INTRA-VARIETAL DIVERSITY IN LANDRACE AND MODERN VARIETY OF RICE AND BUCKWHEAT

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ABSTRACT

The increased intra-varietal diversity has been considered as coping mechanism against unpredictable environmental factors in crop production. Relatively the risk of crop failure is minimum in landraces than in modern variety mainly because of homogenous population in modern variety. The diversity was estimated and compared between landrace and modern variety of rice and common buckwheat in both quantitative and qualitative traits. Three landraces and three modern varieties of rice were used as self-pollinated crop and experiment was conducted in Jumla. Common buckwheat was used as cross pollinated crop in Kabre consisted of nine landraces and one modern variety. These two experiments were unreplicated and variation was measured at population level. Standard deviation, coefficient of variation and Shannon' diversity index were estimated and variation between landraces and modern varieties was tested using F-test. Dendogram was drawn considering all observed traits for both the crops. In case of rice, variation was higher in landraces than in modern varieties for most of the traits. Variation for majority of the traits was also higher in landraces than in modern varieties of common buckwheat. This higher level of intra-varietal diversity in landraces of both crops might be the major phenomenon to have increased capacity to cope with different environmental stresses. The level of variation in both landraces and modern varieties is trait specific, in some traits, landraces showed higher intra-varietal diversity. The higher level of intra-varietal diversity should be considered for resilient production system and favorable policy environment should be created to promote the use of such diversity.

Keywords: Cluster analysis, diversity index, landrace, modern variety, variation

INTRODUCTION

Genetic diversity is the most important factor to develop new variety that suit diverse environments and farmers' requirements. In Nepal, there are 250 released varieties of 50 crops, 373 registered varieties of 38 crops and 36 denotified varieties of 6 crops (Joshi et al., 2017a). The estimated numbers of landraces are 30,000 of 484 cultivated species across the country (Joshi et al., 2017b). Released and registered varieties are developed either selection of landraces or hybridization followed by selection and it is also called modern/improved variety or high yielding variety. Cultivars are the distinct group of genotypes under cultivation and it includes both landrace and improved variety. Variety is developed by breeders whereas landrace is maintained over the years by farmers. Adoption rate of modern varieties of rice obtained from the farm level survey of 30 districts in 2012 is 12% in High Hill, 65% in Mid Hill and 97% in Taraiagro-ecozones (Gauchan, 2017).

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In many cases, farmers have reported complete crop failure from the field of modern varieties. Some farmers later therefore, turn to grow landraces in some areas.

Modern varieties are genetically homogenous and are grown other than the places where evolution took place. In contrast, landraces are heterogeneous population and can withstand the unpredictable environmental stresses. The higher intra-varietal diversity in landraces might be the major factor to minimize the risk of crop failures due to different stresses. High level of intra-specific diversity in traditional varieties is being generated and maintained due to multiple environmental stresses and this diversity has increased their capacity to cope with unpredictable stresses (Jarvis et al., 2016). Broad genetic base in a variety is, therefore, considered one of the strategies to cope with the climate changes. Use of diversity can be a risk-minimizing strategy to reduce insect pests and diseases damages (Mulumba, 2012).

Complete crop failure has not been reported in case of landraces by most of the farmers. Fields of landraces and modern varieties can easily be distinguished simply looking on the morphotypes. The population of modern variety looks similar each other, whereas, field of landraces looks diverse. Even though recent seed policy allows registration of the farmers' varieties (landraces), the need of homogenous population is the requirement of the official policy for the release of modern variety in the country (SQCC, 2014). Farmers have managed unpredictable risk factors by continued cultivation of landraces which has high level of intra-landrace genetic diversity. Development of variety with high level of intra-varietal diversity is one of the strategies to cope with the agricultural problems created by climate changes and provide livelihood options of smallholder farmers in marginal environments. Self and cross pollinated crops varieties may have different level of diversity and resilience capacity to cope with climatic stresses. Therefore, this study was conducted to assess the intra-varietal diversity of landrace and modern variety of both self and cross pollinated crops. Rice (*Oryza sativa* L., 2n = 2x = 24, self-pollinated) and common buckwheat (*Fagopyrum esculentum* Moench, 2n = 2x = 16, cross pollinated) were selected and population level diversity in both landrace and modern variety was quantified.

MATERIALS AND METHODS

Self-pollinated crops are more homogenous than cross pollinated. Due to the inbreeding nature of self-pollinated crops, intra varietal variation may be different than that of cross pollinated crops. Therefore, two crops with different mode of pollination, (rice as self-pollinated and common buckwheat as cross pollinated) were selected for this study. Among the 97 modern varieties of rice, 7 are recommended for High Hill (Joshi et al., 2017a). Three common modern varieties were selected and three local landraces were collected from nearby areas of Bijayanagar, Jumla. There is only one modern variety of buckwheat and therefore, only one was selected for this study. Nine landraces which were grown many years in research stations were selected from coordinated variety trial (CVT) of Hill Crop Research Program (HCRP), Dolakha.

Two experiments were conducted, one in Agriculture Research Station (ARS), Jumla and second in Hill Crop Research Program (HCRP), Kabre in 2016 crop seasons. Rice experiment was in Jumla and buckwheat experiment was in Kabre. Three landraces (Jumli Marshi Darema, Jumli Marshi Mehela and Kali Marshi Humla) and three modern varieties (Lekali-1, Lekali-3 and Chandannath-3) of rice were included in the experiment. Rice was seeded at 31 May 2016 in Jumla. One modern variety (Mithe Phaper-1) and nine landraces (Acc#493, KLF-72-22-520, PL15, FCE5283, Acc#2213, Acc#2234, Acc#5670, Acc#6529 and PC-30) of common buckwheat were used in buckwheat experiment. Buckwheat was seeded at 12 Sept 2016 in Kabre. Experiments were established in unreplicated conditions with plot size of 4 $m^2$for rice and 6 m^2 for buckwheat. All standard agronomical practices were followed.

Three agronomical traits, namely panicle length, number of panicle and root length were measured in five individual plants of each rice landrace and modern variety. Four diseases infestation of blast, neck blast, bacterial leaf blight and sheath rot were scored in 50 individual plants of each landraces and modern variety. In case of buckwheat, four quantitative traits (plant height, number of branches, number of flower clusters and number of seed set) and six qualitative traits (flower color, stem size, stem color, seed color, seed shape and disease occurrence) were observed in 30 individual plants of each cultivar. All characters were measured as described in rice and buckwheat descriptors, which are available at Bioversity International website (https://www.bioversityinternational.org/e-library/publications/categories/descriptors/)

Intra-varietal diversity was explained by mean ± standard deviation and coefficient of variation for quantitative traits. Population variance of landrace and modern variety was tested using F-test. Shannon diversity index (H') was estimated for qualitative data and disease score. Considering all observations, cluster analysis was applied to see the relatedness between landraces and modern varieties. MS-Excel and Minitab software were used for data analysis.

RESULTS AND DISCUSSION

SELF-POLLINATED CROP: RICE

Standard deviation (SD) and coefficient of variation (CV) of panicle length, number of panicle and root length of rice cultivars are given in Table 1. The SD of panicle length was the highest in Kali Marshi Humla followed by Jumli Marshi Mehela. Jumli Marshi Darema expressed the highest SD for number of panicle. The variation in root length was found higher in Jumli Marshi Mehela. The CV of root length in Jumli Marshi Mehela was the highest among three traits of six rice cultivars. Within panicle length and number of panicle, the highest CVs were found in Jumli Marshi Mehela and Jumli Marshi Darema. Landraces have higher SD and CV for all traits.

Table 1. Variation in panicle and root length among modern and landraces of rice evaluated in Jumla 2016

Cultivar	Panicle length (cm)			Panicle/ Hill (n)			Root length (cm)		
	Mean	SD	CV, %	Mean	SD	CV, %	Mean	SD	CV, %
Jumli Marshi Darema	114.2	12.6	11.0	11.8	3.8	32.5	8.4	1.1	13.6
Jumli Marshi Mehela	101.2	15.3	15.1	9.8	2.8	28.3	10.8	4.0	36.7
Kali Marshi Humla	113.4	15.4	13.6	8.4	2.1	24.7	11.4	2.1	18.2
Lekali-1	121.8	13.9	11.4	7.4	1.5	20.5	8.4	1.3	16.0
Lekali-3	119.4	14.1	12.5	9.4	1.1	12.1	8.2	2.2	26.4
Chandannath-3	117.2	13.2	11.3	7.4	2.1	28.0	9.6	2.1	21.6

Variance between landrace and modern variety was tested for each of three traits. The variances were significantly different for number of panicle and root length (p=0.05) between landrace and modern variety (Table 2). Landrace had more SD for panicle length however; variation was not significantly different between them. Shannon's diversity index (H') based on the disease infestation score was higher in landrace than that of modern variety for four diseases, bacterial leaf blight, blast, sheath rot and neck blast (Table 3). Cluster analysis had formed four clusters (Figure 1). All three modern varieties (Lekali-1, Lekali-3 and Chandannath-3) made a single cluster and each of three landraces made other separate cluster. Jumli Marshi Mehela was noticed as separate landrace considering these three agronomical traits and four disease infestation score.

Table 2. Variance test between landrace and modern variety of rice

Cultivar type	Panicle length (cm)			Panicle/ hill (n)			Root length (cm)		
	Mean	SD	p-value	Mean	SD	p-value	Mean	SD	p-value
Landrace	109.6	14.8	0.75	10.0	3.1	0.04	10.2	2.8	0.05
Modern variety	119.5	13.5		8.1	1.8		8.7	1.9	

Table 3. Shannon's Diversity Index (H') of diseases for rice cultivar types

Cultivar type	Bacterial leaf blight	Blast	Sheath rot	Neck blast
Landrace	1.36	1.31	1.67	1.01
Modern variety	1.18	1.03	1.55	0

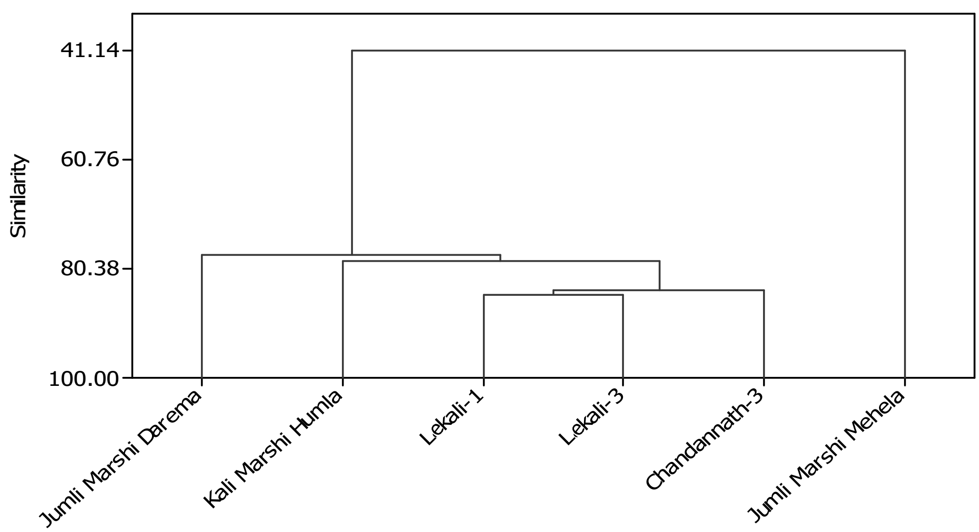

Figure 1.Clustering of landraces and modern varieties of rice based on seven traits

CROSS POLLINATED CROP: COMMON BUCKWHEAT

The highest SD for plant height was observed in landrace, Acc#2234 (Table 4). FCE5283 landrace expressed the highest SD for number of branches and number of flower clusters. The SD for number of seed set was higher in modern variety (Mithe Phaper-1). Among the traits, the highest CV was of number of seed set in landrace PL15. The CV of all four traits was higher in landraces.

Table 4. Variation in agronomical traits among modern and landraces of common buckwheat evaluated in Dolakha, 2016

Cultivar	Plant height (cm)			Branches/plant (n)			Flower clusters/plant (n)			Seed set/ cluster (n)		
	Mean	SD	CV, %	Mean	SD	CV, %	Mean	SD	CV, %	Mean	SD	CV, %
Acc#493	80.80	8.85	10.96	5.40	1.52	28.19	11.90	3.23	27.15	2.03	0.76	37.62
KLF-72-22-520	85.80	10.14	11.82	5.40	1.40	26.01	11.60	4.01	34.53	1.97	0.32	16.26
PL15	80.40	10.12	12.59	5.27	1.53	29.05	11.93	3.69	30.96	1.83	0.79	43.17
FCE5283	79.10	10.03	12.67	5.43	2.03	37.34	10.87	4.21	38.72	2.23	0.68	30.40
Acc#2213	72.03	9.84	13.66	4.97	1.16	23.34	9.87	1.76	17.80	2.23	0.68	30.40
Acc#2234	76.97	10.88	14.13	5.10	1.24	24.34	10.40	3.86	37.16	2.30	0.60	25.91
Acc#5670	74.07	9.14	12.34	5.53	1.94	35.11	9.97	3.98	39.92	2.10	0.55	26.08
Acc#6529	74.97	8.31	11.09	5.20	1.37	26.44	10.73	4.19	39.07	2.17	0.53	24.49
PC-30	75.83	7.28	9.60	5.00	1.82	36.39	8.53	2.98	34.92	2.23	0.57	25.45
Mithe Phaper-1	76.40	10.72	14.03	4.97	1.13	22.73	9.80	2.87	29.28	2.10	0.88	42.13

Among the four agronomical traits, the variation was significantly different between landrace and modern variety of common buckwheat only for number of branches (Table 5). Landrace type had more variation compared to modern variety. Shannon's diversity index of modern variety was higher than landraces for flower color and stem color (Table 6). However, Shannor's diversity index (H') was higher in landrace for stem size, seed color, seed shape and disease occurrence. At 87.44 similarity coefficient, there are eight clusters for ten cultivars of buckwheat (Figure 2). Modern variety, Mithe Phaper-1 made a separate cluster with Acc#2234. Each of six landraces made a separate cluster. KLF-72-22-520 landrace was found different among these ten cultivars of common buckwheat based on the both qualitative and quantitative traits.

Table 5. Variance test between landrace and modern variety of common buckwheat

Cultivar type	Plant height (cm)			Branches/plant (n)			Flower clusters/plant (n)			Seed set/ cluster (n)		
	Mean	SD	p-value	Mean	SD	p-value	Mean	SD	p-value	Mean	SD	p-value
Landrace	80.80	8.85		5.40	1.52		11.90	3.23		2.03	0.76	
Modern variety	76.40	10.72	0.31	4.97	1.13	0.05	9.80	2.87	0.52	2.10	0.88	0.42

Table 6. Shannon's Diversity Index (H') of qualitative traits for common buckwheat cultivar types

Cultivar type	Flower color	Stem size	Stem color	Seed color	Seed shape	Disease
Landrace (KLF-72-22-520)	0.90	1.07	0.95	1.06	0.50	0.25
Modern variety	1.04	1.01	1.04	1.04	0.24	0.33
Landrace (Acc#2213)	0.94	1.06	0.3	1	0.64	0.25

Due to narrow genetic base in modern varieties, there is high risk of cultivating them in the context of climate changes. Farmers have two types of cultivars, one landrace and second are modern variety (high yielding variety). Generally it is perceived that the intra-varietal diversity is higher in landrace as compared to modern variety. We quantified and compared statistically the variation between landrace and modern variety through measuring observation at population level in rice and buckwheat. In both crops, variation was higher in landraces for most of the traits and it was significantly different (p = 0.05). Rice is self-pollinated crop, even though diversity is noticed in landraces. Sample size in case of rice was low in this study, and few numbers of quantitative traits were assessed. If we could study in large sample size in many agro-morphological traits, there might be more reliable structure and results can be related to stress management.

Common buckwheat is cross pollinated crop and normally all types of cultivars retain high level of intra-varietal diversity (Joshi and Baniya, 2006). Landraces relatively possessed higher diversity in most of traits observed. The selected landraces were from Coordinated Varietal Trial (CVT) of HCRP (the research station) where, they have been continuously grown over the year giving selection pressure. CVT generally includes selected promising genotypes, which are homogenous. This selection might have narrowed the diversity in these landraces and scenario might be different if we could compare with landraces without any selection (i.e. directly collecting from the farmers' fields). Even during selection of landraces, there might be less variation in landraces collected from progressive farmers as they keep selecting better plants from the population for next season planting.

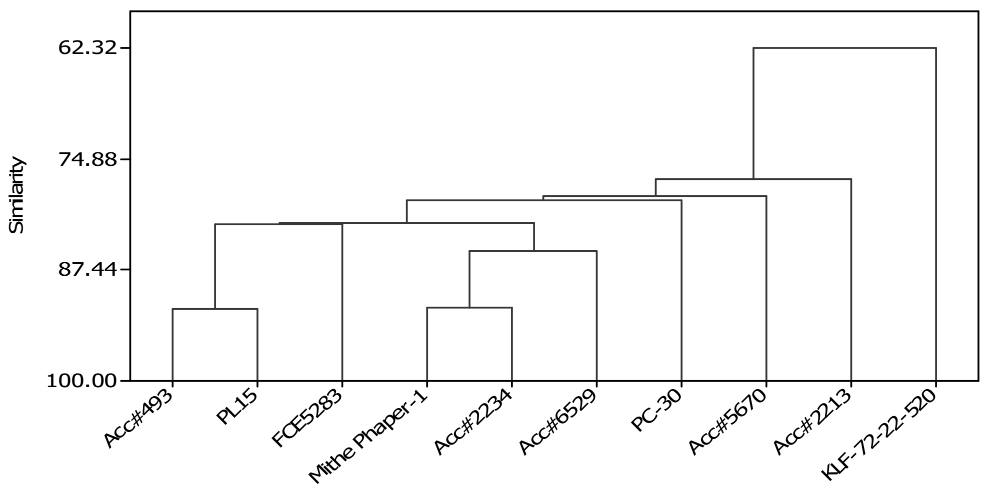

Figure 2. Clustering of landraces and modern varieties of common buckwheat based on ten characters

Higher intra-varietal diversity is reported in landraces of many cultivated crop species. Genetic diversity in wheat landraces was higher than in modern varieties. The degree of associated of landraces with geographical region was relatively stronger than that of modern wheat varieties (Hao et al., 2008). Rice landrace is predominantly inbreeded, however, high level of genetic variation was recorded using micro-satellite markers (Pusadee et al., 2009).The level of gene diversity, even within population level was found same in barley landraces and the representative sample of modern varieties grown in Italy (Bellucci et al., 2013). There are many landraces that are better than modern varieties in terms of production, tolerant to abiotic and biotic stresses and intra-varietal diversity (Genebank, 2016).

Since this trial was conducted on-station with small plot size covering small population size, study is needed to further validate it by studying on-farm taking larger sample size in real farmers' fields. Many of the landraces considered here are imposed to some degree of selection. It would be better to use the landraces either directly collecting from the farmers or taking from the National Genebank to get actual diversity of landraces. It is shown that landraces have higher diversity in both self and cross pollinated crops and separate group have been formed for landraces and modern varieties. Focused study is needed further to quantify the advantages that farmers are taking from such high intra-varietal diversity and to promote the application of the concept at wider scale. Landraces are more resilient, less risk to grow and make agriculture production more sustainable. All these advantages might be because of high intra-varietal diversity, therefore, favorable policy environment should be in practice to release and register the heterogeneous cultivars.

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