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Research Paper

Diversity Assessment and Characterization of Landraces of Rice (*Oryzasativa* L.) in Terai of Nepal

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ABSTRACT
The switch over to high-yielding modern varieties of rice with advancements in agriculture has posed a serious threat to the erosion of local landraces which have immense potential for different valuable traits. Thirty local landraces of rice germplasms collected from different parts of the Terai region of Nepal were evaluated and characterized for different agro-morphological traits at the Rampur campus, Chitwan. The experiment was conducted in a Rod row matrix design, during the rainy season, 2018, and fifteen qualitative and ten quantitative agro-morphological traits were recorded. Among qualitative characters maximum variability was recorded in culm strength, lemma, and palea color, lemma color of apiculus, flag leaf attitude of the blade (late), and anthocyanin coloration. Correlation studies revealed that total yield registered a positive significant association with culm length, the width of grain, and 1000 grain weight, indicating that these characteristics were important for yield improvement. Shannon index ranged from 0.54-1.39 while the evenness value ranged from 0.43-0.93. Cluster analysis was performed for different genotypes of landraces and genetic diversity was measured, genotypes with larger cluster distances carry greater genetic diversity and are suitable for further varietal improvement. Hence, culm length, width of grain, and 1000-grain weight traits must be considered as important attributes in formulating selection criteria for achieving desired targets in future breeding programs.
Keywords: *Cluster analysis, Genotypes, Selection, Variability*

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I. INTRODUCTION

Rice (*Oryza sativa* L.) is the major food crop for the people of the world in general and Asians in particular. Nearly 90% of the rice is produced and consumed in this region (Sajid et al., 2015). Furthermore, it is a staple food and provides two-thirds of the calories for most Asians with rice-based diets (Khush, 1997; Pokhrel et al., 2020). Rice is grown under diverse eco-geographical conditions in various tropical and sub-tropical countries. The demand for rice is expected to rise from 676 million tons in 2010 to 763 million tons by 2020 and to further increase to 852 million tons by 2035. From the above-mentioned data, it is clear that about 25% more production is required in the upcoming 25 years. However the area under cultivation is decreasing rapidly due to urbanization and industrialization (Khush, 2013).

In Nepal, rice is the first most important crop in terms of area and production. It is grown in 1.49 million hectares and produces 5.61 million tons with a productivity of 3.376 t ha^{-1} (MOAD, 2018). Nepal is rich in diversity in both cultivated and wild relatives of rice and is estimated that about 2500 different landraces exist in Nepal (Dhakal et al., 2020)

Rice has the largest collection of germplasm in the world, which provides diverse genetic traits for rice breeding (Nandedkar et al., 2020). Landraces are the local highly diverse crop varieties developed in traditional locally adapted agriculture systems by human and selected for long period of time (Dhakal et al., 2020; Mathure et al., 2011; Ogunbayo et al., 2005). They carry different useful traits with genetic potential for improvement of rice varieties with not only high yield potential and quality but also resistance to biotic and abiotic stresses,(Parikh et al., 2012) ultimately play important role in the local food security and development of agriculture (Tang, Jiang, Li, and Yv, 2002). Land races maintained by farmers over a long period of time are endowed with tremendous genetic variability, as they are not subjected to subtle selection. Landraces are also important genetic resources of resistance to pests and diseases, (Tiwari et al., 2020) as they provide “adaptability genes” for particular environmental condition (Vijayakumar et al., 2012).

Diversity assessment and characterization of existing landraces is useful in varietal improvement (Kumar et al., 2016). Characterization is a technique used to evaluate the phenotypic diversity through agro-morphological traits that are useful for gene bank management of rice (Bajracharya et al., 2006). Qualitative traits are reliable for characterization of varieties as these traits remain stable over generations (Keerthivarman et al., 2019).

Over time, selective breeding, random mutation, and frequent hybridization between landraces and wild relatives resulted in a high level of phenotypic and genetic diversity(Ray et al., 2013).

Wild rice genotypes that are diverse and agronomically valuable have been discovered, and the richness of Nepalese rice is reflected by a huge collection of landraces and several wild rice species. However, passport data for these landraces is scarce, and as a result, they have made little contribution to national and international rice improvement (Sharma et al., 2007). Rice varieties such as Nakhi saro and Mutmur, for example, are well adapted to the hard and arid soils of Nepal's uplands. In flood-prone locations, the Bhathi, Silhat, and Lal tengar types do well. Other landraces, like as Basmati and Sathi, are culturally significant and are used in feasts and festivals. These examples highlight the value of local landraces in terms of food security and the local economy (Gauchan et al., 2005; Chaudhary et al., 2004). Concerns over the replacement of landraces by modern varieties, as well as the loss of potentially valuable alleles and genotypes, have led to the sampling and storage of large numbers of landraces in ex situ gene banks since the 1970s. Recently, scientific interest in in-situ conservation measures has resurfaced(Gauchan et al., 2005).

The switch over to high yielding modern varieties of rice with the advancement in agriculture sector , has posed a serious threat to the erosion of growing of traditional varieties and landraces which may have immense potential for different valuable traits (Dikshit et al., 2013). For the prevention of such valuable genetic resources of rice from erosion, characterization, collection and assessment is essential (Tiwari et al., 2020). Although green revolution has increased the production of food grains in large quantity, but the modern high yielding varieties which are the back bone of green revolution , have indirectly caused the erosion of landraces and wild varieties of rice (A.K. Sinha & Mishra, 2013; Pokhrel et al., 2020). Importance of landraces cannot be denied because improvement in existing varieties requires the desirable genes, which are undoubtly present in landraces and wild varieties (Shishir Sharma, Amrit Pokhrel, 2020).

As Terai region is home for many landraces of rice varieties which are being cultivated and maintained by farmers through selected breeding from the time of immemorial. Nowadays, due to introduction of modern high yielding and hybrid varieties these native landraces are in verge of erosion or extinction, especially in the irrigated rice ecosystem leading to reduced genetic base and thus increased genetic vulnerability (Mathure et al., 2011; Islam et al., 2019). As we know that, landraces are of immense importance in rice breeding programme as they carry suitable traits for the improvement of existing varieties (Ogunbayo et al., 2005). So, collection and characterization of these local landraces helps to preserve the important genetic characters which may be used in future for further breeding purpose to develop desirable variety of rice. (Tiwari et al., 2020)

Keeping in view these facts, the present research was aimed at characterizing the local landraces of rice genotypes of terai region, through qualitative and quantitative traits to understand in-situ variability of different agro-morphological traits and their relationship among them.

II. MATERIALS AND METHODS

Experimental site, Design and Weather parameter

The experiment was carried out at the research farm of Agriculture and Forestry University, Rampur, Chitwan, Nepal situated at 27^{o} 37' N latitude 84^{o}25' E longitude, and at an altitude of 228 m above mean sea level. Study was conducted during rainy season of 2018 i.e. June-December in rod row matrix design with single replication. Each genotype was transplanted in 5 rows of 2m length with row to row and plant to plant spacing of 20*20 cm. Each plot of size 2m^{2}and a gap of 0.5m between the plots was maintained. The study site's climate is humid and subtropical, with an average annual rainfall of 2000 mm.

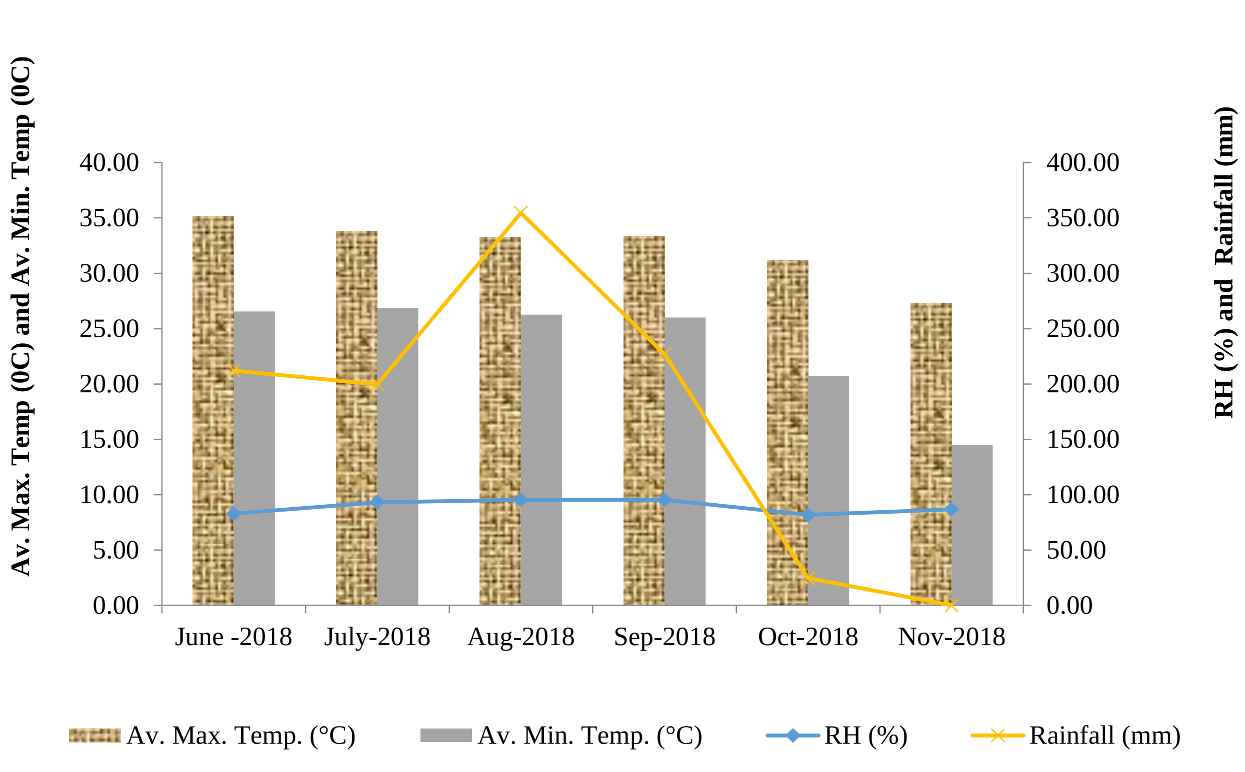

Figure 1. Agro-meteorological data over the experimental period (Source: NMRP, Rampur, Chitwan)

Plant materials and field experiment

A total of thirty rice landraces, used in this study were collected from community seed bank of Dang, Jhapa, Bara and Nawalparasi districts of Nepal. (Table 1) Twenty-five days old seedling were transplanted in irrigated puddled condition. All the recommended agronomical practices were followed during the study for the healthy crop establishment. Well-decomposed farmyard manure @ 12-15 ton/ha was applied during land preparation. Chemical fertilizer and pesticides were not used during the experiment. Two manual weeding were performed 30 and 60 days after sowing.

Data collection and data analysis

Observations were recorded on five randomly selected plants of each genotype for 15 qualitative and 10 quantitative traits at different stages of growth. The accessions were characterized according to descriptors established by the by Diversity International, IRRI & WARDA (2007). Quantitative characters recorded were culm length, tillers per hill, panicle length, length of leaf blade, flag leaf length, flag leaf width, panicle number per plant, grain yield, number of grains per panicle, filled and unfilled grains per panicle, grain length, grain width and 1000 grain weight. The qualitative characters studied were: Basal leaf sheath color, culm: habit(angle), lemma (color of apiculus), lemma and palea color, flag leaf (attitude of blade), culm(underlying node color), culm strength, panicle exertions, panicle (attitude of branches), leaf blade(green color), leaf blade(pubescence), auricle color, color of ligule, spikelet(color of stigma) and panicle (attitude of main axis).The qualitative characters were scored visually, and the quantitative characters were measured. Data was handled and processed through the spreadsheet of MS Excel 2013. R and its packages along with Minitab-14 were further used to analyze the data.

Table. 1 List of landraces and their area of collection

Plot no.	Name of Genotype	Location
1	Bhadhhi	Bara
2	Kajh	Bara
3	Amaghauj	Jhapa
4	Sete dhan	Nawalparasi
5	Hodbachhi	Jhapa

6	Lalka basmati	Check
7	Ratosetoanadi	Jhapa
8	Ratoanadi	Dang
9	Champasari	Jhapa
10	Jagad	Bara
11	Hapsa	Jhapa
12	Gauriya	Nawalparasi
13	Bangalya	Bara
14	Bagaranadi	Jhapa
15	Chulthe	Jhapa
16	Dhankute	Jhapa
17	Dudhraj	Bara
18	Anjana	Bara
19	Aapjhute	Jhapa
20	Andi	Bara
21	Atte dhan	Jhapa
22	Tude basmati basandar	Dang
23	seto basmati	Jhapa
24	Ghusara	Bara
25	Katarkhera	Jhapa
26	Bakuli anadi	Nawalparasi
27	Anadi	Jhapa
28	Bagadi	Dang
29	Brahavusi	Bara
30	Jhahardhan	Jhapa

III. RESULT AND DISCUSSION

Quantitative character

Pearson's correlation coefficients for ten traits showed negative association of culm number per plant with culm length of plant (-.121). Number of panicles per plant showed negative association (-.225) with culm length but significantly high positive correlation with number of culms per plant (.820**). Similar result was conveyed by (Sowmiya & Venkatesan, 2017). Panicle length was found positively associated with culm number (.199), and panicle no. per plant whereas negatively associated with culm number per plant. Grain width showed positive association with culm length (.217) and number of panicles per plant (.052) similarly, negative association with culm number per plant and panicle length. NuFG showed negative association with culm length but negative high significant correlation with width of grain (-.493**). It also showed positive association with culm number and panicle number per plant. NFG found to be positively significantly correlated with culm length (.425*) and panicle length (.373*) whereas positively associated with culm and panicle number. Grain width and number of unfilled grains per panicle showed negative association with NFG. 1000 grain weight showed high significant correlation with width of grain (.803**) and positive association with culm length. Similarly, negative high significant correlation with number of unfilled grains (-.572**) and negative association with culm and panicle number, panicle length and number of filled grains per panicle. Length of grain showed positive high significant correlation with 1000 grain weight (.598**) and significant correlation with width of grain (.421*). Similarly, negative association with culm length, culm and panicle number, panicle length, no of unfilled grains and no of filled grains per panicle. Yield per plot showed positive high significant correlation with culm length (.467**), grain width (.513**) and positive significant correlation with 1000 grain weight.(Kibria et al., 2008) also reported the similar findings as current findings. Similarly, positive association with culm and panicle number, NFG and grain width.

Table 2. Correlation coefficient analysis

	CL	CNP	PNP	PL	GB	NuFG	NFG	1000 GW	GL	YPP
CL	1									
CNP	-.121	1								
PNP	-.225	.820**	1							
PL	.199	-.068	.021	1						
GB	.217	-.155	.052	-.202	1					
NuFG	-.161	.046	.099	.244	-.493**	1				
NFG	.425*	.139	.080	.373*	-.059	-.044	1			
1000 GW	.276	-.349	-.175	-.084	.803**	-.572**	-.093	1		
GL	.115	-.164	-.061	-.078	.421*	-.206	-.207	.598**	1	
YPP	.467**	.179	.238	-.017	.513**	-.197	.146	.440*	.324	1

** Significant at 1 percent level of significance *Significant at 5 percent level of significance
CL=culm length, PNP=panicle no. per plant, CNP=culm no. per plant, PL=panicle length, GB= grain breadth, GL=grain length, NuFG =no. of unfilled grain, NFG=no. of filled grains, YPP=yield per plot, 1000 grain weight

Qualitative characters

The results of agro-morphological characterization as observed in studied rice accessions are presented in Table 3. Out of 15 plant and grain qualitative characters recorded, one character showed dimorphic, four characters tri-morphic and remaining eleven showed more than 3 states of expression among the varieties. The maximum variability was recorded in three traits; lemma and palea color, lemma color of apiculus, culm lodging resistance and panicle exsertion. For the intensity of green color in the leaf blade, all accessions exhibited light to dark green color, with 63% exhibiting medium, 17% exhibiting light, and 20% exhibiting light and dark green color, respectively. Similarly, 47% of the landraces possessed green colored basal leaf sheath color, 7% light green, 43% light purple and 3% purple color.One of the most key traits in detecting mixtures at the seedling stage is basal leaf sheath pigmentation (Dikshit et al., 2013). Pubescence in leaf blade was glabrous in 43%, intermediate in 40% and pubescent in 17% of land races. 53% of the landraces possessed whitish auricle color ,13% yellowish green, 7% light purple and was absent in 27%. For the ligule color character, 83% of the landraces possessed whitish coloration, 10% light purple and 3% possessed purple and purple line coloration respectively. Culm habit angle was intermediate in 53% of the landraces followed by 37% open, 7% erect and 3% spreading. Lemma (color of apiculus) was green in 47% of the landraces, purple 33%, white 10%, brown 7% and straw color in 3%. The color of the apiculus and glume helps in distinguishing one variety from another (Dikshit et al., 2013). Lemma and Palea color were Green in 70%, 10% brown furrows on green, 7% brown tawny and purple, 3% yellowish green and purple furrows 1 of studied landraces. 60% of the spikelet (color of stigma) possessed whitish coloration, 27% and 13% purple and light purple respectively.Regarding flag leaf (attitude of blade), 60% intermediate, 27% erect, 10% descending and 3% drooping was found. With respect to culm lodging resistance (culm strength) 37% of the landraces showed very strong resistance, 30% showed strong,20% intermediate, 10% weak and 3% very weak resistance. Out of 30 landraces for panicle exsertion, 57% were well-exserted, 20% exserted and 3% moderately well-exserted. For the panicle (attitude of main axis), 70% of the landraces possessed strongly drooping panicle, followed by 27% slightly drooping and semi-upright 3%. Similarly, for culm (underlying internode coloration), 77% of the landraces showed green coloration and rest 23% showed light gold coloration. Our findings are consistent with those of (Kumar et al., 2016), who characterized sixty-four rice germplasms for thirty-five morphological and quality traits and found adequate variation among the germplasms for the most of the traits studied. Sixty-four germplasms were identified as distinct based on thirty-one agro-morphological and quality traits. The current findings are further supported by the findings of Parikh et al., (2012), who assessed 71 aromatic rice accessions for twelve morphological features and discovered a large range of diversity for all morphological traits studied. Out of the twelve morphological characters, basal leaf sheath color, leaf blade color, ligule color, plant habit, apiculus color, and awning showed the most variation across the accessions, swith the remaining six features found in each of two classes. Rao (2013)'s findings also support the current findings. They identified sixty-five rice landraces based on forty-three characters and identified thirty-two unique landraces based on twenty-two essential and twenty-four additional characters. Intensity of green color in the leaf blade, basal leaf sheath color, color of ligule, culm: habit angle, lemma and palea color, flag leaf (attitude of blade) and culm strength which is more similar type of work reported by(Keerthivarman et al., 2019; H.N., 2012; Dey et al., 2016; Sajid et al., 2015). Similar findings were also reported by other researchers (A K Sinha & Mishra, 2013; Anjan Kumar Sinha et al., 2015; Joshi et al., 2011; Chakrabarty et al., 2012; Dikshit et al., 2013; Moukoumbi et al., 2011).

Table 3. Frequency distribution of landraces of rice for various qualitative characters

S.N.	Character	State of expression	No of varieties	Frequency (%)
1	Leaf blade(green color)	Dark	6	20
		Light	5	17
		Medium	19	63
2	Basal leaf sheath color	Green	14	47
		Light green	2	7
		Light purple	13	43
		Purple	1	3
3	Leaf blade pubescens	Glabrous	13	43
		Intermediate	12	40
		Pubescent	5	17
4	Auricle color	Absent	8	27
		Light purple	2	7
		Whitish	16	53
		Yellowish green	4	13
5	Color of ligule	Light purple	3	10
		Purple	1	3
		Purple line	1	3
		Whitish	25	83
6	Culm: habit angle	Erect	2	7
		Intermediate	16	53
		Open	11	37
		Spreading	1	3
7	Lemma (color of apiculus)	Brown	2	7
		Green	14	47
		Purple	10	33
		Straw	1	3
		White	3	10
8	Lemma and palea color	Brown furrow	3	10
		Yellowish green	1	3
		Brown tawny	2	7
		Green	21	70
		Purple	2	7
		Purple furrows 1	1	3
9	Spikelet (color of stigma)	Light purple	4	13
		Purple	8	27
		Whitish	18	60
10	Flag leaf (attitude of blade)	Descending	3	10
		Drooping	1	3

		Erect	8	27
		Intermediate	18	60
11	Culm lodging resistance (culm strength)	Intermediate	6	20
		Strong	9	30
		Very strong	11	37
		Weak	3	10
		Very weak	1	3
12	Panicle exsertion	Exserted	6	20
		Moderate	1	3
		Moderately well-exserted	6	20
		Well-exserted	17	57
13	Panicle (attitude of main axis)	Semi-upright	1	3
		Slightly drooping	8	27
		Strongly drooping	21	70
14	Panicle(attitude of branches)	Drooping	3	10
		Horizontal	13	43
		Open	11	37
		Semi-compact	3	10
15	Culm (underlying internode coloration)	Green	23	77
		Light gold	7	23

Shannon Weiner index and Evenness

The frequency of appearance of all the traits observed are presented in Table 4. The diversity was assessed with the help of Shannon Wiener index presented in table. The maximum number of diversities in trait culm strength (1.39) followed by lemma (color of apiculus) (1.24), panicle (attitude of branches) (1.19) and auricle color (1.13). Least diversity was observed in trait of culm (underlying internode coloration) (0.54) followed by color of ligule (0.6). Shannon-Weiner diversity indices for 36 morphological traits among germplasm accessions ranged from 0 to 1.242 with a mean value of 0.524 (Nandedkar et al., 2020). Panicle: Length of longest awn had the highest diversity index value of 1.242, while Leaf: Auricles, Leaf: collar, Leaf: ligule, and Leaf: Shape of ligule had the lowest diversity index value of 0.The Shannon Weiner index for other traits can are explained in the Table 4.

The evenness of the genotypes of different traits calculated revealed that leaf blade anthocyanin was very even (J=0.93) followed by culm strength (j= 0.86) and panicle (attitude of branches) (j=0.85). The color of ligule (j=0.43) and lemma and palea color (j=0.59) were the least even traits found in the genotypes.

A lot of variation was observed among the genotypes used in the experiment. Shannon Wiener diversity index explains the condition of the diversity in the given trait and species. Higher the value of the diversity index, more the diversity presents in the trait. Highest diversity was exhibited by the trait culm strength followed by lemma (color of apiculus). This means that the germplasms had shown most diversity in these traits. Culm (underlying internode coloration showed least diversity index (0.54), which means that the 30 germplasms were least diverse in case of their Culm (underlying internode coloration). Evenness value gives the equality in the distribution of the traits in the population. Evenness value equal to one means a completely even population i.e. the traits and population are equally distributed. The 30 genotypes were highly even in some traits whereas they were observed to have unevenness in the distribution as well. The trait having higher evenness value was found to be leaf blade anthocyanin (J=0.93). The trait which had least evenness was observed to be the color of ligule (j=0.43) which also had the lower diversity index (H).

Table 4. Shannon Weiner index and Evenness value for different qualitative traits

Character	Shannon Weiner indexH'	Evenness
Leaf blade(green color)	0.9	0.82
Basal leaf sheath color	1.01	0.72
Leaf blade pubescence	1.02	0.93
Auricle color	1.13	0.82
Color of ligule	0.6	0.43
Culm: habit angle	0.99	0.71
Lemma (color of apiculus)	1.24	0.77
Lemma and palea color	1.06	0.59
Spikelet (color of stigma)	0.92	0.84
Flag leaf(attitude of blade)	1.002	0.72
Culm lodging resistance (culm strength)	1.39	0.86
Panicle exsertion	1.07	0.77
Panicle (attitude of main axis)	0.71	0.65
Panicle(attitude of branches)	1.19	0.85
Culm (underlying internode coloration)	0.54	0.78

Cluster analysis of quantitative traits

The D2 analysis of the quantitative characters grouped the genotypes in to four clusters, cluster II comprised of maximum number (17) of varieties and cluster III (9) and IV (3) and the minimum 1 for cluster I. The intra-cluster distance was maximum (549.811) in cluster III and minimum (153.271) in cluster IV. Hence, the genotypes within the cluster III were genetically more divergent from each other than those in cluster IV. The highest inter- cluster distance was recorded between clusters III and IV, followed by cluster II and I. In general, the values of intra-cluster and inter-cluster distances are independent of the number of varieties grouped into a particular cluster. The varieties belonging to distantly located clusters may be used for further improvement of the desired trait(s). From the Table 6. it is found that the cluster I was having highest mean value for length of leaf blade, flag leaf width, culm length, panicle length, width of grain, number of filled grains, grain length and yield per plot, cluster III had highest mean values for flag leaf length, cluster IV recorded maximum mean values for culm number per plant, panicle number per plant, number of unfilled grains and 1000 grain weight. The promising landraces from these clusters with high mean values for different traits may be directly used for adaptation or may be used as parents in future hybridization, depending upon the objective of the breeding programs to derive superior transgressive segregants. (Chakrabarty et al., 2012) classified 91 farmer varieties into four clusters based on genetic divergence for eight quantitative traits. The maximum genetic divergence was observed in stem length, leaf blade length, and 1000 grain weight, while breadth of the leaf blade was the least variable trait, followed by grain width. Highly substantial differences between rice varieties for quantitative parameters such as leaf blade length and width, stem length, 1000 grain weight, grain length and width, and decorticated grain revealed the presence of genetic divergence in the released varieties. (Salgotra et al., 2017)to determine the genetic relationship among 141 basmati rice accessions for ten agro-morphological traits, cluster analysis was performed classifying the genotypes into six clusters.

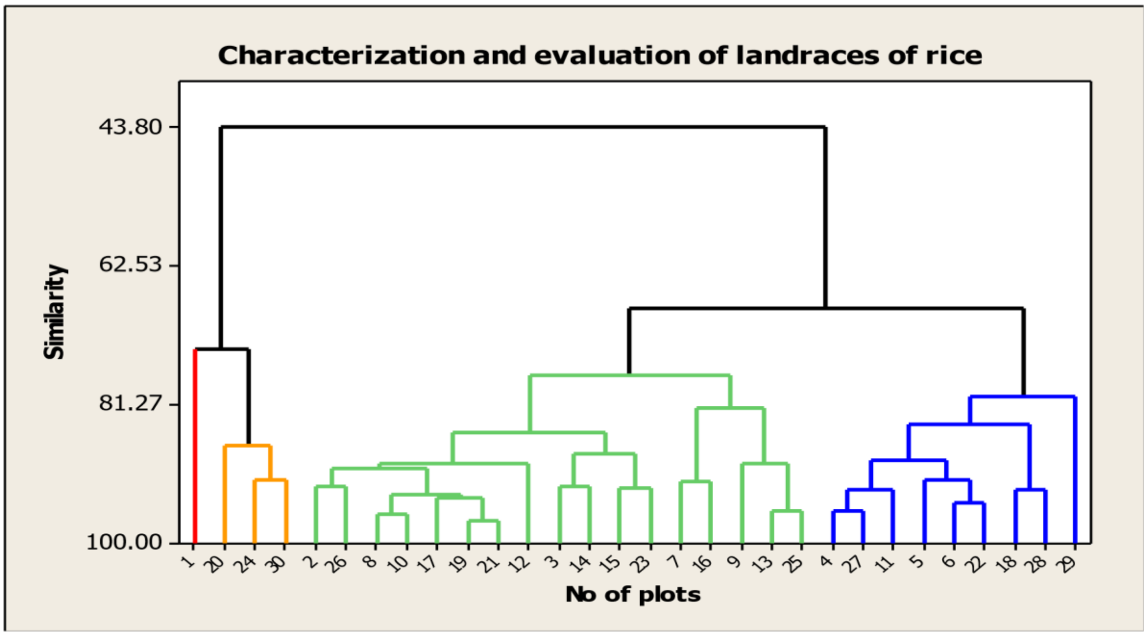

Figure:

Table .5 Clustering pattern among 30 landraces of rice

Cluster no.	No. of landraces	Name of the landraces
I	1	Bhadhi
II	17	Kajh, Amajhagauj, Ratosetoanadi, Ratoanadi, Champasari, Jagad, Gauriya, Bagaranadi, Bangalaya, Chulthe, Dhankute, Dudhraj, Aapjhutte, Atte dhan, Katarkhera, Seto basmati,Bakuli Anadi
III	9	Sete dhan, Anadi, Hapsa, Hodbacchi, Lalka basmati, Tude basmati basandar, Anjana, Bagadi, Brahavusi
IV	3	Andi, Ghusara, Jahar dhan

Table 7. Mean value and centroid value of quantitative traits

Variable	Cluster1	Cluster2	Cluster3	Cluster4	Centroid
LLB	43.400	42.096	43.222	40.667	42.793
FLL	27.200	28.224	30.422	28.067	28.833
FLW	1.150	1.245	1.271	1.307	1.269
CL	121.800	103.941	97.533	106.667	102.887
CNP	9.200	8.847	9.022	9.733	9.000
PNP	8.000	7.324	7.511	8.867	7.557
PL	25.600	21.855	23.989	23.193	22.754
GB	3.308	2.941	2.619	3.220	2.884
NuFG	57.200	27.941	45.533	22.267	33.627
NFG	156.600	108.659	104.000	99.200	107.913
1000 GW	20.090	23.259	18.533	28.100	22.220
GL	8.634	8.245	8.081	8.586	8.243
YPP	642.000	270.371	95.389	505.367	253.763

Correlation study revealed that total yield of grain per plot was positively highly significant with culm length, width of grain and 1000 grain weight. Grain yield was found positive and no significant with other characters. The result showed that culm length, grain width and 1000 grain weight are highly associated with yield of grain so, these factors need to be considered during selection in further breeding programs. Similarly, regression analysis showed positive relationship between independent variables such as culm length, grain width and 1000 grain weight and dependent variable as total grain yield per plot. It showed that 21.84%,26.28% and 19.34% variation in grain yield was contributed by culm length, grain width and 1000 grain weight respectively while other variation are caused by other unknown factors.

A considerable amount of diversity was observed in some of the traits of the given genotypes in cluster analysis which was divided into four clusters. Cluster II comprised of maximum number (17) of varieties which showed that the genotypes carry some similar characteristics followed by cluster III (9) and IV (3) and the minimum (1) for cluster I. The intra-cluster distance was maximum in cluster III and minimum in cluster IV indicating that some genetic divergence still existed among the genotypes within each of these clusters. Selection within such clusters might be executed based on maximum mean values for the desirable characters. The highest inter- cluster distance was recorded between clusters III and IV, followed by cluster II and I. The varieties belonging to distantly located clusters may be used for further improvement of the desired trait(s). The greater the distance between two clusters, the wider the genetic diversity among the genotypes of those clusters. Such highly divergent, high performing genotypes would be of great use in recombination breeding program in order to get high heterotic recombinants.

The study of qualitative traits revealed that majority of the genotypes of landraces showed medium green leaf blade color, green basal leaf sheath color, glabrous leaf blade pubescence, whitish auricle and ligule color, intermediate habit angle, green lemma and palea color and lemma (color of apiculus). Similarly, most of the genotypes resulted whitish color of stigma, descending flag leaf altitude, very strong culm strength, well exserted panicle, strongly drooping panicle (attitude of main axis) and green culm underlying internode coloration. Shannon Weiner diversity index ranged from 0.54-1.39, which indicates higher the value of the diversity index, more the diversity presents in the trait. Highest diversity was exhibited by the trait culm strength followed by lemma (color of apiculus). This means that the germplasms had shown most diversity in these traits. Culm (underlying internode coloration showed least diversity index, which means that the 30 germplasms were least diverse in case of their Culm (underlying internode coloration). The evenness value ranged from 0.43-0.93. Evenness value gives the equality in the distribution of the traits in the population. Evenness value equal to one means a completely even population. The 30 genotypes were highly even in some traits whereas they were observed to have unevenness in the distribution as well. The trait having higher evenness value was found to be leaf blade pubescence and least evenness was observed in color of ligule.

IV. CONCLUSION

At present, a large number of local rice landraces in Nepal are replaced by few modern high yielding hybrid cultivars due to better yield potential, higher market demand, higher market price and short stature(Chaudhary et al., 2004). Which has ultimately resulted in the extinction and genetic erosion of these valuable landraces that are the carrier of valuable traits for varietal improvement in breeding programs. Landraces having short plant height, very long panicle length, more number of panicle per plant, and long slender grain can be used as potential donor in hybridization programs(Kumar et al., 2016). In order to identify these valuable traits hidden in our landraces collection, identification, characterization, conservation and multiplication is essential, which is a major objective of our study. Before enforcing conservation strategies, detailed understanding on how these landraces is lost from farming communities is needed. In-situ conservation and participatory plant breeding approach should be carried out at community level to provide farming communities with regular supply of seeds of these valuable landraces.

REFERENCES

[1]. Bajracharya, J., Steele, K. A., Jarvis, D. I., Sthapit, B. R., & Witcombe, J. R. (2006). Rice landrace diversity in Nepal: Variability of agro-morphological traits and SSR markers in landraces from a high-altitude site. Field Crops Research, 95(2–3), 327–335. https://doi.org/10.1016/j.fcr.2005.04.014

[2]. Chakrabarty, S. K., Joshi, M. A., Singh, Y., Maity, A., Vashisht, V., & Dadlani, M. (2012). Characterization and evaluation of variability in farmers' varieties of rice from West Bengal. Indian Journal of Genetics and Plant Breeding, 72(2), 136–142.

[3]. Chaudhary, P., Gauchan, D., Rana, R. B., Sthapit, B. R., & Jarvis, D. I. (2004). Potential loss of rice landraces from a Terai community in Nepal: a case study from Kachorwa, Bara. Plant Genetic Resources Newsletter, 137, 1–8.

[4]. Dey, S., Badri, J., Prakasam, V., Bhadana, V. P., Eswari, K. B., Laha, G. S., Priyanka, C., Rajkumar, A., & Ram, T. (2016). Identification and agro-morphological characterization of rice genotypes resistant to sheath blight. Australasian Plant Pathology, 45(2), 145–153. https://doi.org/10.1007/s13313-016-0404-9

[5]. Dhakal, A., Sharma, S., Pokhrel, A., & Poudel, A. (2020). Variability and Heritability Estimate of 30 Rice Landraces of Lamjung and Tanahun Districts, Nepal. Indonesian Journal of Agricultural Science, 21(1), 1. https://doi.org/10.21082/ijas.v21n1.2020.p1-10

[6]. Dikshit, N., Das, A. B., Sivaraj, N., & Kar, M. K. (2013). Phenotypic diversity for agro-morphological traits in 105 landraces of rice (Oryza sativa L.) from Santhal Parganas, Jharkhand, India. Proceedings of the National Academy of Sciences India Section B - Biological Sciences, 83(3), 291–304. https://doi.org/10.1007/s40011-012-0139-5

[7]. Gauchan, D., Smale, M., & Chaudhary, P. (2005). Market-based incentives for conserving diversity on farms: The case of rice landraces in Central Tarai, Nepal. Genetic Resources and Crop Evolution, 52(3), 293–303. https://doi.org/10.1007/s10722-003-1386-3

[8]. H. N., S. (2012). Collection and agro-morphological characterization of aromatic short grain rice in eastern India. African Journal of Agricultural Reseearch, 7(36), 5060–5068. https://doi.org/10.5897/ajar12.1612

[9]. Islam, M., Khalequzzaman, M., Bashar, M., Ivy, N., Haque, M., Mian, M., & Tomita, M. (2019). Agro-morphological Characterization of Bangladeshi Aromatic Rice (Oryza sativa L.) Germplasm Based on Qualitative Traits. Bangladesh Rice Journal, 22(2), 41–54. https://doi.org/10.3329/brj.v22i2.44041

[10]. Joshi, A., Agrawal, R. C., & Chawla, H. S. (2011). Assessment of distinctiveness, uniformity and stability of indigenous aromatic rice (Oryza sativa) varieties based on morphological descriptors. Indian Journal of Agricultural Sciences, 81(7), 595–601.

[11]. Keerthivarman, K., Juliet Hepziba, S., Gnanamalar, R. P., & Ramalingam, J. (2019). Characterization of rice (Oryza sativa L.) landraces based on agromorphological traits. Electronic Journal of Plant Breeding, 10(2), 627–635. https://doi.org/10.5958/0975-928X.2019.00079.6

[12]. Khush, G. S. (1997). Origin, dispersal, cultivation and variation of rice. Plant Molecular Biology, 35(1–2), 25–34. https://doi.org/10.1007/978-94-011-5794-0_3
[13]. Khush, G. S. (2013). Strategies for increasing the yield potential of cereals: Case of rice as an example. Plant Breeding, 132(5), 433–436. https://doi.org/10.1111/pbr.1991
[14]. Kibria, K., Islam, M. M., & Begum, S. N. (2008). Screening of aromatic rice lines by phenotypic and molecular markers. Bangladesh Journal of Botany, 37(2), 141–147. https://doi.org/10.3329/bjb.v37i2.1720
[15]. Kumar, V., Rastogi, N. K., Sarawgi, A. K., Chandraker, P., Singh, P. K., & Jena, B. K. (2016). Agro-morphological and quality characterization of indigenous and exotic aromatic rice (Oryza sativa L.) germplasm. Journal of Applied and Natural Science, 8(1), 314–320. https://doi.org/10.31018/jans.v8i1.793
[16]. Mathure, S., Shaikh, A., Renuka, N., Wakte, K., Jawali, N., Thengane, R., & Nadaf, A. (2011). Characterisation of aromatic rice (Oryza sativa L.) germplasm and correlation between their agronomic and quality traits. Euphytica, 179(2), 237–246. https://doi.org/10.1007/s10681-010-0294-9
[17]. MOAD. (n.d.). Statistical Information in Nepalese Agriculture. Ministry of Agriculture and Livestock, 290. https://nepalindata.com/resource/statistical-information-nepalese-agriculture-207374-201617/
[18]. Moukoumbi, Y., Sié, M., Vodouhe, R., N'dri, B., Toulou, B., Ogunbayo, S., & Ahanchede, A. (2011). Assessing phenotypic diversity of interspecific rice varieties using agro-morphological characterization. Journal of Plant Breeding and Crop Science, 3(5), 74–86.
[19]. Nandedkar, K., Sarawgi, A. K., Parikh, M., Saxena, R. R., & Rawte, S. (2020). Assessment of Diversity based on Agro-morphological and Quality Characterization of Germplasm Accessions of Rice (Oryza sativa L.). International Journal of Current Microbiology and Applied Sciences, 9(8), 2397–2408. https://doi.org/10.20546/ijcmas.2020.908.274
[20]. Ogunbayo, S. A., Ojo, D. K., Guei, R. G., Oyelakin, O. O., & Sanni, K. A. (2005). Phylogenetic diversity and relationships among 40 rice accessions using morphological and RAPDs techniques. African Journal of Biotechnology, 4(11), 1234–1244. https://doi.org/10.4314/ajb.v4i11.71398
[21]. Parikh, M., Motiramani, N., Rastogi, N., & Sharma, B. (2012). Agro-Morphological Characterization and Assessment of Variability in Aromatic Rice Germplasm. Bangladesh Journal of Agricultural Research, 37(1), 1–8. https://doi.org/10.3329/bjar.v37i1.11168
[22]. Pokhrel, A., Dhakal, A., Sharma, S., & Poudel, A. (2020). Evaluation of Physicochemical and Cooking Characteristics of Rice (Oryza sativa L.) Landraces of Lamjung and Tanahun Districts, Nepal. International Journal of Food Science, 2020(August). https://doi.org/10.1155/2020/1589150
[23]. Rao, L. V. S. (2013). DUS Characterization for Farmer varieties of rice. IOSR Journal of Agriculture and Veterinary Science, 4(5), 35–43. https://doi.org/10.9790/2380-0453543
[24]. Ray, A., Deb, D., Ray, R., & Chattopadhayay, B. (2013). Phenotypic characters of rice landraces reveal independent lineages of short-grain aromatic indica rice. AoB PLANTS, 5(June 2014). https://doi.org/10.1093/aobpla/plt032
[25]. Sajid, M., Khan, S. A., Khurshid, H., Iqbal, J., & Muhammad, A. (2015). Characterization of Rice (Oryza Sativa L.) Germplasm Through Various Agro-Morphological Traits. Scientia Agriculturae, 9(2). https://doi.org/10.15192/pscp.sa.2015.9.2.8388
[26]. Salgotra, R. K., Bhat, J. A., Gupta, B. B., & Sharma, S. (2017). Characterization of Indian basmati rice (Oryza sativa L.) germplasm collected from NW Himalayas using agro-morphometric markers. Research Journal of Biotechnology, 12(8), 44–55.
[27]. Sharma, R. C., Chaudhary, N. K., Ojha, B., Yadav, L., Pandey, M. P., & Shrestha, S. M. (2007). Variation in rice landraces adapted to the lowlands and hills in Nepal. Plant Genetic Resources: Characterisation and Utilisation, 5(3), 120–127. https://doi.org/10.1017/S1479262107837828
[28]. Shishir Sharma, Amrit Pokhrel, A. D. and A. P. (2020). Annals of plant sciences. Annals of Plant Sciences, 2(11), 489–493. https://doi.org/10.5281/aps.2020.9.2.3
[29]. Sinha, A.K., & Mishra, P. K. (2013). Agro-morphological characterization and morphology based genetic diversity analysis of landraces of rice variety (Oryza sativa L.) of Bankura district of West Bengal. International Journal of Current Research, 5(10), 2764–2769.
[30]. Sinha, A K, & Mishra, P. K. (2013). Agro-morphological characterization of rice landraces variety (Oryza sativa L.) of Bankura district of West Bengal. Research in Plant Biology, January 2013. http://updatepublishing.com/journal/index.php/ripb/article/view/2498
[31]. Sinha, Anjan Kumar, Mallick, G. K., & Mishra, P. K. (2015). Grain morphological diversity of traditional rice varieties (Oryza sativa L.), in lateritic region of West Bengal. International Journal of Conservation Science, 6(3), 419–426.
[32]. Sowmiya, C. A., & Venkatesan, M. (2017). Studies on correlation and path coefficient analysis in Rice (Oryza Sativa L.). International Journal of Current Microbiology and Applied Sciences, 6(9), 1757–1763. https://doi.org/https://doi.org/10.20546/ijcmas.2017.609.217
[33]. Tiwari, S., Yadav, M. C., Dikshit, N., Yadav, V. K., Pani, D. R., & Latha, M. (2020). Morphological characterization and genetic identity of crop wild relatives of rice (Oryza sativa L.) collected from different ecological niches of India. Genetic Resources and Crop Evolution, 67(8), 2037–2055. https://doi.org/10.1007/s10722-020-00958-9