Indian J. Plant Genet. Resour. 28(3): 335-344 (2015)
DOI 10.5958/0976-1926.2015.00045.5

Agri-biodiversity Maintained On-farm by Ethnic Groups in Peninsular India: Legacy of Landrace Sustainability in Cereals and Millets

SR Pandravada[1*], N Sivaraj[1], R Jairam[1], N Sunil[1], SK Chakrabarty[1], R Eshwar Charan[2], P Ramesh[2] and IS Bisht[3]

[1] *National Bureau of Plant Genetic Resources, Regional Station, Rajendranagar, Hyderabad-500030, Andhra Pradesh, India*

[2] *Acharya N.G.Ranga Agricultural University, Krishi Vigyana Kendra, Adilabad-504001, Andhra Pradesh, India*

[3] *National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi-110012, India*

(Received: 16 July 2014; Revised: 15 October 2015; Accepted: 15 October 2015)

The on-farm sustainability of landrace diversity of cereal and millet genetic resources covering 10 crop species was analyzed for Adilabad, Andhra Pradesh, India. It was assessed based on 14 special agri-biodiversity surveys undertaken during 2010-12 for collection and salvaging the current spectrum of genetic diversity from the district. A total of 447 accessions belonging to landrace populations of cereals (172), millets (195) and small millets (80) could be collected during the missions which formed the source of the inventory documentation. In all, 88 named landraces, maximum represented by sorghum (45) and rice (18) could be collected. It was interesting to note that a number of landrace populations collected from the district during early nineties, 81 in rice, 43 in sorghum and three in wheat could not be recollected as these traditional varieties are no longer under cultivation. However, 16 landraces in sorghum and 12 in rice are under continuous patronage of the farming communities for livelihood reasons. A total of 48 new landraces: six in rice, 29 in sorghum, 10 in maize and three in wheat which were not collected earlier could be augmented due to intensive surveying in remote tribal pockets. The data documented is useful for proper planning and adopting appropriate strategies for crop genetic resources management at micro-level in the region and also devising a rational conservation plan, both *ex-situ* and on-farm.

Key Words: Agri-biodiversity, Landraces, On-farm conservation, Sustainability

Agri-diversity refers to inter and intra-specific variability in different crops that are used directly or indirectly for food, fodder, fibre, fuel and medicine. The role of agri-diversity is immense as elucidated by Thrupp (1997) which can "increase productivity, food security and economic returns, reduce the pressure of agriculture on fragile areas, forests, endangered species, make farming systems more stable, robust and sustainable, conserve soil and increase natural soil fertility and health, contribute to sustainable intensification, diversify products and income opportunities, reduce or spread risks to individuals and nations, help maximize effective use of resources and the environment, reduce dependency on external inputs, improve human nutrition and conserve ecosystem structure and stability of species diversity". The existing indigenous food production systems are under severe threat which has a bearing on local knowledge, culture and skills of tribal farmers resulting in fast erosion of landrace diversity. The degree of loss is largely extensive as more than 75% of diversity in crop genetic resources has been on the wane since 1900s. This can be attributed to farmers' abandoning their local landraces and traditional cultivars with genetically uniform and high-yielding varieties worldwide (FAO, 1999).

Adilabad is the fifth largest district in Andhra Pradesh State, India, which lies between 18° 40' and 19° 56' N latitudes and 77° 47' and 80° 00' E longitudes with a total geographical area of 16,128 sq.km which is quite a large area when compared to many of the small nations in Africa, Americas, Asia, Europe and Middle East. It is bounded by Yeotmal and Chandrapur districts in the North, Chandrapur in the East, Karimnagar and Nizamabad in the South and by Nanded district in the West. Adilabad is administratively divided into 52 mandals with 15 towns and 1,752 revenue villages and is also covered up to 44.8% area mostly by dry deciduous forests. About 65% of the district is inhabited by tribal groups to an extent of 17.8 % of the total population (second in the State of Andhra Pradesh) with Gond, Naikpod, Kolam (Primitive Tribal Group (PTG)), Pardhan, Koya, Manne, Andh, Thoti (PTG), Lambada and Yerukala, as the major groups. The tribal population is dominated by the *Gond* (52%), *Lambada*

*Author for Correspondence: E-mail: pandravadasr@yahoo.com

(22%), *Kolam* (8%) and others (*Naikpod, Koya, Andh, Manne, Pardhan* and *Porja*- 8%). The most important river that traverses the district is the Godavari with Penganga, Wardha, Pranahita, Kadem and Peddavaagu as the tributaries and the rivulets flowing through are Satnala, Swarna and Suddavaagu. The major crops of the district are rice, sorghum, cotton, pigeon pea, maize and soybean, etc. Very deep black cotton soils are predominant and also found are *chalkas*, red and sandy loams. The average annual rainfall ranges between 700 to 1,200 mm, mostly precipitated during the south-west monsoon. The minimum and maximum temperatures range between 5 to 52 °C (Anonymous, 2005 and Pandravada *et al*., 2012).

To arrest the alarming rate of depletion of local landraces, appropriate plant genetic resources (PGR) management strategies are to be adopted to mitigate the situation. The proper management strategy calls for inventorization of information from various sources including that of germplasm exploration and collection, conservation and documentation etc. In this regard, an attempt has been made to prepare the agri-biodiversity inventory, especially with respect to cereal and millet crops of tribal dominated Adilabad district of Andhra Pradesh, India based on extensive passport data generated during 14 biodiversity surveys undertaken in the district. It is hoped that the generated information would be highly useful for micro-level planning for sustainable PGR management, the results of which could be extrapolated to other parts of the country as well.

Materials and Methods

A total of 14 agri-biodiversity surveys were undertaken during 2010-12 in 187 villages belonging to 52 mandals (District sub-units) of Adilabad district of Andhra Pradesh for collection, conservation, inventorization and documentation of agri-biodiversity in general and of cereals, millets and small millets in particular (Fig. 1). Under cereals, rice, wheat and maize, under millets sorghum and pearl millet and under small millets, Italian millet, little millet, proso millet, barnyard millet and kodo millet are the important crops under cultivation.

To conserve the prevailing genetic diversity in cereals, millets and small millets, population samples of germplasm were collected from tribal farmers' fields, threshing yards, farm stores and also augmented from the market. The overall collection tactics and logistics were taken into consideration as suggested by Astley (1991) and Bennett (1995). Garmin-12 model of Global Positioning System (GPS) was used to record the geographical coordinates of the collection sites.

The germplasm collections were properly cleaned, processed and packed in aluminium foil pouches for medium-term conservation in the MTS Module facility at the Station. An inventory of cereals, millets and small millets landrace diversity was prepared based on the germplasm collection missions organized and passport data recorded and the same is summarized in this paper.

Results

During the 14 intensive collection missions organized in Adilabad, a total of 447 germplasm accessions belonging to cereals, millets and small millets could be sampled from tribal farmers' dwellings in 47 mandals (District sub-units). No landrace diversity could be recorded and collected under cereals and millets from the remaining five mandals (Dandepally, Laxmanchanda, Lokeshwar, Mandamarri and Tandur). Of the 10 crops belonging to cereals, millets and small millets, maximum crops could be collected from Sirpur (U) (9) mandal and maximum accessions from Kerameri (35) mandal. The ethnic groups associated with the origin, evolution, domestication and on-farm conservation of named landraces include, *Andh, Gond, Kolam, Koya, Lambada* and *Nayakpod*.

The tribal groups that contributed maximum to landraces are the Gond (59) and the Kolam (16). The landraces collected could be broadly categorized into two groups *viz.* named and unnamed landraces, characterized by distinct phenotypic traits which are under the patronage of ethnic groups. With respect to named landraces, maximum could be collected in sorghum (45) followed by rice (18) and no named landraces could be collected in crops pearl millet, barnyard millet, kodo millet and proso millet under the millets and small millets groups.

The inventory of landrace diversity augmented in all the three crop groups from the district is presented in Table 1. The distribution of diversity mandal-wise and crop-wise and landraces sampled under cereals, millets and small millets from the district is presented in Table 2. The diversity spectrum of collections made under cereals, millets and small millets crop groups is depicted in Fig. 2. The cereals contributed 38.5% of the total diversity assembled while the rest 61.5% was contributed by the millets and small millets. With respect to number of landraces, sorghum topped the list with

Table 1. Inventory of cereals, millets and small millets diversity and named landraces collected from Adilabad, Andhra Pradesh

Crop group/ Crop	Diversity collected (No. of accessions)	Named Landraces collected (No.)	Landrace name
Cereals			
Rice	66	18	*Akasavai vadlu, Budamavanji, Chittimutyalu, Chittiporu, Dasara vadlu, Davaralvanji, Erra vadlu, Gowrani vadlu, Kakirekkala vadlu, Nalla vadlu, Pandadivanji, Pandrisadi, Pisodi vadlu, Polala vadlu, Puraval, Ragalvanji, Regadi vadlu, Tella vadlu*
Maize	89	10	*Chinna makka, Gangatriyulu, Gowrani makka, Gundu makka, Local makka, Pedda makka, Pelala makka, Popcorn makka, Ragal makka, Somaram makka*
Wheat	17	3	*Erra godhuma, Metta godhuma, Rabi godhuma*
Millets			
Sorghum	188	45	*Aragidi jonna, Badigi jonna, Boda jonna, Chikkati jonna, Chinna jonna, Chinnaboda jonna, Dambral, Darawat jonna, Deyam jonna, Dhane jowar, Erra jonna, Gadda jonna, Gundu jonna, Gunjidi jonna, Gunjidipedda jonna, Guvvi jonna, Jalleda jonna, Kathani jonna, Konkadala jonna, Leha jonna, Mudda jonna, Pachchaboda jonna, Pala jonna, Pandari jonna, Pandimutte jonna, Parasa jonna, Pasupu jonna, Pasupupachcha jonna, Pedda jonna, Pelala jonna, Potiki jonna, Purabodaka jonna, Pyru jonna, Rabi jonna, Sanna jonna, Sevata jonna, Sivira jonna, Talki jonna, Tekedari jonna, Tella jonna, Tellaboda jonna, Varagadi jonna, Vayunowka jonna, Vubiripatti jonna, Vullipitta jonna*
Pearl millet	7	–	–
Small millets			
Italian millet	44	9	*Amba korra, Chikto, Erra badi, Erra burakalu, Karri badi, Nalla badi, Nalla burakalu, Sivera korra, Tella burakalu*
Little millet	12	3	*Badhali, Erra sama, Ragal sama*
Barnyard millet	20	–	–
Proso millet	2	–	–
Kodo millet	2	–	–
Total	447	88	

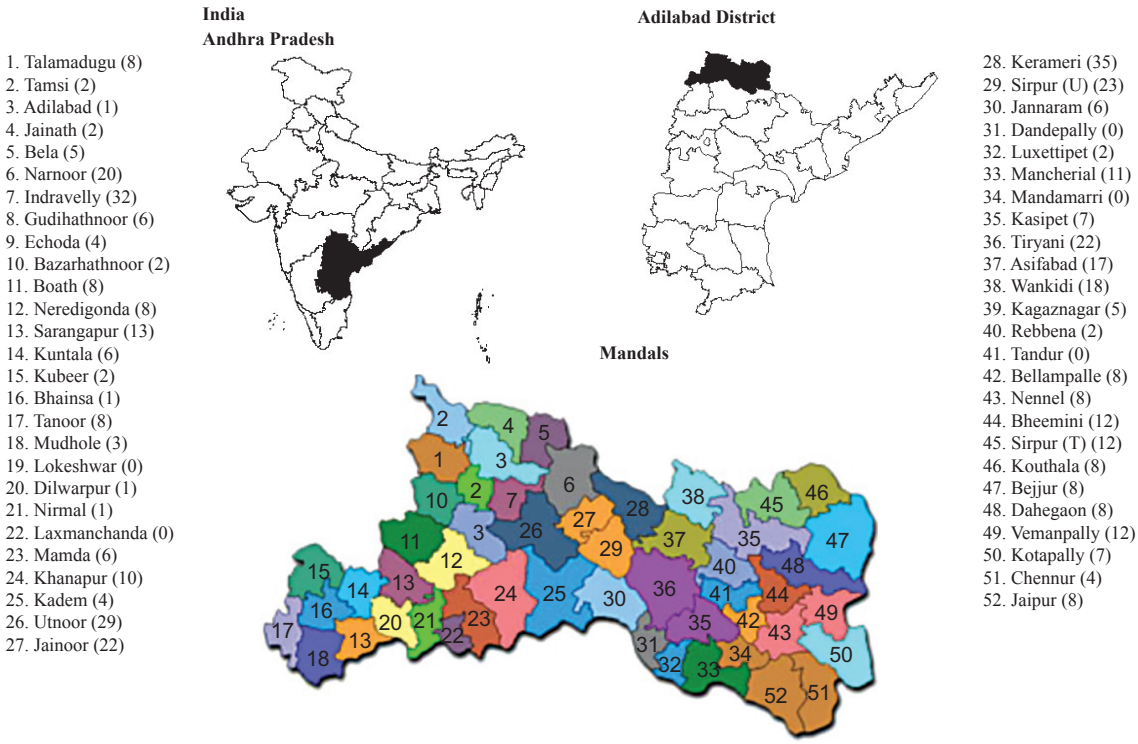

Fig. 1. Map of Study Area (Adilabad district with 52 mandals)

• *Values in parentheses indicate the numbers of germplasm accessions collected under cereals and millet from the respective Mandal*

Table 2. Distribution of cereals, millets and small millets diversity (mandal wise and cropwise) in Adilabad, Andhra Pradesh

Mandal	Crop (No. of named landraces salvaged)	Total diversity collected (No. of accs.)
Adilabad	Maize (1)	1
Asifabad	Sorghum (7)	17
Bazarhathnoor	Rice (2)	2
Bejjur	Rice (1), Wheat (1), Maize (1), Sorghum (2)	8
Bela	Maize (1), Sorghum (1), Wheat (1)	5
Bellampalli	Rice (1), Maize (1), Sorghum (3)	8
Bhainsa	Rice (1)	1
Bheemini	Rice (2), Maize (1), Sorghum (6)	13
Boath	Maize (2), Sorghum (3)	8
Chennur	Rice (1), Maize (1), Sorghum (1)	4
Dahegaon	Rice (1), Maize (1), Sorghum (2)	8
Dilwarpur	Wheat (1)	1
Echoda	Rice (2), Sorghum (1)	4
Gudihathnoor	Rice (1), Sorghum (2), Wheat (1), Italian millet (1)	6
Indravelly	Rice (5), Maize (1), Sorghum (8), Italian millet (3)	32
Jainath	Rice (1), Sorghum (1)	2
Jainoor	Rice (4), Maize (2), Sorghum (7)	22
Jaipur	Maize (1), Sorghum (3)	8
Jannaram	Wheat (1), Maize (1), Sorghum (3)	6
Kadem	Rice (1), Maize (1)	4
Kagaznagar	Maize (1), Sorghum (1)	5
Kasipet	Maize (1), Sorghum (4)	7
Kerameri	Rice (2), Maize (2), Sorghum (8)	35
Khanapur	Wheat (2), Maize (3), Sorghum (4)	10
Kotapally	Maize (2), Sorghum (2)	7
Kouthala	Maize (1), Sorghum (2), Rice (1)	8
Kubeer		2
Kuntala	Rice (1), Wheat (1), Sorghum (2), Little millet (1)	6
Luxettipet	Sorghum (1)	2
Mamada	Rice (2), Maize (1), Italian millet (1)	6
Mancherial	Maize (1), Sorghum (4)	11
Mudhole	Sorghum (2)	3
Neredigonda	Rice (2), Maize (2), Sorghum (1), Italian millet (2)	8
Narnoor	Rice (2), Maize (1), Sorghum (6), Italian millet (1)	20
Nennel	Maize (1), Sorghum (2)	8
Nirmal		1
Rebbana	Maize (1), Sorghum (1)	2
Sarangapur	Rice (1), Maize (1), Sorghum (4)	13
Sirpur-T	Wheat (1), Maize (1), Sorghum (4)	12
Sirpur-U	Rice (3), Wheat (1), Sorghum (6), Italian millet (2)	23
Talamadugu	Rice (2), Maize (1), Sorghum (2)	8
Tamsi	Rice (1), Sorghum (1)	2
Tanoor	Sorghum (6)	8
Tiryani	Rice (2), Maize (2), Sorghum (9), Italian millet (1)	21
Utnoor	Rice (4), Maize (1), Sorghum (8), Italian millet (1)	29
Vemanpalle	Maize (3), Sorghum (6)	12
Wankhidi	Maize (1), Sorghum (4)	18

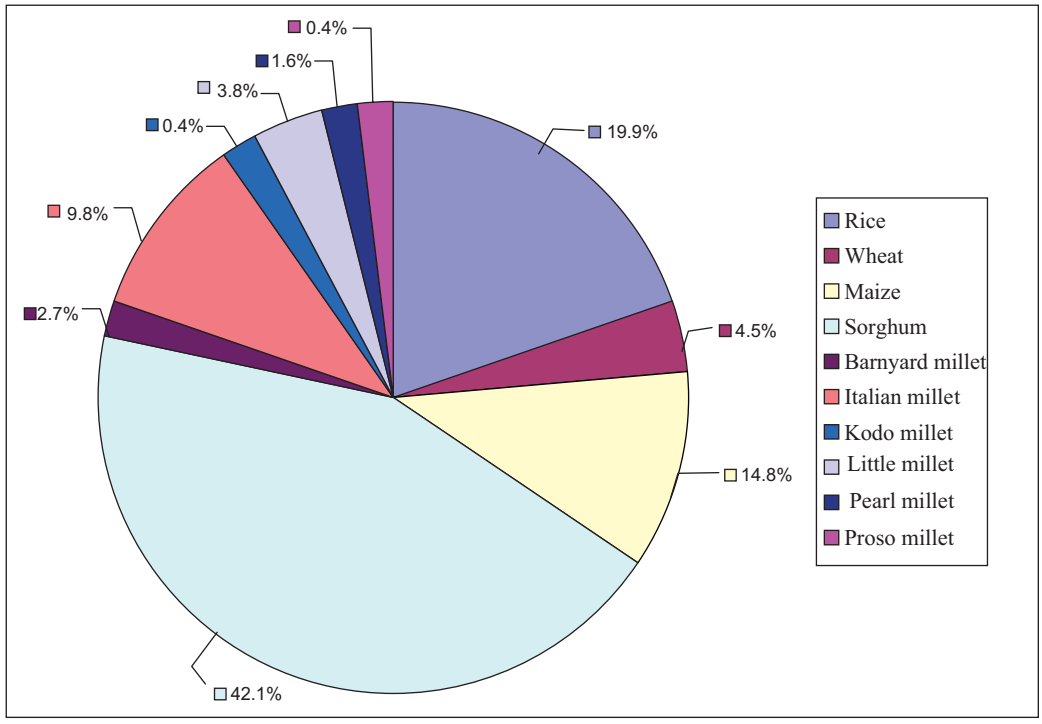

Fig. 2. Diversity spectrum of collections made under cereals, millets and small millets from Adilabad, Andhra Pradesh

Table 3. Trends in on-farm sustainability of sorghum and rice landraces in Adilabad between 1988 and 2010-12 periods

Crop	Named landraces collected (No./Year(s))		Landraces collected in earlier missions salvaged during 2010-12 (No./Name)	Landraces could not be recollected (No.)	New landraces salvaged for the first time during 2010-12 (No.)
Sorghum	59 (1988 & 1992)	45 (2010-12)	16 *Kharif* (Rainy season): *Gundu jonna, Leha jonna, Pandimutte jonna, Parasa jonna, Tekedari jonna* *Rabi* (Post-rainy season): *Boda jonna, Chinnaboda jonna, Dhani jowar, Erra jonna, Mudda jonna, Pedda jonna, Pelala jonna, Pyru jonna, Rabi jonna, Tella jonna, Vayunowka jonna*	43	29
Rice	93 (1993)	18 (2010-12)	12 Budamavanji, Davaralvanji, Erra vadlu, Gowrani vadlu, Kakirekkala vadlu, Nalla vadlu, Pandrisadi, Pisodi vadlu, Polala vadlu, Ragalvanji, Regadi vadlu, Tella vadlu	81	6

(50.5%) followed by rice (20.6%) and maize (11.4%) among millets and cereals in the diversity share.

In Adilabad, significant landrace diversity was reported in cereals especially in rice (Pandravada and Sivaraj, 1996). In rice, maximum accessions (9) and maximum landraces (5) could be collected from Indravelly mandal. Most of the rice landrace contributors are Gonds. Variability was mainly observed for maturity duration (120 to 180 days), grain length (short to long), grain size (bold to slender), kernel colour (red/ white), husk color (shades of straw to black) and awn (absent/present) characters.

Of the 93 named rice landrace populations collected earlier during 1993 from the district by the authors (Pandravada and Sivaraj, 1996), only 12 are under continuous cultivation and maintained on-farm and all

Table 4. Matrix ranking of sorghum landraces based on farmer selection criteria

Landrace	Farmers' perception (Rank*)								
	Subsistence	Good initial establishment	Drought tolerance	Market value/ preference	Less bird damage	Fire wood	Earliness	Fodder value	Thatching value
Aragidi jonna	14	1	19	22	10	2	17	18	19
Badigi jonna	18	18	4	44	24	28	33	25	4
Boda jonna	4	19	1	24	31	11	28	30	1
Chikkati jonna	26	20	43	15	3	17	41	32	43
Chinna jonna	27	21	28	4	42	29	34	19	27
Chinnaboda jonna	28	2	41	28	18	43	12	42	41
Dambral	29	22	36	16	32	36	35	20	36
Darawat jonna	15	3	3	41	2	37	36	38	3
Deyam jonna	30	23	29	43	43	9	27	34	29
Dhane jowar	31	32	20	21	27	26	10	5	20
Erra jonna	11	45	12	23	25	41	3	45	12
Gadda jonna	13	4	15	10	41	35	45	35	14
Gundu jonna	19	24	30	17	30	15	29	39	30
Gunjidi jonna	32	25	27	5	21	44	16	21	28
Gunjidipedda jonna	34	26	38	30	4	45	5	43	38
Guvvi jonna	35	5	21	20	11	12	40	22	22
Jalleda jonna	36	30	10	38	6	6	26	17	11
Kathani jonna	20	27	5	39	14	1	24	11	5
Konkadala jonna	12	28	9	11	22	27	42	33	9
Leha jonna	3	29	11	37	38	5	25	16	10
Mudda jonna	21	31	17	8	33	32	22	1	17
Pachchaboda jonna	22	33	8	12	34	7	19	24	8
Palajonna	37	42	44	26	17	20	14	41	45
Pandari jonna	6	34	42	27	7	42	1	27	42
Pandimutte jonna	38	6	2	40	1	3	43	12	2
Parasa jonna	23	7	26	6	35	18	30	2	26
Pasupu jonna	17	35	14	35	8	38	6	36	15
Pasupupachcha jonna	39	36	13	36	9	39	7	37	16
Pedda jonna	8	8	35	1	20	40	11	23	35
Pelala jonna	7	9	39	45	44	8	8	44	39
Potiki jonna	45	37	7	13	19	31	39	15	7
Purabodaka jonna	41	38	33	32	23	22	38	28	34
Pyru jonna	16	39	22	7	39	14	44	3	21
Rabi jonna	1	10	24	18	28	23	31	6	23
Sanna jonna	42	11	23	19	29	24	32	7	24
Sevata jonna	2	12	16	9	40	16	23	10	13
Sivira jonna	10	13	25	33	12	34	2	8	25
Talki jonna	43	14	31	3	36	30	15	4	31
Tekedari jonna	24	40	40	29	26	33	4	26	40
Tella jonna	5	41	45	25	16	19	13	40	44
Tellaboda jonna	25	15	18	34	15	4	18	9	18
Varagadi jonna	44	43	37	31	13	13	20	31	37
Vayunowka jonna	9	16	34	42	5	25	9	14	33
Vubiripatti jonna	33	44	32	2	45	10	37	13	32
Vullipitta jonna	40	17	6	14	37	21	21	29	6

**1- Most important; 45- Least important*

other 81 remaining landrace populations are replaced and no longer under cultivation. Rice landraces, *Budamavanji, Davaralvanji, Erra vadlu, Gowrani vadlu, Kakirekkala vadlu, Nalla vadlu, Pandrisadi, Pisodi vadlu, Polala vadlu, Ragalvanji, Regadi vadlu* and *Tella vadlu* are the ones under continuous cultivation since 1993. However, six new landraces (*Akasavai vadlu, Chittimutyalu, Chittiporu, Dasara vadlu, Pandadivanji* and *Puraval*) could be sampled for the first time during these biodiversity surveys which were not recorded and collected earlier (Table 3) due to intensive surveying in remote tribal pockets.

Interaction with the farmers yielded startling feed back with respect to sustained cultivation of these landraces the main premise being dependability under adverse situations in niche environments, the traits include good early plant vigour, good tillering ability, tall plant stature, earliness, reasonable panicle and grain length, good seed weight and assured yield levels. All these landraces, in addition to the above stated characters, also have good biomass suitable for straw for feeding the cattle in the backyards.

In maize, maximum accessions were collected from Kerameri (7) mandal and maximum landraces from Vemanpally (3) mandal. Of the 10 named landraces sampled, most of them were contributed by the Gond tribe and good diversity was observed mainly in plant, cob and grain characters. Not much diversity was observed in wheat landraces except for grain colour and size, and a total of three named landraces could be sampled which were not collected earlier.

Millets are small-seeded grasses that are hardy and grow well as rain-fed crops under marginal conditions of soil fertility and moisture in the surveyed district. A total of 188 accessions belonging to 45 named landraces, maintained by various tribal communities, were collected and documented in sorghum recording the highest named landrace diversity from the district. Maximum accessions were collected from Kerameri (17) mandal and maximum landraces from Tiryani mandal (9). High variability exists among the landraces for plant height, flowering, maturity, panicle size/ shape/ compactness, glume colour, glume covering, grain colour and grain size.

The landraces are a rich reservoir of diversity and valuable source for quality traits, resistance to diseases and pests and also to drought, high temperatures and other vagaries of climate change (Sivaraj *et al*., 2012). Of the cumulative 59 named sorghum landraces collected during 1988 (Pandravada and Gopal Reddy, 1988) and 1992 (Pandravada, 1992) from the district only 16 (*Kharif: Gundu jonna, Leha jonna, Pandimutte jonna, Parasa jonna, Tekedari jonna*; *Rabi*: *Boda jonna, Chinnaboda jonna, Dhani jowar, Erra jonna, Mudda jonna, Pedda jonna, Pelala jonna, Pyru jonna, Rabi jonna, Tella jonna, Vayunowka jonna*), mostly the *rabi* (winter season) cultivars could be salvaged from the present surveys and all other remaining populations eroded and are no longer cultivated and maintained on-farm (Table 3). However, 29 new landraces (*Aragidi jonna, Badigi jonna, Chikkati jonna, Chinna jonna, Dambral, Darawat jonna, Deyam jonna, Gadda jonna, Gunjidi jonna, Gunjidipedda jonna, Guvvi jonna, Jalleda jonna, Kathani jonna, Konkadala jonna, Mudda jonna, Pachchaboda jonna, Pala jonna, Pandari jonna, Pasupu jonna, Pasupupachcha jonna, Potiki jonna, Purabodaka jonna, Sanna jonna, Sevata jonna, Sivira jonna, Tellaboda jonna, Varagadi jonna, Vubiripatti jonna* and *Vullipitta jonna*) surfaced for the first time during the biodiversity surveys which were not recorded and collected earlier due to intensive combing of ethnic pockets.

The ranking of sorghum landraces of Adilabad based on utility perception by ethnic farmers which has a bearing on their on-farm sustainability is given in Table 4. Out of the nine utility traits listed, landrace *rabi jonna* was ranked number one for subsistence, *aragidi jonna* for good initial establishment, *boda jonna* for drought tolerance, *pedda jonna* for market value/ preference, *pandimutte jonna* for less bird damage, *kathani jonna* for fire wood, *pandari jonna* for earliness, *mudda jonna* for fodder value and *boda jonna* for thatching value. Among the landraces which were ranked as number one for different traits, *boda jonna, pandimutte jonna* and *pedda jonna* were in continuous cultivation since 1988 and incidentally *boda jonna* was ranked number one for two traits *i.e.* drought tolerance and thatching value. The desired traits from farmer perspective leading to continuous cultivation of landraces of sorghum include good initial plant vigour, medium tall plant habit, juicy stems, late maturity, medium grain size and semi-compact medium panicles, the characters of which are best suited for cultivation under *rabi* season under rainfed situations majority of landraces belong to.

In pearl millet even though local diversity exists, there are no endemic named landraces that could be collected.

In small millets endemic variability occurs especially in Italian millet and little millet and maximum accessions were collected from Utnoor (9) mandal. A total of nine named landraces in Italian millet and three in little millet could be sampled during the agri-biodiversity surveys undertaken in the district. Conspicuously, in barnyard millet, proso millet and kodo millet, no named landrace could be collected. Most of the small millet crops and their landraces are being replaced at an alarming rate and in due course of time they may become extinct.

Discussion

Maintenance of diversity for long term ecological balance and agricultural sustainability is primarily based on agro-climatic conditions, assured market and economic viability of farming. Under tremendous agricultural intensification pressures, the scope for on-farm conservation of different crops and their landrace diversity directly depends upon continuity of rituals/ customs/traditions/cultural practices and also their *sinequa-non* role in the livelihood/nutritional security of the ethnic groups only. Gradual decline in the cultivation of landraces on-farm resulting in genetic erosion in different parts of the world was reported by several workers. Hammer *et al*. (1996) reported the down trend in many crops in Albania and southern Italy, Peroni and Hanazaki (2002) and Willemen *et al*. (2007) in cassava in Brazil and Peru respectively, Gai *et al*. (2005) in soybean in China, Teklu and Hammer (2006) in tetraploid wheat and Mekbib (2008) in sorghum in Ethiopia.

Adilabad is a rich abode and a treasure trove for ethnic diversity in different cereal and millet crops which is a vibrant and indispensable component in the overall conservation strategies. However, bio-edaphic factors, population pressure and socio-economic policies especially the subsidized rice scheme transformed the hitherto subsistence farming being practiced by the tribal groups in to commercial farming looking for remuneration and profits in cultivation as they were getting rice at a very cheap rate for consumption. This has resulted in unforeseen changes in the cropping systems and replacement of traditional crops like sorghum, pearl millet and small millets with other profitable new crops (Bt cotton and soybean etc.) thereby losing the diversity in those crops (Pandravada *et al*., 2004).

The genetic erosion is more visible in case of rice with the replacement of 81 landraces (87.1%) with improved varieties having fine grains the cultivars of which people prefer for consumption due to changed food habits. However, in case of sorghum, the genetic erosion with the replacement of 43 landraces (72.9%) is comparatively low as the farmers grow the crop mostly during the *rabi* season as major staple for their own consumption, the quality of the landraces being much superior over improved varieties/ hybrids.

The inventory of landrace populations, as a case study of cereals and millets, of the tribal district of Adilabad, Andhra Pradesh raises several issues with regards to conservation *ex-situ* and management on-farm of crop landrace diversity. Large scale abandonment of traditional landraces calls for systematic combing of all diversity rich areas so that important diversity is collected and safely conserved *ex-situ* in gene banks before lost from production systems.

Further, as climate change is leading to the erosion of world's biological diversity, severe implications are predicted in agriculture and food supply notably in subsistence farming. As a consequence, a two-pronged strategy for mitigation and adaptation to climate change is advocated. Agro-biodiversity plays a key role in this and calls for a revision of the present conservation approaches. Instead of *ex-situ* conservation in gene banks a broader concept needs to be envisaged through which emphasis is on *in-situ* on-farm conservation complemented by gene banks. It has two-fold advantage, as the future needs are unknown, maximum genetic resources could be conserved at the lowest possible public cost and as the genetic resources get exposed to environmental changes, well adapted material gets evolved instead of being stored in a gene bank. In their study of rice landraces from Uttarakhand Himalayas, Kumar *et al*. (2010) reported greater number of alleles/ locus in on-farm conserved populations as compared to the ones under static management (Genebanks). However, climate change induced environmental stress may in fact go beyond the reach of adaptation and *in-situ* on-farm approach offers a great chance to shape a future worth living (Kotschi, 2006). On-farm conservation, however, cannot be made a system-wide approach in general but can be taken up as an approach at selected target sites.

All the above referred landraces are being conserved in the Medium Term Storage (MTS) facility at the ICAR-National Bureau of Plant Genetic Resources (ICAR-NBPGR), Regional Station, Hyderabad for posterity and present utilization of germplasm by breeders and

other researchers. Further, systematic characterization of landrace populations collected earlier and stored *ex-situ* in National Genebank at NBPGR, New Delhi and the present landraces being maintained on-farm needs to be investigated for loss of diversity over time and space at genetic (allele/genotype) level so that precise documentation of level of genetic diversity still maintained by farmers in traditional production systems could be assessed. The findings could also help optimize the number of populations of a particular named landrace to be collected and conserved *ex-situ* in gene banks, which is a capital intensive exercise. The research findings would also help suggest PGR researchers the need of periodic sampling of landrace populations as farmers deliberately introduce new diversity in production systems through informal seed exchange.

Acknowledgements

The authors thankfully acknowledge the financial support through GEF for the NAIP Project "Harmonizing biodiversity conservation and agricultural intensification through integration of plant, animal and fish genetic resources for livelihood security in fragile ecosystems" which facilitated taking up the present study in the Adilabad district of Andhra Pradesh. The authors also acknowledge the tribal farmers belonging to *Andh, Gond, Kolam, Koya, Lambada, Manne, Nayakpod, Pardhan* and *Porja* groups for liberally sparing samples of their landraces and indigenous traditional knowledge.

References

Anonymous ((2004-2005) *Handbook of Statistics Adilabad District*. Chief Planning Officer, Adilabad, pp 1-162.

Astley D (1991) Exploration: Methods and problems of exploration and field collecting. *Biol. J. Linn. Soc.* **43:** 11-22.

Bajracharya J, RB Rana, D Gauchan, BR Sthapit, DI Jarvis and JR Witcombe (2010) Rice landrace diversity in Nepal. Socio-economic and ecological factors determining rice landrace diversity in three agro-ecozones of Nepal based on farm surveys. *Genet. Resour. Crop Evol.* **57:** 1013-1022.

Bennett E (1970) Tactics of plant exploration. *In:* OH Frankel and E Bennett (eds.) *Genetic Resources in Plants – Their Exploration and Conservation*. IBP Handbook No. 11, F.A.Davis Co., Philadelphia, pp 157-179.

Bezancon G, JL Pham, M Deu, Y Vigouroux, F Sagnard, C Mariac, I Kapran, A Mamadou, B Gerard, J Ndjeunga and J Chantereau (2009) Changes in the diversity and geographic distribution of cultivated millet (*Pennisetum glaucum* (L.) R.Br.) and sorghum (*Sorghum bicolor* (L.) Moench) varieties in Niger between 1976 and 2003. *Genet. Resour. Crop Evol.* **56:** 223-236.

FAO (1999) Women: Users, preservers and managers of Agrobiodiversity. *www.fao.org/ FOCUS/ E/ Women/ Biodiv-e. htm*.

Gai J, T Zhao, D Xiong, H Li and Y Qian (2005) A sample survey on genetic erosion of soybean landraces in China. Paper presented at the expert consultation on genetic erosion, methodologies and indicators. ICRISAT, Patancheru, India, pp 19-21.

Hammer K, H Knü pffer, L Xhuveli and P Perrino (1996) Estimating genetic erosion in landraces – two cases studies. *Genet. Resour. Crop Evol.* **43**: 329-336.

Kotschi Johannes (2006) Coping with Climate Change and the Role of Agrobiodiversity**.** Conference on International Agricultural Research for Development, Tropentag, University of Bonn, October 11-13.

Kumar S, IS Bisht and KV Bhat (2010) Population structure of rice (*Oryza sativa*) landraces under farmer management. *Ann. Appl. Biol.* **156**: 137-146.

Mekbib F (2008) Genetic erosion of sorghum (*Sorghum bicolor* (L.) Moench) in the centre of diversity, Ethiopia. *Genet. Resour. Crop Evol*. **55**: 351–364.

Pandravada SR (1992) Survey report on *rabi* sorghum germplasm collection mission undertaken during February/March, 1992 in Telangana region of Andhra Pradesh. NBPGR Regional Station, Rajendranagar, Hyderabad, India.

Pandravada SR and V Gopal Reddy (1988) Survey report on *kharif* sorghum germplasm collection mission undertaken in collaboration with ICRISAT during November, 1988 in Adilabad district, Andhra Pradesh. NBPGR Regional Station, Rajendranagar, Hyderabad, India.

Pandravada SR and N Sivaraj (1996) Collection of Rice germplasm from Adilabad district, Andhra Pradesh, India. *Indian J. Pl. Genet. Resour*. **9**: 255-260.

Pandravada SR, N Sivaraj and KS Varaprasad (2004) The changing pattern of plant biodiversity in the Eastern Ghats. *In:* BS Dhillon, RK Tyagi, Arjun Lal and S Saxena (eds.) *Plant Genetic Resource Management*, New Delhi, pp 136-152.

Pandravada SR, N Sivaraj , N Sunil, R Jairam, SK Chakrabarty, P Ramesh, SN Jadhav, IS Bisht and KC Bansal (2011) NAIP Brochure on Adilabad, Andhra Pradesh. National Bureau of Plant Genetic Resources, Regional Station, Rajendranagar, Hyderabad, Andhra Pradesh, pp 1-4.

Peroni N and N Hanazaki (2002) Current and lost diversity of cultivated varieties, especially cassava, under swidden cultivation systems in the Brazilian Atlantic Forest. *Agr. Ecosyst. Environ.* **92**: 171-183.

Sivaraj N, SR Pandravada, N Sunil, R Jairam, SK Chakrabarty, IS Bisht and KC Bansal (2012) Sorghum landrace diversity of Adilabad. National Bureau of Plant Genetic Resources, Regional Station, Rajendranagar, Hyderabad, Andhra Pradesh, pp 1-8.

Teklu Y and K Hammer (2006) Farmers' perception and genetic erosion of tetraploid wheat landraces in Ethiopia. *Genet. Resour. Crop Evol.* **53:** 1099-1113.

Thrupp LA (1997) Linking biodiversity and agriculture: Challenges and opportunities for sustainable food security. World Resources Institute, USA.

Willemen L, X Scheldeman, V Soto Cabellos, S Rafael Salazar and L Guarino (2007) Spatial patterns of diversity and genetic erosion of traditional cassava (*Manihot esculenta* Crantz) in the Peruvian Amazon: an evaluation of socio-economic and environmental indicators. *Genet. Resour. Crop Evol*. **54:** 1599-1612.