Soil characteristic and shallot growth with gypsum and zeolite amendments in irrigated saline Alfisol and Inceptisol

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Abstract

Salinity of soil and irrigation is a factor that may cause a decrease in shallot productivity, so it requires efforts with amendments. This research aimed to determine the effect of gypsum and zeolite amendments on soil and shallot growth with saline irrigation. A pot experiment was conducted in the field using a completely randomized design with three factors. The first factor was two soil types (Alfisol and Inceptisol); the second factor was three shallot cultivars (Brebes, Purbalingga, and Pemalang); and the third factor was two types of soil amendments. The results showed that gypsum and zeolite reduced pH, sodium adsorption ratio (SAR), electric conductivity paste (ECp) and Na of the soils studied. Gypsum and zeolite increased the uptake of N, P and K by shallot plants. The increase of N uptake by applying gypsum on Inceptisol was more effective to Brebes and Purbalingga cultivars than Pemalang cultivar. Gypsum increased the diameter and number of bulbs in Inceptisol. Zeolite and gypsum increased bulb weight of Purbalingga cultivar in Alfisol.

Keywords:
gypsum
nutrient uptake
salinity
shallots
zeolite

Introduction

Shallot centre in Indonesia is mainly coastal areas, especially the north coast of Java. One of the shallot areas is Brebes District of Central Java which covers 72.65% of the land area, while the other 34 districts in Central Java covers only 25.35% (Central Jawa BPS, 2017). The current land suitability classes in Brebes are marginally suitable for shallot (Rahayu et al., 2018). Commonly, the shallot centre of the north coast has a potential limiting factor in soil salinity from flooding of seawater. Soil salinity is a global problem that affects about 20% of irrigated land and reduces yields significantly (Qadir et al., 2014). In Indonesia, the total area of saline land reaches 440,300 hectares, divided into 304,000 hectares of low saline and 140,300 hectares of saline (Rachman et al., 2007). Tidal flood disaster followed by the phenomenon of sea-level rise and land subsidence has the potential to continue to increase both the frequency and extent of tidal inundation flood in the future (Marfai et al., 2008). Some areas experience inundation of tidal floods that occur almost every day with a duration of inundation of 3-5 hours (Sauda et al., 2019). The rate of land subsidence is around 16.74 cm/year and the rate of sea-level rise is 4.3 mm/year, so that land subsidence is the dominant factor in changes in the area of tidal flood inundation (Iskandar et al., 2020).

Soil with high salinity has a negative effect on shallots, such as a decrease in bulb quality (Sta-Baba et al., 2010). Koswara (2007) reported that the shallot yield on saline soils was 18.39% lower than the shallot yield on acid sulfate soils. Chang and Randle (2004) reported that the decrease in shallot yield was due to the application of high Na⁺ ion that triggered stress, caused the absorption of water and essential nutrients, especially nitrogen, phosphorus and potassium. Making amendments is a mitigation action that can be
done on saline soils (Prapagar et al., 2012). Salinity in agricultural land is generally caused by factors such as fertilizer application, pesticide application, land management, and the application of other inputs (Muliawan et al., 2016). The saturated extract at the point where soil salinity begins to reduce yields on shallot is 1.2 mS/cm. Meanwhile, the extract of soil salinity saturation that reduces the maximum yield by 12.82% in shallots is 2 mS/cm (Natural Resources Conservation Service, 2017). The potential for reduction in shallot yield is 25% in saline soil with a salinity level of 2.8 mS/cm, and for a potential reduction in shallot yield by 50% when the soil salinity is 4.3 mS/cm (Cardon et al. 2003).

Gypsum (CaSO₄·2H₂O) is a soil amendment that has an effective and beneficial effect in changing the chemical properties of saline soil. Gypsum soil amendment is most effective at removing sodium from soil particles (Sasongko and Warstis, 2003). Gypsum has been used as an ameliorant in saline and sodic soils (Makoi and Verplancke, 2010). Gypsum can reduce the pH of sodic soil by reducing the hydrolysis reaction associated with Na⁺ ions in the exchange complex (Cardon et al., 2003). Application of gypsum and cow manure increased leaf chlorophyll index in sodium susceptible plant and could increase grain yield in the range from 6 to 18% (Yamika et al., 2018). Types of amendments that can be used to mitigate saline soils include gypsum and zeolite (Al-Busaidi et al., 2008).

Natural zeolite can be used as an inexpensive and effective method to control the sodium adsorption ratio (SAR) due to its high cation exchange capacity. Natural zeolites can increase yields, growth in nutrient-poor, sandy and porous soils (Noori et al., 2006). Using zeolites to convert soils irrigated with salt water can reduce the harmful effects of salinity on barley. The application of zeolite also increases the holding capacity of water and ground salt. Soil amendment with zeolites can effectively improve salinity stress and improve nutrient balance in sandy soils (Al-Busaidi et al., 2008).

Shallot is a nutrient-sensitive plant (Deden, 2014); excess nitrogen causes longer vegetative growth of plants, and the resulting bulbs are large but become porous when dry. However, nitrogen-deficient shallot plants will grow thin and stunted, which in the end, the resulting bulbs are small. Potassium also functions for bulb development (Jazilah et al., 2007). Potassium can provide better bulb yields, higher quality and storage capacity of bulbs, and bulbs remain solid even though they are stored for a long time (Gunadi 2009). Shallot plants require soil that has a crumb structure, medium to clay texture, proper drainage, and sufficient organic matter (Sudadi and Arieiyant, 2012). Soil pH that is good for the growth of shallots is in the range of 5.5-7.0 (Relf and McDaniel, 2015). Shallots are also sensitive plants, although their production can be found in salty soils worldwide (Chang and Randle, 2004). The effects of salinity on plants include conditions where the plants cannot absorb water from the soil. Vegetative growth of shallot plants in saline soil is quite normal, but the bulb formation is hampered, so that production is low (Koswara, 2007). In general, Alfisols have low fertility (Rao and Virmani, 2015). Alfisol is one of the soil orders that have undergone intensive weathering but still contains a number of primary minerals that are easily weathered and rich in nutrients (Kurniawan et al., 2013). Alfisol is characterized by the accumulation of clay on the subsoil with clay minerals of illite, kaolinite, vermiculite and the amount of hydroxyl contaminated with vermiculite and chloride (Ndzana et al., 2017). Alfisol is generally susceptible to dispersion (Rengasamy et al., 1984). Unbalanced nutrients, low soil organic carbon, lack of recycling of plant residues and micronutrient deficiencies are problems of plant nutrition grown in Alfisols (Rao and Virmani, 2015). Inceptisol is the main agricultural land in Indonesia, especially for dryland agriculture (Nursyamsi, 2011). Inceptisol has very moderate to high nutrient content (Ketaren et al., 2014). Inceptisol is a soil that shows minimal horizon development (Bockheim and Hartemink, 2017), relatively thick soil solum, sand, silk, and clay texture, pH 5.0 to 7.0; soil productivity is moderate to high (Ketaren et al. 2014).

The purpose of this study was to determine the effect of gypsum and zeolite application on characteristics of Alfisol and Inceptisol irrigated with saline and growth of various shallot varieties.

Materials and Methods

A pot experiment was carried out from June to December 2018 at the UNS Faculty of Agriculture, Sukosari Village, Jumantono District Karanganyar. The experiment was arranged in a completely randomized design with three treatment factors. The first factor consisted of two soil orders, namely Alfisol = T1 and Inceptisol = T2. The second factor consisted of three shallot cultivars, namely Brebes = V1, Purbalingga = V2, and Pemalong = V3. The third factor consisted of three soil amendments, namely gypsum with CaSO₄·2H₂O content, 25 t/ha = G, zeolite with CEC of 223.153 cmol(+)/kg, 15 t/ha = Z, and K = without amendments). Each treatment combination was repeated three times. Saline irrigation treatment was 2 mS/cm. Irrigation water of 2 mS/cm was obtained by dissolving NaCl with 1.28 g/L of water. The Alfisol used was taken from land with a depth of 0-30 cm, with a clay texture (81.1% clay, 3.7% silt, and 15.3% sand). The Inceptisol used came from sugarcane plantations, with a silt clay texture (43.9% clay, 42.2% silt and 14.0% sand). The soil was put into a 30 cm diameter pot as much as 15 kg/pot. The soil was then incubated with saline irrigation at a concentration of 2 mS/cm for two weeks to obtain saline conditions. Application of gypsum and zeolite was carried out two weeks after incubation, followed by incubation of the amendments for one week. Shallot planting was done vegetatively by cutting the top of the bulb part to accelerate the growth of shallot shoots. Each pot was planted with three shallot bulbs, with a
spacing of 10 cm. Fertilization was carried out two times, namely week 2 and week 4 weeks with 250 kg urea/ha, 180 kg ZA/ha, 300 kg SP-36/ha, and 200 kg KCl/ha. The fertilizers applied in the second week were SP-36 and KCl, while urea and ZA fertilizers were given in the fourth week after planting. Watering the shallots was carried out with 2 mS/cm of saltwater. Watering was made once a day as much as 1 L/pot. The plant tissue analysis was conducted using a water bath at 70°C until a constant weight was reached (1 x 24 hours). The plant tissue analysis carried out was the determination of the nutrient uptake at the maximum vegetative phase of the plant, including total tissue nitrogen uptake and total tissue potassium uptake using the wetashing method HNO₃ and HClO₄ (Balittan 2009). Analysis of data was made using correlation test and F test with a confidence level of 95%, continued with the Duncan's Multiple Range Test (DMRT).

### Results and Discussion

Data presented in Table 1 show that the initial soil pH has increased after being conditioned with saline. The initial soil showed very low electrical conductivity paste (ECp) and sodium adsorption ratio (SAR) values, but after the soil was conditioned to saline, the ECp and SAR have increased. Soil organic C showed the level of organic matter contained in the soil, as well as low N and P values. Potassium available in the initial Alfisol was low, while that in the Inceptisol was moderate. One of the factors influencing the level of potassium in the soil is pH. Widowati et al. (2012) reported that low soil pH caused potassium to be easily lost due to leaching. Incubation of soil with salt irrigation water showed an increase in potassium. The application of gypsum affected the soil organic-C content in Pemalong cultivar on Alfisol and Brebes cultivar on Inceptisol. Zeolite did not affect soil organic C (Table 2).

### Table 1. Soil characteristics before and after incubation.

| Characteristics                        | Alfisol Before | Alfisol Salinized | Inceptisol Before | Inceptisol Salinized |
|----------------------------------------|----------------|-------------------|-------------------|----------------------|
| pH                                     | 6.18 sa        | 6.80 n            | 6.57 sa           | 6.93 n               |
| Electrical Conductivity (EC), mS/cm    | 0.02 vl        | 2.03 m            | 0.08 vl           | 2.73 m               |
| Sodium Adsorption Ratio (SAR)          | 0.09 vl        | 11.13 vh          | 0.05 vl           | 10.59 vh             |
| Na (me/100 g)                          | 0.18 l         | 13.15 vh          | 0.91 l            | 12.95 vl             |
| Ca (me/100 g)                          | 7.89 m         | 1.94 l            | 10.36 h           | 1.81 l               |
| Mg (me/100 g)                          | 0.88 vl        | 0.34 l            | 0.10 l            | 1.24 l               |
| Organic C (%)                          | 0.89 vl        | 1.36 l            | 1.05 vl           | 1.29 l               |
| Cation Exchange Capacity (CEC), me/100 g | 26.05 h       | 23.69 m           | 21.22 m           | 20.37 m              |
| Base Saturation (BS), %                | 36.58 l        | 66.99 h           | 58.24 m           | 79.03 h              |
| Total N (%)                            | 0.13 l         | 0.16 l            | 0.19 l            | 0.14 l               |
| Available P (ppm)                      | 0.12 vl        | 0.91 vl           | 1.10 vl           | 1.44 vl              |
| Available K (me/100 g)                 | 0.31 l         | 0.58 m            | 0.43 m            | 0.8 h                |

Note: Estimation according to Bogor Soil Research Institute (2009) vl (very low), l (low), m (moderate), h (high), vh (very high); sa (sightly Acid), n (neutral).
ECp of Inceptisol only. Gypsum and zeolite significantly reduced SAR in Alfisol and Inceptisol. The high level of Na⁺ in the control treatment was thought to be due to the continuous saline irrigation causing higher Na⁺ deposits than the amended soil. According to Muliawan et al. (2016), the number of Na⁺ ions in the soil causes a reduction in Ca²⁺ ions. According to Mukmin et al. (2016), calcium is the basic ingredient in gypsum; adding gypsum to the soil will increase exchangeable Ca, which will replace Na⁺. Jaman (2013) stated that not only Na⁺ is replaced by Ca²⁺ but also Mg²⁺. Gypsum is able to replace Na⁺ and Mg²⁺ ions in the exchange complex by Ca²⁺ ions. In general, the zeolite application has the lowest SAR value. This is due to the Na⁺ ion being absorbed by the zeolite. Wang et al. (2013) stated that zeolite used at a ratio of 30% by weight with soil could reduce the sodium content from 563.0 to 182.7 ppm; and SAR from 70.3 to 18.5 me/100 g soil. Gypsum application increased N uptake in Inceptisol, while zeolite application increased N uptake in both Alfisol and Inceptisol (Table 4). Nitrogen uptake is the concentration of nitrogen in plants (%) multiplied by the plant dry weight (milligrams). Increased N uptake by application of gypsum to Inceptisol was effective on Brebes and Purbalingga cultivars. The effect of the treatment without amendment showed that the N uptake was not significantly different between the soil treatment and shallot cultivars. In general, the application of gypsum and zeolite increased the uptake of N, P and K by shallot plants (Table 5). Uptake of N, P, and K by the plant was low in the control. The salt concentration is thought to have a significant effect on NPK uptake by the plant. Nugraheni et al. (2003) reported that the low nitrogen content of plants grown in soils containing high salt is because of the influence of Cl⁻ ion, which inhibits NO₃⁻ absorption, due to the formation of Ca(NO₃)₂, which causes nitrogen deficiency.

Table 2. Soil characteristics difference by treatments after harvesting shallot.

| Treatments | Amendments | Shallot Cultivar | Soil | pH | ECp mS/cm | Na me/100 g | Ca me/100 g | Mg me/100 g | SAR | Organic C % |
|------------|------------|-----------------|------|----|-----------|-------------|-------------|-------------|-----|-------------|
|            |            | Brebes          | Alfisol | 6.64 cd | 0.25 ab | 1.43 cde | 30.09 f | 0.81 abcd | 0.51 abcd | 1.09 bcd |
|            |            | Brebes          | Purbalingga | 6.69 cd | 0.23 ab | 0.81 abc | 14.28 bcde | 0.66 ab | 0.42 a | 1.17 d |
|            |            | Brebes          | Pemalang | 6.53 cd | 0.23 ab | 0.49 a | 3.68 a | 0.70 ab | 0.61 abcd | 1.01 bcd |
|            |            | Zeolite         | Brebes | 5.78 e | 0.23 ab | 1.32 cde | 16.89 de | 0.75 abcd | 0.63 abcd | 0.78 a |
|            |            | Zeolite         | Purbalingga | 6.46 cd | 0.18 a | 1.17 bcd | 18.20 e | 0.71 abc | 0.54 abcd | 1.04 bcd |
|            |            | Zeolite         | Pemalang | 6.71 bcd | 0.22 a | 0.57 ab | 7.00 abc | 0.64 ab | 0.45 ab | 1.13 cd |
|            |            | Control         | Brebes | 6.77 bc | 0.21 a | 0.56 ab | 10.44 abde | 0.80 abcd | 0.36 a | 0.88 ab |
|            |            | Control         | Purbalingga | 6.44 cd | 0.23 ab | 0.89 abc | 8.78 abde | 0.73 abc | 0.72 abcd | 0.92 abc |
|            |            | Control         | Pemalang | 6.27 d | 0.21 a | 0.63 ab | 5.61 ab | 0.58 a | 0.48 ab | 1.04 bcd |
|            |            | Brebes          | Alfisol | 6.71 bcd | 0.18 a | 1.74 def | 12.77 abde | 0.97 def | 0.95 cde | 0.89 ab |
|            |            | Brebes          | Inceptisol | 6.77 bc | 0.23 ab | 0.50 a | 15.22 bcde | 1.00 ef | 0.26 a | 0.99 abcd |
|            |            | Brebes          | Pemalang | 6.67 cd | 0.31 b | 1.89 ef | 7.82 abcd | 0.86 bcde | 1.32 ef | 1.16 d |
|            |            | Zeolite         | Brebes | 6.80 bc | 0.25 ab | 0.99 abc | 16.32 cde | 1.04 f | 0.49 abc | 1.10 bcd |
|            |            | Zeolite         | Purbalingga | 6.74 bcd | 0.37 c | 1.46 cde | 11.04 abced | 1.00 ef | 0.92 bcde | 1.09 bcd |
|            |            | Zeolite         | Pemalang | 6.70 bcd | 0.26 ab | 2.14 f | 6.68 abc | 0.82 bcde | 1.58 f | 1.19 d |
|            |            | Control         | Brebes | 7.41 a | 0.22 a | 0.91 abc | 14.62 bcde | 0.94 cdef | 0.54 abc | 1.12 bcd |
|            |            | Control         | Purbalingga | 7.56 a | 0.25 ab | 1.37 cde | 7.79 abc | 0.99 ef | 0.96 de | 1.07 bcd |
|            |            | Control         | Pemalang | 7.33 a | 0.24 ab | 2.24 f | 3.89 a | 0.78 abcd | 2.08 g | 1.08 bcd |

Note: mean values in a column followed by the same letters are not significant based on DMRT.

Table 3. Effect of amendments on soil characteristics.

| Treatments | Amendments | Soil | pH | ECp mS/cm | Na me/100 g | Ca me/100 g | Mg me/100 g | SAR | Organic C % |
|------------|------------|------|----|-----------|-------------|-------------|-------------|-----|-------------|
|            | Gypsum     | Alfisol | 6.38 a | 0.23 abc | 1.11 b | 19.14 c | 0.79 bc | 0.50 a | 0.91 a |
|            |            | Inceptisol | 7.02 b | 0.22 ab | 1.22 b | 14.57 b | 0.99 d | 0.66 a | 1.03 ab |
|            | Zeolite    | Alfisol | 6.65 ab | 0.21 a | 0.96 ab | 13.76 bc | 0.71 ab | 0.56 a | 1.04 ab |
|            |            | Inceptisol | 6.79 ab | 0.28 c | 1.11 b | 11.35 ab | 1.00 d | 0.71 a | 1.05 ab |
|            | Control    | Alfisol | 6.65 ab | 0.22 ab | 0.56 a | 5.43 a | 0.64 a | 0.51 a | 1.06 b |
|            |            | Inceptisol | 6.89 b | 0.27 bc | 2.09 c | 6.13 a | 0.82 c | 1.66 b | 1.14 b |

Note: mean values in a column followed by the same letters are not significant based on DMRT.
cultivars, and did not have a plant height effect on yields, higher quality and storage capacity of bulbs, (2009), potassium can provide better bulb shallots

The problem with plants in high salinity soils is the (2018), zeolite increases the availability of Ca effect on P uptake. According to Jakkula and Wani (2009) that soil salinity significantly reduces plant nutrient uptake, especially phosphorus, because potassium ions precipitated by Ca ions in salt-stressed soils. In general, the zeolite amendment had the most absorption. It is suspected that the provision of saline irrigation water with a concentration of NaCl (2 mS/cm) causes salinity so that P absorption is low. This is consistent with the statement of Bano and Fatima (2009) that soil salinity significantly reduces plant nutrient uptake, especially phosphorus, because phosphate ions precipitated by Ca ions in salt-stressed soils. In general, the zeolite amendment had the most effect on P uptake. According to Jakkula and Wani (2018), zeolite increases the availability of Ca\(^{2+}\), K\(^+\) and P in the soil and retains minerals needed by plants. The problem with plants in high salinity soils is the absorption of K\(^+\) where Na\(^+\) ion competes for uptaking K\(^+\) ion by plants, so the high absorption of Na\(^+\) will inhibit the absorption of K\(^+\). According to Gunadi (2009), potassium can provide better bulb shallots yields, higher quality and storage capacity of bulbs, and bulbs remain solid even though they are stored for a long time. Gypsum ameliorant increased plant height on Inceptisol, especially Brebes and Purbalingga cultivars, and did not have a plant height effect on Alfisol (Table 6). The application of zeolite increased plant height and bulb diameter in Alfisol. Cultivars of Brebes and Purbalingga in control grew higher in Inceptisol than on Alfisol. Gypsum application increased bulb diameter in Inceptisol, but it did not have an effect on Alfisol. The increase in the number of bulbs generally occurred in the application of zeolite to Inceptisol, while specifically, the Purbalingga cultivar on Alfisol increased by giving gypsum and zeolite. Gypsum and zeolite increased the fresh weight of bulbs in Inceptisol, whereas in Alfisol, only Purbalingga cultivar increased with zeolite application. Gypsum application to the soil of the Brebes cultivar Alfisol showed a low bulb weight. Plant fresh weight increased with the application of gypsum and zeolite to Inceptisol, and there was no increase in Alfisol. Yadav et al. (2015) stated that the use of gypsum could increase the height and number of branches of the plant. Potassium in plants has a function in strengthening the upright stems of plants (Rusmarkam and Yuwono, 2014). According to Arief et al. (2018), nitrogen functions in the division and enlargement of cells in the apical meristem, allowing shoot growth to occur.

### Table 4. Nutrient uptake of shallot by treatment after harvesting shallot.

| Soil     | Amendment | Shallot Cultivar | N uptake (mg/plant) | P uptake (mg/plant) | K uptake (mg/plant) |
|----------|-----------|-----------------|---------------------|---------------------|---------------------|
| Inceptisol | Gypsum    | Brebes          | 15.52 e             | 0.027 c             | 11.13 d             |
|          |           | Purbalingga     | 51.51 bc            | 0.109 ab            | 37.60 bc            |
|          |           | Pemalang        | 70.39 bc            | 0.131 ab            | 47.15 abc           |
|          | Zeolit    | Brebes          | 47.94 bcd           | 0.093 bc            | 26.76 cd            |
|          |           | Purbalingga     | 93.19 ab            | 0.160 a             | 67.98 ab            |
|          |           | Pemalang        | 40.68 cde           | 0.066 bc            | 32.85 bc            |
|          | Control   | Brebes          | 16.70 de            | 0.031 c             | 22.89 cd            |
|          |           | Purbalingga     | 18.94 de            | 0.017 d             | 8.15 d              |
|          |           | Pemalang        | 17.58 e             | 0.025 bc            | 12.89 d             |
|          | Gypsum    | Brebes          | 100.48 a            | 0.142 a             | 59.15 ab            |
|          |           | Purbalingga     | 121.56 a            | 0.149 ab            | 71.55 a             |
|          |           | Pemalang        | 60.36 bc            | 0.094 bc            | 36.89 bc            |
|          | Zeolit    | Brebes          | 80.89 bc            | 0.160 a             | 49.73 abc           |
|          |           | Purbalingga     | 81.82 bc            | 0.098 bc            | 51.50 ab            |
|          |           | Pemalang        | 98.39 ab            | 0.134 ab            | 56.88 ab            |
|          | Control   | Brebes          | 35.53 cde           | 0.068 bc            | 30.79 bc            |
|          |           | Purbalingga     | 66.76 bc            | 0.109 ab            | 42.38 abc           |
|          |           | Pemalang        | 70.75 bc            | 0.124 ab            | 44.74 abc           |

Note: mean values in a column followed by the same letters are not significant based on DMRT.

### Table 5. Effect of amendments on nutrient uptake by shallot.

| Amendment | Soil | N uptake (mg/plant) | P uptake (mg/plant) | K uptake (mg/plant) |
|-----------|------|---------------------|---------------------|---------------------|
| Gypsum    | Alfisol | 45.80 ab          | 0.089 ab            | 31.96 ab            |
|           | Inceptisol | 94.13 c           | 0.128 b             | 55.86 b             |
| Zeolite   | Alfisol | 60.60 abc          | 0.106 b             | 42.53 ab            |
|           | Inceptisol | 87.03 bc          | 0.131 b             | 52.70 b             |
| Control   | Alfisol | 18.73 a           | 0.024 a             | 14.64 a             |
|           | Inceptisol | 57.68 abc         | 0.100 b             | 39.30 ab            |

Note: mean values in a column followed by the same letters are not significant based on DMRT.
The diameter of shallot bulbs showed a positive relationship with N uptake ($r = 0.8637$) and K uptake ($r = 0.8446$). The positive regression curve results are also supported by the results of the correlation analysis, in which bulb diameter has a positive correlation with N, K uptake ($r = 0.802; r = 0.671$). In accordance with the results of the correlation analysis, where bulb diameter has a positive correlation with the dry stover weight of bulbs ($r = 0.721$). Potassium functions for bulb development (Jazilah et al., 2007). According to Uke et al. (2015), potassium is water-soluble and readily available, so that its availability in plants is very important for the bulb formation process. Bulbs that have a larger diameter have relatively more bulb layers and have a larger root cross-sectional area so that they can increase the ability to absorb water and plant nutrients (Darma et al., 2015). According to Lana (2010), the number of bulbs in one clump is determined by the ability of the plant to form bulbs and then grow the bulbs. In general, the three shallot cultivars showed significantly different results, where the Purbalingga cultivar had the highest average number of bulbs. According to Azmi (2011), the different number of bulbs in varieties is due to genetic factors for each variety and is only slightly influenced by the environment. Deden (2014) also concluded that differences in the number of bulbs between varieties were influenced by genetic factors/varieties.

The yield data were influenced by soil factors, which were influenced by genetic factors/varieties. Differences in the number of bulbs between varieties is due to genetic factors for each variety and is only slightly influenced by the environment. Deden (2014) also concluded that differences in the number of bulbs between varieties were influenced by genetic factors/varieties.

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### Table 6. Shallot yield by treatments at harvest.

| Treatments | Soil | Amendment | Shallot Cultivar | Plant height (cm) | Bulb diameter (cm) | Bulb number | Bulb fresh weight (g) | Bulb Stover weight (g) |
|------------|------|-----------|-----------------|------------------|-------------------|-------------|----------------------|------------------------|
|            | Al fisol | Gypsum | Brebes           | 13.33 de         | 1.06 b            | 3.67 c      | 6.83 c               | 0.56 d                 |
|            |       |          | Purbalingga     | 10.83 e          | 1.00 b            | 9.00 a      | 11.73 bc             | 2.1 bc                 |
|            |       |          | Pemalang        | 15.00 cde        | 1.30 ab           | 5.67 bc     | 15.00 b              | 1.66 bcd               |
|            | Zeolite | Gypsum | Brebes           | 14.66 cd         | 1.46 ab           | 4.67 c      | 9.66 bc              | 1.06 cd                |
|            |       |          | Purbalingga     | 16.33 cd         | 1.65 ab           | 7.33 ab     | 23.00 a              | 3.00 a                 |
|            |       |          | Pemalang        | 17.00 cd         | 1.33 ab           | 4.33 bc     | 11.93 bc             | 1.40 b                 |
|            | Kontrol | Gypsum | Brebes           | 13.66 de         | 1.44 ab           | 4.00 c      | 11.96 bc             | 1.76 bc                |
|            |       |          | Purbalingga     | 12.16 e          | 1.02 b            | 4.67 c      | 8.00 c               | 1.13 bc                |
|            |       |          | Pemalang        | 14.00 d          | 1.10 b            | 5.00 bc     | 9.20 bc              | 1.83 bc                |
|            | Inceptisol | Gypsum | Brebes           | 28.33 a          | 1.91 a           | 6.33 bc     | 22.00 a              | 3.36 a                 |
|            |       |          | Purbalingga     | 23.66 ab         | 1.78 ab           | 6.33 bc     | 28.60 a              | 3.23 ab                |
|            |       |          | Pemalang        | 20.00 bc         | 1.58 ab           | 5.67 bc     | 14.16 b              | 3.26 ab                |
|            | Zeolite | Gypsum | Brebes           | 16.33 cd         | 1.56 ab           | 8.00 a      | 19.20 ab             | 1.30 b                 |
|            |       |          | Purbalingga     | 21.00 bc         | 1.66 ab           | 6.67 abc    | 19.73 ab             | 3.36 a                 |
|            |       |          | Pemalang        | 19.66 bc         | 1.56 ab           | 8.00 a      | 20.00 ab             | 2.26 bc                |
|            | Control | Gypsum | Brebes           | 16.16 cd         | 1.35 ab           | 5.00 bc     | 16.60 b              | 0.96 cd                |
|            |       |          | Purbalingga     | 22.00 ab         | 1.45 ab           | 6.67 abc    | 15.56 bc             | 2.29 abc               |
|            |       |          | Pemalang        | 12.33 e          | 1.41 ab           | 5.67 bc     | 12.93 bc             | 2.96 abc               |

Note: mean values in a column followed by the same letters are not significant based on DMRT.

Figure 1. Relationship between N, K, and P uptake and the bulb fresh weight.

Table 6. Shallot yield by treatments at harvest.
Nutrient uptake provided a positive impact on the fresh weight of bulbs. The higher absorption caused an increase in bulb weight. Figure 1 shows that N uptake was the most influential nutrient ($R^2 = 0.9143$). The weight of fresh shallot bulbs had a positive correlation with phosphorus uptake ($R^2 = 0.8037$). The weight of fresh shallots also had a positive correlation with potassium uptake ($R^2 = 0.733$). In bulb formation, N forms the vegetative part of plants (Arista et al., 2015), while K maintains plant water and cell turgor pressure, regulates stomata and the translocation of newly formed carbohydrates (Uke et al., 2015). According to Setiyawati et al. (2010), the increase in bulb fresh weight is due to a large amount of water absorption and the accumulation of photosynthetic products on the leaves to be translated for bulb formation. According to Sudadi and Ariyanti (2012), the greater the uptake of P nutrients will increase the dry weight or production of shallots. This opinion is strengthened by research by Arman et al. (2016), who reported that P uptake had a positive correlation with bulb weight.

**Conclusion**

Application of gypsum 25 t/ha decreased ECp, Na, increased Ca and Mg in both soils. Zeolite application 15 t/ha increased Ca and Mg and decreased SAR of Alfisol and Inceptisol while reduced Na and Alfisol and pH of Inceptisol. Gypsum application increased N uptake in Inceptisol, while zeolite application could increase N uptake in both Alfisol and Inceptisol soils. Increased N uptake by application of gypsum to Inceptisols was more effect on Brebes and Purbalingga cultivars. Application of zeolite increased N and P uptake of both soil, while gypsum application increase N and P uptake in Inceptisol only. Application Zeolite and gypsum also increased K uptake in Alfisol with cultivar Purbalingga and Pemalang. Gypsum increases bulb diameter in Inceptisol soils. The increase in the number of bulbs generally occurred in the application of zeolite to Inceptisol, while specifically, the Purbalingga cultivar on Alfisol increased with the application of gypsum and zeolite. Fresh weight increased by giving zeolite to Alfisol cultivar Purbalingga.

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