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Selection of Lines BC1F5 Pandan Ungu/Kambang//Pandan Ungu (PU/K//PU) Based on Agronomic Characteristics

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ABSTRACT

This research was conducted from May to September 2022 to assess the growth and yield of BC1F5 Pandan Ungu/Kambang//Pandan Ungu rice plants, determine the influence of environmental factors on the agronomic characteristics of BC1F5 Pandan Ungu/Kambang//Pandan Ungu rice lines through heritability analysis, and establish correlations between agronomic characteristics and the yield of the BC1F5 Pandan Ungu/Kambang//Pandan Ungu line. The research followed a randomized block design with three replications, using different strains as treatments. Data obtained were subjected to variance analysis (Fisher's test) at a 5% significance level. If a significant effect was observed, Duncan's Multiple Range Test (DMRT) was conducted at the 5% level. To assess the impact of environmental factors, heritability analysis (h2) was performed. Additionally, a correlation analysis was carried out using the Pearson product-moment correlation formula to understand the relationships between characters. The results of the research revealed variations in growth and yield among the 24 backcross lines of Purple Pandan/Kambang//Purple Pandan. Three characters exhibited high heritability values: plant height, panicle length, and the number of grains per panicle. Four characters showed moderate heritability values: harvest age, number of grains per hill, weight of 1000 grains, and weight of grain per hill. One character had a low heritability value: the number of offspring. Based on the four selection criteria, 12 lines were identified for further selection, specifically lines 17, 41, 55, 57, 117, 141, 149, 197, 296, 303, 375, and 389. Notably, the character of grain weight per hill had a significant and positive correlation with the number of tillers and the number of grains per hill, while the other characters did not significantly affect grain weight per hill.

Keywords: Agronomic characteristics, correlation, F5 strains, heritability, Pandan Ungu/Kambang//Pandan Ungu..

INTRODUCTION

Rice (Oryza sativa L.) is a crucial food commodity for a significant portion of the global population, particularly in Indonesia. As the population continues to grow each year, there is a demand for increased rice production to meet the food needs of the population. However, the capacity and availability of food production are becoming increasingly limited. In 2021, rice production amounted to 244,677.96 Mg, which represented a decrease of approximately 17,756.56 Mg or a decline of 6.77% compared to 2020 when it was 262,434.47 Mg (BPS, 2021). Several factors contribute to the decline in rice productivity, including unpredictable climate conditions, pest and disease attacks, limited functional rice field areas for production, the conversion of rice fields to other uses, declining soil fertility, and inadequate primary and secondary irrigation network conditions (BPS, 2019).

One of the efforts to address this issue is by utilizing local rice varieties and developing them into superior rice varieties. The use of superior rice varieties is expected to enhance rice productivity even in limited quality and land areas. Based on explorations conducted in several regions of East Kalimantan, 12 rice germplasms cultivated by farmers were identified. Following identification and selection, five of theserice cultivars displayed good agronomic characteristics and high yield potential. These cultivars are knownas Kambang, Roti, Sikin Merah, Amas, and Pandan Ungu (Rusdiansyah, 2012). Subsequently, crossbreeding was carried out between Pandan Ungu and Kambang to produce F1 plants. Selection was conducted among the F1 plants, and then a backcross was performed with the female parent, Pandan Ungu,resulting in BC1F1 lines. Selection continued until BC1F5 lines were obtained. Based on this background, research was conducted to select BC1F5 Pandan Ungu/Kambang//Pandan Ungu (PU/K//PU) lines based on their agronomic characteristics. The objectives were to assess the growth and yield of BC1F5 Pandan Ungu/Kambang//Pandan Ungu rice plants, determine the influence of environmental factors on the agronomic characters of BC1F5 Pandan Ungu/Kambang//Pandan Ungu rice lines through heritability analysis, and establish correlations between agronomic characteristics and the yield of the BC1F5 Pandan Ungu/Kambang//Pandan Ungu lines.

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MATERIALS AND METHODS

The research was conducted from May to November 2022, taking place in the paddy fields of Karang Tunggal Village, Tenggarong Seberang District, Kutai Kartanegara, East Kalimantan. The materials used in the research included 24 BC1F5 strains, which were part of the collection by Prof. Dr. Ir. H. Rusdiansyah, M. Si, and were the result of seed selection from BC1F4 research in the previous study. Additionally, urea and NPK fertilizers, pesticides (insecticides and herbicides), and dolomite lime (CaMg(CO3)2) were also used. The equipment used in the research included a hand tractor, sprayer, plastic clips, analytical scale, moisture meter, plastic labels, label strings, scissors, measuring tape, hoe, machete, brown envelopes, ruler, sacks, camera, and writing tools. The data obtained were subjected to analysis of variance (Fisher's test) at a significance level of 5%. If a significant effect was observed, the Duncan's Multiple Range Test (DMRT) was performed at a 5% significance level. To determine the influence of environmental factors, heritability analysis (h2) was conducted in a broad sense. Correlation analysis was also conducted to study the relationships among the observed parameters and the yield. All data analyses were carried out using SAS Ver. 12 software. The parameters observed in this research included plant height (cm), harvesting age (days), number of tillers (stems), panicle length (cm), number of grains per panicle (grains), number of grains per hill (grains), weight of 1000 grains at 14% moisture content (g), and grain weight per hill (g).

RESULT AND DISCUSSION

Plant height, number of tillers, and harvesting age

The analysis of variance conducted on the 24 BC1F5 strains that were selected showed significant effects on plant height, number of tillers, panicle length, and harvesting age. This indicates a considerable variation among the 24 selected BC1F5 strains in terms of plant height, number of tillers, panicle length, and harvesting age. The Duncan's Multiple Range Test (DMRT) at a 5% significance level for plant height revealed that there were 11 strains with no significant difference in plant height compared to the Pandan Ungu and Kambang parent strains. The shortest plant height was recorded in strain 41 at 103.01 cm, while the tallest plant height was found in strain 209 at 130.49 cm (Table 1; Figure 1). Overall, it can be observed that there are 6 strains with a plant height of <110 cm, namely strains 41, 141, 303, 375, 117, and 296, indicating their potential as short-stemmed strains. Furthermore, the DMRT at a 5% significance level for the number of tillers showed that there were 19 strains with no significant difference compared to the Pandan Ungu and Kambang parent strains. The highest number of tillers was obtained in strain 141 at 14.74 stems, while the lowest number of tillers was recorded in strains 43 and 57, at 10.71 stems each (Table 1; Figure 2). According to the Department of Agriculture (2003), the ability to form tillers in the 24 selected BC1F5 strains falls into the moderate category (10-19 stems).

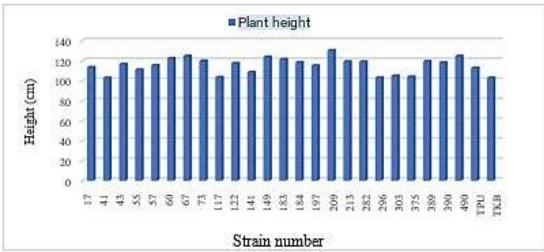

Figure 1. Average Plant Height Graph of 24 BC1F5 Backcrossing Strains PU/K//PU

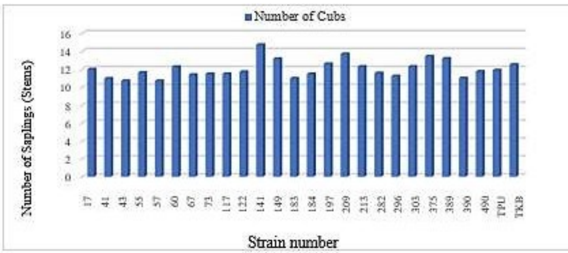

Figure 2. Average Number of Tillers Graph of 24 BC1F5 Backcrossed Strains PU/K//PU.

Regarding the panicle length parameter, the DMRT test at 5% significance level showed that there were 11 strains significantly different from the Pandan Ungu and Kambang parents. The longest panicle length was obtained in strain 73 with a length of 27.45 cm, while the shortest panicle length was obtained in strain 141 with a length of 22.38 cm (Table 1; Figure 3). According to Janne et al. (2018), overall, the panicle length of the 24 BC1F5 strains selected falls into the moderate category (20-30 cm). Meanwhile, the DMRT test at the 5% significance level for the harvest age parameter showed that there were 15 strainswith no significant difference in harvest age compared to the Pandan Ungu and Kambang parents. The shortest harvest age was obtained in strain 183 at 86.67 days after planting (DAP), while the longest harvestage was obtained in strain 55 at 94 DAP (Table 1; Figure 4). Overall, it can be observed that all 24 selectedBC1F5 strains have moderate tiller numbers, moderate panicle length, and early harvest age, meeting the expected selection criteria. Based on the parameters of plant height, tiller number, panicle length, and harvest age

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analyzed, it can be concluded that the backcross method is highly effective in eliminating undesirable traits and obtaining the desired traits.

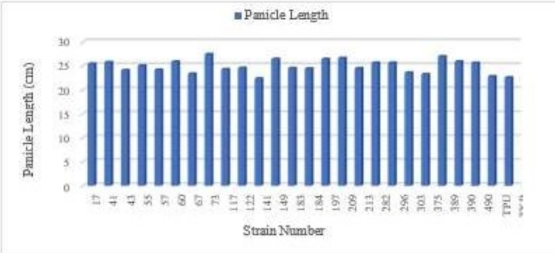

Figure 3. Average panicle length chart of 24 BC1F5 backcross strains PU/K//PU.

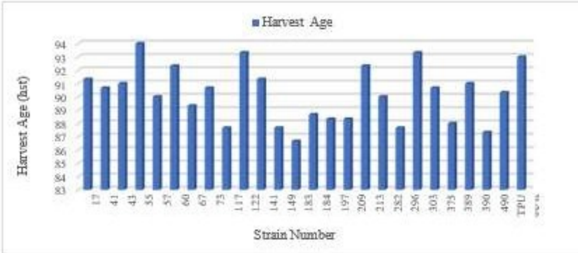

Figure 4. Average Harvest Age chart of 24 BC1F5 backcross strains PU/K//PU.

Table 1. Average plant height, number of tillers, panicle length and harvest age of 24 PU/K//PU backcross F5 lines

No	Variety	Plant Height		Number ofTiller		Panicle Length		Harvest Age	
1	17	113,63	a-e	12,00	Ab	25,47	bcde	91,33	a-e
2	41	103,01	A	10,96	B	25,79	abcd	90,67	a-e
3	43	116,70	a-f	10,71	B	24,12	d-i	91,00	a-e
4	55	111,22	a-e	11,63	Ab	25,08	b-f	94,00	A
5	57	115,69	a-e	10,71	B	24,21	d-i	90,00	a-e
6	60	122,65	Def	12,27	Ab	25,91	abcd	92,33	abcd
7	67	124,92	Ef	11,38	Ab	23,39	fghi	89,33	a-e
8	73	120,01	Def	11,48	Ab	27,45	a	90,67	a-e
9	117	103,75	Ab	11,50	Ab	24,31	d-h	87,67	De
10	122	117,69	b-f	11,71	Ab	24,59	c-g	93,33	Ab
11	141	108,69	Abcd	14,74	A	22,38	i	91,33	a-e
12	149	124,09	Ef	13,17	Ab	26,48	abc	87,67	De
13	183	121,72	Def	10,98	B	24,56	c-g	86,67	E
14	184	118,68	Cdef	11,48	Ab	24,47	d-h	88,67	bcde
15	197	115,39	a-e	12,60	Ab	26,45	abc	88,33	bcde
16	209	130,49	F	13,71	Ab	26,65	ab	88,33	bcde
17	213	119,47	Def	12,29	Ab	24,50	d-h	92,33	abcd
18	282	119,28	Def	11,56	Ab	25,66	abcd	90,00	a-e
19	296	103,32	A	11,23	Ab	25,67	abcd	87,67	De
20	303	105,01	Abc	12,29	Ab	23,60	e-i	93,33	Ab
21	375	104,11	Ab	13,46	Ab	23,27	fghi	90,67	a-e
22	389	119,63	Def	13,19	Ab	27,01	ab	88,00	Cde
23	390	118,50	Cdef	11,00	B	25,92	abcd	91,00	a-e
24	490	124,84	Ef	11,75	Ab	25,66	abcd	87,33	De
25	TPU	113,01	a-e	11,90	Ab	22,84	ghi	90,33	a-e
26	TKB	103,09	A	12,52	Ab	22,60	hi	93,00	Abc
		KK = 5.65%		KK = 15.24%		KK = 3.98%		KK = 2,96%	

Note: Average numbers followed by the same letter in the same column are not significantly different based on the DMRT 5%test.

Number of grains per panicle and number of grains per hill

The analysis of variance on 24 BC1F5 strains that were selected showed a significant effect on the parameters of the number of grains per panicle and the number of grains per hill. This indicates a significant variation among the 24 BC1F5 strains selected for the number of grains per panicle and the number of grains per hill. The DMRT test at the 5% level for the number of grains per panicle showed that there were 19 strains that did not significantly differ from the Pandan Ungu and Kambang parents. The highest number of grains per panicle was obtained in strain 55, with 194.17 grains, while the lowest number of grains per panicle was obtained in strain 213, with 112.13 grains (Table 2; Figure 5). The number of grains per panicle is categorized into three groups: few <150 grains, moderate 150-300 grains, and many >300 grains (Budi Irawan and Kartika, 2008). Based on these categories, it can be seen that out of the 24 selected BC1F5 strains, nine strains had a moderate number of grains per panicle (>150), namely strains 183, 197, 122, 296, 389, 184, 73, 149, and 55. Meanwhile, the DMRT test at the 5% level for the number of grains per hill showed that there were two strains that did not significantly differ from the Pandan Ungu and Kambang parents. The highest number of grains per hill was obtained in strain 55, with 1991.80 grains, while the lowest number of grains per hill was obtained in strain 117, with 1235.85 grains (Table 2; Figure 6). Overall, it can be seen that out of the 24 strains planted, 12 strains had a number of grains per hill >1500, namely strains 122, 375, 390, 303, 396, 197, 282, 184, 209, 55, 389, and 73, making them potential candidates for further selection.

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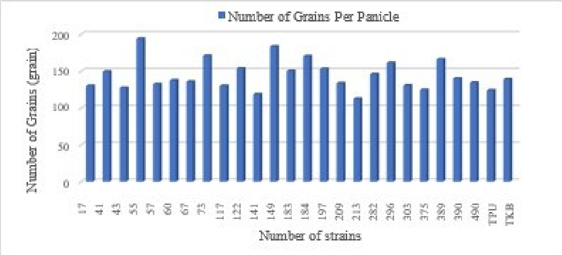

Figure 5. Average graph of the number of grains per panicle for 24 BC1F5 crossbred PU/K//PU lines.

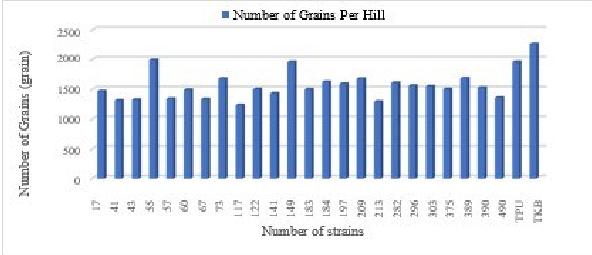

Figure 6. Average graph of the number of grains per hill for 24 BC1F5 crossbred PU/K//PU lines.

Table 2. Average number of grains per panicle and per hill from 24 F5 backcrossed lines PU/K//PU

Number	Strain	Number of Grains			
		Per Panicle		Per Hill	
1	17	130,18	f-k	1465,70	De
2	41	149,21	c-h	1312,00	De
3	43	127,55	g-k	1324,30	De
4	55	194,17	A	1991,80	Ab
5	57	132,33	f-k	1338,50	De
6	60	137,32	e-j	1492,10	De
7	67	135,61	f-k	1334,10	De
8	73	170,88	Bc	1681,50	Bcd
9	117	130,27	f-k	1235,90	E
10	122	153,81	Cdef	1502,60	De
11	141	118,74	Jk	1433,30	De
12	149	183,58	Ab	1957,10	Abc
13	183	150,15	c-g	1499,00	De
14	184	170,45	Bc	1624,60	Bcde
15	197	153,43	Cdef	1592,40	Bcde
16	209	133,63	f-k	1678,20	Bcd
17	213	112,13	K	1293,30	De
18	282	145,96	d-i	1609,90	Bcde
19	296	161,14	Bcde	1563,50	Cde
20	303	130,71	f-k	1552,90	Cde
21	375	124,38	Hijk	1503,80	De
22	389	166,23	Bcd	1687,30	Bcd
23	390	140,04	e-j	1529,20	De
24	490	134,37	f-k	1359,40	De
25	TPU	123,74	Ijk	1959,20	Abc
26	TKB	138,92	e-j	2259,10	A
			KK = 8.89%		KK = 13.52%

Note: Average numbers followed by the same letter in the same column are not significantly different based on the DMRT (Duncan's Multiple Range Test) at 5% level.

Weight of 1000 grains and weight of grains per hill

The analysis of variance on the 24 BC1F5 strains that were selected showed a significant effect on the parameter of weight of 1000 grains and weight of grains per hill. This indicates that there is a considerable variation among the 24 BC1F5 strains that were selected for the parameters of weight of 1000 grains and weight of grains per hill. The DMRT (Duncan's Multiple Range Test) at a 5% level for the weight of 1000 grains showed that there were 18 strains that did not differ significantly from the Pandan Ungu parent but differed significantly from the Kambang parent. The heaviest weight of 1000 grains were obtained from strain 41, weighing 26.49 g, while the lightest weightof 1000 grains were obtained from strain number 213, weighing 21.78 g (Table 3; Figure 7).

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The weight of 1000 grains are grouped into three categories: light <20 g, medium 20-25 g, and heavy >25 g (Ninik, 2013). Overall, it canbe seen that out of the 24 strains planted, 7 strains have a weight of >25 g or fall into the heavy category, namely strains 17, 41, 67, 183, 197, 209, and 375, and thus have the potential for selection as the next strains, while the otherstrains fall into the medium category. On the other hand, the DMRT at a 5% level for the weight of grains per hill showed that there were 6 strains that did not differ significantly from the Pandan Ungu and Kambang parents. The heaviest weight of grains per hill was obtained from strain 209, weighing 41.83 g, while the lightest weight of grainsper hill was obtained from strain number 43, weighing 24.90 g (Table 3; Figure 7). The weight of grains per hill is grouped into three categories: light <25 g, medium 25-50 g, and heavy >50 g (IRRI, 2002). Overall, it can be seen thatalmost all of the strains planted have a weight of >25 g, falling into the medium category, and thus have the potentialfor selection as the next strains, except for strain number 43, which has a weight of 24.90 and falls into the light category.

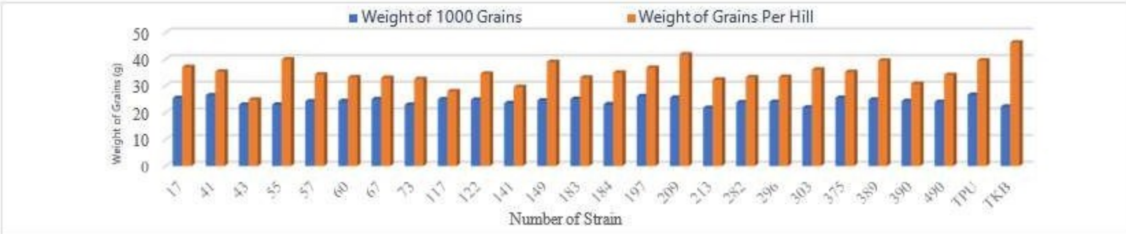

Figure 7. Average weight of 1000 grains and weight of grains per hill of 24 bc1f5 crossbreed strains pu/k//pu

Table 3. Average Weight of 1000 Grains and Weight of Grains per Hill of 24 BC1F5 Crossbreed Strains PU/K//PU.

Number	Strain	Weight of Grains (g)			
		1000 Grain		Per Hill	
1	17	25,45	Abcd	37,11	Abcd
2	41	26,49	Ab	35,35	Bcd
3	43	22,98	Cde	24,90	E
4	55	22,98	Cde	39,93	Abc
5	57	24,23	a-e	34,29	Bcde
6	60	24,35	a-e	33,23	Bcde
7	67	25,04	a-e	33,02	Bcde
8	73	22,97	Cde	32,61	Bcde
9	117	25,00	a-e	28,02	De
10	122	24,85	a-e	34,60	Bcde
11	141	23,57	a-e	29,61	Cde
12	149	24,54	a-e	39,00	Abc
13	183	25,14	a-e	33,12	Bcde
14	184	23,13	Bcde	35,00	Bcde
15	197	26,15	Abc	36,80	Abcd
16	209	25,62	Abcd	41,83	Ab
17	213	21,78	E	32,40	Bcde
18	282	23,87	a-e	33,23	Bcde
19	296	24,02	a-e	33,39	Bcde
20	303	21,91	E	36,12	Bcd
21	375	25,55	Abcd	35,24	Bcd
22	389	24,87	a-e	39,49	Abc
23	390	24,36	a-e	30,78	Cde
24	490	24,03	a-e	34,09	Bcde
25	TPU	26,70	A	39,54	Abc
26	TKB	22,26	De	46,30	A
		KK = 7.10%		KK = 14.79%	

Note: The average numbers followed by the same letter in the same column do not differ significantly based on the DMRT 5% test.

Heritability (h2)

To ensure that the selection process runs effectively, the genetic variability needs to be analyzed. Heritabilityvalues are classified into three categories: low heritability when h2 < 0.2, moderate heritability when 0.2 ≤ h2 ≤ 0.5,and high heritability when h2 > 0.5 (Riswanto, 2020). The analysis of heritability showed that all observed characteristics have heritability values ranging from (0.04-0.69). There are three characteristics with high heritabilityvalues, namely plant height (0.53), panicle length (0.62), and the number of grains per panicle (0.69). Four characteristics have moderate heritability values, which include harvest age (0.22), the number of grains per hill (0.50), weight of 1000 grains (0.21), and weight of grains per hill (0.29). There is one characteristic with low heritability, which is the number of tillers (0.04) (Table 4).

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Table 4. Heritability (h2) Analysis Results

Parameter	$\sigma^2 g$	$\sigma^2 e$	$\sigma^2 p$	h^2	Category
Plant height	48,53	42,46	90,99	0,53	High
Harvest age	2,04	7,14	9,18	0,22	Medium
Number of tillers	0,12	3,35	3,23	0,04	Low
Panicle length	1,61	0,99	2,59	0,62	High
Weight of 1000 grains (JGM)	357,89	164,34	522,23	0,69	High
Weight of grains per hill (JGR)	45692,00	45008,25	90700,26	0,50	Medium
Weight of 1000 grains(Berat 1000 butir)	0,79	2,98	3,77	0,21	Medium
Weight of grains per hill (Berat gabah per rumpun)	10,79	26,74	37,52	0,29	Medium

The obtained high heritability values for the traits of plant height, panicle length, and number of grains per panicle indicate that these traits are more influenced by genetic factors than environmental factors. Therefore, plant height, panicle length, and number of grains per panicle can be used as selection criteria. Additionally, even though the number of grains per hill has moderate heritability, its value of 0.50 suggests it can still be used in selection activities. High heritability values indicate that selection can be efficiently applied to these traits, making it easier to modify them. Traits with higher heritability are easier to improve. Based on the heritability values obtained, it is suggested that there is a good chance to improve the observed traits. The 12 selected strains (lines 17, 41, 55, 57, 117,141, 149, 197, 296, 303, 375, and 389) can be further evaluated and used in breeding programs.

Correlation Analysis (r)

The relationship between agronomic traits can be assessed through correlation analysis, which provides correlation coefficients. Based on the correlation analysis results, it is evident that the weight of grains per hill has a highly significant and positive correlation with the number of tillers (r = 0.39112) and the number of grains per hill (r= 0.81616). However, the other traits do not significantly affect the weight of grains per hill (Table 5).

Table 5. Correlation Analysis Results

	TT	UP	JA	PM	JGM	JGR	B1000	BGR
TT	1,00000							
	0,0							
UP	-0,31560	1,00000						
	0,0049	0,0						
JA	0,18600	-0,18149	1,00000					
	0,1030	0,1118	0,0					
PM	0,43022	-0,28926	-0,03731	1,00000				
	0,0001	0,0102	0,7457	0,0				
JGM	0,10478	-0,15627	0,00271	0,46095	1,00000			
	0,3613	0,1719	0,9812	0,0001	0,0			
JGR	-0,05086	0,07090	0,34620	0,00771	0,41588	1,00000		
	0,6583	0,5373	0,0019	0,9466	0,0002	0,0		
B1000	0,18475	-0,29954	0,05416	0,05688	-0,00154	-0,11650	1,00000	
	0,1054	0,0077	0,6377	0,6208	0,9894	0,3098	0,0	
BGR	0,04868	0,02899	0,39112	0,06537	0,29427	0,81616	0,07415	1,00000
	0,6721	0,8011	0,0004	0,5696	0,0089	0,0001	0,5188	0,0

Note: TT = plant height, UP = harvest age, JA = number of tillers, PM = panicle length, JGM = number of grains per panicle, JGR = number ofgrains per hill, B1000 = weight of 1000 grains, and BGR = weight of grains per hill

The positive correlation values between the weight of grains per hill and the number of tillers and the number of grains per hill indicate that an increase in the number of tillers will lead to an increase in the weight of grains per hill. The number of tillers produced by rice plants significantly influences the weight of grains producedbecause a plant with a higher number of productive tillers will result in an increased number of grains. Similarly,an increase in the number of grains per hill will lead to an increase in the weight of grains per hill. Conversely, adecrease in both of these characteristics will result in a decrease in the weight of grains per hill. Therefore, to increase rice grain production per hill Yyield), efforts can be made to improve the number of tillers and the number of grains on rice plants.

This can be achieved through optimal fertilizer application, proper irrigation practices,and careful spacing during planting (Pusat Penyuluh Pertanian, 2019).

CONCLUSION

The research results indicate that there are differences in growth and yield among the 24 backcross strainsof Pandan Ungu/Kambang//Pandan Ungu (PU/K//PU). Three characters, namely plant height, panicle length, andthe number of grains per panicle, have high heritability values, indicating that these agronomic traits are more influenced by genetic factors than environmental factors. Four characters, including days to maturity, number ofgrains per hill, 1000-grain weight, and grain weight per hill, have moderate heritability values. Additionally, onecharacter, the number of tillers, has low heritability, meaning it is more influenced by environmental factors than genetic factors. Based on these four selection characters, 12 strains are recommended for further selection: strains17, 41, 55, 57, 117, 141, 149, 197, 296, 303, 375, and 389. The character of grain weight per hill has a highly significant and positive correlation with the number of tillers and the number of grains per hill, while the other characters do not significantly influence grain weight per hill.

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