Screening of Indonesian rice (*Oryza sativa* L.) genotypes against salinity stress using NaCl under hydroponic condition

M Farid BDR, Y Musa, Nasaruddin, I Ridwan, and A Yassi

Department of Agronomy, Faculty of Agriculture, Hasanuddin University, Jl. Perintis Kemerdekaan KM 10 Makassar 90245, Indonesia.

E-mail: farid_deni@yahoo.co.id

Abstract. The development of rice in saline soils was constrained by the limited number of genotypes suitable to be developed in the area and also the lack of germplasm as a gene donor for saline soil tolerant properties. The study aims to select rice genotypes that are tolerant of salinity stress at the level of germination and hydroponic production. The research on the level of germination carried out at the University of Hasanuddin Tissue Culture Laboratory and the level of production carried out at the Screen House in Tamalanrea District, Makassar. Trials were set using a split plot design with NaCl concentration set as the main plot and rice genotypes as the subplots. Four NaCl were used in the germination trial 0, 3, 6, and 9 g L⁻¹, while NaCl concentration used in the production trial were 0 g L⁻¹ and 6 g L⁻¹. A total of 25 rice genotypes was tested. The results show that genotypes that were tolerant to salinity stress at the germination test with the concentration of 6 g L⁻¹ NaCl were Inpari 43, Limboto, Inpago 10, IR 58443-6B-10-3, Inpari 35, Inpari 4, MSP 8 and Cigeulis. Whereas the rice genotype with the potential to be tolerant to salinity stress, indicated with production of > 15 g per plant at the 6 g L⁻¹ NaCl concentration, were Inpari 35 (21.53 g per plant), Inpari 43 (20.24 g per plant), Pokali (19.39 g per plant), and IR 58443-6B-10-3 (18.87 g per plant).

1. Introduction

In Indonesia, there are around 39.4 million hectares classified as saline land and in South Sulawesi there are approximately one million hectares of land that cannot be planted due to salinity problems especially in coastal areas such as in Jeneponto, Pangkep, Bantaeng, Selayar, and Barru Regencies. Salinity gets more attention in agriculture, because it can cause toxicity conditions when absorbed in plant tissues [1]. The development of rice in saline soils was constrained by the limited number of genotypes suitable to be developed in the area and also the lack of germplasm as a gene donor for saline soil tolerant properties. To overcome salt stress problems, Slavich et al. [2] recommend the use of rice genotypes that are tolerant to salt stress. Therefore, the use of tolerant varieties in high salinity conditions is expected to create a more conducive growing condition in marginal land to increase rice production. The first step in obtaining saline-tolerant rice varieties is to test the tolerance of several Indonesian varieties to assess the level of tolerance based on the concentration of NaCl used. Based on these tests, varieties which have the best tolerance can be determined.

Rice plants are one of the agricultural crops that can grow in stagnant water conditions but are not tolerant to salt stress [3]. High levels of salt in the soil cause retard growth. NaCl is one of the dissolved salts in the soil which is also an essential element for plant growth, but the presence of excess salt solution in the soil can affect growth patterns in plants. Symptoms of salt stress in rice
plants can cause abnormal growth, such as dried leaves at the tip and yellow symptoms in the leaves (chlorosis) [4]. Salinity stress is a soil with a salt content that can affect soil properties and subsequently affect plant growth. The amount of Na\(^+\) in the soil causes a decrease in the availability of elements of Ca\(^{2+}\), Mg\(^{2+}\), and K\(^{+}\) which can be absorbed by plants. High salt levels can reduce P uptake even if there is no deficiency. The salt content as a value of soil salinity will reduce crop production, including rice. The initial symptoms of plant damage due to salinity stress are the size of the leaves becomes smaller and the distance between the stem and leaf stems becomes shorter. If the problem becomes more severe, the leaves will turn yellow (chlorosis) and the edges of the dead leaves dry out like burning and brownish in color [5].

Previous studies have been conducted on salt stress and methods to make plants more tolerant of salt stress. Suwarno's study [6] states that the results of the physiology study of rice showed that nutrient solutions with 4,000 ppm NaCl were appropriate enough for testing salinity tolerance. Sadjad [7] suggested that the testing of seed vigor in the germination phase is a fast and efficient selection method in determining the tolerance level of a genotype. Plants have the ability to respond to environmental factors as well as groups of other organisms. This response arises due to environmental stress that can affect its growth. Environmental stress is an inhibiting factor for plant growth. According to Gedoan [8], among environmental stress, salinity is one of the most common stresses.

Plants that live on saline land face two main problems, namely in terms of obtaining more negative ground water potential and in overcoming high concentrations of sodium (Na\(^{+}\)) and chloride (Cl\(^{-}\)) which are likely to be toxic. More negative groundwater potential will spur water comes out of the tissue so the plant loses turgor pressure. The abundance of Na\(^{+}\) and Cl\(^{-}\) can result in ion imbalances so that metabolic activity in the plant's body becomes disrupted. Hazardous conditions that can even cause death will spur plants to adapt in order to increase tolerance. Adaptation can be shown by the formation of certain molecules in cells, such as proline and various other free amino acids, which play a role in increasing tolerance to salt stress. These responses vary depending on plant species, degree and duration of stress [9].

The use of local varieties in breeding programs has often been recommended, this aims to expand the genetic background of the superior varieties of plants that will be produced [10]. The use of genes tolerant to various stresses owned by local varieties in plant breeding can improve the superiority of the varieties that will be produced. Nafisah et al. [11] used local rice as a crossbred parent to obtain the tolerant nature of bacterial leaf blight. From these activities, strains that have been tolerated against bacterial leaf blight have been produced that are multi-genic. Abdullah [12] used wild rice and local rice as elders to obtain new type of rice and expected lines that had better morphological and physiological properties, such as less empty grain and were more tolerant of major pests and diseases. Since the release of superior varieties of IR5 and IR8 in 1967, local varieties have gradually become increasingly urgent, especially since the 1970s and 2000s. The suggestion of planting national superior varieties has intensified, replacing the position of local varieties. In the 2000s, the amount of local rice on farmers' land has greatly decreased [13].

To obtain superior varieties, it is necessary to determine the genetic parameters such as genetic diversity, heritability, and estimation of genetic progress to be achieved. In accordance with the opinion of Viana & Piepho [14] who state that genetic parameters used in plant breeding processes include predictive values of heritability, genetic variability, and genetic progress, which are important as indicators of the population's genetic value of selection. The value of heritability is a quantitative statement of the role of genetic factors in providing a final performance or phenotype of a character [15].

2. Methodology
The study consisted of two stages namely the germination stage and the stage of plant growth and production. The germination test was conducted at the Tissue Culture Laboratory of University of Hasanuddin. While the production stage was conducted at the Screen House in Tamalanrea District,
Makassar at an altitude of ± 12 meters above sea level (m asl), an average night temperature of 28 °C and an average day temperature of 32 °C. The study was conducted from August to December 2017.

2.1. Testing at germination levels
The stage started with the selection of 25 paddy rice genotypes using a test on paper method. A total of 35 seeds per genotype were placed in a jar on filter paper. This test method was carried out to determine the germination power, seed vigor and growth rate of seeds and to obtain NaCl concentration which gave a high level of genetic diversity in each genotype tested.

The study used a split plot design with three replications. The main plot was the concentration of NaCl consisted of four levels, namely: 0 g L⁻¹ (k0), 3 g L⁻¹ (k1), 6 g L⁻¹ (k2), and 9 g L⁻¹ (k3). While the subplots were 25 rice genotypes, namely: g1 (Cimalayang Muncul), g2 (Inpari 4), g3 (Situ Bagendit), g4 (Ciliwung) g5 (Inpari 19), g6 (Inpari 10), g7 (Inpari 43), g8 (Limboto), g9 (Inpago 6), g10 (Inpago 10), g11 (Inpari 35), g12 (Cigeulis), g13 (Inpari 32), g14 (Inpari 33), g15 (IR 58443-6B-10-3), g16 (Inpari 39), g17 (Ciherang), g18 (Mekongga), g19 (IR 29), g20 (Pokali), g21 (MSP 8), g22 (MSP 9), g23 (MSP 13), g24 (MSP 14) and g25 (MOD 1 F 1).

2.2. Testing at the level of growth and production
The testing at the stage of growth and production was carried out hydroponically using the Deep Flow Technique (DFT) system. A glass container were used as the pot containing compost and rice husk charcoal media in a ratio of 3:1. The test used two installations for treatment of NaCl concentrations, which are 0 g L⁻¹ (k0) and 6 g L⁻¹ (k2), the two concentrations are concentrations which indicate a high level of genetic diversity in the germination testing phase.

2.3. Data analysis
Data obtained from observations were analyzed using two way Analysis of Variance (ANOVA) for split plot design. If there is significant effect of the treatments, then a further analysis is carried out with the Least Significant Difference (LSD) Test at the level of 5%.

2.4. Analysis of heritability
The estimated value of heritability and its criteria are calculated using equations:

\[ h^2 (bs) = \frac{\sigma^2_G}{\sigma^2_P} \times 100\% \]

where:

\[ \sigma^2_G : \text{MSerror subplot–MSerror interaction} \]

\[ \sigma^2_P : \text{number of blocks x number of Main Plot} \]

\[ \sigma^2_E : \text{MS error} \]

Category of heritability values: \( h^2 (bs) > 0.5 \): high; \( 0.2 < h^2 (bs) < 0.5 \): moderate; \( h^2 (bs) < 0.2 \): low.

2.5. Stress tolerant index (STI)
Stress tolerant index was calculated to determine the genotype tolerance to salinity stress using equation:

\[ \text{STI} = \frac{(Y_{pi} \times Y_{si})}{Y_{p}^2} \]

where:

\[ Y_{pi} = \text{Average of a genotype untreated with salinity stress.} \]

\[ Y_{si} = \text{Average of a genotype treated with salinity stress.} \]

\[ Y_{p}^2 = \text{Average of all genotypes untreated with salinity stress.} \]
Genotype with STI value of ≤ 0.5 is categorized as sensitive, value of 0.5 < STI < 1.0 categorized as medium tolerant, and STI value of > 1.0 as tolerant.

3. Results

3.1. Rice Germination and Morpho-physiological character of rice seedlings under saline condition

3.1.1. Germination percentage. Salinity significantly decreased capability of the rice seeds to germinate (Table 1). Decrease in percentage of germination of 25 Indonesian rice genotypes varied with genotypes accounted ranged between 20% and 80% at NaCl concentration of 9 g L\(^{-1}\) compared to control. Genotypes with the lowest seeds germination percentage was genotype MOD I F 1 and MSP 9 even at the small increase in salinity with addition of 3 and 6 g L\(^{-1}\) NaCl in the germination media. One genotype maintained its seeds germination percentage at level of 82.22% namely variety Limboto.

Table 1. Mean of germination percentage (%) of Indonesian rice genotypes on difference concentration of NaCl in the growth media.

| Genotypes                  | Concentration of NaCl | LSD\(_{genotype 0.05}\) |
|---------------------------|-----------------------|-------------------------|
|                           | 0 g L\(^{-1}\)       | 3 g L\(^{-1}\)        | 6 g L\(^{-1}\)        | 9 g L\(^{-1}\)        |
| g1 (Cimalayang Muncul)    | 93.33\(_{p}^{a}\)    | 77.78\(_{q}^{bc}\)   | 80.00\(_{q}^{a}\)    | 71.11\(_{r}^{cde}\)   |
| g2 (Inpari 4)             | 91.11\(_{p}^{ab}\)   | 77.78\(_{q}^{bc}\)   | 80.00\(_{q}^{a}\)    | 71.11\(_{r}^{cde}\)   |
| g3 (Situ Bagendit)        | 91.11\(_{p}^{ab}\)   | 77.78\(_{q}^{bc}\)   | 77.8\(_{r}^{a}\)     | 66.67\(_{q}^{def}\)   |
| g4 (Ciliwung)             | 95.56\(_{p}^{a}\)    | 84.44\(_{q}^{a}\)    | 84.44\(_{q}^{a}\)    | 80.00\(_{p}^{ab}\)    |
| g5 (Inpari 19)            | 95.56\(_{p}^{a}\)    | 84.44\(_{q}^{a}\)    | 80.00\(_{q}^{a}\)    | 73.33\(_{r}^{bde}\)   |
| g6 (Inpari 10)            | 95.56\(_{p}^{a}\)    | 84.44\(_{q}^{a}\)    | 80.00\(_{q}^{a}\)    | 73.33\(_{r}^{bde}\)   |
| g7 (Inpari 43)            | 95.56\(_{p}^{a}\)    | 82.22\(_{q}^{ab}\)   | 80.00\(_{q}^{a}\)    | 77.78\(_{q}^{abc}\)   |
| g8 (Limboto)              | 95.56\(_{p}^{a}\)    | 86.67\(_{q}^{a}\)    | 84.44\(_{q}^{a}\)    | 82.22\(_{q}^{a}\)    |
| g9 (Inpago 6)             | 84.44\(_{p}^{b}\)    | 71.11\(_{q}^{c}\)    | 60.00\(_{r}^{e}\)    | 46.67\(_{s}^{j}\)    |
| g10 (Inpago 10)           | 84.44\(_{p}^{b}\)    | 71.11\(_{q}^{c}\)    | 53.33\(_{r}^{e}\)    | 42.22\(_{q}^{kh}\)   |
| g11 (Inpari 35)           | 95.56\(_{p}^{a}\)    | 84.44\(_{q}^{a}\)    | 77.78\(_{q}^{ab}\)   | 77.78\(_{q}^{abc}\)   |
| g12 (Cigeulis)            | 88.89\(_{p}^{ab}\)   | 77.78\(_{q}^{bc}\)   | 73.33\(_{r}^{b}\)    | 64.44\(_{q}^{efg}\)   |
| g13 (Inpari 32)           | 88.89\(_{p}^{ab}\)   | 77.78\(_{q}^{bc}\)   | 71.11\(_{r}^{bc}\)   | 62.22\(_{q}^{f}\)     |
| g14 (Inpari 33)           | 84.44\(_{p}^{b}\)    | 73.33\(_{q}^{c}\)    | 71.11\(_{r}^{bc}\)   | 60.22\(_{q}^{f}\)     |
| g15 (IR 58443-6B-10-3)    | 95.56\(_{p}^{a}\)    | 84.44\(_{q}^{a}\)    | 84.44\(_{q}^{a}\)    | 77.78\(_{q}^{abc}\)   |
| g16 (Inpari 39)           | 84.44\(_{p}^{b}\)    | 73.33\(_{q}^{c}\)    | 57.78\(_{r}^{de}\)    | 57.78\(_{q}^{df}\)    |
| g17 (Cihering)            | 84.44\(_{p}^{b}\)    | 73.33\(_{q}^{c}\)    | 64.44\(_{r}^{cd}\)    | 51.11\(_{q}^{ij}\)    |
| g18 (Mekongga)            | 95.56\(_{p}^{a}\)    | 75.56\(_{q}^{bc}\)   | 80.00\(_{r}^{a}\)    | 75.56\(_{q}^{abc}\)   |
| g19 (IR 29)               | 95.56\(_{p}^{a}\)    | 84.44\(_{q}^{a}\)    | 84.44\(_{q}^{a}\)    | 80.00\(_{p}^{ab}\)    |
| g20 (Pokali)              | 95.56\(_{p}^{a}\)    | 84.44\(_{q}^{a}\)    | 84.44\(_{q}^{a}\)    | 80.00\(_{q}^{a}\)    |
| g21 (MSP 8)               | 95.56\(_{p}^{a}\)    | 75.56\(_{q}^{bc}\)   | 84.44\(_{q}^{a}\)    | 75.56\(_{q}^{abc}\)   |
| g22 (MSP 9)               | 84.44\(_{p}^{b}\)    | 64.44\(_{q}^{d}\)    | 42.22\(_{q}^{f}\)    | 37.78\(_{q}^{i}\)    |
| g23 (MSP 13)              | 95.56\(_{p}^{a}\)    | 84.44\(_{q}^{a}\)    | 84.44\(_{q}^{a}\)    | 77.78\(_{q}^{abc}\)   |
| g24 (MSP 14)              | 95.56\(_{p}^{a}\)    | 77.78\(_{q}^{c}\)    | 80.00\(_{p}^{a}\)    | 71.11\(_{q}^{cde}\)   |
| g25 (MOD I F 1)           | 84.44\(_{p}^{b}\)    | 60.00\(_{q}^{d}\)    | 24.44\(_{q}^{g}\)    | 22.22\(_{r}^{m}\)    |
3.1.2. Vigor index. Vigor index of the rice seeds decreased with increased in salinity levels in the germination media (table 2). However, the genotypes showed varied response to the stress level with the best vigor index at saline condition was shown by genotypes Inpari 43 and Ciherang, with the value of 14.44 and 14.25, respectively. There were no significantly different to genotype of Inpari 35 at Control treatment.

**Table 2.** Mean of vigor index of Indonesian rice genotypes on difference concentration of NaCl in the growth media.

| Genotypes       | Concentration of NaCl | LSD_{genotype} |
|-----------------|-----------------------|----------------|
|                 | 0 g L^{-1} | 3 g L^{-1} | 6 g L^{-1} | 9 g L^{-1} | 0.05 |
| g1 (Cimalayang Muncul) | 12.19^{ef}_{p} | 10.42^{ijk}_{q} | 8.04^{ij}_{p} | 7.77^{ef}_{p} |
| g2 (Inpari 4)    | 8.36^{a}_{p} | 8.08^{a}_{p} | 6.28^{kl}_{q} | 5.66^{a}_{q} |
| g3 (Situ Bagendit) | 10.08^{b}_{p} | 8.82^{bm}_{q} | 6.69^{e}_{p} | 4.87^{gh}_{s} |
| g4 (Ciliwung)    | 14.26^{bc}_{p} | 13.50^{abc}_{q} | 4.83^{m}_{p} | 3.74^{i}_{q} |
| g5 (Inpari 19)   | 13.19^{cde}_{p} | 9.48^{bklm}_{q} | 4.84^{pm}_{p} | 2.61^{jk}_{s} |
| g6 (Inpari 10)   | 12.03^{f}_{p} | 9.69^{blm}_{q} | 8.27^{u}_{r} | 2.98^{f}_{s} |
| g7 (Inpari 43)   | 14.87^{ab}_{p} | 13.33^{abcd}_{q} | **12.62^{a}_{q}** | **10.61^{a}_{r}** |
| g8 (Limboto)     | 12.17^{ef}_{p} | 11.61^{efgh}_{p} | 9.52^{fgh}_{q} | 7.66^{ef}_{p} |
| g9 (Inpago 6)    | 13.67^{cd}_{p} | 9.75^{bklm}_{q} | 8.44^{hij}_{q} | 7.65^{ef}_{p} |
| g10 (Inpago 10)  | 11.72^{fg}_{p} | 11.25^{fghi}_{p} | 8.01^{ij}_{q} | 5.30^{g}_{r} |
| g11 (Inpari 35)  | **15.00^{a}_{p}** | **14.44^{a}_{q}** | 11.08^{cde}_{p} | 8.35^{cde}_{q} |
| g12 (Cigeulis)   | 13.67^{cd}_{p} | 12.72^{bcde}_{q} | 10.14^{defg}_{q} | 7.43^{f}_{r} |
| g13 (Inpari 32)  | 11.65^{fg}_{p} | 12.17^{def}_{p} | 9.40^{gh}_{p} | 8.94^{bcda}_{r} |
| g14 (Inpari 33)  | 12.64^{def}_{p} | 11.70^{efg}_{q} | **11.14^{cd}_{d}** | 9.26^{bc}_{c} |
| g15 (IR 58443-6B-10-3) | 11.54^{fg}_{p} | 8.19^{q}_{p} | 6.56^{kl}_{p} | 5.77^{gh}_{r} |
| g16 (Inpari 39)  | 10.30^{h}_{p} | **10.06^{jk}_{p}** | 6.32^{g}_{p} | 5.63^{ar}_{p} |
| g17 (Cigerang)   | 14.83^{ab}_{p} | 14.25^{a}_{p} | 12.40^{ab}_{p} | 8.69^{cde}_{r} |
| g18 (Mekongga)   | 10.86^{gh}_{p} | 10.19^{ijk}_{p} | 10.58^{cdef}_{p} | 6.03^{cde}_{q} |
| g19 (IR 29)     | 13.29^{cd}_{p} | 11.05^{ghij}_{p} | 11.47^{abc}_{p} | 8.28^{cde}_{q} |
| g20 (Pokali)    | 13.83^{bc}_{p} | 12.39^{cd}_{p} | 5.52^{bmn}_{q} | 5.94^{hi}_{i} |
| g21 (MSP 8)     | 13.83^{bc}_{q} | 12.32^{def}_{q} | 2.47^{f}_{r} | 1.81^{k}_{r} |
| g22 (MSP 9)     | 12.50^{ef}_{q} | 10.49^{hijk}_{q} | 10.08^{defg}_{q} | 8.71^{bcde}_{r} |
| g23 (MSP 13)    | 10.03^{gh}_{p} | 9.03^{bmn}_{q} | 9.26^{ghi}_{q} | 7.46^{f}_{r} |
| g24 (MSP 14)    | 13.19^{cde}_{p} | 10.00^{def}_{p} | 10.00^{efg}_{q} | 9.83^{ab}_{q} |
| g25 (MOD I F 1) | 12.17^{ef}_{p} | 11.08^{ghij}_{p} | 10.36^{cdefg}_{p} | 8.11^{def}_{q} |

LSD_{0.05} = 8.91

Numbers followed by the same letters in subplot columns (a,b,c,d,e,f,g,h,i,j,k,l,m) and main plot columns (p, q, r, s) are not significantly different LSD α = 0.05.
3.1.3. Plumula length. Saline condition retarded the growth of the rice plumula in the later stage of germination. Table 3 shows that salinity stress induced by the presence of NaCl in the growth media decreased the length of plumula. This was more evident when the NaCl concentration increased to 6 g L$^{-1}$ and 9 g L$^{-1}$. The decline generally was almost 50% in the 6 g L$^{-1}$ NaCl treatments compared to control. When saline level in the growth media getting worse, retardation of the plumule growth even reached 75%. Although the responses varied between genotypes, the genotypes that was able to maintain plumule growth in the NaCl concentration of 6 g L$^{-1}$ and 9 g L$^{-1}$ were MSP 9 and Inpari 35, respectively.

Table 3. Mean of plumula length (cm) of Indonesian rice genotypes on difference concentration of NaCl in the growth media.

| Genotypes               | Concentration of NaCl | LSD$^{0.05}$ |
|-------------------------|-----------------------|--------------|
|                         | 0 g L$^{-1}$ | 3 g L$^{-1}$ | 6 g L$^{-1}$ | 9 g L$^{-1}$ |
| g1 (Cimalayang Muncul)  | 5.400$^{jk}$ | 4.967$^{fgh}$ | 3.507$^{defgh}$ | 1.907$^{abc}$ |
| g2 (Inpari 4)           | 4.953$^k$   | 4.373$^{ghi}$ | 3.587$^{defg}$ | 0.520$^{fg}$  |
| g3 (Situ Bagendit)      | 6.533$^{fghi}$ | 3.767$^{i}$  | 2.647$^{j}$  | 0.547$^{fg}$  |
| g4 (Ciliwung)           | 5.447$^{jk}$ | 3.867$^{i}$  | 2.400$^{j}$  | 0.340$^{g}$   |
| g5 (Inpari 19)          | 5.973$^{hij}$ | 5.593$^{def}$ | 4.980$^{bc}$ | 0.738$^{efg}$ |
| g6 (Inpari 10)          | 8.607$^a$   | 7.307$^{ab}$ | 4.820$^{bc}$ | 1.197$^{cdefg}$ |
| g7 (Inpari 43)          | 8.607$^a$   | 6.627$^{bc}$ | 5.273$^{ab}$ | 2.120$^{ab}$  |
| g8 (Limboto)            | 7.687$^{abc}$ | 6.947$^{abc}$ | 5.580$^{ab}$ | 1.667$^{abcd}$ |
| g9 (Inpago 6)           | 7.680$^{bcd}$ | 6.293$^{cde}$ | 3.673$^{defg}$ | 1.180$^{cdefg}$ |
| g10 (Inpago 10)         | 6.153$^{ghiij}$ | 5.273$^{f}$  | 4.800$^{bc}$ | 0.540$^{fg}$  |
| g11 (Inpari 35)         | 8.760$^g$   | 6.453$^{bcd}$ | 5.413$^{ab}$ | 2.367$^g$    |
| g12 (Cigeulis)          | 6.670$^{ghi}$ | 4.780$^{fgh}$ | 3.827$^{de}$ | 0.853$^{fg}$  |
| g13 (Inpari 32)         | 5.600$^{jk}$ | 3.860$^{i}$  | 2.800$^{ghi}$ | 1.600$^{abcd}$ |
| g14 (Inpari 33)         | 7.333$^{p}$  | 5.593$^{def}$ | 3.800$^{de}$ | 0.500$^{fg}$  |
| g15 (IR 58443-6B-10-3)  | 7.040$^{p}$  | 5.347$^{f}$  | 4.387$^{cd}$ | 1.193$^{cdefg}$ |
| g16 (Inpari 39)         | 6.680$^{efgh}$ | 5.100$^{fgh}$ | 2.913$^{efgh}$ | 1.140$^{cdefg}$ |
| g17 (Ciheraang)         | 6.553$^{fghi}$ | 5.367$^{f}$  | 3.573$^{defg}$ | 1.127$^{cdefg}$ |
| g18 (Mekongga)          | 5.607$^{jk}$ | 4.900$^{f}$  | 3.087$^{efghi}$ | 0.447$^{g}$   |
| g19 (IR 29)             | 5.787$^{jkl}$ | 5.067$^{p}$  | 3.693$^{q}$  | 0.373$^{g}$   |
| g20 (Pokali)            | 6.940$^{defg}$ | 4.120$^{hi}$ | 2.980$^{efghi}$ | 0.487$^{fg}$  |
| g21(MSP 8)              | 8.327$^{ab}$ | 7.647$^{p}$  | 1.916$^{j}$  | 1.360$^{bcdef}$ |
| g22 (MSP 9)             | 7.660$^{bcd}$ | 6.693$^{bc}$ | 5.800$^{q}$  | 0.960$^{defg}$ |
| g23 (MSP 13)            | 6.600$^{fghi}$ | 7.060$^{abc}$ | 3.507$^{defgh}$ | 0.560$^{fg}$  |
| g24 (MSP 14)            | 7.553$^{bcd}$ | 5.453$^{ef}$ | 5.407$^{ab}$ | 0.413$^{g}$   |
| g25 (MOD IF 1)          | 6.160$^{ghij}$ | 3.620$^{i}$  | 3.277$^{efgh}$ | 1.567$^{abde}$ |

LSD$_{0.05}$ = 0.890

Numbers followed by the same letters in subplot columns (a,b,c,d,e,f,g,h,i,k,l) and main plot columns (p, q, r, s) are not significantly different LSD $\alpha = 0.05$.

3.1.4. Radicle length. The growth of radicle of Indonesian rice genotypes on different saline level in the germination growth media is shown in table 4. Compared to plumule growth, salinity effect on the
Redicle growth was not clear to some extent in the recent study. Increasing the concentration of NaCl in the growth media up to 6 g L\(^{-1}\) seems to increase the radicle length. However, this did not apply when NaCl concentration was increased to 9 g L\(^{-1}\). The salinity level at this point retarded the radicle growth 25 to 80% with response varied between genotypes. Inpari 35 showed longest radicle compared to other genotypes at this condition.

Table 4. Mean of radicle length (mm) of Indonesian rice genotypes on different concentration of NaCl in the growth media.

| Genotypes              | Concentration of NaCl | LSD\(_{\text{genotype}}\) 0.05 |
|------------------------|------------------------|-----------------------------|
|                        | 0 g L\(^{-1}\)         | 3 g L\(^{-1}\)              | 6 g L\(^{-1}\)              | 9 g L\(^{-1}\)              |
| g1 (Cimalayang Muncul) | 5.69 \(^{d\text{efgh}}\) | 7.28 \(^{d\text{edef}}\)   | 7.87 \(^{d\text{ef}}\)     | 4.14 \(^{b}\)              |
| g2 (Inpari 4)          | 4.55 \(^{g\text{hi}}\)  | 4.91 \(^{g\text{hi}}\)     | 6.19 \(^{g\text{hi}jk}\)  | 2.24 \(^{d\text{efgh}}\)  |
| g3 (Situ Bagendit)     | 3.99 \(^{p\text{jkmp}}\) | 4.50 \(^{p\text{hij}}\)   | 4.57 \(^{p\text{i}}\)    | 2.14 \(^{d\text{efgh}}\)  |
| g4 (Ciliwung)          | 2.79 \(^{p\text{m}}\)  | 4.22 \(^{ij\text{f}}\)    | 6.53 \(^{p\text{ghi}j}\)  | 1.55 \(^{r\text{fg}}\)   |
| g5 (Inpari 19)         | 3.66 \(^{p\text{jkmp}}\) | 4.89 \(^{p\text{ghi}}\)   | 5.49 \(^{p\text{ijkl}}\)  | 1.06 \(^{r\text{g}}\)    |
| g6 (Inpari 10)         | 4.15 \(^{p\text{jkil}}\) | 4.94 \(^{p\text{ghi}}\)   | 5.07 \(^{p\text{kl}}\)    | 0.96 \(^{b}\)             |
| g7 (Inpari 43)         | 7.69 \(^{p\text{b}}\)  | 7.76 \(^{p\text{bc}}\)    | 9.51 \(^{p\text{a}}\)     | 3.88 \(^{b}\)             |
| g8 (Limboto)           | 8.53 \(^{p\text{a}}\)  | 8.91 \(^{p\text{a}}\)     | 9.09 \(^{p\text{d}bc}\)   | 1.80 \(^{e\text{fg}}\)   |
| g9 (Inpago 6)          | 3.64 \(^{p\text{jkmp}}\) | 5.63 \(^{p\text{gh}}\)    | 7.06 \(^{p\text{efgh}}\)  | 2.62 \(^{r\text{cdef}}\)  |
| g10 (Inpago 10)        | 6.72 \(^{p\text{bcd}}\) | 7.32 \(^{p\text{bcd}}\)   | 8.24 \(^{p\text{bcd}de}\) | 1.94 \(^{r\text{defgh}}\) |
| g11 (Inpari 35)        | 7.31 \(^{p\text{bc}}\)  | 8.44 \(^{p\text{abi}}\)   | 9.22 \(^{p\text{abc}}\)   | 4.45 \(^{p}\)             |
| g12 (Cigeulis)         | 4.13 \(^{p\text{jkmp}}\) | 4.90 \(^{p\text{hi}}\)    | 5.30 \(^{p\text{kl}}\)    | 3.05 \(^{r\text{cde}}\)   |
| g13 (Inpari 32)        | 5.12 \(^{p\text{efghi}}\) | 5.92 \(^{p\text{efg}}\)   | 6.50 \(^{p\text{ghi}j}\)  | 2.35 \(^{r\text{defg}}\)  |
| g14 (Inpari 33)        | 5.57 \(^{p\text{dfgh}}\) | 6.18 \(^{p\text{pq}}\)    | 7.25 \(^{p\text{defg}}\)  | 3.11 \(^{r\text{bcdde}}\) |
| g15 (IR 58443-6B-10-3) | 8.53 \(^{p\text{a}}\)  | 8.91 \(^{p\text{a}}\)     | 9.09 \(^{p\text{bcd}}\)   | 3.24 \(^{r\text{abcde}}\) |
| g16 (Inpari 39)        | 3.02 \(^{p\text{mn}}\)  | 5.35 \(^{p\text{ghi}}\)   | 8.91 \(^{p\text{bc}}\)    | 1.93 \(^{r\text{efgh}}\)  |
| g17 (Ciherring)        | 4.35 \(^{p\text{hijkl}}\) | 6.40 \(^{p\text{cd}}\)    | 8.07 \(^{p\text{bcd}de}\) | 1.47 \(^{r\text{fg}}\)    |
| g18 (Mekongga)         | 4.95 \(^{p\text{ghi}}\)  | 5.77 \(^{p\text{gh}}\)    | 7.25 \(^{p\text{defg}}\)  | 1.63 \(^{r\text{fg}}\)    |
| g19 (IR 29)            | 4.41 \(^{p\text{ghij}}\) | 5.16 \(^{p\text{ghi}}\)   | 9.13 \(^{p\text{abc}}\)   | 2.81 \(^{r\text{bcdef}}\) |
| g20 (Pokali)           | 5.75 \(^{p\text{df}}\)  | 8.23 \(^{p\text{g}}\)     | 9.33 \(^{p\text{b}}\)     | 3.98 \(^{r\text{bc}}\)    |
| g21 (MSP 8)            | 6.40 \(^{p\text{bcd}}\)  | 8.93 \(^{p\text{a}}\)     | 9.02 \(^{p\text{bc}}\)    | 3.14 \(^{r\text{def}}\)   |
| g22 (MSP 9)            | 6.15 \(^{p\text{def}}\)  | 7.60 \(^{p\text{gbc}}\)   | 9.43 \(^{p\text{ab}}\)    | 1.94 \(^{r\text{cdef}}\)  |
| g23 (MSP 13)           | 4.91 \(^{p\text{bcd}}\)  | 7.35 \(^{p\text{cd}}\)    | 8.45 \(^{p\text{bcd}de}\) | 2.22 \(^{r\text{defg}}\)  |
| g24 (MSP 14)           | 1.82 \(^{p\text{b}}\)   | 3.14 \(^{p\text{i}}\)     | 5.80 \(^{p\text{hijkl}}\)  | 1.07 \(^{r\text{gh}}\)    |
| g25 (MOD I F 1)        | 5.62 \(^{p\text{defgh}}\) | 5.93 \(^{p\text{efg}}\)   | 6.87 \(^{p\text{fgi}}\)   | 3.05 \(^{r\text{cde}}\)   |

LSD\(_{\text{NaCl,0.05}}\) 1.36

Numbers followed by the same letters in subplot columns (a,b,c,d,e,f,g,h,i,j,k,l,m,n) and main plot columns (p, q, r) are not significantly different LSD \(\alpha = 0.05\).

3.2. Growth of rice genotypes under saline condition

3.2.1. Plant height. Increasing the salinity level in the nutrient solution of hydroponic planting system, by adding NaCl 6 g L\(^{-1}\), significantly affected the height of the rice genotypes (table 5). Rice
genotypes grown under saline condition resulted in shorter plants and the response varied between the genotypes. Compared to normal condition, the genotype Inpari 35 (g11) showed the lowest level of decline in plant height which was about 7.8% due to salinity stress. On the contrary, the most sensitive genotype to salinity was Inpago 10 indicated by the shortest average plant height compared to all genotypes when grown in the saline condition.

Table 5. Mean of plant height (cm) of Indonesian rice genotypes on difference concentration of NaCl in the growth media.

| Genotypes           | Concentration of NaCl | LSD<sub>genotype 0.05</sub> |
|---------------------|-----------------------|-----------------------------|
|                     | 0 g L<sup>-1</sup>     | 6 g L<sup>-1</sup>          |
| g1 (Cimalayang Muncul) | 62.06<sub>p</sub><sup>cdefg</sup> | 46.97<sub>q</sub><sup>ef</sup> |
| g2 (Inpari 4)       | 64.33<sub>p</sub><sup>abcdefg</sup> | 54.00<sub>p</sub><sup>q</sup> |
| g3 (Situ Bagendit)  | 66.33<sub>p</sub><sup>abc</sup>     | 52.03<sub>q</sub><sup>bcd</sup> |
| g4 (Ciliwung)       | 65.97<sub>p</sub><sup>abcd</sup>    | 51.57<sub>q</sub><sup>bcd</sup> |
| g5 (Inpari 19)      | 64.33<sub>p</sub><sup>abcdefg</sup> | 46.33<sub>q</sub><sup>ef</sup> |
| g6 (Inpari 10)      | 65.00<sub>p</sub><sup>abced</sup>   | 51.52<sub>q</sub><sup>bcd</sup> |
| g7 (Inpari 43)      | 66.00<sub>p</sub><sup>abcd</sup>    | 59.67<sub>q</sub><sup>q</sup> |
| g8 (Limboto)        | 63.00<sub>p</sub><sup>abcddefg</sup> | 50.33<sub>q</sub><sup>bde</sup> |
| g9 (Inpago 6)       | 61.50<sub>p</sub><sup>efg</sup>    | 48.33<sub>q</sub><sup>bdef</sup> |
| g10 (Inpago 10)     | 60.63<sub>p</sub><sup>fg</sup>     | 45.67<sub>q</sub><sup>f</sup>  |
| g11 (Inpari 35)     | 67.00<sub>p</sub><sup>a</sup>       | 61.77<sub>q</sub><sup>a</sup>  |
| g12 (Cigeulis)      | 60.00<sub>p</sub><sup>g</sup>       | 52.87<sub>q</sub><sup>bc</sup> |
| g13 (Inpari 32)     | 60.67<sub>p</sub><sup>fg</sup>     | 50.30<sub>q</sub><sup>bcd</sup> |
| g14 (Inpari 33)     | 65.00<sub>p</sub><sup>abcdef</sup> | 58.43<sub>g</sub>            |
| g15 (IR 58443-6B-10-3) | 65.33<sub>p</sub><sup>bcd</sup> | 58.63<sub>q</sub><sup>q</sup> |
| g16 (Inpari 39)     | 62.63<sub>p</sub><sup>abcdefg</sup> | 54.00<sub>p</sub><sup>q</sup> |
| g17 (Ciherang)      | 61.93<sub>p</sub><sup>defg</sup>   | 50.00<sub>p</sub><sup>bcd</sup> |
| g18 (Mekongga)      | 61.33<sub>p</sub><sup>efg</sup>    | 50.67<sub>pq</sub><sup>bcd</sup> |
| g19 (IR 29)         | 64.57<sub>p</sub><sup>abcdef</sup> | 59.20<sub>g</sub><sup>q</sup> |
| g20 (Pokali)        | 64.13<sub>p</sub><sup>abcddefg</sup> | 60.17<sub>p</sub><sup>q</sup> |
| g21 (MSP 8)         | 63.67<sub>p</sub><sup>abcddefg</sup> | 53.67<sub>b</sub><sup>bc</sup> |
| g22 (MSP 9)         | 64.27<sub>p</sub><sup>abcdefg</sup> | 49.37<sub>q</sub><sup>bdef</sup> |
| g23 (MSP 13)        | 63.43<sub>p</sub><sup>b</sup>       | 50.40<sub>q</sub><sup>bcd</sup> |
| g24 (MSP 14)        | 67.33<sub>p</sub><sup>3</sup>       | 51.67<sub>q</sub><sup>bcd</sup> |
| g25 (MOD I F 1)     | 63.76<sub>p</sub><sup>abcdefg</sup> | 52.00<sub>q</sub><sup>bcd</sup> |

LSD<sub>NaCl 0.05</sub> 4.85

Numbers followed by the same letters in subplot columns (a,b,c,d,e,f,g) and main plot columns (p, q) are not significantly different LSD α = 0.05.

3.2.2. Productive tillers. Number of productive tillers of Indonesian rice genotypes grown under saline condition is shown in table 6. Salinity significantly reduced the number of productive tillers produced by rice genotypes and the response was varied between genotypes. The salinity stress due to
addition of NaCl 6 g L\(^{-1}\) in the nutrient solution can reduce the productive tillers to almost 50% compared to normal condition. Despite this, table 6 indicates that genotype Inpari 35 was able to maintain its productive tillers compared to other genotype when exposed to saline condition. On the other hand, genotype Inpari 33 seems to be the most sensitive genotype to salinity stress accounted for about 46.2% loss in the productive tillers number parameter.

**Table 6.** Mean of productive tillers (tillers) of Indonesian rice genotypes on difference concentration of NaCl in the growth media.

| Genotypes            | Concentration of NaCl | LSD\(_{\text{genotype} 0.05}\) |
|----------------------|-----------------------|-------------------------------|
|                      | 0 g L\(^{-1}\)        | 6 g L\(^{-1}\)                |
| g1 (Cimalayang Muncul)| 11.23\(_p^g\)         | 6.43\(_q^g\)                  |
| g2 (Inpari 4)        | 11.13\(_p^{ab}\)      | 7.32\(_q^{bcde}\)             |
| g3 (Situ Bagendit)   | 10.00\(_p^{abcdef}\)  | 6.83\(_q^g\)                  |
| g4 (Ciliwung)        | 9.73\(_p^{cdef}\)     | 6.67\(_q^g\)                  |
| g5 (Inpari 19)       | 10.33\(_p^{abcd}\)    | 6.23\(_q^g\)                  |
| g6 (Inpari 10)       | 9.73\(_p^{cdef}\)     | 6.33\(_q^g\)                  |
| g7 (Inpari 43)       | 10.72\(_p^{abcdde}\)  | 8.67\(_p^{ab}\)               |
| g8 (Limboto)         | 9.73\(_p^{cdef}\)     | 6.80\(_p^g\)                  |
| g9 (Inpago 6)        | 8.90\(_p^{ef}\)       | 6.33\(_q^g\)                  |
| g10 (Inpago 10)      | 10.07\(_p^{abcdef}\)  | 6.90\(_q^g\)                  |
| g11 (Inpari 35)      | 9.80\(_p^{bcdef}\)    | 9.37\(_p^a\)                  |
| g12 (Cigeulis)       | 10.23\(_p^{abcd}\)    | 7.30\(_q^{de}\)               |
| g13 (Inpari 32)      | 10.77\(_p^{abcd}\)    | 6.47\(_q^c\)                  |
| g14 (Inpari 33)      | 11.23\(_p^g\)         | 6.04\(_q^g\)                  |
| g15 (IR 58443-6B-10-3)| 9.63\(_p^{cdedf}\)   | 8.61\(_p^{abc}\)              |
| g16 (Inpari 39)      | 10.80\(_p^{abcd}\)    | 7.32\(_q^{bcde}\)             |
| g17 (Ciherrang)      | 10.47\(_p^{abcd}\)    | 7.27\(_q^{cdedef}\)           |
| g18 (Mekongga)       | 10.23\(_p^{abcdde}\)  | 7.07\(_q^{de}\)               |
| g19 (IR 29)          | 10.23\(_p^{abcdde}\)  | 8.40\(_p^{abcd}\)             |
| g20 (Pokali)         | 10.00\(_p^{abcdef}\)  | 9.00\(_q^p\)                  |
| g21 (MSP 8)          | 9.70\(_p^{cdedf}\)    | 6.23\(_q^g\)                  |
| g22 (MSP 9)          | 11.07\(_p^{abc}\)     | 6.63\(_q^e\)                  |
| g23 (MSP 13)         | 10.10\(_p^{abcddef}\) | 6.83\(_q^g\)                  |
| g24 (MSP 14)         | 8.73\(_p^f\)          | 6.47\(_p^e\)                  |
| g25 (MOD I F 1)      | 10.57\(_p^{abcd}\)    | 6.77\(_q^g\)                  |

Numbers followed by the same letters in subplot columns (a,b,c,d,e,f) and main plot columns (p, q) are not significantly different LSD \(\alpha = 0.05\).

3.2.3. **Length of panicle.** Table 7 shows the mean of panicle length of Indonesian rice genotypes as response to different concentration of NaCl in the nutrient solution. Increased salinity level in the growing media of hydroponically grown rice genotypes resulted in decreased length of panicle. Although salinity stress significantly decreased the panicle length of the rice genotypes, but the response were varied. Genotype showed longest panicle in the saline condition was Inpari 43 (g7) with
a 1.4 cm difference compared to the parameter value obtained in the normal condition. The reduction on
the panicle length of Inpari 43 genotype could be accounted for about 5%, and were not significantly
different with genotypes of Inpari 35, IR 5844-6B-10-3, and Pokali at the same salinity level. Highest
reduction in the parameter is shown by genotype Inpari 19 with 23.7% reduction in the length of
panicle parameter.

Table 7. Mean of panicle length (cm) of Indonesian rice genotypes on difference concentration of
NaCl in the growth media.

| Genotypes                  | Concentration of NaCl | LSD<sub>genotype 0.05</sub> |
|---------------------------|-----------------------|-----------------------------|
|                           | 0 g L<sup>-1</sup>    | 6 g L<sup>-1</sup>          |                            |
| g1 (Cimalayang Muncul)    | 22.70<sup>bcde</sup> | 17.48<sup>defgh</sup>      |                            |
| g2 (Inpari 4)             | 23.44<sup>bc</sup>   | 18.53<sup>cde</sup>        |                            |
| g3 (Situ Bagendit)        | 21.51<sup>efghi</sup>| 18.80<sup>cd</sup>          |                            |
| g4 (Ciliwung)             | 21.79<sup>efg</sup>  | 17.11<sup>fg</sup>          |                            |
| g5 (Inpari 19)            | 21.73<sup>efg</sup>  | 16.57<sup>h</sup>           |                            |
| g6 (Inpari 10)            | 22.06<sup>def</sup>  | 17.87<sup>efgh</sup>        |                            |
| g7 (Inpari 43)            | 22.72<sup>bcdde</sup>| 21.23<sup>a</sup>           |                            |
| g8 (Limboto)              | 21.05<sup>fghi</sup> | 17.05<sup>fg</sup>          |                            |
| g9 (Inpago 6)             | 22.30<sup>bcddef</sup>| 18.33<sup>cdef</sup>        |                            |
| g10 (Inpago 10)           | 22.13<sup>cdef</sup> | 17.89<sup>defgh</sup>       |                            |
| g11 (Inpari 35)           | 21.87<sup>efg</sup>  | 20.45<sup>ab</sup>          |                            |
| g12 (Cigeulis)            | 20.56<sup>ghi</sup>  | 17.22<sup>efgh</sup>        |                            |
| g13 (Inpari 32)           | 21.44<sup>efghi</sup>| 17.10<sup>fg</sup>          |                            |
| g14 (Inpari 33)           | 22.00<sup>def</sup>  | 16.95<sup>gh</sup>          |                            |
| g15 (IR 58443-6B-10-3)    | 21.95<sup>def</sup>  | 20.97<sup>a</sup>           | 1.33                       |
| g16 (Inpari 39)           | 23.52<sup>b</sup>    | 18.05<sup>cdefg</sup>       |                            |
| g17 (Cigerang)            | 25.07<sup>p</sup>    | 17.60<sup>de</sup>          |                            |
| g18 (Mekongga)            | 21.68<sup>efgh</sup> | 17.57<sup>q</sup>           |                            |
| g19 (IR 29)               | 22.02<sup>def</sup>  | 20.99<sup>a</sup>           |                            |
| g20 (Pokali)              | 22.44<sup>bcdde</sup>| 21.00<sup>a</sup>           |                            |
| g21(MSP 8)                | 20.36<sup>ghi</sup>  | 18.32<sup>cdef</sup>        |                            |
| g22 (MSP 9)               | 22.46<sup>bcde</sup> | 19.33<sup>bc</sup>          |                            |
| g23 (MSP 13)              | 23.32<sup>bcd</sup>  | 18.45<sup>cde</sup>         |                            |
| g24 (MSP 14)              | 21.77<sup>efg</sup>  | 17.79<sup>defgh</sup>       |                            |
| g25 (MOD I F 1)           | 20.33<sup>i</sup>    | 17.70<sup>de</sup>          |                            |

LSD<sub>NaCl 0.05</sub> = 1.38

Numbers followed by the same letters in subplot columns (a,b,c,d,e,f,g,h) and main plot columns (p, q) are not
significantly different LSD α = 0.05.
3.3. Yield components of rice genotypes under saline condition
Salinity significantly reduced the yield components of Indonesian rice genotypes. Use of NaCl 6 g L\(^{-1}\) was generally attributed to earlier flowering and harvest age, lower number of grain and filled seeds per panicle, and decreased weight of 100 grains and productivity. Despite this, the length of seed filling period seems not to be affected by the salinity. Response of the rice genotypes to saline growing condition also varied in terms of the flowering age, seeds filling period, number of grain and filled grain per panicle, weight of 100 grains and productivity.

3.3.1. Flowering age. Time from planting to 50% flowering of rice genotypes was reduced when the plants were exposed to saline condition (table 8). Stressed plants showed about 6-10 days earlier in the flowering age compared to normal condition. A variation in the time of flowering between genotypes also observed as a consequence of variation in the genetic of the plants. The latest time to flower was shown by Inpari 32 either in normal or stressed condition.

Table 8. Mean of flowering age (DAP) of Indonesian rice genotypes on difference concentration of NaCl in the growth media.

| Genotypes            | Concentration of NaCl | LSD\(_{\text{genotype}}\) 0.05 |
|----------------------|------------------------|---------------------------------|
|                      | 0 g L\(^{-1}\)          | 6 g L\(^{-1}\)                  |                                  |
| g1 (Cimalayang Muncul) | 61.00\(_{p}^{deef}\)   | 52.33\(_{q}^{fg}\)             |                                  |
| g2 (Inpari 4)        | 61.67\(_{p}^{cde}\)    | 53.33\(_{q}^{g}\)              |                                  |
| g3 (Situ Bagendit)   | 59.33\(_{p}^{fggh}\)   | 50.00\(_{q}^{gh}\)             |                                  |
| g4 (Ciliwung)        | 58.67\(_{p}^{h}\)      | 49.67\(_{q}^{gh}\)             |                                  |
| g5 (Inpari 19)       | 60.67\(_{p}^{defggh}\) | 51.67\(_{q}^{dfg}\)            |                                  |
| g6 (Inpari 10)       | 59.33\(_{p}^{fggh}\)   | 51.33\(_{q}^{efg}\)            |                                  |
| g7 (Inpari 43)       | 62.67\(_{p}^{bcd}\)    | 58.33\(_{q}^{bc}\)             |                                  |
| g8 (Limboto)         | 58.67\(_{p}^{h}\)      | 49.33\(_{q}^{gh}\)             |                                  |
| g9 (Inpago 6)        | 59.00\(_{p}^{gh}\)     | 50.67\(_{q}^{gh}\)             |                                  |
| g10 (Inpago 10)      | 60.33\(_{p}^{efgh}\)   | 50.67\(_{q}^{gh}\)             |                                  |
| g11 (Inpari 35)      | 61.33\(_{p}^{deef}\)   | 56.67\(_{q}^{d}\)              |                                  |
| g12 (Cigeulis)       | 61.00\(_{p}^{defg}\)   | 51.67\(_{q}^{efg}\)            |                                  |
| g13 (Inpari 32)      | 60.33\(_{p}^{eegh}\)   | 51.00\(_{q}^{fgh}\)            |                                  |
| g14 (Inpari 33)      | 66.00\(_{p}^{q}\)      | 60.67\(_{q}^{a}\)              | 1.33                             |
| g15 (IR 58443-6B-10-3) | 63.33\(_{p}^{bc}\)   | 58.33\(_{q}^{bc}\)             |                                  |
| g16 (Inpari 39)      | 60.33\(_{p}^{efgh}\)   | 50.67\(_{q}^{gh}\)             |                                  |
| g17 (Ciherang)       | 59.33\(_{p}^{fggh}\)   | 49.33\(_{q}^{gh}\)             |                                  |
| g18 (Mekongga)       | 60.67\(_{p}^{defggh}\) | 50.33\(_{q}^{gh}\)             |                                  |
| g19 (IR 29)          | 64.00\(_{p}^{ab}\)     | 59.33\(_{q}^{ab}\)             |                                  |
| g20 (Pokali)         | 60.67\(_{p}^{defggh}\) | 56.00\(_{q}^{gh}\)             |                                  |
| g21 (MSP 8)          | 59.00\(_{p}^{gh}\)     | 49.67\(_{q}^{gh}\)             |                                  |
| g22 (MSP 9)          | 61.00\(_{p}^{defg}\)   | 51.00\(_{q}^{fgh}\)            |                                  |
| g23 (MSP 13)         | 59.00\(_{p}^{gh}\)     | 50.00\(_{q}^{gh}\)             |                                  |
| g24 (MSP 14)         | 61.33\(_{p}^{cdde}\)   | 51.67\(_{q}^{efg}\)            |                                  |
3.3.2. Harvest age. Salinity treatment significantly affected the harvest time of several Indonesian rice genotypes. While the parameters varied between genotypes, NaCl concentration of 6 g L\(^{-1}\) reduced the time to harvest of the plant about four days earlier compared to normal condition (table 9).

Table 9. Mean of harvest time (DAP) of Indonesian rice genotypes on difference concentration of NaCl in the growth media.

| Genotypes               | Concentration of NaCl | Average | LSD\(_{\text{genotype}} 0.05\) |
|-------------------------|-----------------------|---------|-------------------------------|
|                         | 0 g L\(^{-1}\) | 6 g L\(^{-1}\) |                  |
| g1 (Cimalayang Muncul)  | 126.67    | 121.67    | 124.17\(^a\)        |
| g2 (Inpari 4)           | 116.00    | 111.00    | 113.50\(^d\)        |
| g3 (Situ Bagendit)      | 120.00    | 115.33    | 117.67\(^c\)        |
| g4 (Ciliwung)           | 111.00    | 106.00    | 108.50\(^f\)        |
| g5 (Inpari 19)          | 107.33    | 104.33    | 105.83\(^g\)        |
| g6 (Inpari 10)          | 102.33    | 99.00     | 100.67\(^l\)        |
| g7 (Inpari 43)          | 101.00    | 97.67     | 99.33\(^k\)         |
| g8 (Limboto)            | 123.33    | 120.67    | 122.00\(^b\)        |
| g9 (Inpago 6)           | 114.00    | 110.67    | 112.33\(^{de}\)     |
| g10 (Inpago 10)         | 115.00    | 111.67    | 113.33\(^d\)        |
| g11 (Inpari 35)         | 123.67    | 119.67    | 121.67\(^b\)        |
| g12 (Cigeulis)          | 106.00    | 101.33    | 103.67\(^hi\)       |
| g13 (Inpari 32)         | 119.33    | 115.00    | 117.17\(^c\)        |
| g14 (Inpari 33)         | 107.00    | 103.33    | 105.17\(^{gh}\)     |
| g15 (IR 58443-6B-10-3)  | 114.00    | 110.67    | 112.33\(^{de}\)     |
| g16 (Inpari 39)         | 111.00    | 107.33    | 109.17\(^f\)        |
| g17 (Ciherang)          | 124.00    | 120.67    | 122.33\(^b\)        |
| g18 (Mekongga)          | 107.00    | 102.67    | 104.83\(^{gh}\)     |
| g19 (IR 29)             | 105.00    | 100.33    | 102.67\(^i\)        |
| g20 (Pokali)            | 113.00    | 109.67    | 111.33\(^e\)        |
| g21 (MSP 8)             | 105.67    | 101.33    | 103.50\(^{hi}\)     |
| g22 (MSP 9)             | 114.33    | 109.33    | 111.83\(^{de}\)     |
| g23 (MSP 13)            | 107.33    | 102.00    | 104.67\(^{gh}\)     |
| g24 (MSP 14)            | 111.33    | 106.33    | 108.83\(^f\)        |
| g25 (MOD IF 1)          | 106.33    | 101.33    | 103.83\(^{hi}\)     |
| **Average**             | 112.47\(^p\) | 108.36\(^q\) |               |
| **LSD\(_{\text{NaCl}} 0.05\)** | 1.20     |           |                 |

Numbers followed by the same letters in subplot columns (a,b,c,d,e,f,g,h,i,j,k) and main plot columns (p, q) are not significantly different LSD \(\alpha = 0.05\). DAP=days after planting.
3.3.3. Seeds filling period. Salinity stress significantly prolong the seed filling period of Indonesian rice genotypes. The rice genotypes were observed to have longer seed filling period when the NaCl concentration of 6 g L\(^{-1}\) was added into the nutrient solution as their responses to the saline condition. The genotypes varied in the parameter values (table 10). The longest period observed was shown by Ciherang genotype with additional about 6.7 days compared to normal condition. The delay for seeds filling period when the growing condition failed to stressed condition was about six days shown by Inpari 19, Inpago 10, Inpari 39, and Mekongga. One genotype did not show any changes in the parameter values was IR 29.

| Genotypes                  | Concentration of NaCl | LSD\(_{\text{genotype} 0.05}\) |
|----------------------------|-----------------------|-------------------------------|
|                            | 0 g L\(^{-1}\)       | 6 g L\(^{-1}\)               |
| g1 (Cimalayang Muncul)     | 65.33\(^a\)          | 69.33\(^p\)                  |
| g2 (Inpari 4)              | 54.33\(^f\)          | 57.67\(^e\)                  |
| g3 (Situ Bagendit)         | 60.67\(^c\)          | 65.33\(^b\)                  |
| g4 (Ciliwung)              | 52.33\(^f\)          | 56.33\(^g\)                  |
| g5 (Inpari 19)             | 46.67\(^h\)          | 52.67\(^i\)                  |
| g6 (Inpari 10)             | 43.00\(^k\)          | 47.67\(^p\)                  |
| g7 (Inpari 43)             | 38.33\(^l\)          | 39.33\(^m\)                  |
| g8 (Limboto)               | 64.67\(^ab\)         | 69.33\(^p\)                  |
| g9 (Inpari 6)              | 55.00\(^e\)          | 60.00\(^de\)                 |
| g10 (Inpari 10)            | 54.67\(^f\)          | 61.00\(^cd\)                 |
| g11 (Inpari 35)            | 62.33\(^bc\)         | 63.00\(^bc\)                 |
| g12 (Cigeulis)             | 45.00\(^j\)          | 49.67\(^p\)                  |
| g13 (Inpari 32)            | 59.00\(^d\)          | 64.00\(^b\)                  |
| g14 (Inpari 33)            | 41.00\(^k\)          | 42.67\(^l\)                  |
| g15 (IR 58443-6B-10-3)     | 50.67\(^g\)          | 52.33\(^h\)                  |
| g16 (Inpari 39)            | 50.67\(^g\)          | 56.67\(^f\)                  |
| g17 (Ciherang)             | 64.67\(^ab\)         | 71.33\(^p\)                  |
| g18 (Mekongga)             | 46.33\(^hi\)         | 52.33\(^hi\)                 |
| g19 (IR 29)                | 41.00\(^k\)          | 41.00\(^lm\)                 |
| g20 (Pokali)               | 52.33\(^p\)          | 53.67\(^h\)                  |
| g21(MSP 8)                 | 46.67\(^hi\)         | 51.67\(^ij\)                 |
| g22 (MSP 9)                | 53.33\(^f\)          | 58.33\(^ef\)                 |
| g23 (MSP 13)               | 48.33\(^gh\)         | 52.00\(^ij\)                 |
| g24 (MSP 14)               | 50.00\(^g\)          | 54.67\(^gh\)                 |
| g25 (MOD IF 1)             | 45.33\(^j\)          | 49.67\(^jk\)                 |

Numbers followed by the same letters in subplot columns (a,b,c,d,e,f,g,h,i,j,k, l, m) and main plot columns (p, q) are not significantly different LSD \(\alpha = 0.05\). DAP= days after planting.

3.3.4. Number of grains per panicle. The rice genotypes showed parameter values of number of grains per panicle that were significantly varied between genotypes and salinity levels (table 11). Plants
exposed to saline conditions had lower number of grain per panicle compared to the normal condition. Loss in the number of grain per panicle due to the salinity stress in this hydroponics trial ranged between 5 to 26%. Genotype showed highest number of grain per panicle in saline stressed condition was Pokali (g20) with parameter value of 129.93 grains. However, genotypes showed the lower reduction in the number of grain per panicle when salinity increased were Cigeulis and Inpari 35 with reduction accounted for about 5.2% and 5.5%, respectively. The lowest number of grain per panicle in saline condition was shown by Inpari 19. Despite this, genotype showed highest reduction in the parameter was Ciliwung with 26.1% loss in number of grain per panicle.

**Table 11.** Mean of number of grains per panicle (grains) of Indonesian rice genotypes on difference concentration of NaCl in the growth media.

| Genotypes               | Concentration of NaCl | LSD_{genotype 0.05} |
|-------------------------|-----------------------|---------------------|
|                         | 0 g L\(^{-1}\)        | 6 g L\(^{-1}\)      |
| g1 (Cimalayang Muncul)  | 145.33\(^{abc}\)      | 115.73\(^{cdefg}\) |
| g2 (Inpari 4)           | **150.67\(^{p}\)**    | 115.06\(^{defg}\)  |
| g3 (Situ Bagendit)      | 131.00\(^{defg}\)     | 100.35\(^{jk}\)     |
| g4 (Ciliwung)           | 136.33\(^{bcde}\)     | 100.72\(^{efghi}\)  |
| g5 (Inpari 19)          | 121.67\(^{p}\)         | 92.59\(^{k}\)       |
| g6 (Inpari 10)          | 121.00\(^{p}\)         | 111.33\(^{q}\)      |
| g7 (Inpari 43)          | 135.00\(^{bcde}\)     | 126.23\(^{abc}\)    |
| g8 (Limboto)            | 136.67\(^{bcde}\)     | 112.25\(^{efghi}\)  |
| g9 (Inpago 6)           | 128.53\(^{efgh}\)     | 106.94\(^{fgij}\)   |
| g10 (Inpago 10)         | 123.33\(^{fgi}\)      | 106.66\(^{ghij}\)   |
| g11 (Inpari 35)         | 133.67\(^{abcdef}\)   | 126.28\(^{abc}\)    |
| g12 (Cigeulis)          | 126.67\(^{efgh}\)     | 120.03\(^{abcde}\)  |
| g13 (Inpari 32)         | 123.00\(^{fgi}\)      | 98.16\(^{jk}\)      |
| g14 (Inpari 33)         | 142.00\(^{abc}\)      | 117.46\(^{bcdef}\)  |
| g15 (IR 58443-6B-10-3)  | 136.67\(^{bcde}\)     | 127.94\(^{ab}\)     |
| g16 (Inpari 39)         | 143.67\(^{abc}\)      | 111.33\(^{egi}\)    |
| g17 (Ciharang)          | 142.67\(^{bcde}\)     | 119.23\(^{bcd}\)    |
| g18 (Mekongga)          | 126.67\(^{efgh}\)     | 114.94\(^{defgh}\)  |
| g19 (IR 29)             | 134.67\(^{bcde}\)     | 124.35\(^{abcd}\)   |
| g20 (Pokali)            | 139.00\(^{bcd}\)      | 129.93\(^{g}\)      |
| g21 (MSP 8)             | 137.00\(^{bcde}\)     | 113.30\(^{efg}\)    |
| g22 (MSP 9)             | 119.33\(^{p}\)        | 104.69\(^{ghi}\)    |
| g23 (MSP 13)            | 144.33\(^{abc}\)      | 117.61\(^{bcdef}\)  |
| g24 (MSP 14)            | 119.67\(^{h}\)        | 101.99\(^{ijkl}\)   |
| g25 (MOD IF 1F 1)       | 128.00\(^{efgh}\)     | 111.61\(^{fghi}\)   |

LSD_{NaCl 0.05} = 13.37

Numbers followed by the same letters in subplot columns (a,b,c,d,e,f,g,h,i,j,k) and main plot columns (p, q) are not significantly different LSD $\alpha = 0.05$. 
3.3.5. **Number of filled grains per panicle.** Similarly to the parameter of number of grain per panicle, the number of filled grains per panicle also decreased with the increase of salinity in the nutrient solution. Genotype that showed highest number of filled grain per panicle when grown in saline condition was Inpari 43 (table 12). The extent of the decrease in the number of filled grain per panicle varied between genotypes ranged between 29% to almost 50% of the parameter values in the normal condition. Rice genotype observed to have the lowest decline in the parameter was Inpari 43 with only 29.4% decreased in the number of filled grain per panicle, while Inpari 35 showed the highest decline in the parameter or about 48.7% loss in filled grain number per panicle compared when grown in normal condition.

**Table 12.** Mean of number of filled grains per panicle (grains) of Indonesian rice genotypes on difference concentration of NaCl in the growth media.

| Genotypes                        | Concentration of NaCl | LSD_{genotype 0.05} |
|----------------------------------|------------------------|---------------------|
|                                  | 0 g L^{-1}             | 6 g L^{-1}          |                     |
| g1 (Cimalayang Muncul)           | 130.67^{abc}           | 73.95^{def}         |
| g2 (Inpari 4)                    | 136.00^{pabc}          | 75.67^{cde}         |
| g3 (Situ Bagendit)               | 120.33^{pdefg}         | 65.48^{q}          |
| g4 (Ciliwung)                    | 128.00^{pcdef}         | 71.97^{ef}         |
| g5 (Inpari 19)                   | 102.67^{p}             | 61.00^{q}          |
| g6 (Inpari 10)                   | 114.33^{gh}            | 70.00^{qfg}         |
| g7 (Inpari 43)                   | 129.33^{pbcdef}        | **91.33^{aq}**      |
| g8 (Limboto)                     | 131.00^{abcdef}        | 71.33^{q}          |
| g9 (Inpago 6)                    | 119.33^{pgh}           | 69.00^{qfg}         |
| g10 (Inpago 10)                  | 120.00^{efg}           | 68.00^{qfg}         |
| g11 (Inpari 35)                  | 127.33^{pdef}          | 85.33^{qabc}       |
| g12 (Cigeulis)                   | 116.67^{gh}            | 66.67^{qfg}         |
| g13 (Inpari 32)                  | 113.33^{gh}            | 64.33^{qg}          |
| g14 (Inpari 33)                  | 134.00^{pbc}           | 73.00^{q}          |
| g15 (IR 58443-6B-10-3)           | 130.33^{pabc}          | 85.67^{qab}        |
| g16 (Inpari 39)                  | 137.33^{pab}           | 71.00^{qf}         |
| g17 (Ciherang)                   | 135.67^{pabc}          | 72.00^{qf}         |
| g18 (Mekongga)                   | 120.00^{pfg}           | 73.33^{qdef}       |
| g19 (IR 29)                      | 130.67^{pabc}          | 82.33^{qabcd}      |
| g20 (Pokali)                     | 130.33^{pabc}          | 86.67^{q}          |
| g21 (MSP 8)                      | 130.00^{pabcd}         | 72.00^{qfg}         |
| g22 (MSP 9)                      | 110.00^{hi}            | 67.67^{qfg}         |
| g23 (MSP 13)                     | **139.00^{a}**         | 76.00^{bade}        |
| g24 (MSP 14)                     | 117.00^{gh}            | 66.67^{qfg}         |
| g25 (MOD I F 1)                  | 117.33^{gh}            | 70.33^{efg}         |
| **LSD_{NaCl 0.05}**              |                        | 13.58              |

Numbers followed by the same letters in subplot columns (a,b,c,d,e,f,g,h,i,j,k) and main plot columns (p, q) are not significantly different LSD α = 0.05.
3.3.6. Weight of 100 grains. Table 13 shows the weight of 100 grains parameter of Indonesian rice genotypes when grown in hydroponic system with saline nutrient solution. Saline condition significantly decrease the weight of 100 grains of the Indonesian rice genotypes, but the effect varied between genotypes and salinity levels. Even though concentration of NaCl of 6 g L\(^{-1}\) in the nutrient solution decreased the weight of 100 grains of the rice, the size of rice produced in saline condition was only slightly differed to the normal condition. Genotype showed highest weight of 100 grain was Inpari 35 which was 2.70 g that only differed about 0.12 g to the value in the normal condition of 2.82 g.

**Table 13.** Mean of weight of 100 grains (g) of Indonesian rice genotypes on difference concentration of NaCl in the growth media.

| Genotypes          | Concentration of NaCl | LSD\(_{\text{genotype 0.05}}\) |
|--------------------|-----------------------|-------------------------------|
|                    | 0 g L\(^{-1}\)        | 6 g L\(^{-1}\)                |
| g1 (Cimalayang Muncul) | 2.74\(_p\)            | 2.42\(_q\)                   |
| g2 (Inpari 4)       | 2.71\(_bc\)           | 2.38\(_{bc}\)                 |
| g3 (Situ Bagendit)  | 2.18\(_f\)            | 2.00\(_bc\)                  |
| g4 (Ciliwung)       | 2.17\(_f\)            | 2.03\(_bc\)                  |
| g5 (Inpari 19)      | 2.41\(_g\)            | 2.23\(_ab\)                  |
| g6 (Inpari 10)      | 2.42\(_g\)            | 2.13\(_bc\)                  |
| g7 (Inpari 43)      | 2.68\(_bcd\)          | 2.56\(_p\)                   |
| g8 (Limboto)        | 2.52\(_ef\)           | 2.24\(_q\)                   |
| g9 (Inpago 6)       | 2.53\(_f\)            | 2.25\(_ab\)                  |
| g10 (Inpago 10)     | 2.66\(_cd\)           | 2.27\(_q\)                   |
| g11 (Inpari 35)     | 2.82\(_p\)            | 2.70\(_a\)                   |
| g12 (Cigeulis)      | 2.68\(_bcd\)          | 2.33\(_ab\)                  |
| g13 (Inpari 32)     | 2.48\(_fg\)           | 2.19\(_ab\)                  |
| g14 (Inpari 33)     | 2.66\(_cd\)           | 2.22\(_ab\)                  |
| g15 (IR 58443-6B-10-3) | 2.65\(_cd\)        | 2.55\(_p\)                   |
| g16 (Inpari 39)     | 2.64\(_d\)            | 2.29\(_q\)                   |
| g17 (Cihering)      | **2.88\(_a\)**        | 2.42\(_q\)                   |
| g18 (Mekongga)      | 2.17\(_f\)            | 2.00\(_bc\)                  |
| g19 (IR 29)         | 2.63\(_d\)            | 2.47\(_ab\)                  |
| g20 (Pokali)        | 2.64\(_d\)            | 2.49\(_q\)                   |
| g21 (MSP 8)         | 2.04\(_k\)            | 1.86\(_g\)                   |
| g22 (MSP 9)         | 2.27\(_i\)            | 1.94\(_g\)                   |
| g23 (MSP 13)        | 2.68\(_bcd\)          | 2.23\(_q\)                   |
| g24 (MSP 14)        | 2.13\(_j\)            | 1.91\(_p\)                   |
| g25 (MOD I F 1)     | 2.54\(_e\)            | 2.21\(_q\)                   |

LSD\(_{\text{NaCl 0.05}}\) 0.13

Numbers followed by the same letters in subplot columns (a,b,c,d,e) and main plot columns (p, q) are not significantly different LSD \(\alpha = 0.05\).

3.3.7. Productivity. Salinity decreased the production per plant of rice genotypes grown using hydroponic system and the responses were varied between the genotypes (table 14). Decline in productivity per plant could reach 75% of the normal condition. Nevertheless, there were significant
differences between genotypes in the level of decreased productivity. Several genotypes were observed to be able to maintain the productivity under saline condition such as Inpari 35, Inpari 43, and IR 58443-6B-10-3 with production per plant decreased to about 21.53, 20.24, and 18.87 g per plant, respectively. These numbers accounted for 38.8%, 43.2%, and 43.1% decreased from productivity obtained in normal condition. Based on the stress tolerance index calculation, these genotypes were categorized as medium tolerance. In addition, other genotypes were also suggested to be medium tolerance based on the STI analysis such as Inpari 4 and IR 29 although the level of decreased in productivity were 50 to 60% of the normal condition.

Table 14. Mean of Production (g plant\(^{-1}\)) of Indonesian rice genotypes on difference concentration of NaCl in the growth media.

| Genotypes                  | Concentration of NaCl | STI | LSD\(_{\text{genotype}}\) (NaCl 0.05) |
|----------------------------|-----------------------|-----|-------------------------------------|
|                            | 0 g L\(^{-1}\)       | 6 g L\(^{-1}\) |                                     |
| g1 (Cimalayang Muncul)     | 40.27\(_p\)           | 11.51\(_q\)     | S                                   |
| g2 (Inpari 4)              | 41.08\(_g\)           | 13.20\(_q\)     | MT                                  |
| g3 (Situ Bagendit)         | 26.33\(_p\)           | 8.98\(_q\)      | S                                   |
| g4 (Ciliwung)              | 27.09\(_p\)           | 9.77\(_q\)      | S                                   |
| g5 (Inpari 19)             | 25.56\(_p\)           | 8.43\(_q\)      | S                                   |
| g6 (Inpari 10)             | 26.94\(_j\)           | 9.69\(_q\)      | S                                   |
| g7 (Inpari 43)             | 35.62\(_bcde\)        | 20.24\(_q\)     | MT                                  |
| g8 (Limbotto)              | 32.08\(_e\)           | 10.12\(_de\)    | S                                   |
| g9 (Inpago 6)              | 26.96\(_j\)           | 9.88\(_q\)      | S                                   |
| g10 (Inpago 10)            | 31.96\(_fg\)          | 10.67\(_de\)    | S                                   |
| g11 (Inpari 35)            | 35.22\(_cde\)         | 21.53\(_g\)     | MT                                  |
| g12 (Cigeulis)             | 31.56\(_efg\)         | 11.41\(_de\)    | S                                   |
| g13 (Inpari 32)            | 30.18\(_ghi\)         | 9.10\(_de\)     | 4.44                                |
| g14 (Inpari 33)            | 40.05\(_ab\)          | 9.79\(_de\)     | S                                   |
| g15 (IR 58443-6B-10-3)     | 33.20\(_def\)         | 18.87\(_ab\)    | MT                                  |
| g16 (Inpari 39)            | 39.02\(_abc\)         | 11.89\(_de\)    | S                                   |
| g17 (Ciherang)             | 40.77\(_a\)           | 12.68\(_cde\)   | S                                   |
| g18 (Mekongga)             | 26.97\(_j\)           | 10.33\(_de\)    | S                                   |
| g19 (IR 29)                | 35.18\(_cde\)         | 17.08\(_bc\)    | MT                                  |
| g20 (Pokali)               | 34.47\(_def\)         | 19.39\(_ab\)    | S                                   |
| g21(MSP 8)                 | 25.85\(_ijk\)         | 8.33\(_e\)      | S                                   |
| g22 (MSP 9)                | 27.57\(_ghi\)         | 8.72\(_e\)      | S                                   |
| g23 (MSP 13)               | 37.63\(_abcd\)        | 11.57\(_de\)    | S                                   |
| g24 (MSP 14)               | 21.75\(_k\)           | 8.25\(_e\)      | S                                   |
| g25 (MOD IF 1)             | 31.50\(_efgh\)        | 10.51\(_de\)    | S                                   |

LSD\(_{\text{NaCl} \, 0.05}\) \(= 8.26\)

Numbers followed by the same letters in subplot columns (a,b,c,d,e) and main plot columns (p, q) are not significantly different LSD \(\alpha = 0.05\). STI= Stress Tolerant Index, S= sensitive, MT= medium tolerant.
3.4. Heritability analysis

Heritability analysis in table 15 shows that all characters described above had high heritability values. The characters that show high heritability values were percentage of germination, seed vigor index, plumula length, radicle length, flowering and harvest age, seed filling period, number of grain per panicle, filled grain, weight of 100 seeds, grain weight, and production. Moderate heritability is shown by parameter of plant height and panicle length, while low heritability is shown by the number of productive tillers.

**Table 15.** Heritability values of parameters of Indonesian rice genotypes on difference concentration of NaCl in the growth media.

| No. | Character                          | Heritability (%) | Category |
|-----|-----------------------------------|------------------|----------|
| 1   | Percentage of Germination         | 79               | High     |
| 2   | Seeds Vigor index                 | 77               | High     |
| 3   | Plumula length                    | 62               | High     |
| 4   | Radicle Length                    | 63               | High     |
| 5   | Plant height                      | 38               | Moderate |
| 6   | Number of productive tillers      | 7                | Low      |
| 7   | Panicle length                    | 27               | Moderate |
| 8   | Flowering age                     | 78               | High     |
| 9   | Harvest time                      | 96               | High     |
| 10  | Seeds filling period              | 96               | High     |
| 11  | Number of grains per panicle      | 52               | High     |
| 12  | Number of filled grains per panicle| 53          | High     |
| 13  | Weight of 100 grains              | 96               | High     |
| 14  | Production                        | 82               | High     |

Low = < 20%; Moderate = 20%-50%; High = > 50%

4. Discussion

The main constraints of plant growth in high salinity conditions are three things, namely water (water stress) deficit caused by low (more negative) water potential from growing media, ion toxicity due to excessive absorption of sodium and chloride ions, nutrient imbalance due to inhibition of ion uptake and/or transport to shoots and mismatches of distribution of nutrient minerals to the internal, especially calcium. It is very difficult to see the relative contribution of these three factors at high salinity conditions, because various factors may also be involved. These factors include ion concentration and its relationship to the medium, duration of stress, plant species, cultivars and types of root stock (excluder or includer), growth stages, plant organs, and environmental conditions.

The observations at the laboratory experiments showed that several genotypes tested on various NaCl concentrations had a very significant effect on the interactions of all parameters observed, namely the percentage of germination, seed vigor, plumule and radicle length. Interactions that occur in several parameters such as germination percentage, vigor index, plumule and radicle length as responses of the rice plant growth to various NaCl concentrations tend to show a decrease and inhibition of growth due to salt ion levels like Na⁺, Cl⁻, and Mg²⁺ which can bind water. The treatment concentration which has the highest average is 3 g L⁻¹ NaCl and 6 g L⁻¹ NaCl. These concentration are the lowest concentration compared to the concentration of other treatments in the use of NaCl. NaCl
concentration that is too high can inhibit sprout growth. Metabolic disorders caused by salinity will reduce the absorption of other nutrients such as Na, urging Ca, K, Mg, which causes plants to be deficient in Ca, K, Mg. The stress is a result of the effect of salinity which induces salinity stress, dryness, and nutrient deficiency [16] resulting in a decrease in osmotic potential and ion poisoning.

The inhibition of growth in the treatment given a high concentration of NaCl was due to high levels of salt ions such as Na$^+$, Cl$^-$, and Mg$^{2+}$. This situation results in the inhibition of the process of cell division, cell elongation, or both due to stress which is the accumulation of salt levels in plants. This is in accordance with the opinion of Salisbury [17] which states that the strategy of tolerant plants faces stress conditions starting during the germination phase.

Plants that experience environmental stress will produce abscisic acid hormone (ABA) in response to a lack of water to be supplied to the plant due to osmotic pressure. ABA is a plant hormone that is produced and accumulates in plants that experience water shortages. The ABA concentration is found to be high in the xylem root sap. ABA is transported in xylem signals as a response to ABA which has a lower concentration in shoots [18, 19]. This resulted in several genotypes treated with various concentrations of NaCl having a higher average radicle length than the genotype in the control treatment.

Seed plants will use a tolerant strategy in the face of stress conditions through a persistent mechanism (tolerance mechanism) with the potential for low osmotic adjustment in the tissue by producing and accumulating certain compounds in the form of free amino acids in plant tissues to maintain turgor [20, 21]. Maintaining turgor by decreasing water potential is very important for cell expansion, growth and biochemical processes, physiology, and plant morphology which is a process that occurs during the imbibition phase and activation of metabolism takes place [21].

The results of observations at the screen house show that several genotypes tested in the treatment of various NaCl concentrations had a very significant interaction effect of all observed parameters, except the harvesting age in the screen house experiment. While the age parameters of harvest have a very significant effect on the treatment of NaCl concentration and genotype. Based on observations of plant growth on the parameters of plant height which has the highest average is MSP 14 at the normal condition (0 g L$^{-1}$ NaCl) which is 67.33 cm. As for the parameters of the number of tillers which are simple and easily observable parameters to determine sensitive or tolerant plants for certain reserves, it shows the treatment interaction between g1 (Cimalayang Muncul) at control which is 13.47. Both of these genotypes have the highest average values due to the absence of NaCl concentration. The statement was supported by Theerkulipsut et al. [22] that some types of salt including NaCl, NaSO$_4$, Na$_2$CO$_3$, and salt from calcium and magnesium compounds, each of which will provide various levels of salinity. Stress salinity in food crops can cause growth and production to be disrupted and in vulnerable types cause plants cannot grow [23, 24].

In the case of plants experiencing environmental stress, one of them is the salinity stress will result in the age of flowering and the age of harvest becomes faster, where it will cause the seed filling time to be not optimum so that a decrease in production can occur. This is a natural mechanism of plants in terms of responding to environmental stresses that occur, so that the flowering age and harvest age are faster, as in Inpari 33 and IR 29 at NaCl concentrations of 6 g L$^{-1}$ NaCl compared to other genotypes. This is supported by the opinion [25] that plants that experience salt stress will accelerate their life cycle by accelerating the flowering process.

Stress that occurs during reproduction after fertilization, greatly affects the size of the seeds and the number of seeds. Seed appearance is very dependent on the availability of available photosynthetic food reserves that can be translocated from other parts into the seeds. This is very evident in all the parameters of production observation (number of seed grains, filled grain, percentage of seeds contained, weight of 100 seeds, grain weight, and production). Nasaruddin [19] states that the size of seeds produced is very dependent on the assimilation process, either through a decrease in the rate of photosynthesis or due to a decrease in the surface area of the photosynthetic organ. In addition, this can have a direct effect on shortening the duration of seed filling, resulting in smaller size and yield of seeds.
NaCl is used as a selection agent to see genotypes belonging to the group sensitive or tolerant of salinity, consisting of sodium which can form in plant growth if the plant has nutrient deficiency, but if the content is excessive in the plant's body, then Na can also be toxic or even inhibit the growth of other nutrients. This is supported by the opinion of Hardjowigeno [26] which states that sodium can improve plant growth which is intended to show symptoms of potassium deficiency (K). Sodium is involved in the physiological process with Potassium, which blocks or prevents excessive taking or absorption of K. But if excessive Na levels in plants, it can cause poisoning which is seen directly on plant morphology.

NaCl also consists of Chlorine which is involved in the movement of water and photosynthesis in the body of the plant, but if the levels are excessive it can also cause poisoning to the body of the plant. Chlorine (Cl) is involved in the osmosis process (movement of water or solute in cells), the ion balance needed for plants to take mineral elements and in photosynthesis. If the level is excessive, it can cause symptoms of growth not normal [26].

5. Conclusions

- Genotypes that are tolerant of salinity stress at the germination phase with NaCl 6 g L⁻¹ concentrations are Inpari 43, Limboto, Inpago 10, IR 58443-6B-10-3, Inpari 35, Inpari 4, MSP 8 and Cigeulis.
- Potential rice genotypes tolerant to salinity stress with the production of > 15 g per plant in the treatment of the NaCl concentration of 6 g L⁻¹ are Inpari 35 (21.53 g per plant), Inpari 43 (20.24 g per plant), Pokali (19.39 g per plant), and IR 58443-6B-10-3 (18.87 g per plant).
- Concentration of NaCl 6 g L⁻¹ is the concentration with the highest diversity at the germination rate and can be used for testing salinity stress resistance at growth and production levels.
- Characters that have high heritability values in hydroponic salinity testing with NaCl are were percentage of germination, seed vigor index, plumule length, radicle length, flowering and harvest age, seed filling period, number of grain per panicle, filled grain, weight of 100 seeds, and production.

References

[1] Chen M, Yang Z, Liu J, Zhu T, Wei X, Fan H, & Wang B 2018 Adaptation mechanism of salt excluders under saline conditions and its applications Int. J. Mol. Sci. 19 3668.
[2] Slavich P, McLead, Moore N, Iskandar T, & Rachman A 2006 Mengatasi Pengaruh Salinitas Terhadap Pertumbuhan Tanaman di Lahan yang Terkena Dampak Tsunami di Provinsi Nanggroe Aceh Darussalam, Indonesia (NAD: BPTP NAD Balai Penelitian Tanah Indonesia).
[3] Zhenhua X, Dongmei G, Xiuli S & Ying X 2012 A review of endophyte and its use and function Adv. in Biomed. Eng. 8 124- 127.
[4] McCauley A, Jones C, & Jacobsen J 2009 Plant nutrient functions and deficiency and toxicity symptoms Nut. Manag. Mod. 9 1-16.
[5] Hariadi Y C, Nurhayati A Y, Soeparjono S & Arif I 2015 Screening six varieties of rice (Oryza sativa) for salinity tolerance Proc. Environ. Sci. 28 78-87.
[6] Suwarno & Solahudin S 1983 Toleransi varietas padi terhadap salinitas pada fase perkembangan Bul. Agron. XIV 1-11.
[7] Sadjad S 1993 Dari Benih Kepada Benih (Jakarta: Grasindo).
[8] Gedoan S P, Didik I A, & Syukur 2004 Respon kacang tunggak terhadap cekaman salinitas Agrisains 17 77-85.
[9] Rachmawati D 2000 Tanggapan tanaman sorgum terhadap cekaman NaCl: Pertumbuhan dan osmoregulasi Biologi 2 515-529.
[10] Zamir D 2001 Improving plant breeding with exotic genetic libraries Nat. Rev. Gen. 2 983-989.
[11] Nafisah A A, Daradjat B S & Triny S K 2007 Heritabilitas karakter ketahanan hawar daun...
bakteri dari tiga populasi tanaman padi hasil seleksi daur siklus pertama J. Pen. Pert. Tan. Pang. 26 100-105.

[12] Abdullah 2009 Pengantar Nanosains (Bandung: Penerbit ITB).

[13] Direktorat Perbenihan 2011 Kebijakan Perbenihan dalam Mendukung Pengembangan Usaha Penangkar Benih (Jakarta: Direktorat Jenderal Tanaman Pangan).

[14] Viana J M S & Piepho H P 2017 Quantitative genetics theory for genomic selection and efficiency of genotypic value prediction in open-pollinated populations Scient. Agric. 74 41-50.

[15] Griffiths A J, Miller J H, Suzuki D T, Lewontin R C & Gelbart W M 2000 Quantifying heritability in An Introduction to Genetic Analysis (New York: W H Freeman).

[16] Eart H J & Davis R F 2003 Effect of drought stress on leaf and whole canopy radiaus use efficiency and yield of maize Agron. J. 95 688-696.

[17] Salisbury F B & Ross C W 1995 Fisiologi Tumbuhan (Bandung: ITB).

[18] Djalil M 2003 Pengaruh pemberian Pupuk KCl terhadap pertumbuhan dan pembentukan komponen tongkol jagung hibrida Andalas 4 J. Stigma 9 303.

[19] Nasaruddin 2018 Tanggap Tanaman terhadap Lingkungannya dan Aspek Fisiologinya (Makassar: Laboratorium Fisiologi Tanaman Universitas Hasanuddin).

[20] Sharma A, Shahzad B, Kumar V, Kohli S K, Sidhu G, Bali A S, Handa N, Kapoor D, Bhardwaj R & Zheng B 2019 Phytohormones regulate accumulation of osmolytes under abiotic stress Biomolecules 9 285.

[21] Wahditiya A A 2012 Pertumbuhan Beberapa Varietas Jagung Hasil Iradiasi pada Berbagai Konsentrasi PEG dan NaCl [Theses] (Makassar: Jurusan Budidaya Pertanian Universitas Hasanuddin).

[22] Theerkulpisut P, Bunnag S & Kong-ngern K 2005 Genetic diversity, salinity tolerance and physiological responses to NaCl of six rice (Oryza sativa L.) cultivars Asian J. Plant Sci. 4 562–573.

[23] Kusumawardhani A, & Widodo W D 2003 Pemanfaatan pupuk majemuk sebagai sumber hara budidaya tomat secara hidroponik Bul. Agron. 31 15-20.

[24] Suhartini T & Try Zulchi P H 2017 Toleransi plasma nutfah padi lokal terhadap salinitas Bul. Pasma Nutfah 23 51-58.

[25] Nasution T, Hakiki, Rosmayati, & Yusuf H 2013 Respon pertumbuhan dan produksi kedelai yang diberi fungi mikoriza arbuskular (FMA) pada tanah salin J. Online Agroekoteknol. 2 421-427.

[26] Hardjowigeno S 2003 Ilmu Tanah (Jakarta: Akademika Presindo).