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Research Article

Partial Submergence Tolerance in Rice (*Oryza sativa* L.) Cultivated in North Sulawesi at the Vegetative Phase

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Abstract

Background and Objective: The partial-submergence-tolerant crop plants, including rice are required for fulfilling food needs when a flooding disaster occurs in Indonesia. The information of effective selection method for obtaining submergence tolerant rice is required for increasing the North Sulawesi capacity as a pillar of national food security. This study evaluated the partial-submergence-tolerance in 10 rice cultivars that are cultivated in North Sulawesi Province based on the morphological characters (plant height, shoot dry mass, shoot length, root dry mass, root length, root volume, shoot:root ratio and leaf number) at the vegetative phase. **Materials and Methods:** This experiment was conducted in the greenhouse using 10 rice cultivars (cv. Cigeulis, Seruni, Mekongga, Ciherang, TB, Ombong, Inpari 13, Burungan, Temo and Superwin). These cultivars were grown at the vegetative phase in partial submergence condition (the entire root system and 30 cm of above-ground shoot was under water) for 20 days, with 8 replicates, in a randomized block design. **Results:** The longer duration of partial-submergence treatment resulted in the decrease of leaf number, the increase of plant height and the increase of shoot elongation. There were three categories of partial-submergence tolerance, i.e., tolerant for Cigeulis and TB, semi tolerant for Seruni, Mekongga, Inpari 13, Burungan, Temo and Superwin and non-tolerant for Ciherang and Ombong. **Conclusion:** Rice cv. TB as tolerant cultivar showed better growth response under partial submergence rather than other rice cultivars at the vegetative phase.

Key words: Glasshouse, morphology, partial submergence, rice vegetative

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Global warming resulted in climate change that significantly affected many aspects in our life, including the phenomenon of flooding and drought. Uncertain flooding and drought decreased the production of crop plants as these plants were annual plants that were sensitive to water excess and water deficit[1]. Temporary or long period of submergence often occurred in the tropical lowland area with high rainfall. This condition interfered with plant metabolism because of O_2 deficiency[2].

Flooding often happens in Indonesia and it can be caused by the combination of enhanced intensity and duration of rain, precipitation and soil characteristics. The increased flooding cases in rice field reduced rice production, especially for the countries where rice was the main source of the staple food[3]. The damaged rice field and decreased rice production that were resulted from flooding in Indonesia were about 268,823 ha and 1.344 million t of rice per year, respectively[4]. Flooding occurred many times in North Sulawesi, especially in the rice barn area and rice field was submerged until 1-1.5 m in 2013. For example, flooding caused by the overflow of Ongkag river resulted in submergence of 100 ha of rice field in North Dumoga, Bolaang Mongondow District, North Sulawesi Province[5].

Crop plants, such as rice, that are submergence tolerant, are required for fulfilling food necessity during the flooding disaster. Rice plants were able to adapt to live in the soil with water excess, however, generally rice plants would die if all parts of the plants were submerged for one week or more than one week[6]. The young rice plants were usually more sensitive to the submergence resulted from flooding, because the plant organs were broken during submergence. This happened because the availability of O_2 and CO_2 decreased and this condition inhibited respiration and photosynthesis[7].

Flooding duration, the plant stage when the plants are starving from flooding and flooding water turbidity influenced morphophysiological plant responses to submergence caused by flooding[8]. The most sensitive response of rice plants to submergence happened at the vegetative stage, i.e., about one week after sowing[9]. Flooding at the vegetative stage did not result in optimal growth and inhibited tiller growth, so that the plant production decreased. While the plants were submerged, the photosynthesis and respiration processes in plants inhibited because the rate of gas diffusion in the water was 104 times lower than in the air[10] and the penetrated light accepted by the plants was low[11].

Sasidharan *et al.*[12] reported four terminology to illustrate the condition of excess water for the plants, i.e., water logging or soil flooding (only the root system is flooded), partial water logging or soil flooding (partial flooding of the root system), submergence (root system and above-ground shoot are under the water) and partial submergence (part of root system and above-ground shoot are under the water). The treatment in this study was categorized as partial submergence.

Morphological responses to partial-submergence were evaluated in North Sulawesi local rice cultivars, i.e., Superwin, Ombong, Temo and Burungan. Poluan *et al.*[13] reported that rice plant height increased continually before partial-submergence and 20 days after submergence until a week after recovery. The treatment of 10 day partial-submergence decreased the leaf number of rice cultivar Superwin, Ombong, Temo and Burungan and this condition did not change at 15 and 20 days after partial-submergence. The leaf number of rice cultivar Hartog, however, reduced at the recovery period because some leaves were damaged. Kakanga *et al.*[14] observed that root to shoot ratio was not significantly different among these local rice cultivars as response to partial-submergence at the vegetative phase.

The evaluation of submergence tolerance in the cultivated rice cultivars in North Sulawesi has been scarcely conducted. Therefore, the study of morphological response of rice plants to partial submergence at the vegetative stage based on the percentage of alive plants as well as shoot and root characteristics, with variation of partial submergence period should be carried out. This study aimed to determine the partial-submergence tolerant cultivar among 10 rice cultivars cultivated in North Sulawesi.

MATERIALS AND METHODS

Location and duration of study: The study was carried out in Manado, North Sulawesi Indonesia from April-November, 2018.

Experimental design and treatment: The experiment was carried out in the greenhouse and consisted of 10 rice cultivars cultivated in North Sulawesi grown in the partial submergence condition for 20 days, with 8 replicates, in a randomized block design. The chosen rice cultivars were Cigeulis, Seruni, Mekongga, Ciherang, TB, Ombong, Inpari 13, Burungan, Temo and Superwin. Seeds of rice were selected by soaking them in the salty water for 2 h and the sunken seeds only (good quality seeds) were used. The selected seeds were surface-sterilized with 2% commercial bleaching solution for 2 min, washed with boiled water[13], then placed on plastic container with black sand as the medium and covered containers with wet paper. The 3 day-germinated seeds were sown at 10 mm depth in the pots (3 germinated seeds in each pot) with the media that was watered until field capacity. The plastic pots had 60 mm diameter and 160 mm height. The media was a mixture of soil, manure and rice hull with the ratio 5:1:1. The 500 g of media was supplied in each plastic pot. The top of each pot was covered with moist plastic bag after sowing to minimize evaporation. The pot covers were removed after seedling emergence about 5 days after sowing and the emerged seedlings were thinned to one per pot at 7 days after sowing[15]. Pots were watered with nutrient solution to field capacity by weight every second day before the treatment commenced. The nutrient solution contained 0,1% Gandasil D® (20% N total, 15% P_2O_5, 15% K_2O, 1% $MgSO_4$, Mn, B, Cu, Co, Zn, aneurin, lactoflavin, nicotinic acid amide). The partial-submergence treatment commenced when the plants reached 4-fully expanded leaf stage[15]. The pots with the plants were submerged in the container filled with water and the water was 30 cm above the media level[13].

Data collection: The data of morphological responses such as percentage of alive plants, shoot dry mass, root dry mass, root length and root volume were collected at 20 days after the treatment only. The data of leaf number, plant height and shoot length were collected on day 0 (before partial submergence commenced) 10, 15 and 20 days after the treatment. The decrease of leaf number, increase of plant height and rate of stem elongation at 10, 15 and 20 days were resulted from dividing the difference of leaf number, plant height and shoot length between day 10, 15 and 20 and day 0, respectively.

Statistical analysis: Analysis of variance (ANOVA) and Duncan Multiple Range Test (DMRT) using SPSS 16.0 were used to identify significant differences ($p<0.05$) of morphological characters among 10 rice cultivars. ANOVA one-way was used to analyze the percentage of alive plants, shoot dry mass, root dry mass, root length and root volume and ANOVA two-way was used to analyze the data of leaf number, plant height and shoot length. Pearson correlation coefficients of morphological characters were calculated using Minitab 17. The levels of partial-submergence tolerance in 10 rice cultivars were determined using deviation standard of each morphological character and then was categorized in three groups: 1) Tolerant (T) if $x_i>x+SD$, 2) Semi tolerant (ST) if $x-SD \le x_i \le x+SD$ and 3) Non tolerant (NT) if $x_i<x-SD$ where x_i is mean of certain morphological character in each cultivar, x is mean of certain morphological character in all cultivars and SD is deviation standard[2].

RESULTS

Morphological characters at 20 days after partial-submergence at the vegetative stage: This study evaluated eight kinds of morphological characters of 10 rice cultivars cultivated in North Sulawesi after 20 days partial-submergence at the vegetative stage, i.e., plant height, shoot dry mass, shoot length, root dry mass, root length, root volume, shoot:root ratio and leaf number. Among these characters, only root volume had no significant difference ($p<0.05$) among 10 rice cultivars. Rice cv. The TB had the highest plant height (94.712 cm), shoot dry mass (7.401 g), shoot length (95.925 cm), root dry mass (2.618 g) and root length (24.278 cm). The largest shoot:root ratio were observed in rice cv. Ciherang and Superwin, respectively (Table 1). The reduction rate of leaf number increased from 0-10 days and then declined gradually from day 10 until day 20 in all rice cultivars, except in the cv. Burungan. The lowest reduction rate of leaf number were observed in cv. Ombong and Burungan. Decrease of leaf number in cv. Burungan did not change from 10-15 days and then declined slightly towards day 20 (Fig. 1). The growth rate of plant height (Fig. 2) in all cultivars increased drastically from 0-10 days of partial-submergence, then it declined gradually from day 15-20 in cv. Cigeulis, Seruni, Ciherang, TB, Inpari 13 and Superwin. The growth rate of plant height in cv. Mekongga and Ombong at day 10 were almost similar to those at day 15 and decreased slightly at day 20. The growth rate of plant height in cv. Burungan and Temo increased slightly from 10-15 days and did not change at day 20. The lowest growth rate of plant height were in cv. Burungan and Temo. On average, the rate of shoot elongation (Fig. 3) increased drastically from day 0-10 in all cultivars, then reduced gradually from day 10-20 in cv. Cigeulis, Seruni, Ciherang, TB, Inpari 13 and Superwin. The rate of shoot elongation in cv. Mekongga dropped 2-fold from day 10 until 20. It was similar at day 10 and 15 in cv. Ombong, Burungan and Temo, then declined slightly until day 20.

Correlation between the morphological characters at 20 days after sub-mergence at the vegetative stage: Root dry mass had significant strong and positive correlation with root volume, shoot dry mass, leaf number and shoot length. The higher root dry mass, the larger root volume, shoot dry mass and leaf number. Strong correlation between root and

Table 1: Morphological characters of 10 north-Sulawesi-cultivated-rice cultivars at 20 days after partial sub-mergence at the vegetative stage

Cultivars	Plant height (cm)	Shoot dry mass (g)	Shoot length (cm)	Root dry mass (g)	Root length (cm)	Root volume (cm^3)	Shoot:root ratio	Leaf number
Cigeulis	84.350±0.966^{abc}	6.594±0.350^{e}	84.925±0.903^{cd}	2.874±0.264^{f}	23.856±0.427^{bc}	2.973±0.115^{ns}	2.465±0.271^{ab}	15.750±0.940^{d}
Seruni	83.188±3.306^{ab}	4.491±0.605^{d}	83.188±3.306^{c}	1.913±0.406^{cde}	23.278±0.429^{bc}	2.768±0.222	2.923±0.442^{abc}	10.125±1.716^{c}
Mekongga	76.538±4.654^{a}	4.300±0.706^{cd}	30.287±1.591^{a}	1.726±0.261^{bcd}	17.178±0.373^{a}	2.698±0.312	2.755±0.404^{abc}	9.250±1.780^{bc}
Ciherang	77.550±2.591^{a}	3.100±0.584^{abc}	30.400±0.939^{a}	0.874±0.215^{a}	23.144±0.825^{bc}	2.416±0.288	5.606±1.221^{d}	9.250±1.770^{bc}
TB	94.712±2.305^{d}	7.401±0.404^{e}	95.925±2.390^{e}	2.618±0.215^{ef}	24.278±0.469^{c}	3.202±0.056	2.915±0.191^{abc}	9.000±0.732^{bc}
Ombong	90.712±2.227^{bcd}	3.677±0.176^{bcd}	89.475±2.730^{d}	0.996±0.188^{ab}	23.478±0.700^{bc}	2.432±0.213	4.553±0.619^{cd}	4.250±0.559^{a}
Inpari 13	89.212±2.147^{bcd}	3.588±0.583^{abcd}	37.112±1.169^{b}	1.047±0.153^{ab}	22.144±0.961^{b}	2.506±0.203	4.172±0.813^{bcd}	5.375±1.426^{ab}
Burungan	91.925±1.515^{cd}	2.298±0.118^{ab}	38.750±0.766^{b}	1.373±0.099^{abc}	23.522±0.337^{bc}	2.848±0.082	1.753±0.156^{a}	6.250±0.726^{abc}
Temo	87.575±2.018^{bcd}	2.220±0.137^{a}	37.025±0.492^{b}	1.509±0.207^{abc}	23.289±0.745^{bc}	3.208±0.110	1.670±0.215^{a}	7.375±0.680^{abc}
Superwin	76.775±2.097^{a}	2.947±0.251^{abc}	31.338±0.609^{a}	2.263±0.279^{def}	23.922±0.617^{bc}	2.772±0.340	1.476±0.196^{a}	17.250±0.881^{d}

Values are mean±SE (n = 8). Means with the same letter in the same column are not significantly different at $p<0.05$ using Duncan multiple range test (DMRT), ns: Non-significant

shoot dry mass indicated that there was a balance of root and shoot. Shoot dry mass also showed positive strong correlation with shoot length and shoot elongation. It implied that shoot dry mass increased when shoot length and shoot elongation increased. On the other hand, there were negative strong correlation between plant height and decrease of leaf number as well as between percentage of alive plants and increase of plant height. The decrease of leaf number was lower when the plant height increased and the percentage of alive plants was larger when the shoot elongation was lower (Table 2).

The level of submergence tolerance based on morphological characters: The level of submergence tolerance in ten rice cultivars cultivated in North Sulawesi under submergence for 20 days based on the morphological characters was categorized based on deviation standard[16]. There were nine morphological characters that were used in categorizing the level of submergence tolerance, i.e., plant height, shoot dry mass, shoot length, root dry mass, root length, root volume, shoot root ratio, leaf number and percentage of alive plants (Table 3). Total level of submergence tolerance based on 9 morphological characters that was observed in each cultivar showed that cv. Cigeulis and TB were tolerant rice, cv. Seruni, Mekongga, Inpari 13, Burungan, Temo and Superwin were semi tolerant rice and cv. Ciherang and Ombong were non tolerant rice cultivars.

DISCUSSION

In this study, the highest plant height, shoot dry mass, shoot length, root dry mass, root length were observed in rice cv. TB under partial-submergence for 20 days at the vegetative stage. The plant growth indicated the plant's ability to survive under partial-submergence condition as reported in chili[2]. Under flood conditions, the functional equilibrium between shoots and roots was preserved by the plants. The entrance of CO_2 and light penetration were postponed and also the photosynthesis process was limited when the shoots were fully submerged. The function of shoot as carbohydrate sources and roots as water and nutrients sources were influenced under this condition. As a result, the root growth was also affected because of the alteration of carbohydrate supply to the root[17,18].

The longer duration of partial-submergence treatment influenced the reduction rate of leaf number, the growth rate of plant height and the rate of shoot elongation. The relationship between treatment duration and the reduction rate of leaf number was shown by linear negative equation as $y = -0.3771x+14.98$ and R-squared value (R^2) = 0.7009. The

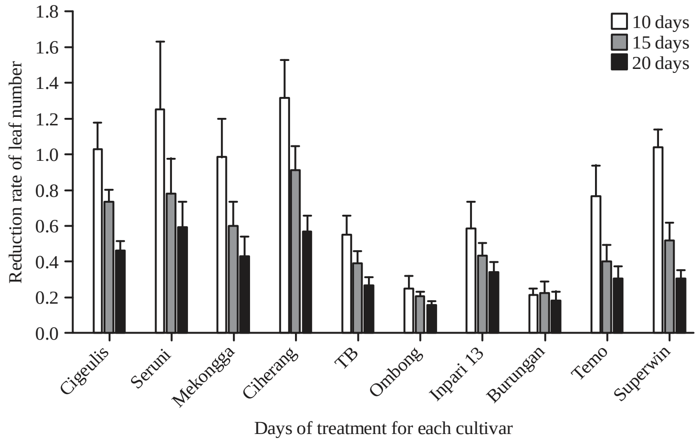

Fig. 1: Reduction rate of leaf number in North-Sulawesi-cultivated-rice cultivars at 0, 10, 15 and 20 days after partial-submergence treatment at the vegetative stage

Values are significantly different among 10 rice cultivars at 0, 10, 15 and 20 days after treatment ($p<0.05$)

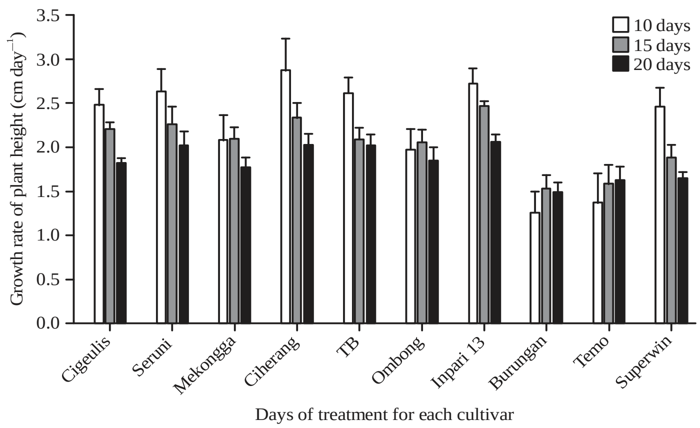

Fig. 2: Growth rate of plant height in North-Sulawesi-cultivated-rice cultivars at 0, 10, 15 and 20 days after partial-submergence treatment at the vegetative stage

Values are significantly different among 10 rice cultivars at 0, 10, 15 and 20 days after treatment ($p<0.05$)

Table 2: Pearson correlation coefficient of morphological characters of North-Sulawesi-cultivated-rice cultivars after 20 days of partial-submergence at the vegetative stage

Parameters	Root length	Root volume	Root dry mass	Shoot dry mass	Leaf number	Plant height	Shoot length	Reduction rate of leaf number	Rate of shoot elongation	Growth rate of plant height
Alive plants (%)	0.225^{ns}	0.619^{ns}	0.398^{ns}	-0.065^{ns}	0.225^{ns}	0.212^{ns}	-0.060^{ns}	-0.316^{ns}	-0.162^{ns}	-0.751*
Root length		0.254^{ns}	0.196^{ns}	0.086^{ns}	0.143^{ns}	0.454^{ns}	0.426^{ns}	-0.214^{ns}	0.389^{ns}	0.021^{ns}
Root volume			0.685*	0.356^{ns}	0.254^{ns}	0.344^{ns}	0.246^{ns}	-0.164^{ns}	0.169^{ns}	-0.337^{ns}
Root dry mass				0.725*	0.719*	-0.012^{ns}	0.458^{ns}	0.115^{ns}	0.436^{ns}	-0.079^{ns}
Shoot dry mass					0.263^{ns}	-0.224^{ns}	0.739*	0.186^{ns}	0.741*	0.481^{ns}
Leaf number						-0.599^{ns}	-0.038^{ns}	0.386^{ns}	0.023^{ns}	-0.140^{ns}
Plant height							0.516^{ns}	-0.641*	0.427^{ns}	0.018^{ns}

*$p<0.05$ significant, ns: Non-significant

longer period of partial-submergence resulted in the growth rate of plant height that was demonstrated by linear positive equation as $y = 1.8903x+49.689$ ($R^2 = 0.9805$). The prolonged period of submergence induced the rate of shoot elongation that was indicated by linear positive equation as $y = 1.3754x+31.056$ ($R^2 = 0.9813$).

The growth rate of plant height in all cultivars elevated drastically from day 0-10 of partial-submergence. Stagnant flooding that were 30 and 50 cm above the media surface resulted in the growth rate of plant height as much as 13 and 17%, respectively[19]. The growth rate of plant height under partial-submergence was induced by the elevated

Table 3: Level of submergence tolerance in 10 north-Sulawesi-cultivated-rice cultivars based on the morphological characters at 20 days after partial-submergence at the vegetative stage

Morphological characters (x±SD)	Cultivars									
	Cigeulis	Seruni	Mekongga	Ciherang	TB	Ombong	Inpari 13	Burungan	Temo	Superwin
Plant height (cm)	84.350	83.188	76.538	77.550	94.713	90.713	89.213	91.925	87.575	76.775
85.254±6.643	(ST)	(ST)	(NT)	(NT)	(T)	(ST)	(ST)	(T)	(ST)	(NT)
Shoot dry mass (g)	6.594	4.491	4.300	3.100	7.401	3.677	3.588	2.298	2.220	2.947
4.061±1.727	(T)	(ST)	(ST)	(NT)	(T)	(ST)	(ST)	(NT)	(NT)	(NT)
Shoot length (cm)	84.925	83.188	30.288	30.400	95.925	89.475	37.113	38.750	37.025	31.338
55.843±8.962	(T)	(T)	(NT)	(NT)	(T)	(T)	(NT)	(NT)	(NT)	(NT)
Root dry mass (g)	2.874	1.913	1.726	0.874	2.618	0.996	1.047	1.373	1.509	2.263
1.719±0.693	(T)	(ST)	(ST)	(NT)	(T)	(NT)	(ST)	(ST)	(ST)	(ST)
Root length (cm)	23.856	23.278	17.178	23.144	24.278	23.478	22.144	23.522	23.289	23.922
22.809±2.059	(ST)	(ST)	(NT)	(ST)	(ST)	(ST)	(ST)	(ST)	(ST)	(ST)
Root volume (cm^3)	2.973	2.768	2.698	2.416	3.202	2.432	2.506	2.848	3.208	2.772
2.782±0.286	(T)	(ST)	(ST)	(NT)	(T)	(NT)	(ST)	(ST)	(T)	(ST)
Shoot: root ratio	2.465	2.923	2.755	5.606	2.915	4.553	4.172	1.753	1.670	1.477
3.029±1.357	(ST)	(ST)	(ST)	(T)	(ST)	(T)	(ST)	(ST)	(NT)	(NT)
Leaf number	15.75	10.125	9.250	9.250	9.000	4.250	5.375	6.250	7.375	17.250
9.388±4.209	(T)	(ST)	(ST)	(ST)	(ST)	(NT)	(ST)	(ST)	(ST)	(T)
Percentage of alive plants	82.353	76.471	76.471	70.588	82.353	68.421	64.706	100.000	82.353	82.353
78.607±9.912	(ST)	(ST)	(ST)	(ST)	(ST)	(NT)	(NT)	(T)	(ST)	(ST)
Total level	5 T	1 T	0 T	1 T	5 T	2 T	0 T	2 T	2 T	1 T
	4 ST	8 ST	6 ST	3 ST	4 ST	3 ST	7 ST	5 ST	4 ST	4 ST
	0 NT	0 NT	3 NT	5 NT	0 NT	4 NT	2 NT	2 NT	3 NT	4 NT
Category of level	Tolerant	Semi tolerant	Semi tolerant	Non tolerant	Tolerant	Non tolerant	Semi tolerant	Semi tolerant	Semi tolerant	Semi tolerant

xi: Mean in certain cultivar, x: Mean in all cultivars, SD: Standard deviation. Tolerant (T): xi>x+SD, Semi tolerant (ST): x-SD≤xi≤x+SD, Non tolerant (NT): xi<x-SD

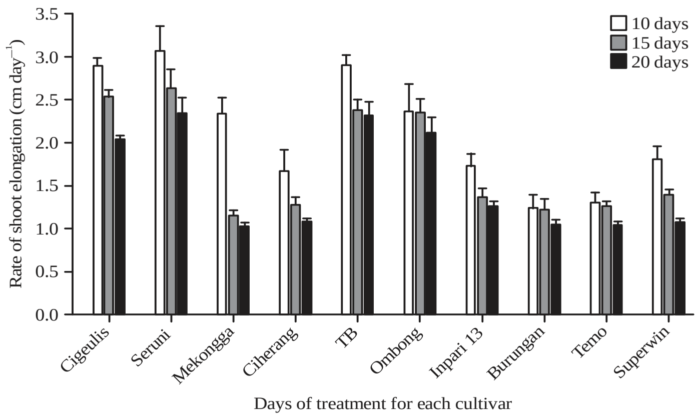

Fig. 3: Rate of shoot elongation in North-Sulawesi-cultivated-rice cultivars at 0, 10, 15 and 20 days after partial-submergence treatment at the vegetative stage
Values are significantly different among 10 rice cultivars at 0, 10, 15 and 20 days after treatment ($p<0.05$)

concentration of ethylene and gibberellin[20]. The fact that the growth rate of plant height did not change at day 20 and the rate of shoot elongation were the lowest in cv. Burungan and Temo showed that these cultivars develop conserve strategy, so that the plant growth were inhibited during submergence[3,21]. Energy and carbohydrates were required for cell divisions and the synthesis of new cell-wall material during shoot elongation underwater. Rapid underwater elongation elevates the fitness mainly under prolonged, but relatively shallow floods. The non-elongating strategy is more appropriate for short-lasting and/or deep-flooding events that cannot be outgrown[22,23].

The coleoptile, leaf and stem of rice elongated faster as the plant responded to submergence. Stem elongation as response to submergence, however, should be controlled, so that the plants were able to stand erectly when the submergence was ended. Shoot elongation was a process to reduce the prolonged impact of submergence as the shoots were able to reach the water surface, make contact with the air more rapidly and obtain O_2 immediately[3,21,24].

Shoot elongation under submergence was resulted from hormonal changes that were regulated by ethylene, gibberellin acid (GA) and abscisic acid (ABA). The ethylene concentration as well as GA concentration increased, whereas ABA concentration decreased drastically. Water uptake was also required for cell elongation in rice shoot and this elongation was associated with cell-wall loosening, cell-wall extensibility, cell-wall acidification and synthesis of cell-wall polysaccharides[22,23,25].

The submergence-tolerant cultivars had good root system, good ability to grow and good productivity. On the other hand, non-tolerant cultivars had problems in the physiological processes under submergence and this condition negatively affected their growth both in the vegetative and generative phases. The submergence tolerance indicated plant ability to grow and produce sub optimally. The soil water content under submergence was 20% higher than field capacity condition. The plants were still alive and able to grow under submergence by physiological, anatomical and morphological adaptation[2,17,26]. Rice cv. TB as tolerant cultivar showed better growth response under partial submergence rather than other rice cultivars at the vegetative phase. The growth response of these ten rice cultivars under submergence should be further evaluated at the generative phase in the greenhouse as well as in rice field.

CONCLUSION

Total level of submergence tolerance based on 9 morphological characters that were observed in each cultivar showed that cv. Cigeulis and TB were tolerant rice, cv. Seruni, Mekongga, Inpari 13, Burungan, Temo and Superwin were semi tolerant rice and cv. Ciherang and Ombong were non tolerant rice cultivars. Rice cv. TB as tolerant cultivar showed better growth response under submergence rather than other rice cultivars at the vegetative phase.

SIGNIFICANT STATEMENT

The results of this study showed that rice cv. TB as North Sulawesi local rice varieties was potential to be used as a source of germplasm for staple food. This study also provided information of simple selection method for obtaining submergence-tolerant-rice cultivars that were required to meet the food demand. This finding will be able to be applied in the adaptation strategy by using high yielding varieties under submergence and the impact of flooding disaster on the loss of rice production can be minimized.

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