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Conservation of agricultural biodiversity-an experience in the Chotonagpur plateau region

S. ADHIKARY

Agricultural and Ecological Research Unit
Biological Sciences Division
Indian Statistical Institute, Kolkata-700108

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ABSTRACT

The Agricultural farm of Indian Statistical Institute, Giridih, Chotonagpur Plateau region, is well maintaining the biodiversity of crops and soils. The present paper discussed the experience, policies adopted for conservation of biodiversity and results. Findings show that due to less effect of Green Revolution and World Trade Organization as well as contract farming in Jharkhand, a sustainable biodiversity is maintained in comparison to that of developed states of India. Regeneration of vast gravel land into fertile land and now sustained vegetation achieved adopting 20 years back aforestation program. Collection and identification have been done for a good no. of varieties of several crops practiced in Jharkhand and maintaining them since long period. Some traditional upland rice cultivars were identified as drought tolerant through drought susceptibility index. 40 germplasms of horsegram were collected from different farmers' age-old collections, tested the genetic variation at the seed storage protein level, grouped only into five broad groups. Under the rainfed farming system, cropping systems and cropping sequences had been developed to maintain crop biodiversity, land use and climatic ecosystems as well as production potential following traditional practices of this region. Numbers of wild species of the cultivated crops are found those could be used as genetic race in the breeding program.

Keywords: Biodiversity, maize, millets and rice

The term "Agricultural biodiversity" is relatively recent, perhaps post-Convention on Biological Diversity (CBD), recognized as essential for global food production, livelihood security and sustainable agricultural development. The plant, animal and microbial organisms which are important to food and agriculture must be conserved and used sustainably. The importance of agro-biodiversity encompasses socio-cultural, economic and environmental elements. All domesticated crops and animals result from human activities and management of biological diversity, which is constantly responding to new challenges to maintain and increase productivity.

Indian agriculture, in spite of being dry land amounting to 65% of all cultivated lands of the country is home to wide range of biodiversity. The harsh environments and diverse production niches provide a challenging opportunity for farmers' creativity to select and adapt crop varieties to suit their environments and their community needs. In one region of Koraput district of Orissa alone, scientists identified over 1500 varieties (Richaria and Govindaswami, 1990). The Green Revolution has directly led to the wide spread loss of the very genetic and biological diversity on which agriculture depends (Balain, 1992). Another threat towards the agro-biodiversity is to be greatly intensified with the implementation of the recently included General Agreement on Tariffs and Trade (GATT) which would further result in the displacement of traditional varieties and homogenization. The total geographical area of the state is 79714 sq km. The landscape of the state has a mix of wild, semi-wild and cultivated habitats. The biodiversity of the state is now a days under some threat due to some adverse factors. These are mining, roads and rails construction, dams and irrigation schemes, construction of mineral based factories and industries, stone quarrying and unrestricted grazing by cattle etc. The Green Revolution technology has not spread here for several reasons, including its exorbitant costs, and lack of appropriate packages for so-called marginal areas and obviously for another reason that lack of irrigation facility. An important tendency of the farmers was noticed that if they grow HYV, it is only for market but for their own consumption, these are traditional varieties. These lead the Jharkhand to maintain agricultural biodiversity (agro-biodiversity).

Considering this scenario our objectives are to study the methods of agricultural practices in Jharkhand so that the biodiversity of crops and soils are till maintained and the technology development for conservation of biodiversity and to increase the production or return under rainfed situation with maximum land use, crop selection for betterment of the livelihood of the people.

MATERIALS AND METHODS

The Chotonagpur plateau region is characterized by lateritic red soils having slopes, gravel undulated slopes, uplands, medium lands and lowlands also and because of their character host a wide variety of agricultural crops including rice, maize, sorghum, a range of millets, pulses and oilseeds, vegetables, fruit plants and forest plants, all

Email: drsujitadhikary@yahoo.com

of which grow under rain-fed conditions. The area is to be considered as semi-arid tract although having 1200-1300 mm annual mostly monsoon precipitation which is very much erratic in distribution. The agricultural farm of Indian Statistical Institute, Giridih situated at the Chotonagpur Plateau region of eastern India, is well maintaining the biodiversity of crops and soils since the time of Green Revolution. Here, number of traditional crop varieties are maintaining in diversified range of soils, agro-forestry ecosystems, livelihood of poor and marginal mostly tribal farmers. Methodology includes different cropping systems, cropping sequences, fertilizer and water management, aforestation through traditional trees like mahua, palash, teak, pongamia, cashew etc., collection and conservation of traditional varieties as well as traditional methods of cultivation.

RESULTS AND DISCUSSION

The present paper discussed the experience, policies adopted for conservation of biodiversity and results. Findings show that due to less effect of Green Revolution and WTO as well as contract farming in Jharkhand a sustainable biodiversity is maintained in comparison to that of developed states of India. The diversity of the cropping system and its suitability to highly infertile soils receiving no irrigation or external input makes it uniquely significant for the survival of ecologically sustainable agricultural systems. As a matter of fact, the local populations practiced a no. of diversified crops (Fig.1, 2) like maize (*Zea mays*), kodo (*Paspalum scrobiculatum*), gundli (*Coix lachryma-jobi*), sorghum (*Sorghum vulgare*), oat (*Avena sativa*), barley (*Hordeum vulgare*), pigeonpea (*Cajanus cajan*), horsegram (*Macrotyloma uniflorum*), niger (*Guizotia abyssinica*), kudrum (*Hibiscus* sp.), sunhemp (*Crotalaria juncea*) and upland rice (*Oryza sativa*) to signify the fact that these crops grow with virtually no inputs at all surviving on the available sub-soil moisture (Bandhyopadhayay *et al.*, 1990). In uplands, subsistent farmers, in order to get a quick crop often go for small millet or indigenous gora rice (Mohsin *et al.*, 1986). This resulted perception of biodiversity based agricultural system through a series of agro-economic, social, cultural and spiritual paths. Some crops have been identified through farmers' practices having special qualities and vulnerabilities, which are recognized, valued, and accounted for in farming practices for this region (Table 1).

Table 1: Crops practiced in Jharkhand for special qualities

Qualities	Crops or Plants
No weeding required	Niger, Sunhemp
Soil binders	Pigeonpea, Jatropha, Sisal
Most labour involved [in processing]	Little Millet, Foxtail millet
High storability	Foxtail millet, Kodo millet, Little millet
The tastiest foods	Super fine Rice, Pigeonpea, Traditional Aus Rice, Baby Corn, Pearl millet roti, Foxtail millet
Low water requirement	Horse gram, Pigeonpea, Linseed, Niger, Barley
Domestic fuel	Linseed, Pongamia, Sesame, Jatropha, Straw of Pigeonpea, Maize, Sorghum etc.
High commercial value	Groundnut, Pigeonpea, Sesame, Cashew, Yam
Fibre	Sisal, Sunhemp
Staple food	Mahua
Medicinal value	Horse gram, Pigeonpea, Pongamia, Arjun
Non grazable	Jatropha

A wide range of crops during different seasons is noted in practice since very long time in different soil and land situation and these are beside the above mentioned crops, greengram (*Vigna radiata*), wheat (*Triticum vulgare*), linseed (*Linum usitassimum*), chickpea (*Cicer arietinum*), field pea (*Pisum sativum*), proso millet (*Panicum miliaceum*), finger millet or marwa (*Eleusine coracana*), pearl millet (*Pennisetum glaucum*), foxtail millet (*Setaria italica*), groundnut (*Arachis hypogea*). These crops are mostly grown as mixed cropping system to minimize crop failure as well as for better soil and crop management. In the low lands extensively different traditional rice cultivations are found in practice instead of HYV. Results showed the interesting cultural practices followed for biodiversity and these are weed management, water management, nutrients management at low cost, using traditional resources, all of which are responsible to keep its' own biodiversity. In our experiment over a series of years, tall indica selection from *Oryza sativa*, based on the farmers' knowledge with zero level of chemical fertilizer and pesticide produced around 30q ha^{-1} grain and 70q ha^{-1} straw. Significantly higher grain and straw yield of long duration traditional rice cultivars was obtained from closer row spacing with 2-3 seedlings hill^{-1} where only basal application of FYM was practiced. Some weeds are seemed to be useful inputs in biodiversity can also serve as green fodder for animals. The seeds of these weeds usually get recycled through the farmyard manure and cowdung into which kitchen waste and waste from the cattle are thrown to fertilize the crop, in this way the field became benefited continuously. As chemical fertilizers were not used, this recycling through FYM and cow dung was not broken and the regeneration of uncultivated plants continued thereby maintained biodiversity. Based on a meticulous study of the moisture requirement of each crop and the rainfall pattern in the region, farmers have developed own system of cultivation of specific crops during specific periods of the monsoon. Finally, we developed suitable cropping systems and crop calendar. Among the different cropping sequence trial under rainfed situation rice-linseed cropping sequence produced the highest land-use efficiency and rice equivalent yield of 32.7q ha^{-1}. Our results suggested that even in driest spell a few crops like barley, mustard (toria) and niger, if sown at early November may also contribute reasonably sustained productivity in this region where monocropping is the practice presumably due to moisture scarcity.

Under the rainfed farming system number of cropping systems and cropping sequences had been developed to maintain biodiversity, ecosystems, maximum land use as well as increased production. Being drought resistant crop barley, linseed and niger have proven suitable succeeding crop followed by rainy season cropping system. Crop biodiversity is very important for both the functioning of ecological systems and the generation of a vast array of ecosystem services, more agricultural biodiversity is associated with higher agricultural production and lower risk exposure (Falco, 2012). Intercropping of different crops is practiced for optimal land use. Ensuring food security makes it imperative that they grow crops like kharif maize, the main staple food grain of the region. Maize equivalent yield 41.62q ha^{-1}, 31.35q ha^{-1} and 30.37q ha^{-1} were obtained from the intercropping systems of maize + groundnut, maize + green gram and maize + soybean, respectively instead of 28.15q ha^{-1} from sole cropping of maize. Bio-economic evaluation of maize + groundnut intercropping system showed the promising food and economic security in drought-prone areas of Chotonagpur plateau region of Jharkhand.

Intercropping of maize with groundnut following paired row cropping system (2:2) produced maximum maize grain equivalent yield 62.26q ha^{-1} and economy of ` 18,595 ha^{-1} in comparison to other cropping systems.Intercropping of jatropha with maize and horse gram is become promising cropping systems during the first three years of jatropha plantation due to the short plant canopy. As jatropha is a good eco-friendly crop producing bio diesel and remains non productive in the first three years, these intercropping systems are remunerative during the period. Since the farmers use a variety of fodder mixes for their cattle, they also need diverse varieties of fodder. The cattle are fed on a mix of green and dry fodder, straw, pods and husk. To meet this need, the fodder-feed mix has become a part of the cropping system in the region. Growing a mixture of maize, pearl millet, pigeonpea, cowpea, horse gram and rice bean to ensure that they get green and dry fodder. In an experiment we got a fodder mixture of 145.00 q ha^{-1} maize + 95.00q ha^{-1} rice bean + 110.00q ha^{-1} cowpea when grown in mixture of 50: 25: 25 seed ratio, respectively. Tilman *et al*., (2006) also indicated that high diversity plots were 70% more stable than monocultures. Increased productivity is also associated with greater stability of yield.

Diversity of kingdoms, species and genepools can increase the productivity of farming systems in a range of growing conditions, and more diverse farming systems are also generally more resilient in the face of perturbations, thus enhancing food security (Frison *et al.*, 2011). Horse gram and finger millet are crops, which make the least demand on water or moisture. They also grow on lands, which are least fertile. The unique cropping system is developed with a variety of crops not just for their produce value but also for their interaction with soils rejuvenating soil fertility and strength. For example, niger is an oilseed grown on the hardiest and the least fertile patches of soil. Through its root activity niger loosens the soil on which it is sown and fertilizes it through leaf fall. Over a period of time, the farmer has not only enjoyed the produce of niger for oil needs but will also have reclaimed the least fertile patches of his farm to grow 'better' crops further. Soil fertility had been improved through incorporation of legumes in the intercropping systems with cereals and it was reflected on succeeding crop. In an experiment in Giridih, 10.65q ha^{-1} barley was obtained as succeeding crop from groundnut-barley cropping system.

Collection and identification have been done for a good no. of varieties of several crops practiced in Jharkhand and maintaining them since long. A good number of traditional rice varieties were identified and collected and also these varieties are maintained in our farm (Fig. 3, 4). Using these varieties several cropping systems and technologies for food security has been developed. Sathya *et al*., (2007) while evaluating the biodiversity of traditional rice varieties in Tamil Nadu documented some of the rice varieties available and their unique characteristics.

Fig. 1: Diversity in maize

Fig. 2: Kodo millet (*Paspalum scrobiculatum*)

Fig. 3: Rice variety Azusena

Fig. 4: Rice variety Ramsar

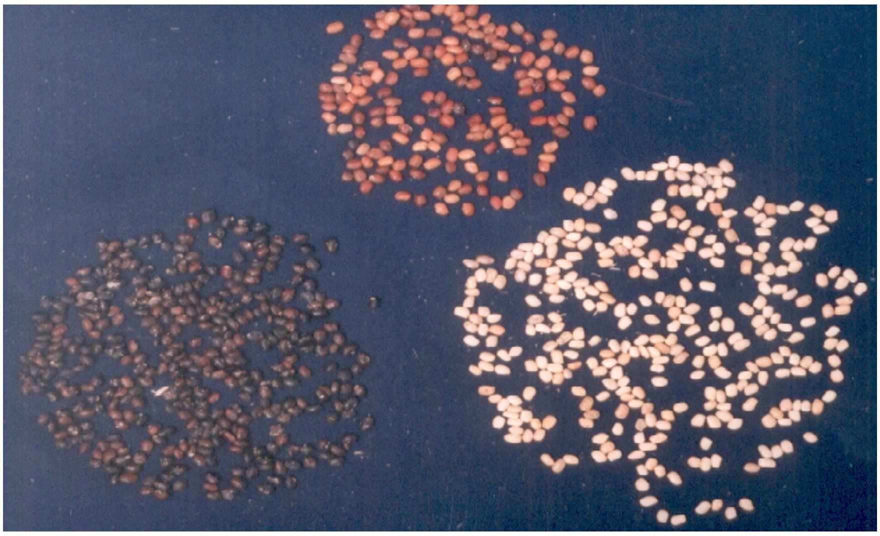

Fig. 5: Horse gram diversity

Deploying agricultural biodiversity more effectively is not simply a return to traditional practices. It requires a scientific approach to understand how different forms of agricultural biodiversity contribute to the goals of improved food and nutrition security and sustainability, and recognition that while some principles and practices will be globally applicable, others may be constrained by locality and culture (Hajjar *et al*., 2008; Marquard *et al*., 2009; Weigelt *et al*., 2009; Wolfe, 2000; Zhang and Li, 2003). Fisher and Maurer (1978) identified some traditional upland rice cultivars as drought tolerant through drought susceptibility index and observed (Table 2) that Brown Gora, a traditional upland rice variety showed maximum drought tolerance [Drought Susceptibility Index (DSI)=0.38, as the value < 1 represents tolerance] followed by Birsa-101 (DSI=0.67). During field visit in Jharkhand number of wild species of the cultivated crops were observed e.g. kudrum a wild of ladies' finger, oat, kodo, gudli, marwa (minor millets), sesame, ber, grapes, tulsi, jatropha, cotton, no. of weeds etc. which could be used as genetic race in the breeding program. Hajjar *et al*., (2008) argued that both within and between-species diversity of crops enhance pollinator availability and improve production. Wide range of minor millets were cultivated over a long period by the farmers of this area because of mostly they were poor and marginal. We collected some of those abolishing millet germplasms in our farm and maintained for germplasm bank and also cultivated in diversified cropping systems for maximum yield and other advantages. In India a long series of studies to improve the use of so-called minor millets among very poor farmers has shown multiple beneficial impacts on yields, incomes, profits, the nutritional value of popular snack and breakfast foods, and female empowerment, all promoting the likely conservation of those crops and their biological diversity in farmers' fields (Bala *et al*., 2010; Sanathakumar *et al*., 2010). We have been able to regenerate a vast gravel land into fertile land and now sustained vegetation achieved through 20 years back aforestation programme.

Table 2: Grain yield and drought susceptibility index (DSI) of different cultivars

Cultivars	Rice grain yield (q ha^{-1})		Mean drought susceptibility index (S)
	Drought year	Mean of normal years	
Brown Gora	10.90	12.75	0.38
RR-167-982	14.70	20.54	0.87
Kalinga-3	10.80	17.26	0.94
RR-151-3	10.90	15.90	0.78
RR-51-1	8.13	15.22	1.24
RR-50-5	10.10	14.46	0.90
RR-2-6	6.07	12.41	2.06
Birsa-101	8.51	10.71	0.67
LSD (0.05)	**1.42**	**-**	**-**

Note: Adapted from Adhikary and Sarkar (2003)

Forty germplasms of horse gram were collected from different farmers' age-old collections (Fig. 5) and tested the genetic variation among these germplasms at the seed storage protein level. Our results show that 40 different cultivars can be grouped only into five broad groups (Table 3 and Fig. 6). Our efforts have resulted over a time in the conservation of more than 300 rice varieties including indigenous rice varieties that have been adapted over centuries to meet different ecological demands. We have also conserved 300 varieties of wheat, millets, pseudo-cereals, pulses, oilseeds, vegetables and multipurpose plant species including medicinal plants. Additionally, these seeds conserved by the local farmers have climate resilient properties developed through hundreds of years of farmer selection, and are vital to overcome the agriculture crises caused by climate instability. Jharkhand is still maintaining its' biodiversity instead of what modernization of agriculture is going on in the third world under the pressure of the developed countries. Therefore, programe of collection and characterization of indigenous crop varieties should be supported and extended, paying particular attention to their ability to yield under low-input conditions under biodiversity-rich farming systems for conservation of biodiversity. Support should be given particularly to Jharkhand in their efforts to assess their genetic resources, establish systems for its use which brings benefits to the country. Breeding needs to be decentralized and efforts made to include local needs and constraints into the criteria for selection of new varieties. Priority should be given to projects seeking environmentally friendly ways of improving soil fertility, and reducing pesticide applications. Development programs must ensure the aspects of traditional farming systems which are still relevant for conservation of biodiversity at any cost. Also, it is realized that conservation of agricultural biodiversity is impossible without the participation of the communities who have evolved and protected the plants that form the basis of sustainable agriculture.

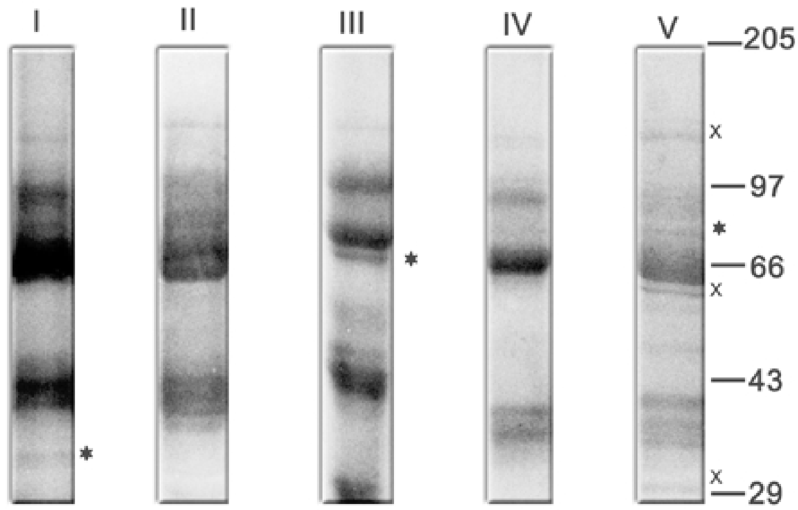

Fig. 6: Comparison of SDS-PAGE gel patterns of horse gram germplasms (40 germplasms were characterized into 5 groups based on their band patterns. I-V represents 5 broad groups of germplasms identified at the SDS-PAGE level. Numbers on the right hand side represents standard molecular weights in kilodaltons (Kd). × represents 30 Kd, 60 Kd and 120 Kd bands, while asterisks represents unique bands in some of these broad groups of germplasms.

Table 3: Characterization of 40 different germplasms of horse gram at the SDS-PAGE level

Approx. molecular wt. of protein bands (Kd)	Group I[a]	Group II[b]	Group III[c]	Group IV[d]	Group V[e]	Band unique to group (s)
130	+	-	-	-	-	I
125	+	+	-	-	+	I, II, V
120	+	+	+	+	+	All
115	-	-	-	+	-	IV
100	+	-	-	+	+	I, IV, V
95	+	-	+	+	-	I, III, IV
85	-	+	-	-	+	II, V
80	+	+	-	+	+	I, II, IV, V
66	+	+	+	+	+	All
64	+	+	+	-	+	I, II, III,V
60	-	-	+	-	+	III,V
50	-	-	+	-	+	III,V
40	-	-	+	-	+	III,V
38	+	+	+	+	+	All
36	+	+	+	+	+	All
34	-	+	-	-	+	II,V
32	+	+	-	-	-	I, II
31	+	+	-	-	-	I, II
30	-	+	+	-	-	II, III
29	+	+	+	+	+	All

Note: *Out of 40 germplasms tested following are the distribution of protein bands of different germplasms in five different groups- I[a] -12 germplasms; II[b]- 9 germplasms; III[c]- 4 germplasms; IV[d]- 11 germplasms; V[e]- 4 germplasms. '+': band observed; `-': band not found.*

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