

Growth performance and yield stability of selected local upland rice genotypes in Buton Utara of Southeast Sulawesi

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Abstract. To evaluate the growth performance and yield stability of seven selected local upland rice genotypes, field experiment was conducted in Buton Utara during rainy season 2015 and 2016. Seven selected upland rice genotypes were grown in six different locations and evaluated in a randomized complete block design with three replications. The variables observed were plant height, leaf area, number of tillers, number of productive tillers, panicle length, number of grains per panicle, number of filled grain per panicle, percentage of unfilled grain, 1000 grain weight, grain dry weight, and grain yield (t/ha). The results were analyzed using analysis of variance and combined analysis of variance for the interaction of environment x cultivars. Data on various growth characters and yield stability indicated different among genotypes and significant effect followed by the DMRT test at the significant level $\alpha = 0.05$. The genotypes of *Wakawundu*, *Wabalongka*, and *Mantebeka* have high yield stability, while the genotypes of *Waapolo*, *Warangka*, *Wabila Lambale*, and *Warara* have low yield stability. Hence, *Wakawundu*, *Wabalongka*, and *Mantebeka* could be recommended for cultivation by the farmers in Buton Utara and these cultivars should be popularized in larger scale to make use of its superiority.

1. Introduction

Rice is the second largest produce cereal in the world in 158.3 million hectare area with annual production of about 685.24 million metric tons [1] and the staple food for over one third of the world's population, but more than 90% of rice is produced and consumed in Asia. Rice grain contains 75 to 80% starch, 12% water and 7% protein [2-3].

Rice is a very important staple food in Indonesia. Indonesia has been major rice producing but in another side as the main rice consumer [4-5]. The rice demanding is expected to increase in line with the increase in population. The government of Indonesian has two policy to reach rice self-sufficiency [6]. First is through the increasing rice production and second through the decreasing level rice consumption, and promoting local source staple foods such sago [7], cassava or corn [5]. One effort to improve rice production is through development of upland rice in dry land [8].

Upland rice comprises 11% of the total global rice production and is cultivated on about 14 million hectares [9]. It is also important in cropping systems, because of the lack of irrigation facilities and lower cost of production [10]. Genotype relationship is mainly based on information about plant



characteristic. Agronomic and morphological characters are usually used as an initial tool to distinguish between varieties [11]. The sustainability of rice production depends on the development of new rice cultivars with high yield and stable performance across diverse environments [12]. Many tools related to grain yield analysis are available for this purpose. One of the effective factors to study of stability is to determine interaction between genotype and environment and it was studied by many researchers on the various genotypes of rice [13-14]. The $G \times E$ interaction can cause differences in grain yield performance and stability of a genotype developed in different environments [15].

The stability of yield in cultivars in different places can be due to cultivar performance that derived from a specific collection of genes (G), the characteristic that associated factors of the environment in which it is grown (E), and the interaction between genotype and location which are usually conducted in various years and locations to satisfactorily stand for spatio temporal variation [16].

Statistical analyzed using AMMI analysis and biplot facility, the promising rice yield data were analyzed to determine the nature and magnitude of $G \times E$ interaction effects on grain yield in diverse production environments to identify high yielding and stable genotypes adapted to diverse production environments, and to determine the areas where rice genotypes would be adapted and produce economically competitive yields [17]. Present study was carried out to evaluate the growth performance and yield stability of seven promising local upland rice genotypes in the various locations and agro-climatic regions of North Buton Regency, Indonesia.

2. Materials and Methods

Seven selected upland rice genotypes were grown in six different locations and evaluated in a randomized complete block design (RCBD) in each location. The field was divided into three blocks; representing three replications. The seeds were directly grown in the soil plots. The local upland rice cultivars consisted of *Wabalongka*, *Waapolo*, *Warangka*, *Wakawondu*, *Mantebeka*, *Wabila Lambale*, and *Warara*.

Land preparation for the planting of seeds involved slashing of the bush, plowing and harrowing. The seeds were planted at the rate of three seeds per hole at a depth of 5 cm, with an inter and intra-row spacing of 25 x 25cm. The plot size was 3 x 4 m². Several agronomic traits, i.e: plant height, leaf width, leaf length, flag leaf length, tillers number, and productive tillers number were observed to characterize the cultivars phenotypically. Data on grain yield and some other yield components, i.e: harvesting date, the number of grains per panicle, filled grains, unfilled grains, 1000 grain weight, and total grain yield (t ha⁻¹) at 14% moisture level were collected. The results were analyzed using analysis of variance and combined analysis of variance for the interaction of environment x cultivars. Data on various growth characters and yield stability indicated different among genotypes and significant effect followed by the DMRT test at the significant level $\alpha = 0.05$.

Overall characterization results data were analyzed using analysis of variance (ANOVA) and displayed descriptively. The mean differences were adjudged with Duncan's Multiple Range Test (DMRT), Genotype-Environment Interaction (GEI) were estimated by the AMMI model [18]. All data were subjected to analysis using Cropstat version 7.2.

3. Results and Discussion

3.1. Growth components

Plant height of local upland rice recorded different among seven rice genotypes at observation on 30, 60, 90, and 120 days after planted (DAP) (Fig. 1). All cultivars gained different plant height at maturity due to various internodal lengths. The cultivars having longer internodes produced taller plants.

The findings are in agreement with those of other research stated that longer internodes increased plant heights in rice [19]. Genetic differences between different varieties also caused variation in plant lengths. Similar results were described that plant height depends on genetic character of a plant and environmental conditions [20]. Montebeka cultivar gained the highest plant length at maturity (Fig. 1). From transplanting to maximum tillering stage it was similar to Warangka and Wabila lambale

cultivars but afterwards length increased at much faster rate than others, so it became vulnerable to lodging. Other reported lodging in varieties having length of 4th and 5th internode equal to or more than 15 cm [21].

Wakawondu cultivar produced higher number of tillers as compared to other cultivars, except *Warangka* and *Montebeka* cultivars statistically the same (Fig. 2). It was due to their genetic variations. At maximum tillering stage *Warangka* achieved higher number of tillers than *Wakawondu* but this number decreased rapidly as compared to *Wakawondu* which retained significantly higher number at maturity.

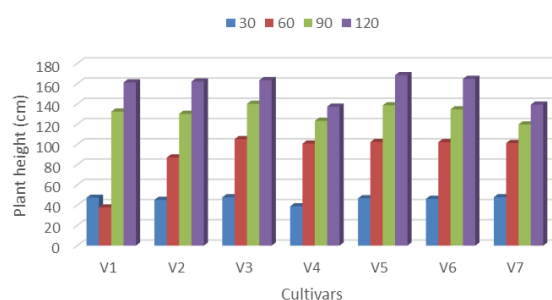


Fig. 1. Plant height of seven cultivars at 30, 60, 90 and 120 DAP
V1= *Wabalongka*, V2= *Waapolo*, V3= *Warangka*, V4= *Wakawondu*,
V5= *Montebeka*, V6= *Wabila lambale*, V7= *Warara*

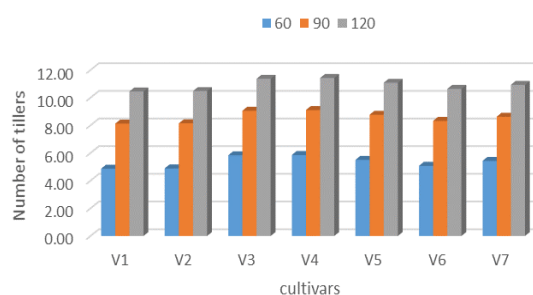


Fig. 2. Tillers number of local upland rice at 60, 90, and 120 DAP
V1= *Wabalongka*, V2= *Waapolo*, V3= *Warangka*, V4= *Wakawondu*,
V5= *Montebeka*, V6= *Wabila lambale*, V7= *Warara*

3.2. Yield components and yield

Yield components and yield of local upland rice cultivar obtained differed based on panicle length, grains number, filled grain number, fresh weight grain, dry weight grain, grain weight per clump, and yield t.ha^{-1} (Table 1). The DMRT result shows that *Wabalongka* has longest panicle length compared with other cultivars, but was not significantly different with *Waapolo* and *Wabila Lambale* cultivars (Table 1). *Wa Apolo* found to be the cultivar with highest number of grains but was not significant different with *Wakawondu* cultivar.

The largest number of filled grain was obtained from *Wa Apolo* cultivar which was significantly different with other cultivars. The heaviest fresh and dry weight grains recorded on *Wakawondu* cultivar which was significantly different with other cultivars. *Warara* obtained as cultivar with the heaviest grain weight clump $^{-1}$, but was not significantly different with *Wakawondu*, *Wabalongka* and *Warangka* cultivars, respectively.

The highest yield (t.ha^{-1}) recorded on *Wakawondu* cultivar which was not significantly with *Wabalongka* and *Warangka* cultivars, but found significantly different from other cultivars. It can be considered that panicle number and grain number of almost local upland rice in the present study depends on tillers number and panicle length. Other reported that number of panicles depends on number of tillers and proportion of effective tillers [4].

Table 1. Yield components of local upland rice

Varieties (V)	Panicle Length	Grains Number	Filled Grain Number	Fresh Weight Grain	Dry weight grain	Grain weight clump ⁻¹	Yield (t.ha ⁻¹)
<i>Wabalongka</i>	41.84 ^a	141.76 ^b	134.85 ^b	41.62 ^e	32.38 ^e	53.43 ^{ab}	4.23 ^d
<i>Wa Apolo</i>	40.50 ^{ab}	154.42 ^a	147.00 ^a	49.08 ^c	38.33 ^c	50.99 ^{bc}	4.24 ^{cd}
<i>Warangka</i>	39.89 ^{bc}	125.73 ^{ef}	117.39 ^d	44.06 ^d	31.86 ^{ef}	53.07 ^{ab}	4.53 ^{bc}
<i>Wakawondu</i>	37.32 ^d	149.37 ^{ab}	141.31 ^a	53.80 ^a	44.88 ^a	56.65 ^a	4.81 ^a
<i>Mantebeka</i>	39.00 ^{bcd}	128.88 ^{cde}	121.41 ^{cd}	51.49 ^b	35.49 ^d	51.27 ^{bc}	4.38 ^{bc}
<i>Wabila Lambale</i>	40.69 ^{ab}	130.68 ^{cd}	118.09 ^d	50.60 ^{bc}	39.44 ^c	52.07 ^{bc}	4.59 ^{bc}
<i>Warara</i>	39.55 ^{bc}	132.50 ^c	123.70 ^c	51.31 ^b	41.56 ^b	56.80 ^a	4.65 ^{ab}

Mean value followed by same letter at the same column are not significantly different at 5 % level by DMRT

The grain weight character per clump for all cultivars tested were stable at all locations, there were *Wabalongka* cultivar with specifically adapted to several locations (Table 2). *Mantebeka* and *Warara* cultivars were most adaptable at Eelahaji and Ronta, while *Warangka* cultivar was most adaptable at Lauki. *Waapolo*, *Wakawondu* and *Wabila lambale* cultivars were most adapted at Peteta'a, West Bubu and Labajaya, respectively.

Table 2. Stability analysis for grain dry weight (clump⁻¹) of seven upland rice genotypes in six environments

Cultivars	Average	IPCA 1	IPCA 2	ASV
<i>Wabalongka</i>	31.433	2.954	3.718	6.407*
<i>Waapolo</i>	32.329	-4.370	5.427	9.436*
<i>Warangka</i>	30.749	-0.706	-6.743	6.857*
<i>Wakawondu</i>	23.172	-8.381	2.762	15.061*
<i>Mantebeka</i>	30.222	10.715	0.795	18.944*
<i>Wabila lambale</i>	31.947	-3.596	-6.128	8.827*
<i>Warara</i>	26.487	3.385	0.168	5.982*
Location	Average	IPCA 1	IPCA 2	
Lauki	28.354	5.633	-3.115	
Peteta'a	32.036	10.372	-0.254	
Eelahaji	37.109	-2.408	-2.079	
West Bubu	22.582	-0.348	4.730	
Labajaya	33.496	-8.167	-6.636	
Ronta	23.285	-5.082	7.354	

*significant different to zero on ASV

Based on AMMI analysis with ASV value approach for the character of grain dry weight per panicle (Table 2) showed that all cultivars significantly different to zero. This means all the cultivars are not stable and only adaptable to the specific region. Lauki and Peteta'a location have large absolute scores of IPCA 1 and small IPCA 2 means high productivity environment, so genotypes that planted at Lauki and Peteta'a sites will reflect the true genetic ability due to small environmental influences.

According to the character of grain dry weight per clump indicated all tested genotypes were stable in all locations, there were also specific cultivars adapted very well at some locations. *Wabalongka* and *Warara* cultivars were most adaptable at West Bubu. *Mantebeka* was most adapted at Peteta'a location, *Wabila lambale* and *Warangka* were most adapted cultivars at Eelahaji and Labajaya locations, respectively. *Waapolo* and *Wakawondu* cultivars were most adapted at Ronta.

In Figure 3, the environments fell into three sections. Among the environments Eelahaji, West Bubu, Labajaya and Ronta had short spokes and they do not exert strong interactive forces but the

environments Lebajaya, Ronta and Peteta'a had long spokes therefore represent the most discriminating environments.

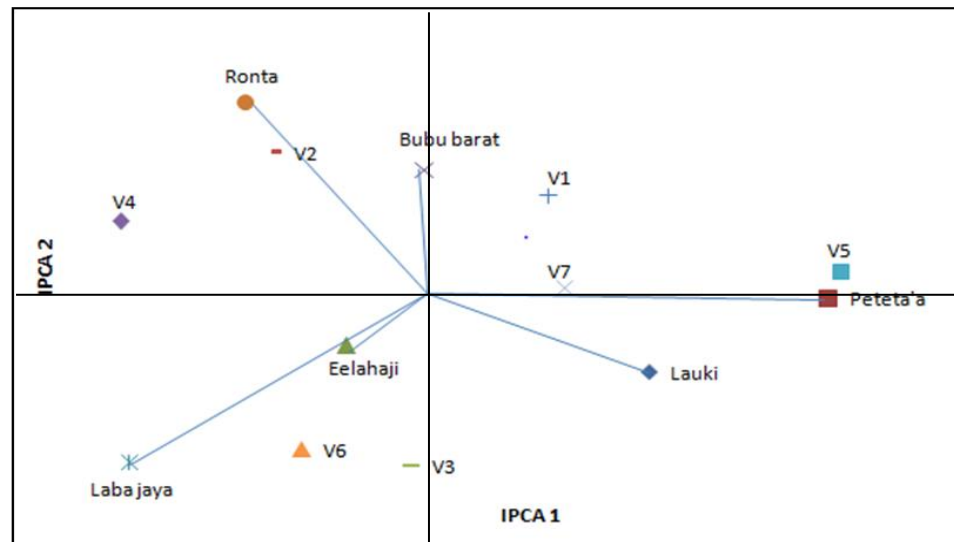


Fig. 3. AMMI 2 biplot for grain dry weight (clump⁻¹) showing the interaction of IPCA2 against IPCA1 scores of seven upland rice genotype (V) in six environments

Genotypes and environments that fall in the same sectors interact positively; in contrast if they fall in opposite sectors interact negatively. If they fall into adjacent sectors, interaction is somewhat more complex. In the present study, the best genotype with respect to sites Lebajaya and Eelahaji was *Wabila lambale* and *Warangka* genotypes but unsuitable for Peteta'a. Genotype *Waapolo* and *Wakawondu* were suitable for Ronta and West Bubu but unsuitable for Lauki and Peteta'a. The AMMI model is better for partitioning the G x E into the causes of variation, which ease identification of environments' potential and is used to identify superior genotypes either with specific adaptation or wide adaptation [26].

4. Conclusions

The genotypes of *Wakawondu*, *Wabalongka*, and *Mantebeka* have high yield stability, while the genotypes of *Wa Apolo*, *Warangka*, *Wabila Lambale*, and *Warara* have low yield stability. Hence, *Wakawondu*, *Wabalongka*, and *Mantebeka* could be recommended for cultivation by the farmers in Buton Utara and these cultivars should be popularized in larger scale to make use of its superiority.

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