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Rice Seedling Resistance due to Seed Priming and Seeding Density under Submergence Stress Condition

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ABSTRACT

The study of rice seedling resistance due to seed priming and seeding density under submergence stress condition was carried out to evaluate the effect of seed priming and also to estimate proper seeding population density to improve rice seedlings vigor under submergence stress condition. The experiment was conducted in tidal freshwater swamp of Sako in Rambutan District, Banyuasin Regency (3.067° S, 104.8616° E). Randomized block design was used where the seeds were soaked into $ZnSO_4.7H_2O$ solution as priming treatment, and then sown with three different seeding rates: 30, 40 and 50 kg ha^{-1}. Three cultivars consisted of Inpara 3, Inpara 5 and Ciherang were tested. The observation was carried out until 4 weeks after sowing to measure the seedling height, shoot dry weight, carbohydrate content in stem, and leaf chlorophyll. Results showed that all treatments indicated insignificant effect to all parameters. However, the highest result from all parameters was obtained from priming treatment. The higher seeding density the lower dry weight, carbohydrate and chlorophyll content. All three tested cultivars, Inpara 3 gave the best performance.

INTRODUCTION

The need to increase Indonesian rice production to meet the national demand through either intensification by improving seed and cultivar quality, proper use of fertilizer and practicing appropriate cultivation techniques or extensification by expanding farming land area is beneficial to compensate the massive population growth and the risk of land conversion. Total Indonesian rice production in 2015 was 75,397,841 tons increasing 6.4 % of that in 2014. Particularly in South Sumatra, rice production was 4,247,922 tons resulted from irrigated and swamp rice fields for both tidal and non-tidal swamp (Central Bureau of Statistics, 2016). Yield improvement for freshwater swamp rice is still needed to be boosted considering many

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constraints faced in this area, such as the attack of pests and diseases, drought, and flood (Susanto, 2015).

The improvement of cultivation techniques to increase rice yield includes enhancing seed quality, developing new superior cultivars, and increasing cultivar resistance to suboptimum environmental conditions, such as to flooding and drought. During nursery, rice farmers in freshwater swamp rarely apply fertilizer to the seedlings due to financial and knowledge limitations. The mitigation of flooding and risk of submergence stress by improving seedlings vigor and using submergence tolerant cultivars have been reported by many studies. Ali *et al*. (2016) reported the attempt of sub1 gene induction into non tolerant cultivars and Zn application in rice field. Seed priming prior to planting has also been studied by researchers in Southeast Asian countries including Indonesia, such as by Prom-u-thai and Rerkasem (2011) stating that the concentration of 5.0 mM could increase rice seedlings vigor.

Seed priming using micro nutrients solutions before germination would be easier and practical compared to the application of micro nutrients to the soil since the amount given will be much lesser than of that in soil application (Rehman *et al*., 2012). Aboutalebian *et al*. (2012) reported that seed priming in 0.2% Zn solution for 10 hours could increase the yield, 1000 seed weight, and plant biological products. Iftekharuddaula *et al*. (2015) also reported seed priming application to increase rice seedlings resistance to submergence stress. However, the study of seed priming combined with seeding population density per area has not yet been carried out.

Seed requirement per hectare is always attributed to seeding population density sown in a nursery area. The farmers generally will not specify the certain sowing amount to anticipate high seedling mortality rate and pests attack such as rat, snail, bird, and chicken. Therefore, the more the seeds being sown, the better the seeding stock will be. However, the competition of mineral nutrients and sunlight among the seedlings in nursery should be put into consideration. Somantri (2016) recommended population density for about 1 kg per 20 m^{-2} of nursery plot. Generally, seed requirement for broadcasting system is about 25 – 30 kg ha^{-1}. Ikhwani (2015) reported the population would decrease in legowo planting system using 30 cm x 20 cm of planting space resulting in 3.29 ton ha^{-1} of yield, while using 25 cm x 25 cm planting space would result in 2.22 ton ha^{-1} (Putra, 2011) and Ikhwani *et al*. (2013). Donggulo *et al*. (2017) also reported that population deduction to the optimum limit not only could lessen seed requirement, but also could increase the yield. It is then understandable that rice seedling will have faster growth due to more spacious growing area which in turn increase the yield.

Thus, this study was conducted to evaluate the effect of seed priming prior to germination and examine seeding density in nursery to improve seedlings vigor under submergence stress on several rice cultivars.

MATERIALS AND METHODS

The research was conducted in freshwater swamp in Sako, Rambutan District, Banyuasin Regency (3.067° S, 104.8616° E) from May to June 2020. The treatments consisted of no seed priming (control) and priming with 5 mM $ZnSO_4.7H_2O$ solution with the combination of seeding density in nursery: 30, 40 and 50 kg ha^{-1}. Three cultivars were tested consisting of Inpara 3, Inpara 5, and Ciherang where the seeds were obtained from Sukamandi Rice Research Center. Priming treatment was applied before sowing for about 24 hours, then the seeds were germinated in the floating nursery. The seedlings were then transplanted into the nursery plot at 2 weeks after sowing. Submergence stress was given to the seedlings for 5 days at 3 weeks after sowing. The observation then was carried out after 1 week recovery to measure seedling height (cm), shoot dry weight (mg), carbohydrate content in stem (%), and leaf chlorophyll (mg g^{-1}).

RESULTS AND DISCUSSION

Results

The result of analysis of variance (ANOVA) showed that the treatment did not significantly affect on all variables measured (Table 1).

Based on the above results, the treatment showed insignificant effect to seedling height at 4 weeks after sowing. Ciherang was the cultivar with the appear to be the highest height after being submerged for 5 days, while Inpara did not show any elongation even after one week recovery. Stem elongation is a submergence avoidance mechanism of plant to reach out water surface for respiration. Seed priming treatment could prevent stem elongation in all cultivars, while in control plants the elongation still occurred. Figure 1 shows that seedling height in nursery was decreased due to higher seeding *population* density.

Figure 2 showed that the effect of seed priming and seeding density to seedling dry weight. Both Inpara cultivars had higher dry weight compared to Ciherang. While, seed priming treatment resulted the highest dry weight in all tested cultivars. For the seeding density treatment, the density of 50 kg ha^{-1} had the lowest dry weight. In contrast, the lowest density resulted the highest dry weight.

Seed priming showed better result in all cultivars for carbohydrate content in stem after being submerged for 5 days compared to no priming plants. Denser seeding density treatment resulted in lower carbohydrate depletion, as seen in Figure 3.

Based on the results of leaf chlorophyll analysis (Figure 4), Ciherang showed a tendency to have the lowest chlorophyll content due while Inpara 3 showed the contradictory. Similar results was showed by priming treatment as well as low seeding density (30 kg ha^{-1}).

Discussion

Rice cultivars showed different response to five days submergence, especially as shown in

Table 1. Analysis of variance of seed priming, seeding density and cultivar to seedling height, shoot dry weight, stem carbohydrate and leaf chlorophyll

No	Parameter	F value		F 0.05	F 0.01	Coef. of variance
		Treatment	Block			
	Seedling height (cm)	3.08 ns	1.93 ns	3.28	5.29	4.93
	Shoot dry weight (g)	5.22 ns	2.38 ns	3.28	5.29	8.44
	Stem carbohydrate (%)	2.50 ns	8.70 ns	3.28	5.29	21.33
	Leaf chlorophyll (g g^{-1})	3.25 ns	0.05 ns	3.28	5.29	10.62

ns = non significant

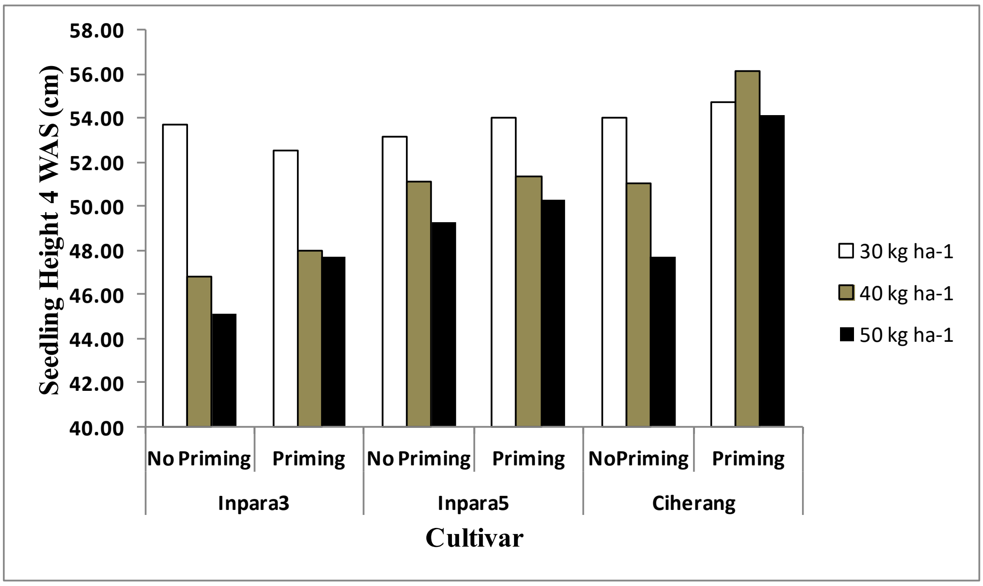

Figure 1. The effect of seed priming and seeding density to seedling height (cm) at 4 weeks after sowing.

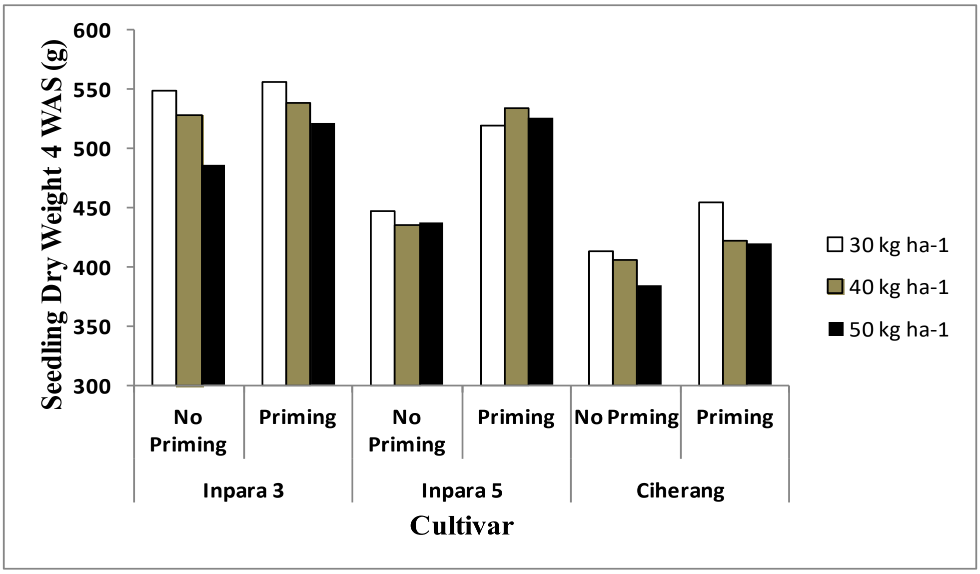

Figure 2. The effect of seed priming and seeding density to seedling dry weight (g) at 4 weeks after sowing.

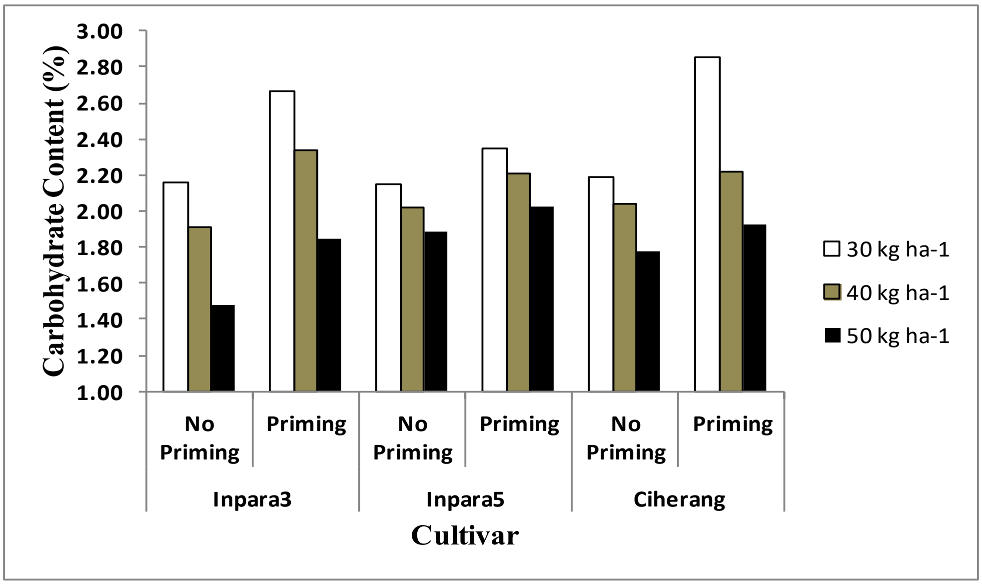

Figure 3. The effect of seed priming and seeding density to carbohydrate content in stem (%)

seedling weight at 4 weeks after sowing. Submergence inhibited height growth of Inpara 3, while height increase still occured in Ciherang. A study by Suwignyo *et al*. (2012) had also reported height increase in some rice cultivars during submergence. Furthermore, it was stated that more energy would be consumed to compensate the height increase resulting in rapid depletion of plant dry weight, carbohydrate and leaf chlorophyll. Similarly, this study discovered that Ciherang had the lowest dry weight and carbohydrate content as it had higher seedling height compared to other two cultivars.

Seed priming using Zn resulted in the increase of seedling dry weight (Figure 2). Of all cultivars, Ciherang was the cultivar with the lowest dry weight. Priming treatment could improve seedlings vigor to adapt in suboptimum environment (Roy *et al*., 2013). Based on the results, priming could increase seedling height after recovery period, and also the accumulation of dry weight. Similar result was also reported by Afzal *et al*. (2013) where plant vigor was improved by priming the seeds in Zn solution. Response of each cultivar to Zn priming was expressed in the increase of dry weight and carbohydrate

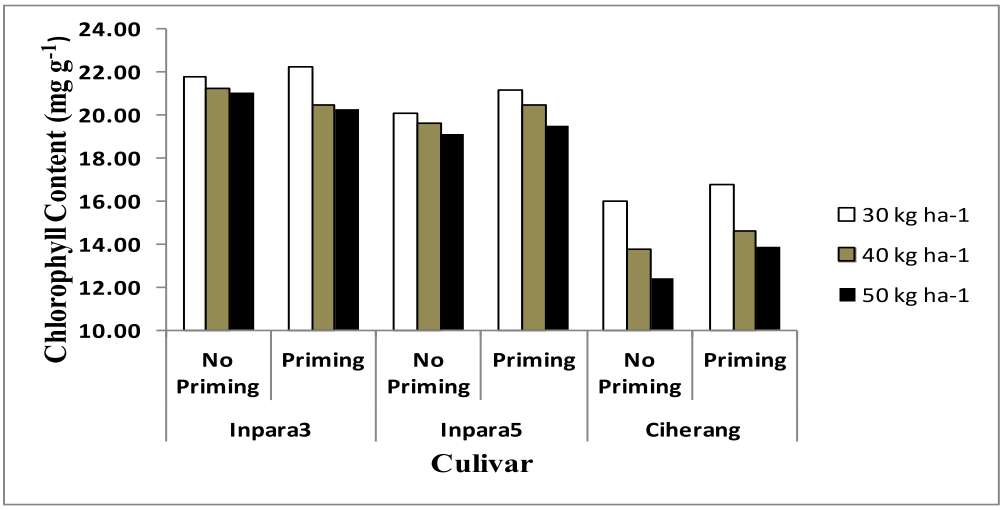

Figure 4. The effect of seed priming and seeding density on leaf chlorophyll (mg g^{-1}).

content in stem. Some studies have also reported the contribution of Zn in rice and other crops stating that Zn priming increased plant tolerance to submergence condition (Prom-u-thai and Rerkasem, 2011; Munawar *et al*., 2013; Samad *et al*., 2014). Deficiency of Zn in plants would inhibit the activity of Zn containing enzyme (Ahmad *et al*., 2012). Zn is essential for plant in tryptophan formation functioning as major precursor of IAA synthesis which in turn would actively involve in cells growth of plant organs. Submergence stress affected photosynthetic inability disrupting the metabolism and decreasing carbohydrate translocation in stem (Luo *et al*., 2011).

Seedling ability to compete for mineral nutrition, water and light would be attributed to seeding population density in nursery. Plants should have survival ability to submergence, even at the seedling stage. Seeding density of 50 kg ha^{-1} was considered too densely populated resulting in the decrease of dry weight, carbohydrate content in stem, and leaf chlorophyll (Figure 2, 3 and 4). Such recommendation had been suggested by Ikhwani (2015) in *legowo* cropping system. Putra (2011) and Ikhwani *et al*. (2013) stated that decreasing plant population to the optimum limit not only could decrease seed requirement but also could increase the yield of rice. Furthermore, Donggulo *et al*. (2017) reported that the more spacious planting area could enhance the growth and increase seedling vigor under suboptimum condition, including submergence stress condition.

CONCLUSIONS

Seed priming prior to germination did not improve seedling vigor to submergence stress as shown by the parameters of seedling height, carbohydrate content and leaf chlorophyll after 5 days submergence. Lower seeding density treatment of 30 kg ha^{-1} showed a tendency to be better resistance to submergence as it had higher dry weight, carbohydrate content in stem and leaf chlorophyll. Regardless of the results, we recommended that farmers need to do seed priming when growing Inpara 3.

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