Evaluation of the Yield of Upland Rice Varieties under Open Field Trial

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ABSTRACT Rice is a major staple food in most Asian countries. In Malaysia, the self-sufficiency level is currently at 72% that is, still 8% lower than the 80% target. One of the constraints in the industry is low rice production especially rice farms in hilly areas. Hence, the objective of this study was to evaluate the phenotypic diversity and yield of selected upland rice varieties under open field trial. The study was carried out from March to October 2017. Three upland rice varieties were selected in this study, which was Bario, Tadong, and Kondoduvon. The varieties were sampled from Telupid and Ranau, Sabah, Malaysia. The study was conducted at a 30 m X 10 m plot of Faculty of Sustainable Agriculture, Universiti Malaysia Sabah, Malaysia (5°55'43.8"N 118°00'20.2"E) in a randomized complete block design (RCBD) with six replications. Selected seeds were directly sown in beds of size 5 m X 1 m on 3rd March 2017 with 3 seeds per hill. The spacing between hills was 30 X 30 cm. Granular fertilizer, NPK green was manually applied ten days after sowing at 200 Kg/ha. Application of 200 Kg/ha of NPK blue fertilizer was done at panicle initiation of each variety. Ultisols soil was used as a planting medium. Bario showed the highest mean of the productive tiller (26.83) and percentage of filled grain (61.5%). Tadong showed the longest panicle length (28.47 cm) and highest extrapolated yield (3.77 tons ha^{-1}) while Kondoduvon showed the highest mean of 100-grain weight (3.39 g) and number of spikelets (159.67). In conclusion, Tadong is suggested to be the most suitable candidate for future breeding of high yielding upland rice variety.

KEYWORDS: Upland rice; Phenotypic diversity; Yield parameters; High yielding; Tadong
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INTRODUCTION

Rice present as a major staple food in most Asian countries. According to information by the Malaysia Department of Agriculture (2016), the approximate planted area was 681,559 ha with a total production of approximately 2,741,404 tonnes. Rice production in Malaysia has currently reached 72% of the self-sufficiency level, still 8% short of the 80% target.

In 2017, the population in Malaysia is estimated at 32.0 million and are expected to increase to 41.5 million by 2040 (Department of Statistics Malaysia, 2016). The area under rice cultivation has remained the same but the human population has become manifold. The options available are to enhance the yield of rice on per unit area basis (Cassman *et al.*, 2003) and development of rice cultivars with the high yielding ability which can increase production (IRRI, 1993). Different morphological traits play a very important role in the selection and breeding new plant type characteristics associated with the plant yield (Yang *et al.*, 2007; Yang & Hwa, 2008).

Generally, rice can be classified into four types of ecosystems which are; irrigated, rain-fed lowland, deep-water, and rain-fed upland. These ecosystems are categorized based on water regimes, drainage, temperature, soil type, topography, and location. Irrigated rice ecosystem contributes to 1/3 of the world's rice (Edirisinghe & Bambaradeniya, 2006). Upland rice ecosystem ranges from low-lying valleys to undulating and sloping lands with high runoff and lateral water movement. Upland rice constitutes less than 13% of the world's rice planted area. The remaining rice ecosystems are classified as flood-prone rice ecosystems.

In Malaysia, upland rice cultivation is practiced mostly by the rural communities living especially in Sabah and Sarawak. Upland rice farming is done mostly for home consumption and sometimes the farmers sell their surplus to earn some money. Farmers plant upland rice for their desirable characteristics, such as their fragrance, colours, sizes, and shapes. Health conscious consumers often regard this rice as organic food (Hanafi *et al*., 2009). Upland rice varieties have not been largely commercialized due to their low grain yields. However, the low grain yields upland rice is caused by the poor management of farmer during the cultivation period, weed infestation, insect-pest attack, lack water availability and lack mineral supply (Zainal, 2015). There is also little documentation done on the yield of upland rice in Sabah.

This study provides farmers the information on the grain yield of selected varieties. The objective of this study was to evaluate the phenotypic diversity of upland rice based on yield parameters.

METHODOLOGY

This study was carried out from March to October 2017. Three upland rice varieties were studied namely, Bario, Tadong, and Kondoduvon. The seeds of the varieties were collected from Telupid and Ranau, Sabah, Malaysia. The study was conducted at a 30 m X 10 m plot of Faculty of Sustainable Agriculture, Universiti Malaysia Sabah, Malaysia (5°55'43.8"N 118°00'20.2"E) in a randomized complete block design (RCBD) with six replications. Selected seeds were directly sown in beds of size 5 m X 1 m on 3rd March 2017 with 3 seeds per hill. The spacing between hills was 30 X 30 cm. Granular fertilizer, NPK green was manually applied ten days after sowing at 200 Kg/ha. Application of 200 kg/ha of NPK blue fertilizer was done at panicle initiation of each variety. Ultisols soil was used as a planting medium.

Weeding was done manually whenever necessary. Watering was done on a daily basis until the soil moisture is saturated. For pest management, the black thread netting was installed to control bird pest.

Data Recording

At maturity, eight plants from each bed were sampled for morphological traits. Productive tillers of each sample were counted. The number of productive tillers also indicates the total number of panicles in each plant. The panicle length was measured starting from the base of the lowest spikelet to the tip of the latest spikelet on the panicle, excluding awn. Right after harvesting, the number of spikelet per panicle and number of fertile spikelet was counted. After drying the samples in a 70°C oven for 3 days, the constant 100-grain weight was determined. In addition, the extrapolated yield was also calculated (Patel *et al*., 2010).

Statistical Analysis

All the data were subjected to One-way Analysis of Variance (ANOVA) by using the Statistical Analysis Software (SAS) Version 9.4 (SAS Institute Incorporation, 2002) software, to test the significant difference between the varieties. Duncan's Multiple Range test (DMRT) at 0.05 level of probability was carried out if there are significant differences among the means.

RESULTS AND DISCUSSION

Yield Components

Bario showed the highest mean of the productive tiller (Fig 1) and the percentage of filled grain (Fig 5). Tadong showed the highest mean panicle length (Fig 3) and extrapolated yield (Fig 6) while Kondoduvon showed the highest mean of 100-grain weight (Fig 2) and number of spikelets (Fig 4).

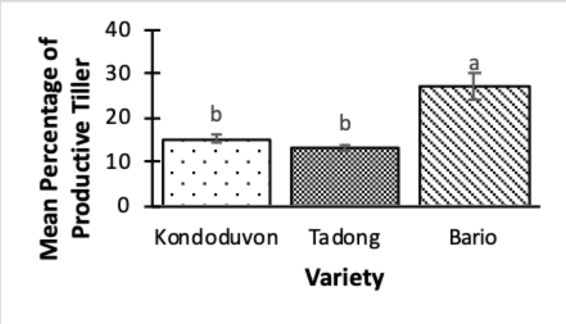

Figure 1. Mean percentage of the productive tiller of Kondoduvon, Tadong, and Bario

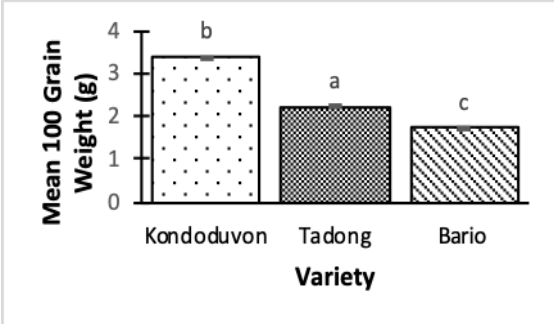

Figure 2. Mean 100-grain weight of Kondoduvon, Tadong, and Bario

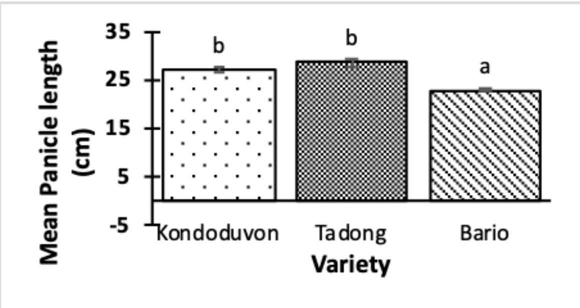

Figure 3. Mean panicle length of Kondoduvon, Tadong, and Bario

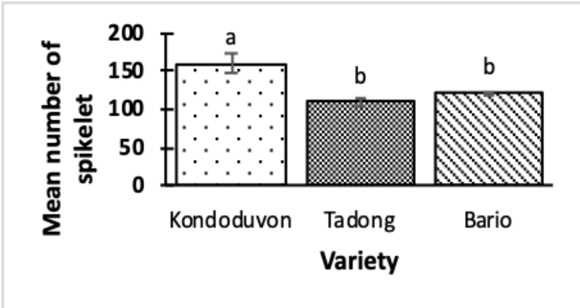

Figure 4. Mean number of the spikelets of Kondoduvon, Tadong, and Bario

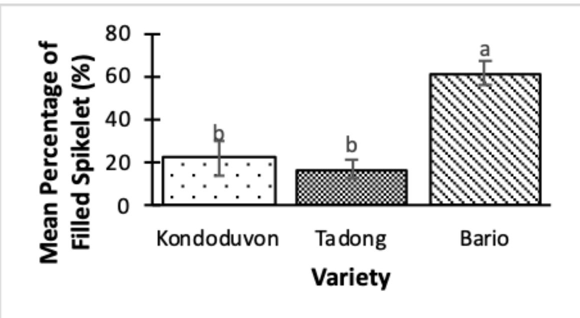

Figure 5. Mean percentage of filled grain of Kondoduvon, Tadong, and Bario

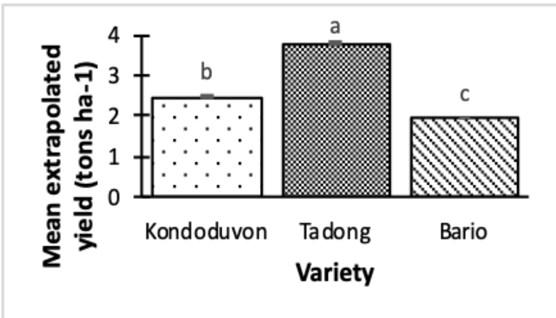

Figure 6. Mean extrapolated yield of Kondoduvon, Tadong, and Bario

Number of Productive Tiller

There was a significant difference in the number of productive tillers per hill between the rice ($p<0.05$). From Figure 1, it can be seen that Bario (26.83) achieved the highest productive tillers while Tadong was the lowest (13.17). The difference between Bario and Tadong was 13.66.

According to Kusutani *et al*. (2000) and Dutta *et al*. (2002), genotypes that produce the higher number of productive tillers per hill and a higher number of grains per panicle also showed higher grain yield in rice. The number of productive tillers also represents the number of panicles. The number of panicles produced was the result of the number of tillers and the proportion of productive tillers, which survived to produce panicle (Ashrafuzzaman *et al*., 2009). Even though Bario produced the most number of productive tillers, the extrapolated yield of Bario was low (Fig 6) due to low grain weight as well as short panicle length. These findings are similar to those of Gagandeep *et al*. (2016), where the variation in the number of productive tillers was due to the genetic make-up of different paddy varieties.

100-Grain Weight

In Figure 2, the mean 100-grain weight was significantly different between the rice varieties ($p<0.05$), where Kondoduvon was heaviest (3.39 g), followed by Tadong (2.21 g), and lastly, Bario (1.73 g). The difference between Kondoduvon and Bario was 1.66 g. The results were in accordance with those of Mondal *et al*. (2005) who reported a difference in 100-grain weight among 17 studied varieties. The difference in the grain weight was probably due to the difference in grain size in studied varieties.

Panicle Length

The mean panicle length was significantly different between rice varieties ($p<0.05$). From Figure 3, Tadong showed the highest mean panicle length of 28.47 cm, followed by Kondoduvon (27.03 cm), and Bario (22.72 cm). The difference between Tadong and Bario was 5.75 cm.

Morishima *et al*. (1962) reported that the average panicle length of 106 lines of *O. sativa* was 20.0 cm. All the studied rice varieties achieved above average on the panicle length. A study was done by Sohrabi *et al*. (2012) on 50 upland rice varieties in Malaysia found that the highest mean panicle length was 30.07 cm, which is higher than all the studied varieties in this study.

Longer panicle length is more favourable as yield is higher among those varieties with longer panicle length (Salam *et al*., 1990). Panicle length is an important trait in the improvement of panicle architecture and grain yield in rice (Liu *et al*., 2016).

Number of Spikelets

There was a significant difference in the mean of spikelet number between the studied rice varieties ($p<0.05$). From Figure 4, the highest mean spikelet number was Kondoduvon (159.67), followed by Bario (122.50), and Tadong (105.17). The difference in number of spikelet between Kondoduvon and Tadong was 54.5. The difference in spikelet number can be attributed to the genetic nature of different varieties (Hussain *et al*., 2014). Sohrabi *et al*., (2012) reported that the mean spikelet number of 50 upland rice varieties in their study was 159.14, which is similar to that of the Kondoduvon (159.67) in this study.

Percentage of Filled Grain

The mean percentage of filled grain was significantly different between the rice varieties ($p<0.05$). From Figure 5, the highest mean percentage of filled grain was achieved by Bario (61.5%), followed by Kondoduvon (22.5%) and lastly, Tadong (17.17%). Even though Kondoduvon recorded a higher number of spikelet per panicle, but Bario has a higher percentage of filled grain.

During this study, insect pest was a problem. It was found that *Leptocorisa* sp. was infesting the study site at the flowering stage and even though sprayed with insecticide, the damaged spikelets did not undergo filling stage properly. In addition, shorter rice photosynthesis time and higher temperature at panicle initiation stage might also be the possible reasons for the fewer grain number per panicle (Mo *et al*., 2017).

Extrapolated Yield

The mean extrapolated yield was significantly affected by the different rice varieties. From Figure 6, Tadong has the highest mean extrapolated yield of 3.77 tons ha^{-1}, followed by Kondoduvon (2.46 tons ha^{-1}) and lastly, Bario (1.93 tons ha^{-1}). Tadong has the highest extrapolated yield in comparison with Bario and Kondoduvon, this might be because Tadong has heavier 100-grain weight.

CONCLUSION

Although upland rice is gaining popularity among health-conscious consumers, there is little known about the yield of upland rice varieties in Sabah. Based on this study, Tadong showed better yielding ability in comparison with Bario and Kondoduvon. Further study needs to be conducted to develop the Tadong variety as high yielding, drought tolerant upland rice.

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REFERENCES

[1] Ashrafuzzaman, M., Rafiqul Islam, M. D., Ismail, M. R., Shahidullah, S. M., and Hanafi, M. M. (2009). Evaluation of Six Aromatic Rice Varieties for Yield and Yield Contributing Characters. *International Journal of Agriculture and Biology*, **11**(5), 616–620.

[2] Cassman, K. G., Dobermann, A., Walters, D. T., and Yang, H. (2003). Meeting Cereal Demand while Protecting Natural Resources and Improving Environmental Quality. *Annual Review of Environment and Resources*, **28**(1), 315–358.

[3] Department of Statistics Malaysia. (2016). *Population Projection (Revised), Malaysia, 2010-2040*. Retrieved from https://dosm.gov.my/v1/index.php?r=column/cthemeByCat&cat=118&bul_id=Y3kwU2tSNVFDOWp1YmtZYnhUeVBEdz09&menu_id=L0pheU43NWJwRWVSZklWdzQ4TlhUUT09

[4] Dutta, R.K., Baset Mia, M.A. and S. Khanam. (2002). Plant Architecture and Growth Characteristics of Fine Grain and Aromatic Rices and Their Relation with Grain Yield. *IRC Newsletter*, **51**: 51–56

[5] Edirisinghe, J. P., and Bambaradeniya, C. N. B. (2006). Rice Fields : an Ecosystem Rich in Biodiversity. *Journal of the National Science Foundation of Sri Langka*, **34**(2), 57–59.

[6] Gagandeep, H. N., Sunil, C. and Gopakkali, P. (2016). Growth, Yield and Grain Quality of Traditional Paddy Varieties as Influenced by Nutrient Management Practices. *International Journal of Farm Sciences*, **6**(1): 120-133

[7] Hanafi, M. M., Hartinie, A., Shukor, J., and Mahmud, T. M. M. (2009). Upland Rice Varieties in Malaysia : Agronomic and Soil Physico-Chemical Characteristics. *Pertanika Journal of Tropical Agricultural Science*, **32**, 225–246.

[8] Hussain, S., Fujii, T., McGoey, S., Yamada, M., Ramzan, M., and Akmal, M. (2014). Evaluation of Different Rice Varieties for Growth and Yield Characteristics. *Journal of Animal and Plant Sciences*, **24**(5): 1504-1510

[9] IRRI. (1993). *Rice Research in a Time of Change. IRRI's Medium-term plan for 1994-1995*. International Rice Research, Los Banos, Philippines.

[10] Kusutani, A., Tovata, M., Asanuma, K. and Cu, J. (2000). Studies on the Varietal Differences of Harvest Index and Morphological Characteristics of Rice. *Japanese Journal of Crop Science,* **69**: 359–364

[11] Liu, E., Liu, Y., Wu, G., Zeng, S., Tran Thi, T. G., Liang, L., Liang, Y., Dong, Z., She D., Wang, H., Zaid, I.U., and Hong, D. (2016). Identification of a Candidate Gene for Panicle Length in Rice (*Oryza sativa* L.) Via Association and Linkage Analysis. *Frontiers in Plant Science*, **7**, 1–13. https://doi.org/10.3389/fpls.2016.00596

[12] Malaysia Department of Agriculture. (2016). *Paddy Statistic of Malaysia, 2015.* Department of Agriculture, Peninsular Malaysia.

[13] Mo, Z. W., Pan, S. G., Ashraf, U., Kanu, A. S., Li, W., Wang, Z. M., and Tang, X. R. (2017). Local Climate Affects Growth and Grain Productivity of Precision Hill-Direct-Seeded Rice in South China. *Applied Ecology and Environmental Research*, **15**(1), 113–125. https://doi.org/10.15666/aeer/1501_113125

[14] Mondal, M.M.A., Islam, A.F.M. and Siddique, M.A. (2005). Performance of 17 Modern Transplant Aman Cultivar in the Northern Region of Bangladesh. *Bangladesh Journal of Crop Science*, **16**, 23–29

[15] Morishima, H., Hinata, K. and Oka, H.I. (1962). Comparison between Two Cultivated Rice Species, *Oryza sativa* L. and *O. glaberrima* Steud. *Japanese Journal of Breeding*, **12**, 17-29.

[16] Patel, D. P., Das, A., Munda, G. C., Ghosh, P. K., Bordoloi, J. S., & Kumar, M. (2010). Evaluation of Yield And Physiological Attributes of High-Yielding Rice Varieties Under Aerobic and Flood-Irrigated Management Practices in Mid-Hills Ecosystem. *Agricultural Water Management*, **97**(9), 1269–1276. https://doi.org/10.1016/j.agwat.2010.02.018

[17] Salam, M. A., Khorshed, A. and Chowdhury. S. I. (1990). Morpho-Physiological Aspects of Binasail for its Improved Yield Potential Over the Parent Nizersail. *Bangladesh Journal of Nuclear Agriculture*, **5** (5), 15-21.

[18] SAS Institute Inc. (2002). *SAS Version 9.4.* SAS Institute. North Carolina (USA)

[19] Sohrabi, M., Rafii, M. Y., Hanafi, M. M., Akmar, A. S. N., and Latif, M. A. (2012). Genetic Diversity of Upland Rice Germplasm in Malaysia Based on Quantitative Traits. *The Scientific World Journal*, 2012, Article ID 416291.

[20] Yang, W., S. Peng, R.C. Laza, R.M. Visperas and M.L.D. Sese, (2007). Grain Yield and Yield Attributes of New Plant Type and Hybrid Rice. *Crop Science*, **47**, 1393–1400

[21] Yang, X.C. and C.M. Hwa, (2008). Genetic Modification of Plant Architecture and Variety Improvement in Rice. *Heredity*, **101**, 396–404

[22] Zainal, N.F. (2015). *Growth Performance and Yield of Lowland Rice Variety (Mr220cl and Mr 263), Cultivated in Different Soil Type of Sarawak*. B.S Thesis. Universiti Malaysia Sarawak, Malaysia.