Original Research Article

Significance Of Mixed-Cropping In Jhum Based Traditional Agroforestry In Tirap And Longding District Of Arunachal Pradesh, India

Tonlong Wangpan and Sumpam Tangjang*

Department of Botany, Rajiv Gandhi University, Rono Hills, Doimukh 791112, Arunachal Pradesh, India

***Corresponding Author:** Sumpam@gmail.com

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Abstract: *Jhum* based traditional agro-forestry is considered to be a key element of farming system with the potential for sustainability and improved livelihoods among the indigenous *Noctes* and *Wancho*s. The multi-cropping is prominent and a general rule offering opportunities for the cultivation of a wide variety of local crops including cereals, millets, vegetables, oilseeds and tuber crops. Owing to its rich biodiversity and availability of vast plant resources, including crop diversities in this region, it becomes necessary to collect and records the valuable resources before this traditional system disappears from its very existence. During the survey and exploration trip the *Jhum* fields of 28 remote hamlets were visited to collect local landraces and traditional varieties of all major crops and vegetables of agricultural as well as horticultural importance. A total of 140 plant species are being intercropped, maintained and conserved by indigenous farmers actively involved in *jhumming*. Among the collected crop materials, germplasm of *Oryza sativa* L., Millets, *Colacasia esculanta* L., *Capsicum annuum* L. and *Dioscorea esculenta* (Lour.) Burk showed a wide range of variability. There is an immediate requirement of well designed, integrated strategy of production, processing and marketing to excite the full potential of these crops particularly with reference to their contribution to food self-sufficiency.

Key words: *Jhum*, Indigenous knowledge, Mixed-cropping

Introduction

Arunachal Pradesh has 26 major tribes and 110 sub-tribes that are well-known for its wealth of traditional ecological knowledge (Murtem, 2000; Tag *et al.,* 2005). It has been identified as one of the "hotspot" in the world (Myers *et al*., 2000). With 68,757 sq km under forest cover it has rich floral and faunal diversity due to its physiography, altitude variation (150 to 6500 meters) and climatic conditions (Bhuyan, 1999). Agriculture as primary occupation the natives of this region are actively involved in *jhumming,* the very prominent type of agriculture in hilly terrains where the farmers transform forests into a mosaic of rural landscapes (Tangjang, 2009). This farming practice is considered to be a key element of farming portfolios with the potential for sustainable development and enhanced livelihoods among the rural poor (Toledo *et al.* 2003). Without disturbing the chemical properties of soil, *jhumming* also shows an effective form of land use as they use limited space for optimum production in a specific time (Das and Das, 2014).

The farming communities have a vast store of local knowledge about their particular landscape and how best to maintain it for survival (Kerkhoff and Sharma, 2006). The mix-cropping is very prominent and a general rule in slash-and-burn agriculture that offers scope and a foundation for the cultivation of a wide variety of local agricultural crops including cereals, pseudo cereals, millets, vegetables and tuber crops (Wangpan and Tangjang, 2012).

Owing to its rich biodiversity and availability of vast plant resources, including crop diversities in this region, it was necessary to collect and records the valuable resources before this traditional system disappears from its existence. Moreover, indigenous crops are on the fringe of extinction and require immediate attention (Seburanga, 2013). Thus, the attempt was made to collect plants from remote and unexplored areas. More emphasis was given to underutilized plants, endemic plant species, rare and endangered economic plants, primitive cultivars, landraces and absolute varieties if available. An extensive exploration was designed with an objective to collect the local landraces of crop plants. The basic purpose was to collect the materials in the form of either vegetative or seed materials and to identify useful traits/genes that may contribute in crop improvement and simultaneously to make an assessment of genetic erosion.

Materials and methods

Study sites

Tirap District is situated within the periphery of the Patkai range of Himalaya. The district lies between 27° 132 N and 27° 242 N latitudes and 95° 202 E and 95° 402 E longitudes

Fig.1. Map of Study area.

and becomes independent district in 1980 (Bose, 1997). On the other hand, Longding District is situated between 27° 012 N and 27° 132 N latitude and 95 ° 16' E to 95 ° 20' E longitude. Tirap district is bounded by Changlang District of Arunachal Pradesh towards the East, Longding District towards the West, Assam towards the North and Myanmar in the South. Longding district is bounded by the Tirap District of Arunachal Pradesh towards the East, Nagaland towards the West, Assam towards the North and Myanmar in the South. Tirap district is inhabited by the *Noctes* and the *Tutsas* while the Longding district is inhabited by the *Wanchos*.

All these indigenous tribes belong to the Indo-Mongoloid ethnic group while their local dialects are believed to be Indo-Burman origin. Occupying a distinct geographical area these tribes bears rich social norms, customs, beliefs, faiths and practices. In the past, they were actively engaged in headhunting practices; true follower of animism and the society was filled with myths, superstitions, tattoo customs and rituals. Nevertheless, due to modernization, these people have been positively influenced by Christian missionaries and modern education leading to permanent shunning away of headhunting practice and rituals became concentrated to major festivals and events only. The society is traditionally governed by the council of chieftains where the King is the Head of the Council. Approximate elevation of the districts ranges from 200 MSL (in the foothills) to 4000 MSL (in mountains). The Patkai Range coinciding with both the districts has the surface build on Disang, Baruil, Tipam and Dining series of Tertiary sediments (Sharma and Shukla, 1992). The major river in this area is the Chatzo, also known as the river Namsang. It flows down with its tributary Namchuchang and joins the Dihing River at Namsang mukh, the confluence of the Assam-Arunachal boundary. The Tissa, Tissing, Tirat and Dirok are other important rivers flowing down to Assam.

Ethnobotanical Survey and analysis

The ethnobotanic survey was carried out in 27 remote hamlets (Khonsa, Kheti, Lapnan, Runu, Wakka, Pongchau, Longo, Kapu, Chanu, Mingtong, Bera, Tupi, Bunting, Khela, Senua, Zedua, Niausa, Niaunu, Bonya, Longphong, Longkai, Ngissa, Nginu Khanu, Khasa, Konnu, Konsa and adjoining areas) following methods of Rao and Jain (1967). The villages such as Bera, Bunting, Kapu, Kheti, Khonsa, Lapnan, Longo and Tupi falls under Nocte inhabited areas and the rest of the village falls under Wanchos. The *Jhum* fields of hilly terrains were visited in order to collect local landraces and traditional varieties of all major crops and vegetables of agricultural as

Table 1. Accessions of various Plants collected from jhum plots

Crop Groups	Crops	Local name	No. of Accession	Total Accessions
Cereals	Oryza Sativa L.	*Chah*	40	**42**
	Maize	*Sowang, Pu, Pungwong*	02	
Millets	Millets	*Hikha, Semui, Hami*	15	**15**
Oil seeds	*Sesamum indicum* L.		01	**2**
	Perilla frutescense Var	*Nam*	01	
Grain legumes	*Phaseolus vulgaris* L.	*Philo*	04	**10**
	Vigna unguiculata (L.) Walp	*Longphi, Phisi*	01	
	Glycine max (L.) merr.	*Phikam, Phidong*	02	
	Vigna umbellata (Thunb.Ohwi & Ohashi)	*Phinu*	01	
	Psophocarpus tetragonolobus (L.) D.C.	*Platzi*	01	
	Lablab purpureus (L.) Sweet	*Plat(Philap)*	01	
Vegetables	*Cucurbita mosschata* Dutch ex poir	*Manlong, Goomkey, Goomchak*	03	**21**
	Benincasa hipsida (Thunb.) Cogn	*Waw, Goomphom*	03	
	Momordica charantia L.	*Soikhah*	01	
	Lagneria siceraria (Molina) Standl.	*Wumkoak, Goomlak*	01	
	Solanum melangena L.	*Anthaw, Banthoi*	01	
	Solanum lycopersicum L	*Soisik*	02	
	Solanum torvum Sw.	*Kamkhah*	01	
	Solanum indicum L.	*Kamkhah-khahsa*	01	
	Solanum nigrum L.	*Kamkhah*	01	
	Solanum kurzii Brace *ex* Prain	*Kamkhah-khahnu*	01	
	Cucumis sativus L.	*Chinkaam*	01	
	Brassica oleracea L.	*Soinak Jukang-kangnyak*	01	
	Brassica nigra L.	*Soitho, Jukang*	01	
	Plantago major L.	*Woondak*	01	
	Spilanthes paniculata Wall.	*Soi bu*	01	
	Clerodendrum viscosum Vent.	*Mangmik*	01	
Tuber/root crops	*Colocasia esculenta* L.	*Toa, Tu, Tudak*	14	**31**
	Dioscorea esculenta	*Khan, Hahkhoan*	09	
	Dioscorea bulbifera L.	*Poi*	01	
	Dioscorea allata L.	*Khalak*	01	
	Manihot esculenta Crantz.	*Pankhan, Bang*	03	
	Ipomea batatas (L.) Lam	*Sokhan, Luhahkhoan*	03	
Spices	*Capsicum annuum* L.	*Hing, Hinri, Richit*	07	**18**
	Zingiber officinale Rosc	*Chi, Chin*	02	
	Allium sativum L.	*Tehsa, Chitkat*	01	
	Coriandrum sativum L.	*Soingansa*	01	
	Amaranthus viridis	*Zamtong-bazaa, Balla*	01	
	Amaranthus spinosus	*Hingchi-bazaa*	01	
	Eryginum foetidum L.	*Soingan, Goomthoa*	01	
	Houttuynia cordata Thunb.	*Zanthuhing, Jobanhin*	01	
	Allium hookeri Thwaites,	*Tehnu, Risoan*	01	
	Zanthoxylum alatum Roxb.	*Chilip, Matkat*	01	
	Zanthoxylum rhetsa (Roxb.) DC	*Zuhnu, Charu*	01	
Sugarcane	Sugarcane	*Woido, Namthunku*	01	1
			Total	140

well as horticultural importance. Individual and selective sampling methods were adopted for horticultural crops and random sampling method adopted for other agricultural crops. The collection was made from farm stores, farmer's field, threshing yards and traditional local markets. For each collected germplasm, the necessary standard passport datasheet was filled and collected accession allotted with a collection number. The NBPGR descriptor for agri-horticultural crops (Mahajan *et al*., 2000) was used as a guideline for discriminating the variability in some of the collected germplasm. Moreover, PCA (Principle coordinate analysis) and cluster analysis of accessions were also performed using XLSTAT and STATISTICA software respectively.

Results

The plant specimens collected are shown in Table 1. The range of variability on cereal crops, tubers, legumes, vegetables and spices has also been recorded as remarkable variation was observed within the genotypes. A wide range of diversity was observed in collecting germplasm which is discussed as follows:

Cereals

Paddy (*Oryza sativa* L.)

Total 40 accession of upland rice were collected during the survey. The traditional nomenclature was followed and the varieties' names in the local dialect often reflect the rice's appearance and characters. For instances, chahtho (chah=rice;

Table 2. Grain parameters of Indigenous rice varieties (GL: Grain Length; GW: Grain width; Gwt: Grain weight; SLL: Sterile lemma length; KL: Kernel length; KB: Kernel breadth; KL: Kernel thickness)

Name of Local variety	GL(mm)	GW(mm)	1000 GWt (g)	SLL(mm)	KL(mm)	KW(mm)	KT(mm)
Aaosah	7.02±0.14	3.3±0.02	20.76±0.5	1.68±0.05	5.22±0.11	2.99±0.03	2.17±0.01
aratlisa	8.52±0.19	2.63±0.09	22.78±0.42	2.16±0.13	5.85±0.16	2.1±0.03	1.62±0.03
aratratnu	8.99±0.22	2.99±0.12	27.7±0.28	2.13±0.02	6.38±0.08	2.46±0.12	1.85±0.04
champo	6.21±0.16	3.03±0.06	16.94±0.33	1.73±0.13	4.22±0.05	2.89±0.26	1.78±0.02
chahchia	6.11±0.21	2.72±0.04	13.63±0.15	1.9±0.06	4.37±0.06	2.33±0.05	1.42±0.04
chahchiang	6.24±0.15	2.81±0.12	14.76±0.1	1.82±0.1	4.35±0.10	2.42±0.07	1.7±0.10
Chhaggo	6.59±0.11	3.5±0.1	21.73±0.13	1.39±0.03	4.55±0.03	2.99±0.08	1.97±0.03
Chahlo	6.84±0.16	2.96±0.06	19.76±0.14	2.34±0.13	4.95±0.14	2.59±0.04	1.79±0.05
chahmai	6.7±0.1	2.76±0.06	16.84±0.09	2.31±0.04	4.62±0.07	2.21±0.11	1.54±0.05
chahnu	5.71±0.05	3.37±0.04	17.86±0.58	1.87±0.06	4.32±0.13	2.08±0.03	1.7±0.10
Chahsa	5.61±0.31	2.87±0.07	17.44±1.75	2.2±0.05	3.82±0.04	2.56±0.07	1.52±0.07
chahtam	6.63±0.31	3.2±0.07	19.96±2	2.27±0.04	4.84±0.09	2.9±0.15	1.97±0.02
chahyong	6.11±0.09	3.55±0.03	21.86±0.26	1.85±0.13	4.43±0.08	3.1±0.05	1.9±0.07
chahzaa	6.48±0.13	3.49±0.07	23±0.84	20±.044.	75±0.11	2.99±0.08	2.06±0.03
chamchak	6.79±0.1	3.62±0.03	16.28±0.25	2.43±0.09	4.47±0.14	3.09±0.09	1.99±0.10
Champo-W	5.85±0.21	3.32±0.08	17.26±0.35	1.32±0.07	4.1±0.25	2.69±0.22	1.88±0.05
Lailo	7.45±0.09	2.87±0.06	18.31±0.44	2.32±0.21	4.88±0.11	4.88±0.11	1.72±0.03
Longri	8.01±0.22	3±0.09	22.62±0.76	2.81±0.06	5.71±0.25	2.61±0.06	1.82±0.06
Lozon	5.81±0.16	3.01±0.05	16.95±0.29	2.19±0.05	3.77±0.06	2.58±0.11	1.76±0.04
Maichong	8.74±0.06	2.67±0.06	16.29±0.27	2.04±0.05	6.12±0.13	2.28±0.08	1.69±0.06
Maijah	7.02±0.07	3.14±0.05	22.12±0.26	2.34±0.2	4.79±0.11	2.79±0.05	1.85±0.04
Osusah	6.5±0.23	3.17±0.13	23.17±0.23	2.18±0.17	4.71±0.09	2.82±0.06	1.93±0.02
Patam	6.1±0.15	3.23±0.12	18.03±0.37	2.29±0.06	4.03±0.09	2.93±0.05	1.91±0.06
Phanu	7.17±0.08	2.92±0.03	19.28±0.23	2.04±0.1	5.12±0.09	2.48±0.03	1.65±0.02
Phihsa	6.13±0.17	3.39±0.09	22.69±0.37	1.48±0.1	4.64±0.09	3.23±0.02	2.16±0.04
Sahtho	6.79±0.08	3.62±0.12	25.18±0.2	2.14±0.19	4.37±0.13	3.13±0.02	2.06±0.03
Sahkhee	7.4±0.16	2.86±0.07	20.01±0.16	2.04±0.05	5.21±0.07	2.4±0.04	1.73±0.02
saulingnu	8.22±0.22	2.57±0.09	23.42±0.28	1.99±0.16	5.87±0.09	2.24±0.09	1.64±0.02
Semoi	6.13±0.24	2.99±0.09	15.07±0.36	2.11±0.14	4.2±0.11	2.51±0.02	1.77±0.05
Senai	7.25±0.14	3.33±0.11	24.5±0.32	2.37±0.04	5.16±0.16	2.88±0.04	1.78±0.08
taigo	6.78±0.22	3.39±0.07	17.09±1.54	2.22±0.19	4.61±0.13	2.92±0.05	1.96±0.03
thho	7.1±0.11	3.62±0.04	24.55±0.29	2.53±0.08	4.64±0.12	3.14±0.04	1.99±0.05
Toinu	6.57±0.16	3.48±0.09	24.61±0.15	2.34±0.21	4.58±0.11	2.82±0.02	1.8±0.06
Toisa	6.1±0.14	2.91±0.1	14.86±0.29	2.43±0.14	4.08±0.09	2.67±0.05	1.74±0.10
zaamkhee	6.34±0.17	3.19±0.15	17.08±0.64	2.09±0.05	4.24±0.08	2.6±0.12	2.1±0.18
zaamlo	7.36±0.14	2.91±0.08	15.6±0.15	2.48±0.17	5.15±0.06	2.3±0.03	1.67±0.03
Zaamnu	7.7±0.07	3.68±0.1	24.43±0.83	2.15±0.16	5.05±0.03	2.94±0.03	2.08±0.03
zaamsa	7.16±0.17	2.98±0.12	18.61±0.21	2.18±0.03	4.85±0.21	2.42±0.1	1.98±0.1
Zaamzan	7.52±0.12	3.62±0.03	28.69±0.42	2.25±0.08	5.04±0.13	2.98±0.07	2.07±0.07
Zungnu	6.3±0.11	3.12±0.11	21.07±0.39	1.74±0.04	4.47±0.13	2.76±0.03	1.83±0.06

tho=white), sahkhee (sah=rice; khee=red), chahmai (chah=rice; mai=good), zungnak (nak=black), zaamlo (zaam=glutineous rice; lo=long), maichong (good and healthy) etc. The major traditional rice landrace collected during the trip are *Aaosah, Aratlisa, Aratratnu, Champo, Chahchia, Chahchiang, Chhaggo, Chahlo, Chahmai, Chahnu, Chahsa, Chahtam, Chahyong, Chahzaa, Chamchak, Champo-W, Lailo, Longri, Lozon, Maichong, Maijah, Osusah, Patam, Phanu, Phihsa, Sahtho, Sahkhee, Saulingnu, Semoi, Senai, Taigo, Thho, Toinu, Toisa, Zaamkhee, Zaamlo, Zaamnu, Zaamsa, Zaamzaan and Zungnu*.

Their shape ranges from long (long and slender kernel i.e. four to five times longer than its width), medium grain (shorter and wider kernel i.e. two to three times longer than its width), short grain (short, plump, almost round kernel). Diversity in paddy was recorded on the basis of present/ absent of awing, husk colour, kernel colour, type of species, grain length (mm), grain diameter (mm) and 1000-seed weight (g). Most of the paddy accessions belong to *japonica* type whereas only few are *indica* which was recorded using phenol reaction (Chang and Bardenas, 1965).

The detail quantitative characteristics of rice grains are portrayed in Table 2. *Aratratnu* was recorded with the maximum grain length as well as a kernel length of 8.99 (± 0.22) mm and 6.33 (± 008) mm, whereas *Chahsa* has a minimum grain length of 5.61 (± 0.31) mm. *Zaamnu* was observed with a maximum grain width of 3.68 (±0.1), whereas *Saulingnu* has minimum with 2.57(±0.09) mm. *Longri* was recorded with a maximum length of grains sterile lemma of 2.81(±0.06) mm, whereas *L-Champo* has minimum with 1.32 (±0.07) mm. Minimum kernel length was observed in *Lozon* (3.77 ± 0.06 mm). Maximum kernel thickness was observed in *Aaosah* (2.17 ±0.01) mm and minimum kernel thickness was observed in *Chahchia* (1.42 ± 0.04) mm.

According to 1000 grains weight the *Zaamzaan* was the heaviest with 28.69 (±0.42) gm, while *Chahchia* was recorded to be lighter with 13.63 (±0.15) gm among all other rice varieties. *Aratlisa* (with *2*.79 cm) was found with the highest value of length-to-wide ratio, whereas *Lailo* (with 1 cm) was recorded to have the lowest.

Table 4. Variation among rice accessions accounted for first four principle component

Parameters	F1	F2	F3	F4
GL	-0.4218	0.4592	-0.0305	0.1637
GW	0.5191	0.2770	0.0193	-0.3314
1000 GWt	0.0633	0.5641	-0.1335	-0.2084
SLL	-0.2088	0.1524	0.8772	-0.3681
KL	-0.4345	0.4363	-0.1941	0.1422
KB	0.3562	0.2098	0.3959	0.8073
KT	0.4351	0.3697	-0.1300	-0.1113
Eigenvalue	2.4830	2.3512	0.9669	0.6500
Variability (%)	35.47	33.58	13.81	9.28
Cumulative %	35.47	69.05	82.87	92.15

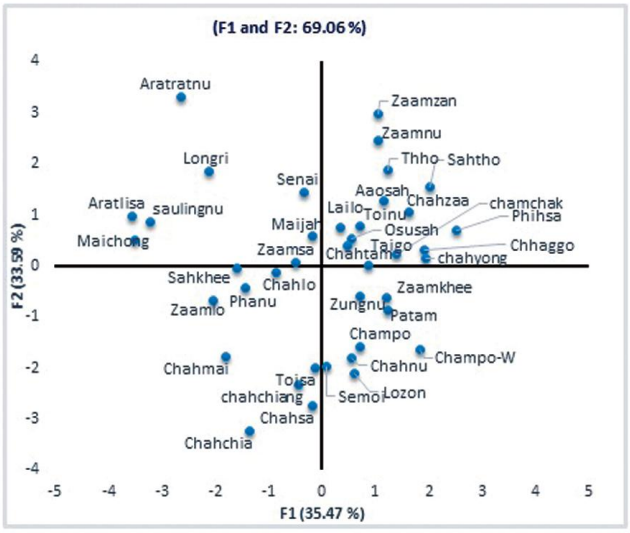

Fig.2. The score plot of PC1 (F 1) and PC2 (F 2) based on rice grain traits.

All the accessions of rice harbor a considerable range of morphological variation. The first principal component (F1) individually explained nearly 35.47 % of the total variation and the combination of component-1 (F1) and component-2 (F2) explained the 69.06 % of the total variation covered by all rice accessions (Table 4). Rice accessions of *Phihsa* of F1 axis and *Aratratnu* of F2 shows high positive scores, reflecting the highest contribution from Grain width, 1000 Grain weight, kernel breadth and Kernel thickness, while accessions of *Sahkhee, Zaamlo, Phanu, Toisa, Chahchiang, Chahsa and Chahchia* showed the comparatively low PC scores in both F1 and F2 component (Fig. 2) reflecting contributions from grain length, sterile lemma length and Kernel length (Table 2). Fig. 2 showed the plot obtained from the first two eigenvectors of the PCs analysis as they constitute a high variability. Furthermore, cluster analysis of all the rice

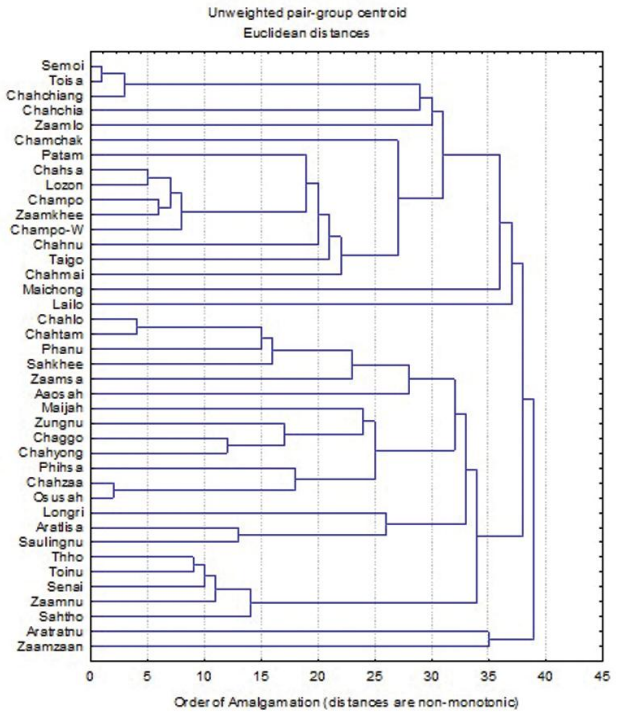

Fig. 3. Dendrogram: Variability among 40 rice accessions based on grain quantitative traits.

Table 3. Correlation matrix (Pearson): Grain traits of rice

Variables	GL	GW	1000 GWt	SLL	KL	KB	KT
GL	1	-0.2566	0.4580	0.3193	0.9474	-0.0835	-0.0306
GW	-0.2566	1	0.4562	-0.0855	-0.2912	0.4318	0.7689
1000 GWt	0.4580	0.4562	1	0.0876	0.4630	0.2055	0.4517
SLL	0.3193	-0.0855	0.0876	1	0.1886	0.0288	-0.1482
KL	0.9474	-0.2912	0.4630	0.1886	1	-0.1745	-0.0491
KB	-0.0835	0.4318	0.2055	0.0288	-0.1745	1	0.4278
KT	-0.0306	0.7689	0.4517	-0.1482	-0.0491	0.4278	1

Values in bold are different from 0 with a significance level alpha=0.05

accessions reveals 3 clusters at 4.56 minimum distance (Fig. 3). Numbers of rice accessions in these clusters were 16, 2 and122 in the cluster-I, cluster-II, cluster-III respectively. Rice accessions *Chahzaa* and *Osusah* from cluster-I and *Semoi* and *Toisa* from cluster-III respectively, were first formed into a group at minimum distance of 0.46 and 0.4 respectively. Therefore, these accessions can be considered as closest accessions among the tested ones in context of grain morphological traits. However, many of these traits also displayed significant relation (significance level alpha=0. 05) among them. 1000 grain weight was found with the highest level of significance in comparison to other traits (Table 3).

Varied qualitative characters were also displayed by rice accessions. Awn of 3 different colors, i.e. yellow, black and brown color was observed in four varieties (*Aaosah, Lailo, Chahnu*). Among them the variety *Chahnu* with 1.56 (± 0.01) cm possesses longest awn while *Lailo* with 0.2 cm was recorded with shortest awn. Some of the varieties like *Aaosah, Semoi, Toisa, Toinu, Chatam, Lozon, Patam, Chahlo* and *Champo* etc. bear aromatic properties with additional flavors while the varieties like *Zaamnu, Zaamlo, Zaamsa* and *Zaamkhee* are aromatic as well as sticky on cooking.

Maize (*Zea mays* L.)

Mostly two local landraces of maize is prominent in this region such as *Sowang jaamnu* and *Sowang jaamsa*. These accessions were collected in cob form. Morphological data recorded on cob length (cm), cob diameter (cm), number of kernel row, the number of seeds/row, kernel row arrangement, grain shape, grain size, seed color and 100-seed weight (g). Each collected accessions showed variability among the genotypes. The cob length of *Sowang jaamnu* and *Sowang jaamsa* was recorded to be 22.51 (± 0.34) cm and 11.7 (± 0.58) cm respectively. The cob diameter was recorded as 2.42 (±0.11) cm in *Sowang jaamsa* and 4.5 (± 0.07) cm in *Sowang jaamnu*. The number of kernel rows/cob was varied as 10.25 ± 0.03 (*Sowang jaamsa*) and 18.29 ± 0.04 (*Sowang jaamnu*). The number of seeds/ row was found to be 12.4 ± 0.07 (*Sowang jaamsa*) and 32.59 ±0.97 (*Sowang jaamnu*). The average 100-seed weight was recorded as 42.37 ±0.67 gm (*Sowang jaamnu*) 20.15 ±0.56 gm (*Sowang jaamsa*). The kernel color was found to be orange or brown (*Sowang jaamnu*) and yellow (*Sowang jaamsa*). Variation in kernel row arrangement was also observed as regular, irregular and straight in both cases. The grain size was recorded bold (*Sowang jaamnu*) and small (*Sowang jaamsa*). The grain shape was recorded as rounded and shrunken (*Sowang jaamnu*); and indented and pointed (*Sowang jaamnu*).

It is considered as the most important source of food in the region with high elevation that is not much favorable for paddy cultivation. The jhum fields of high altitude are dedicated to extensive cultivation of maize. However, it may be mixed farmed with Colacasia. It is considered as cost effective and can be stored for longer periods which thus

enhance the sustainability during dry periods. Interestingly, some of the villages, even incorporate maize in their daily diet as primary staple food in substitute to rice. Moreover, natives favor *Sowang-jaamsa* because of its taste and puffing property.

Millets

The climatic adaptability of these millets has allowed their spreading across different agro-ecological habitats. The natives inhabiting high altitude where the paddy cultivation does not prosper depends mostly on millets as a primary food source. Due to its natural hardiness communities have deliberately selected, manipulated them to adapt to diverse local physio-geographic condition of growth, and survival, which reflects in the great genetic variability among millets today.

Survey reveals 15 different varieties of millet. Their vernacular names are as follows: *Chela, Sanu, Basa, Honai, Tula, Goksa, Jam chahoap, Chah chak, Chhonu kolo, Hikha linu, Wowsoi, Aphom, Henai naitho, Chhaho* and *Henai nainak.* Millets are the pioneer crop to be cultivated and is considered to be an important source of food, fodder and beverage in this region. It is found to be cultivated by almost all farmers in the different *Wancho* village, but, the varieties used by them depend on the personal choice and availability of seed. Thus, the farmers had to keep its own reserve seed safe and must cultivate it in the next season to avoid loss of seed. Some of the *Wancho* villages like Khanu, Khasa, Konnu, Konsa etc., which are situated in higher elevation are pure cultivars of millet and maize. Thus, major cultivars of millet are inhabitants of the upper Wancho region and they keep relying on plants like millet, maize, tapioca, *Colocasia* and wild vegetables etc. for providing the primary source of food. Moreover, it was also observed that there is delaying of ripening of rice and millet with the increase in elevation of the study area.

Grain legumes

Legumes play a crucial role in the rural lifestyle, providing them with essential proteins and other nutrients in the diet. Moreover, the legume grains can be stored for a long time in both dried and fermented form. French bean (*Phaseolus vulgaris* L.), cowpea (*Vigna unguiculata* (L.) Walp.), soybean (*Glycine max* (L.) Merr.), rice bean (*Vigna umbellata* (Thunb.) Ohwi & Ohashi), winged bean (*Psophocarpus tetragonolobus* (L.) D.C.), and *Lablab purpureus* (L.) Sweets are most common and important legumes recorded from the *jhum* field of this region. However, two accessions of soybean and 4 accessions of French bean were collected. Both seeds and seed pods are edible on cooking, whereas *P. tetragonolobus* can be eaten raw in salad. The seeds of the legumes (soybean) are used for the preparation of fermented food. However, the sun-drying can extend the life of fermented beans and dried seeds.

Tubers

Tubers are one of the important staple foods in this region. For decades, it has played a very crucial role in rural sustenance and act as a secondary source of nutrition for ethnic people inhabiting these regions. Owing to its advantageous significance, such as durability, availability, easy propagation, flavorsome property and stress free management in the field; the tuberous plants play a very significant role in managing the scant harvest of cereals. Some of the important tubers are as follows:

1. Colocasia esculenta L.

The leaves, petioles, corms and cormels are edible (Thirugnanavel *et al.,* 2013) and are considered as a rich source of carbohydrates, starch, dry matter, minerals and vitamins (Bradburry and Holloway, 1998). 14 different indigenous accessions of Colacasia were collected from this region such as *Dhahliak, Asam, Tolosa, Tolonu, Totho zangcha, Shamlo, Baibo, Tolih, Tahdoh, Tomai, Ochak, Thanthak, Tonak* and *Phalang*. Among them, *Shamlo* is most popular among them considering its property such as unique flavor and takes less time to cook. While the accession, such as Tolih and Ochak are not much favored because of its flavor, cooking time and fibrous texture. Farmers usually differentiate between them with the help of its morphological features and flavor. The periderm was found to have black (*Tonak*), orange (*Tolosa* and *Baibo*), greenish brown (*Shamlo*) and brown (rest of accession) in color. However, on scratching of periderm of *Shamlo* the cortex appears pink in color. Ground tissue of underground stem possessed pinkish red (*Dahliak*), grey (*Tonak*) and Milky

(rest of accessions) color. Tubers are recorded to have different shapes such as flat (*Asam, Baibo*), oval, long (*Tolonu* and *Tolosa*) and round (remaining accessions). On comparing their morphological appearances, *Totho zangcha* was largest among them while *Tomai* was the smallest. *Thanthak* usually have 6-7 buds that differentiate it from others. Moreover, *Tonak* have dark green leaves when others are light green. Interestingly, in case of *Thotho zangcha*, farmers only prefers offsprings in their diet debarring its main stem.

2. Dioscorea

The inhabitants of these regions have been using *Dioscorea* as a source of food due to its high starch content and calorie value. Most species contain steroid saponins and also sapogenins, such as diosgenin (Dutta, 2015). Moreover, *Dioscorea* tuber was also recorded with anti-inflammatory properties (Olayemi and Ajaiyeoba, 2007). Three major species of *Dioscorea* are prominent in this region such as *Dioscorea esculenta* (Lour.) Burk, *Dioscorea allata* L. and *Dioscorea bulbifera* L.

Total 9 different accessions of *D. esculenta* were collected from this region such as *Khannu, Khanjiam, Kaikhan, Joankhan, Chahling khan, Khanmoat, Khansian, Onyi* and *Tingziat*. Their tuber size ranges from 10 cm (*Poi*) to 100 cm (Khannu). The color of the ground tissue was recorded as light-red (*Chahling khan* and *Joankhan*), yellowish (*Khanmoat*) and creamy white (remaining accession). *Joankhan* was recorded with lightest weight of 1 kg approx. while *Khannu* was heaviest with 7.5 kg. *Chahling khan* and *Khannu* was very popular among them owing to its flavor and cooking time. Most of them were actively cultivated in the *jhum* field with exception of *Khansian* and *Khanmoat* which were harvested directly from wild.

3. Manihot esculenta Crantz.

Cassava or *M esculenta* is considered an important tuber in this region because of its availability, durability and adaptability against high altitude and requirement of less maintenance in the field. Moreover, dried form of cassava can be stored for more than a year. It is the prime ingredient for the preparation of traditional beverage. Three different accessions of *M esculenta* are recorded from this region such as *Pankhan-khantho, Pankhan-khankhee* and *Pankhan-khannaan*. They can be easily differentiated by their morphological appearances. For instance periderm of varied color was found, such as red (*Pankhan-khankhee*), white (*Pankhan-khantho*) and yellow (*Pankhan-khannaan*); whereas a starchy flesh portion of ground tissue of two different color was recorded i.e. white (*Pankhan-khantho* and *pankhan-khankhee*) and yellow (*Pankhan-khannaan*).

4. Ipomea batatas (L.) Lam.

3 main accessions of *Ipomea batatas* (L.) Lam, were collected during the survey such as *Sokhan-khantho*, *Sokhan-kahnkhee* and *Sokhan-khannaan*. They have distinguished color of periderm and ground tissue, which help a farmer in easy identification such as white (*Sokhan-khantho*), red (*Sokhan-kahnkhee*) and yellow (*Sokhan-khannaan*).

Vegetables

The vegetables play a crucial role in maintaining rural sustenance by providing them with required essential nutrients. However, these can be found in both *jhum* plots as well as home-gardens.

1. Cucurbita mosschata Dutch ex poir

During this exploration trip total 3 accessions were collected as fruit form such as *longlo, longjya* and *longnyeh.* The morphological variability on the basis of per fruit weight, fruit length, fruit diameter, number of seeds/fruit, seed length, seed diameter, peduncle separation from fruit, nature of the base of the peduncle, 100-seed weight, number of seed placenta/ fruit, fruit shape, flesh thickness and flesh texture. The maximum and minimum fruit weight were recorded in *longlo* (4.94 ±0.22 kg) and *longngyeh* (1.08 ± 0.07kg), respectively. The fruit length ranged between 11.94 (± 0.17) cm (*longngyeh*) to 26.45 ± 1.84 cm (*longlo*), whereas, fruit diameter ranged between 8.25 (± 0.34) (*longngyeh*) to 13.83 (± 0.37) cm (*longlo*). However, flesh thickness was maximum in *longlo* (4.08 ± 0.38 cm) and minimum in *longngyeh* (1.54 ± 0.15 cm). The fruit

shape was recorded as long (*longlo*), oval (*longjya*) and round (longngyeh).

2. Benincasa hispida (Thunb.) Cogn

Three accessions of *B hispida* were recorded from this region such as *wawzing*, *wawnu* and *wawsa*. Farmer easily differentiates between them taking its sizes and its taste on consumption as parameters. Wawnu is the largest (5.38 ± 0.19 kg) while wawsa (1.48 ± 0.17 kg) is smallest among them. However, wawzing the medium sized winter melon is mostly preferred because of its taste.

3. Lageneria siceraria (Molina) Standl.

They come with a variety of shapes such as, huge and rounded, small and bottle shaped or slim and serpentine. In this region, it is not usually grown for food, but for use as a container for water, spatula for serving and containers to store seeds of various crops and vegetables.

4. Solanum lycopersicum L.

It is an important plant commonly cultivated in this region. Two accessions of *S. lycopersicum* are collected from this region such as *Soisiksa* and *Soisiknu*. However, *Soisiksa* is smaller in size.

5. Other important vegetables

Fruits of *Cucumis sativus* L., *Solanum torvum* Sw., *Solanum indicum* L., *Solanum nigrum* L., *Solanum kurzii* Brace *ex* Prain and *Solanum melangena L.* is edible. These plants are intermixed with tubers in new *jhum* field (1st year cycle). Other common edible leafy vegetables, which are cultivated along with tuber plants in *jhum* fields are *Brassica oleracea* L., Brassica nigra L., *Plantago major* L., *Clerodendrum viscosum* Vent. and *Spilanthes paniculata* Wall.

Spices

Local spices play a very significant role in adding essence in traditional cuisine. Moreover, it also helps in uplifting the rural economy, thus providing broader ground for income generation. Some of the important local spices are *Zingiber officinale* Rosc, *Allium sativum* L., *Coriandrum sativum* L., *Amaranthus viridis* L.; *Amaranthus spinosus* L.; *Eryginum foetidum* L., *Houttuynia cordata* Thunb. and *Allium hookeri* Thwaites. However *Zanthoxylum alatum* Roxb. and *Zanthoxylum rhetsa* (Roxb.) DC are other common spices which are collected directly from wild while the rest of the spices were cultivated along with other vegetables in *jhum* plots.

Rhizome of *Z. officinale* (traditionally known as "chi") plays an important role not only in supporting sustenance but also in uplifting of rural economy because of its high demand in the local market. Furthermore, it is core part of almost all traditional cuisine. Two different accession is collected from this region such as *Chisa* and *Chinu*. *Chisa* is smaller and possess its unique aroma in compare to *Chinu*.

Leaves of *C. sativum*, *A. viridis*, *A. spinosus, E. foetidum*, *H. cordata* and *A. hookeri* are used in the preparation of traditional relish and to add flavor in boil vegetable meals. However, roots of *H. cordata* is edible and used in traditional relish. The fruit of *Capsicum annuum* L. is an important item of traditional cuisine. During this exploration trip a total accessions of 7 different chilles were collected such as *Hingnu, Hingtuak, Hingsa, Hinglo, Hingtoi, Hingchak, Hingmai*. Farmers use the shape, size and colour to identify and to differentiate them from one another. *Hingnu*, also known as Bhoot julokia or King Chili is considered as the hottest chili in the world. It is largest of among all in terms of size. *Hingsa* is small sized chili usually yellowish white in color at maturity is also considered as very hot. Whereas the rest of the accessions were moderately hot. *Hinglo* is considered to be highest in length than other counterparts. *Hingtoi* are round or oval in shape. In case of *Hingtoak* the fruiting habits are unique as the fruits are positively ascending towards the sky. All the accessions were collected in fruit form. This variability was recorded on the basis of fruit length (cm), fruit diameter (mm), ripe fruit color, fruit shape, fruit weight (g), number of seeds/ fruit, seed weight/fruit (g) and 100-seed weight (g). Variability was observed in characters like fruit length, fruit diameter, ripe fruit color, fruit shape, fruit weight, number of seeds /fruit and 100-seed weight. The range of fruit length was 1.31 ± 0.01 cm (*Hingsa*) to 8.29 ± 0.12 cm (*Hinglo*) while fruit diameter 0.4 ± 0.03 cm (*Hingsa*) to 3.26 ± 0.05 mm (*Hingnu*). The maximum fruit weight was recorded in accession *Hingnu* (2.41 ± 0.04 g) and the minimum in Hingsa (0.05 ± 0.01). Maximum

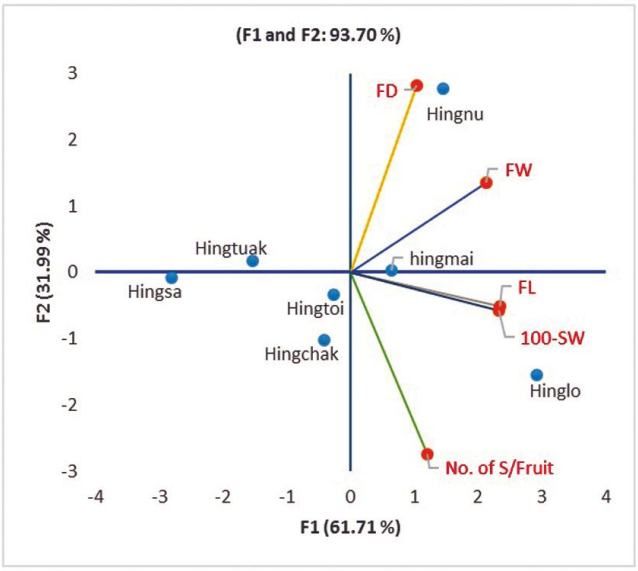

Fig. 4. PCA Score Bi-plot of Accessions and fruit traits of chili.

number of seeds/fruit was 85.6 ± 3.72 (*Hinglo*) while the minimum were 16.25 ± 0.76 (*Hingnu*). The 100-seed weight varies from 0.26 ± 0.01 g (*Hingsa*) to 1.34 ± 0.05 g (*Hinglo*). Observed fruit color was recorded as dark red, light red,

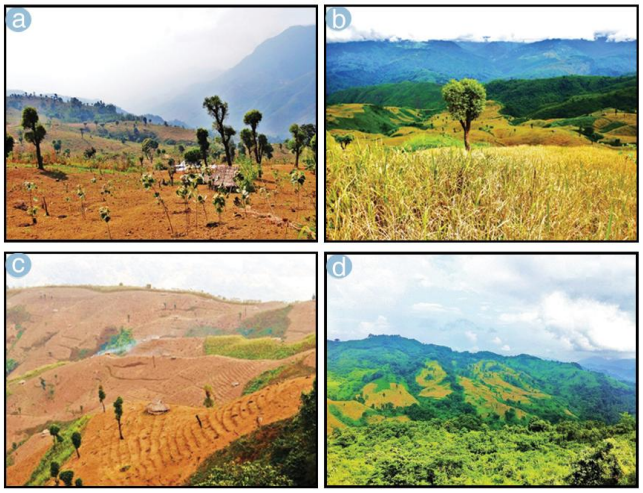

Fig. 5. Jhum landscapes and practices: (a) Field prepared for paddy cultivation, (b) Paddy cultivation in Jhum field, (c) Practice of terracing in jhum field for paddy cultivation, (d) Jhum patches.

orange, red and yellow. While the fruit surface was observed as smooth, wrinkled and semi wrinkled. The fruit shape was conical (*Hingsa and Hingmai*), oval (*Hingchak*), long (*Hingtuak, Hinglo, Hingtuak*), and round (*Hingtoi*).

The first principle component of chili accessions explained nearly 61.47 % of the total variation. Scattered bi-plot of F1 and F2 component reveals chili accessions *Hingnu* with high F2 value contributed especially from traits such as fruit diameter and fruit weight. Whereas, *Hinglo* was observed with high F1 value contributed from 100-seed weight and Fruit length. Thus, the plot obtained from the first two eigenvectors of the PCs analysis of chili constitute high percentage of variability (93.70%) (Fig. 4).

Oilseeds

Sesamum indicum L. and *Perilla frutescense* Var. are two important oil seeds cultivated in *jhum* plot along with other plants.

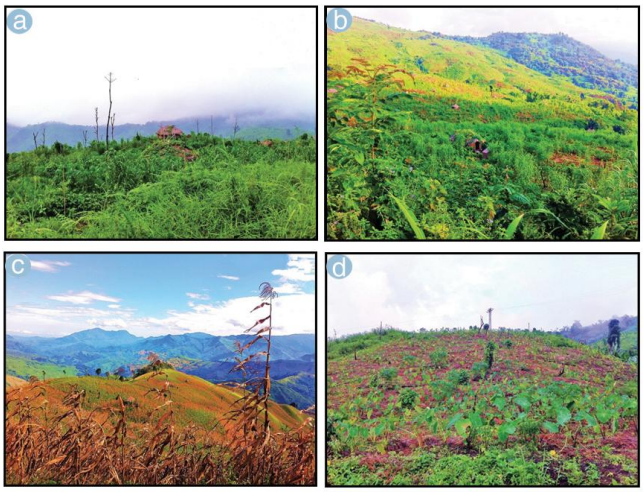

Fig. 6. Mix farming practices in Jhum fields: (a) Mix cropping of vegetables tubers and Spices, (b) Mix cropping of legumes, vegetables and tubers, (c) Paddy (lower elevation) and Maize (higher elevation) cultivation, (d) Mix cropping of Colacasia with beans, millets and sesame

Discussion

Jhumming which is also known as rotational bush, fallow agriculture, swidden cultivation or slash and burn agriculture is an age old predominant agricultural system followed by Northeastern, India (Fig. 5). Numerous problems caused by this type of agriculture as commonly practiced by indigenous tribes has been reported (Rathore *et al.,* 2010; Stracey, 1967; Ninan, 1992; Tripathy and Barik, 2003; Darlong, 2004; Gupta, 2000). However, as there is no other suitable alternate, people had to rely on *jhumming* to sustain the inhospitable hilly terrains of this region. It is best suited against the hilly terrains and harsh environment of this region, giving paramount results in the context of providing farmers with a possible outcome and sustainability. Thus, in spite many drawbacks the slash and burn cultivation is still actively playing a key role in rural sustenance and the economy.

Agricultural fields of these regions are playing vital role in harboring precious germplasms of different indigenous plant varieties. They are maintaining outstanding diversity of crops and other important plant germplasm in their fields. A total of 140 plant species are being intercropped, maintained and conserved by indigenous farmers actively involved in *jhumming* (Fig. 6). The crop group was categorized into 8 different groups such as Cereals (42 accessions), Millets (15 accessions), Oil seeds (2 accessions), Grain legumes (10 accessions), vegetables (21 accessions), tuber crops (31 accessions), spices (18 accessions) and sugarcane (1 accession). However, among the collected crop materials, germplasm of *Oryza sativa* L., Millets, *Colacasia esculanta* L., *Capsicum annuum* L. and *Dioscorea esculenta* (Lour.) Burk showed a wide range of variability. Mixed farming practice further helps in maintaining high diversity of plants in a small plot of land. In addition, mix farming in *jhum* field also enables them to achieve good source of income to add sustenance in rural livelihood. Local market also surveyed varieties of traditional vegetables available at very affordable prices. However, shifting of the present generation from agriculture oriented income to other sectors may lead to permanent shun of *jhum* practice followed by disappearance of large numbers of native plants as well as crop varieties.

They depend mostly on rice, which is also a staple food of this region and its varieties are grown in most of the villages. However, rice doesn't grow well in villages at higher elevation and they depends mostly on Maize, millets and tubers as a primary source of food. Tubers, spices and other crops act as subsidiary food, whereas vegetables provide them with necessary ingredient to complete their nutritional requirements. Combining the entire products of *jhum* field enables them to achieve sustainable livelihood with minimal input.

Providing enough time for rejuvenation these regions still maintains a *jhum* cycle of 10 to 15 years where single *ling* (community jungle) per year is subjected to be slashed and burned for agriculture purpose. It is also reported that community jungles are usually owned by the entire village and is distributed into different plots belonging to individual families. Therefore, in each new cycle instead of doing separately, a site or ling is selected where entire village will perform *jhumming* in their respective plot of land. Such distribution of land among them results in formation of *jhum* patches in the hills.

In order to sustain this region, *jhummias* are constantly laboring in field since many generations and are practicing crop selection for disease prevention and better yield. These treasured ethnic knowledge was orally passed on to the next generation and each generation upgrade their forefather's knowledge with their personal experiences. With the wind of modernization, these treasured possessions may be washed away in near future. Thus, there should be proper documentation of these techniques and Knowledge for future references.

The region still requires constructive scientific mediation to improve the livelihood and reduce the amount of hitches in *jhumming*. Besides, lack of consciousness of modern technologies, lack of marketing opportunities and meager transportations are some of the major hindrance for up-gradation and commercialization of agriculture in this region. Regarding the richness of plant diversity of this region and the chances of lost in the near future, there is a need to have germplasm portfolio, research and development network, assessment and frequent monitoring. Furthermore, there are immediate requirement of well designed, integrated strategy of production, processing, and marketing to excite the full potential of these crops particularly with reference to their contribution to food self-sufficiency.

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