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Growth Evaluation of Backcross Progenies BC2F1 Submergence and Non-submergence at BC_1F_1 and its Parents

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Abstract: *The utilization of dual-resistant varieties that are resistant to soaking and drought in certain periods is an alternative to rice cultivation in swampy land. Inpara 8 is a variety that is confirmed to have SUB 1 gene, resistant to submerged stress and Inpago 5 is identified to be resistant to drought stress. Crosses were made between Inpara 8 (donor parent) with Inpago 5 (recipient parent), resulting in F1, then F1 was crossed back with Inpago 5 and produced BC1F1, then crossed back with Inpago 5 to become BC2F1. This paper contains an evaluation of the growth of BC2F1, which in the BC1F1 stage experienced submerged stress in the vegetative phase and which did not experience submerged stress. The research was carried out in August 2021 - January 2022 at the Greenhouse of the Department of Agricultural Cultivation, Faculty of Agriculture, Sriwijaya University. The results showed that in the vegetative phase, progeny BC2F1 TR has an average value of the highest per plant (113.64 cm) and the average per plant height Inpara 8 (3.93). In the generative phase, the fastest flowering time on the accession of BC2F1 TR (68 days), the fastest harvest time on Inpara 8 (122.93 days), while for the amount of grain per panicle, the amount of grain per clump, and dry weight on Inpago 5 (529.60 g, 2648 g, and 11.62 g). The average yield of BC2F1 progeny is more similar to Inpago 5 as the recipient parent. Both progeny have the same Sub 1 gene in them and can survive to produce, but Accessions that have experienced previous submerged stress are more vulnerable to growth so they have an impact on the resulting production.*

Keywords: *Paddy, Tolerance, Submergence, Drought, Swampy land.*

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INTRODUCTION

Cultivation of rice (*Oryza sativa* L.) in lowland swamp land is an alternative land use that is less than optimal amidst the large amount of fertile land that has been converted into non-agricultural land. Massive land change has an impact on food security, this has an impact on decreasing rice production. According to the Central Bureau of Statistics (2022), there was a decrease in planting land in Indonesia by 8,242,354 hectares in 2017 and continued to decrease until 2020, this led to the unproductive use of paddy fields (Central Bureau of Statistics, 2022).

Agriculture is closely related to climate change, because the agricultural sector is very dependent on and very vulnerable to climate change, so farmers' knowledge is very necessary in dealing with climate change (Nuraisah and Rani, 2019). The changing and erratic climate causes changes in rain patterns, the duration of the rainy season, and shifts in the monsoon. Swamp

land will be flooded in certain periods and its water regime depends on rainfall, upstream flood overflow, and from underground (Effendi, Zainal and Bambang, 2014). The high and low levels of standing water in lowland swamps influence the determination of the type of plants to be planted, especially rice (Pujiharti, 2017). Farmers in the swamp land will experience two phases of stress, the submerged stress in the vegetative phase and drought stress in the generation phase. This will cause disruption and inhibition of plant growth and development plant which then have an impact on their productivity. Therefore, plant technology that can adapt to environmental conditions is needed, one of which is the use of dual-resistant varieties that are resistant to soaking and drought in certain periods.

Inpara 8 is a variety that is confirmed to have Sub 1 genes. Plants that have Sub 1 genes can stimulate various metabolic processes so that they can face submerged stress conditions (Jung et al., 2010 in Gusmiatun et al., 2015). Gen Sub 1 is important for plant resilience when in submerged stress conditions, and can improve the ability of plants to avoid water loss after experiencing stress and after lack of water during drought (Fukao et al., 2011 ; Gusmiatun et al., 2015). Many plants change anatomically and morphologically because they adapt to submerged stress conditions. There are two morphological mechanisms for plants when experiencing stress, namely the formation of aerenchyma tissue in the roots and leaves, and controlled elongation of the stem so that the plant does not fall when the flooding ends (Gribaldi *et al.,* 2014).While Inpago 5 is a variety that has a character tolerant to drought stress in the generative phase and has a high-yield production when cultivated in lowland swamps (Suwignyo *et al.,* 2021).

Crossing is an activity to combine desired genetic traits, increase and utilize genetic diversity, and continue with selection and evaluation of the results (Miranda *et al.,* 2021). The cross between Inpara 8 (recipient parent) and Inpago 5 (donor parent) has been done and produces F1, selection and further cross (F1 (♂) with Inpago 5 (♀) produces BC1F1. BC1F1 (♂) was backcrossed with Inpago 5 (♀) and produced BC2F1. The study reported in this paper aims to evaluate the accession growth of BC2F1 which was previously given submerged and non-submerged stress treatment at the BC1F1 stage and its parent elders Inpago 5 and Inpara 8.

MATERIALS AND METHODS

The research was conducted at the greenhouse, Faculty of Agriculture, University of Sriwijaya from August 2021 to January 2022.

The materials used are plants BC2F1 T (submerged), BC2F1 TR (not submerged), Inpago 5, and Inpara 8, planted using randomized block design (RBD), repeated as many as 3 groups with 15 plants in each repeat. The seeds are pre-soaked in water for 24 hours, further, the seeds were sown in trays for 14 days. The seedlings were transplanted to prepared media, the media used was a 5 kg bucket containing swampy soil from Pemulutan District, Ogan Ilir Regency, South Sumatra.

Plant maintenance carried out was embroidery, watering, and fertilization. Harvesting was carried out at the age of the plant ± 135 - 145 days after planting (30 – 35 days after flowering). Harvest is characterized by 90-95% yellow grain, flag leaves are drying, and grain loss of 16-30% (Agency for Agricultural Research and Development, 2013). Irrigation of the bucket was carried out in the morning according to the

specified water content. Then fertilization was carried out by applying Urea, SP-36, and KCL fertilizer to each planting media.

Observation parameters were plant height, number of tillers, day of flowering, day of harvesting, number of total grains per panicle, number of total grains per clump, percentage of sterile spikelets, biomass dry-weight and weight of 1000 grains.

Data analysis using ANOVA (Analysis of Variance). The results will then be continued using the LSD Test (The least significant difference test) at the 5% level.

RESULTS

Agronomy Character of BC2F1 T, BC2F1 TR, Inpago 5, dan Inpara 8

Table 1 presents data on calculated F values and diversity coefficients of the populations studied, namely BC2F1 submerged (T), BC2F1 not submerged (TR) , Inpago 5, and Inpara 8. Plant height at each accession is known to differ significantly in the first measurement (14 DAT) and the second (28 DAT) with a value of 6.97 and 5.00. Then in the next observation (42 DAT, 56 DAT, 70 DAT, and 84 DAT) plant height was not significantly different on each accession. In the parameters of the total number of tillers, the observation of 14 DAT, 28 DAT, and 42 DAT is not significantly different in each of its Accessions. As for the next observation 56 DAT each accession was significantly different and at 70 DAT and 84 DAT was very significantly different. Productive tillers, flowering time and the amount of grain per panicle have very significantly different values, the amount of grain per clump has significantly different, while for the time of harvest, the percentage of empty grain, biomass weight, and the weight of 1000 grains of grain have no significantly different value at each accession.

Plant height and number of tillers

Table 2 presents plant height data in populations of submerged BC2F1 (T), non-submerged BC2F1 (TR), Inpago 5, and Inpara 8. The result showed that in the observation of 14 DAT, 28 DAT, 42 DAT, and 56 DAT plants that had the highest plant BC2F1 T (45.89 cm, 74.32 cm, 111.15 cm, and 135.03 cm), while for subsequent observations of 70 DAT and 84 DAT that have the highest plant is Inpago 5 (155.95 cm and167.06 cm). Figure 1 shows that the overall average plant height is at BC2F1 TR (113.64 cm).

Table 1. Calculated F value and coefficient of diversity (KK) of rice plant growth in population BC2F1 T and TR, Inpago 5 and Inpara 8

Parameters	F value		KK (%)
	Treatment	Group	
Plant height			
14 DAT	6,97*	0,59 ns	4,68
28 DAT	5,00*	4,43 ns	3,28
42 DAT	2,67 ns	0,36 ns	5,34
56 DAT	1,31 ns	1,03 ns	6,05
70 DAT	3,65 ns	0,42 ns	5,40
84 DAT	2,86 ns	0,44 ns	6,12
Number of tillers			
14 DAT	1 ns	1 ns	5,62
28 DAT	3,09 ns	0,40 ns	15,49
42 DAT	2,32 ns	0,03 ns	15,77
56 DAT	9,14*	2,90 ns	10,04
70 DAT	10,65**	3,52 ns	10,31
84 DAT	23,75**	12,62**	6,04
Number of productive tillers	15,10**	1,74 ns	10,47
Day of flowering	9,96**	0,03 ns	2,97
Day of harvesting	0,80 ns	1,23 ns	9,32
Number of total grains per panicle	14,74**	7,85*	14,03
Number of total grains per clump	6,70*	2,93 ns	20,65
Percentage of sterile spikelets	4,61 ns	3,02 ns	15,00
Biomass dry weight	1,82 ns	0,68 ns	23,62
Weight of 1000 grains	2,20 ns	1,17 ns	22,76

Table 3 shows that overall, the average productivity of tillers that have very significantly different is Inpara 8 (4.27), the fastest flowering time in BC2F1 TR (68 days), the fastest harvest time in Inpara 8

(122.93 days), the highest grain total per panicle and per clump in Inpago 5 (529.60 and 2648 grains), weight 1000 grains in BC2F1 TR (27 g) and biomass dry weight of high agility in Inpago 5 (11.62 g).

Table 2. Plants height and the number of tillers of BC_2F_1 submerged (T), BC_2F_1 not submerged (TR), Inpago 5, and Inpara 8

Parameters	Population	14 DAT	28 DAT	42 DAT	56 DAT	70 DAT	84 DAT
Plant height (cm)	BC_2F_1 T	14,75 ± 1,45 ab	70,01 ± 3,95 ab	105,64 ± 6,20 abc	127,67 ± 14,01 ab	149,40 ± 12,56 ab	156,14 ± 16,35 ab
	BC_2F_1 TR	15,89 ± 1,54 bc	74,32 ± 3,64 abc	111,15 ± 4,48 bcd	135,03 ± 3,32 bdc	154,76 ± 2,56 bc	160,69 ± 4,31 bc
	Inpago 5	39,50 ± 0,31 a	67,23 ± 0,22 a	102,9 ± 6,113 a	131,31 ± 5,23 abc	155,95 ± 5,38 bcd	167,06 ± 3,17 bcd
	Inpara 8	40,87 3,14± cd	69,34 ± 3,28 cd	98,76 ± 2,94 a	122,96 ± 3,36 a	136,56 ± 5,10 a	144,79 ± 4,73 a
	$BNT_{5\%}$	4,00	4,61	11,15	15,61	16,08	19,22
Number of tillers	BC_2F_1 T	1 ± 0,00 a	1,47 ± 0,12 ab	1,73 ± 0,23 a	2,07 ± 0,42 a	2,40 ± 0,53 a	2,40 ± 0,53 a
	BC_2F_1 TR	1 ± 0,00 a	1,73 ± 0,42 abc	1,93 ± 0,42 ab	2,40 ± 0,20 ab	2,80 ± 0,29 ab	3,47 ± 0,46 b
	Inpago 5	1 ± 0,00 a	1,80 ± 0,00 bcd	2,40 ± 0,20 bcd	3,13 ± 0,23 d	3,67 ± 0,31 cd	3,73 ± 0,23 bc
	Inpara 8	1,07 ± 0,12 ab	1,27 ± 0,12 a	2,00 ± 0,20 abc	2,60 ± 0,35 bc	3,53 ± 0,50 c	3,93 ± 0,61 bcd
	$BNT_{5\%}$	0,12	0,48	0,64	0,51	0,64	0,48

Table 3. Agronomy character parameters of vegetative and generative phase of BC2F1 submerged (T), BC2F1 not submerged (TR), Inpago 5, and Inpara 8

Population	PL	DAF	DH	TGP	TGC	PS	WG	BDW
BC_2F_1 T	2,33 ± 0,12 a	70,13 ± 0,81 ab	124,67 ± 6,11 ab	231,47 ± 88,74 a	1157,33 ± 443,71 a	59,87 ± 16,17 abc	17,35 ± 6,04 a	8,39 ± 3,59 ab
BC_2F_1 TR	3,48 ± 0,63 b	68,00 ±2,42 a	128,63 ± 4,32 abcd	473,82 ± 117,48 bc	2224,67 ± 703,89 bc	47,99 ± 10,96 a	27,00 ± 8,15 abcd	10,85 ± 1,94 abc
Inpago 5	3,63 ± 0,32 c	72,50 ± 2,29 bc	126,07± 3,40 abc	529,60 ± 113,82 cd	2648 ± 569,09 bcd	50,42 ± 2,73 ab	24,11 ± 1,18 abc	11,62 ± 1,20 abcd
Inpara 8	4,27 ± 0,31 cd	77,07 ± 1,42 d	122,93 ± 4,96 a	465,32 ± 62,84 b	2152,67 ± 205,2 b	71,52 ± 7,76 cd	19,87 ± 0,91 ab	8,01 ± 1,14 a
$BNT_{5\%}$	10,47	4,27	9,32	119,12	843,89	17,22	10,04	4,58

Note : PL = Number of productive Tiller, DAF = Day of flowering (days), DH = Day of harvesting, TGP = Number of total grains per panicle, TGC = number of total grains per clump, PS = percentage of sterile spikelets (%), WG = Weight of 1000 grains of grain, BDW = Biomass dry weight

Correlation between growth characteristic variables in BC_2F_1, Inpago 5 and Inpara 8

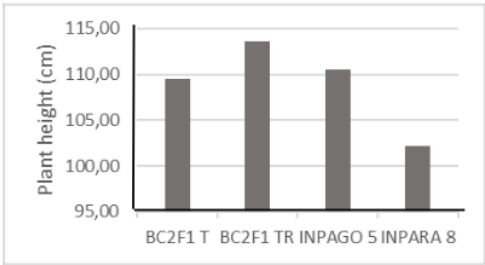
Table 4 shows the correlation between growth characteristics variables BC_2F_1 submerged (T), productive tiller parameters have a very significantly different positive effect on flowering parameters and a real positive effect on the number of grains per panicle and number of grains per clump. Then the parameter number of total grains per panicle positively affects to the parameter number of total grains per clump.

Table 5 shows the correlation between growth characteristic variables BC_2F_1 non-submerged (TR). The results showed that the number of productive tiller parameters had a very significantly negative effect on plant height, while for other parameters there was no significant effect.

Table 6 shows the correlation between the growth characteristic variable Inpago 5, day of flowering parameter has a very significant positive effect on the parameter of biomass dry weight, and the parameter number of total grain per panicle has a very real positive effect on the parameter number of total grain per clump.

Table 7 shows the correlation analysis between the growth characteristics variable Inpara 8. The results showed that the parameters of productive tillers significantly affect the parameters of day after flowering, and the parameter number of total grain per clump has a very significant effect on the parameters of biomass dry weight.

A



B

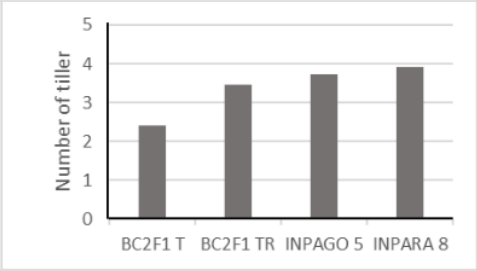


Figure 1. Plant height (A) and number of tillers (B) BC_2F_1 submerged (T), BC_2F_1 non-submerged (TR) , Inpago 5, and Inpara 8

Table 4. Results of correlation analysis between variables of growth characteristics BC_2F_1 submerged (T)

	PH	PL	DAF	DH	TGP	TGC	PS	BDW
PH	1							
PL	0,965	1						
DAF	0,965	1,000**	1					
DH	0,998*	0,945	0,945	1				
TGP	0,947	0,998*	0,998*	0,922	1			
TGC	0,947	0,998*	0,998*	0,922	1,000**	1		
PS	-0,831	-0,947	-0,947	-0,790	-0,966	-0,966	1	
BDW	0,876	0,971	0,971	0,840	0,984	0,984	-0,996	1

Note : PH = Plant height, PL = Number of productive tiller, DAF = Day of flowering, DH = Day of harvesting, TGP = Number of total grains per panicle, TGC = Number of total grains per clump , PS = Percentage of sterile spikelets , BDW= Biomass dry weight.

Table 5. Results of correlation analysis between growth characteristics variable BC_2F_1 non submerged (TR)

	PH	PL	DAF	DH	TGP	TGC	PS	BDW
PH	1							
PL	-1,000**	1						
DAF	-0,619	0,614	1					
DH	-0,950	0,948	-0,833	1				
TGP	-0,898	0,895	-0,902	0,990	1			
TGC	-0,994	0,993	-0,702	0,979	0,941	1		
PS	-0,100	0,107	0,719	-0,215	-0,348	-0,009	1	
BDW	-0,993	0,993	-0,519	0,905	0,837	0,973	-0,22 1	1

Note : PH = Plant height, PL = Number of productive tiller, DAF = Day of flowering, DH = Day of harvesting, TGP = Number of total grains per panicle, TGC = Number of total grains per clump , PS = Percentage of sterile spikelets , BDW= Biomass dry weight.

Table 6. Results of correlation analysis between growth characteristics variable Inpago 5

	PH	PL	DAF	DH	TGP	TGC	PS	BDW
PH	1							
PL	-0,417	1						
DAF	-0,964	0,645	1					
DH	0,692	-0,945	-0,860	1				
TGP	-0,224	0,979	0,477	-0,859	1			
TGC	-0,224	0,979	0,477	-0,859	1,000**	1		
PS	0,713	0,340	-0,500	-0,013	0,523	0,523	1	
BDW	0,966	-0,638	-1,000**	0,855	-0,469	-0,469	-0,507	1

Note : PH = Plant height, PL = Number of productive tiller, DAF = Day of flowering, DH = Day of harvesting, TGP = Number of total grains per panicle, TGC = Number of total grains per clump , PS = Percentage of sterile spikelets , BDW= Biomass dry weight.

Table 7. Results of correlation analysis between growth characteristics variable Inpara 8

	PH	PL	DAF	DH	TGP	TGC	PS	BDW
PH	1							
PL	-0,845	1						
DAF	-0,830	-1,000*	1					
DH	0,421	-0,841	-0,855	1				
TGP	0,991	-0,764	-0,747	0,293	1			
TGC	0,510	-0,891	-0,903	0,995	-0,389	1		
PS	0,024	0,515	0,537	-0,897	0,160	-0,847	1	
BDW	0,511	-0,892	-0,903	0,995	-0,389	-1,000*	0,847	1

Note : PH = Plant height, PL = Number of productive tiller, DAF = Day of flowering, DH = Day of harvesting, TGP = Number of total grains per panicle, TGC = Number of total grains per clump , PS = Percentage of sterile spikelets , BDW= Biomass dry weight.

DISCUSSION

Growth evaluation was conducted on plants BC_2F_1 submerged (T), BC_2F_1 non submerged (TR), Inpago 5, and Inpara 8. Obtained differences from the parameters of plant height, day of flowering, day of harvesting, the number of total grains per panicle, the number of total grains per clump, percentage of sterile spikelets, weight of 1000 grains of grain, and biomass dry weight. Genetics expressed in various plant traits include plant form and function which produces diversity (Afdila, Ezward, and A. Haitami, 2021). Different genetic compositions cause variations in plant appearance, these differences can always occur even from the same type of plant (Oktaviani, Lizah and Nyimas, 2020). A fairly difficult problem is how far a character is influenced by genetic factors and how

far it is caused by the environment (Saleh, 2015).

Figure 1 shows that the plant BC_2F_1 TR is the highest plant, while Inpago 5 and BC_2F_1 T have almost the same value. Waterlogging or soaking stress can cause stunted plant growth and development, but the impact of momentary flooding is much greater (Yullianida *et al*., 2015). Inpara 8 and Inpago 5, which are the parent parents, have more number of tillers than BC2F1 T and BC2F1 TR. The low number of tillers can be caused by genetic factors and the plant's environment when growing. According to Husna (2010) *in* Yulina, Chairil, and A., (2021), plants that have good genetic characteristics in supportive and appropriate environmental conditions can maximize the number of tillers. Soaking when the plant enters the seedling formation phase causes stunted growth, especially for plant height, number of leaves, and level of greenness of the leaves (Sumardi, Mohammad, and Rafi, 2022).

Accession BC_2F_1 T which has experienced submerged stress has a day of flowering that is slightly faster than accession BC_2F_1 TR, followed by Inpago 5 and Inpara 8. As for the day of harvesting faster Inpara 8 and followed by BC_2F_1 T, Inpago 5, and BC_2F_1 TR. These differences indicate that all accessions have no significant effect on the day of flowering and the day of harvesting. Plant flowering is a transition from the vegetative to the generative phase, the influence of which can come from internal and external factors (Suryani, Adriani, and Sumarsono, 2020). Genetic factors that are more dominant will affect the day of flowering and day of harvesting than the environment, it again depends on the activity of genes in the plant so that it can control the flowering time until the day of harvesting (Yulina, Chairil, and A., 2021).

The result parameter biomass dry weight parameter of BC_2F_1 TR and Inpago 5 (Table 3) is related to the parameter of the number of tillers (Figure 1), that the higher the number of tillers, the higher biomass dry weight. BC2F1 T and Inpara 8 plants had lower values for biomass dry weight and number of tillers. Then for the percentage of sterile spikelets (Table 3) the highest values were for Inpara 8 and BC2F1 T plants. The results were negatively correlated with the percentage parameters percentage of sterile spikelets (Table 4). Nitrogen uptake decreases in flooded conditions, mainly because the lower roots in saturated soil die, so the root surface area decreases. Decreased plant nitrogen uptake will reduce plant growth which can be seen in the low biomass produced (Ahadiyat, Muhammad, and Surya, 2023).

The lower percentage of sterile spikelet, the higher number of total grains per panicle, the number of grains per clump, and the weight of 1000 grains of grain. Related to the previous parameter, the largest number of tillers will produce many panicles, so that the grain produced is also higher. According to Darso *et al*. (2016) *in* Riyandi, Erida, and Cut (2018), a high percentage of pithy-containing grain is affected by the amount of grain available, while the number of unproduced karyopsis and low flour content in the flowering period affect the amount of sterile spikelet. Then the weight of 1000 grains of grain is influenced by the size of the grain and the level of its moisture. Varieties with many tillers certainly have the potential to produce highly productive panicles and grain produced is also high. The larger the grain size, the greater the weight of the grain produced, and conversely, a small grain size will produce a lighter grain weight (Afa *et al*., 2021).

Overall, the yield parameters of the BC2F1 T accession were lower than BC2F1 TR. The values of these two accessions had results that were closer to the parent Inpago 5 (recipient parent) than Inpara 8 (donor parent). The consequences that influence this can come from various factors, in the previous examination stage which resulted in a change in the physiological condition of the plant from aerobic to anaerobic. The minimal availability of O_2 and CO_2 gas in the air triggers a decrease in the rate of photosynthesis and anaerobic respiration, this is then followed by an increase in anaerobic protein (Ito *et al.,* 1999 *in* Ikhwani 2013). Carbohydrate content is an important factor in plant tolerance in submerged conditions, which is closely related to the plant's ability to survive submerged conditions. This soaking causes inhibition of plant growth and development, thereby impacting yields. Inundation is an abiotic stress that can determine the success or failure of crop yields based on the frequency and extent of inundation (Chaniago, 2019).

gene in it. Both plants both can *survive* and produce, but the progeny BC_2F_1 T is more vulnerable in growth and yield. Accession of BC_2F_1 has the value of the parameters of plant height, number of tillers, day of flowering, number of total grains per panicle, number of total grains per clump and the weight of 1000 grains are superior to BC_2F_1 T. Both Accessions had parameter results closer to Inpago 5 (recipient parent) than to Inpara 8 (donor parent)

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CONCLUSION

Both Accessions had the Sub 1 gene because the previous one came from a cross between Inpago 5 (donor parent) and Inpara 8 (recipient parent) that had gen the Sub 1

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