Seed priming alleviates crop growth inhibition by salinity

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Abstract. Salinity has become one main obstacle in increasing marginal land crop productivity. Several attempts have been made to deal with salinity. This study aimed to alleviate rice and soybean growth inhibition caused by salinity, using seed priming during pre-sowing. The factorial Randomized Completely Block Design was used in both experiments. First experiment examined the effects of seed priming using four levels of NaCl concentrations, i.e. 0.2, 150, 300 and 450 mM NaCl on the growth and yield of two rice varieties (Dendang and IR 64) in salinity. Whereas in the second experiment, the effects of seed priming using three levels NaCl concentrations, i.e. 0, 40 and 80 mM were tested on three soybean varieties (Anjasmoro, Dering and Grobogan) under salinity. The results of first experiment showed that the two rice varieties responded differently to seed priming treatments. Seed priming using 150 mM NaCl increased leaf and root surface area as well as yield in IR 64 variety. However, Dendang (the salt tolerant variety) was less responsive to seed priming compared to IR 64. Similar results were also found from the second experiment. Among three soybean cultivars, only Dering (the salt sensitive variety) which showed a positive response to seed priming up to 80 mM NaCl.

1. Introduction
As the most important food commodity in Indonesia, the rice supply needs to be increased to meet the needs of most people in Indonesia. The decreasing of agricultural land requires extensification to marginal lands. However, irrigation of agricultural land in coastal areas is often the main source of increasing salinity concentration in the soil. Watering the land with saline water for a long time will cause the accumulation of NaCl salts in the soil and will disrupt plant growth [1]. About 20% of all world agricultural land and 50% of irrigated land are affected by salinity, and even several hundred thousand hectares of irrigated land are abandoned due to salinization every year [2]. The world's dependence on irrigated rice fields is increasing. As a consequence, the total area affected by salinity has increased from 45 million hectares in the early 1990s to 62 million hectares (620,000 square kilometers) in 2014. Every day 2000 hectares of agricultural land in the world become infertile due to salinity [3].

One of the causes of salinity is due to the process of soil formation. The salt contained in the soil may present from weathering salt-containing parent materials [4]. Salinity can also be caused by intrusion of seawater [5] or saline irrigation water [6]. Similarly, land that receives low rainfall with high evaporation rates, accompanied by poor management of irrigation can cause salinity problems [7]. Continuous use of groundwater for irrigation can be followed by salt accumulation on agricultural land [5, 8, 9].

In general, salinity affects plant growth through the following mechanisms: (a) poisoning caused by excessive absorption of salt constituents, (b) decreasing water absorption and (c) decreasing absorption of essential nutrients [2, 10]. Salinity is a problem in reducing rice productivity [1, 11, 12]. If the ECe value (mS / cm) <4 then the estimated loss of rice yield is 10% [2], if the ECe value (mS / cm) 4-6 the
estimated loss is 10% -20%, if the ECe value (mS/cm) 6-10 estimated loss of yield 20% -50%, and if the ECe value (mS/cm) is 10 then the estimated loss of yield is> 50%. Increasing salinity levels from EC dSm-1 to 8 dSm-1 decreases the length of rice internodia, so the stem length decreases to 48% compared to non-saline treatment [11]. Nutritional imbalances due to salt ions cause a decrease in the efficiency of photosynthesis and ion toxicity [35]. Ion poisoning caused by large amounts of salt ions entering the 'transpiration stream' causes disruption of leaf cells thereby reducing plant growth [9, 13, 14].

Soybean is one of the third most important food commodities after rice and corn. In addition, soybeans also include crops that are rich in protein, so they have a very important role in the food and feed industry. The increasing population in Indonesia causes the level of demand for soybeans to continue to increase. Soybean plants are considered moderate sensitive to salinity stress, but the level of sensitivity differs between genotypes. The salinity threshold for soybeans according to Purwaningraty [15] is 5.0 dS/m. The potential of 50% soybean yield is achieved in soil with a salinity level of 7.5 dS/m and soybean yield decreases 20% in soil salinity of 4.0 dS/m and 56% at 6.7 dS/m [16]. Germination and early growth of soybean significantly decreased in soil salinity 11 dS/m [17], soybean germination decreased to 5% at 220 mM NaCl concentration [18]. At a salinity of 4 dS/m soybean root biomass decreased by 50%, and at 8 dS/m salinity more than 50% leaves will senesce on the pod stage [14].

One agricultural method to improve salinity resistance is by soaking the seeds before planting using osmotic solution as osmoconditioning (seed priming). According to [19], osmoconditioning is the process of adding water in a controlled manner by treating seeds in osmotic solutions before they are planted to stimulate metabolic activities in the seeds so that the seeds are ready to germinate and increase plant resistance to unfavourable environmental conditions in the field. Previous studies reported that seeds priming induced faster germination, better vigor and tolerance of drought, early flowering, early harvest and higher yields. This response has been reported in a number of plant species, i.e. in corn, rice, and beans [20].

Seed priming is a hydration treatment that affect the process of imbibition and metabolic function prior to germination, but it prevents the emergence of the radicle. Seed priming using Spermidine and Gibberellic acid improves growth disturbances due to salinity. There is an increase in antocyanins, chlorophyll, the ratio of Na+ / K+, proline and phenol compounds [21, 22].

Seed priming enables better water content regulation in seeds. Some previous studies showed that seed priming was able to increase the percentage of germination in salinity, for example: seed priming with NaCl induced rice varieties BRRI dhan41 to produce the highest percentage of germination (98.7%) and the longest roots compared to those without seed priming [23]. Seed priming with NaCl solutions was able to accelerate corn germination two days earlier compared to germination without seed priming. The yield of corn with 36% seed priming is higher than those without seed priming in the saline condition [24]. In other plants, seed priming in an annual plants of Fabaceae (Trigonella foenum-graecum L.) gave a higher percentage of germination, higher root and shoot weight, leaf area and better yield compared to those without seed priming. The seed priming treatment produced a lower Na+ content, but had a higher accumulation of K+ and Ca2+ compared to those without seed priming [25]. The seeds of safflower (Carthamus tinctorius) which were immersed in 5 g L-1 NaCl solution for 12 hours had higher salinity resistance, shown from the germination percentage, vigor index, root length and plant fresh weight [26].

Previous study by Kerns et al. [19] reported that an osmopriming treatment in soybean using 0.5% NaCl or equivalent to 80 mM NaCl soaked for 24 hours showed higher germination rates compared to those in control treatment (without NaCl immersion). Studies reported by Ahmadvand [10] also showed a significant interaction between seed induction treatment and soybean cultivars used. The application of seed priming resulted in a higher leaf area in two soybean cultivars Sahar and Gorgan-3 cultivars compared to those without seed treatments. The application of seed priming using NaCl solution was reported to increase not only germination, but also the growth of cultivated plants in salinity [27]. The present study would elaborate the effect of seed priming in crop varieties that have different salt
tolerance. Rice and soybean were evaluated since those are considered the most important crops in Indonesia.

2. Materials and Methods

2.1. First experiment

The seed priming was carried out at the Laboratory of Plant Ecology. Subsequently, all the plants were grown at a screen house from April to July 2016. Two rice varieties used in this experiment were Dendang (salt resistant variety) and IR 64 (salt sensitive Variety). The experiment was arranged in a factorial Randomized Complete Block Design. Varieties (IR 64 and Dendang) were the first factor, while NaCl concentrations applied during seed priming (0, 150, 300 and 450 mM) were included in the second factor. Each treatment consisted of 3 replications. During the growth, plants were examined twice. First, at 9 weeks after planting (wap) and then at harvest.

2.1.1. Priming Treatment. Preliminary experiment was conducted to determine the suitable NaCl concentrations applied for seed priming. All the seed used for the experiments had more than 90% germination rates and satisfactory germination speed (Index Vigor). Among several priming durations and NaCl concentrations, 1 x 24 hours of soaking and 0 - 450 mM NaCl caused neither seed injuries nor reduction in germination rate. Therefore those treatments were used for the experiment. After soaking in different NaCl concentrations, the seeds are rinsed thoroughly prior to germination in non-saline water.

2.1.2. Vegetative and Generative Stage. Following the seed priming, the rice seeds var. IR 64 and Dendang were sown for a week prior to transplanting. Two seeds were planted in each polybag. Seedlings were fertilized using manure and inorganic fertilizer, i.e. 275 kg ha\(^{-1}\), 25 kg ha\(^{-1}\), and 30 kg ha\(^{-1}\) for Urea, SP-36 and KCl respectively. Starting from 14 days after transplanting, seedlings were irrigated using 50 mM NaCl twice a week. One set of treatment was irrigated using non-saline (fresh water) as comparison. NaCl application was continued until all crops were ready to harvest.

2.1.3. Environmental and Plant Observation. During the experiment, observations were carried out in the following variables: environmental conditions, plant growth and yield, as well as plant tissue analysis. Environmental conditions observation included: temperature, relative humidity, light intensity as well as soil electric conductivity. All were measured weekly along the experiment. Plant Growth and Yield observation consisted of observations on plant growth and yield included tiller numbers (recorded weekly), shoot dry weight, leaf area, root surface area (measured at maximum vegetative stage) and plant yield (determined at harvest). Both leaf area and roof surface area were measured using Leaf Area Meter using WinDIAS software for image capturing.

Plant tissue analysis consisted of Leaf Na\(^+\) and proline concentration. Leaf Na\(^+\) concentrations were determined by grounding rice leaf. The sample was mashed, put in vials and extracted with HNO\(_3\). The vials were then shaken for 2 days continuously. The filtrate was diluted prior to be observed using a flame photometer (Jenway PFP7).

Proline concentration was analysed by grounding sample of rice leaf as much as 0.5 g, added with 10 mL 3% sulfosalicylic acid and well stirred. The filtrate was then mixed with Ninhydrine acid glacial acetic acid in waterbath of 100°C for one hour, prior to be soaked in ice for 20 minutes. Toluen was added and stirred for 20 seconds. The absorbent solution is read using Spectronic 21D Milton Roy at a wavelength of 520 µm.

2.2. Second experiment

In the second experiment, seeds of soybean were primed using different concentrations of NaCl. The seed priming experiment was conducted at Ecology laboratory, while seedlings were grown in a glass
house, in Faculty of Agriculture, Universitas Gadjah Mada. Three varieties were used, i.e. Anjasmoro, Dering and Grobogan. Whereas the seed priming consisted of three NaCl concentrations, 0, 40 and 80 mM. Both factors were arranged in a factorial Randomized Complete Block Design. One set non-saline treatment was set up as control.

2.2.1. Priming Treatment. Similar with the first experiment, a preliminary experiment was also carried out to determine the range of NaCl concentrations and the priming duration that may give good impact on soybean germination and growth. A study reported that 0.5% NaCl (≈ 80 mM NaCl) increased germination rate in soybean (Kujur dan Lal, 2015). Other study reported that 6 hours seed priming resulted in the highest soybean germination rates [2]. Among any NaCl concentrations that we had applied in our preliminary experiment, it showed that 40 and 80 mM NaCl lead to the highest germination rates, and therefore these concentrations was used in the present experiment.

2.2.2. Vegetative and Generative Stage. Seeds of three varieties of soybean (Anjasmoro, Dering and Grobogan), which had been previously soaked in NaCl concentrations, were then planted on pots. Two seeds were planted in each polybag. Seedlings were fertilized using manure and inorganic fertilizer, i.e. 75kg.ha⁻¹, 100 kg.ha⁻¹, and 50 kg.ha⁻¹ for Urea, TSP and KCl respectively. Starting from 14 days after transplanting, seedlings were irrigated using 50 mM NaCl twice a week. One set of treatment was irrigated using fresh water as comparison.

2.2.3. Environmental and Plant Observation. During the experiment, environmental condition was observed as with the first experiment. Observations on plant growth and yield included leaf Area Index, Net Assimilation Rates, Crop Growth Rate and Yield components. Net Assimilation Rate (NAR) and Crop Growth Rate (CGR) were calculated based on the following formula:

\[
NAR \left( \frac{g}{dm^2/week} \right) = \frac{(W_1 - W_2)}{(T_2 - T_1)} \times \frac{(LnLa_2 - LnLa_1)}{(La_2 - La_1)}
\]
\[
CGR \left( \frac{g/m^2/week} \right) = \frac{1}{Ga} \times \frac{(W_2 - W_1)}{(T_2 - T_1)}
\]

W = dry weight of plants,  La = Leaf area, T = Observation time, La = Leaf Area.

Observations in yield components consisted of percentage of empty pods, number of pods per plant, soybean seed weight and harvest index. To analyse chlorophyll content, one g of soybean leaves is pounded with mortar, then 20 ml of 80% acetone is added and filtered with Whatman no. 2. The absorbent solution is read using Spectronic 21D Milton Roy at a wavelength of 645 µm and 663 µm. Content of chlorophyll a and b are calculated using the formula:

\[
\text{Chlorophyll level } a = (0.0127 \times A_{663} - 0.00269 \times A_{645}) \times 20 \text{ ml}
\]
\[
\text{Chlorophyll level } b = (0.0229 \times A_{645} - 0.00468 \times A_{663}) \times 20 \text{ ml}
\]

Total chlorophyll = chlorophyll level a + chlorophyll level b

A_{645} = Absorbance at a wavelength of 645 µm.
A_{663} = Absorbance at a wavelength of 663 µm.
2.3. Data analysis
Data were analyzed using analysis of variance with a confidence level of 95% in *SAS Portable* 9.1.3 software. The Duncan Multiple Range Test (DMRT), with a confidence level of 95% was used for further test.

3. Results and Discussion

3.1. Rice growth and yield
During both experiments, light intensity (10,000-70,000 Lux), air temperature (25-34°C), relative humidity (50-90%) were still within the optimal range for rice and soybean growth. Environmental data is important to ensure that the results obtained were the effect of the intended treatments. The observed soil Electrical Conductivity showed a slight fluctuation, ranged from 3 to 7 dS m⁻¹ for the salinity treatment, and less than 1 dS m⁻¹ for non-saline treatment.

The high Electrical conductivity in growing medium indicated high concentrations on Na⁺ and Cl⁻ that might be adsorbed by plant via root plasma membrane, to be translocated upwards through transpiration stream and ended up being accumulated in older leaves. The Figure 1 shows the occupation of Na⁺ in leaves in IR 64 rice, at different concentrations of NaCl at seed priming. There is no difference in Na⁺ concentrations in leaves among different seed priming treatments. Dendang variety was also similar features. However, plants that was irrigated using non-saline water had significantly lower leaf Na⁺ concentration.

![Figure 1](image_url)

**Figure 1.** Leaf Na⁺ concentrations of IR 64 rice varieties primed with four different NaCl concentrations during pre-germination. NS: Non Saline treatment; 0: 0 mM NaCl; 150: 150 mM NaCl; 300: 300 mM NaCl; 450: 450 mM NaCl seed priming.

Salinity reduced some growth variables such as leaf area and root surface area at 9 weeks after planting (Table 1). Seed priming with different NaCl concentrations could not increase those variables to reach the non-saline values. However, compared to the salt tolerant variety (Dendang), IR 64 responded better to seed priming, as shown by the increase of leaf and root surface area, when the seed was primed with 150 mM NaCl.
The number of tillers in Figure 1 showed an inhibition of salinity in both varieties. Rice plants which were irrigated with non-saline water had approximately twice tillers compared to those irrigated with saline water. Meanwhile seed priming with 150 mM NaCl produced a slightly more tillers than those without seed priming or seed priming with higher NaCl concentrations (Fig. 1).

**Table 1.** Leaf area and root surface area of IR 64 and Dendang rice varieties primed with four different NaCl concentrations during pre-germination.

| NaCl (mM) | Leaf Area 9 wap (dm²) | Root surface area 9 wap (cm²) |
|-----------|-----------------------|-------------------------------|
|           | IR 64 | Dendang | IR 64 | Dendang |
| 0         | 224 ab | 298 a  | 81.1 ab | 177 a |
| 150       | 336 a  | 264 a  | 172 a  | 90.4 a |
| 300       | 243 ab | 259 a  | 80.3 ab | 71.4 a |
| 450       | 210 b  | 282 a  | 64.7 b  | 50.2 b |
| Salinity  | 254 q  | 276 q  | 99.5 q  | 97.4 q |
| Control   | 511 p  | 743 p  | 214 p  | 226 p  |

CV (%) 2.05 3.54 37.37 8.04

Data given are means, n = 3. Same letters indicate no significant differences at $P = 0.05$ (comparisons down columns, within varieties). The variables were measured at 9 weeks after planting.

**Figure 2.** Tiller numbers of IR 64 and Dendang varieties when exposed to salinity during vegetative stage. A (Varieties) includes A1: IR 64, A2: Dendang. B (Seed priming with NaCl) includes B0: 0 mM, B1: 40 mM, B2: 150 mM, B3: 300 mM and B4: 450 mM.

The increase of proline may be a good indicator that plants are under abiotic stresses. The presence of salinity significantly increased proline concentrations up to four times in both varieties. However,
there was no indication that seed priming with different NaCl concentrations could alter proline concentrations (Table 2). The increase of proline was followed by the decrease in total plant dry weight. Salinity significantly decreased total dry weight both in IR 64 and Dendang rice varieties. However, different seed priming concentrations did not give effect on total dry weight.

Having larger leaf and root surface area give benefits to IR 64 plant which previously treated with 150 mM NaCl, to perform higher assimilation rate and possibly better water uptake. Photosynthesis processes was depended on sufficient water uptake. Hence, this variety responded positively to 150 mM NaCl seed priming by giving better grain yield, compared to other seed priming treatments. Dendang, the salt tolerant variety, did not show significant responses to all concentrations of seed priming [28].

### Table 2. Proline and total dry weight of IR 64 and Dendang rice varieties primed with four different NaCl concentrations during pre germination.

| NaCl (mM) | Proline (μmol g⁻¹) | Total Dry Weight (g) |
|-----------|------------------|---------------------|
|           | IR 64            | Dendang            | IR 64            | Dendang            |
| 0         | 21.17 a          | 18.86 a            | 12.76 a          | 17.08 a            |
| 150       | 14.24 a          | 22.92 a            | 17.88 a          | 18.63 a            |
| 300       | 12.65 a          | 13.31 a            | 12.63 a          | 18.40 a            |
| 450       | 15.16 a          | 17.99 a            | 9.64 a           | 17.70 a            |
| Salinity  | 15.80 p          | 18.27 p            | 13.23 p          | 17.96 q            |
| Control   | 4.62 q           | 4.82 q             | 37.97 q          | 64.84 p            |
| CV (%)    | 34.58            | 46.6               | 30.82            | 30.68               |

Data given are means, n = 3. Same letters indicate no significant differences at P = 0.05 (comparisons down columns, within varieties). The variables were measured at 9 weeks after planting.

### Table 3. Grain yield/pot of IR 64 and Dendang rice varieties primed with four different NaCl concentrations during pre-germination.

| NaCl concentrations (mM) | Yield/ pot (g) |
|--------------------------|----------------|
|                          | IR 64          | Dendang         |
| 0                        | 4.23 b         | 3.83 a          |
| 150                      | 7.00 a         | 3.85 a          |
| 300                      | 3.85 b         | 3.58 a          |
| 450                      | 3.71 b         | 3.65 a          |
| Salinity                 | 4.69 q         | 3.73 q          |
| Control                  | 20.35 p        | 28.99 p         |
| CV (%)                   | 37.37          | 8.04            |

Data given are means, n = 3. Same letters indicate no significant differences at P = 0.05 (comparisons down columns, within varieties).

### 3.2. Soybean growth and yield

Soybean growth during salt exposure would depend on the amount of Na⁺ entered the plant cells and interacted with the existing K⁺ within cytoplasm. The Na⁺ concentrations in leaves of three soybean varieties were not significantly different, but those concentrations were higher than those in non-saline treatments. The high Na⁺ concentrations was reported to displace K⁺ and could lead to K⁺ leakage out of cytoplasm. Figure 3 shows that salinity resulted in lower Na⁺/K⁺ ratios. Among the three varieties, Dering, the sensitive varieties, had the least ratio.
Having lower Na\(^+\)/K\(^+\) ratio might indicate that Dering variety could not resist to the high internal Na\(^+\) concentrations, as with the other two varieties. The low Na\(^+\)/K\(^+\) ratio in Dering variety enabled this plant to have wider leaf area and finally higher plant dry weight (Table 4). Compared to Anjasmor and Grobogan varieties, Dering had larger Crop Growth Rate and Net Assimilation Rate (Table 5), hence were able to accumulate larger biomass in non-saline condition. Seed priming using 40 and 80 mM NaCl also significantly increased leaf area and total dry weight.

![Figure 3. Na\(^+\)/K\(^+\) ratios of three varieties of soybean at seven weeks after planting. V1: Anjasmor; V2: Dering; V3: Grobogan varieties.](image)

**Table 4.** Leaf area and total dry weight of three soybean varieties primed with four different NaCl concentrations during pre-germination.

| Treatments | Leaf area (cm\(^2\)) | Total dry weight (g) |
|------------|-----------------------|----------------------|
| **Cultivars** | | |
| Anjasmor | 1595 a | 12.48 b |
| Dering | 1822 a | 16.79 a |
| Grobogan | 950 b | 9.18 b |
| **NaCl (mM)** | | |
| 0 | 1221 q | 11.09 q |
| 40 | 1482 pq | 120.05 pq |
| 80 | 1664 p | 15.31 p |
| **Interaction** | | |
| CV | 29.42 | 31.54 |

Data given are means, n = 3. Same letters indicate no significant differences at \(P = 0.05\) (comparisons down columns, within variables).

The effect of seed priming in soybean was clearly seen in Figure 4. There was no interaction between variety and Net Assimilation Rate. Seed priming with 80 mM NaCl significantly increase Net Assimilation Rate in all soybean varieties tested [8].
Table 5 shows that total chlorophyll content did not decrease in salinity. However, compared to the other varieties, Dering showed significant reduction (≈ 25 %) in Crop Growth Rate as well as Net Assimilation Rate when exposed to salinity.

**Figure 4.** Net Assimilation Rates of three soybean varieties (average of Anjasmoro, Dering and Grobogan) at 4-7 weeks after planting.

Table 5. Total chlorophyll, crop growth rate, and net assimilation of three soybean varieties primed with four different NaCl concentrations during pre-germination.

| Varieties   | Total Chlorophyll (mg/g) | CGR (g/g/week) | NAR (g/dm²/week) |
|-------------|--------------------------|----------------|------------------|
| Anjasmo     |                          |                |                  |
| Non-Saline  | 2.24 a                   | 0.54 a         | 0.24 a           |
| Saline      | 2.27 a                   | 0.43 a         | 0.29 a           |
| Dering      |                          |                |                  |
| Non-Saline  | 1.99 a                   | 0.81 a         | 0.64 a           |
| Saline      | 1.53 a                   | 0.63 b         | 0.46 b           |
| Grobogan    |                          |                |                  |
| Non-Saline  | 1.97 a                   | 0.61 a         | 0.36 a           |
| Saline      | 1.77 a                   | 0.25 a         | 0.15 a           |

CGR and NAR were evaluated at 4 to 7 weeks after planting. Total chlorophyll was analysed at maximum vegetative stage. Data given are means, n = 3. Same letters indicate no significant differences at $P = 0.05$ (comparisons down columns, within variety).

The reduction in CGR and NAR lead to a decline in Dering yield components at harvest. The lower plant biomass due to less assimilate production in Dering as exposed to salinity is likely to increase the percentage of empty pods, since large capacity of sink (number of pods per plant at non-saline) could not be fulfilled by limited source (Table 6).

As compared with other soybean varieties which have better salt tolerant, Dering responded better to salt priming. As seen in Table 7, only Dering variety which could impair its percentage of empty pods
with seed priming treatments. Compared to Dering, the other varieties (Anjasmoro and Grobogan) did not show significant improvement in many growth and yield variables.

Table 6. Number of pods per plant, percentage of empty pods, harvest index and soybean seed weight of three soybean varieties primed with four different NaCl concentrations during pre-germination.

| Varieties  | Number of pods per plant | Percentage of empty pods | Harvest Index | Soybean seed weight (g) |
|------------|--------------------------|--------------------------|---------------|-------------------------|
| Anjasmoro  |                          |                          |               |                         |
| Non-Saline | 76 a                     | 12.00 a                  | 0.48 a        | 21.46 a                 |
| Saline     | 43 a                     | 5.33 a                   | 0.34 b        | 9.39 a                  |
| Dering     |                          |                          |               |                         |
| Non-Saline | 140 a                    | 17.14 b                  | 0.13 a        | 7.20 a                  |
| Saline     | 29 b                     | 68.69 a                  | 0.06 b        | 0.19 b                  |
| Grobogan   |                          |                          |               |                         |
| Non-Saline | 13 a                     | 0 a                      | 0.36 a        | 5.97 a                  |
| Saline     | 15 a                     | 6.61 a                   | 0.43 a        | 4.47 a                  |

All the yield components were determined at harvest. Data given are means, n = 3. Same letters indicate no significant differences at $P = 0.05$ (comparisons down columns, within variety).

Table 7. Percentage of empty pods of three soybean varieties primed with four different NaCl concentrations during pre-germination.

| Varieties  | Percentage of empty pods (%) | Average | mM NaCl |
|------------|------------------------------|---------|---------|
|            | 0                            | 40      | 80      |
| Anjasmoro  | 5.33 b                       | 14.32 b | 7.01 b  | 8.89     |
| Dering     | 68.69 a                      | 9.68 b  | 12.95 b | 27.48    |
| Grobogan   | 6.61 b                       | 9.09 b  | 6.73 b  | 7.48     |
| Average    | 21.65                        | 11.03   | 8.39    | (+)      |

Data given are means, n = 3. Same letters indicate no significant differences at $P = 0.05$. (+) is a sign of an interaction between variety and NaCl concentrations.

4. Conclusion

The growth and yield of rice and soybean were significantly reduced during salt exposure. In rice, the present of high $\text{Na}^+$ in growing medium resulted in higher $\text{Na}^+$ accumulation in leaves. Seed priming using 150 mM NaCl promoted rice IR 64, salt sensitive variety to have wider leaves as well as larger root surface area. These characters might enable plants to build more biomass to produce higher yield. However, seed priming did not affect the salt tolerant rice.

Among three soybean varieties, Dering was the most sensitive to salt. The reduction in its relative growth and assimilation rate was more evidenced than other varieties tested. Application of seed priming promoted this variety to increase assimilation rate. The larger biomass production than the other varieties leads to better pod and seed formation in Dering. However, this mechanism was unlikely to be adopted by the other two varieties that have more tolerance to salt.
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