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To cite this article: R A Suwignyo *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **741** 012022

IOP Conf. Series: Earth and Environmental Science **741** (2021) 012022 doi:10.1088/1755-1315/741/1/012022

Development of Rice Varieties Adaptive to Nontidal Swampland using MABC: Growth Characteristics of Parent Plant and F1 Result

R A Suwignyo*, I Irmawati, F Hose, and S L Aulia

Department of Agronomy, Faculty of Agriculture, Sriwijaya University, Indonesia

Email: rujito@unsri.ac.id

Abstract. Lowland swamps have enormous potential and have been proven to provide significant contributions as a buffer in the national food security system. Rice farmers in non-tidal swamplands of South Sumatra plant rice at the end of the rainy season, because they wait for the water to recede, and therefore rice plants are very vulnerable to submerged stress in the vegetative phase and drought stress in the generative phase. This study aims to obtain rice varieties that are adaptive to these conditions and superior to lowland swamp agro-ecosystems. The research was conducted at the Plant Physiology Laboratory and Green House of Department of Agronomy, Faculty of Agriculture, Sriwijaya University. In this study, reciprocal crosses were carried out between Inpago 5 and Inpara 8 rice varieties. Inpago 5 variety was used because it has tolerant characters to drought stress in the generative phase and also has high production in farmers' nontidal swampland. Inpara 8 has a Sub1 gene so that resistant to submerged stress in the vegetative phase. The results showed that both varieties had different characters in their growth and yield. Both varieties were crossed reciprocally and the success of crossing was more than 50%. F1 plants will be backcrossed with their female parents to get BC1F1 plants, and then selected using the MABC method [foreground selection, phenotypic selection, and background selection]. From the results of the MABC selection process, there will be BC1F1 plants with the genome proportion close to the female parent and confirmed to have the Sub1 gene.
Keywords: Nontidal swamplands, Submergence, Drought, Rice crossing, MABC

1. Introduction

Swampland is a sub-optimal land that has the potential to be used for various agricultural activities because Indonesia has 33.43 mil Ha of swamp and 13.29 mil Ha of which are nontidal swamplands [1]. The farming pattern that is carried out still relies on and is very dependent on natural conditions [2]. Nontidal swampland has specific characteristics and very marginal so that requires special handling different to other lands and difficult to predict the water level in the field [3]. The level of difficulty in the field is getting bigger because nontidal swamp areas do not have an irrigation system.

Rice cultivation activities in lowland swamps face the problem of uncontrolled water management. The implementation of rice cultivation in swampy swamps with the bund has encountered problems with the dual abiotic stress of submerged stress and drought stress at the same time in one growing season. This causes newly planted rice plants to experience submerged stress in the vegetative-stage and also drought stress in the reproductive-stage. For this reason, it is necessary to have rice varieties that can tolerate these two conditions. The search for tolerant varieties must be devoted to obtaining varieties that are resistant to being submerged in the initial growth phase [4] [5] and also drought-resistant at the end of the growth period [3] [6] [7]. The opportunity to produce these varieties is very possible because the genes controlling these two characters are at different loci [5].

Research activities are being carried out to obtain rice varieties that are adaptive to nontidal swamp agroecosystem conditions which have dual resistance [tolerant of submerged stress in the vegetative phase and drought stress in the generative phase] and also have better growth and production. The results of this research presented are the initial stage in the research process, namely F1 crosses, and then will be continued by backcross crosses and selected using marker-assisted selection.

2. Materials and methods

This research was conducted in the greenhouse of the Department of Agronomy, Faculty of Agriculture, Sriwijaya University using a randomized block design with 3 replications to evaluate the growth and yield of the two parent varieties. Crosses are carried out using the reciprocal method. The varieties used for the crossing were Inpago 5 and Inpara 8. Inpago 5 was one of the selected varieties which tolerated drought stress in the generative phase, and Inpara 8 was a variety that had the Sub1 gene. Before the rice seeds were sown, the seeds were soaked in a petri dish for 24 hours, and allowed to stand for 24 hours in dark conditions until the radicles emerged. The germinated seeds are transferred to a tray seedbed for ± 14 days. Seedlings were transplanted into buckets that have previously been filled with soil and water as high as 2 cm from the soil surface. The fertilizer used was Urea, SP-36, and KCl, 0.8 g, 0.52 g, and 0.3 g for each bucket respectively. Crosses of plants were carried out by conventional techniques through castration, emasculation, pollination, and plant isolation. The plant ages of the crossing were 77 and 80 days after planting for Inpara 8 and Inpago 5 respectively. The parameters observed were the growth and production of parent plants and the success of their crosses.

3. Results and Discussion

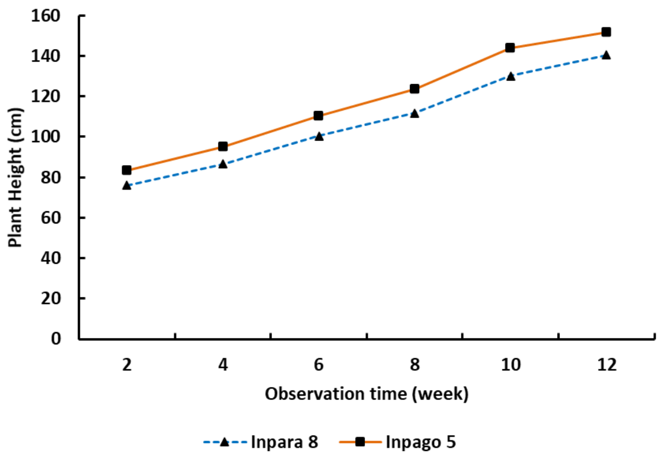

Figure 1. The height of plant during twelve weeks of Inpara 8 and Inpago 5

The results showed that the Inpago 5 had higher plants than Inpara 8 during twelve weeks [Figure 1and Figure 3], but the number of tillers was less [Figure 2, Figure 4]. Higher plant height and a smaller number of tillers will be beneficial for rice plant characters grown in lowland swamps. Inpago 5 is upland rice that can produce 6.63 productive panicles and grain production 4.5 tons/Ha on dry land [8] and our previous experimental results showed that this variety could produce 5.39 tons/Ha in nontidal swamplands.

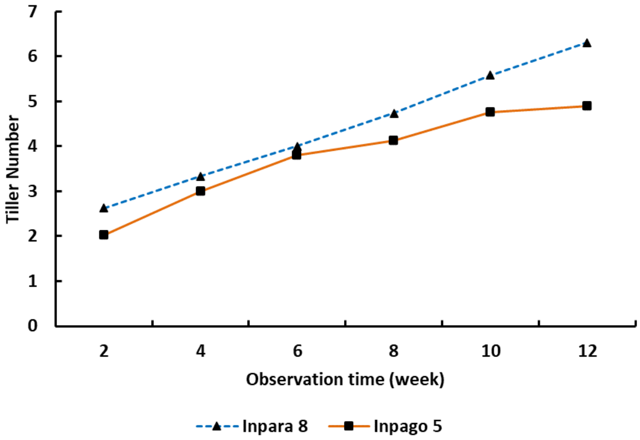

Figure 2. The number of tillers during twelve weeks of Inpara 8 and Inpago 5

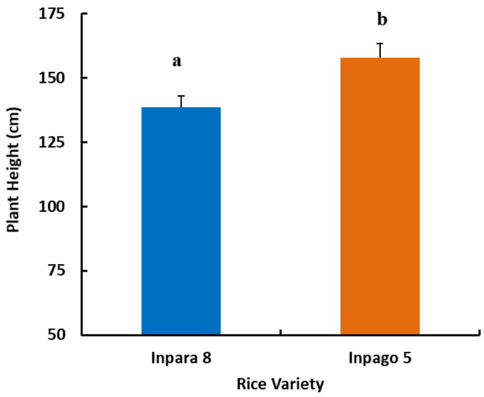

Figure 3. Plant height at 12 weeks after planting of Inpara 8 and Inpago 5

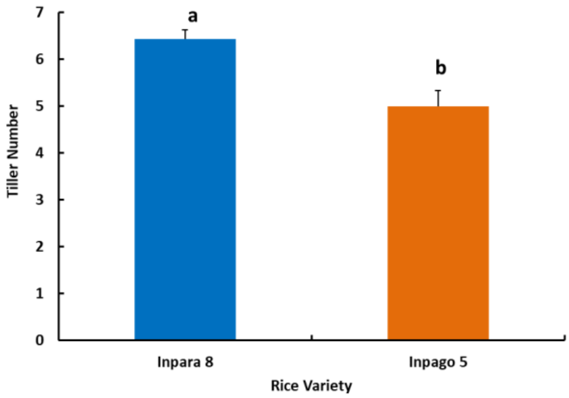

Figure 4. The number of tillers at 12 weeks after planting of Inpara 8 and Inpago 5

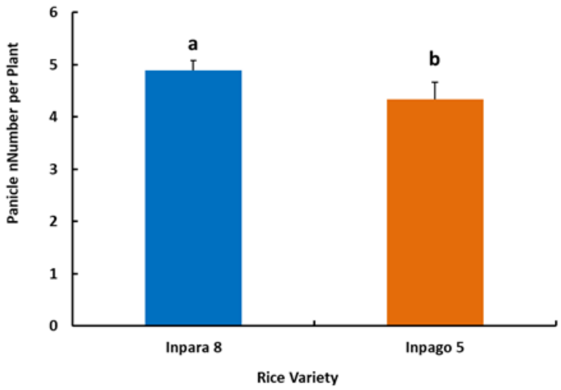

Figure 5. The number of panicles per plant at 12 weeks after planting of Inpara 8 and Inpago 5

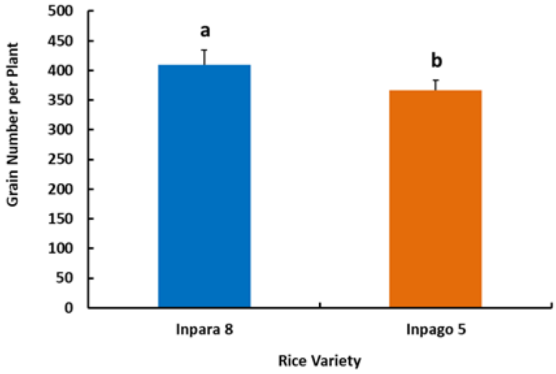

Figure 6. The number of grains per plant at 12 weeks after planting of Inpara 8 and Inpago 5

Inpago 5 variety had a smaller number of tillers than Inpara 8 [Figure 4], and this resulted in a smaller number of panicles [Figure 5]. Moreover, this smaller number of panicles resulted in a lower number of grains per plant [Figure 6]. Although the number of grain per plant is lower, with a smaller number of tillers, Inpago 5 has the potential to be cultivated using the direct broadcasting system in lowland swamps [9] [10].

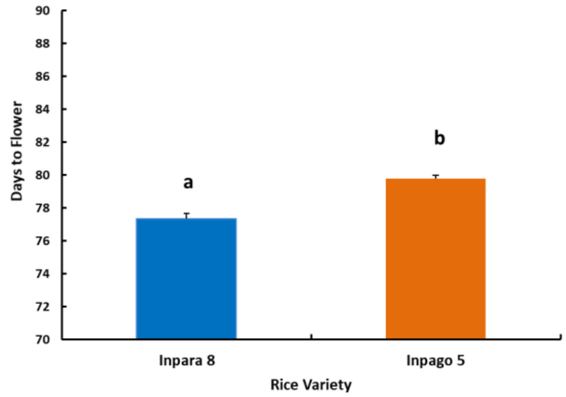

Figure 7. Days to the flower of Inpara 8 and Inpago 5

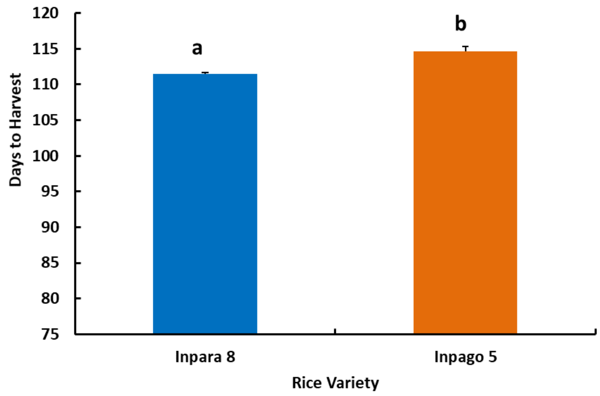

Figure 8. Days to the harvest of Inpara 8 and Inpago 5

The Inpara 8 and Inpago 5 varieties have 77 and 80 days to flower, and 111 and 115 days to harvest, respectively [Figure 7, Figure 8]. The flowering time and harvest time between these two varieties were not significantly different, but we have made a three-time 5 days different seeding time so that at the time of crossing, both varieties can flower together. Each cross was carried out for three replications and each replication consisted of five plants. Early flowering and shorter grain-filling stages can determine early maturity [11]. Vegetative growth and period of flowering are determined by genetic characteristics and it is inhibited by several independent pathways [12]. The crossing of Inpara 8 and Inpago 5 was done reciprocally. The results of these crosses have shown the success of more than 50% and produced 116 and 154 F1 seeds resulting from their reciprocal crosses [Table 1]. The F1 seeds will then be used for back cross F1 [BC1F1] and a selection will be made using Marker Assisted Selection [MAS] as has been done by other researchers [13] [14].

Table 1. Reciprocal crossing result between Inpara 8 and Inpago 5

♀ X ♂	Number of flowers crossed	Number of seeds obtain	Percentage of crossing result [%]
Inpara 8 [♀] X Inpago 5 [♂]	221	116	52.28
Inpago 5 [♀] X Inpara 8 [♂]	298	154	51.68

4. Conclusions

Parent varieties had different characters in their growth and yield. Inpago 5 had higher plant height, but lower tiller number and grain number per plant. Both varieties were crossed reciprocally and the success of crossing was more than 50%. F1 plants will be backcrossed with their female parents to get BC1F1 plants, and then selected using the Marker-Assisted Backcrossing [MABC] method [foreground selection, phenotypic selection, and background selection] to obtain BC1F1 plants with the genome proportion close to the female parent and confirmed to have the Sub1 gene.

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Acknowledgments
We deeply appreciate the Rector of Universitas Sriwijaya who funded this research under the scheme of *Penelitian Unggulan Profesi* using Universitas Sriwijaya's budget of SP DIPA-023.17.2.677515/2020, following the Rector's Decree Number: 0687/UN9/SK.BUK.KP/2020.