Folk Rice Varieties, Traditional Agricultural Knowledge and Food Security

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Genetic diversity as contained in folk varieties (also called landraces) of rice and its wild relatives provides the bedrock of evolution for cultivated rice (*Oryza sativa*) and its differentiation into various cultivars to adapt to different environments. In South Asia, more than 100,000 folk landraces of the *indica* group of rice were distributed in remote villages (Richharia and Govindasamy 1990; Morishima and Oka 1995), where they coevolved with crop pathogens, pests and their predators. In addition, various gastronomic preferences and culinary practices in different food cultures have engendered genotypic selection and breeding of rice varieties characterized by wide ranges of cooking time, grain elongation on cooking, stickiness, bran colour, aroma and taste. However, this astounding genetic diversity began to decline in the 1970s when modern high yielding varieties (HYVs) were introduced with grain yield enhancement as the primary objective (Shiva 1991; Dwivedi 1997; Deb 2005). Most of the germplasm of the old landraces is now stored in a few gene banks only, not in the hands of farmers. For instance, some 100 landraces grown by the mountain tribes in different villages in Taiwan which were largely tropical Japonica types were collected by the Taichung Agricultural Experimental Station in 1943. These are no longer available in the country (Morishima and Oka 1995). About 5000 rice varieties from the Northeast Indian States were shipped to the International Rice Research Institute in the Philippines (IRRI) in 1965. None of this “Assam Collection” survives in Assam and the adjoining States (Jackson 1994). In West Bengal, over 5500 varieties were recorded to have existed until the 1970s, of which about 3500 varieties were shipped to the IRRI (Deb 2005). In Bangladesh, about 7000 rice varieties were replaced by modern HYVs (Thrupp 2000). Of these, only about 400 varieties survive on marginal farms. Similarly, the number of local varieties has drastically declined in China, Japan and South East Asian countries, owing to a shift to monoculture of modern varieties since the 1970s (Chang 1984; Morishima and Oka 1995; Van Nguyen 2002; Gao 2003). During the twentieth century, about 75% of crop genetic diversity of the world has been lost, as farmers have abandoned their heirloom varieties for genetically uniform HYVs (Gliessman 2007).

The disappearance of thousands of rice landraces entails an erosion of folk knowledge pertaining to the properties of specific varieties, extinction of many traditional agricultural systems, derangement of food cultures, and pauperisation and displacement of marginal farmers. The special arts that evolved with specific rice varieties, for example, the traditional rice cloth of the Philippines, is no longer woven because the rice variety that produced the fibre is no longer in cultivation. Many of the traditional rice delicacies of India are forgotten because the rice varieties with those specific culinary traits are no longer available. The economic impact of modernization is more incisive. Modern upland farmers are no longer growing traditional rice varieties suited to the rain-fed upland, because they are motivated to grow modern varieties with subsidized irrigation from pump sets. With an irreversible dependence of the farmer on an external supply of seeds and inputs, the escalating costs of agrochemicals and machinery then compels the farmer to either sell off his land and migrate to cities as a development refugee, or commit suicide, which has become the norm in India in the past decade. With mechanization of agriculture and the advent of monoculture of rice, the traditional knowledge base for sustaining farm productivity is also lost. The knowledge of adaptations of various local landraces to diverse environmental stresses is forgotten through disuse. With the linear approach of industrial agriculture to grain yield maximization, associate plants and insects are eliminated with pesticides and herbicides, thereby truncating biodiversity on-farm, making it particularly vulnerable to pest attacks (Deb 2009c). Thus, agricultural modernization has occasioned loss of genetic diversity in rice, which in turn has precipitated the erosion of local cultural diversity. Further, the erosion of local cultural identity, through modernization and homogenization of local food cultures, has caused disuse and extinction of landraces that were valued for their specific cultural uses.

Over the past few decades, ethno-ecological research has indicated that indigenous peoples "possess, in their ecological knowledge, an asset of incalculable value: a map to the biological diversity of the earth on which all life depends. Encoded in indigenous languages, customs, and practices may be as much understanding of nature, as is stored in the libraries of modern science." (Durning 1992:7). Nevertheless, there is a stubborn institutional recalcitrance to the appreciation of local knowledge systems and cultures. The dominant epistemic paradigm tends to view indigenous knowledge and institutions as local in scope, relevance, and power, whereas the rules and knowledge of the state are viewed as bigger in scale, scope, and significance. As a consequence, “there is a strong tendency to override, minimize or ignore local considerations, issues, or preferences” (Alcamo et al. 2003), which entails continuation of the erosion of both folk crop landraces and folk knowledge associated with agro-biodiversity, in spite of the international concerns over conservation of crop genetic diversity.

The value of folk crop varieties

Small farmers, as a rule, encounter complex and heterogeneous environments. Crop diversity allows a farmer to grow food in a variety of environments characterized by different soil and qualities, temperature and rainfall regimens, topographies, and exposures to diverse pests and pathogens (NRC 1993; Soleri and Cleveland 2004; Deb 2005, 2009a). The natural resistance of certain crop cultivars to certain pests and diseases, which have developed through a long coevolutionary process, has been identified as one of the key contributions to the maintenance of crop genetic diversity, plant breeding and modern agriculture (Hawkes 1983; NRC 1993).

Within a crop, distinctive traits of landraces allow indigenous farmer-breeders in developing countries to recognize and name individual landraces, create and manage of their diversity and the transfer of knowledge of each distinct landrace to other farmers and succeeding generations. Worldwide examples illustrate how indigenous farmers can perceptively identify distinctive traits on seeds and vegetative propagules to maintain genetic purity, distinguish important markers at planting time, identify landraces suitable for planting at particular locations and times, and value landraces for different uses (Gibson 2009). Farmers in Uttar Pradesh know the different soil, water, and manure requirements of each of their landraces of wheat, finger millet, barnyard millet, soybean, and rice; each one’s seed basket being distinctively different (Tiwari and Das 1997).

For example, farmers know the different seed colours of landraces indicate different degrees of drought resistance (Vaughan and Chang 1992), and that chalkiness or translucence of the rice grain indicates glutinous or non-glutinous rice on cooking (Gibson 2009). Several folk varieties, maintained for their distinctive aroma and colours are used for different gastronomic and religious purposes (Deb 2005). Several traditional farmers are able to distinguish varieties by the flowering time, basal leaf sheath colour, flag leaf angle, panicle length, grain size, shape and colour variations, and eliminate the “off types” from the field in order to maintain genetic purity of the selected landraces. In the Jeypore tract of southern Odisha, traditional farmers grow the Khara rice every three years to “eradicate all mixtures and weed rice from the field” (Mishra and Chaudhury 2010), and this roguing is based simply on the distinctive purple leaves of *Khara*, in contrast to all other varieties. Thus, the unique purple colour of *Khara* rice is grown not only for its aesthetic value, but also employed to periodically cleanse the stock of rice varieties of impurities.

Genetic diversity constitutes the 'use value' of rice. However, three other categories – option value, cultural value, and existence value – are also embodied by the rice landraces developed and maintained by traditional farmers. Option value is the potential benefit of a thing as opposed to actual, present use value (Pearce and Turner 1990). The conservation of diversity has a positive option value, since it keeps options open, as farmers may not know the future benefit or availability of particular varieties today (Brush et al. 1992).

A part of the genetic diversity of rice owes its existence to its aesthetic value. Hawkes (1983) argues that the search for beauty has played an important role in the development and maintenance of infraspecific diversity in many crops. Different landraces are cultivated for the aesthetic appeal of their characteristic chromatic patterms on the hull – gold, brown, purple and black, longitudinal furrows of yellow, purple apex, gold base etc. (Fig. 1). The Burma Black rice is valued by many farmers and consumers for its black pericarp. Many farmers see beauty in the wing-like extensions of the sterile lemma in Moynatundi rice from Odisha and Ramigali rice from Chhattisgarh, so they maintain these varieties on their farms.

Fig. 1. Diverse Colours of Rice Seeds and Decorticated Grains. From left to right: Dakhina laghu, Kaliray, Sada dumra, Jal kamini, Khatia tika, Rani kajal, Patnai, Chitra kanhai.

Aesthetic appreciation is related to the cultural significance of rice genetic diversity. Apart from the interesting colours of lemma and palea and grain pericarp, aroma has a strong aesthetic appeal. Different aromatic rice varieties are associated with religious ceremonies and cultural festivals in all rice growing countries. Several varieties are also grown for their cultural and ritual value. Many small farmers in West Bengal grow *Jamai-sal* rice – even though there is no market for it – in very small areas (about 0.04 ha) because it has a special cultural use – for making a special dish for the son-in-law (*jamai*) at the Jamai Shashthi ceremony (Deb 2000, 2005).

Finally, people often value diversity for its own sake (Bellon 1996). Many farmers of the Jeypore tract in Odisha prefer to grow a combination of awned and awnless varieties on their farms, rather than only awned or only awnless varieties, regardless of any particular agronomic benefits. Such preferences may be understood as an existence value for crop diversity. Not only the cultivated landraces, but also wild relatives of rice like *Buno dhan* (*Oryza rufipogon*) and *Uri dhan* (*Hygroryza asiatica*) are associated with certain religious rites, and maintained on many farms in West Bengal (Watabe 1972; Deb 2005).

TAK and sustainable agriculture

Indigenous farmers have an extensive knowledge of ecological, agronomic and consumptive characteristics of crop varieties (Deb 1996; 2005; Soleri and Cleveland 2004). This knowledge is used to make decisions regarding specific farm management patterns, storage of seeds, culinary use, and ritual practices (Bray 1986; Bellon 1996; Deb 1996). TAK is a rich repertoire of farmers' experiences that are accumulated from informal farm experiments conducted over generations. TAK constitutes a knowledge commons in traditional agrarian communities, where farmers freely exchange seeds, farming methods, and insights gained from past experiences. Until the advent of seed and agrochemicals market, which limited access to seeds and "inputs", young generations of farmers used to inherit the knowledge of crop varieties and farming techniques from the community's elders and peer groups. This body of knowledge, based on local experiments, observations and innovations, was empirically tested and validated through experiences of farmers at multiple locations and across generations, before being incorporated into the indigenous TAK base of the society. This informal, oral transmission of information, often incorporating local innovations, defines the traditional nature of indigenous knowledge systems (Deb 2009b), which is contrary to the formal, technology-based, centralised knowledge systems of modern agriculture. Indigenous knowledge systems, including TAK, are based on local resources, fine-tuned to local environmental conditions, devoid of external inputs, and are constantly evolving. Cultivation systems and pest management approaches are different in various traditional farming systems in different regions of the country because the differences in indigenous experiences over generations of close contact with nature have evolved sustainable and locally suitable agriculture systems (Chhetry and Belbahri 2009).

Because TAK consists of the average consequences of different farm operations, it is conservative, and provides an average prescription of behaviours and techniques to ensure crop protection against foreseeable disasters. However, it also provides a scope for heuristic learning, experimentation, and innovation, because it cannot exhaust all possible combinations of farm operations and environmental conditions. For example, planting crop X before, after, or along with crop Y; undertaking shallow tillage, deep tillage, or no tillage; removing weeds a week or 2 weeks or a month after transplanting, or no weeding, etc. are decisions that may be influenced by the enormous complexity of farm ecosystems, which vary according to selection of crop species and varieties, edapho-climatic conditions, and cultural and economic particulars of the farm. Each of these decisions, with different crop combinations, will yield novel and distinctive results, which will enrich the repertoire of TAK. A real-life example is in order. A young farmer in Bankura district who used to remove weed grasses from his paddy field soon after the rain every year, was unable in 2003 to undertake the weeding due to a heavy and prolonged rainfall. Subsequently, he noticed that the weed grasses like *Cynodon dactylon* and *Brachiaria subquadripara* were effectively suppressed in his inundated paddy field. Based on this experience, "no weeding in a water-logged field" became an additional operational option for this farmer and his peers. Such experiences add to the TAK repertoire of valuable information.

The Green Revolution introduced HYVs that are appropriate only for irrigated lowland farms (FAO 2002: 57). However, all agricultural institutions and development agencies promoted the new "miracle varieties" and irrigation technology for all type of farms, leading to the demise of varieties adapted to upland and deepwater paddy farms, and the subsidence of the water table (Shiva 1991; Deb 2009b). The market-based supply of the modern variety seeds turned all farmers into consumers, totally dependent on seed dealers for seeds as well as agrochemicals. Previously, farmers used to meticulously plant selected landraces according to farm soil type (loamy/ sandy) and topography (hill slope/ seasonally flooded lowland/ rain-fed upland). Indigenous farmers in remote areas where agricultural modernization has not yet changed the landscape continue to carefully distinguish between early and late maturing photoperiod-sensitive varieties while selecting the farm plot for cultivating them. If early maturing varieties are planted, the farm plot must be accessible for harvesting across the neighbouring fields planted with late varieties. Conversely, if the neighbouring farm plots are all planted with early-maturing varieties, the plot planted with a late-maturing variety will be easily accessible to the farmer as well as cattle after the surrounding farms have been harvested, in which case the farmer must make efforts to fence his plot. Resource-poor farmers often plant dense thorny hedges around the farm. Alternatively, the farmer may choose a photoperiod-insensitive late variety and sow it sufficiently early so that its harvesting time synchronizes with the neighbours' varieties that mature earlier.

In contrast with the Green Revolution's singular focus on cereal yield increase and its negligence of adverse social and environmental consequences[1] (FAO 2002), the traditional farmer's objective is to maintain biodiversity linkages and ensure long-term farm productivity, which includes production of diverse crop species and yield of all types of biomass – not just grain. Thus, yields of paddy straw, fodder grass, and leafy vegetables grown on the rice farm are also considered as the farm's produce, because they are linked to farm work, such as feeding the domestic animals, thatching the roof, and securing nutritional security for the household. In order to achieve sustainable yield of all farm produce, the traditional farmer enhances biodiversity at both, the species and genetic levels. Poor farmers of south-western districts of Bengal grow *Kakua, Kaya and Nata* for their distinctive long awns, which deter depredation from the grazing animals (Deb 2000). Likewise, many traditional farmers prefer rice landraces with erect flagleaf, because gramnivore birds cannot perch on them (Deb 2000, 2005). Traditional farmers who practice agro-forestry systems not only maintain a large spectrum of crop diversity, but also plant nitrogen fixing trees such as *Alnus nepalensis* and *Flemingia vestita* to enhance soil fertility.

Maintaining on-farm agricultural diversity is an important trait of traditional farming, in contrast with modern industrialized monoculture farming. On traditional farms, different plants are sown along the field margins as hedge plants. Ancient ballads of Lakshmi, the goddess of farming in Bengal, Jharkhand and Odisha, commends planting of sprawling trees and shrubs amid the farm field in order to provide perches for predatory birds, for a "blessed harvest" (Deb 2000). Ancient texts also prescribe the planting of sacred trees like *Streblus asper* in the farm field (so as to invite birds to perch), and keystone species like *Ficus religiosa* and *Aegle marmelos.* They also mention a list of crop landraces blessed by Lord Shiva and other divinities (Chakraborty 1995). Barn Owl is the mythical associate of Lakshmi, signifying its paramount role in crop protection. The folkloristic elements express biophilia (love and respect for life) for indigenous societies along the metaphorical corridor (Deb and Malhotra 2001).

Folk rice landraces are also a storehouse of valuable genes for important agronomic traits include submergence tolerance, drought tolerance, osmotic stress tolerance, culm elongation in response to flood water, aroma, and resistance to diverse pests and pathogens. Indigenous farmers of the western, low-rainfall zone of Bengal used to grow *Bhutmoori, Bombai mugi, Noichi, Kalo gorah and Kelas*, which are drought tolerant and resilient to a wide range of environmental stresses

(Deb 2005; Patra and Dhua 2010). Recent screening tests reveal that *Kelas* and *Bhutmoori* show a high degree of tolerance to osmotic stresses (Karmakar et al. 2012). Furthermore, these landraces show high genetic similarity (*ibid.*), indicating their common origin from an osmotic stress-tolerant ancestral stock. Several traditional rice landraces like *Jabra, Jal kamini and Harma nona* from West Bengal can withstand inundation by stem elongation in response to rise in flood water levels. Other types of flood tolerant landraces, like *Ganga siuli* and *Kalaputia* from Odisha (Patra and Dhua 2010) and *Baish-bish* from Bangladesh can remain alive after a week of submergence. These landraces yield above 1.5 t/ha on inundated rice farms, where no modern landrace can survive.

Thus, traditional crop landraces are often superior to modern cultivars in marginal environmental conditions (Deb 2009a). Most traditional upland rice varieties are adapted to non-flooded soils (Atlin et al. 2006), while all traditional deepwater landraces can withstand flooding and has developed a ‘quiescent strategy’ for flash flooding and an ‘escape strategy’ for deepwater flooding (Hattori et al. 2011). Modern rice breeders and agronomists now recognize the immense value of these adaptations in the climate change scenario. Rice geneticists as well as seed companies are engaged in “gene mining” – identifying valuable genes for incorporation into modern rice lines. Alongside this corporate gene mining, agricultural modernization programs are pushing this wealth of rice genetic diversity existing on marginal farms across the continent, to extinction.

Modern rice breeding is actively searching for salinity tolerant landraces, which can supply the genes for breeding new cultivars in coastal flood plains. This particular trait is a major weapon to adapt our food production systems to the impending disaster from sea water incursion into coastal and estuarine farmlands. Following the hurricane Aila in 2009, the state agriculture department was unable to provide the Sunderban farmers with any rice varieties that could be grown on the salinated farms. The Vrihi seed exchange network distributed small amount of seeds from our seed bank’s repertoire of traditional salinity-tolerant landraces like *Lal Getu, Matla, Nona bokra* and *Talmugur*, among a small number of farmers in a few villages of the Sunderban. These were the only seeds which yielded a crop on the salinated farms in that year of disaster (Deb 2009a). Likewise, several folk varieties (like *Bhut moori, Kalo gorah, Kelas* and *Rangi*) rescued several farmers in West Bengal when late monsoon rains caused a severe drought in 10 districts of West Bengal in 2010. Such disasters prove, time and again, the long term reliability of folk rice varieties, and the sagacity of traditional selection of genotypes.

Agricultural knowledge extends beyond crop selection, breeding, and crop protection. It also includes efficient techniques of harvesting, seed storage and preservation. Rice itself is traditionally used to protect food grains and seeds from insect damage. To protect the germinating seeds from ant predation and fungal infection, indigenous farmers spread charcoal powder on the sown seeds in the nursery. Farmers also mix the germinating seeds with rice bubbles before sowing, in order to protect the seeds from termite attack. A layer of rice bubbles on top of the rice grains stored in a vessel protects the grains, because the pests consume the rice bubble and spare the grains.

The components of sustainability of food production – namely, resilience of the crop production system to environmental perturbations, crop genetic diversity, and yield stability are all present in the traditional biodiversity-based agricultural systems. Agro-forestry and multiple cropping systems, involving species and crop genetic diversity – through alley cropping, intercropping, hedgerows, cover cropping, crop rotations, fallow cycles and integration of animals – are the most reliable methods of ensuring long term sustainability of crop production (Gliessman 2007; Deb 2009b). Knowledge of crop and site specific management of pests and pathogens, methods of soil moisture maintenance, nutrient management, and adaptive responses to climatic vagaries are all stored in TAK, which needs to be retrieved in order to achieve yield stability without decimating biodiversity and driving toxins into the food chain.

Several folk rice varieties containing iron, riboflavin, and high quantities of labile starch have been identified in South Asia. *Pichha vari* and *Karthigai samba* of Tamil Nadu and *Dudhsar* of West Bengal are traditionally believed to enhance milk production in lactating mothers. Several folk rice varieties, like *Kelas* and *Bhutmoori* of West Bengal, are believed to cure anaemia in women during and after childbirth (Deb 2005). Recent studies indicate that the content of iron and zinc in many traditional rice genotypes are significantly higher than that of improved cultivars (Anandan et al. 2011). Folk medicine in West Bengal prescribes *Parmai-sal* for improving growth in children (Deb 2005). Various micro-nutrients like vitamin E (α-tocopherol), the B vitamins (riboflavin, thiamin and niacin), iron, zinc and certain alkaloids have already been identified in a range of rice genetic diversity developed and grown by indigenous farmers over centuries. Considerable amount of β-carotene (provitamin-A) is also found in the bran of some red and black rice varieties from the Philippines, Malaysia, Vietnam and Thailand (Frei and Becker 2004). In Tamilnadu and Kerala, folk medicine prescribes consumption of *Nyavara* rice for treating patients suffering from a group of neurotic disorders. Biochemical analysis reveals that this rice contains oridine (Juliano 1993), which has neuro-therapeutic functions. In Bengal *Kabiraj-sal* rice is recommended for convalescing patients. There are dozens of such rice landraces with amazing therapeutic properties, known to folk medicine, awaiting detailed investigation and validation, which will benefit modern medicine while ensuring community health and nutritional security.

TAK and the future

After 35 years of the Green Revolution brouhaha, the Government of India's Ministry of Agriculture (http://www.agricoop.nic.in/foreword.htm) observed:

> "The Green Revolution ... by-passed the rain-fed areas, remaining confined primarily to the irrigated tracts. Moreover, the normal professionalism of agricultural research and extension served the irrigated areas better, but was not as responsive to the needs and priorities of rain-fed agriculture. With productivity levels of staple crops in the irrigated areas plateauing off and factor productivity declining it is clear that unless food production in the rain-fed areas increases significantly, food security may be adversely affected."

With the failure of rice breeding and biotechnology to provide the marginal farmers with any reliable rice germ line, our best bet is the folk rice varieties that are fine-tuned to local environmental conditions. Improvement of productivity on rain-fed farms can be achieved by conserving and intensifying cultivation of folk crop varieties that are selected for their adaptation to marginal environmental conditions.

Over the past two decades there is a realization that indigenous knowledge is critical for sustainability. An important milestone was the 1992 Convention on Biological Diversity. Article 8(j) calls for signatories to "respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity."

The prevalent global meteorological trend warn that disasters driven by climate change – long spells of drought, increased frequency of storms and floods, late rains, soil salination and so on – will severely jeopardise food production in the global South (Solomon et al. 2007; Findell and Delworth 2010; Dai 2011). The only scope for adaptation of agriculture to climate change lies in a rapid shift from monoculture and a narrow genetic base to diversity-based agriculture. To execute this shift is not impracticable, because we are fortunate to have millions of indigenous farmers as our contemporaries and compatriots, who are custodians of our heirloom crop varieties, a rich legacy of sustainable agricultural systems, and an immense storehouse of traditional agricultural knowledge.

Our universities and research institutions need to borrow from this storehouse of experience and wisdom, in order to test the applicability and appropriateness of TAK to the current agro-ecological problems, ensure our food security, and enrich our understanding of nature.

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Endnote

(Endnotes)

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FAO (2002, p. 57) admits the following "shortcomings" of the Green Revolution:

- "It was heavily geared to the world's three leading cereal crops, which were suited to its emphasis on maximizing yields. Other crops, including many that are important in sub-Saharan African, such as cassava, millet, sorghum, banana, groundnut and sweet potato, needed a different approach.
- It was suited only to areas with good soils and water supplies, and largely neglected the more marginal rainfed areas with problem soils and uncertain rainfall.
- It relied on farmers being able to afford inputs, and did little for poor smallholders with insufficient funds or access to credit.
- Finally, it largely ignored the possible environmental consequences of high input use, such as the pollution of water and soils with nitrates and pesticides."