Salinity and potassium fertilizer on growth and proline of the medicinal plant *Pereskia bleo*

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Abstract. There is strong observational evidence that climate change patterns impact the salinization of agricultural land in some countries. It is suspected that a significant increase in soil salinity of the root zone occurs due to the impact of prolonged drought conditions. Rainfall in Indonesia is strongly influenced by EL NINO and LA NINA/Southern Oscillation (ENSO) events, and global warming will cause ENSO events to occur more frequently. Salinity will provide adverse effects, such as plant growth, by decreasing leaf water potential, morphological and physiological changes, increased osmotic stress, and changes in biochemical processes. Potassium has some role in plants, including medium nutrient transportation, resistance to drought, expanding root growth, and enzyme activation. This study aims to find out the tolerance of the *Pereskia bleo* plant to salinity and the effect of applying Potassium in growth with proline indicators. The study used a Completely Randomized Design with 2 factors (NaCl 0 ppm; 4 ppm; 8 ppm/plant and KCl 0 g; 1.5 g; 3 g/plant). The results showed that salinity has a significant effect on growth, and there is an interaction between salinity and potassium fertilizer on proline. In general, the application of potassium fertilizer increases the tolerance ability of *Pereskia bleo* plants to salinity.

1. Introduction

Climate change is a fact; its impacts have been felt by the inhabitants of our earth for many years. The condition of Indonesia as a tropical region, perceived symptoms of climate change, among others, the increase in atmospheric temperature and changes in rain patterns. The frequency of El Nino events tends to increase with a longer duration causing a shift in rainfall patterns in one year, it is decreasing rainfall, and a long dry season, prolonged dry season will result in drought. The impact of this drought will expand the accumulation of salinity in the soil surface and root zone. Salinity stress is one of the abiotic stress factors that worsen plant growth, productivity, and physiology [1].

Soil salinization inhibits water uptake by plants and causes osmotic stress. To hold salinity stress, plants accumulate proline, which will decrease the osmotic potential of the cytoplasm, facilitate water absorption and activate ROS (*Reactive Oxygen Species*) molecules [2] and in turn enable protein activation, which will determine the plant phenotype under salinity stress [3].

The effects of drought stress and salinity can be reduced by added Potassium to plants. Several studies show that Potassium (K) sprayed in drought conditions can increase plant tolerance to various types of abiotic stress and increase growth and yield. Mengel and Kirby [4] reported that K enhances physiological processes by regulating turgor pressure and photosynthesis, cation translocation, and enzyme activation. Meanwhile, Cakmak [5] also observed that plants suffering from drought stress require more Potassium. In legumes, the damaging effects of drought can be reduced by high K...
supplies [6]. Increasing the supply of K can overcome the impact of limiting water availability [7]. So it can be said that in conditions of drought stress or salinity stress, yield losses can be minimized with a sufficient supply of K.

Climate change causes significant effects on the life cycle, distribution, and phytochemical composition vegetation of the world, including medicinal plants and aromatic plants. In general, under conditions of environmental stress, the production of secondary metabolites increases, while the impact of climate change will worsen plant growth. Therefore, in this study, we want to know the level of tolerance of *Pereskia bleo* that grows at salinity conditions and the application of potassium fertilizer with growth indicators and dynamics of proline levels.

2. Materials and methods

The research was conducted from May to November 2018 in Greenhouse C, Faculty of Agriculture, Sebelas Maret University, Surakarta. *Pereskia bleo* seeds come from shoot cuttings. The planting medium used was a mixture of alfisol soils and manure with a ratio of 2:1. Salinity was treated using NaCl while fertilizing K with KCl. The salinity treatment was given by watering every three days as much as 500 ml (22.60% field capacity). The research is arranged in a complete randomized block design with 2 factors (NaCl: 0 ppm, 4 ppm, 8 ppm per plant, and KCl: 0 g, 1.5 g, 3 g per plant). Observation of growth parameters, chlorophyll, and proline levels. Chlorophyll analysis used spectrophotometry and proline analysis using the Ninhydrin method.

3. Result and discussion

3.1. Growth and component

The altitude of the research location is 95 m above sea level, and the Greenhouse C Faculty of Agriculture is located at 110° 33’ 2” East Longitude and 7° 33’ 3” South Latitude. The average temperature in the greenhouse ranges from 34 - 42°C, with a relative humidity of 84%. Plants are harvested when it starts the generative phase at the age of 3 months.

Table 1. Analysis of the variance on the effect of salinity and potassium fertilizer dose on growth parameters and proline.

| Parameter                  | Source         | Plant Height (cm) | Leaf number | Root volume (ml) | Root shoot ratio | Root dry weight (g) | Chlorophyll total (mg g⁻¹) | Proline (µmol/g) |
|----------------------------|----------------|-------------------|-------------|------------------|------------------|---------------------|---------------------------|-----------------|
|                            | Salinity (S)   | * ns              | *           | ns **            | ns **            | ns                  | ns **                     | **              |
|                            | Potassium (K)  | * ns              | *           | ns *             | ns *             | ns                  | ns **                     | **              |
| Interaction Kd*Pd          | ns             | ns                | ns          | ns Ns            | ns Ns            | *                   | **                       |                 |

Note: ns= not significantly; * or** = significant or highly significant in 5% or 1%.

Salinity and K fertilization significantly affected plant height, and there was no interaction between the two treatments. Salinity has the potential to suppress plant height (Table 1 and Figure 1) because it interferes with the osmotic stress system. Salinity stress causes water absorption in the root system to decrease. Then there is a nutritional imbalance and reduces photosynthetic activity so results in disturbances in growth [8].

In this study, salinity and fertilization with Potassium had a significant effect on plant height, and there was no interaction between the two treatments. Plant height increases at a dose of KCl 1.5 g/plant and will decrease at doses above it. Potassium has a role in protein synthesis and cell development and activates ATPase in the plasma membrane to stimulate cell development [9], [10]. However, at high concentrations in the media, it can inhibit the uptake of other nutrients by roots such as Magnesium (Mg) [11].
Salinity and KCl fertilization did not affect the number of leaves. This is possible because *Pereskia bleo* is a type of cactus plant that has leaves. *Pereskia bleo* leaves contain lots of minerals and high antioxidants. The potassium content is 2 times higher than that of tomatoes [12]. Potassium in plant organs affects the water content in the leaves so that plants can be more resistant to environmental stress, including salinity [13].

Salinity has a significant effect and tends to increase root volume. This is possible as a response to plant adaptation to salinity, in accordance with the research of [14] who revealed that the *Setaria italica* (Hotong) plant could adapt when it is in salinity conditions. When the hotong plant was in the salinity condition, the Na' concentration increased significantly in the root, stem and leaf tissue compared to the control. Hotong plants can tolerate Na' presumably by allowing some of the Na' ions into the plant tissue to be compartmented into vacuoles, causing enlargement of the cell vacuole. This mechanism causes plants to experience an increase in cortex thickness and an increase in the size of root cortex cells during salinity stress. Therefore, in the salinity conditions, the dry weight of the roots increased significantly (Figure 1). Meanwhile, Potassium up to 3 g per plant did not affect root volume but significantly reduced root dry weight. This may be because the administration of Potassium tends to develop cells in the shoots, including plant height and chlorophyll (Figures 1 and 3).
3.2. Chlorophyl and proline content

Figure 3. Interaction of Salinity and Potassium fertilizer dose on Chlorophyll and Proline.

Figure 3 shows a very significant interaction between salinity and Potassium on chlorophyll and proline levels. Under conditions of salinity stress, chlorophyll and its components may be reduced. This is due to inhibition of chloroplast development and degradation of plasticides. While the supply of Potassium will maintain stomata function, water availability in the plant body and photosynthesis [4] also protect chloroplasts from oxidative damage. This is evident in the research on peanuts [6]. The decrease of chlorophyll levels in plants during drought stress is caused by biochemical activity in plant cells in self-defense from drought stress by producing proline compounds. This causes photosynthesis results to be used more for biochemical activities and less used chlorophyll formation. The low chlorophyll content in water deficiency is also caused by chlorophyll disintegration due to the increase in temperature and transpiration [15]. Decreased chlorophyll results in reduced absorption of sunlight, so that the photosynthesis process will be hampered [16]. Proline accumulation has been shown in most drought-stressed plants. In the Arabidopsis plant, after experiencing drought stress, proline can reach 20% of the free amino acid pool. This study shows that the higher salinity level and potassium dose make the higher proline formation. So it can be said that giving Potassium to salinity-stressed plants will increase the tolerance of Pereskia bleo plants [17].

4. Conclusion
Climate change is no longer just an issue and has become a reality so that in dealing with it for cultivation and sustainability for plant life, efforts to increase plant adaptability and tolerance are very important. The limitation in this study showed that salinity reduced the plant height of Pereskia bleo but increased root volume and root dry weight. The application of Potassium fertilizer is able to improve shoot growth; however, Potassium suppresses the root dry weight. The salinity and Potassium fertilization can increase chlorophyll and proline levels which are very significant at high levels of salinity and potassium fertilization. It can be concluded that the Pereskia bleo plant can increase tolerance to salinity by applying potassium fertilizer.

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