ISSN: 1412-4718, eISSN: 2581-138x

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Development of adaptive rice variety to non-tidal swamp: Growth evaluation of backcrossed progenies (BC_1F_1) and its parents, Inpago 5 and Inpara 8

Abstract. Rice (*Oryza sativa* L.) cultivation in non-tidal swamp is severely constrained by abiotic stresses, i.e., submerged stress in the vegetative phase and drought stress in the generative phase. The development of rice varieties that have dual-tolerant to those abiotic stresses can improve adaptability and increase productivity. Efforts to obtain adaptive varieties under those abiotic stress conditions are being carried out by selecting the parents and crossing them, and has resulted in the population of BC_1F_1. The research was carried out on April – June 2021 at greenhouse of the Agriculture Faculty, Sriwijaya University. The study aimed to evaluate the growth of BC_1F_1 progenies and parental varieties, Inpago 5 (live well in drought condition) and Inpara 8 (inherited *Sub1* gene). The results showed that the vegetative growth (plant height and number of total tillers) of BC_1F_1 was influenced by genetics of the parents. While generative growth parameters, Inpago 5, as a recipient parent, had the highest number of total spikelets per panicle (181.42 grains), the lowest percentage of sterile spikelets (25.05%) and the lowest biomass dry weight (27.88 g). Inpara 8, as a donor parent, had the highest average number of productive tillers (8.34 tillers), took the longest time to flower (76 days), and the shortest time to harvest (115 days). Then, BC_1F_1 got the highest average number of total spikelets per plant (1348.2 grains), weight of 1000 grains (25.49 g), and grains dry weight (9.71 g). Based on study, the most growth traits of BC_1F_1 were genetically influenced by the parents, indicated a segregation from the parents. The plants will be used for second backcrossing (BC_2F_1) and a molecular selection using Marker-Assisted Backcrossing (MABC) method to obtain plants that have *Sub1* gene and the closest characteristic to recipient parent (Inpago 5).

Keywords: Dual tolerance · Inpago 5 · Inpara 8 · *Oryza sativa*

Pengembangan varietas padi adaptif di lahan rawa lebak: Evaluasi pertumbuhan progeni backcross (BC_1F_1) dan tanaman induk, Inpago 5 dan Inpara 8

Sari. Budidaya padi (*Oryza sativa* L.) di lahan rawa lebak sangat terkendala dengan cekaman abiotik cekaman terendam pada fase vegetatif dan cekaman kekeringan pada fase generatif. Pengembangan varietas padi yang memiliki *dual tolerant* terhadap cekaman abiotik tersebut dapat memperbaiki daya adaptasi dan meningkatkan produktivitasnya. Upaya untuk mendapatkan varietas adaptif dengan kondisi cekaman abiotik tersebut sedang dilakukan dengan melakukan seleksi tetua dan menyilangkannya, dan telah menghasilkan aksesi BC_1F_1. Penelitian dilaksanakan pada bulan April – Juni 2021 di *greenhouse* Fakultas Pertanian, Universitas Sriwijaya. Tulisan menyampaikan hasil evaluasi pertumbuhan progeni BC_1F_1 dan kedua varietas induk, Inpago 5 dan Inpara 8. Hasil penelitian menunjukkan pertumbuhan vegetatif (tinggi tanaman dan jumlah anakan total) BC_1F_1 dipengaruhi oleh genetik dari kedua induk. Sementara parameter pertumbuhan generatif, Inpago 5 (induk resipien) memiliki jumlah gabah total per malai tertinggi sebanyak 181,42 butir; persentase gabah hampa terendah sebesar 25,05%; bobot kering biomassa terendah sebesar 27,88 g. Inpara 8 (induk donor) memiliki rata-rata jumlah anakan produktif terbanyak (8,34 anakan), waktu berbunga terlama (76 hari), dan waktu panen tercepat (115 hari). Kemudian BC_1F_1 memiliki jumlah gabah total per rumpun tertinggi sebanyak 1348 butir), bobot 1000 butir gabah tertinggi (25,49 g), dan berat kering gabah (9,71 g). Berdasarkan hasil penelitian, sebagian besat karakteristik pertumbuhan populasi BC_1F_1 dipengaruhi secara genetik oleh kedua induk yang mengindikasi adanya segregasi sifat dari keduanya. Tanaman akan digunakan pada silang balik generasi kedua (BC_2F_1) dan diseleksi secara molekular menggunakan metode *Marker-Assisted Backcrossing* (MABC) untuk mendapatkan tanaman terbaik yang memiliki gen *Sub1* dan karakter agronomi paling dekat dengan Inpago 5.

Kata kunci: *Dual* toleransi · Inpago 5 · Inpara 8 · *Oryza sativa*

Manuscript received : 3 August 2022, Revision accepted : 13 December 2022, Published : 21 December 2022
DOI: http://dx.doi.org/10.24198/kultivasi.v21i3.41072

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Introduction

Rice (*Oryza sativa* L.) is an important and strategic food commodity in Indonesia. It has a major effect on economic and political stability. Although the government has taken a policy of not importing rice in recent years, the condition of rice production in Indonesia is quite worrying (Lakitan *et al.* 2018). According to BPS Indonesia (2022), there has been a gradual decline in the area of rice harvested from 10.65 million hectares (Mha) in 2020 to 10.51 Mha in 2021. With land productivity not changing significantly, rice production has decreased from 59.20 million tons in 2018 to 54.42 million tons in 2021. Decreasing of productive areas caused by agricultural land conversion and extreme climate fluctuation (Tirtana *et al.* 2021). Utilization of swamp land is one of an ideal solution to increase rice cultivation area (Sulaiman *et al.*, 2019).

The swamp lands of Indonesia are approximately 33.43 Mha and non-tidal swamp are 13.28 Mha which is suitable for agriculture activity (Sulaiman *et al.*, 2019). The main problems of agricultural activity in non-tidal swamp are unorganized hydrotopography (Oladosu *et al.* 2020) and unpredictable of water level (Suwignyo *et al.* 2021). In South Sumatra, the farmers are begin the rice cultivation at the end of rainy season in March-April, when the water surface is not too high (Lakitan *et al.*, 2018).

The development of submergence tolerant cultivars in the early growth phase (Adriansyah *et al.* 2022; Singh *et al.* 2017) as well as drought resistance at the end of the growing period are need more attention (Singh *et al.* 2018). The rice cultivation at the end of rainy season is very susceptible influenced by submergence stress on vegetative phase and drought stress on generative phase.

One of the main goal of breeding is to insert am interested gene in a new cultivar (Shin *et al.* 2022). Chozin *et al.* (2017) suggested to improve rice yield tackled by the genetic and physiological natures. So, increasing of productivity in suboptimal area with adaptive characters and higher production in submergence condition can be initiated by introgressed *Sub1* gene in rice cultivar which has good agronomy character (Adriansyah *et al.* 2021). Tiwari *et al.*, (2017) obtained a dual tolerant rice line in submergence and drought conditions, from crosses between Swarna *Sub1* x NDR 9830102. Development of new varieties (with dual tolerance ability) can be initiate by *Sub1* gene introgression through cross-breeding from parent genotype.

The previous study by Suwignyo (2016) explained that rice variety, Inpago 5 has good tolerance to drought conditions in the generative phase from 14 varieties of upland rice observed. Inpara 8, inherited *Sub1* gene, was a backcrossed line between Cinglonik/IRBB7//Memberamo/ IR64 (Rumanti *et al.* 2016) and has a high growth and productivity (Ningsih *et al.* 2020). The *Sub1* gene slackens the production of ethylene hormone and gibberellin hormone during submerged, maintains carbohydrate and significantly elongates durability (Fukao *et al.* 2011). *Sub1* gene is located at chromosome 9 (Xu and Mackill 1996) and hereditarily to the next generation. Inpara 8 and Inpago 5 have their own superiority. Inpago 5 can be inserted *Sub1* gene from Inpara 8 to survive in non-tidal swamp. This research aimed to evaluate growth of BC_1F_1 population and its parental, Inpago 5 (as recipient parent) and Inpara 8 (as donor parent). In future, the plants will be used as plant material for second backcrossing and further study, which molecular selection using Marker Assissted Backcrossing (MABC) method.

Materials and Method

Soil materials. Non-tidal swamp soil was taken from non-tidal swampland in the observation area of the Agriculture Faculty, Universitas Sriwijaya, Indralaya. The soil was put into pots, 8 kg for each pot. The agricultural lime-stone was broadcast as much as 27.7 g considering to soil-pH score. The media was left in a flooded condition.

Plant materials. BC_1F_1, Inpago 5, and Inpara 8 seeds were used in this study. BC_1F_1 was progenies from backcrossing of Inpago 5 (♀) and Inpara 8 (♂) and had been selected on previous study by Aulia (2021). Inpago 5, a rice variety with high productivity under drought condition based on previous study by (Rusdan, 2019). Inpara 8, a tolerant to submergence condition variety., derived from a double cross of Cinglonik/IRBB7 x Memberamo/IR64 (Rumanti *et al.* 2016).

Germination and seedling growth. Seeds were soaked for 24 hours and germinated on two-layer wet filter papers in a tray. Filter papers were moistened by gently water spraying to the tray. Germinated seeds were sown in

Jurnal Kultivasi Vol. 21 (3) Desember 2022
ISSN: 1412-4718, eISSN: 2581-138x

seedling trays filled with soil for 14 days. The trays were labeled according to population.

Pot experiment. 14-days-old seedlings were transplanted into the soil filled pots and orderly arrange in a greenhouse. As many as 45 pots were used in this study. The plants were fertilized with Urea (1.5 g/pot), KCl (0.75/pot), and SP36 (0.75 g/pot) at 7, 23, and 42 days after transplanting (DAT). Pots were laid out according to the group randomized block design with three replications and five plants for each replication.

Growth evaluations parameter. The parameters observed in the trial were plant height, total number of tillers, number of productive tillers (panicle), days to flowering, days to harvesting, number of total grains per panicle, number of total grains per plant, percentage of sterile spikelets, weight of 1000 grains, biomass dry weight, and grains dry weight.

Data analysis. All data were analyzed using the statistical analysis software SAS version 9.0 (SAS 2004). Analysis of variance and the coefficient of variance (%) were used for evaluating the significance of individual population and their interaction. Correlation analysis was revealed the degree and direction of the association between all possible pair of traits being studied. The least significant difference (LSD) test was carried out to calculate the significant difference in all sets of collected data ($P < 0.05$).

Result and Discussion

Plant growth in rice classified into three main stages: vegetative stage, generative stage, and maturation stage (Zaman *et al*., 2018). The growth characteristics of the vegetative stage and generative stage in Inpago 5, BC_1F1, and Inpara 8 indicated some similarity which represented on Table 1. In general, all populations showed similar time for reaching maximum plant height and maximum tiller number. A significantly increasement of plant height caused by stem elongation and more significantly increased at 70 DAT. Different result was obtained by Aulia (2021) in previous study, that plant height of three population showed not significantly increment from 28 DAT to 70 DAT. The plant height of BC_1F_1 (Table 2) indicates that the population of backcross was genetically affected by the parents. (Ren *et al*. 2021) stated that performance of progenies influenced by genetics of both parents, although the plants were grew in same condition.

The number of total tillers of three populations were not significantly developed at the beginning of vegetative stage (14, 28, and 42 DAT), but significantly showed the increasing of tillers at 56 DAT. While, the tillers number of population in previous study (Aulia 2021), showed significantly different since 28 DAT. Table 1 showed the harvesting time among three populations were more significantly different. The total number of spikelets per panicle and total number of spikelets per plant were significantly different for all populations. In this study, the percentage of sterile spikelets was found not significantly different. In other hand, the weight of 1000 grain was found significantly different for Inpago 5, BC_1F_1, and Inpara 8. Then, biomass dry weight and grains dry weight parameters showed Inpago 5, BC_1F_1, and Inpara 8 were not found significantly different.

Plant Height. Plant growth was affected by internal factors and external factors. Genetic is the internal factor and growth environment and nutrient are the external factor (Liu *et al.* 2018). The highest average of plant height was found in Inpago 5 followed by BC_1F_1, and Inpara 8 (Figure 1). Plant height is one of the important aspects in rice breeding development as an important factor for plant vigor (Tang *et al.,* 2017). According to Rice Standard Evaluation System data (IRRI 2013), plant height of rice grouped into (1) Semi dwarf (less than 110 cm for lowland rice and less than 90 cm for upland rice), (2) Intermediate (110-130 cm for lowland rice and 90-125 cm for upland rice), (3) Tall (more than 130 cm for lowland rice and more than 125 cm for upland rice). Figure 1 showed the average plant height of all plants was ranged from 93 to 96 cm that grouped into semi dwarf category and assumed to be able to live well in lowland condition.

The plant height of each population (Table 1) were significantly increased at 14 DAT at the beginning of vegetative stage but not significantly increased at 28 DAT and 42 DAT. The plant height of Inpago 5, BC_1F_1, and Inpara 8 were more significantly increased at 70 DAT (Table 1). Based on Figure 1, BC_1F_1 got an average height was 93.95 cm, higher than Inpara 8 (93.64 cm) and lower than Inpago 5 (96.03 cm).

Table 1. F values and coefficient of varians (%) of growth parameters of Inpago 5, BC_1F_1, and Inpara 8

Parameters	F value		Coefficient of
	Group	Treatment	variance (%)
Plant Height			
14 DAT	0.22ns	42.74**	5.97
28 DAT	0.29 ns	5.28 ns	4.29
42 DAT	0.08 ns	2.64 ns	3.41
56 DAT	0.32 ns	13.09*	1.70
70 DAT	1.65 ns	95.78**	0.32
Total Tillers			
14 DAT	0.99 ns	2.16ns	76.81
28 DAT	1.13 ns	2.75 ns	18.36
42 DAT	0.05 ns	2.44 ns	8.92
56 DAT	0.11 ns	12.06*	8.51
70 DAT	0.01 ns	28.33**	9.00
Productive Tillers	0.05 ns	23.62**	9.00
Days to flowering	0.15 ns	0.37 ns	19.45
Days to harvesting	0.61 ns	278.59**	0.46
Total Spikelets per panicle	1.99 ns	80.86**	7.35
Total Spikelets per Plant	1.06 ns	7.56*	20.94
Percentage of Sterile Spikelets	0.20 ns	3.46 ns	21.71
Biomass Dry Weight	0.8 ns	0.71ns	6.48
Weight of 1000 Grains	1.36 ns	7.44*	6.42
Grains Dry Weight	1.22 ns	76.84ns	3.54

Note: values within a row followed by the same letters were not significantly different based on the LSD at P ≤ 0,05; ns = not significant at ≤ 0,05; * and ** = significant ≤ 0,05; DAT = Days after transplanting

Table 2. Plant height (cm) and number of total tillers parameters of Inpago 5, BC_1F_1, and Inpara 8

Parameters	Pop	14 DAT	28 DAT	42 DAT	56 DAT	70 DAT
Plant height (cm)	Inpago 5	35.37 b	69.27 ab	102.17 a	127.13 a	146.23 a
	BC_1F_1	31.67 a	64.00 b	101.07 a	126.73 a	146.30 a
	Inpara 8	48.18 b	71.58 a	96.17 a	119.29 b	133.00 b
	$LSD_{.05}$	5.20	6.64	7.72	4.80	3.07
Total tillers	Inpago 5	1.33 a	2.33 a	5.13 a	5.80 b	5.80 b
	BC_1F_1	2.07 a	3.13 a	4.67 a	5.27 b	5.27 b
	Inpara 8	0.41 a	2.35 a	5.48 a	7.28 a	8.65 a
	$LSD_{.05}$	2.21	1.08	1.03	1.18	1.34

Note: values within a row followed by the same letters were not significantly different based on the LSD at P ≤ 0,05; Pop = Population; DAT = Days after transplanting.

Total and productive tillers. The tillers number increase rapidly until it reached the primordial phase due to nutrients competition (Tilahun, 2019). The number of total tillers of three populations were not significantly developed at the beginning of vegetative stage (14, 28, and 42 DAT), but significantly showed the increasing of tillers at 56 DAT (Table 1). The number of total tillers of BC_1F_1 and Inpago 5 were not increased at 70 DAT (Table 2) due to maximum tillers reached at 56 DAT. Figure 1 showed the highest number of tillers was found in Inpara 8 (4.83 tillers) followed by BC_1F_1 (3.91 tillers) and Inpago 5 (3.76 tillers). Table 3 showed the highest number of productive tiller was found in Inpara 8 (8.34 tillers). The productive tillers number of BC_1F_1 (5.33 tillers) was not significantly different to Inpago 5 (5.73 tillers).

The tillers number affected the total of productivity tillers, as explained by Wang *et al.* (2019) that the number of tillers per plant and their ability to maintain various physiological functions will affect the formation of panicles. It showed by tillers number of BC_1F_1 (Table 5) and Inpara 8 (Table 6) exhibited strong association with productive tillers (r = 1 and 0.932). Same result reported on study of Chozin *et al.* (2017) that panicles (productive tillers) is largely determined by the tillers number produced by the plant. It also indicated by proportion of photosyntates source, that Table 5 and Table 6

ISSN: 1412-4718, eISSN: 2581-138x

showed strongly association between total tillers and biomass dry weight of BC_1F_1 (r = 0.935) and Inpara 8 (r = 0.931).

Takai *et al.* (2021) suggested that rice crops have a potential to increase its production along with the number of tillers. Tillering ability of rice greatly influenced by genetic (Ren *et al.* 2021) and environmental factors (Gao *et al.* 2019). Tiller productivity was categorized into 4 groups, (1) Low (less than 10 tillers), (2) Medium (11-15 tillers), (3) High (16-20 tillers), and (4) Very high (more than 20 tillers) (IRRI, 2013). Based on the result, Inpago 5, BC_1F_1, and Inpara 8 was categorized into the few tillers group.

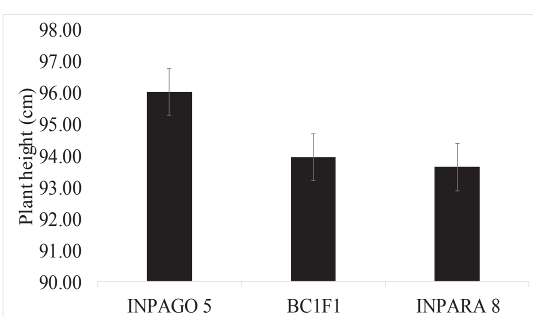
Days to flowering and harvesting. In this study, all population were not significantly different in flowering time and significantly different in harvesting time (Table 3). The result showed the flowering time of Inpago 5 was 66 days after sowing (DAS), BC_1F_1 was 71 DAS, and Inpara 8 was 76 DAS. Inpara 8 had the shortest time to flowering, but had shorter grain filling phase than Inpago 5 and BC_1F_1. The flowering and harvesting time of BC_1F_1 population were 3 days longer than Inpago 5. Inversely with previous study by Suwignyo *et al.* (2021) that flowering time and harvesting time of Inpara 8 shorter than Inpago 5. Tabel 6 showed strongly association of harvesting time with plant height (r=0.93) and productive tillers (r=0.91). As reported by Kartina *et al.* (2016) that harvesting time and flowering time were correlated to plant height and productive tillers.

Number of total spikelets. Based on the LSD test, the means values of the number of total spikelets per panicle of BC_1F_1 and Inpago 5 were not significantly different at 181.42 and 177.1 spikelets. The number of spikelets per panicle of Inpara 8 was significantly lower than the other populations with 82.19 spikelets. Inpara 8 produced significantly lower number of total spikelets per plant at 695.4 spikelets than BC_1F_1 (1,348.2 spikelets) and Inpago 5 (1,342 spikelets). At the end of vegetative stage, the plants were reached the maximum plant height and maximum tiller number. The beginning of reproductive stage is characterized by initiated panicle formation and the appearance of flag leaves. After the panicle is perfectly formed, the plants begin into the flowering stage lasts about 25 - 28 days influenced by genetic and environmental differences (Guo *et al.* 2020). Table 5 showed number of total spikelets per panicle had positive correlation to productive tillers (r = 0.88) and grains dry weight (r = 1). While number of total spikelets per plant showed positive correlation to productive tillers (r = 0.96) and negative correlation to grains dry weight (r = -1).

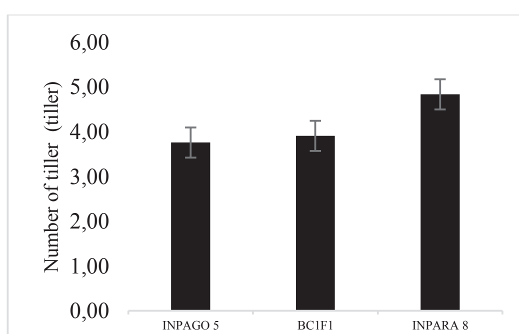
Table 3. Agronomy parameters of vegetative and generative stage of Inpago 5, BC_1F_1, and Inpara 8

Pop	PL	DF	DH	TSP	TSC	PS	DB	WG	GDW
Inpago 5	5.73 b	66.53 a	123.60 b	181.42 a	1342.00 a	25.02 a	27.88 a	20.99 b	9.45 a
BC_1F_1	5.33 b	71.16 a	126.20 a	177.10 a	1348.20 a	29.40 a	29.68 a	25.49 a	9,71 a
Inpara 8	8.34 a	76.33 a	115.87 c	82.19 b	695.40 b	39.23 a	29.09 a	22.29 ab	2,78 b
$LSD_{.05}$	1.32	31.46	1.26	24.49	535.68	15.36	4.24	3.34	11.57

Note: values within a column followed by the same letters were not significantly different based on the LSD at P ≤ 0,05; PL = Number of productive tillers; DF = Day to flowering; DH = Day to harvesting; TSP = Number of total spikelets per panicle; TSC = Number of total spikelets per plant; PS = Percentage of sterile spikelets (%); DB = Biomass dry weight (g); WG = Weight of 1000 grains (g); GDW = Grains dry weight (g); Pop = Population.



(a)



(b)

Figure 1. Average of plant height (A) and number of total tillers (B) of Inpago 5, BC_1F_1, and Inpara 8

Percentage of sterile spikelets. Table 3 showed the lowest percentage of sterile spikelets was Inpago 5 at 25.02% and the highest percentage was Inpara 8 with 39.23% of sterile spikelets. The percentage of sterile spikelets of BC_1F_1 (29.4%) also found not significantly different from the parents. Inpara 8 got the highest percentage of sterile spikelets (Table 3) due to the highest damaged caused by pest. It explained by Sugiura *et al.* (2022) that decreasment of the percentage of filled spikelets caused by pest attacked. Table 6 showed number of productive tillers had positive association with total spikelets per panicle and plant (r = 0.983 and 0.955). The more number of attacked tillers, the higher of sterile spikeletes. It also reported by Akhmadi *et al.* (2017) that sterile spikelets parameter was strongly correlated to productive tillers.

Table 4. Comparison of correlation analysis result among growth parameters of Inpago 5

	PH	TL	PL	DF	DH	TSP	TSC	PS	BDW	WG	GDW
PH	1										
TL	-0.11	1									
PL	-0.64	0.41	1								
DF	-0.21	0.52	0.21	1							
DH	-0.53	-0.15	0.44	-0.676	1						
TSP	0.12	-0.84	-0.73	-0.23	-0.13	1					
TSC	0.40	0.12	0.38	0.15	-0.30	-0.48	1				
PS	0.52	-0.22	0.01	-0.78	0.38	-0.19	0.46	1			
BDW	0.48	0.15	0.26	-0.49	0.24	-0.55	0.67	0.91*	1		
WG	-0.07	0.92	0.12	0.99	-0.74	-0.57	0.96	-0.97	-0.99	1	
GDW	-0.31	0.99	0.36	0.99	-0.56	-0.75	0.87	-1.00*	-0.99	0.97	1

Table 5. Comparison of correlation analysis result among growth parameters of BC_1F_1

	PH	TL	PL	DF	DH	TSP	TSC	PS	BDW	WG	GDW
PH	1										
TL	-0.77	1									
PL	-0.77	1,00**	1								
DF	-0.64	0.36	0.36	1							
DH	-0.63	0.42	0.41	0.40	1						
TSP	0.63	-0.75	-0.75	-0.78	-0.36	1					
TSC	0.03	0.52	0.52	-0.58	-0.13	-0.80	1				
PS	0.53	-0.92*	-0.92*	-0.34	-0.35	0.84	-0.54	1			
BDW	-0.92*	0.94*	0.94*	0.53	0.66	-0.75	0.26	-0.80	1		
WG	-0.83	0.96	0.96	-0.95	-0.24	-0.44	0.84	-0.67	0.99	1	
GDW	0.97	-0.41	-0.41	0.37	-0.59	-0.40	-0.12	-0.14	-0.74	-0.65	1

Table 6. Comparison of correlation analysis result among growth parameters of Inpara 8

	PH	TL	PL	DF	DH	TSP	TSC	PS	BDW	WG	GDW
PH	1										
TL	-0.20	1									
PL	-0.39	0.93*	1								
DF	-0.34	0.77	0.86	1							
DH	0.93*	-0.41	-0.48	-0.36	1						
TSP	-0.49	0.88	0.88*	0.91*	-0.62	1					
TSC	-0.48	0.95*	0.96*	0.82	-0.64	0.95*	1				
PS	-0.95*	0.12	0.34	0.16	-0.86	0.31	0.38	1			
BDW	0.14	0.931*	0.81	0.60	-0.09	0.66	0.78	-0.15	1		
WG	-0.96	-0.04	0.47	0.47	-0.88	0.61	0.60	0.91	-0.53	1	
GDW	0.36	-0.76	-0.98	-0.98	0.18	1.00**	-1.00*	-0.24	-0.34	-0.62	1

Note: (Table 4, Table 5, Table 6) PH = Plant height; TL = Number of total tillers; PL = Number of productive tillers; DF = Day to flowering; DH = Day to harvesting; TSP = Number of total spikelets per panicle; TSC = Number of total spikelets per plant; PS = Percentage of sterile spikelets (%); BDW = Biomass dry weight (g); WG = Weight of 1000 grains (g); GDW = Grains dry weight (g); * = Correlation is significant at the 0.05 level; **= Correlation is significant at the 0.01 level

Weight of 1000 grains. Based on the LSD test (Table 3), the weight of 1000 grains of BC_1F_1 was 25.49 g, significantly higher than Inpara 8 (22.29 g) and Inpago 5 (20.99 g). The photosynthates translocate from the source (leaves) to the sink (parts of plant) (Jeong *et al.* 2017) and grain is the main photosynthate sink (Mathan *et al.*, 2021). The process of grains filling is very important to get high yields showed by the highest of weight of 1000 grains and percentage of grain content (Table 3).

Biomass dry weight and Grains dry weight. Table 3 showed the biomass dry weight BC_1F_1 (24.4 g) not significantly different from Inpago 5 (27.88 g) and Inpara 8 (29.09 g). meanwhile, the highest grains dry weight was BC_1F_1 (9.71 g) not significantly different from Inpago 5 (9.45 g) and significantly different from Inpara 8 (2.78 g). Table 4 showed biomass dry weight were correlated to grains dry weight (r = 1). The percentage of sterile spikelets and the weight of 1000 grains not only were caused by pest attacked but also affected by an imbalance between the sink and the source in the photosynthate translocation. In addition to translocated to the grains, the photosynthates are also translocated to other parts, such as young leaves. Table 3 showed the biomass of the total dry weight of the vegetation above the soil surface. The biomass is affected by differences of phenological generative growth for each varieties (Vijayaraghavareddy *et al.* 2020). The shorter grains filling phase, causing uneven distribution of photosynthates. An imbalance of photosyntates distribute, could influence grains dry weight and biomass. It showed by Table 4, that percentage of sterile spikelets were negatively correlated to grains dry weight (r = -1) and positively correlated to biomass dry weight (r = 0.91).

Conclusion

The result showed that Inpago 5, as a recipient parent, got the highest number of total spikelets per panicle (181.42 grains), the lowest percentage of sterile spikelets (25.05%) and the lowest biomass dry weight (27.88 g). Inpara 8, as a donor parent, got the highest average number of productive tillers (8.34 tillers), took the longest time to flowering (76 days), and the shortest time to harvesting (115 days). Then, the progenies BC_1F_1 got the highest average number of total spikelets per plant (1348.2 grains), weight of 1000 grains (25.49 g), and grains dry weight (9.71 g). According to the result, population of BC_1F_1 was indicated a segregation gene traits from the parents. It showed by 63.6% observed parameters of BC_1F_1 have means value between Inpago 5 and Inpara 8. The days to harvesting and total spikelets per plant of BC_1F_1 had the highest average value, exceeding the Inpago 5. Then, BC_1F_1 got the highest means value of biomass dry weight and weight of 1000 grains, tending to Inpara 8. This study was evaluated the growth traits of progenies plants. The next backcrossing of the plants and molecular selection with Marker Assisted Backcrossing (MABC) method would be further selection to obtained plants that have *Sub1* gene and the closest characteristic to recipient parent (Inpago 5).

Acknowledgement

The authors would like to thank and appreciate anonymous reviewers and editors of Kultivasi Journal for their meaningful comments and suggestions. We deeply appreciate the Ministry of Education, Culture, Research and Technology who has funded this research under research scheme of national competitive program research fiscal year 2022 No. 142/E5/PG.02.00.PT/2022 with DIPA No. SP DIPA-023.17.1.690523/2022.

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