Harnessing the potential of indigenous rice lines: an issue of food sovereignty

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Rice is the seed of the monocotyledonous plant *Oryza sativa* L. (Asian rice) or *Oryza glaberrima* Steud. (African rice). It is grown in more than 100 countries (Chang, 2003) of the world, spanning from 45° S to 53° N latitudes. It is the predominant staple food in at least 15 countries in Asia and the Pacific, 10 countries in Latin America and the Caribbean, one country in North Africa, and seven countries in sub-Saharan Africa (FAOSTAT, 2005). In terms of production volume, rice is second only to corn. With respect to human nutrition, rice provides more than one fifth of human calorific intake, worldwide. In Asia alone, more than 2 billion people obtain 60-70% of their daily calories intake from rice (Diouf, 2003).

Rice landraces and the Green Revolution

Like other cereals, rice has a long list of cultivated species, landraces, wild species and wild relatives, which are grown in varied agro-ecological locations. These constitute a rich source of crop genetic diversity. Based on the study of an extensive collection of rice accessions, Vavilov (1951; 2009) proposed that rice originated from its wild progenitors in “The Hindustan Centre of Origin” around 135 million years ago. This area extends from Eastern India (Assam) to present-day Myanmar, Thailand, Malaysia and Indonesia. Indigenous lines or landraces are the local or traditional folk varieties of domesticated crop species which have developed over time, by adapting to their native and cultivated environments across a defined range of agro-ecological environments. A number of rice landraces, particularly from South and Southeast Asia, have adapted across wide agro-climatic regions. Cultivation of these lines is important for sustainable agriculture as it safeguards dependence on one or more species.

The Green Revolution led to the development of a number of high-yielding rice varieties (HYV). These improved lines had a higher harvest index, photosynthetic allocation rate and an insensitivity to day length, which ultimately increased the overall yields. However, they require both irrigation and fertiliser management and specific cultivation practices to achieve their full yield potential. The HYV remain unused in marginal agro-climatic regions, particularly in fields used by poor smallholder and subsistence farmers. The most detrimental effect of these high-yielding rice lines has been the premature abandonment of many indigenous lines. Many landraces have become extinct without having been ~~being~~ properly evaluated. ~~and~~ Efforts were not made to conserve them in a timely manner because of the large-scale adoption of the semi-dwarf high-yielding rice cultivars (Herre, 2008).

Given the high degree of genetic heterogeneity and a long evolutional history, rice landraces have proven to be highly adaptive to diverse environmental conditions and are believed to harbour a number of valuable genetic resources for crop improvement (Karmakar *et al.*, 2012; Roychowdhury *et al.*, 2013; Ganie *et al.*, 2014). In tropical Asian countries such as India, there are still many local landraces, despite the adoption of high-yielding modern cultivars. A list of such landrace lines as reported by farmers from Eastern India is provided in Table 1. Though these lines have an immensely important role to play in rice improvement, the majority of them are not yet utilised in breeding. The information available on these lines has been obtained from the growers and have not yet been fully explored. The only way to popularise and utilise such lines in future breeding programmes is through the development of a databank with detailed agro-morphology, physio-biochemical and molecular screening with trait-linked markers and specific genes. Currently, many research laboratories are working on improving the knowledge base and a number of promising lines are being utilised in breeding through marker-assisted selection (Steele *et al*., 2000; Singh *et al.,* 2012, Biswas and Bhattacharya, 2013).

Table 1. List of some rice lines reported to be tolerant to common biotic and abiotic stresses

Stress type	Name of the indigenous rice lines
Rice gall midge	Velluthachira, Hanumanjata, Bhumansam
Brown leaf hopper	Chemban, Nagra
Blast	Todukan, Kalonuniya, kartik Sail
Sheath blight	Buhjan, Banshpata, Bhasamanik, Nagra Sail, Raghu Sail
Bacterial blight	Asanleya, Dudheswar
Drought	Ashu, Bhutmoori, Gorah, Guruji, Kakhri, Kakua, Kalomakua, Kaya,

	Kelas, Kheera Sail, Kotki, Kele, Kala bakhri, Noichi, Para, Sada kaya, Sekara, Shati
Salinity	Talmugur, Getu, Matla, Nona bokhra, Nona kati, Hogla, Marich Sail, Nona Sail, Kaminibhog, Dudheswar, Khejurchori, Harmanona
Submergence	Bajal, Jalkamini, Laxmidighal, Sada Jabra, Meghi, Jal Jabra, Katarangi, Sholey, Hogla
Flooding (Deep water rice)	Aushpakal, Banya Sail, Kumrogorhe, Jabra, Jalaj, Jaldhepi, Dubraj, Panidhan, Narayan kamini, Panikalash, Sholey
Non-lodging	Bohurupi, Birpana, Boubhog, Chakramala, Gheos, Lal seeta, Lohagorah, Moti

Harnessing the genetic potential of traditional rice lines

High-yielding lines developed through monoculture, particularly through inbreeding, are homozygous for most of the genes carried out by the respective lines. In contrast, landraces maintained by farmers, though less productive, exhibit tremendous genetic variability, as they are not subjected to breeders' selection over a long period of time across a wide geographical region. This varied valuable genetic potentiality benefits the adaptation of landraces to wide agro-ecological places. Landraces are important for developing resistance to pests and fungal diseases (Taguchi-Shiobara *et al.*, 2013). They have good qualitative traits and medicinal properties (Lai, 1995). They are also high in nutrient content. Most are a good source of complex carbohydrates. They are very low in fat, salt and contain little traces of cholesterol. Several landraces are a good source of vitamins (thiamine, niacin, riboflavin, vitamin D), minerals (iron and calcium) and fibre (Frei and Becker, 2004; García Montecinos *et al.*, 2011). Research results suggest that black rice containing a high degree of anthocyanin can prevent cancer (Chang *et al.*, 2010). The rich variability of complex quantitative traits still remains un- and under-exploited.

Conclusion

Genetic erosion of crop resource diversity is a common threat to the sustainable use of plant genetic resources for meeting the needs and aspirations of present and future generations. Indigenous plant genetic resources harbour a number of valuable alleles that can help the crop to withstand altered environmental conditions. Therefore, with regard to sustainable rice production, if efforts are not made to conserve and characterise extant landraces now, the result will be a further marked reduction in the diversity, a narrowed genetic base, and eventually genetic vulnerability of these species. Dependence on a few selected high yielding varieties is not an option for the future of food and farming and sustaining livelihoods. It is also a food sovereignty issue which urgently needs to be addressed in responding to the global food and nutrition challenge.

References

Biswas, T. and Bhattacharya, S. 2013. Microsatellite marker based diversity analysis for drought tolerance in some Bengal landraces of rice (*Oryza sativa* L.). *Indian Journal of Agricultural Research* 47 (5), 431-435.

Chang, T.T. 2003. Origin, domestication and diversification. In *Rice: origin, History, Technology and Production.* Smith, C.W. and Dilday, R.H. (eds), John Wiley and Sons. Inc., NJ, USA. pp. 3-25.

Chang Hui, Yu Bin, Yu XiaoPing, Yi Long, Chen ChunYe, Mi ManTian *et al.* 2010. Anticancer activities of an anthocyanin-rich extract from black rice against breast cancer cells *in vitro* and *in vivo*. *Nutrition and Cancer* 62 (8), 1128-1136.

Diouf, J. 2003. Director-General's statements. Official Launch of the International Year of Rice, 2004. United Nations, New York, USA. 31 October 2003.
http://www.fao.org/rice2004/en/speeches.htm

FAOSTAT data, 2005. Food and Agriculture Organization of the United Nations, Rome, Italy.
http://faostat3.fao.org/faostat-gateway/go/to/home/E

Frei, M. and Becker, K. 2004. Agro-biodiversity in subsistence-oriented farming systems in a Philippine upland region: nutritional considerations. *Biodiversity and Conservation* 13 (8), 1591-1610.

Ganie, S.A., Karmakar, J., Roychowdhury, R., Mondal, T.K., and Dey, N. 2014. Assessment of genetic diversity in salt-tolerant rice and its wild relatives for ten SSR loci and one allele mining primer of *salT* gene located on 1st chromosome, *Plant Systematics and Evolution* (DOI 10.1007/s00606-014-0999-7, Published online).

García Montecinos, K.L., Godoy Godoy, J.A.; Carrillo Centeno, P.M. and Pachón, H. 2011. Sensory evaluation of the Azucena rice (*Oryza sativa*) variety in Nicaragua's Región Autónoma del Atlántico Norte. *Perspectivas en Nutrición Humana* 13 (2), 135-146.

Herre, B. 2008. Productive smallholders. *D + C, Development and Cooperation* 35 (5), 200-201.

Karmakar, J., Roychowdhury, R., Kar, R.K., Deb, D., Dey, N. and Srivastava, H.S. 2012. Profiling of selected indigenous rice (*Oryza sativa* L.) landraces of Rarh Bengal in relation to osmotic stress tolerance. *Physiology and Molecular Biology of Plants* 18 (2), 125-132.

Lai, J.H. 1995. Rare black glutinous rice germplasm in eastern Guizhou province. *Crop Genetic Resources* 2, 53-54.

Roychowdhury, R., Karmakar, J. Adak, M.K., Dey, N. and Mitra, A. 2013. Physio-biochemical and microsatellite based profiling of lowland rice (*Oryza sativa* L.) landraces for osmotic stress tolerance. *American Journal of Plant Sciences* 4 (12C), 52-63.

Singh, S.P., Goel, R.K., Hunjan, M.S., Vikal, Y. and Lore, J.S. 2012. Screening of land races of rice (*Oryza sativa*) for bacterial blight resistance and marker assisted surveying of known *Xa*/*xa* gene(s). *Plant Disease Research (Ludhiana)* 27 (2), 209-215.

Steele, K.A., Moore, B.J., Witcombe, J.R., Virk, D.S. and Price, A.H. 2000. Variation in RFLP markers associated with root-growth QTLs in Indian upland rice. *International Rice Research Notes* 25 (2), 16-17.

Taguchi-Shiobara, F., Ozaki, H., Sato, H., Maeda, H., Kojima, Y., Ebitani, T. *et al.* 2013. Mapping and validation of QTLs for rice sheath blight resistance. *Breeding Science* 63 (3), 301-308.

Vavilov, N.I. 1951. The origin of variation, immunity and cultivated plants. Chronica Botanica. 13:1-1364, Waltham, MA, USA. (Translation from Russian).

Vavilov, N.I. 2009. *Origin and geography of cultivated plants.* Cambridge University Press, Cambridge, UK.

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