

Agro-morphological Characteristics of Local Upland Rice in Arakan Valley, Cotabato, Philippines

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Abstract

Agronomic and morphological characteristics of fourteen (14) local upland rice cultivars of Arakan Valley, Cotabato, Philippines were evaluated to determine desirable traits in improving upland rice production and for future breeding purposes. Traditional upland rice seeds differ in shape, size, colour and aroma. Azucena and Kapalawan have longer grains of 9-12 mm and the smallest grain was from Mal-os of 5.5 - 8 mm. Bungulan, Ulipapa, and Magalitok cultivars have medium size grain of about 8-11 mm. Azucena and Bungulan have translucent caryopsis and aromatic. Mubpon had medium grain size and semi-aromatic and Dinorado had aromatic pinkish to purplish caryopsis and medium size grain. Hinumay and Azucena have the tallest height among rice cultivars with 126.5 and 127 cm, respectively. Malundiang got the shortest height of 91 cm. Kawilan got the highest number of tillers with 6.5 and 5 panicles per plant. Malundiang cultivar flowered early at 65-70 days while Azucena and Kawilan have late flowering of more than 90 days after planting. Magalitok had the longest panicle with 31.06 cm and the shortest panicle was measured from Malundiang with 16.63 cm. Ulipapa had the highest 1,000-grain weight of 28.54 g while Manisi got the lowest grain weight of 15.33 g only. The result of the study showed variation in the agro-morphological characteristics of the indigenous upland rice. Bungulan, Ulipapa, Malundiang, Mubpon, Sinulid and Kawilan have potential agronomic characteristics in improving upland rice production in the IP community. Dinorado, Hinumay, and Azucena have been planted by the local farmers for its desirable grain characteristics and aroma.

Keywords: agro-morphological, indigenous upland rice, Arakan Valley, aromatic.

Introduction

Agro-morphological study deals on the plant growth structure characterization (morphological) and yield component of an important crop like upland rice. The characteristics include visual expression of growth structure largely influenced by the environment, cultural practices and gene-environment interaction (Bruschi et al., 2003). Morphological study in rice is important to determine the desirable characteristics of certain rice species including its potential yield (Seetharam et al. 2009). Accordingly, the practice of agro-morphological characterization is the easiest method among the formal and standardized approaches of measuring crop genetic diversity (Watson and Eyzaguirre, 2002). Modern rice plant breeders are concerned with diversity at the molecular level but local farmers are most interested in the visible characteristics and yielding ability of rice.

Cotabato province is one of the rice bowls in the Southern Philippines due to favorable climate, fewer typhoons and vast track of rich soils despite of the uncertain political stability. The place is inhabited by the Tri-people, the “Moro” (Muslims), “Lumad” (indigenous people or IPs), and the Christian migrants or settlers. Much indigenous upland rice in Arakan Valley, Cotabato

were kept and grown by the Manobo (Menuvu) communities for generations and considered as insignia of their ethnic culture and beliefs. They identified desirable characteristics of upland rice like grain quality, aroma, and apparently its recuperative effect. It can resist adverse condition like low rainfall and lower temperature in the undulating landscape (Arakan-LGU, 2001).

Most of the “Lumad” (primarily Menuvu tribe) lived in the mountainous areas intertwining upland rice in their daily existence. The local government unit of Arakan Valley, Cotabato through the Municipal Agriculture Officer (MAO) instigated to retrieve and conserve the remaining indigenous upland rice particularly those with desirable characteristics. The conservation work started in the early 1990s by a non-government organization, Southeast Asia Regional Initiatives for Community Empowerment (SEARICE) and formerly known as CONSERVE. There is a risk and higher possibility for upland rice genetic erosion and extinction due to continuous landscape transformation and massive conversion of the production areas into high-valued plantation crops like rubber, oil palm and banana. It is necessary to save the remaining traditional upland rice proven to resist environmental pressures with good edibility. This is the best way to secure the food sources of the tribal farmers and safeguard their rights to keep the commodity from generation to generations.

Increasing agricultural productivity is one of the government priorities to meet the food demands of the country’s population. Aside from increasing production, the indigenous peoples (IP) and other local farmers are helped out in their food needs. The study was conducted to evaluate the agro-morphological characteristics of local upland rice kept and grown by the IPs for several years in Arakan Valley Complex. In this aspect, it would help improve rice production in the countryside specifically in the indigenous community and identify potential local upland rice cultivars for future breeding purposes.

Materials and Methods

Description of the collection site

Traditional upland rice cultivars were collected from different tribal communities in Arakan Valley Complex composed of the municipalities of President Roxas, Antipas, Arakan, and the eastern part of Matalam, situated in the second district of Cotabato Province, Philippines (Figure1). The place is bounded by Bukidnon province in the north and Davao del Sur in the east. The collection areas are known as the major upland rice producer in Central Mindanao since the early 1960s and 1970s with marked landscape and varied terrain to small hills that gradually rise to mountains. Arakan is predominantly inhabited by Manobo (Menuvu) tribes and with the presence of other ethnic groups like Bagobo and Tiduray (Arakan-LGU, 2001).

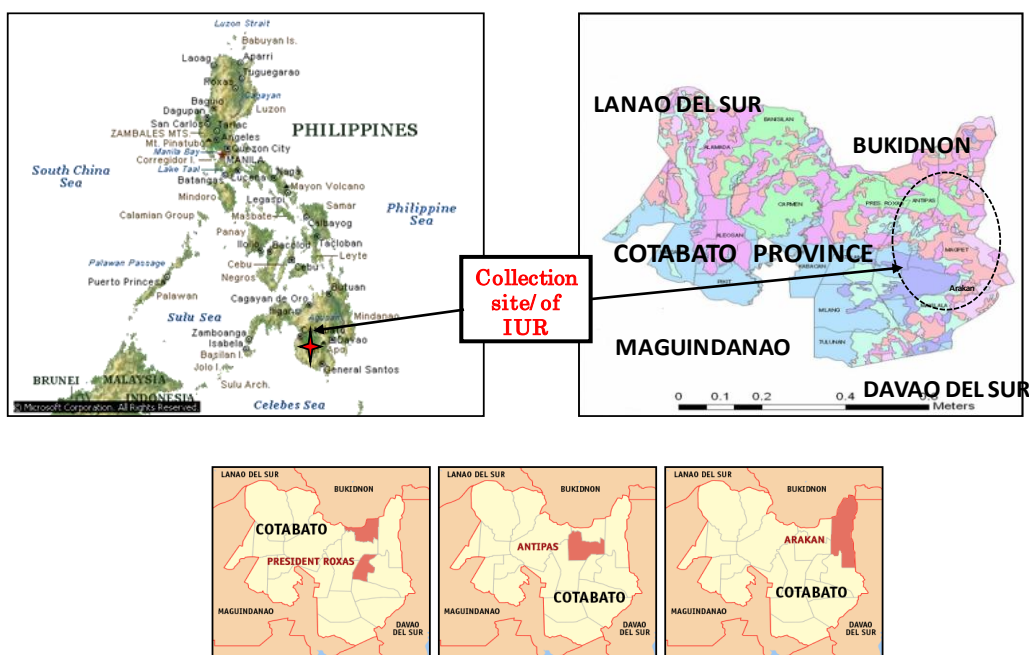


Figure 1: Geographical location of Arakan Valley municipalities composed of President Roxas, Antipas, Matalam East and Arakan, Cotabato as collection site of indigenous upland rice (IUR).

Collection of plant materials

Ethno-botanical principles were followed in the collection of local upland rice grains kept by the farmers. A prior informed consent was secured from the Manobo tribal council leaders or “datu” (chieftains) in Arakan Valley, Cotabato, Philippines and from the local government unit (LGU) represented by the Municipal Agriculture Officer (MAO) in the seed collection. Permissions were also sought through certification from non-government organization, Southeast Asia Regional Initiatives for Community Empowerment (SEARICE) (formerly CONSERVE) which pioneered in the collection and conservation of traditional upland rice in the study area.

Fourteen (14) traditional upland rice cultivars were collected in the identified production areas (Table 1). Local names were used in the identification and the names of the farmer/s or contributors including the place of collection were recorded separately as necessary information. Certifications were secured from the Philippine Rice Research Institute (PhilRice) and International Rice Research Institute (IRRI) to validate related agronomic study on the collected local upland rice cultivars.

Table 1: Traditional upland rice collected in different geographical location in Arakan Valley, Cotabato, Philippines.

Traditional Names	Collection sites
Dinorado*	Arakan, Cotabato
Azucena*	Arakan, Cotabato
Bungulan	Kulaman Valley, Salat, President Roxas,
Mal-os	Matalam and Arakan, Cotabato
Magalitok	Guinto, President Roxas, Cotabato
Kapalawan	Arakan, Cotabato
Mubpon	President Roxas, Cotabato
Manisi	Salat, President Roxas, Cotabato
Kawilan	President Roxas, Matalam and Arakan, Cotabato
Malundiang	President Roxas and Arakan, Cotabato
Sinulid	Arakan, Cotabato
Ulipapa	Arakan, Cotabato
Dabao	President Roxas, Matalam and Arakan, Cotabato
Hinumay	Arakan, Cotabato

*Upland rice cultivars locally grown by the Manobo tribal farmers.

Agro-morphological characteristics of local upland rice

The collected upland rice grains were morphologically characterized while other seeds were directly sown in the pots and boxes/plots filled with garden soil added with organic materials under greenhouse condition. The agronomic parameters gathered were plant height (cm), number of tillers, number of days to flower and maturity, number of panicle per plant, length of panicle and weight of 1,000 grains. Data collections were done at two weeks interval except for 1,000 grain weight (g) which was taken after harvesting. These agro-morphological traits are measured based from the methods used by Sohrabi et al. (2012).

Data Analysis

In the agronomic characterization, one plant was maintained for every pot -10 inches in diameter until harvesting replicated 4 times and 10 to 12 plants per 1m² box/plot. All plants were considered as samples in the quantitative characteristics. Data taken were analyzed using STAR software (from IRRI) in the analysis of variance (ANOVA) and means are compared using HSD test.

Results and Discussion

Morphological description of local upland rice grains

The morphological characteristics of local upland rice grains differ among cultivars (Table 2). Most of the grains vary in size, shape, plumpness, hulls (pericarp) and caryopsis color with aroma or scent. The grain size of upland rice ranged from 5-12 mm, width and hull thickness vary also among local upland rice while some seeds have longer awn while others have short to awn-less characteristics (Figure 2). Azucena and Bungulan have similarities in seed color with light yellow to yellowish brown, oblong and elongated shape, 10-12 mm seed length and aromatic. The caryopsis is medium

to long and translucent. Seeds of Mubpon and Ulipapa have round to oval shape but differ in hull color, texture and aroma. The former has thicker purple hulls and semi-aromatic while the latter is non-aromatic with golden brown hulls with shades of light yellow. Magalitok upland rice seeds have unique shape, slim and elongated (like thin stick) with short awn and black tip. Kapalawan has long grain with short to long awn, yellow to light brown yellow color hulls and semi-aromatic reddish caryopsis (Table 2 and Figure 2). Other upland rice seeds like Sinulid and Kawilan have similar morphological characteristics. They have comparable medium size of 7- 9.5 mm length, oblong shape, light yellow lemma and palea, and translucent non-aromatic caryopsis. Mal-os has the smallest seed with light yellow to brown yellow hulls, awnless, translucent caryopsis and non-aromatic (Table 2 and Figure 2).

The observed morphological characteristics of the upland rice grains were mostly comparable with the description of Japonica and Javanica type of rice (Rabara et al., 2014; Zang et al., 1992; IRRI, 1975; Chang et al., 1972). The Japonica grains are short, roundish, awnless to long-awned and have variety of colors (white, brown, black, purple and red), while those grains that are long, broad, thick hulled and awned or awn-less are the Javanica type of upland rice (Rabara et al., 2014; IRRI, 1975; Chang et al., 1972). The study of Semwal et al. (2014) and Phunngam et al. (2017) have similar findings in the local upland rice variation in grain characteristics like size, shape, hull and endosperm color, presence of awn and some are aromatic.

Wang et al. (2012) considered the importance of grain size and form which are main components of yield and quality. These traits have been used as the basis of selection in the first domestication of cereals. Vua Xionsiyee and Chanakan Prom-U-Thai (2016) mentioned rice grain characteristics as source of the primary information on the genetic variation of different rice varieties in the local germplasm. The variations in the grain structure of upland rice cultivars were proven in the genetic diversity analysis done by Bangi and Aquino (2014). There are upland rice grains that are morphologically similar but it showed a very low (nil) genetic similarity when it was analyzed using SSR markers. The findings were observable with Azucena and Bungulan, between Mubpon and Malundiang and other upland rice cultivars.

Table 2: Grain characteristics of local upland rice cultivars collected in Arakan Valley Complex, Cotabato, Philippines

Traditional Upland Rice	Seed morphological characteristics					
	Seed size (mm)	Shape	Color		Other features	
			Hulls (lemma & palea)	caryopsis		
1. Azucena	10-12 (long grain)	elongated oblong	light yellow to yellowish brown	white or luminous	or	short awn (0.5-2mm) to awnless, aromatic
2. Dinorado	6-8 (small to medium)	semi-round	brown to darker brown	lighter and red	pink and darker	short awn to awnless; aromatic
3. Mal-os	5.5-8 (small to medium)	oblong	light yellow to brown yellow	white or luminous	or	awnless ; non-aromatic
4. Malundiang	7 -8.5 (medium)	plump round or oval	Yellow brown	white or luminous	or	with awn & others awnless; tip of grain dark brown color, non-aromatic
5. Dabao	7-9 (medium)	plump semi-round	light yellow or brown color	white or luminous	or	dark brown awn about 0.5 mm; non-aromatic
6. Kawilan	7-9 (medium)	oblong	light yellow	white or luminous	or	short awn (0.5 - 1mm); non-aromatic
7. Mubpon	7-8.5	round or	light yellow	white	or	short awn; semi-

	(medium)	oval	brown	luminous	aromatic
8. Ulipapa	8-11(med.-long)	round or oval	golden brown with shades of light yellow	white or luminous	or awnless; non-aromatic
9. Magalitok	8-11(med.-long)	slim-elongated	variegated light yellow brown-dark brown	white or luminous	short awn and brown-black tip; non-aromatic
10. Bungulan	8-11(med.-long)	oblong, semi-elongated	dark brown to golden brown	pinkish to luminous /white grain	yellowish brown shades at the tip and side of grain, aromatic
11. Manisi	7-8 (medium)	plump, oblong	light brown with shades of dark brown	white / luminous grain	short dark brown awn; non-aromatic
12. Sinulid	7-9.5 (medium)	oblong	light yellow with brown to dark brown tip	white/ luminous	Short to long awn ; non-aromatic
13. Kapalawan	9-12(long grain)	oblong	yellow to light brown yellow	red grain	short to long awn (1-2mm); semi-aromatic
14. Hinumay	7-9.5 (medium)	semi-round or oval	yellowish brown to light yellow brown	Mixture luminous /white and red grains	very short awn 0.3 to 1mm (others awnless); non-aromatic



Figure 2 . Traditional upland rice cultivars commonly planted in Arakan Valley, Cotabato, Philippines.

Agronomic characteristics of local upland rice

The agronomic characteristics of the local upland rice showed differences in height, number of tillers, days to flower, panicle numbers and length, and grain weight (Table 3). Hinumay had the

tallest height of 127.00 cm on the 14th week but did not vary with Azucena with 126.50 cm. Magalitok had 116.50 cm height but statistically comparable with Manisi, Sinulid, Ulipapa, Mubpon, Mal-os, Dabao and Bungulan upland rice cultivars (Table 3). Malundiang had the shortest plant height of 91 cm but did not vary with Kawilan and Dinorado upland rice (Table 3 and Figure 3). Plant height of the local upland rice increased exponentially during vegetative stage and slowed down during the reproductive stage (booting to flowering) (Figure 3).

Table 3: Agronomic characteristics of traditional upland rice cultivars in Arakan Valley, Cotabato, Philippines under greenhouse condition

Traditonal upland rice	Plant height (cm) at 14 th weeks*	No. of tillers / plant*	No. of days to flower*	No. of panicles / plant*	Panicle length (cm)*	1,000 grain weight (g)
Azucena	126.50 a	2.50 b	92.25 a	2.25 bc	30.33 ab	25.24 ab
Dinorado	96.50 bc	2.75 b	88.25 ab	2.25 bc	23.25 c	18.56 b
Bungulan	105.25 abc	3.75 b	74.25 def	2.75 bc	30.05 ab	27.35 a
Dabao	105.50 abc	3.75 b	74.00 ef	2.75 bc	26.50 abc	16.24 bc
Kawilan	98.50 bc	6.50 a	90.75 a	5.00 a	26.38 abc	18.56 b
Magalitok	116.50 ab	3.50 b	72.00 f	3.25 bc	31.06 a	16.99 bc
Mal-os	106.75 abc	3.75 b	82.75 bc	2.75 bc	26.70 abc	17.31 bc
Malundiang	91.00 c	2.00 b	68.75 g	1.75 d	16.63 d	22.69 ab
Manisi	113.75 ab	2.50 b	79.75 cde	2.00 c	24.55 abc	15.33 c
Mubpon	109.00 abc	3.25 b	75.75 def	2.50 bc	23.88 bc	24.86 ab
Sinulid	112.00 abc	3.50 b	75.50 def	3.50 b	27.93 abc	18.32 b
Ulipapa	110.00 abc	2.75 b	80.25 cd	2.75 bc	23.88 bc	28.54 a
Kapalawan	108.00 abc	3.75 b	85.75 ab	2.75 bc	29.17 ab	22.40 ab
Hinumay	127.00 a	3.50 b	78.25 cde	2.50 bc	30.15 ab	20.75 b

*All means (ave.of 4 reps) with the same letter/s in a column are not significantly different at 1% level by HSDe Test.

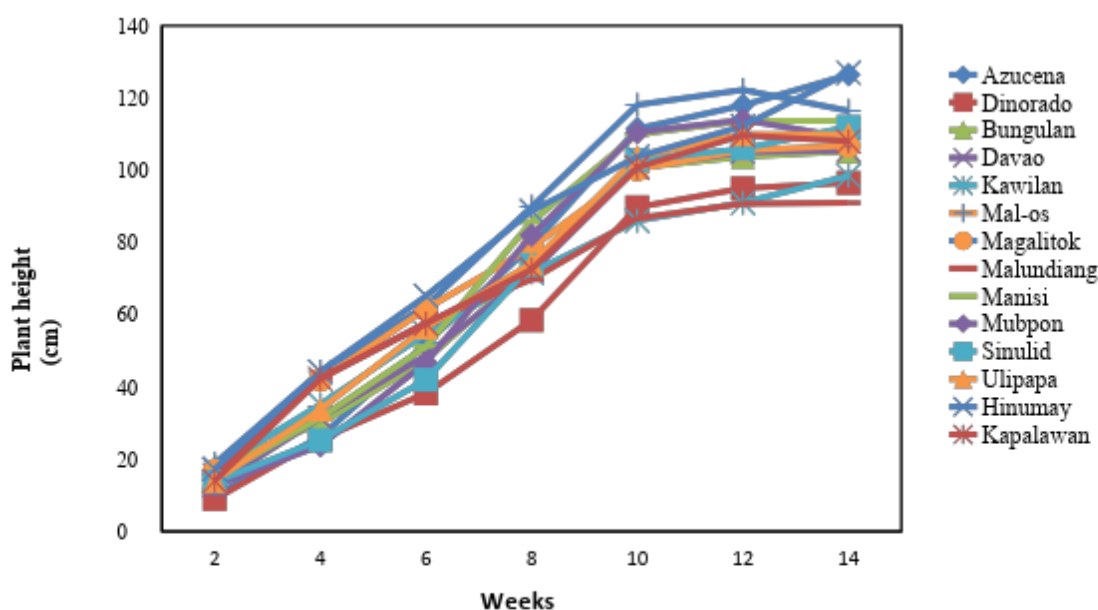


Figure 3. Average plant height (cm) of local upland rice cultivars in Arakan Valley Complex, Cotabato, Philippines under greenhouse condition.

The description on the phenotypic structure specifically the plant height of traditional Philippine rice supported the findings of the study (Rabara et al., 2014; Caldo et al., 1996; IRRI, 1975; Chang et al.,

1972). Upland rice cultivars were found to have tall stature, thick long sturdy stem (culm), longer erectophile and droopy leaves with wide leaf area (broad) than lowland rice. These morphological characteristics were apparent during the growing period of upland rice cultivars although the data presented was plant height only. These characteristics were observable on Bungulan, Sinulid, Ulipapa and Dinorado upland rice which have narrow to medium leaf area, droopy to semi-erectophile leaves and with long stiff culms. The study of Chang and Vergara (1972) and Schlosser et al. (2000) positively identified traditional upland rice cultivars to have long culms and droopy leaves while other cultivars have narrower leaves. These phenotypic characteristics like erectophile leaves, sturdy stem and culm length were considered important in developing new type of rice plant that affect yield component according to the study of Rabara et al. (2014) and Caldo et al. (1996).

Medium to tall stature upland rice are bred specifically for upland condition or selected locally on the basis of performance under poor moisture conditions (Salazar, 1993). Upland rice cultivars usually of tall stature are prone to lodging. Rabara et al (2014) emphasized the importance of local rice varieties that are cultivated by farmers. Accordingly, it is the main sources of germplasm for breeding new rice varieties since they have traits potentially adaptable to various abiotic and biotic stresses. Characterization of the germplasms is vital in rice improvement and gives valuable information in the new rice varieties.

Upland rice Kawilan produced the highest number of tillers of 6.5 while other cultivars produced 2 to 4 tillers per plant (Figure 4). Upland rice have low number of tillers produced per plant compared to lowland irrigated rice varieties (Rabara et al., 2014; IRRI, 1975; Chang and Vergara, 1975; Chang et al., 1972). Tiller production is an indicator of the yielding capability of upland rice hence, greater number of tillers would likely to produce greater number of panicles during reproductive stage (Rabara et al., 2014; Caldo et al., 1996; IRRI, 1975; Chang et al., 1972).

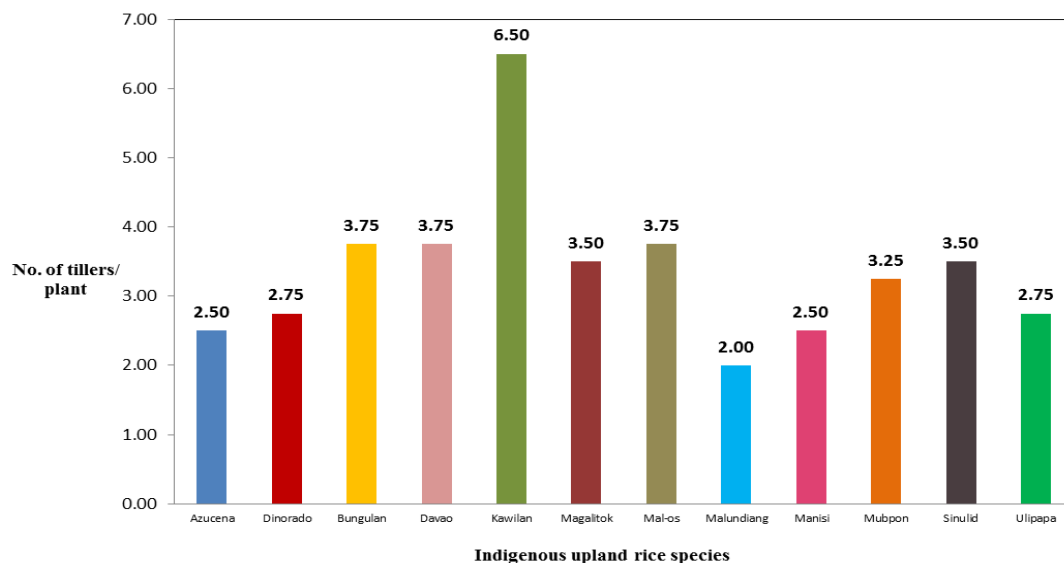


Figure 4. Number of tillers per plant of indigenous upland rice species of Arakan Valley Complex, Cotabato, Philippines under greenhouse condition.

Reproductive stage of upland rice started on the 9th and 10th weeks as indicated by booting followed by panicle initiation and flowering period. Malundiang upland rice flowered early at about 69 days after sowing. Azucena and Kawilan have longer period to flower at about 93 and 91 days, respectively. The flowering period of Azucena and Kawilan did not vary much with Dinorado with 88.25 days (Table 3). Magalitok upland rice flowered at 72 days (next to Malundiang), and Davao, Bungulan, Mubpon, Sinulid and Manisi rice cultivars flowered at 73 -75 days. The upland rice Mal-os and Ulipapa did not differ in the flowering days with 80.25 (Table 3). Accordingly, the flowering of upland rice is relative to the vegetative growth of the plants. Long profuse tillering period and continued growth able to delay the flowering of the plants while short vegetative growth leads to early reproductive stage (IRRI, 1975; Chang et al., 1972; Chang and Vergara, 1975).

The number of rice panicles per plant is shown in Table 3. Kawilan upland rice had the highest number of 5 panicles per plant while the least number of panicles counted were from Manisi

and Malundiang cultivars with 2 and 1.75 panicles per plant, respectively (Table 3). The rest of the upland rice cultivars have panicles ranging from 2- 5 per plant. The result of the study showed upland rice produced very minimal number of panicles compared to lowland irrigated rice varieties. This result is related to the tillers produced per plant as it is potential for panicle formation (Rabara et al. 2014; Zang et al, 1992; IRRI, 1975; Chang et al, 1972). The length of panicle is one of the yield components of rice coupled with the number of grains per panicle. Table 3 shows the variability of upland rice cultivars in terms of panicle length. Magalitok upland rice got the longest panicle of 31.06 cm and followed by Azucena and Bungulan upland rice with 30.33 and 30.05 cm, respectively. The shortest panicle was measured from Malundiang with 16.63 cm. The upland rice Dabao, Kawilan, Mal-os and Sinulid were found to have a comparable panicle length. In like manner, the Dinorado, Manisi, Mubpon and Ulipapa upland rice cultivars were almost of similar panicle length (Table 3). The study of Rabara et al. (2014), Zang et al (1992), IRRI (1975), Chang et al (1972) and Caldo et al. (1996) found out variations in the different yield components of Philippine upland rice varieties. The study of Sohrabi et al. (2012) confirmed that most traits such as plant height, yield of plant, panicle length, number of panicles, and days to flowering are associated among each other, which suggested that utilization of these traits could help in the selection of cultivars to improve upland rice production.

In terms of 1,000 grain weight, Ulipapa got the highest grain weight of 28.54 g but did not differ with Bungulan statistically with 27.35 g (Table 2). The upland rice Azucena, Mubpon, Kapalawan and Malundiang have grain weight of 25.24 g, 24.86 g, 22.4 g and 22.69 g, respectively but it did not vary among cultivars. The grain weight of upland rice Dinorado, Kawilan, Sinulid and Hinumay were heavier than the grain weight of Dabao, Magalitok and Mal-os. The lowest 1,000 grain weight was measured from Manisi with 15.33 g (Table 2). The differences in grain weight among upland rice cultivars were due to the seed size and shape. The rice cultivars with long grains and round or oval shape are anticipated to have higher yield potential than the grains with smaller size and slim shape (Table 2). Upland rice with smaller grains were likely to have lower yield based on the findings of the study of Wu et al. (2011), Rabara et al. (2014, IRRI (1975), Chang et al. (1972) and Chang & Vergara (1972).

Conclusion

The local upland rice cultivars vary in grain size and shape. Some grains were round or oval while others have oblong contour. Azucena, Kapalawan, and Bungulan have longer (9-12 mm) translucent caryopsis (endosperm) and aromatic. Mubpon had medium grain size and semi-aromatic while Dinorado had aromatic pinkish to purplish caryopsis and medium size grain. Bungulan, Ulipapa, and Magalitok cultivars have medium size grain of about 8-11 mm. Azucena, Dinorado and Bungulan have been planted for several decades by the local farmers due to desirable grain traits like longer to medium grains, oblong and aromatic.

Most of the upland rice were medium to tall, produced few tillers and panicles. Hinumay and Azucena were the tallest among rice cultivars with plant height of 126.5 and 127 cm, respectively. Kawilan got the highest number of tillers with 6.5 and 5 panicles per plant. Malundiang cultivar flowered early at 65-70 days while Azucena and Kawilan have late flowering of more than 90 days after planting. Magalitok had the longest panicle with 31.06 cm and the shortest panicle was measured from Malundiang with 16.63 cm. Ulipapa had the highest 1,000-grain weight of 28.54 g while Manisi got the lowest grain weight of 15.33 g only. The result in grain weight shows that Malundiang and Ulipapa have high yield potential, a good characteristics of upland rice. Bungulan, Mubpon, Sinulid and Mal-os have desirable agronomic characteristics based from the result of this study. The phenotypic variations of traditional upland rice (for both grains and plant structure) indicate species diversity in the locality. Besides, Bangi and Aquino (2014) made prior genetic analysis of the said upland rice cultivars which further prove the distinctions among local cultivars. With the findings of this study, the local community must safeguard the remaining upland rice cultivars that are found potential for improving production and the genetic traits necessary for upland rice breeding programs.

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Appendix Figure 1: Vegetative stage of selected local upland rice of Arakan Valley, Cotabato, Philippines



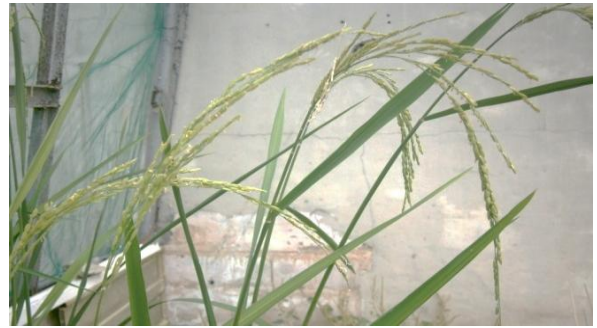
Appendix Figure 2: Selected indigenous upland rice at reproductive stage and ripening period.



Malundiang



Hinumay



Dabao



Kapalawan



Appendix Figure 3: Rice panicles of traditional upland rice cultivars of Arakan Valley, Cotabato, Phils.



Bungulan Mubpon



Dinorado



Malundiang



Dabao Manisi



Ulipapa



Sinulid



Mal-os



Kawilan



Azucena



Magalitok

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