Effect of salinity on agronomic characteristics of three rice varieties (*Oryza sativa* L.) at tillering stage

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Abstract

This research aims to identify the effects of salinity from sodium chloride (NaCl) on agronomic characteristics of Thai rice varieties as compared with a tolerant variety for salinity stress at the tillering stage. The experiment was conducted as a 4x3 (CRD). The first factor consists of four concentrations of NaCl. The second factor consists of three lowland-rice varieties, namely, Inpari 35 (salt-tolerant rice variety) and two Thai rice varieties, Pathum Thani 1 (PTT1) and Chai Nat 1 (CNT1). The results showed the effects on all observed characteristics: tillers, plant height, and score symptoms on plant. In the first week after adding salinity (three weeks after planting), the salinity stress initially affected leaf symptoms in all rice varieties. However, the salinity stresses severely affected the number of tillers per plant more than other traits at three weeks after adding salinity (five weeks after planting). Overall means of observed agronomic characteristics values of Inpari 35 generally showed higher values than PTT1 and CNT1 in one and three weeks after adding salinity. Inpari 35 also showed a lower reduction percentage (compared with the normal condition; 0 mM NaCl) than two Thai rice (CNT1 and PTT1) at three weeks after adding salinity, especially in the number of tillers per plant from the concentration of 50 mM NaCl onward.

Keywords: *Salinity stress, Thai rice, Tillering stage, Rice varieties, Salinity susceptible*

1. Introduction

More than fifty percent population in the world, commonly people in developing countries, consume rice as a staple food (Seck et al., 2012). Thus, rice is considered as one of the plants belonging to the monocot system, with the most important role in cereal crops classified in the agronomic field. (Lee et al., 2011). Apart from the consumption, rice cultivation can create employment and income, which is considered most important for Asian farmers who live in fertile humid land that is suitable for rice cultivation (Smith et al., 2007). Considering these apparent benefits, rice farming development should be improved rapidly, both on yield and quality. Instead, it was found that many factors can hinder the global development for increasing rice yield and quality such as environmental factors (Mariano et al., 2012). Climate change is one of the environmental challenges affecting crop production and can disrupt food availability. Global warming, for example, can cause an increase in temperature, a reduction in water availability, and the outbreak of pests in the field; ultimately, resulting in reduced agricultural productivity (Hatfield et al., 2011). For these reasons, the screening of plants under either biotic or abiotic stresses are important for the success of selection in breeding program (Khush, 2005).

In rice production, climate change will aggravate a variety of stresses, namely heat, drought, salinity, and submergence (Wassmann et al., 2009). Salinity is one of the major impediments to increasing production in rice-growing areas worldwide, being secondary only to drought (Flowers & Yeo, 1995). Rice threshold for salt stress is 3 dS/m, with a 12% reduction in yield per dS/m beyond this value (Maas, 1990), making rice a salt-sensitive crop (Maas & Hoffman, 1977; Chinnusamy, Jagendorf, & Zhu., 2005). Rice yield in salt-affected land is significantly reduced, with an estimation of 30–50% yield loss annually (Eynard, Lal, & Wiebe, 2005). Additionally, rice sensitivity to salt stress was found to vary according to the growth stage (Lutts, Kinet, & Bouharmont, 1995; Shannon et al., 1998; Zeng & Shannon, 2000). During germination, rice is more tolerant to salt than during other growth stages (Khan et al., 1997). However, rice becomes sensitive at the seedling stage, tillering stage, and reproductive phase (Lutts, Kinet, & Bouharmont, 1995; Zeng & Shannon, 2000; Shereen et al., 2005).

For these reasons, a study to determine the level of salinity affecting important agronomic characteristics in a vegetative stage, the period of tiller establishment, is required. Data obtained will be highly useful for both conducting plantation of a specific rice variety in saline soil and genetic improvement for salinity tolerance. Moreover, the results can be used in the management in the rice field, such as water supplying and administering other external factors to increase rice growth under severe salinity stress.

2. Objective

This research aims to identify the effects of salinity from sodium chloride (NaCl) on the agronomic characteristics of three rice varieties at the tillering stage.

3. Materials and methods

3.1 Plant material, salinity levels, and cultural practice

A total of three lowland rice varieties were used in this study. Two Thai rice varieties obtained from a seed distribution agency that has been certified in Thailand were Chai Nat 1 (CNT1) and Pathum Thani (PTT1). These varieties are well-known and used by most Thai farmers because of their high yield capacity and non-photosensitive properties. Besides, they can be grown in both rainy and dry seasons that rely on irrigated water. However, both CNT1 and PTT1 were reported to be susceptible to salinity (Amano et al., 1993; Cha-am et al., 2008). Another variety of rice is Indonesian rice named Inpari 35. Inpari 35 is a saline tolerant variety and can be grown at 12 dS/m salinity in paddy fields (Hairmansis, Nafisah, & Jamil, 2017).

Treatments include four levels of salinity, prepared by different concentrations of sodium chloride **(**NaCl**)**: 0 mM (control; 0 dS/m), 50 mM (5 dS/m), 100 mM (10 dS/m), and 150 mM (15 dS/m). Rice seeds from each variety were soaked in water for 24 hours and then sown into the soil at the depth of 2-3 cm at the nursery for two weeks. The seedlings were transferred from the nursery to a polybag of size 15 cm x 28 cm (diameter x height), by maintaining three plants per polybag. The rice plants started to receive salinity water after 2 weeks of transplanting. Salinity stress was manipulated by pouring salinity solution in each polybag according to treatment concentration once a week. Each polybag received normal nil water twice every day for maintenance.

3.2 Soil physical and chemical properties

Some physical and chemical properties of soil sampling were measured before the study begins. Soil properties include soil texture, which is Sandy loam with 70.97% sand, 20.43% silt, and 8.60% clay, and soil organic matter (OM), which is 0.93 % (determined by the Walkley and Black method). Soil pH (measured in 1:1 soil and water solution ratio using a pH meter) is 6.39. The electrical conductivity of the saturated soil extract (ECe) is 0.92 dS/m, and the sodium adsorption ratio (sodium and calcium in saturated soil extract) (SAR) is 0.22. Chemical nutrient available properties in soil were determined such as phosphorus (P) (determined by Bray II extraction) (5.18 mg/kg), potassium (K) (83.09 mg/kg), calcium (Ca) (88.31 mg/kg), and magnesium (Mg) (69.98 mg/mg). Electrical conductivity ($EC_{1:5}$) (soil: water ratio at 1:5) was evaluated again after receiving water salinity following each treatment of NaCl concentration. The results showed that $EC_{1:5}$ were 0.02, 4.81, 9.84, and 14.39 dS/m for 0, 50, 100, and 150 mM NaCl, respectively.

3.3 Determination of agronomic characteristics

Data of four agronomic characteristics were recorded, including the number of leaves, the number of tillers, plant height, and leaf symptom score, at Week 1 and Week 3 after adding the salinity**.** The data were collected from three plants in each polybag**.** The height of the plant (cm) was measured from the base of the stem to the tip of the highest leaves**.** Leaf number and tiller number per plant were counted from each plant by recording the new leaf that comes out of the tip of the stem**.** A score of leaf symptoms was estimated based on the modified standard evaluation score (SES) of visual salt injury (Gregorio, Semadjora, & Mendoza, 1997**)**. Leaf score injured from salinity is evaluated as 1) Highly tolerant; normal growth and no leaf symptoms, 3) Tolerant; virtually normal growth but leaf tips or few leaves whitish and rolled, 5) Moderately tolerant; growth severally retarded, most leaves dry, and some plants dying, 7) Susceptible; complete abolition of growth, most leaves dry, and some plants dying, and 9) Highly susceptible; almost all plants dead or dying**.**

The reducing/increasing percentage in all four characteristics at each salinity level was calculated compared with value at the normal condition at 0 dS/m salinity as followed**:**

Reducing/increasing percentage (%) = [(Value at salinity level - Value at normal condition) / Value at normal condition] x 100

3.4 Statistical analysis

The experiment was conducted in Factorial 4x3 (salinity levels x varieties) in Completely Randomized Design (CRD) with 5 replications. The data were analyzed using the analysis of variance (ANOVA) for statistically significant difference between treatments, then compared the treatments using Duncan's New Multiple Range Test (DMRT). All statistical analysis was performed using the R program (R Core Team, 2017).

3.5 Site experiment

The study was conducted at the Faculty of Animal Sciences and Agricultural Technology, Information and Technology Campus, Silpakorn University, Phetchaburi Province, Thailand, in 2020.

4. Result and Discussion

The effects of different salinity levels on agronomic characteristics of three rice varieties were evaluated on four agronomic characteristics at one week after adding salinity or three weeks after planting (Table 1). Four measured characteristics, namely the number of leaves per plant, the number of tillers per plant, plant height, and leaf symptom scoring, were significantly affected by the variety of rice. However, the salinity level and interaction between the variety and salinity did not result in a significant difference in agronomic characteristics (except the effects of the salinity level on leaf symptom scoring) (Table 1). The highest number of leaves per plant and plant height was found in Inpari 35. The highest number of tillers per plant was observed in PTT1. The lower three characteristics; the number of leaves per plant, the number of tillers per plant, and plant height were recorded in CNT1. For the leaf symptom scoring, a higher score was found in both Thai rice; PTT1 and CNT1.

The percentage of decreasing or increasing (values in parenthesis), as compared with the normal condition (0 dS/m salinity) was calculated at Week 1 since tillering establishment was found (Table 1). Increasing the salinity affected differently in varieties and characteristics. No reduction percentage was observed in the number of tillers per plant in all varieties; Inpari 35, PTT1, and CNT1, in which positive values were presented. Although tiller numbers showed an increasing trend at higher salinity stress, effective or non-effective tillers could not be detected at the beginning of the tillering stage. Many characteristics of Thai rice varieties were affected by the salinity, demonstrating a negative percentage in the number of leaves per plant and plant height and a positive percentage in leaf symptom scoring.

No significant difference in the effects of salinity was found on three characteristics; the number of leaves per plant, the number of tillers per plant, and plant height (Table 1). The findings showed very similar actual values in salinity levels and low percentages, either positive or negative, as compared with the actual value at 0 dS/m in each character in any variety. However, only Inpari 35 had a positive change percentage under increasing salinity stress for the number of leaves per plant and the number of tillers per plant. This finding in Inpari 35 could mean the effects of the salinity at one week after adding salinity.

A significant difference was found in leaf symptom scores ($P<0.01$) (Table 1). At higher salinity levels (100 mM and 150 mM NaCl), it showed either higher actual scores or higher positive percentages as compared with the control condition (at 0 mM NaCl). The results in leaf symptom score showed an effect by the salinity stress, although, not much to decreasing on other agronomic traits recorded in the first week after adding salinity. The symptoms of leaves such as yellowing leaves and pale and burn-like appearance at the tips of plant leaves were reported as a result of the salinity stress (Liu et al., 2019). These leaf symptoms can affect plant physiology, reducing the effectiveness of the leaf's sunlight absorption and photosynthesis. The presence of these symptoms on leaves can also negatively impact the number of leaves, the size of leaves, withering, and scorch (Tatagiba, DaMatta, & Rodrigues, 2016). Besides, the plant stems can become stunted, leading to death. Though, other plant parts that interfere with carrying out activities in the transportation process and metabolism can run normally (Tatagiba, DaMatta, & Rodrigues, 2016).

The influence of leaf formation, plant height, number of tillers, and other agronomic properties occurs at the vegetative and reproductive stages (Hussain et al., 2019). Salt stress can cause symptoms in plants such as reduced leaf numbers, decreased plant height, and reduced formation number of tillers (Elias et al., 2020). Some plants can also demonstrate stunted growth, chlorosis, interveinal chlorosis, and necrosis during salt stress (Acosta-Motos et al., 2017).

Table 1 Effect of different salinity levels (0 mM, 50 mM, 100 mM, and 150 mM NaCl) on number of leaves per plant, number of tillers per plant, plant height, and leaf symptom score of three rice varieties [(Inpari 35, Pathum Thani 1 (PTT1) and Chai Nat 1 (CNT1)], at week 1 after adding salinity

Variety/Salinity	**Characteristic values (% NC)**			
	Number of leaves per plant	**Number of tillers per plant**	**Plant height (cm)**	**Leaf symptom scoring**
Inpari 35				
0 mM **(NC)**	14.0 ± 1.2	3.2 ± 0.4	55.7 ± 2.1	1.2 ± 0.4
50 mM **(% NC)**	14.8 ± 1.1 **(**+5.71**)**	3.6 ± 0.6 **(**+12.50**)**	55.7 ± 5.2 (0.00)	1.4 ± 0.6 **(**+16.67**)**
100 mM **(% NC)**	14.6 ± 1.7 **(**+4.29**)**	3.8 ± 0.4 **(**+18.7**)**	53.8 ± 5.6 **(**-3.41**)**	2.0 ± 0.0 **(**+66.67**)**
150 mM **(% NC)**	14.4 ± 1.5 **(**+2.86**)**	3.4 ± 0.6 **(**+6.25**)**	52.1 ± 3.9 **(**-6.46**)**	2.4 ± 0.6 **(**+100**)**
Mean **(**Inpari 35**)**	14.4 ± 1.3 a	3.5 ± 0.5 b	54.3 ± 4.3 a	1.8 ± 0.6 a
PTT1				
0 mM **(NC)**	13.4 ± 1.7	3.4 ± 0.6	48.9 ± 4.5	1.4 ± 0.9
50 mM **(% NC)**	12.8 ± 1.3 **(**-4.48**)**	3.8 ± 0.4 **(**+11.76**)**	48.2 ± 5.3 **(**-1.43**)**	1.8 ± 0.4 **(**+28.57**)**
100 mM **(% NC)**	14.6 ± 1.8 **(**+8.96**)**	3.6 ± 0.6 **(**+5.88**)**	47.3 ± 3.1 **(**-3.27**)**	2.4 ± 0.6 **(**+71.43**)**
150 mM **(% NC)**	11.8 ± 1.5 **(**-11.94**)**	3.6 ± 0.6 **(**+5.88**)**	47.9 ± 4.4 **(**-2.04**)**	3.0 ± 0.0 **(**+114.29**)**
Mean **(**PT1**)**	12.6 ± 1.6 b	3.6 ± 0.5 a	48.1 ± 4.1 b	2.2 ± 0.8 b
CNT1				
0 mM **(NC)**	13.8 ± 1.8	4.2 ± 0.8	50.1± 2.3	1.2 ± 0.4
50 mM **(% NC)**	13.6 ± 2.0 **(**-1.45**)**	4.2 ± 0.4 (0.00)	48.9 ± 3.0 **(**-2.40**)**	2.0 ± 0.7 **(**+66.67**)**
100 mM **(% NC)**	12.8 ± 1.1 **(**-7.25**)**	4.2 ± 0.4 (0.00)	48.1 ± 2.3 **(**-3.99**)**	2.8 ± 0.4 **(**+133.33**)**
150 mM **(% NC)**	12.6 ± 1.7 **(**-8.70**)**	4.4 ± 0.9 **(**+4.76**)**	48.0 ± 1.3 **(**-4.19**)**	2.8 ± 0.4 **(**+133.33**)**
Mean **(**CNT1**)**	13.2 + 1.6 b	4.2 ± 0.6 b	48.8 ± 2.3 b	2.2 ± 0.8 b
Over all mean	13.4	3.8	50.4	2.03
0 mM **(NC)**	13.7 ± 1.5	3.6 ± 0.7	51.6 ± 4.2	1.3 ± 0.6 A
50 mM **(% NC)**	13.7 ± 1.6 **(**0.00**)**	3.9 ± 0.5 **(**+8.33**)**	51.0 ± 5.6 **(**-1.16**)**	1.7 ± 0.6 B **(**+30.77**)**
100 mM **(% NC)**	13.3 ± 1.8 **(**-2.92**)**	3.9 ± 0.5 **(**+8.33**)**	49.7 ± 4.7 **(**-3.68**)**	2.4 ± 0.5 C **(**+84.62**)**
150 mM **(% NC)**	12.9 ± 1.8 **(**-5.84**)**	3.9 ± 0.8 **(**+8.33**)**	49.3 ± 3.8 **(**-4.46**)**	2.7 ± 0.5 C **(**+107.69**)**
P value (Varieties)	0.0016**	0.00024 **	4.43×10^{-6} **	0.0153 *
P value (Salinity)	0.423 NS	0.547 NS	0.340 NS	9.7×10^{-10} **
P value (Salinity**:**Variety)	0.821 NS	0.864 NS	0.976 NS	0.628 NS
CV (%)	11.55	15.25	7.60	25.41

Note**:** NC = normal condition, CV = Coefficient of variance), *, ** = Significant difference at 0.05 and 0.01 levels of probability, respectively, NS = Non-Significant difference at 0.05 level of probability, Lower case letters **(**a, b, c,**…)** =

significant difference at 0.05 level of probability, Upper case letters (A, B, C) = significant difference at 0.05 level of probability.

The effects of salinity stress are related to the availability of nutrients contained both from plants and in the soil, including the photosynthesis process. Salt stress, the various initial steps in the diagnosis of nutrient deficiency, namely to explain the symptoms and function of each nutrient associated with plants (Hatibu, 2018). Stunting is a common symptom of many nutrient deficiencies due to their different roles in plants (Hajiboland, 2018), for example, when the nutrients involved in plant functions such as plant leaves become pale, the leaves become smaller but possibly a little thicker than normal, reducing for photosynthesis, and when protein production is lacking, plant growth is usually slow and the plants are small (Elemike et al., 2019).

Salinity also has a stress effect on plants, causing a nutrient imbalance. NaCl treatment can induce potassium (K) deficiency and increase sodium (Na), calcium (Ca), magnesium (Mg), and chloride (Cl) in rice plants (Chrysargyris et al., 2019). This imbalance of salt associated with the redox system can cause oxidation damage, especially on nucleic acids, fats, and proteins. At the beginning of the salinity stress, the plant might respond by releasing several antioxidant enzymes and osmoprotectant molecules to protect their tissue from toxins and oxidative residues. However, if the effect of salinity is longer and greater, the plant's ability to respond to stress tolerance in plants is reduced (Ahmad et al., 2019).

Moreover, rice susceptible to salinity, an abiotic factor, can become less resistant to other biotic stressors, such as diseases and insects. This is obviously due to the deterioration of plant health under the stress condition, however, might be variety specific (Quais et al., 2020). A low concentration of salinity stress was reported to stimulate plant growth, but a high concentration can severely decrease a plant's physiological characteristics (Warne et al., 1990; Yu et al., 2018). The duration that plants experiencing salinity stress is also an important consideration for management (Eisa et al., 2012). It had been found in many plants that were stressed that high salt concentration greatly affects physiological and biochemical processes in plants and will have decreased yield production and eventual death (D'antonio & Meyerson, 2002).

For rice at three weeks after transplanting, both variety and salinity showed highly significant ($P<0.01$) (Table 2) effects on all four characteristics; the number of leaves per plant, the number of tillers per plant, plant height, and leaf symptom score (Table 2). However, a non-significant difference was shown in the effect of interaction between the variety and salinity in all these characteristics. The overall means of leaf symptom score at ≥100 mM NaCl showed a positive percentage as compared with the value at 0 mM NaCl. There were different responses for salinity levels in each rice variety. A positive percentage, as compared with the normal condition (0 mM NaCl), was found at the salinity levels of 50 mM, 100 mM, and 150 mM NaCl in PTT1, Inpari 35, and CNT1 (Table 2), respectively. These results demonstrate that the rice's responses to the salinity stress depend on the genetic factor since PT1 had a higher leaf symptom score while Inpari 35 and CNT1 had lower scores.

In contrast, Inpari 35 showed higher values of the number of leaves per plant, the number of tillers per plant, and plant height than CNT1 and PTT1. The lowest number of tillers per plant and the highest leaf symptom score were shown in PTT1, as compared with other varieties. Hence, there is a possibility that PTT1 was more susceptible to salinity stress than CNT1 and Inpari 35. Tiller numbers per plant in rice are very important to yield component since the value of the trait could indicate the final yield (Xue et al., 2008). Tiller establishment is affected by both genetic and environmental factors (Hussien et al., 2014).

Salinity stress can affect many yield components and yields in rice (Shannon, 2000). In plants experiencing moderate stress from high salinity levels, the salt is generally spread to several parts of the plants while causes symptoms on the leaves and reduces the number of leaves, the number of tillers, and plant height (Weon et al., 2003). Salinity has the most severe impact on plant growth and development at high concentrations. Salinity inhibits the activity of cells in food transportation in various parts of the plant (Kumar et al., 2020). The presence of salt stress can minimize the synthesis of chlorophyll pigments, and photosynthesis experiences a rate of pressure and other important processes involved in it (Desoky et al., 2020).

Salt stress is now evident and shows that the induced suppression of photosynthesis is always dependent on gas changes, photosynthetic pigments, cultivar species or types, stomata, and accumulation of organic and inorganic metabolites, as well as antioxidants (Zhang et al., 2020). Evidence of accumulated Na^+ and Cl^- in several tissues in leaves beyond the usual situation is due to the increased air loss and dehydration of the cytoplasm. The dehydration of the cytoplasm means that cells can no longer perform their metabolism normally and can ultimately reduce growth in plants (Khare et al., 2020).

Higher negative percentages of changeable values in the increased salinity level, when compared with the normal condition (0 mM NaCl), on the number of tillers per plant in Thai rice varieties (PTT1 and CNT1) could be observed over Inpari 35 at 50 mM NaCl (Table 2). However, there was a similar reduction percentage among these three varieties on the number of leaves per plant and plant height, stating that each component produced by each plant production is highly dependent on the genetics of a particular variety (Donald, 1968; Sagare et al., 2020), the ability of the varieties to utilize every existing capacity in the process of growth and production, as well as the ability to adapt to the environment in which it grows. The varieties with higher adaptability can produce better growth and more ability to adapt physiologically and morphologically than other varieties under specific stress conditions (Khan et al., 2020). In this study, these three rice varieties showed different corresponding salt tolerances at the tillering stage. Nevertheless, the salinity is very effective in influencing all measured agronomic characteristics of these varieties (Mujeeb-Kazi et al., 2019).

Table 2 Effects of different salinity levels (0 mM, 50 mM, 100 mM, and 150 mM NaCl) on the number of leaves per plant, the number of tillers per plant, plant heights, and leaf symptom scores of three rice varieties [(Inpari 35, Pathum Thani 1 (PTT1) and Chai Nat 1 (CNT1)], at week 3 after adding salinity

Variety/Salinity	**Characteristic values** (% NC)			
	Number of leaves per plant	**Number of tillers per plant**	**Plant height (cm)**	**Leaf symptom scoring**
Inpari 35				
0 mM (NC)	22.2 ± 1.8	6.2 ± 0.4	64.4 ± 1.8	1.2 ± 0.4
50 mM (% NC)	21.2 ± 1.8 (-4.50)	6.0 ± 0.0 (-3.23)	65.2 ± 3.4 (+1.24)	1.0 ± 0.0 (-16.67)
100 mM (% NC)	19.6 ± 2.2 (-11.71)	5.2 ± 0.4 (-16.13)	60.9 ± 2.7 (-5.42)	1.6 ± 0.9 (+33.33)
150 mM (% NC)	18.8 ± 1.8 (-15.32)	4.8 ± 0.4 (-22.58)	60.3 ± 1.6 (-6.37)	3.2 ± 1.1 (+166.67)
Mean (Inpari 35)	20.4 ± 2.2 a	5.6 ± 0.7 a	62.7 ± 3.2 a	1.8 ± 1.1 a
PTT1				
0 mM (NC)	20.2 ± 1.9	5.6 ± 0.6	60.1 ± 2.8	2.0 ± 0.7
50 mM (% NC)	19.4 ± 2.1 (-3.96)	5.0 ± 0.7 (-10.71)	57.6 ± 2.6 (-4.16)	2.2 ± 0.8 (+10.00)
100 mM (% NC)	17.6 ± 2.3 (-12.87)	4.2 ± 0.4 (-25.00)	58.0 ± 2.2 (-3.49)	2.8 ± 0.8 (+40.00)
150 mM (% NC)	16.4 ± 2.0 (-18.81)	3.8 ± 0.4 (-32.14)	56.4 ± 2.2 (-6.16)	4.2 ± 0.4 (+110.00)
Mean (PT1)	18.1 ± 2.4 b	4.6 ± 0.9 c	58.0 ± 2.6 b	2.8 ± 1.1 b
CNT1				
0 mM (NC)	21.0 ± 1.6	5.8 ± 0.4	60.1 ± 2.0	2.0 ± 0.7
50 mM (% NC)	20.0 ± 1.6 (-4.76)	5.4 ± 0.6 (-6.90)	59.2 ± 2.7 (-1.50)	1.4 ± 0.6 (-30.00)
100 mM (% NC)	18.4 ± 10.1 (-12.38)	4.8 ± 0.4 (-17.24)	58.6 ± 2.1 (-2.50)	2.0 ± 0.7 (0.00)
150 mM (% NC)	17.4 ± 1.9 (-17.14)	4.0 ± 0.7 (-31.03)	56.3 ± 2.4 (-6.32)	3.2 ± 0.8 (+60.00)
Mean (CNT1)	19.2 ± 2.2 b	5.0 ± 0.9 b	58.5 ± 2.6 b	2.2 ± 0.9 a
Over all mean	19.4	5.1	59.8	2.2
0 mM (NC)	21.1 ± 1.9 A	5.9 ± 0.5 A	61.5 ± 3.0 A	1.7 ± 0.7 AB
50 mM (% NC)	20.2 ± 1.9 A (-4.27)	5.5 ± 0.6 B (-6.78)	60.7 ± 4.3 AB (-1.30)	1.5 ± 0.7 A (-11.76)
100 mM (% NC)	18.5 ± 2.2 B (-12.32)	4.7 ± 0.6 C (-20.34)	59.2 ± 2.5 BC (-3.74)	2.1 ± 0.9 B (+23.53)
150 mM (% NC)	17.5 ± 2.0 B (-17.06)	4.2 ± 0.7 D (-28.81)	57.7 ± 2.7 C (-6.18)	3.5 ± 0.9 C (+105.88)
P value (Varieties)	0.0055**	3.59×10^{-6}**	0.00035**	0.00014**
P value (Salinity)	167×10^{-5}**	8.92×10^{-12}**	1.14×10^{-7}**	1.96×10^{-10}**

Variety/Salinity	Characteristic values (% NC)			
	Number of leaves per plant	Number of tillers per plant	Plant height (cm)	Leaf symptom scoring
P value (Salinity:Variety)	0.910 NS	0.89 NS	0.43 NS	0.775 NS
CV (%)	9.90	9.87	4.04	32.44

Note: NC = normal condition, CV =Coefficient of variance), *, ** = Significant difference at 0.05 and 0.01 levels of probability, respectively, NS = Non-Significant difference at 0.05 level of probability, Lower case letters (a, b, c…) = significant difference at 0.05 level of probability, Upper case letters (A, B, C) = significant difference at 0.05 level of probability.

5. Conclusion

From the results of this study, salinity had a highly significant effect on the number of leaves per plant, the number of tillers per plant, plant height, and the score of symptoms on leaves in tested rice varieties. The effect of salinity stress could be observed on the leaf symptom at the first week after adding salinity, and other characteristics were significantly determined at Week 3 after adding salinity. For rice varieties, there is a significant difference at the first week after adding salinity. Overall means of observed agronomic characteristics of Inpari 35 generally showed higher values than PTT1 and CNT1 in Week 1 and 3. Inpari 35 also showed a lower reduction percentage in the number of tillers per plant (compared with the normal condition; 0 mM NaCl) than two Thai rice (CNT1 and PTT1) at Week 3 after transplanting.

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