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Heritability and Predicted Gain of Twelve Traits in Fifty-five Upland Rice Varieties

Aldrin Y. Cantila[1*], Sailila E. Abdula[2] and Alvin John R. Quitel[1]
[1]Philippine Rice Research Institute Midsayap Experimental Station, North Cotabato
[2]Philippine Rice Research Institute Central Experimental Station, Nueva Ecija
*Corresponding author: aldrincantila@gmail.com

Abstract

The genetic information about upland rice traits in terms of heritability (H^2b) and predicted gain expressed to the mean (RAM) could lead to an effective selection process of upland varietal development. Fifty-five upland rice varieties (URVs) were evaluated using 12 traits in three seasons. Traits culm length (CL), days to 50% flowering (DF), days to maturity (DM), flag leaf length (FLL), flag leaf width (FLW), grain length (GL), grain width (GW), one thousand grain weight (OTGW), plant height (PH), panicle length (PL), productive tillers (PT) and yield (YCC) had an overall mean of 102.7 cm, 55.3 days, 91.2 days, 37.9 cm, 1.6 cm, 8.69 mm, 2.92 mm, 21.2 g, 120.6 cm, 26.5 cm, 6.7 tillers and 2.25 t/ha, respectively. STAR V2.01 provided a combined analysis of variance (ANOVA) and found a high significance among URVs in all traits with corresponding coefficient of variation range of 3.3% (DM) to 24.16% (YCC). H^2b on the other hand had a range of 89.3% (PH) to 99.2% (OTGW) while RAM had a range of 14.5% (GL) to 91.7% (YCC). It was CL, DF, DM, FLL, GL, OTGW, PH, PL and YCC with H^2b >95% were highly heritable and FLL, FLW, PL and YCC with RAM >30% were high in genetic gain. Therefore, bigger flag leaves (FLL and FLW) as first indicator and yield as last indicator could be recommended in deciding what genotypes to keep and develop in the upland breeding process.
Keywords: Heritability, Predicted gains, Upland rice

Introduction

Upland rice could be a dollar earner as export crop product is important to the economy of any country (IRRI, 1975). It is cultivated in the mountainous area by financially unfortunate farmers that could yield 0.5 to 1.5 tons/ha in Asia and about 0.5 tons/ha in Africa (IRRI, 1975). However, several upland rice varieties have superior grain quality over lowland rice varieties (Villareal et al 1990) and have distinct characteristics to withstand abiotic stresses like drought and nutrient-deficient soils. However, most of the upland rice research findings could not be easily accessed, leading to a little or no effect in upland rice production industry (Tuhina-Khatun et al 2015). Nonetheless, Cantila et al (2017) found out that upland grain attributes (grain length, width, size and weight) were high in variation over other traits in the lowland of the Philippines. In different studies, Sohrabi et al (2012) revealed that plant height, days to flowering, days to maturity, flag leaf length and width ratio, 1000 grain weight, yield per plot, panicle length, spikelet per panicle and spikelet fertility were highly heritable while number of tillers, number of grains per panicle and number of panicle per hill were moderately heritable based on 50

URVs in Malaysia while Tuhina-Khatun et al (2015) discovered that days to maturity, plant height, photosynthetic rate, transpiration rate, stomatal conductance, intercellular CO_2, number of filled grains, and yield per plant were highly heritable while 100 grain weight, grain length and width ratio, grain length, number of unfilled grains, number of effective tillers/plant, total number of tillers/plant, flag leaf length and days to flowering were moderately heritable; and panicle length and leaf chlorophyll content were in low heritability based on 43 URVs in Bangladesh. However, Cantila et al (2016) used inbred lowland rice varieties and realized that plant height, panicle weight and spikelet number per panicle were highly heritable while panicle weight alone had the highest predicted gain expressed to the mean (RAM) with 21.14%. This study was done to discover and understand different upland rice traits based on heritability (H^2b) and RAM.

Methodology

Fifty-five URVs were collected by Philippine Rice Research Institute (PhilRice) and used as experimental materials (Table 1). The materials were laid out in randomized complete block design (RCBD) replicated three times in PhilRice Midsayap experimental station following a rainfed condition for three seasons. Season dates were as follows: season 1 on April to July 2015, season 2 on September to December 2016, and season 3 on May to August 2017. The experimental materials were supplemented and developed by fertilizers while protected by chemicals and herbicides. The data gathered was the culm length (CL) in cm, days to 50% flowering (DF), days to maturity (DM), flag leaf length (FLL) in cm, flag leaf width (FLW) in cm, grain length (GL) in mm, grain width (GW) in mm, plant height (PH) in cm, panicle length (PL) in cm, productive tillers (PT), one thousand grain weight (OTGW) in grams and yield (YCC) in t/ha. Then it was analyzed using STAR V2.01 (2014), Wricke and Weber (1986) for the genotypic and phenotypic variance, Singh and Chaudhary (1985) for the genotypic and phenotypic coefficient of variability, Nyquist (1991) for the H^2b, and Shulka et al (2006) for the RAM.

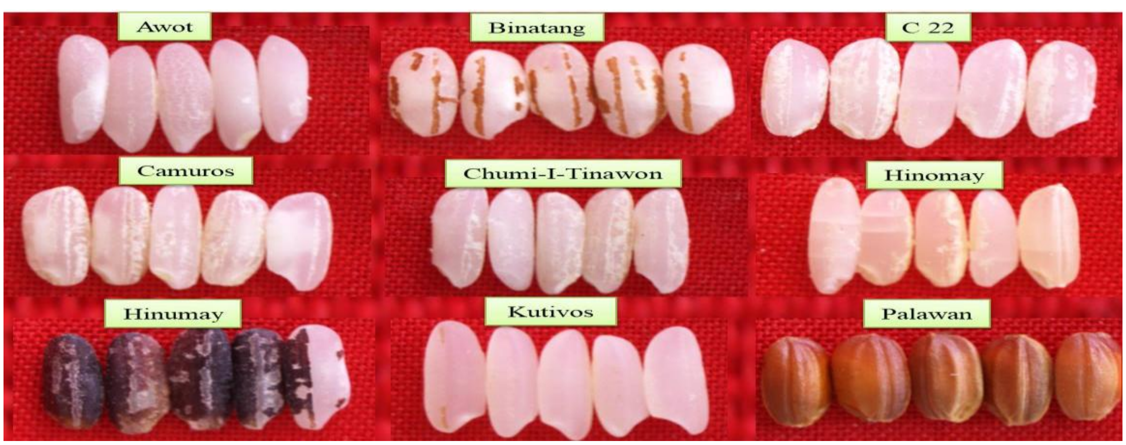

Figure 1. Samples of upland rice varieties showing grain variation.

Name	Origin	Name	Origin	Name	Origin
Arabon	V	Hinomay	M	Minarugon	SL
Aritao-Cagayan	V	Hinumay	CL	Murado	V
Awot	M	Inamos	SL	P1-2-2 (Mimis)-16	NL
Balibod	SL	Inipot-Ibon	SL	Palawan	SL
Batangueño (Glut)-16	CL	Kawatil Gold	M	Parirutong	CL
Binatang	SL	Kinaboag	V	Pe-2	SL
Binato	SL	Kutivos	V	Penantad	M
Binisaya	CL	Langangan	CL	Pilit Tapol	V
Buntot Kabayo	CL	Linangka	SL	Pinalwa	M
C 2	CL	Magsanaya	CL	Pingkitan	NL
C 22	SL	Magsanaya Seln (Ci 12039)-16	CL	Piniling Baybay	CL
C 43	CL			Pinursigi	SL
Camuros	SL	Malagkit (Inaku-Neneng Dinakot)	SL	Pirurutong	V
Chumi-I-Tinawon	SL			Pokkali	NL
Daludo	NL	Maligaya 2	CL	Ranan	NL
Dinit-An	NL	Maliket	NL	Sang-Laya	NL
Dinorado	SL	Mangglutus	SL	Sinaguing	CL
Dukpayon	M	Milbuen 3	SL	Sinampablo	CL
Guinata	CL	Milpal 18	SL	Wagwag	CL

V=Visayas, M=Mindanao, SL=Southern Luzon, CL=Central Luzon and NL=Northern Luzon.

Table 1. Name of 55 upland rice varieties collected in different areas of the Philippines.

Results and Discussion

Data Significance

Descriptive statistics can explain basic analysis of the genetic variation. Genetic variation in traits (sample in Figure 1) is vital to plant breeding for it gives wide opportunity to select genotypes in developing new breeding materials (Pandey et al 2009). CL, DF, DM, FLL, FLW, GL, GW, OTGW, PH, PL, PT and YCC had an overall mean of 102.7 cm, 55.3 days, 91.2 days, 37.9 cm, 1.6 cm, 8.69 mm, 2.92 mm, 21.2 g, 120.6 cm, 26.5 cm, 6.7 tillers and 2.25 t/ha, respectively in 55 URVs for three seasons (Table 2). URVs expressed higher values of CL, DF, DM, FLL, GW, PH, PT and YCC while lower values of PL showed up in season 2 compared to the other seasons. In season 1, URVs had higher values of FLW and GL but lower in DF, DM and FLL; season 3 had URVs with lower values of FLW, GL, GW, OTGW and PH. Results implied that URVs in season 2 were taller plants with longer flag leaves, late flowering and maturing and high tillering and yielding. In contrast to the URVs in season 3, they had narrower flag leaves, lighter grains and short stature. URVs in season 1 on the other hand were also early flowering and maturing, wider but shorter flag leaves, and longer grains. However, the combined ANOVA showed that most of the traits' differences between seasons were not significant. And, high significant difference was found among URVs in all traits while high or significant difference was found in GxE in CL, DF, OTGW, PH and PT (Table 3). CV in the same way revealed a range of 3.3% to 24.16%, where only YCC and FLW had >20% CV. Maphumulo et al (2015) revealed that 20% and below CVs connote low error made in a research.

Result therefore in ANOVA implied that the data gathered was valid and the experimental materials had provided enough variation in the study.

Traits	**Mean**			**Overall mean**	**Standard error of the mean**
	Season 1	**Season 2**	**Season 3**		
Culm length (cm)	102.5	104.2	101.5	102.7	0.80
Days to 50% flowering	54.9	55.9	55.2	55.3	0.30
Days to maturity	90.8	91.7	91.1	91.2	0.27
Flag leaf length (mm)	37.7	38.0	37.8	37.9	0.08
Flag leaf width (mm)	1.8	1.5	1.4	1.6	0.12
Grain length (mm)	8.84	8.66	8.58	8.69	0.08
Grain width (mm)	2.91	2.96	2.89	2.92	0.02
One thousand grain weight (g)	21.2	21.3	21.1	21.2	0.05
Plant height (cm)	119.7	123.5	118.8	120.6	1.44
Panicle length (cm)	26.6	26.3	26.6	26.5	0.11
Productive tillers	6.7	6.9	6.6	6.7	0.08
Yield (t/ha)	2.17	2.52	2.06	2.25	0.14

Table 2. STAR V2.01 showed the means and standard errors of the 12 traits.

Traits	**Mean squares**					**CV (%)**
	Season (E)	**Rep/E**	**Genotype (G)**	**GxE**	**Pooled Error**	
Culm length (cm)	313.2^{ns}	364.6**	2605.2**	240.8**	72.8	8.31
Days to 50% flowering	43.8^{ns}	19.5*	433.1**	10.0^{*}	6.5	4.6
Days to maturity	35.3^{ns}	31.5*	429.7**	11.0^{ns}	9.1	3.3
Flag leaf length (mm)	3.5^{ns}	30.6*	383.4**	4.2^{ns}	8.7	7.81
Flag leaf width (mm)	6.8**	0.1^{ns}	0.8**	0.0^{ns}	0.1	23.21
Grain length (mm)	3.0^{ns}	0.3^{ns}	3.9**	0.2^{ns}	0.2	5.01
Grain width (mm)	0.2^{ns}	0.1^{ns}	0.9**	0.0^{ns}	0.1	11.4
One thousand grain weight (g)	1.3^{ns}	2.0**	58.1**	0.5**	1.8	6.32
Plant height (cm)	1030.3^{ns}	166.8**	2240**	239.6**	28.0	4.39
Panicle length (cm)	6.0^{ns}	7.5^{ns}	93.1**	2.6^{ns}	4.0	7.56
Productive tillers	3.3^{ns}	1.6^{ns}	45.1**	3.8**	1.2	16.45
Yield (t/ha)	9.4^{ns}	2.5**	10.1**	0.4^{ns}	0.3	24.16

*^{ns} = not significant with p value ≥ 0.05, * = significant with p value ≥ 0.01 , ** = highly significant with p value ≥ 0.001.*

Table 3. STAR V2.01 provided the combined ANOVA and showed the mean squares and coefficient of variation (CV) of the 12 traits.

Heritability and Predicted gain

Genetic variation is the key to broaden the rice gene pool, but this variation requires a reliable estimation of H^2b that shall be used in the breeding activity (Akinwale et al 2011). Variation in genotype as genotypic variance (GV) and in phenotype as phenotypic variance (PV) are only raw components to solve H^2b. GV was ranged in 0.08 to 285.01, PV was ranged in 0.11 to 298.36; and H^2b was ranged in 89.3 to 99.2% (Table 4). H^2b gives information on the trait inheritance while splitting the effect of environment from the total variance (Allard 1960). Information about H^2b aids plant breeders and researchers to predict the mode of the successive generation and serve as decision tool in proper selection assessing the genetic level that was improved through selection (Tuhina-Khatun et al 2007). Robinson et al (1949) said that H^2b falls in three conditions; >50% is high, 50% is moderate and <50% is low. Since all traits had >80% H^2b, the study recommended H^2b >95% to increase reliability in the estimation. DF, DM, FLL, FLW, GL, GW, OTGW, PT and YCC had >95% H^2b. Several studies in rice also found high heritability on these traits. Phenological traits such as DF and DM were highly heritable according to Mulugeta et al (2012) based on 14 URVs evaluated in six environments and Singh et al. (2014) based on 48 URVs. DF and YCC (Kishore et al 2015), DM (Akhtar et al 2011), FLL (Yadav et al 2010), OTGW (Fentie et al 2014) and PT (Dutta et al 2013; Rai 2014) were highly heritable based on irrigated or rainfed lowland. High H^2b implies that environment had less effect on the traits in their phenotypic expression (Akinwale et al 2011) but H^2b does not give exact data for the possible gains. Predicted gain computes the progressive advantage for a trait under strict selection process (Wolie et al 2013). Aside from high H^2b, Johnson et al (1955) and Burton and De Vane (1953) reported that high genetic gain was effective for selecting progenies. Nirmaladevi et al (2015) recommended traits with high H^2b and >20% genetic gain in rice. However, this study used >30% predicted gain expressed to the mean (RAM). RAM was ranged from 15% to 91.7%. Since FLL had 34.9% RAM, FLW had 38.5% RAM and YCC had 91.7% RAM, all with >95% H^2b, they can be recommended as criterion in selecting URVs for the next generation. To be specific, flag leaves should be used as indicator in early stage of selection while yield as last indicator.

Traits	GV	PV	H^2b (%)	RAM (%)
Culm length (cm)	285.01	298.36	90.8	29.5
Days to 50% flowering	47.45	49.37	97.7	24.9
Days to maturity	46.84	49.47	97.4	15
Flag leaf length (mm)	41.52	44.77	98.9	34.9
Flag leaf width (mm)	0.08	0.11	97.2	38.5
Grain length (mm)	0.41	0.47	95.4	14.5
Grain width (mm)	0.08	0.13	98.4	21.3
One thousand grain weight (g)	6.3	6.77	99.2	24.4
Plant height (cm)	246.14	254.4	89.3	22.7
Panicle length (cm)	4.91	5.24	91.6	60.3
Productive tillers	9.64	11.77	97.2	23.9
Yield (t/ha)	1.08	1.21	96.3	91.7

Table 4. Results in genotypic variance (GV), phenotypic variance (PV), heritability (H^2b) and predicted gain expressed to the mean (RAM) of the 12 traits.

Conclusion

The combined ANOVA had proved the validity and significance of the data. In a H^2b range of 89.3% (PH) to 99.2% (OTGW) and RAM range of 14.5% (GL) to 91.7% (YCC), CL, DF, DM, FLL, GL, OTGW, PH and YCC with H^2b >95% were highly heritable while FLL, FLW, PL and YCC with RAM >30% were high in genetic gain. Since only three traits, FLL, FLW and YCC had reached the criterion;

these traits should be used together as selection criteria for upland breeding and development of varieties.

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