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Genetic Analysis on Some Agro-morphological Characters of Hybrid Progenies from Cultivated Paddy Rice and Local Upland Rice

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Abstract

Six progenies F2 plants deriving from crossbreeding of cultivated rice 33/Wagamba were planted. The objectives of the experiment were to study the morphology and agronomic characters of F2 plants, and to study the heritability, genetic and phenotype variances of F2 progenies resulting from rice crossbreeding. The results showed that there were high variations in the growth of local upland rice crosses (F2), both on the components of growth such as plant height, number of productive tillers and the yield components such as panicle length, number of grains per panicle, filled grain percentage, and 1000-grain weight. Genetic factors contributed more than environmental factors, so that selection would not be effective if done on next-generation; hence, must be selected in early generations. Number of grains per panicle, plant height, filled grain percentages, and harvesting stage had high heritability accompanied with high genetic advance indicating that these are simply inherited traits, and the heritability is most likely due to additive gene effects. On the other hand, panicle length, number of productive tillers and 1000-grain weight had high heritability coupled with low genetic advance indicating non-additive gene effects.

Keywords: Agro-morphological character, Upland rice cultivar, Hybrid progeny, Crossbreeding, High yield

1 Introduction

Rice (*Oryza sativa* L.) is one of the most important food crops in the world and feeds over half of the global population. Lack of sufficient investment to improve varieties and yield is one of the factors that has delayed the increase in grain production [3].

The yield potential of current modern rice varieties in the tropics of Asia has stagnated recently. It is essential to improve the yield potential of modern rice varieties that may be accomplished through improving genetic potentiality of the genotypes. Yield is complex character and various morphological and physiological characters contribute to grain yield [11]. The plateau in yield levels of existing rice varieties and the adverse effects of climate and deteriorating soil health on crop yield are the major cause of concern. Rice varieties with increased yield potential in adverse conditions as well as in normal conditions have to be developed, in order to sustain the rice production across wide range of environments and over the years.

The demand for rice continues to increase due to population growth still high, changes in food consumption patterns of the traditional staple of the non-public part rice to rice, and the improvement of the people's economy. On the other hand, the pressure of pests, diseases and environmental as well as the shrinking of the potential wetland which tends to increase every year, causing an increase in rice production to achieve sustainable levels of production and offset the increase in demand will be difficult.

Challenge of meeting the needs of the future rice will be more difficult, because many irrigated fertile paddy fields converted for non-agricultural productivity levels tend to decline as well as residents who require growing rice. To overcome these problems can be done with the new paddy fields and increased productivity of existing wetland. However, the new paddy fields will be constrained by water resources are relatively limited irrigation and irrigated printing costs are quite expensive, and it takes long time for the new field to be able to achieve a stable level of production. The efforts to increase the productivity of paddy fields is already very difficult and the level of productivity of rice is now nearing the maximum for the tropics. Thus, the potential alternative is to develop sub-optimal land in the form of dry land for the development of upland rice.

Different trait may be important to increase the rice grain production. The considered traits may include short plant height, strong culms, moderate tillering, short and erect leaves, large and compact panicles, and early maturation [14]. Tillering in rice is one of the most important agronomic characters for grain production [18], because the tiller number per plant determines the panicle number, a key components of grain yield [20]. Panicle characters represent the most important part of rice plant type in respect of yield improvement.

Development and assembly of superior local upland rice high yielding potential and tolerance to drought is important to do in Indonesia because, most of the land potential for rice development is dry land. Dry land is generally located in areas with relatively low rainfall, high evapo-transpiration rate, water deficits that causing rice leaf or tiller death [6], and the ability of the soil to bind (retention) of water is also low, so the development of upland rice is the best alternative to increase rice production.

In addition, the local upland rice in Indonesia has high genetic potential, it has an advantage in terms of flavor, texture, and market acceptance. Some of the upland rice is upland rice landrace specific location and has the potential resistance to drought. Assembling of local upland rice high yielding potential and stress resistance possibly to use as seeds for upland rice planting expansion, it can avoid the problem of insecurity and scarcity of rice at the local level. In general, insecurity and food shortages arising from harvest failures, climate change and transportation, which may hinder the achievement of food security and rice production compliance. Rice breeding for high yield is one of the important factors to increase rice production as a solution of food shortage. Breeding method for rice high yield include conventional hybridization and selection, F1 hybrid breeding, ideo-type (ideal plant type) breeding and enhancement of photosynthesis [8]. The objective of the study was to study the development of high yielding rice varieties by crossing cultivated paddy rice and local upland rice varieties.

2 Materials and Methods

A cross between Wagamba upland rice (high grains quality) and 33-line (high yielding) were carried out to obtain a population of F2 plant progenies for analysis. The experiment was conducted at the experimental field of faculty of Agriculture, University of Halu Oleo Kendari, Indonesia. A single cross was performed between high yielding 33-line as a female parent (♀) (P1) and Wangkoito upland rice (high grain quality) as a male parent (♂) (P2) to produce F1. Furthermore, backcross method was carried out between F1 as female and donor parent (33-line) as a male, so that resulting the BC1. Half of F1 seeds were grown to form the F2 population. Crossing techniques was performed with the following steps: In the previous day evening, top 1/3rd portion and bottom 1/3rd portion in the panicle of the desired female parent are clipped off by scissors, leaving the middle spikelets. With the help of scissors again, top 1/3rd portion in each spikelet is clipp-off in a slanting position. The six anthers present in each spikelet are removed with the help of the needle (Emasculation). Then, to prevent contamination from the foreign pollen, the emasculated spikelets are covered with a butter paper bag. In the next day morning (usually at 9.00 AM), the bloomed panicle from the desired male parent is taken. The top portion of the butter paper bag which is originally inserted in the emasculated female parent is now cut to expose the panicle. The male parent panicle is inserted in an inverted position into the butter paper bag and sturned in both ways in order to disperse the pollen. After ensuring the abundant disbursement of pollen, the opened butter paper bag is closed using a pin. After ensuring pollination, the bag may be removed.

The following characters were subject of our investigations, i.e.: morphological characters consisting of leaves, ligule, stem, panicle and grains. While agronomic characters consisted of plant height, number of productive tillers, panicle length, number of grains per panicle, filled grain percentage, 1000-grain weight and date to harvest. The data obtained for each agronomic character in the F2 generations were estimated by the analysis of variance. To calculate the value of heritability in a broad sense and narrow sense of the formula used by Allard [2] as follows:

$$\sigma_{\sigma_g^2} = \sqrt{\frac{2}{n^2}\left\{\frac{KT_g^2}{db_g + 2} + \frac{KT_e^2}{db_e + 2}\right\}}$$

$$h_{bs}^2 = \frac{\sigma_G^2}{\sigma_P^2} = \frac{\sigma_g^2}{\sigma_g^2 + \frac{\sigma_g^2}{n}}$$

Based on the above analysis, the information about heritability could be obtained. This information contains the number and role of genes controlling the high yielding potency and resistance to drought stress, as well as other properties such as flowering date, number of grains per hill and other characters.

3 Results and Discussion

3.1 Morphology and Agronomic Characters of F2 Progenies

F2 progenies derived from crosses in the first year showed a segregation of morphology and agronomic characters, both on the qualitative traits, the components of growth and yield of rice plants resulting from crosses (Tables 1 and 2).

Vegetative growth of plants such as plant height seems that some F2 populations are more dwarf compared with the average of both parents (Table 2). However, the number of plant productive tillers becomes less than the average of both parents (33 and BU3). This is presumably due to the inheritance of quantitative traits are more influenced by environmental factors, especially solar radiation that is needed at the time of the establishment of rice tillers [10, 13].

In Table 3 shows that the yield components of F2 rice plant populations from the crosses was quite varied. For panicle length appears that some populations of F2 progenies had panicle length better than the average of both parents and close to the parent with longest panicle (Figure 1). The components of grains number per panicle from one of the F2 progeny showed the number of grains per panicle more than both parents, despite having the lowest percentage of filled grain. It is thought to be caused by differences in the genetic constitution that are owned and also because of the influence of the environment for planting in the field. Similarly, when viewed in terms of the variation seen phenotype plants are quite high, both on the stems, leaves and panicles produced.

In the production components such as the percentage of filled grain and 1000-grain weight showed that the F2 progeny (BU3/33) had the highest 1000-grain weight and significantly different from some other progeny.

Table 1. Morphological characteristic of F2 plants resulting from upland rice crosses.

Plants	Leaves			Ligule			Characters							Spikelet			
							Stalk			Panicle							
Parent	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
33	2	1	1	2	1	1	1	1	1	1	0	1	2	0	4	5	3
BU3	2	2	2	2	3	1	3	4	4	2	3	1	1	9	4	5	3
F2 Plants																	
33/BU3 (A)	2	2	1	2	3	1	1	4	4	1	3	1	2	0	4	5	3
33/BU3 (B)	2	1	1	2	1	1	1	1	1	1	3	1	2	0	4	5	3
33/BU3 (C)	2	1	2	2	1	1	1	1	1	1	3	5	2	0	4	5	3
33/BU3 (D)	2	1	2	2	1	1	1	4	1	1	3	5	2	0	4	5	3
33/BU3 (E)	2	1	2	2	1	1	1	1	4	1	3	1	1	0	4	5	3
BU3/33 (F)	2	2	1	2	3	1	3	4	1	2	3	1	2	9	4	5	3

Explanation:

LEAVES
A (Leaf overlay color) = (2) green; (3) dark green
B (Leaf Sheathts color) = (1) green; (2) Striped purple
C (Flag leaf angle) = (1) erect; (2) intermediate

STEM
G (Trunk angle) = (1) uprigth; (3) intermediate
H/I (Node/Internode color) = (1) green; (2) goldeness; (3) Striped purple; (4) purple

SPIKELET
N (Tail/Awn) = (0) absence; (9) length and overall
O (Apiculus color) = (1) white; (4) red
P/Q (Stigma/Anther color) = (1) white; (3) yellow; (5) purple

LIGULE
D (Ligule form) = (2) cleft
E (Collar color) = (1) ligth green; (3) purple
F (Auricle color) = (1) light green; (2) green

PANICLE
J (Panicle type) = (1) compact; (5) intermediate; (9) open
K (Secundary branching) = (0) absence; (3) clustering
L (Exersion) = (1) neck; (5) no-necked
M (Axis) = (1) uprigth; (2) droopy

Table 2. Average of plant height and number of productive tillers of local upland rice at flowering stage

Number	Cross combination	Plant height (cm)	Total productive tillers
1	33/BU3 (A)	103.5 b	7.67 b
2	33/BU3 (B)	91.4 d	4.33 de
3	33/BU3 (C)	72.3 e	5.67 c
4	33/BU3 (D)	102.3 b	3.67 e
5	33/BU3 (E)	91.6 d	4.67 cde
6	BU3/33 (F)	91.2 d	4.00 e
7	33	95.2 c	11.67 a
8	BU3	126.6 a	5.33 cd

Table 3. Observed result of yield component of upland rice crosses

No.	Crossing combination	Panicle lenght (cm)	Grains number per panicle	Percent of filled grain	1000-grain weight (g)	Harvest stage (day)
1	**A (33/BU3)**	27,7 c	244,7 a	42,7 d	25,0 bc	123 b
2	**B (33/BU3)**	27,3 c	183,3 b	45,0 d	26,0 b	125 b
3	**C (33/BU3)**	22,3 e	135,0 d	57,2 c	25,7 bc	118 c
4	**D (33/BU3)**	26,0 d	167,0 c	69,1 b	26,2 b	115 d
5	**E (33/BU3)**	22,3 e	128,0 e	68,4 b	27,0 ab	115 d
6	**F (BU3/33)**	28,3 b	165,0 c	59,4 c	31,0 a	113 de

The difference in the character of growth and crop production observed are difference in the genetic character of each progeny tested in the same environmental conditions, and only progeny are able to adapt to an environment such as climate, soil fertility, cultivation technique, and local pest can maintain optimum growth process so as to produce maximum. Thus the progeny that have the character of a good plant growth can be used as a further selection material against the high yielding character and tolerance to drought stress [4, 12]. According to Kobayashi *et al*. [9], rice yield related characters (tiller number, grain number and grain weight) and agronomic characters (plant height and days to flowering) are inherited quantitatively, related genetically to one another and influenced by growing environments [21].

3.2 Evaluation of Genetic Variance of F2 High Yielding plant progenies

Based on observations, each F2 population derived from crosses showed good growth, but the number of tillers produced were relatively low, because from planting until the last observation rainfall was high enough. A Number of environmental factors such as manuring, planting density, light, temperature, and water supply influenced the tillering power of plants [7, 18]. Therefore, to get the desired culm number and panicle length in farm, farmers could use adequate fertilizers.

The results of testing heritability, phenotypic variance, genotype variance, coefficients of phenotype variance and coefficients of genotypic variances are represented in Table 4.

Table 4. Heritability, phenotype variances, genotype variances, phenotypic coefficient of variance, genotypic coefficient of variance, and genetic advance from some of the quantitative traits of upland rice crossing

No.	Traits	Mean	σ_G^2	σ_P^2	GCV (%)	PCV (%)	h_{bs}^2 (%)	GA
1	Plant height	96.76	221.94	266.44	15.40	16.87	83.30	28.01
2	Number of productive tillers	5.88	6.95	7.96	44.83	47.98	87.31	5.07
3	Panicle length	25.91	12.66	12.90	13.73	13.86	98.14	7.26
4	Number of grains per panicle	166.89	1641.49	1655.49	24.27	24.38	99.15	83.10
5	Filled grain percentages	61.64	170.36	171.43	21.17	21.24	99.38	26.80
6	1000-grain weight	27.08	4.55	4.68	7.88	7.99	97.22	4.33
7	Harvesting stage	118.87	36.94	48.69	5.11	5.87	75.87	10.91

h_{bs}^2= Heritability (broad sense); σ_G^2 = Genotype variance;); σ_P^2= Phenotype variance;
PCV= Phenotypic coefficient of variance; GCV= Genotypic coefficients of variance; GA = Genetic Advance

The test results showed that the heritability value of quantitative characters were various in each character and ranged from 75.87 % to 99.38 %. All quantitative traits in some F2 progenies tested had very high heritability values, indicates that the high heritability values will be effective for the selection. In contrast, the low heritability means that the selection will be relatively less effective, because the appearance of phenotypic variance of plants is more influenced by environmental factors. Breeding for traits with low heritability is difficult because low heritability means that the phenotype is not highly correlated with the genotype. In other words, the contribution of the environmental conditions is relatively high in such traits [17].

The phenotypic variance and phenotypic coefficient of variance (PCV) were more than their respective genotypic variance and genotypic coefficient of variance for all the traits indicating the influence of environment on the expression of these traits.

High genetic variance was found in plant height, number of grains per panicle and filled grain percentage (Table 4). Genetic variance value of those characters are not only influenced by the genetic diversity among progeny, but also influenced by other factors that were not detected [19].

The results revealed considerable phenotypic and genotypic variances among the genotypes for the traits under consideration. The estimates of GCV were high for number of productive tillers (44.83), number of grains per panicle (24.27), filled grain percentages (21.17), plant height (15.40). The remaining traits recorded moderate to low GCV estimates (Table 4). The PCV values were higher than GCV values for all the traits which reflect the influence of environment on the expression of traits. The results of heritability indicated that high heritability estimates were recorded for all the traits. The most important function of the heritability in the genetic study of quantitative characters is its predictive role to indicate the reliability of the phenotypic value as a guide to breeding value [5, 15]. High heritability along with high genetic advance is an important factor predicting the resultant effect for selecting the best individuals. Number of grains per panicle, plant height, filled grain percentages, and harvesting stage had high heritability accompanied with high genetic advance, while panicle length, number of productive tillers and 1000-grain weight had high heritability coupled with low genetic advance. Heritability and genetic advance are important selection parameters. The estimation of genetic advance is more useful as a selection tool when considered jointly with heritability estimates. High heritability accompanied with high genetic advance as percentage of the mean in case of number of grains per panicle, plant height, filled grain percentages, and harvesting stage indicate that these are simply inherited traits and most likely the heritability is due to additive gene effects and selection may be effective in early generations for these traits. Similar findings have been reported by some authors [1, 16]. However, panicle length, number of productive tillers and 1000-grain weight had high heritability coupled with low genetic advance indicates non-additive gene effects.

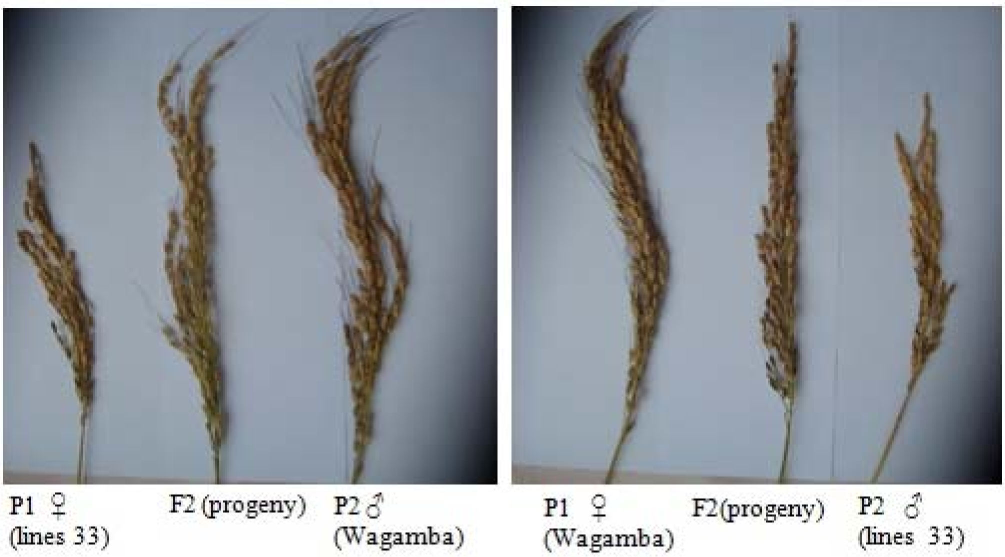

Figure 1. Performance of F2 and their parents panicles.

Conclusion

Based on the results of the study can be summarized as follows:

1) There was a high variation in local upland rice growth from crosses (F2), both components of growth such as plant height, number of productive tillers and the yield components such as panicle length, number of grains per panicle, filled grain percentage and 1000 grains weight.

2) Genetic factors play a greater role than environmental factors so that the selection will not be effective if done in the next generation, but must be selected in early generations.
3) Number of grains per panicle, plant height, filled grain percentages, and harvesting stage had high heritability accompanied with high genetic advance, while panicle length, number of productive tillers and 1000-grain weight had high heritability coupled with low genetic advance.

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References

[1] Y. Ali, B.M. Atta, J. Akhter, P. Monneveux and Z. Lateef, Genetic variability, association and diversity studies in wheat (*Triticumaestivum* L.) germplasm, *Pak. J. Bot.* 40(5)(2008): 2087-2097.

[2] R.W. Allard, *Principles of plant breeding*, John Wiley and Sons Inc., New York, 1960: 485.

[3] R. Amiri-Fahliani, M. Khodambashi, S. Housmand, A. Arzani and K. Sorkheh, Heritability for some agronomic characters of rice (*Oryza sativa L.*) and their linked microsatellite identification, *Turk J Agric For*, 35(2011): 481-490.

[4] A. Bahrun, C.R. Jensen, F. Asch and V.O. Mogensen, Drought Induced Changes In Xylem pH, Ionic Composition and ABA Concentration act As Early Signals In Field Grown Maize (*Zea mays* L.), *Journal of Experimental Botany*, 53(2002):1-3.

[5] D.S. Falconer and T.F.C. Mackay, *Introduction to quantitative genetics*, 4^{th} Ed. Benjamin Cummings, England, 1996.

[6] T.C. Hsiao, J.E. O'Toole, E.B. Yambao and N.C. Turner, Influence of OsmotikAdjusment on Leaf Rolling and Tissue Death in Rice (*Oryzasativa* L.), *Plant Physiol*. 75(1984): 338-341.

[7] M. Ismunadji, Crop production in acid sulphate and saline soil in Indonesia, *J. India Soc. Coastal Agric. Res*., 1(1983):58-65.

[8] J.S. Jeon, K.H. Jung, H.B. Kim, J.P. Suh and G.S. Khush, Genetic and molecular insights into the enhancement of rice yield potential, *J. Plan Biol.,* 54(2011): 1-9.

[9] S. Kobayashi, Y. Fukuta, T. Sato, M. Osaka and G.S. Khush, Molecular marker dissection of rice (*Oryza sativa* L.) plant architecture under temperate and tropical climates, *Theory Appl. Genet.*, 107(2003): 1350-1356.

[10] H.R. Lafitte, A. Ismail and J. Bernett, Abiotic stress tolerance in tropical rice: progress and future prospects, *Oryzae*, 43(3)(2006.): 171-186.

[11] L.J. Luo, Z.K. Li, H.W. Mei, Q.Y. Shu, R. Tabien, D.B. Zhong, C.S. Ying, J.W. Stansel, G.S. Khush and A.H. Paterson, Overdominant epistatic loci are the primary genetic basis of inbreeding depression and heterosis in rice. II. Grain yield components, *Genetics*, 158(2001): 1755-1771.

[12] Nasrullah, *Plant Breeding Vulume 2*, Agriculture Shoot Course, Indonesia Australia Eastern University Project (AIDAB). 1994:136 p.

[13] J.C. O'Toole and T.T. Changi, Drought resistance in cereals-Rice: A case study in *Stress physiology in crop plants,* H. Mussell. and R.C. Staples (Eds), John Willy and Sons New York, . 1979 p. 374 – 483.

[14] A.H. Paterson, M. Freeling and T. Sasaki, Grains of knowledge: genomics of model cereals, *Genome Res,.* 15(2005): 1643-1650.

[15] F.C. Pert and K.J. Fre,. Genotypic correlations, dominance, and heritability of quantitative characters in oats, *Crop Sci.*, 6(1966): 259 – 262.

[16] A.K. Sharma and D. Garg, Genetic variability in wheat (*Triticum aestivum* L.) crosses under different normal and saline envirenments. *Annal Agric Res*., 23(3)(2002): 497-499.

[17] B.D. Singh, *Plant Breeding*, 2nd ed. Kalyani Publishers, New Delhi, 2005.

[18] C.W. Smith and R.H. Dilday, *Rice: Origin, history, technology, and production*, 1st ed. John Wiley & Sons, Inc., Hoboken, New Jersey, 2003.

[19] O.P. Verma, U.S. Santoshi and H.K. Srivastava, Heterosis and inbreeding depression in half diallel crosses involving diverse ecotypes of rice (*Oryza sativa* L.) I. For yield and its contributing components, *J. Genet. & Breeding*, 56(2002): 205-212.

[20] J.Q. Yan, J. Zhu, C. He, M, Benmoussa and P. Wu, Quantitative trait loci analysis for the developmental behaviorof tiller number in rice (*Oryza sativa* L.), *Theor Appl. Genet*, 97(1998): 267-274.

[21] S. Yoshida and F.T. Parao, Climatic influence on yields and yields of lowland rice in tropics, in *Climate and Rice*, IRRI, the Phillipines, 1976.

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