)(cm)*	*LW(± SD)(cm)*	*LGL(± SD)(cm)*	*PH(± SD) (cm)*
P-1	35.40 ± 0.5	44.10 ± 0.4	1.10 ± 0.1	3.30 ± 0.2	97.70 ± 3.5
P-2	55.50 ± 3.8	51.90 ± 1.0	0.80 ± 0	2.40 ± 0.1	99.50 ± 5.9
P-3	50.10 ± 0.8	66.00 ± 3.4	0.90 ± 0	3.10 ± 0.1	131.00 ± 6.9
P-4	39.30 ± 2.1	48.00 ± 3.8	1.00 ± 0.1	4.30 ± 0.3	113.80 ± 10.6
P-5	40.80 ± 0.8	28.10 ± 0.9	1.00 ± 0.1	2.40 ± 0.1	128.20 ± 4.5
P-6	27.10 ± 1.8	31.80 ± 0.7	0.80 ± 0.1	2.20 ± 0.1	93.70 ± 1.2
P-7	31.10 ± 0.8	59.10 ± 1.0	0.90 ± 0.1	3.30 ± 0.1	81.30 ± 1.5
P-8	48.00 ± 1.0	57.00 ± 1.0	0.90 ± 0.1	3.30 ± 0.2	93.00 ± 3.0
P-9	53.10 ± 2.3	50.70 ± 1.6	0.90 ± 0.2	3.60 ± 0.3	115.00 ± 3.0
P-10	50.00 ± 1.0	65.40 ± 1.3	1.00 ± 0.1	2.40 ± 0.2	138.70 ± 6.1

SH = Seedling height, LL = Leaf length, LW = Leaf width, LGL = Ligule length, PH = Plant height.

Table 3
Means of different reproductive characteristics of O. nivara accessions

Population	*PL (± SD) (cm)*	*PBT (± SD) /PL*	*NBT (± SD) /PL*	*NOS (± SD) /PN*	*UG (± SD) /PN*	*FG (± SD) /PN*	*SS (± SD) /PN*	*100GW (± SD)(g)*
P-1	14.9 ± 0.4	22.3 ± 2.5	3 ± 1.7	62 ± 5.3	45.7 ± 6.0	16.3 ± 1.5	51 ± 2.6	1.28 ± 0.03
P-2	17.6 ± 0.4	17 ± 1.7	2.3 ± 1.5	87.3 ± 4.6	37.7 ± 2.5	49.7 ± 2.5	86 ± 5.3	1.47 ± 0.04
P-3	18.9 ± 0.4	20.7 ± 3.1	2.7 ± 1.2	109.7 ± 3.8	47.7 ± 0.6	62 ± 4.4	105.33 ± 7.6	1.28 ± 0.03
P-4	12.8 ± 0.8	16.3 ± 1.5	2.7 ± 0.6	117.3 ± 10.2	39 ± 3.6	78.3 ± 10.1	71 ± 8.2	0.97 ± 0.06
P-5	19.6 ± 1.3	18.7 ± 1.2	2.3 ± 0.6	47 ± 3.6	22.7 ± 2.5	24.3 ± 4.0	44 ± 1.7	1.63 ± 0.06
P-6	12.5 ± 0.5	22.3 ± 2.5	4 ± 1.0	76.3 ± 6.7	37 ± 3.6	39.3 ± 3.1	76.33 ± 6.7	1.57 ± 0.06
P-7	12.2 ± 0.3	16.3 ± 1.5	2 ± 1.0	51.3 ± 5.1	20.7 ± 1.2	30.7 ± 4.0	51.33 ± 5.1	1.60 ± 0.08
P-8	15.0 ± 1.0	25.3 ± 1.2	3.7 ± 0.6	100 ± 2.0	46.7 ± 0.6	53.3 ± 2.5	50 ± 2.0	1.50 ± 0.1
P-9	15.3 ± 0.8	23 ± 1.0	2.7 ± 1.2	81.7 ± 3.5	46.3 ± 1.2	35.3 ± 4.5	77 ± 4.4	1.58 ± 0.05
P-10	31.5 ± 0.3	11.7 ± 2.5	0 ± 0	123 ± 5.3	24.3 ± 5.6	98.7 ± 3.1	47.33 ± 2.1	2.1 ± 0.09

PL = Panicle length, PBT/PL = Panicle bearing tillers per plant, NBT/PL = Non bearing tillers per plant, NOS/PN = Number of spikelets per panicle, UG/PN = Unfilled grains per panicle, FG/PN = Filled grains per panicle, SS/PN = Shattered seeds per panicle, 100GW = 100 grain weight.

Table 4
Matrix of Nei's Original Measures of Genetic Identity among O. nivara accessions

	P-1	*P-2*	*P-3*	*P-4*	*P-5*	*P-6*	*P-7*	*P-8*	*P-9*	*P-10*
P-1	1									
P-2	0.4652	1								
P-3	0.4767	0.3904	1							
P-4	0.3636	0.1861	0.3337	1						
P-5	0.3257	0.1905	0.3172	0.3722	1					
P-6	0.286	0.1952	0.35	0.8581	0.3416	1				
P-7	0.3296	0.1928	0.3457	0.9182	0.3374	0.9136	1			
P-8	0.1818	0.1396	0.2384	0.2727	0.2326	0.2384	0.2825	1		
P-9	0.4238	0.2892	0.3951	0.2354	0.3374	0.2469	0.2439	0.1413	1	
P-10	0.0533	0.0546	0	0.0533	0.0546	0.0559	0.0552	0.1599	0.1104	1

habit and high seed shattering. Hence, results of the present study are comparable with the findings of Caldo *et al.* [3]

As reported by Maduakor and Lal[9], morphological traits are vital as a tool for assessing the extent of genetic diversity of plant genetic recourses. Therefore, the variability observed among populations is indicative of the divergence of populations studied. Among the vegetative traits studied, a huge variability was observed for the plant height, leaf length and seedling height. Size of the seeds (length and width) is one of the most stable characteristics having high heritability and therefore, can be used to distinguish species[6].The low variability observed in grain length and width of *O. nivara* accessions reveals the uniformity of seed size and therefore, less use of the trait for characterizing accessions of the same species (data not shown).

Among the reproductive traits observed, panicle length, panicle-bearing tillers/plant, number of spikelets/panicle, filled grains/panicleand shattered seeds/panicle showed remarkable variability among populations. The highest length of panicles were observed in P-10 (31.5 ± 0.3) from Matara district while shortest panicles were found in P-7 (12.2 ± 0.3) from Baticaloa district. The highest number of panicle bearing tillers was recorded in P-8(25.3 ± 1.2) from Badulla whereas lowest number of panicle bearing tillers was noted in P-10 (11.7 ± 2.5) from Matara. The highest number of spikelets/ panicle was detected in P-10 from Matara and lowest was seen in P-5 from Kilinochchi. In P-10 (Matara) population, the highest number of filled grains/panicle was observed while in P-1 (Anuradhapura), the lowest was recorded. The highest number of shattered seeds was detected in P-3 population from Vavuniya district. Among the reproductive traits observed high diversity was observed among populations showing huge diversity in Sri Lankan *O.nivara* populations.

According to the Nei's Original Measures of Genetic Identity[10], the highest genetic identity was observed in between P-4 from Matale andP-7from Baticaloa(0.9182) while identity values in between P-6 from Mannar and P-7 from Baticaloa (0.9136) and P-4 from Matale and P-6from Mannar (0.8581) scored 2nd and 3rd higher values, respectively. While the lowest genetic identity value (0) was observed in

between P-3 from Vavuniya and P-10 from Matara indicating the highest genetic distance among them (Table 4).

CONCLUSION

Results clearly showed a broad phenotypic diversity among *O. nivara* populations. High degree of variability was found in most of the vegetative and reproductive traits recoded. From 13 quantitative traits studied seedling height, leaf length, number of spikelets per panicle, number of filled seeds per panicle, panicle length, 100 grain weight and plant height were identified as the most important traits which accounted for the overall morphological variation observed in *O.nivara* collection. This study highlights the morphological diversity of *O.nivara* populations collected from Sri Lanka and the potential use of this valuable source to improve cultivated rice in future. Therefore, the knowledge gained on diversity of country's specific rice germplasms will enhanced interest on conservation of valuable genetic recourses such as *O. nivara* to be utilized in rice improvement programs.

ACKNOWLEDGMENTS

The work was supported by the National Research Council, Sri Lanka (Grant No NRC 15-108).

REFERENCES

Aggarwal, RK, Brar, DS, Khush, GS (1997), Two new genomes in the *Oryza* complex identified on the basis of molecular divergence analysis using total genomic DNA hydridization, Mol. Gen. Genet. **254**: 1–12.

Bautista NS, Vaughan D, Jayasuriya AHM, Liyanage ASU, Kaga A, Tomooka N (2006), Genetic diversity in AA and CC genome *Oryza* species in southern South Asia. Genetic Resources and Crop Evolution **53**: 631-640.

Caldo RA, Sebastian LS, Hernandez JE 1996. Morphology based genetic diversity analysis of ancestral lines of Philippine rice cultivars. Philippine Journal of Crop Science **21**(3): 86-92.

Heinrich EA, Medrano FG, Rapusas HR (1985), Genetic evaluation for insect resistance in rice, IRRI, Los Banos, Lagna, Philippines, pp. 356-400.

Hemachandra PV, Nawarathne NMN, Dissanayake DWAJ and Geethica WUS (2010), Morphological characterization of wild rice accessions collected from Sri Lanka. Conservation and utilization of crop wild relatives of Sri Lanka. Book of Abstracts (eds. B. Marambe and A. Wijesekara), 3-4 September. Department of Agriculture and Ministry of Environment and Natural Resources, Sri Lanka. pp.13.

Jakson MT (1995), Biodiversity of rice: The basis for guaranteed future productivity, Protecting heritage of biodiversity. Geo-journal **35**(3): 267-275.

Khush GS (1971), Rice breeding for disease and insect resistance at IRRI. Oryza **8**: 111-119.

Khush GS, Brar DS (1991). Genetics of resistance to insects in crop plants. Adv. Agron. **45**: 223-274.

Maduakor HO and Lal R (1989), Root System, top growth and yield of cassava (*M. esculena* Crantz) as affected by plant population and arid region. *Journal of Root Crops* **15**: 115-122.

Nei M (1978). Estimation of average heterozygosity and genetic distance from a small number of individuals. Genetics **89**: 583–590.

Ndjiondjop MN, Seck PA, Lorieux M, Futakuchi K, Yao KN, Djedatin G, Sow ME, Bocco R, Cisse F, Fatondji B (2012), Effect of Drought on *Oryzaglaberrima* Rice Accessions and *Oryzaglaberrima* Derived-lines. Asian Journal of Agricultural Research **6**(4): 144-157.

Richards RA (2000), Selectable traits to increase crop photosynthesis and yield of grain crops. Journal of Experimental Botany **51**(1): 447-458.

Smruti D, Monalisa N, Patra BC, Ramakrishnan B, Krishnan P (2010). Charactrization of seeds of selected wild species of rice (Oryza) stored under high temperature and humidity condition. Indian Journal of Biochemistry and Biophysics **47**: 178-184.

Thomson M, Septiningsih E, Suwardjo F, Santoso T, Silitona T, McCouch S (2007), Genetic diversity analysis of traditional and improved Indonesian rice (Oryza sativa L.) germplasm using microsatellite markers. TAG Theoretical and Applied Genetics **114**(3): 559-568.

Vaughan DA (1990), A new rhizomatous *Oryza* species (Poaceae) from Sri Lanka. Bot. J. Linn. Soc. **103**: 159-163.

❍❍❍