Study of levels water salinity on the growth of varieties of shallots (*Allium ascalonicum* L) in Alfisols

J Syamsiyah1,2, Rahayu1, A Herawati1 and W Binafsihi1

1 Soil Science Department, Universitas Sebelas Maret, Jl. Ir. Sutami 36 A, Kentingan, Surakarta, 57126, Indonesia
2 Bachelor program in Soil Science Department, Universitas Sebelas Maret, Jl. Ir. Sutami 36 A, Kentingan, Surakarta, 57126, Indonesia

Abstract. The phenomenon of global warming and the depletion of the ozone layer due to the increase in greenhouse gas emissions has an effect on rising sea levels due to the melting of ice in the polar of the earth, potential pairs of saline water occur on land. This event could threaten the continuity of shallot cultivation on the northern coast of Java Island. Salinity causes disruption of germination and growth of shallots, as well as physiological disorders. This study aimed to determine the tolerance level of salinity, the effect of salinity on the nutrient’s uptake and productivity of shallots on Alfisols. This study used a completely randomized design (CRD) with 2 factors, (1) the level of salinity (0, 1, 2 and 3 dS m⁻¹) and shallot varieties (Purbalingga and Brebes). The salinity increased 1 to 3 dS m⁻¹ tends to decrease N, P, K uptake, the yields of Shallot and exchangeable-Ca. The soil pH, electrical conductivity and exchangeable-Na were increased with increasing salinity of water irrigation.

1. Introduction

Greenhouse gas, such as carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), and ozone (O₃) is a gas that absorbs and emits radiant energy. Greenhouse gases caused the greenhouse effect. Paddy field that have high of carbon organic provided C substrate for producing of CH₄ [1], especially of organic paddy field have C-organic higher than conventional paddy field [2]. The phenomenon of global warming and the depletion of the ozone layer due to the increase in greenhouse gas emissions has an effect on rising sea levels due to the melting of ice in the polar of the earth, potential pairs of saline water occur on land. According Arslan et al. [3], climate change can trigger the development of crop productivity problems due to salinity in the soil. [4] stated that the increase in soil salinity or irrigation water in rooting areas will affect plant growth, and all aspect of the biochemistry and physiology, leaf turgor and leaf water potensial [5] and reduce yield [6]; pressure suppressed growth and chlorophyll [7]. Salinity results in a reduction of K⁺ and Ca²⁺ content and an increased level of Na⁺, Cl⁻ and SO₄²⁻ [8], that cause ions imbalance in the plant [9]. Many some previous researchers reported a decrease in wheat seed yield [10], onion growth [11], maize seed yield [12] due to increased water salinity. The results of the pot research showed that irrigation with high saline water decreased wheat yield and nutrient uptake of N, P, K, Ca, Mg, Zn, Mn, Cu and Fe [13], while using saline water (4.0, 8.2 and 12.5 dS m⁻¹ reduced straw and grain yields, leaf soluble proteins and grain protein content [14]. Nevertheless information on the level of tolerance of shallots to salinity is still very limited. The aim of the study was to assess the tolerance level of salinity, the effect of salinity on the nutrients uptake and productivity of shallots on Alfisols.
2. Materials and methods

In this study, the pot experiment was carried out in Sukasari, Jumantono, Karanganyar, Indonesia, using a completely randomized design with eight treatments and three replications. The plants used are shallots with the varieties of Purbalingga and Brebes. The salinity levels used are 0; 1; 2 and 3 dS m\(^{-1}\). Saline irrigation water was prepared by mixing 0.64 g salt/1 l water (1 dS m\(^{-1}\)), 1.28 g salt/1 l water (2 dS m\(^{-1}\)) and 1.92 g salt/1 l water (3 dS m\(^{-1}\)). Pot filled with Alfisol textured clay (sand 15.2: Silt 3.62: Clay 82.38) and chemical properties analyzed (Table 1). Each pot is planted with 3 bulbs of shallots with a distance of 15 cm. The basic fertilizer given is compost (71 g/pot) and SP 36 (2.13 g/pot) that be given 1 week before planting, and while at 4 Urea (1.78 g/pot), Zn (1.28 g/pot) and KCl (1.42 g/pot) was used at 4 weeks after planting. Irrigation of water is done manually every day in the afternoon and no water comes out of the pot.

Soil samples were taken at a depth of 0-20 cm at the end of the study and analyzed several chemical properties such as exchangeable cations (Ca, Mg and Na), SAR, pH, EC, organic C. The plant height, number of bulbs, bulb diameters, dry weight of bulb and fresh weight of bulb, and content of N, P and K in the plant were measured. To compare between treatments, data were analyzed using analysis of variance (ANOVA). Duncan Multilevel Range test was employed as a post hoc test to determine the significant difference between means at a significance level of p <0.05. All statistical analyzes were conducted using SPSS 23.0.

3. Results and discussion

3.1. Soil chemical properties

Table 1 showed that the soil characteristics of Alfisols were slightly acid, soil organic C, total N, available P, exchangeable Ca, Ma, Na were very low but CEC and exchangeable K were medium.

| Parameters                  | Value  | Unit | Assessment     |
|-----------------------------|--------|------|----------------|
| pH H\(_2\)O 1 : 2.5         | 6.18   | -    | slightly acid  |
| Total Nitrogen              | 0.13   | %    | very low       |
| Available phosphorus (Olsen)| 3.98   | Mg kg\(^{-1}\) | very low       |
| Electrical conductivity (EC)| 0.021  | dS m\(^{-1}\) | very low       |
| CEC                         | 25.81  | cmol kg\(^{-1}\) | Medium         |
| Organic carbon              | 0.88   | %    | very low       |
| Exchangeable-K              | 0.63   | cmol kg\(^{-1}\) | Medium         |
| Exchangeable-Ca             | 3.90   | cmol kg\(^{-1}\) | very low       |
| Exchangeable-Mg             | 0.88   | cmol kg\(^{-1}\) | very low       |
| Exchangeable-Na             | 0.21   | cmol kg\(^{-1}\) | very low       |

Table 2 showed that soil pH Alfisols given saline 1-3 dS m\(^{-1}\) vary between Purbalingga and Brebes varieties. The increased of irrigation water salinity, was not give significant changed on soil pH in both shallot varieties. There was an interaction between shallot varieties and water salinity to electrical conductivity (EC). The EC values on Purbalingga increased 14.1 to 48.1% with water salinity 1 - 3 dS m\(^{-1}\). The statistical analysis indicated that no significant difference between level salinity 1, 2 and 3 dS m\(^{-1}\) in both varieties. Soil organic carbon was not significant affected by water salinity and shallot varieties. Soil organic carbon in both varieties almost the same about (0.9%). Irrigation with salinity 1, 2 and 3 dS m\(^{-1}\) incerase soil organic carbon in Purbalingga variety. Table 2. showed that irrigation with saline water up to 3 dS m\(^{-1}\) increased exchangeable Na and decreased exchangeable Ca on Purbalingga. Exchangeable Ca in Purbalingga was higher than Brebes at all level salinity water. On the other hand, exchangeable Mg in Purbalingga was lower than brebes for all salinity level. The statistical analysis indicated that no significant difference between the control treatment and three salinity levels used (1, 2, and 3 dS m\(^{-1}\)) in both varieties. Concerning SAR, there was significant interaction between salinity.
and shallot varieties. The increasing salinity up to 1, 2 and 3 dS m\(^{-1}\) was impact to the increasing SAR in Purbalingga.

Table 2. Soil chemical properties with saline water irrigation in Alfisols

| Saline Water dS m\(^{-1}\) | pH | Electrical Conductivity dS m\(^{-1}\) | C-organic (%) | Exc- Na- (cmol kg\(^{-1}\)) | Exc- Ca (cmol kg\(^{-1}\)) | Exc- Mg (cmol kg\(^{-1}\)) | SAR |
|---------------------------|----|-----------------------------------|----------------|--------------------------|--------------------------|--------------------------|-----|
| Purbalingga               |    |                                   |                |                          |                          |                          |     |
| 3                         | 7.22a | 15.7 \(10^{-4}\)b                | 1.023a          | 0.267a                   | 7.615ab                  | 0.455abc                 | 0.134a |
| 2                         | 6.94a | 15.3 \(10^{-4}\)b                | 1.119a          | 0.330ab                  | 12.868bc                 | 0.285ab                  | 0.119a |
| 1                         | 7.157a | 12.1 \(10^{-4}\)b              | 0.911a          | 0.287ab                  | 12.213bc                 | 0.281ab                  | 0.116a |
| 0                         | 6.883a | 10.6 \(10^{-4}\)ab            | 0.633a          | 0.20a                    | 15.573c                  | 0.233a                  | 0.094a |
| Brebes                    |    |                                   |                |                          |                          |                          |     |
| 3                         | 7.147a | 12.7 \(10^{-4}\)b                | 0.877a          | 0.187a                   | 4.443a                   | 0.510abc                 | 0.121a |
| 2                         | 7.080a | 13.3 \(10^{-4}\)b                | 0.818a          | 0.223a                   | 6.992ab                  | 0.654c                   | 0.140a |
| 1                         | 7.421a | 13.2 \(10^{-4}\)b                | 1.033a          | 0.615c                   | 3.188a                   | 0.579bc                 | 0.493c |
| 0                         | 7.300a | 6.2 \(10^{-4}\)a                | 0.873a          | 0.423b                   | 3.545a                   | 0.465abc                 | 0.305b |
| V                         | 0.129 ns | 0.111 ns                | 0.869 ns        | 0.030\*                  | 0.000\*                  | 0.002\*                  | 0.001\* |
| S                         | 0.384 ns | 0.012 \*                | 0.568 ns        | 0.001\*                  | 0.364\*                  | 0.482\*                  | 0.015\* |
| V x S                     | 0.364 ns | 0.034 \*                | 0.667 ns        | 0.000\*                  | 0.012\*                  | 0.043\*                  | 0.001\* |

Different letters indicate significant differences by Duncant Multiple Ring Test at \(p < 0.05\). V= Variety, S = salinity, ns = not significant, \* = significant

3.2. Nutrient uptake

Table 3. Nutrient uptake as affected by water salinity

| Water Salinity (dS m\(^{-1}\)) | N (%) | P (%) | K (%) |
|--------------------------------|-------|-------|-------|
| Purbalingga               |       |       |       |
| 3                         | 2.190a | 0.007a | 1.983ab |
| 2                         | 2.675abc | 0.007a | 2.525b |
| 1                         | 2.408abc | 0.004a | 1.70ab |
| 0                         | 2.891c | 0.006a | 2.175ab |
| Brebes                    |       |       |       |
| 3                         | 2.371ab | 0.003a | 1.360a |
| 2                         | 2.518abc | 0.006a | 1.687ab |
| 1                         | 2.483abc | 0.005a | 1.601a |
| 0                         | 2.720bc | 0.004a | 1.832ab |
| V                         | 0.871 ns | 0.240 ns | 0.026 \* |
| S                         | 0.021 \* | 0.598 ns | 0.268 ns |
| V x S                     | 0.100 ns | 0.620 ns | 0.161 ns |

Different letters indicate significant differences by Duncant Multiple Ring Test test at \(p < 0.05\). V= Variety, S = salinity, ns = not significant, \* = significant

Irrigation with saline water until level 3 dS m\(^{-1}\) significantly reduced N uptake in both varieties. P uptake was not affected by saline water irrigation. Table 3, showed that no interaction between shallot varieties with saline water on K uptake. K uptake on Brebes was the lowest with increasing level of
salinity, although not significantly different. But in Purbalingga, the K uptake in Purbalingga was fluktutative with increasing water salinity.

3.3. Plants growth
The result of experiment showed there was no interaction between water salinity and shallot variety on plant height, fresh weight and dry weight and number of bulb. Irrigation with water saline 1 - 3 dS/m gave slightly reduce on all plant parameter in both varieties.

Table 4. Growth and yields of shallot affected by water salinity

| Water salinity (dS m⁻¹) | Plant Height (cm) | Fresh Weight of bulb (g) | Dry Weight of Bulb (g) | Bulb Diameter (cm) | Bulb number /pot |
|-------------------------|-------------------|--------------------------|------------------------|--------------------|------------------|
|                         | Purbalingga       | Brebes                   | V                      | S                  | V x S            |
| 3                       | 16.20 a           | 10.10 a                  | 0.31 ns                | 0.010*             | 0.029 ns         |
| 2                       | 16.13 a           | 15.80 a                  | 9.43 a                 | 0.029*             | 0.110 ns         |
| 1                       | 18.56 a           | 17.63 a                  | 1.60 a                 | 0.389 ns           | 0.255 ns         |
| 0                       | 20.56 a           | 17.36 a                  | 7.97 a                 | 1.000 ns           | 0.022*           |

Different letters indicate significant differences by Duncant Multiple Ring Test at p < 0.05 . V= Variety, S = salinity, ns = not significant, * = significant

Pardjo et al. [15] reported that organic fertilizer up to 1 ton/ Ha increased of bulb number and dry weight bulb of shallot. Meanwhile, the fresh weight and dry weight of the tubers and the number of tubers of the Brebes variety are significantly higher than Purbalingga. (Figure 1).

Figure 1. Growth and yield of shallot with saline water irrigation
The use of saline water 1-3 dS m⁻¹ does not change the pH of the Alfisol soil (Table 2). This result is contrary to Mindari [12] that saline water 0.66 - 3.83 mS cm⁻¹ on corn plants with soil from three different locations showed an increase in soil pH 1.1 - 1.2 times than control. In this study, there was no significant correlation between the exchangeable cations and SAR with soil pH. This can be interpreted that although there is an increase in cation levels in the soil due to saline water but it has not caused a significant change in soil pH. On the other hand the EC value increases with increasing saline water of 1-3 dS m⁻¹. This increasing is related to the increase of cations exchanged in the soil by added saline water. The analysis showed that there is a positive correlation between EC and exchangeable Ca and Mg [16].

Adding saline water to Alfisol was increasing the SAR value in Purbalingga, but decreasing in Brebes variety (Table 2). The increase or decrease in SAR values was highly significant correlated with exchangeable Na (r = 0.888; p <0.00). Therefore the increase in SAR is due to an increase in Exchangeable Na level. Exchangeable cations (Na, Ca and Mg) in Alfisol are varied with saline water 1 -3 dS m⁻¹. In this study, exchangeable Na was negative correlated with Ca (r = -0.245; p < 0.00), but positive correlated with Mg (r = 0.277; p >0.00). Between cations in the soil will compete each other for binding sites or uptake by plants [17]. Up to water salinity of 3 dS m⁻¹, uptake N and K in both varieties gradually decrease (Table 3). These result in line with Bhatt et al. [18] and Morales et al. [19] which states the N content in plants has decreased in response to increased salinity. It was caused by disturbances in physiological and biochemical activities or excessive accumulation of Cl and Na in plant tissue due to the saline state [20].

Shallot is an important vegetable in Indonesia but sensitive to salinity. In these study, irrigation with water saline of 1, 2 and 3 dS m⁻¹ did not cause significant changes in plant height, wet weight and dry weight of tubers, diameter and number of tubers in both Varieties Purbalingga and Brebes (Table 4). This result is in line with research by Patel et al. [21], that salinity up to 8 dS m⁻¹ had less effect on height and weight in some coffee cultivars, but it was different with Arslan et al. [3] that state salinity 1.13 dS m⁻¹ is the tolerance level threshold for Allium schoenoprasum. Munns and Tester [22] state that high salinity will cause ionic stress and osmotic stress. Osmotic stress inhibits water absorption, cell enlargement and lateral bud development. Meanwhile, ionic stress occurs when toxic ions such as Na accumulate excessively in plants (leaves) exceeding the threshold, causing leaf death and decreased cellular activity such as photosynthesis [23]. The results showed that there was no increase in Na levels which could be exchanged in the soil with increasing salinity levels (Table 2), so it would not increase N uptake or interfere with other nutrients uptake (Table 3). Brebes varieties show better tolerance to saline water than Purbalingga, which is reflected in the wet and dry weight of bulb, as well as higher in bulb number. According to Li et al. [24] plants that are adaptive to salinity will have normal growth through adjusting root morphology to salinity stress. Razzaque et al. [25] added that genetic variability can cause plant has tolerance to salt stress is due to genetic variability. Rahayu et al. [26] reported that peat and bottom ash beneficial as a amendment in saline condition.

4. Conclusion
The salinity increased 1 to 3 dS m⁻¹ tends to decrease NPK uptake, the yields of shallot and exchangeable-Ca. The soil pH, electrical conductivity and exchangeable-Na were increased with increasing salinity of water irrigation. Brebes variety was more tolerance to the salinity than Purbalingga. Increased water salinity has an impact on crop yields so it needs to be controlled by mitigating global warming.

References
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