MJSIR
Mountain Journal of Science and Interdisciplinary Research
PRINT ISSN: 2619-7855
ONLINE ISSN: 2651-7744
January-June 2020 • 80 (1) : 98-121

Germplasm Collection and Varietal Evaluation of Heirloom Rice Landraces in Benguet, Philippines

Belinda A. Tad-awan[1*], Hector C. Gayomba[1], Teresita D. Masangcay[2], Jasmin M. Chomawat[3], and Wilner S. Mauting[3]

1 – College of Agriculture, Benguet State University (BSU), Benguet, Philippines
2 – Northern Philippines Root Crops Research and Training Center, BSU, Benguet, Philippines
3 - Higher Education Regional Research Center, BSU, Benguet, Philippines
** Corresponding author email address: ba.tad-awan@bsu.edu.ph*

Abstract

Heirloom rice landraces are unique breeds of rice that are distinct from other rices in many characters. Heirloom rice is a principal crop planted in the rice terraces of Benguet and is now gaining momentum in the local and international market. Benguet province, an ethno society depicts an heirloom rice farming community which has preserved its rice landraces as demonstrated by its large production area. Documentation and germplasm collection was done in three major heirloom rice producing municipalities involving 330 heirloom rice farmers using a semi-structured questionnaire. Participatory evaluation of rice landraces with market potential was done with farmer-cooperators in three sites (Bakun, Kapangan, and Kibungan) where selection was done by other heirloom farmers during harvest. There were 82 rice landraces documented and collected in Bakun, Kapangan, and Kibungan. In the participatory evaluation and selection, the best landraces in each location based on yield, stability, and farmers' preference are *Brando, Lablabi* and *Lasbakan* in Bakun; *Sapaw, Balatinaw,* and *Bongkitan* in Kapangan, and *Balatinaw* and *Bongkitan* in Kibungan.

KEYWORDS

Heirloom rice
germplasm collection
participatory evaluation
stability analysis

Introduction

Heirloom rices landraces are usually grown in ancestral farms and were handed down from generation to generation through family members. Because of their aroma, good eating quality, minimum input and management, adaptability to the locality, stable yield and use in traditional practices, these landraces are still preferred by ethno-communities in Benguet and other provinces of the Cordillera region (Tad-awan & Sagalla, 2015).

These landraces are unique breeds of rice that are distinct from other rices in many characters. The quality and characteristics of heirloom rice landraces are attributed to the specific environmental condition, production practices and unique growth habitat (Gavilan, 2014). As a result, the crop carries potential and valuable genes which can be efficiently utilized in the modern day breeding programs.

Landraces serve as a source of local germplasm that has been collected and stored in gene banks. These are important to farming communities not only for food production but also their role in people's culture and traditions. When plant genetic resource diversity is lost, it is not only the genetic base of agriculture that is eroded, but also the rural people's identity and knowledge system (Anon, 1993).

Rice landraces do not only provide diversity and valuable gene pool but also part and parcel of the culture of Benguet province. Benguet rice farmers have been cultivating traditional rice landraces such as *Makanining, Kintoman, Sabul,* etc. which are not only utilized as staple and in some rituals (Solimen et al., 2010). In three locations of Benguet, Tad-awan and Sagalla (2011) found that *Bayabas* and *Lablabi* were the best performers among the glutinous rice cultivars, based on yield and return on cash expense. These cultivars were also selected by the farmers. For the non-glutinous rice cultivars, the best performer was *Sapaw,* having produced the highest yield. *Sapaw* was also selected by the farmers.

Rice growers claim that heirloom rice production had decreased over the years due to low-yielding landraces. One way to increase production is to identify landraces that can produce high yields in specific locations. Evaluation and selection is the first step in identifying heirloom rice variety that is high yielding and adapted to a specific location. 'Heirloom rices' are valuable genetic resources of ethno-communities; thus, these communities play a key role in preventing the genetic erosion of these landraces. The best way to conserve and sustain crop diversity for the community's food security is to motivate heirloom rice grower's participation in the conservation and evaluation activities (Rasabandit et al., 2006). Participatory selection is an excellent way to evaluate and select landraces in ethno-communities of Benguet.

The objective of the study was to conserve the rice landraces with market potential and further identify and recommend the best performing rice landrace/s in terms of growth, yield, resistance to pests and diseases, stability, and farmers' preferences in specific locations.

Materials and Methods

Securing of Free Prior Informed Consent (FPIC)

Prior to the conduct of the study, the indigenous community's FPIC in compliance with RA 8371 was secured. The procedures in the FPIC was followed with NCIP. The conduct of FPIC consultation was done with the representatives from NCIP, local government units, elders, heirloom rice growers, and other stakeholders of Bakun, Kapangan, and Kibungan. One month after the consultation, the FPIC was granted.

Study Sites

The study was conducted in three heirloom rice-producing municipalities and representative ethno-communities (Table 1 and Figure 1). Bakun has two land belts, the low elevation belt where rice is planted on irrigated fields, and the high elevation belt where people plant rootcrops because of the cool climate (LGU-Bakun, 2019). Kapangan's terrain is characterized by rugged mountains and hills, which are used in farming. The main crops being planted are rice, cassava, sweetpotato, gabi, coffee, and banana (LGU-Kapangan, 2019). Kibungan is known as the "Switzerland of Benguet" because of its beautiful alps and rocky mountains. Aside from these, it is also known for its manmade, century old rice terraces at the lower elevated communities where different heirloom rice landraces are being grown (LGU-Kibungan, 2019). Poblacion, Kibungan was the specific study site due to its century-old rice terraces where heirloom rice is being planted (Figure 2).

Table 1

Characteristics of the Study Sites in Benguet, Philippines

Municipality/Barangay		Coordinates	Elevation
Kibungan	Poblacion	N16^{O} 70'48.8" E120^{O} 66'72.1"	843 m asl
Bakun	Poblacion	N16^{O}46'50.3" E120^{O}39'55.9"	1196 m asl
Kapangan	Taba-ao	N16^{O} 58'23.9" E120^{O} 63'16.5"	930 m asl
	Balakbak	N16^{O} 64'09.1" E120^{O} 63'48.9"	963 m asl

Figure 1

Map of the Study Sites in Benguet Province

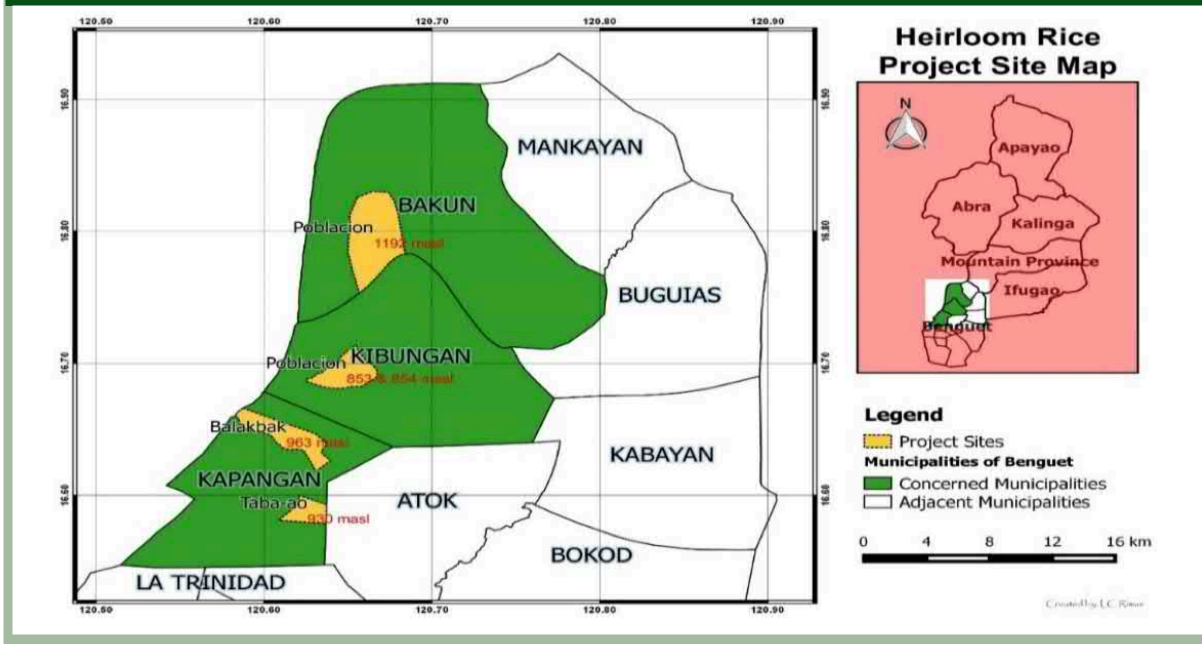


Figure 2

Overview of the Experimental Site in Poblacion, Bakun (left), Balakbak, Kapangan (middle) and Rice Terraces in Kibungan, Benguet (right)

Documentation of Rice Landraces in Benguet

Before the conduct of the multi-location trials, survey, and documentation of heirloom rice landraces were done in the different ethno-communities using a semi-structured questionnaire. The number of respondents was calculated using the Slovins method. The socio-demographic profile of the respondents is shown in Table 2. A total of 330 heirloom rice farmers served as respondents, 71 in Bakun, 109 in Kapangan and 150 in Kibungan. Majority of the respondents are married (85%) aging 51-60 (29%). Majority of the respondents have long experience in rice farming cultivating heirloom rice for 21-30 years (27%) and 41-50 years (23%). As to the source of income, all the respondents are engaged in farming as their main source of income. Aside from farming, 25% of the respondents have some additional source of income.

Table 2

Socio-demographic Profile of the Respondents in Bakun, Kapangan, and Kibungan, 2017

Particulars	Bakun		Kapangan		Kibungan		Total	
	n=71	%	n=109	%	n=150	%	n=330	%
Age (years)								
21-30	4	6	2	3	10	7	16	5
31-40	9	13	10	11	25	17	44	13
41-50	13	18	28	23	34	23	75	23
51-60	29	41	31	33	35	23	95	29
61-70	15	21	29	24	24	16	68	21
71- and above	1	1	9	6	19	13	30	9
Farming Experience (years)								
1-10	1	1	7	6	11	7	19	6
11-20	10	14	11	10	25	17	46	14
21-30	18	25	32	29	37	25	87	27
31-40	23	32	21	19	26	17	70	21
41-50	16	23	31	28	28	19	75	23
51-60	3	4	5	5	12	8	20	6
61-70	-	-	1	1	6	4	7	2
71- and above	-	-	1	1	1	1	2	0.6
Source of Income								
Farming	94	86	67	94	150	100	280	85
Others	15	14	4	6	63	42	82	25

Participatory Evaluation and Selection of Rice Landraces in Different Locations of Benguet

Cropping Seasons

Rice landraces were evaluated for two cropping seasons; December 2017 to July 2018 (1st cropping) and August 2018 to March 2019 (2nd cropping).

Farmer Partners

Farmer-partners who are cultivating heirloom rice for 10 to 20 years were involved in the trials.

Rice Landraces Evaluated

Out of the rice landraces documented and collected in Bakun, Kibungan, and Kapangan, Benguet, some were selected for further evaluation. The foremost consideration was market potential, which was evaluated by the stakeholders (farmer-growers, consumers, LGUs, DA-CAR and BSU) during a consultation meeting. The farmers and LGUs evaluated the market potential based on the grain characters (brown, red, purple, and white pericarp). Aside from their market potential, the distinguishing characteristics of the landraces were considered (Table 3 and Figure 3). These rice landraces vary in their grain characteristics. Specific sets of the documented and collected rice landraces in each location were evaluated in the same site. Each site had a specific check landrace, which is the commonly grown landrace by heirloom farmers in the particular site. In Poblacion, Bakun, the rice landraces evaluated were *Balatinaw, Bongkitan, Kalipago, Lablabi,* and *Lasbakan* (check). The rice landraces evaluated in Taba-ao and Balakbak, Kapangan were B*alatinaw, Bongkitan, Lablabi, Sapaw, and Talokitok* (check). In Poblacion, Kibungan, the rice landraces were *Balatinaw, Bongkitan, Kabal* (check), *Lablabi,* and *Lasbakan.*

Experiment Proper

Preparation of seedlings was based on the farmers' practices, wet-bed method during the first

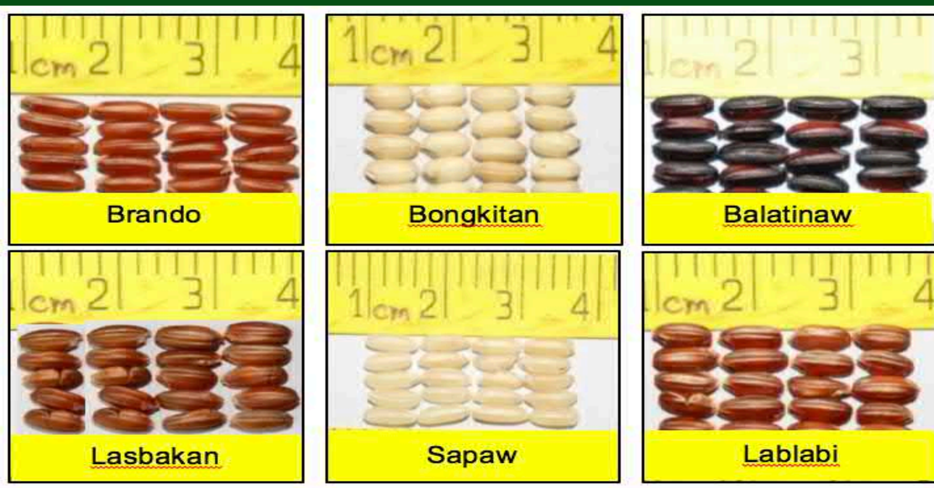
Table 3

Distinguishing Characteristics of the Rice Landraces Evaluated

Rice Landrace	Distinguishing Characteristics				
	Awn Distibution (Awn Char)	Awn Length	Lemma and Pale Color	Caryopsis Shape	Pericarp Color
Balatinaw	Partly awned	Very short	Straw	Spindle shaped	Purple
Bongkitan	No awn	-	Straw	Spindle shaped	White
Kabal	No awn	-	Red	Semi round	Red
Kalipago	Partly awned	Very long	Straw	Half spindle	Red
Lablabi	Whole length	Very long	Black	Half spindle	Red
Lasbakan	Whole length	Very long	Straw	Spindle shaped	Red
Sapaw	Whole length	Very long	Straw	Long spindle	Light brown
Talokitok	Partly awned	Ver short	Purple	Half spindle	Light brown

Figure 3

Some of the Distinguishing Characteristic of Heirloom Rice Landraces



season, and dry-bed method during the second season in Bakun. Dry-bed sowing was done during the first season in Kibungan, while wet-bed during the second season. The wet-bed method was done for both seasons in Kapangan. Each field was thoroughly prepared and equally divided into three blocks (Figure 4). Each block was further subdivided into uniform plot sizes ($8m^2$). Trials were laid out in randomized complete block design (RCBD) with three replications in each location. Farmers practices such as: incorporating crop residues and weeds into the soil during the land preparation and picking golden snails were done before transplanting. Transplanting was done at one seedling per hill at a distance of 25cm x 25cm between hills and rows (Figure 4). Non-application of synthetic fertilizers and pesticides or organic production practices were employed uniformly in all the trials.

Data Gathered

Meteorological Data

The temperature and relative humidity were taken using a hygrometer. Rainfall was gathered

Figure 4

Land Preparation of the Experimental Site (left), Layout (middle) and Transplanting of Rice Seedlings (right)

by placing plastic containers in the field to collect water when precipitation occurs. The volume of water was collected then be measured using a graduated cylinder. Light intensity was taken using a digital light meter.

Soil Chemical and Physical Properties

Soil samples were collected from the experimental area before planting and after harvest, and were analyzed at the laboratory of Soil Science, College of Agriculture, Benguet State University.

Maturity

Number Days from Transplanting to Booting. This was recorded when at least 50% of the total plant in a plot booted, as shown by the swelling of the upper flag leaf sheath.

Number of Days from Heading to Ripening. This was recorded when at least 80% of the plant panicles turned yellow.

Number of Tillers Produced

The number of tillers were counted before booting using ten hills per treatment.

Number of Productive Tillers per Hill

The number of productive tillers were counted using ten hills per treatment selected randomly. Only the rice plants which produced panicles were considered productive.

Reaction to Pest and Disease Incidence

Reaction to Stem Borer. The following key was used in assessing injury of stem borers causing deadhearts (tillering to booting stage) and whiteheads (dough stage to mature grain) on field based on Standard Evaluation System for rice by the International Rice Research Institute (IRRI) (2013).

Scale	Description
0	No injury
1	1-10% injury
3	11-20% injury
5	21-30% injury
7	31-60%
9	61% and above

Reaction to leaf spot. The key for assessing severity of leaf spot was based on Standard Evaluation System for rice by IRRI.

Scale	% Leaf diseased
0	No disease observed
1	Less than 1%
3	1-5%
5	6-25%
7	26-50%
9	51-100%

Yield and Yield Components

Number of filled and unfilled grains per panicle. This was recorded by counting the number of filled and unfilled grains at heading.

Yield per plot (kg). Grain yield per plot was taken after threshing and drying at 14% moisture content (MC) then weighed.

1000 grains weight (g). Random samples of 1000 well-developed, whole grains dried at 13% moisture content were weighed on a sensitive balance.

Computed yield per hectare (kg). This was taken by converting grain yield per treatment into yield per hectare using ratio and proportion.

$$\text{Yield (t/ha)} = \frac{\text{Yield per plot (kg)}}{\text{Plot size}} \times \frac{X}{1 \text{ ha } (10{,}000 \text{ m}^2)}$$

Stability Analysis of Rice Landraces

GGE Biplot Software Version 4.1 was used for the analysis based on GGE biplot (Yan & Tinker, 2006). This software was used to determine the stability of the rice landraces for two seasons in each location. The rice landraces are the genotypes, while the cropping seasons are the environments.

Participatory Varietal Selection

Ten farmers in each community, together with the farmer-partners, participated in the selection of the different rice landraces at harvest. Smiling and sad faces made of paper were distributed after explaining the mechanics of the activity. Smiling faces represented the most preferred variety, while sad faces represented the least preferred variety. The farmers walked through the plots and observed the landraces before expressing their preferences through the ballots. Preference score index was generated for each variety using the following formula (IRRI, 2006):

$$\text{Preference Score Index} = \frac{\text{Number of positive votes} - \text{Number of negative votes}}{\text{Total number of votes}}$$

Sensory Evaluation of Rice Landraces

A total of 20 evaluators aged 18 years and above assessed the different rice landraces based on the sensory qualities of cooked rice.

Nutritional Analysis of Some Rice Landraces

The nutrient analysis of four selected rice landraces was done at IRRI. The Department of Agriculture- Cordillera Administrative Region (DA-CAR) researchers brought samples to IRRI.

Results and Discussion

Documentation and Germplasm Collection of Rice Landraces

Rice Landraces Documented/Collected

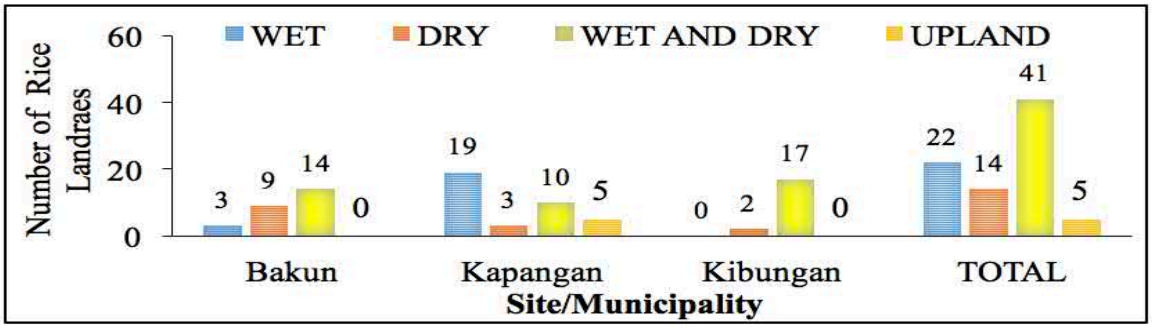
A total of 82 rice landraces were documented and collected: 37 in Kapangan, 26 in Bakun, and 19 in Kibungan (Figure 5). Majority (41) of the documented rice landraces are planted in both wet and dry seasons, 22 for the wet season, 14 for the dry season, and 5 for uplands. In Bakun and Kibungan, most of the rice landraces are planted in both seasons while in Kapangan, most of the rice landraces are planted for wet season only. There were also five rice landraces for upland planting during the wet season in Kapangan.

Among the 26 rice landraces planted by farmers in Bakun, the most cultivated variety is *Balisanga* (Table 4). Other landraces cultivated include B*ongkitan, Kandiling, Balatinaw,* and *Ngimol,* which are cultivated in both wet and dry seasons. In Kapangan, *Bongkitan* is the most cultivated variety (Table 4). *Balatingi* and *Wagwag* are cultivated by 16.5% of the farmers. *Bingawan, Balatinaw, Kulot, Ngalabngab, Saba,* and *Topel* are cultivated by 10.1-12.8%. *Bongkitan* is the most planted variety by the farmers in Kibungan (Table 4). Other landraces commonly planted are *Balisanga, Kabal, Oklan,* and *Talokitok*. These landraces are grown by the respondents during the wet and dry seasons.

It was observed that the number of collected/ documented rice landraces was high in Benguet. This observation coincides with the Department of Agriculture Cordillera Administrative Region (DA-CAR) report, citing that Benguet province had the highest number of rice landraces cultivated

Figure 5

Number of Rice Landraces Documented/Collected per Municipality/Site Classified According to Season When Cultivated, 2017



though it is not known as a rice producing province. The report indicates that 6-18 traditional landraces each in 12 barangays of Atok and Kibungan, Benguet are still being grown by the farmers (Domoguen, 2011). The report of DA-CAR and the result of this present study coincide with Tad-awan and Sagalla (2015), which documented, collected and characterized 90 rice landraces in Benguet.

Participatory Evaluation and Selection of Rice Landraces in Different Locations of Benguet

Climatological Data During the Conduct of the Trials

Bakun. The average temperature ranged from 17-30ºC from February to December except in January, which dropped to 13.9ºC in the second cropping (Figure 6). The temperature was observed to be low for the rice plants during the growing season, which resulted in cold stress. Daba et al. (2016) reported that cold stress delay flowering, inhibited panicle exertion, reduced panicle length, spikelet fertility, grain filling, and strongly reduced yields. Accordingly, an average temperature below 15ºC results in slow vegetative growth and inhibit flowering (IRRI, 2015). Relative humidity ranged from 51 to 66%. Rainfall occurred throughout the two cropping seasons with a total of 2,141mm, which is sufficient for rice production. A high amount of rainfall was recorded from June to September.

Kapangan. The average temperature recorded ranged from 19-31ºC (Figure 7). The temperature is within the optimum range favorable for rice

Table 4

Most Widely Cultivated Rice Landraces (>10%) by Farmers in Bakun, Kapangan, and Kibungan, 2017

Municipality/ Rice Landraces	% Farmers	Season	
		Wet	Dry
Bakun			
Balatinaw	19.7	/	/
Balisanga	28.0	/	/
Bongkitan	21.0	/	/
Kandiling	21.1	/	/
Ngimol	19.7	/	/
Kapangan			
Balatinaw	11.9	/	x
Balatingi	16.5	/	/
Bingawan	10.1	/	/
Bongkitan	19.3	/	/
Kulot	11.9	/	x
Ngalabngab	11.9	/	x
Saba	11.9	x	/
Topel	12.8	/	x
Wagwag	16.5	/	x
Kibungan			
Balatinaw	16.0	/	/
Balisanga	22.7	/	/
Bongkitan	24.0	/	/
Camporo	16.0	/	/
Diket red	14.7	/	/
Kabal	20.0	/	/
Lasbakan	14.7	x	/
Oklan	20.0	/	/

Figure 6

Temperature, Relative Humidity and Rainfall during the Conduct of Study in Bakun, 2018-2019

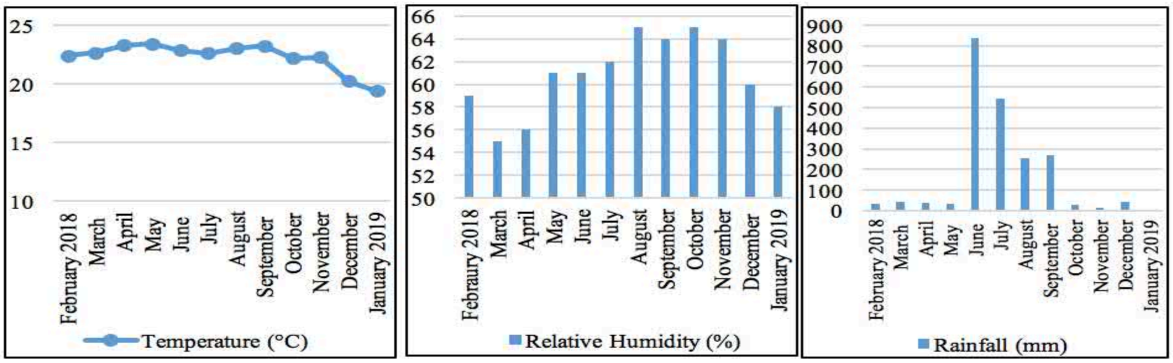
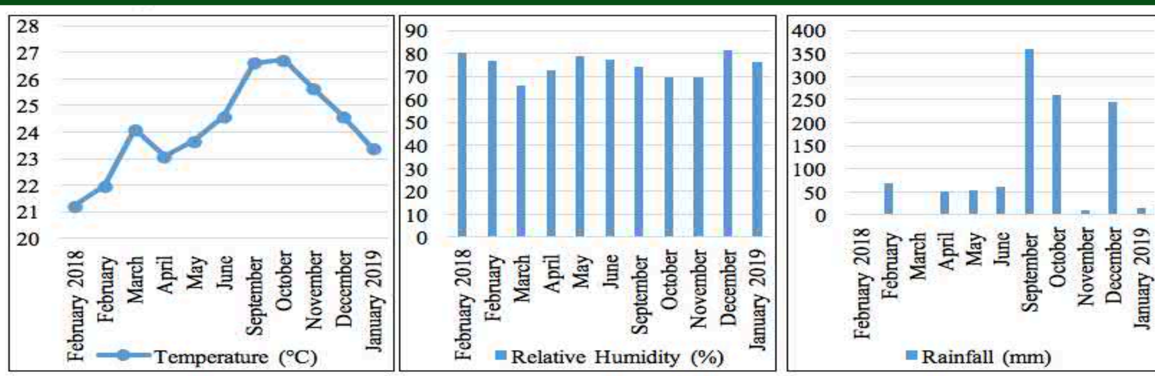


Figure 7

Temperature, Relative Humidity and Rainfall during the Conduct of Study in Kapangan, 2018-2019



production which is 18-40°C as cited by De Datta (1981). The average relative humidity ranged from 63-87.4%. The total rainfall for the first and second cropping was 234.5mm and 890mm, respectively.

Kibungan. The average temperature ranged from 14.1 to 27.1 (Figure 8). Low temperature was observed during ripening stage from January to February. The relative humidity in the two cropping seasons ranged from 53.8 to 80.3%, which is suitable for growing rice. High rainfall was recorded during the cropping seasons.

Growth, Yield, and Stability of Rice Landraces and Varietal Preference of Farmers in Bakun

Number of Days from Transplanting to Booting

The heirloom rice landraces significantly booted at 97 to 114 days for the first season and 107 to 118 days during the second season (Figure 9). Among the landraces, *Kalipago* was the earliest to boot at 97 and 107 days, while *Balatinaw* was the latest to boot at 114 and 118 days during the first and second cropping seasons.

Number of Days from Transplanting to Ripening

The different heirloom rice landraces varied in terms of days from transplanting to ripening (Figure 9). Rice landraces had long maturity ranging from 154 to 171 days for the first cropping season and 159 to 170 days for the second cropping season. *Kalipago* was the earliest to ripen for both season at 154 to 159 days, while the latest was *Balatinaw* at 170 - 171 days. The late-ripening period observed was 160 days, a characteristic of rice landraces (Chakravorty & Ghosh, 2014).

Figure 8

Temperature, Relative Humidity and Rainfall during the Conduct of Study in Kibungan, 2018-2019

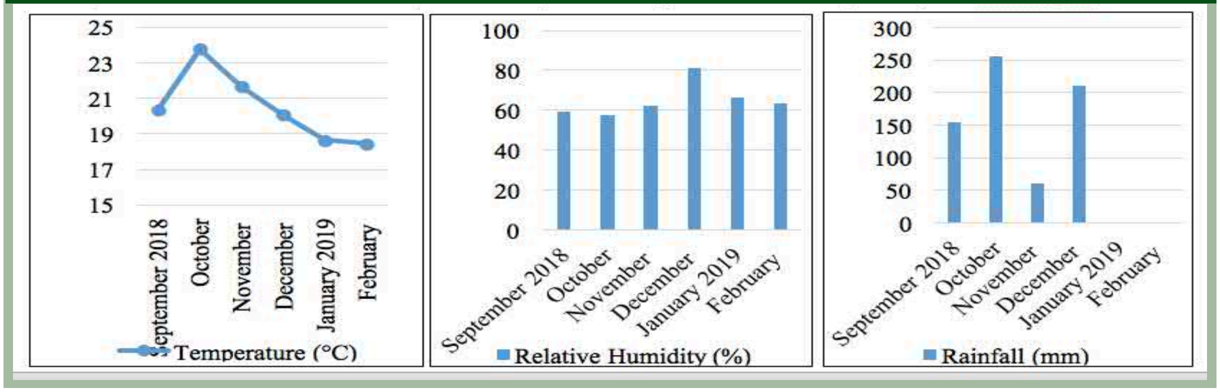
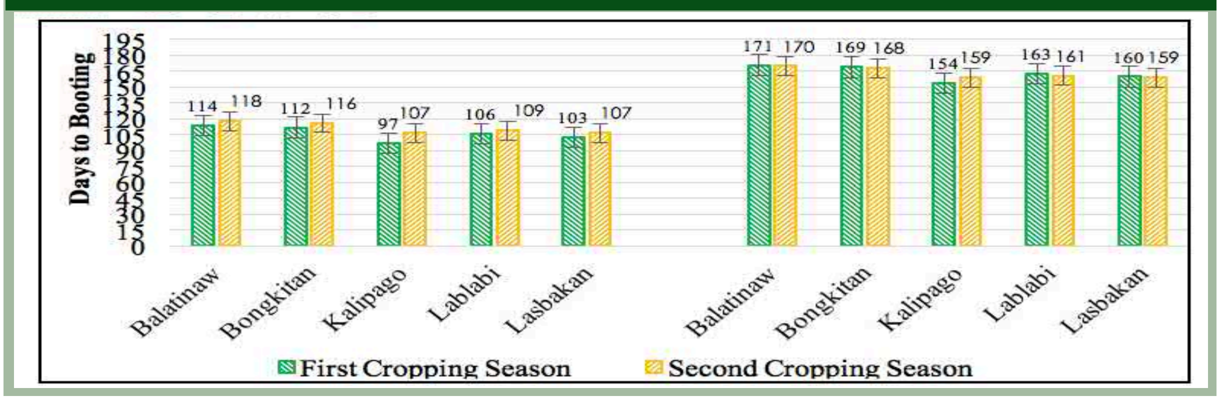


Figure 9

Number of Days from Transplanting to Booting and Ripening of Heirloom Rice Landraces in Bakun for Two Cropping Seasons, 2017-2019



Tillering Ability of Heirloom Rice Landraces

The number of tillers and productive tillers significantly varied among the heirloom rice landraces in Bakun (Figure 10). The rice landraces produced more tillers and productive tillers during the first season. *Balatinaw* had the most tillers and productive tillers in both seasons. In the first cropping season, *Balatinaw* significantly produced the most numberof tillers, but comparable with *Lablabi*. The productive tillers produced by *Balatinaw* and *Lablabi* were comparable with *Lasbakan* and *Bongkitan*. *Kalipago* produced the least productive tillers in the first season and *Lablabi* in the second season. Similar results were reported on genetically controlled characters such as panicle branching and tillering on rice landraces (Sinha & Mishra, 2013).

Number of Filled Grains per Panicle of Rice Landraces

The number of filled grains per panicle varied among the landraces during the second season. More number of filled grains were produced during the first season (Figure 11). *Lablabi* had the most filled grains for both seasons. During the first season, *Balatinaw* significantly produced the highest number of filled grains. *Bongkitan* and *Balatinaw* produced the least filled grains during the second season. The results agree with earlier reports of a wide range of variation of filled grains per panicle on rice landraces in India (Nachimuthu et al., 2014).

Figure 10

Number of Tillers, Productive Tillers per Hill of Heirloom Rice Landraces in Bakun for Two Cropping Seasons, 2017-2019

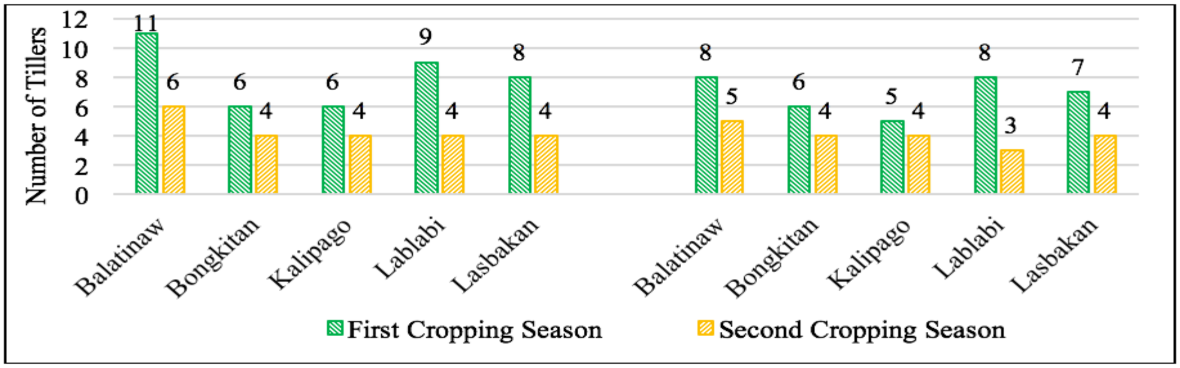
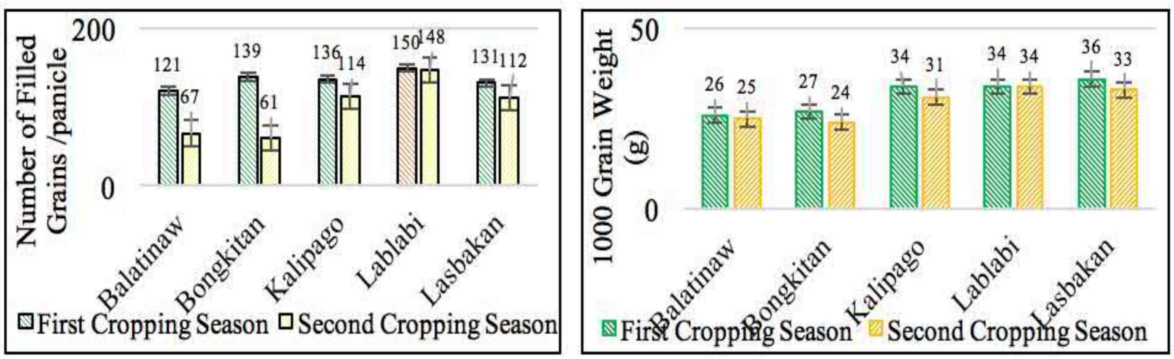


Figure 11

Number of Filled Grains per Panicle and Weight of 1000 grains of Heirloom Rice Landraces in Bakun for Two Cropping Seasons, 2017-2019



Weight of 1000 Filled Grains

There was a significant variation in the weight of 1000 filled grains of rice landraces, which ranged from 24-36g (Figure 11). *Lasbakan, Lablabi,* and *Kalipago* consistently produced heavy grains in both seasons. There is also a high variation for 1000-grain weight. Studies show that grain yield parameters including 1000-grain weight have high heritability in rice landraces, which may explain the significant variation (Chakravorty & Ghosh, 2014).

Grain Yield per Plot and Computed Yield

Grain yield per plot in the first cropping did not vary but ranged from 2.43 to 3.04kg/plot (3.04 to 3.80 t/ha). Rice landraces significantly varied in their grain yield during the second cropping season ranging from 0.64 to 2.43kg/plot (0.80 to 3.04t/ha). *Lablabi* consistently produced the highest grain yield with 3.04kg/plot (3.80t/ha) for the first season and 2.43kg/plot (3.04t/ha) in the second season. *Bongkitan* produced the least grain yield among the heirloom rice landraces. The high grain yield of *Lablabi,* which is more than two tons on average can be attributed to its high number of productive tillers and filled grains per panicle and heavy 1000 filled grains (Figure 12). The same variability were reported by Zahid et al. (2005), who studied 12 rice genotypes. This variation in the grains yield might be due to the environment (Mahapatra, 1993) or the correlation of grain yield/plant with various yield contributing characteristics like; grains/panicle, number of grains/panicle and grain weight. Similarly, Mirza et al. (1992) reported a positive correlation among the number of panicle per plant, panicle length, number of grains panicle and 1000-grain weight and grain yield per plant.

Reaction of Rice Landraces to Stem Borer

The rice landraces were moderately resistant to resistant to stem borer during the first cropping season. *Balatinaw* and *Bongkitan* were rated resistant, while *Lablabi* and *Lasbakan* were moderately resistant. All the landraces during the second cropping were rated resistant (Table 5).

Reaction of Rice Landraces to Leaf Spot

It was observed that leaf spot infection was minimal, which ranged from 2-4 (1 to 10% leaf area diseased) and 0-4 (0 to 10% leaf area diseased) during the first and second cropping seasons, respectively (Table 5). Among the landraces, *Balatinaw* and *Lablabi* were the least infected in the first season. On the other hand, *Kalipago* was the most infected with leaf spot. *Kalipago* and *Lablabi* had no lesions during the second season, while *Balatinaw, Bongkitan,* and *Lasbakan* had 6-10% leaf spot.

Studies show that landraces are part of a vast collection of germplasm known to have genes

Figure 12

Grain Yield/Plot and Computed Yield of Rice Landraces in Bakun for Two Cropping Seasons, 2017-2019

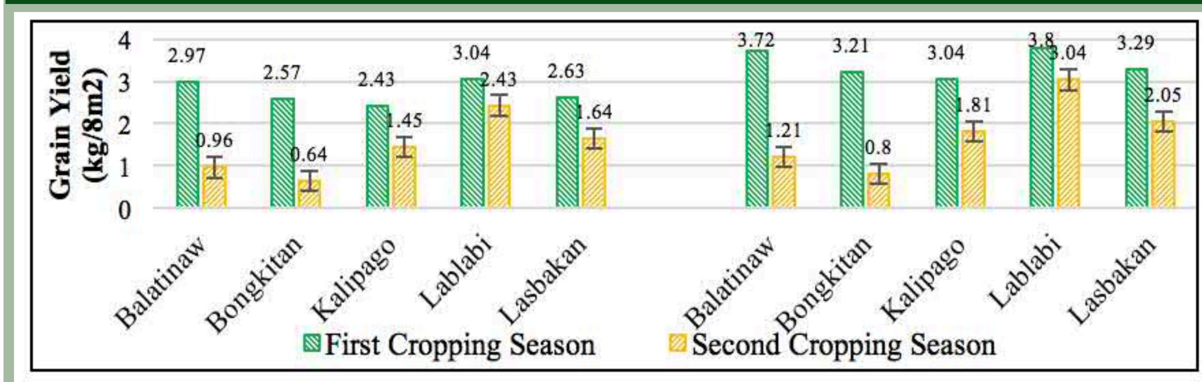


Table 5

Reaction of Rice Landraces to Stem Borer and Leaf Spot in Bakun for Two Cropping Seasons, 2017-2019

Rice Landraces	Stem Borer (Whiteheads)		Leaf Spot	
	1st Season	2nd Season	1st Season	2nd Season
Balatinaw	Resistant	Resistant	2	4
Bongkitan	Resistant	Resistant	3	4
Kalipago	Intermediate	Resistant	4	0
Lallabi	Moderately resistant	Resistant	2	0
Lasbakan	Moderately resistant	Resistant	3	4

**Leaf spot rating: 0=no lesions observed; 1=less than 1% leaf area diseased; 2=1-3% leaf area diseased; 3=4-5% leaf area diseased; 4=6-10% leaf area diseased; 5=11-15% leaf area affected; 6=16-25% leaf area diseased; 7=26-50% leaf area diseased; 8=54-75% leaf area diseased; 9=76-100% leaf area diseased* for resistance to diseases. For instance, in tungro virus, several near isogenic lines carrying resistance genes from diverse donors of traditional varieties have been produced (Leung et al., 2003).

Yield Stability Rice Landraces in Bakun

GGE biplot between genotype (rice landraces) and environment (cropping seasons) is shown in Figure 13. The single arrowed line or average environment coordination (AEC abscissa) points to higher mean across environments (Yan & Tinker, 2006). *Lablabi* and *Lasbakan* are the highest yielding landraces. On the other hand, *Bongkitan* is the lowest yielding among the rice landraces. The double arrowed line is the AEC ordinate that points to greater variability (poorer stability) in either direction. *Lasbakan* and *Kalipago* are considered stable landraces, while *Lablabi*, *Balatinaw,* and *Bongkitan* have poor stability. The best rice landrace for Bakun is *Lasbakan,* as indicated by its high yield and stability. The mean yield of the rice landraces used in this experiment over the cropping period differed substantially. This is indicative of the wide genetic background of the rice landraces. This result agrees with earlier reports of Egesi et al. (2001) and Brondani et al. (2006). The genetic makeup of seed, effect of environment and field management practices have been reported to influence a crop's morphology (Singh & Rachie, 1985).

Varietal Preference of Heirloom Rice Farmers in Bakun

Preference scores of the rice landraces in Bakun was diverse (Table 6 and Figure 14). Among the heirloom rice landraces, *Bongkitan* and *Lablabi* had the highest preference scores implying higher acceptability. Negative scores of *Balatinaw* and *Lasbakan* indicate lower acceptability by the farmers. The reasons for choosing a landrace were: more productive tillers, long panicles with full and plump grains, and tall plants.

Growth, Yield, and Stability of Rice Landraces and Varietal Preference of Farmers in Kapangan

Number of Days from Transplanting to Booting

The number of days to booting varied from 86-98 days and 85-95 days in the first and second cropping seasons, respectively (Figure 15). The earliest to boot was *Sapaw*. The latest to boot was *Balatinaw* in the first cropping while *Bongkitan* in the second cropping.

Number of Days from Transplanting to Ripening

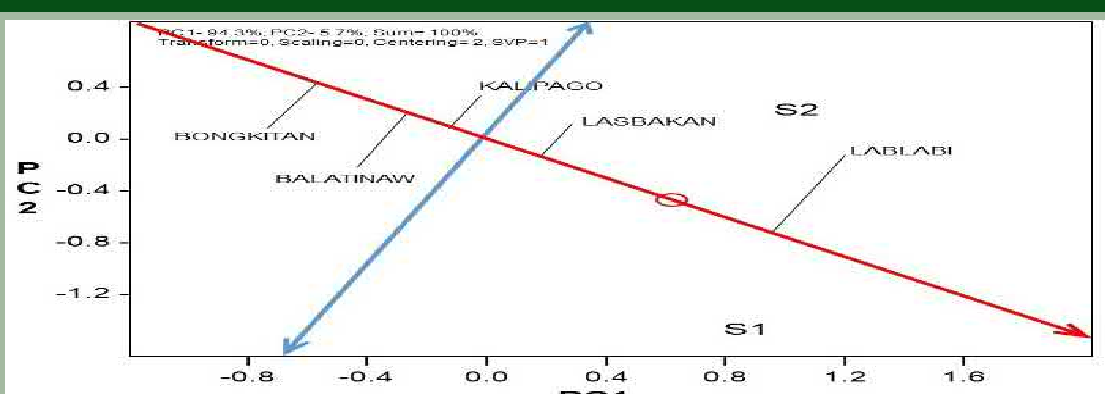
Sapaw ripened earlier (141 and 133 days) than the other rice landraces, while *Balatinaw* and *Bongkitan* were the latest to ripen (138-153 days). Days to ripening of the rice landraces varied from 141 to 153 days in the first cropping season. During the second cropping, maturity of the landraces was slightly earlier, which ranged from 133 to 143 days (Figure 15).

Tillering Ability of Heirloom Rice Landraces

The number of tillers and productive tillers of

Figure 13

GGE Biplot Showing Relationship among Environments for Grain Yield Five Rice Landraces in Bakun



Environments: S1- First season (December to July 2018); S2- Second season (August-March 2019); Grand Mean: 3.15

Table 6

Preference Scores and Reasons for Selecting Rice Landraces by the Farmers in Bakun, Benguet, 2018-2019

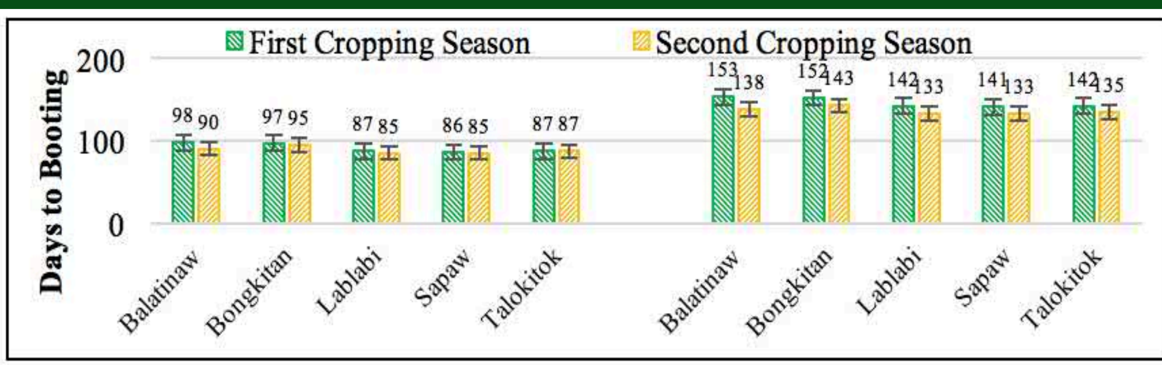
Rice Landraces	Preference Score Index	Reasons
Balatinaw	-0.33	More productive tillers
Bongkitan	1.00	More productive tillers
Kalipago	0.50	Long panicles with full and plump grains
Lallabi	1.00	Long panicles with full and plump grains, tall plant height
Lasbakan	-0.14	More tillers, long panicles with full and plump grains

Figure 14

Heirloom Rice Farmers Doing Selection at the Experimental Field in Bakun, 2019

Figure 15

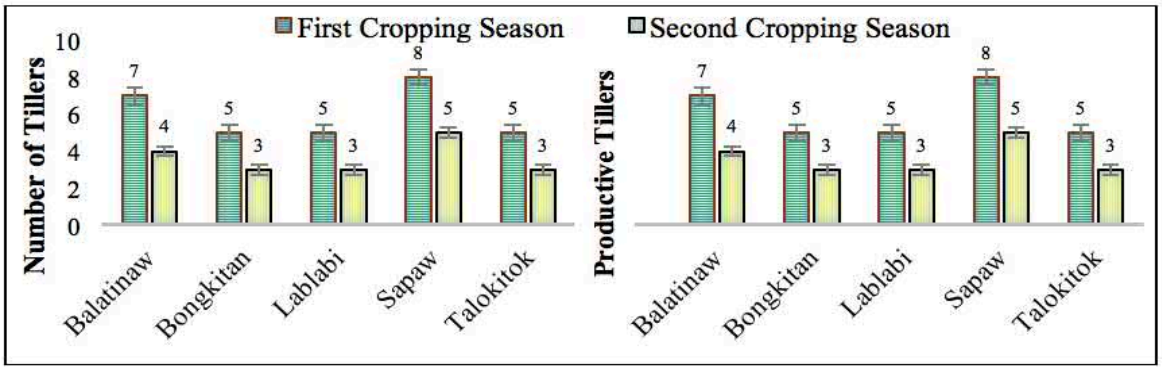
Number of Days from Transplanting to Booting and Ripening of Heirloom Rice Landraces in Kapangan for Two Cropping Seasons, 2017-2019



the rice landraces varied from the highest in *Sapaw* (7-8) during the first and second cropping seasons and lowest in *Talokitok*, *Lablabi,* and *Bongkitan* at 3 (Figure 16). More tillers and productive tillers were produced during the first season. The variation among the heirloom rice landraces for tillering ability may imply high heritability.

Figure 16

Number of Tillers and Productive Tillers of Rice Landraces in Kapangan for Two Cropping Seasons, 2017-2019



Number of Filled Grains per Panicle

The number of filled grains of the rice landraces were significantly different ($p<0.05$) during the second cropping season but not significant in the first cropping (Figure 17). *Bongkitan* produced the most filled grains (124) but comparable with *Balatinaw* (118), *Sapaw* (118), and *Talokitok* (115). *Lablabi* produced the least filled grains during the first cropping season but produced the most filled grains during the second cropping season.

Weight of 1000 Filled Grains

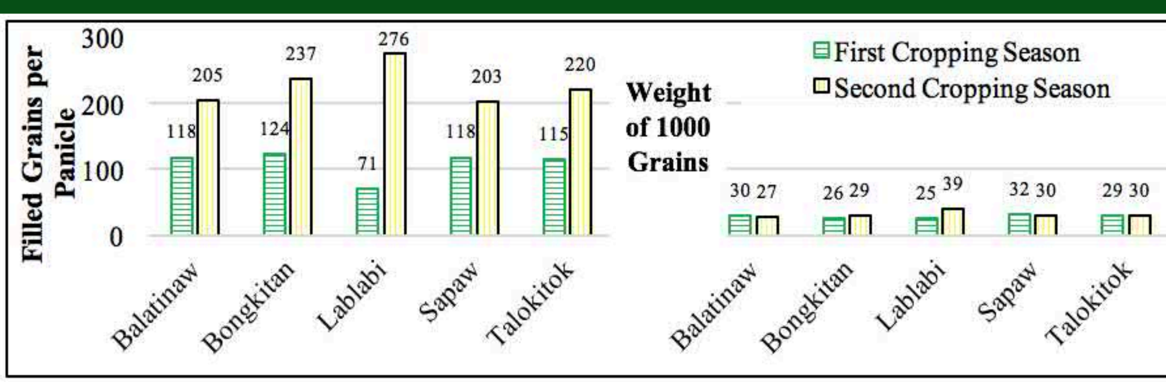
The rice landraces' 1000-grain weight varied in both seasons from 27-39g (Figure 17). *Sapaw* (32g) and *Balatinaw* (30g) significantly produced the heaviest 1000-filled grains, while the lightest was *Lablabi* during the first cropping season. During the second cropping season, *Lablabi* produced the heaviest 1000 seeds at 39g while *Balatinaw* was the lightest at 27g.

Grain Yield per Plot and Computed Yield

There was a significant variation on the grain yield per plot and computed yield of the rice landraces in the first and second cropping seasons (Figure 18). Some of the landraces have more grain yield during the first cropping season but lessened during the second cropping season and vice versa. *Balatinaw* produced the most grain yield perplot at 3.14kg/plot (3.93t/ha) during the first cropping season but comparable with *Talokitok*, *Bongkitan*, and *Sapaw*. During the second cropping season, *Sapaw* produced the highest grain yield at

Figure 17

Filled Grains per Panicle and Weight of 1000 Grains of Rice Landraces in Kapangan for Two Cropping Seasons, 2017-2019



3.51kg/plot (4.39t/ha), while *Lablabi* and *Talokitok* produced the least grain yield at 2.01kg/plot (2.51t/ha) and 2.07kg/plot (2.59t/ha), respectively.

Reaction of Rice Landraces to Stem Borer

All the rice landraces were rated resistant to stem borer in the first cropping season (Table 7). During the second cropping season, stem borer rating was moderately resistant to resistant. *Bongkitan* and *Sapaw* were rated most resistant to stem borer, while *Balatinaw*, *Lablabi,* and *Talokitok* were rated moderately resistant.

Reaction of Rice Landraces to Leaf Spot

The reaction of rice landraces to leaf spot during the first cropping season ranged from 1 to 4 (>1 to 10% leaf area diseased). The least infected the *Talokitok* and *Lablabi,* while the highest infection was noted in *Balatinaw* and *Bongkitan* with 6 to 10% leaf area diseased. During the second cropping season, no lesions were observed in all the rice landraces (Table 7).

Figure 18

Grain Yield and Computed Yield of Rice Landraces in Kapangan for Two Cropping Seasons, 2017-2019

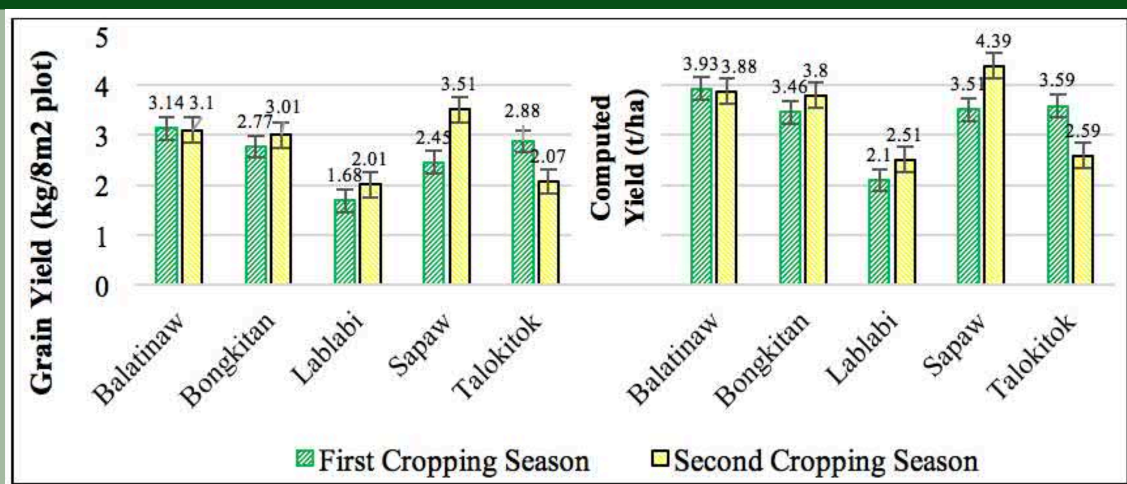


Table 7

Reaction of Rice Landraces to Stem Borer and Leaf Spot in Kapangan for Two Cropping Seasons, 2017-2019

Rice Landraces	Stem Borer (Whiteheads)		Leaf Spot	
	1st Season	2nd Season	1st Season	2nd Season
Balatinaw	Resistant	Moderately resistant	4	0
Bongkitan	Resistant	Resistant	4	0
Lablabi	Resistant	Moderately resistant	2	0
Sapaw	Resistant	Resistant	3	0
Talokitok (check)	Resistant	Moderately resistant	1	0

**Leaf spot rating: 0=no lesions observed; 1=less than 1% leaf area diseased; 2=1-3% leaf area diseased; 3=4-5% leaf area diseased; 4=6-10% leaf area diseased; 5=11-15% leaf area affected; 6=16-25% leaf area diseased; 7=26-50% leaf area diseased; 8=54-75% leaf area diseased; 9=76-100% leaf area diseased; **Stem borer rating: 1-resistant; 2-moderately resistant; 3- intermediate; 4-moderately susceptible; 5-susceptible*

Yield Stability of Rice Landraces in Kapangan

The stability of rice landraces (genotype) during the two seasons (environment) in Kapangan is shown in a GGE bi-plot (Figure 19). *Sapaw*, *Balatinaw,* and *Bongkitan* are the highest yielding genotypes, while *Lablabi* is the lowest yielding. In terms of stability, *Balatinaw* and *Bongkitan* were the most stable while *Talokitok* had the poorest stability. Therefore, the best among the rice landraces in Kapangan are *Balatinaw* and *Bongkitan* because of their high yielding ability and greater stability across environments.

Varietal Preference of Heirloom Rice Farmers in Kapangan

Lablabi, Sapaw, and *Bongkitan* had positive preference scores, with *Lablabi* garnering the highest. *Balatinaw* and *Talokitok* had negative preference scores, which imply lesser acceptability (Table 8). Some of the reasons for selecting a rice landrace were more productive tillers, medium plant height, uniform ripening, long panicles with full and plump grains, and dense panicle secondary branches.

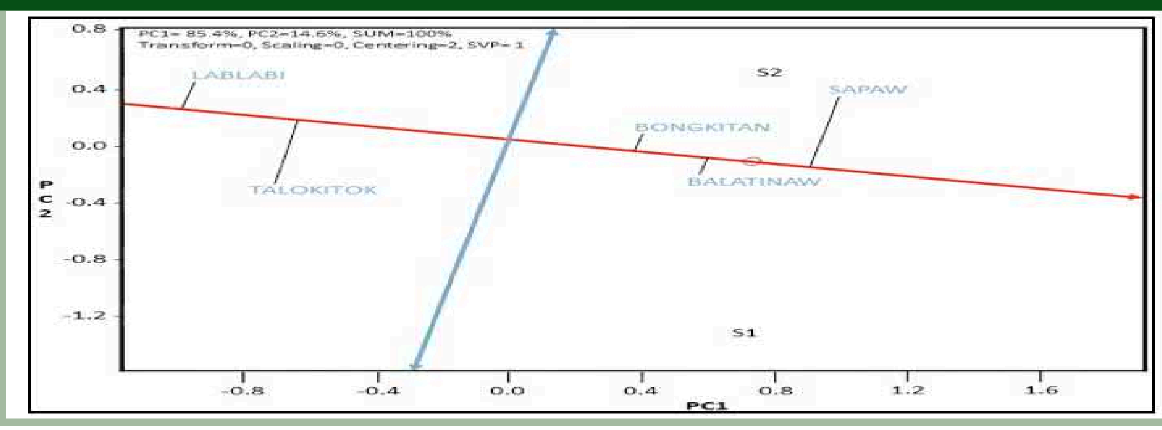
Growth, Yield, and Stability of Rice Landraces and Varietal Preference of Farmers in Kibungan

Number of Days from Transplanting to Booting

The number of days from transplanting to booting varied among the rice landraces from 86 to 108 days and 87 to 101 days for the first and second cropping seasons, respectively (Figure 20). *Lasbakan* booted the earliest at 86 days in the first cropping season. During the second cropping season, *Kabal*, *Lablabi*, *Balatinaw*, and *Lasbakan*

Figure 19

GGE Biplot Showing Relationship among Environments for Grain Yield Five Rice Landraces in Kapangan



Environments: S1- First season (December-July 2018); S2- Second season (August-March 2019); Grand Mean: 2.08

Table 8

Preference Scores and Reasons of Farmers for Selecting Rice Landraces in Kapangan, Benguet, 2018-2019

Rice Landraces	Preference Score Index	Preference Reasons
Balatinaw	-0.80	Uniform ripening
Bongkitan	0.07	More productive tillers, medium plant height
Lablabi	1.00	Long panicles with full and plump grains
Sapaw	0.57	Many productive tillers, long panicles, long awned
Talokitok (check)	-0.15	Long panicles with big grains, dense panicle secondary branches

booted earlier at 87 to 90 days. The latest to boot was *Balatinaw* at 108 days during the first cropping season and *Bongkitan* at 101 days in the second cropping.

Number of Days from Transplanting to Ripening

The days to ripening varied among the landraces from 137 to 159 days in the first cropping and 139 to 153 days in the second cropping. *Lasbakan* and *Lablabi* ripened earlier at 136 and 137 days during the first cropping season, while the latest was *Balatinaw* at 159 days. During the second cropping season, *Kabal* was the earliest at 139 days but comparable with *Lablabi* (140 days), *Balatinaw* (141 days), and *Lasbakan* at 142 days. *Bongkitan* was the latest to ripen at 153 days (Figure 20).

Tillering Ability

There was a significant variation in the number of tillers and productive tillers of rice landraces in both cropping seasons except number of productive tillers during the second cropping season (Figure 21). *Balatinaw* and *Lablabi* produced the highest number of tillers and productive tillers in both cropping seasons.

Number of Filled Grains per Panicle

The number of filled grains during the second cropping season varied. The rice landraces produced more number of filled grains during the second cropping season ranging from 116 to 187. *Kabal* produced the most number of filled grains during the first cropping season but

Figure 20

Number of Days from Transplanting to Booting and Ripening of Heirloom Rice Landraces in Kibungan for Two Cropping Seasons, 2017-2019

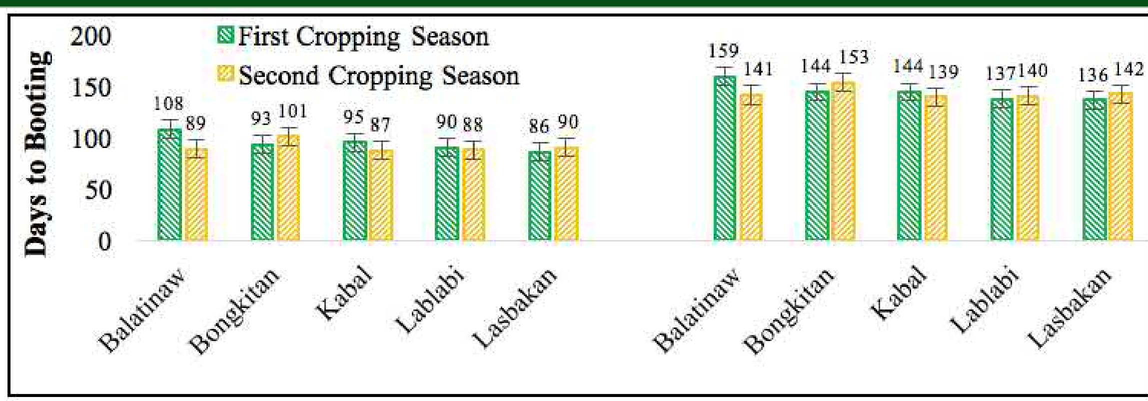
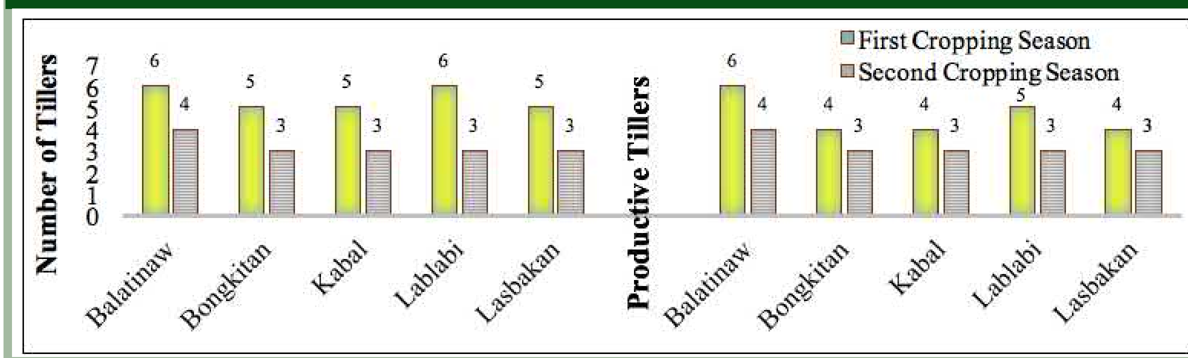


Figure 21

Number of Tillers and Productive Tillers of Rice Landraces in Kibungan for Two Cropping Seasons, 2017-2019



produced the least filled grains in the second season. *Bongkitan* produced 187 filled grains, which is significantly the highest among the landraces (Figure 22).

Weight of 1000 Filled Grains

The weight of 1000 filled grains of rice landraces varied from 27 to 39g and 24 to 36g during the first and second cropping seasons, respectively. *Lasbakan* produced the heaviest 1000 filled grains in both cropping seasons. On the other hand, the lowest weight of 1000 filled grains was produced by *Bongkitan* (Figure 22).

Grain Yield per Plot and Computed Yield

Grain yield per plot and computed yield of rice landraces varied in the second cropping season (Figure 23). *Balatinaw* produced the highest grain yield of 2.54kg/plot (3.17t/ha) in the first cropping season followed by *Kabal* with 2.39kg/plot (2.98t/ha). During the second cropping season grain yield varied, with *Bongkitan* producing the highest with of 2.27kg/plot (2.83t/ha). The least grain yield was produced by *Lablabi* and *Kabal* (1kg/plot).

Reaction of Rice Landraces to Stem Borer

Rice landraces were rated resistant to stem borer during the first cropping season (Table 9) while moderately resistant in the second cropping season. *Balatinaw*, *Bongkitan,* and *Lasbakan* were rated resistant, while *Kabal* and *Lablabi* were rated moderately resistant.

Figure 22

Filled Grains and Weight of 1000 Grains of Rice Landraces in Kibungan for Two Cropping Seasons, 2017-2019

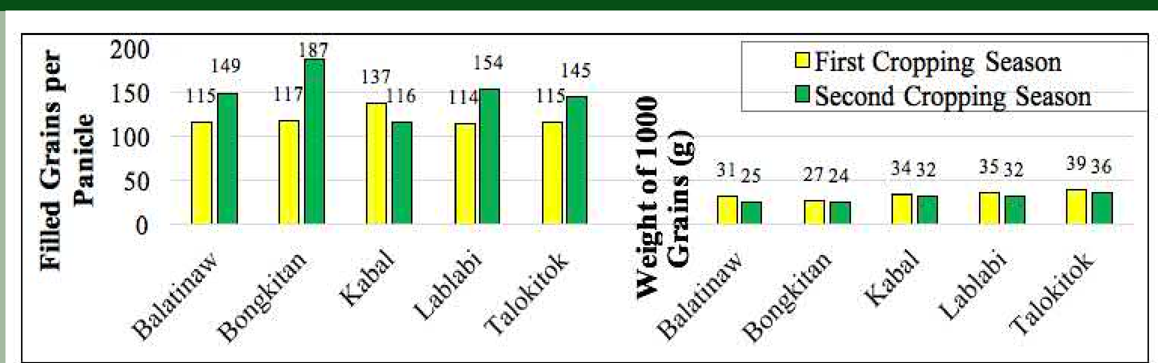
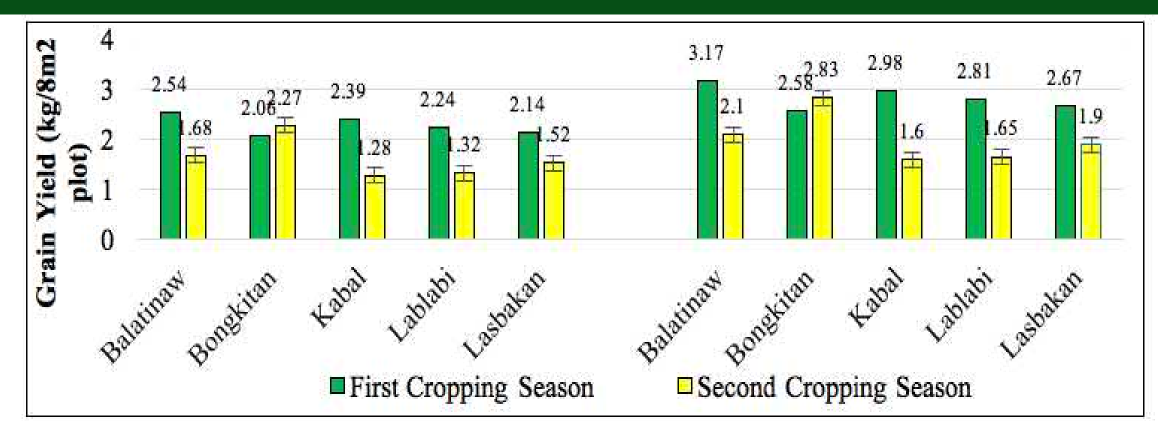


Figure 23

Grain Yield and Computed Yield of Rice Landraces in Kibungan for Two Cropping Seasons, 2017-2019



Reaction of Rice Landraces to Leaf Spot

The leaf spot infection on the rice landraces in both cropping seasons was 6 to 25%. The highest infection was observed in *Lablabi* during the first cropping and *Bongkitan* in the second cropping. No leaf spot infection was observed on *Lablabi* and *Lasbakan* during the second cropping season (Table 9).

Varietal Preference of Heirloom Rice Farmers in Kibungan

Lasbakan, Bongkitan, and *Balatinaw* have positive preference scores (Table 10) indicating higher acceptability than *Kabal* and *Lablabi*. Some reasons for choosing the best rice landraces mentioned by the farmer-evaluators were early maturing, good adaptability in the area, more productive tillers, uniform ripening, long and compact/dense panicles with few unfilled grains, resistance to lodging, and long panicles with full and plump grains.

Yield Stability of Rice Landraces in Kibungan

Figure 24 shows the GGE bi-plot of rice landraces (genotype) and cropping seasons (environments). *Bongkitan* and *Balatinaw* were the highest yielders, while *Lablabi* is the lowest. *Lasbakan* and *Balatinaw* are the most stable rice landraces, while *Bongkitan* though the highest yielding, is unstable. *Balatinaw* is the most stable across environments.

Table 9

Reaction of Rice Landraces to Stem Borer and Leaf Spot in Kibungan for Two Cropping Seasons, 2017-2019

Rice Landraces	Stem Borer (Whiteheads)		Leaf Spot	
	1st Season (Jan-Jul)	2nd Season (Aug-Jan)	1st Season (Jan-Jul)	2nd Season (Aug-Jan)
Balatinaw	Resistant	Resistant	5	4
Bongkitan	Resistant	Resistant	4	6
Kabal (check)	Resistant	Moderately resistant	5	4
Lablabi	Resistant	Moderately resistant	6	0
Lasbakan	Resistant	Resistant	5	0

**Leaf spot rating: 0=no lesions observed; 1=less than 1% leaf area diseased; 2=1-3% leaf area diseased; 3=4-5% leaf area diseased; 4=6-10% leaf area diseased; 5=11-15% leaf area affected; 6=16-25% leaf area diseased; 7=26-50% leaf area diseased; 8=54-75% leaf area diseased; 9=76-100% leaf area diseased; **Stem borer rating: 1-resistant; 2-moderately resistant; 3- intermediate; 4-moderately susceptible; 5-susceptible*

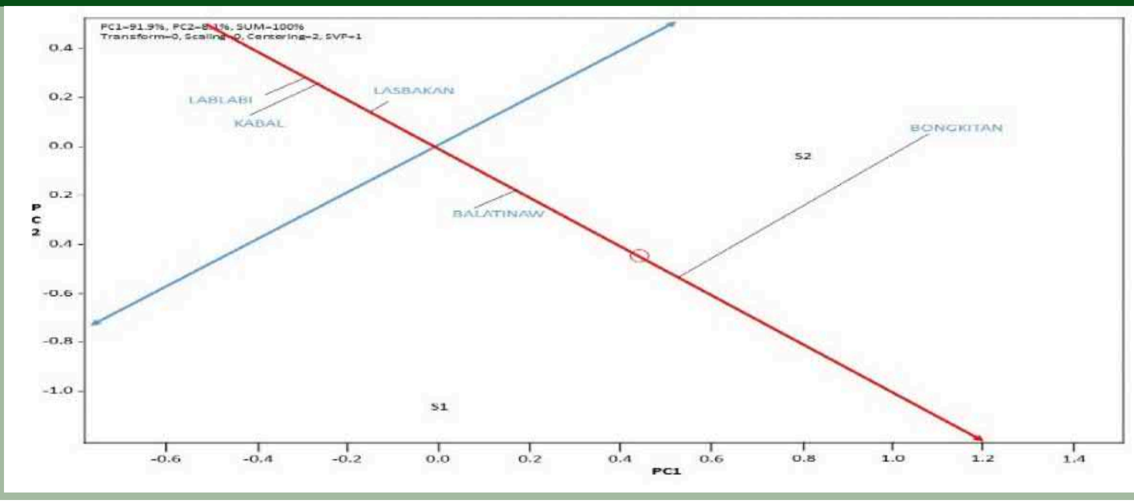
Table 10

Preference Scores and Reasons of Farmers for Selecting Rice Landraces in Kibungan, Benguet, 2018-2019

Rice Landraces	Preference Score Index	Preference Reasons
Balatinaw	0.30	Early maturing, good adaptability in the area, more productive tillers
Bongkitan	0.57	Uniform ripening, more productive tillers
Kabal (ckeck)	-0.10	More tillers, long and compact/dense panicles with few unfilled grains, resistant to lodging
Lablabi	-0.96	Long panicles with full and plump grains, uniform ripening
Lasbakan	0.89	Long panicles with full and plump grains, uniform ripening, less unfilled grains

Figure 24

GGE Biplot Showing Relationship among Environments for Grain Yield Five Rice Landraces in Kibungan



Environments: S1- First season (December-July); S2- Second season (August-March); Grand Mean: 2.4

Sensory Evaluation of Rice Landraces

Aroma. It is one of the most acclaimed rice traits, not only because of its culinary value but also because of its cultural value assigning local and national identity (Chakraborty et al., 2016). Bhonsle and Sellappan (2010) likewise cited that aroma is another important rice trait as indicated by the high demand and preference for aromatic rice in the market and consumers. All the rice landraces evaluated have a moderately perceptible aroma except for *Kalipago* and *Lablabi* that have slightly perceptible aroma (Table 11).

Taste. This characteristic helps in the identification, acceptance, and appreciation of food (Sharif et al., 2017). In terms of taste, *Balatinaw* and *Kabal* were moderately tasty, while the rest of the landraces were slightly tasty (Table 11).

Texture. Appearance is the first characteristic perceived by the human senses and plays an important role in identification and final selection of food (Sharif et al., 2017). This is the visual perception of food composed of color, shape, size, gloss, dullness and transparency. The

Table 11

Acceptability of the Rice Landraces Based on Aroma, Taste and Texture

Rice Landraces	Aroma	Taste	Texture	General Acceptability
Balatinaw	Moderately perceptible	Moderately tasty	Moderately soft	Like moderately
Bongkitan	Moderately perceptible	Slightly tasty	Very soft	Like moderately
Kabal	Moderately perceptible	Moderately tasty	Moderately soft	Like moderately
Kalipago	Slightly perceptible	Slightly tasty	Slightly hard	Like moderately
Lablabi	Slightly perceptible	Slightly tasty	Moderately soft	Like moderately
Lasbakan	Moderately perceptible	Slightly tasty	Moderately soft	Like moderately
Sapaw	Moderately perceptible	Slightly tasty	Moderately soft	Like moderately
Talokitok	Slightly perceptible	Slightly tasty	Moderately soft	Like moderately

panelists ranked the rice landraces according to texture with *Bongkitan* as very soft, *Balatinaw, Kabal, Lablabi, Lasbakan, Sapaw* and *Talokitok* as moderately soft, and *Kalipago* as slightly hard (Table 11).

General Acceptability. Acceptance of the rice grains may be influenced by the aroma, taste and texture of the rice landraces evaluated. All rice landraces were liked moderately (Table 11).

Nutrient Analysis of Selected Rice Landraces

Only four rice landraces were subjected to nutrient analysis. There was a wide range of nutrients found in the rice landraces. *Balatinaw* was noted to have the highest Ca, K, Mg, P, Fe, Zn, and Mn contents (Table 12).

Table 12

Nutrient Analysis of Selected Rice Landraces

Rice Landraces	Kj N (%)	Ca (%)	K (%)	Mg (%)	Na (%)	P (%)	Fe (mg/kg)	Zn (mg/kg)	Mn (mg/kg)
Lasbakan	1.11	0.006	0.182	0.094	0.002	0.226	7.5	19	13
Lablabi	1.19	0.008	0.153	0.085	0.002	0.206	6.7	20	15
Balatinaw	1.64	0.017	0.348	0.196	0.002	0.441	15	31	26
Kintoman	1.30	0.014	0.290	0.149	0.002	0.358	10	19	19
IR64	0.0795*						11.8**	23.2**	

Note:
**Deepa, G., Sing, V., Naidu, K. A. 2007. Nutrient composition and physicochemical properties of Indian medicinal rice - Njavara. Food Chemistry 106 (2008) 165–171;*
***Gregorio, G.B., Senadhira, D., Htut, H., Graham, R. D. 2000. Breeding for trace mineral density in rice. Food and Nutrition Bulletin, vol. 21, no. 4*

Conclusions

Eighty-two heirloom rice landraces are being planted by 330 growers in Bakun, Kapangan, and Bakun, Benguet. Of these landraces, 37 are cultivated in Kapangan; 26 in Bakun; and 19 in Kibungan. The most cultivated landrace in Bakun is *Balisanga,* while *Bongkitan* in Kapangan and Kibungan.

In Bakun, *Lablabi* and *Lasbakan* were the highest yielders, but the most stable was *Lasbakan* and *Kalipago*. *Bongkitan* and *Lablabi* were the most acceptable to the farmers. In Kapangan, *Sapaw, Balatinaw, and Bongkitan* were consistent high yielders, stable landraces, and most preferred by 'heirloom rice' growers. In Kibungan, *Balatinaw* is the highest yielder, most stable, and most highly accepted landrace. In all locations, 'heirloom rice' growers prefer landraces which are early maturing, have more productive tillers, ripen uniformly, have long and compact panicles with full and plump grains, and resistant to lodging. As to sensory evaluation based on aroma, taste, and texture, all rice landraces were liked moderately by the panel of evaluator. *Balatinaw* was noted to have the highest Ca, K, Mg, P, Fe, Zn, and Mn contents of the four landraces subjected to nutritional analysis.

Recommendations

Based on yield and yield components, stability, farmers' preference, and nutrient analysis, the following are location-specific recommendations: *Lablabi* and *Lasbakan* in Bakun; *Sapaw, Balatinaw,* and *Bongkitan* in Kapangan, and *Balatinaw* and *Bongkitan* in Kibungan.

With the alarming loss of diversity of rice landraces, the ethno-farming communities in the preservation and maintenance of heirloom rice through educational campaigns. This study's findings can be used by concerned national agencies, local government units and farmers in the Cordillera towards conservation and protection of heirloom rice.

Rice landraces play pivotal roles as genetic resource bases and preserve cultural identity through their essential position in the agroecosystems and social heritage of indigenous peoples. These landraces can serve as "agricultural survival kit" for household welfare and for adaptation to changing conditions. These landraces meet local cultural practices and environmental constraints and play an inherent role in cultural survival by instituting a living depository of ancestral customs, including cultivar-specific recipes, stories of origin, and unique planting, harvesting, processing, and storage rituals and other practices.

Acknowledgment

The researchers gratefully acknowledge the support of Ms. Berta Degsi, Mr. Manuel Wance, Ms. Sonia Pengosro, Mr. Cruzaldo Cabuten, and Mr. Edwin Dusayan as farmer-partners; other heirloom rice growers, and stakeholders of Bakun, Kapangan, and Kibungan for their active participation during the surveys, FPIC consultation, PNOA, validation meeting, and other activities. The fund support provided by the Department of Agriculture–Cordillera Administrative Region is highly acknowledged. The support of the LGUs of Bakun, Kapangan, and Kibungan through their respective mayors and OMAGs in coordinating the various activities are sincerely appreciated. The support of the partner agencies, PhilRice and IRRI is highly recognized.

References

Anon. (1993). Report of the Working Group on the Assessment of Demersal Stocks in the Baltic. C.M. 1993/Assess:16.

Bhonsle, S.J., & Sellappan, K. (2010). Grain Quality Evaluation of Traditionally Cultivated Rice Varieties of Goa, India. *Recent Research in Science and Technology,* 2(6): 88-97.

Brondani, R.P., Williams, E.R., Brondani, C., & Grattapaglia, G. (2006). A microsatellite-based consensus linkage map for species of Eucalyptus and a novel set of 230 microsatellite markers for the genus. *BMC Plant Biology*, 6(1): 20.

Chakraborty, D., Deb, D., & Ray, A. (2016). An Analysis of Variation of the Aroma Gene in Rice (Oryza sativa L. subsp. indica Kato) landraces. *Genetic Resources and Crop Evolution,* 63: 953–959.

Chakravorty, A., & Ghosh, P. (2014). Interrelationship and cause effect analysis among panicle yield attributing traits in lowland Traditional Rice. *Journal of Central European Agriculture,* 15(4): 213-224.

Daba, K., Warkentin, T.D., Bueckert, R., Todd, C.D., & Tar'an, B. (2016). Determination of photoperiod- sensitive phase in chickpea (Cicer arietinum L.). *Front. Plant Sci.,* 11:478. doi: 10.3389/fpls.2016.00478

De Datta, S.K. (1981). *Principles and practices of rice production*. Int. Rice Res. Inst. Los Banos, Laguna.

Domoguen, R.B. (2011). Cordillera losing its heirloom rice varieties. *Sunstar Baguio*. http://heirloomrice.com/pdfs/Domoguen_losing_Feb28_2011.pdf

Egesi, C.N., Asiedu, R., & Egunjobi, J.K. (2001). *Flowering in yams (Dioscorea spp.)*. In Proceedings of the seventh triennial symposium of the international society for tuber and root crops—Africa. Branch, Cotonou, Benin (pp. 434-437).

Gavilan, J. (2014). Preserving the Tradition of Heirloom Rice in the Cordilleras. *Rappler.* https://www.rappler.com/move-ph/issues/hunger/70991-heirloom-rice-project-irri-cordilleras.

International Rice Research Institute. (2015). *Rice Production Manual*. International Rice Research Institute, Los Baños (Philippines). 1-27.

International Rice Research Institute. (2006). Participatory Approaches. Module 6. Lesson. http://www.knowledgebank.irri.org/ricebreedingcourse/bodydefault.htm#Participatory_Variety_Trials_For_Rainfed_Rice_Cultivar_Evaluation.htm.

International Rice Research Institute. (2013). *Standard Evaluation System for Rice (SES)*. 5th Edition. International Rice Research Institute, Manila, Philippines

Leung, H., Zhu, Y., Revilla-Molina, I., Fan, J. X., Chen, H., Pangga, I., Cruz, C.V., & Mew, T.W. (2003). Using genetic diversity to achieve sustainable rice disease management. *Plant disease*, 87(10): 1156-1169.

Local Government Unit-Bakun. (2019). Bakun Profile. *Province of Benguet Website*. http://www.benguet.gov.ph/index.php/11-municipalities/459-municipality -of-bakun- the- setting).

Local Government Unit-Kapangan. (2019). *Kapangan Profile*. Kapangan, Benguet. Philippines.

Local Government Unit-Kibungan. (2019). *Kibungan Profile*. Kibungan, Benguet. Philippines.

Mahapatra, K.C. (1993). Relative usefulness of stability parameters in assessing adaptability in rice. *Indian Journal of Genetics and Plant Breeding,* 53:435-441.

Mirza J.M., Faiz, A., & Majid, A. (1992). Correlation Study and Path Analysis of Plant Height, Yield and Yield Component. *Sarhad Journal of Agriculture*, 8(6): 647- 653.

Nachimuthu V.V., Robin, S., Sudhakar, D., Raveendran, M., Rajeswari, S., & Manonmani, S. (2014). Evaluation of Rice Genetic Diversity and Variability in a Population Panel by Principal Component Analysis. *Indian Journal of Science and Technology,* 7(10):1555-1562.

Rasabandit, S., Jaisil, P., Atlin, G., Cruz, C.V., Jongdee, B., & Banterng, P. (2006). Participatory Variety Selection (PVS) to Assess Farmer Preferences of Traditional Glutinous Rice Varieties in the Lao PDR. *Khon Kaen Agric.,* 34 (3):128-141.

Sharif, M. K., Butt, M. S., Sharif, H. R., & Nasir, M. (2017). Sensory Evaluation and Consumer Acceptability. *Handbook of Food Science and Technology*. Pp. 362-386. https://www.researchgate.net/publication/320466080_Sensory_Evaluation_and_Consumer_Acceptability

Sinha, A.K., & Mishra, P.K. (2013). Morphology based multivariate analysis of phenotypic diversity of landraces of rice (Oryza sativa L.) of Bankura district of West Bengal. *Journal of Crop and Weed*, 9(2): 115-121.

Singh, S.R., & Rachie, K.O. (1985). *Cowpea Research, Production and Utilization*. John Wiley and Sons, New York, USA.

Solimen, J.A., Tad-awan, B.A., & Tosay, M. (2010). *Compendium of Heirloom Rice Varieties in Benguet*. Benguet State University. La Trinidad, Benguet.

Tad-awan, B.A., & Sagalla, E.J.D. (2015). Heirloom Rice Varieties for Wet Season Cropping in the Highlands of Northern Philippines. *Journal in Organic Agriculture*, 1(1): 1-26.

Tad-awan, B.A., & Sagalla, E.J.D. (2011). Morphological Analysis of Rice Landraces in Benguet. Be*nguet State University Research Journal,* 66: 1-13.

Yan, W., & Tinker, N.A. (2006). Biplot Analysis of Multi-Environment Trial Data: Principles and Applications. *Canadian Journal of Plant Science*, 86(3): 623-645.

Zahid, A.M., Akhtar, M., Sabrar, M., Anwar, M., & Mushtaq, A. (2005). *Interrelation-ship among Yield and Economic Traits in Fine Grain Rice*. Proceedings of the International Seminar on Rice Crop. October 2-3. Rice Research Institute, Kala Shah Kau, Pakistan. pp. 21-24.