Research Article

Influence of *Trichoderma* as a seed treatment on the growth and yield of groundnut under saline environment

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Abstract: Agriculture lands in coastal areas face the risk of increasing salinity due to the influence of sea water. Salinity poses complex problems for plants at all growth stages which are difficult to be addressed. *Trichoderma* is a microorganism known to promote plant growth and to induce plant tolerance to abiotic stresses including salinity. The research aimed to evaluate effective *Trichoderma* for improving groundnut growth and yield in a saline environment. The research was conducted on saline soil (EC >8 dS/m) at Gesikharjo Village, Palang Sub District, Tuban District from July to October 2019. Treatments were combinations between N and P fertilization, and four *Trichoderma* strains and these treatments were arranged in a randomized completely block design with six replicates, using Hypoma 1 groundnut cultivar. Soil fertility and salinity, growth, yield and yield components were recorded as observed parameters. The results showed that NP fertilization on high salinity soils (ECs of 8.80-15.91 dS/m) with low N and high P had no significant effect on all variables compared to those of N fertilization. Applications of *Trichoderma* increased plant height and minimized plant death as indicated by a higher percentage of plant population at harvest compared to that of without inoculation. Among the four *Trichoderma* strains, *Trichoderma* #3 and *Trichoderma* #4 showed more effective than the other two strains in improving plant growth based on the shoot dry weight at the R1 phase, plant height and percentage of plant population at harvest. The positive effect of *Trichoderma* #3 and #4 could be due to the ability to promote plant growth as well as to induce plant resistance against salinity stress. The results suggested that *Trichoderma* was effective to alleviate salinity stress on groundnut crops. This research was the first trial carried out in the field and therefore needs to be further investigated, including *Trichoderma* formulations and application techniques.

Keywords: abiotic stress, groundnut, salinity, *Trichoderma*

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Introduction

High salinity disrupts agricultural land in the coastal area of Java Island (Rachman et al., 2018), and the worst impact on crop production has been reported by many researchers (Marwanto et al., 2009; Suganda et al., 2009; Erfandi and Rachman, 2011; Sembiring et al., 2020). Land affected by salt in the coastal area becomes wider in the future due to the rising of sea water. Erfandi and Juarsah (2014) recorded that sea water increased 0.2-0.6 cm/year during 1993-2008. Salinity stress causes complex problems which are more difficult to be addressed than other abiotic stresses. Minimizing the negative effects of salinity is practical management for economic reasons, easier to be adopted and implemented. Cultivation of salt-tolerant cultivars (Sembiring et al., 2020; Subekti et al., 2020), fertilization with sulphur (Nazar et al., 2009; Subekti et al., 2020), and the use of *Trichoderma* (Taufiq et al., 2020) has been known as alternatives to manage salinity stress.
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2011), potassium (Kopittke 2012), nitrogen (Taufiq et al., 2018), gypsum and manure (Kalhon et al., 2012; Murtaza et al., 2013; Taufiq et al., 2015), as well as mulching (Dong, 2012; Taufiq et al., 2017) have been reported as effective practices for alleviating food crop stress on saline soil. Certain microbes which are able to colonize rhizosphere induce systemic resistance on crops (Berg et al., 2014; Bisen et al., 2016), supply organic compounds from decomposition activities which trigger the number of soil microbes (Mbarki et al., 2016), and produce plant growth hormones which trigger the number of soil microbes (Mbarki et al., 2016; Yasmeen and Siddiqui, 2017). Application of Trichoderma spp. offer various functions and abilities regarding beneficial relationships with the plants (Hidangmayum and Dwivedi, 2018). Priming rice seeds with Trichoderma improves root and shoot growth, increases water and nutrient uptake, and increases plant resistance to abiotic stresses (Rawat et al., 2012), increases salt tolerance and hence lowering the stress of agronomic parameters (Rawat et al., 2016; Yasmeen and Siddiqui, 2017). Application of Trichoderma reduces the adverse effects of salinity stress on wheat growth (Zhang et al., 2016; Zhang et al., 2019), and French bean (Gupta and Pandey, 2019). Microbial exploration conducted by Indonesian Legumes and Tuber Crops Research Institute has collected 54 isolates of Trichoderma since 2016. Several isolates have been identified to survive on extreme pH and salinity condition, are able to colonize root and promote root as well as shoot growth of soybean and groundnut. However, their effectiveness in improving groundnut growth and yield on saline soil needs to be evaluated. Therefore, this research aimed to evaluate four Trichoderma strains for improving groundnut growth and yield in a saline environment.

Materials and Methods

Description of study area

A field experiment was conducted at Gesikharjo Village, Palang Sub District, Tuban District (6°54’ 19.5196” S; 112°8’17.7947” E; 4 m above sea level) from June to September 2019 (dry season). The site is about 570 m from the coastal line, and the soil belongs to Inceptisol, according to Widiatmaka et al. (2015). The experimental land is lowland with planting pattern of rice-palawija, having good soil fertility as indicated by the high status of nutrient availability, but high of both pH and salinity (Table 1).

Table 1. Chemical properties of the upper soil layer (0-20 cm) from the experimental site.

| Properties                  | Methods               | Value  | Classification |
|-----------------------------|-----------------------|--------|----------------|
| pH-H2O                      | 1:5                   | 8.0    | Slight alkaline|
| Total-N (%)                 | Kjeldahl              | 0.18   | L              |
| Organic C (%)               | Walkley & Black       | 2.23   | M              |
| P2O5 (ppm)                  | Olsen                 | 115    | VH             |
| Exchangeable cations (cmol/kg)| NH4OAc, pH 7      |        |                |
| K                           |                       | 1.41   | VH             |
| Na                          |                       | 3.35   | VH             |
| Ca                          |                       | 13.80  | H              |
| Mg                          |                       | 6.36   | H              |
| CEC                         | Σ(K+Na+Ca+Mg)         | 24.92  | M              |
| Na saturation (%)           | (Na/CEC)*100%         | 13.75  | H              |
| SO4 (ppm)                   | NH4OAc pH 4.87       | 67.96  | H              |
| EC (dS/m)                   | Field measurement     | 14.07  | VH             |

Notes: 1)L: low; H: high; VH: very high; M: moderate according to Sulaeman et al. (2005); 2)Mclean (1982); 3)Bremner (1960); 4)Walkley and Black (1934); 5)Olsen and Sommers (1982); 6)Michael (1945); 7)Tabatabai (1982); 8)using a portable EC meter.

Treatment and design

Six combination treatments i.e. (T1): 69 kg N/ha, (T2): T1 + 36 kg P2O5/ha, (T3): T1 + *Trichoderma* #1, (T4) T1 + *Trichoderma* #2, (T5) T1 + *Trichoderma* #3, and (T6) T1 + *Trichoderma* #4 were arranged in a randomized complete block design with four replicates. The T1 and T2 were the best treatments identified from the experiment conducted in the previous year (Taufiq et al. 2018). SP36 (36% P2O5) and Urea (46% N) were used as phosphorous (P) and N fertilizers. Four strains of *Trichoderma* were selected from the fungal culture collection of the Indonesian Legumes and Tuber Crops Research Institute (ILETRI) which showed high pH and salinity tolerance in the laboratory.
Procedure
Weeding and rice straw clearing, as well as soil tillage, were conducted before groundnuts cultivation. Groundnut seeds of Hypoma 1 cultivar were planted on 10 m × 9 m of plots; interrow distances were 30 cm and 15 cm between plants, 1-2 seeds/hole. All of SP36 dosages were broadcasted just after planting, while Urea was applied at 20 and 50 DAP (days after planting) with 50% of the dosage in every application. Organic fertilizer at a dosage of 2.5 t/ha and 100 kg/ha of KCl (60% K₂O) were applied after planting in all plots. Trichoderma treatments were applied as seed coating (1x10⁶ cfu) with 0.1% Tween 80 as emulsifier at 12 hours prior to planting. Manual weeding was carried out at 20 and 50 DAP. Profenofos and Chlorfenapyr insecticides according to recommended dosages were sprayed to control leaf sucking pests and leaf feeders, respectively. Fungal diseases were controlled using Propineb and Zinc fungicides. Irrigation using well water with electrical conductivity (EC) of 3.96-5.72 dS/m was carried out seven times, starting from planting to 90 DAP.

Data collection and analysis
Soil ECs at 20, 45, and 75 DAP were monitored in situ using a portable EC meter. Leaf chlorophyll indexes at 30 and 70 DAP were measured using a chlorophyll meter (SPAD-502). Shoot dry weights were observed at the flowering stage and harvest time. Contents of N, P, K and Na in the soil and shoots were measured at the flowering stage. Plant height, number of filled matured pods and young pods, fresh and dry shoot weight, number of plant stand, fresh and dry pods weight, dry seed weight, and 100 seeds weight were observed at harvest. Analysis of variance and mean comparison were used to determine the effect of treatments.

Results and Discussion
Soil properties
The experimental site is around 570 m from the coast with soil pH of 8.0 (slightly alkaline) and Na saturation (ESP) of 13.75% (Table 1). Based on the EC value >4 dS/m, pH <8.5 and Na saturation (ESP) <15%, the soil in this study site belongs to saline soil. Soil salinity is classified as very saline with a value above the critical level of 3.2 dS/m, according to Yadav et al. (2011). In this condition, seed germination delayed 7-10 days, and hence the harvest date was also 13 days longer than in non-saline soil (Hypoma 1 cultivar matures at about 90 days). In general, the soil properties in this study site had high fertility as indicated by moderate to very high macronutrients, except for N. Groundnut crops on this soil was potentially hampered by low N levels, high soil EC, very high Na content as well as high Na saturation. In saline soils with N-total from 0.13 to 0.26% of N and high available P, groundnut was responsive to N fertilization, but was not responsive to P fertilization (Taufiq et al., 2018). Farmers in the study area only used Urea fertilizer for groundnut cultivation with a dose reaching to 276 kg N/ha (Kasemu, personal communication). Low N content in saline soil might be lost by volatilization due to high soil pH and EC, and also leaching as intensive irrigation during the dry season. In clay texture soil, 17.9% of N from Urea losses due to leaching and becomes 24.4% higher at pH 8.0 than at pH 7.0 (Cevallos et al., 2015). In dry soil conditions, 31.2% of N from Urea losses due to volatilization (Dominghetti et al., 2016), and the volatilization increases as soil EC and pH increase (Li et al., 2017).

Soil EC in all treatments decreased with the increase of plant age. No significant differences between treatments in the three observation dates were observed (Figure 1), but the ECs were still very high. Groundnut crops were irrigated seven times during growing period (at planting, 20, 30, 45, 60, 75, and 90 DAP) using well water with ECs of 3.96-5.72 dS/m. This was equal to twice watering at 20 DAP, while the plants were watered four and six times up to 45 and 75 DAP, respectively. The decline of soil EC was likely related to frequent irrigation. The salt on the top layer was washed out with frequent watering. Apart from high soil EC, the addition of EC from water irrigation could have an adverse effect to groundnut growth according to Aydinsakir et al. (2015), and even plant death (Singh et al., 2010).

Plant growth
The treatments significantly affected (at 10% level) weight of dry shoots at the R1 phase and plant height at harvest but had no significant effect on the weight of dry shoots at harvest as well as the chlorophyll content indexes (CCIs) at 27 and 70 DAP. The highest shoot weight at the R1 phase was achieved by T1 and T6 treatments and T3, as well as T4 treatments, were the lowest. This showed that P fertilization and inoculation of Trichoderma #1 to #4 had no positive effect on shoot biomass accumulation and chlorophyll content, and even the biomass at the R1 phase decreased in treatment with Trichoderma #1 and Trichoderma #2 (Table 2). Fertilization with N (T1) produced the shortest plant height at harvest, but the addition of P fertilizer (T2) increased plant height by 10.3% compared to the T1 treatment. Applications of Trichoderma (T3, T4, T5, and T6) significantly increased the plant height by 13.5% to 42.3%
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Comparison to without Trichoderma (T1), and the highest increase occurred in T6 (Trichoderma #4) followed by T5 (Trichoderma #3) and T3 (Trichoderma #1) (Table 2). The concentrations of N, P and K in the shoots at the R1 phase were not significantly different among all treatments, except for Na. In other words, the applications of Trichoderma did not affect the ability of plants to absorb N, P and K, and even increased the Na uptake. Concentrations of Na in the treatments with Trichoderma #1 (T3) and Trichoderma #2 (T4) were 223% and 246% higher than those of without Trichoderma (T1), while the Na concentrations in Trichoderma #3 (T5) and Trichoderma #4 (T6) were 92% and 33% higher than in T1 (Table 3). The concentration of Na negatively correlated with the shoot biomass at the R1 phase (r = -0.98*). This demonstrated that the decrease of shoot biomass at the R1 phase in the T3 and T4 treatments was caused by higher Na concentration in the shoot. In cucumber plants, Yedidia et al. (2001) showed that application of Trichoderma harzianum strain T-203 increased root and shoot biomass and also increased Cu, P, Fe, Zn, Mn and Na concentrations. The plant height in the treatments of T3 and T4 as well as in the T5 and T6 were higher than in the T1 although Na concentrations were much higher. This indicated that Trichoderma #1 and Trichoderma #2 could induce plant resistance to salinity, therefore performing better plant height. Trichoderma #3 and Trichoderma #4 besides having plant resistance induction to salinity, these strains also stimulated plant growth.

Table 2. Effect of six treatments on the growth parameters and chlorophyll content index (CCI) of Hypoma 1 groundnut cultivar on saline soil. Tuban, 2019.

| Treatments                  | Shoot dry weight (g/plant) | CCI    | At R1 phase | At harvest | 27 DAP | 70 DAP | Plant height at harvest (cm) |
|-----------------------------|-----------------------------|--------|-------------|------------|--------|--------|-------------------------------|
| T1:69 kg N/ha              | 2.87 a                      | 19.78  | 27.32       | 37.17      | 16.3   | d      |                               |
| T2:T1+36 kg P2O5/ha        | 1.86 ab                     | 21.82  | 26.72       | 37.52      | 18.0   | cd     |                               |
| T3:T1+ Trichoderma #1      | 1.49 b                      | 22.48  | 26.53       | 37.60      | 19.5   | bc     |                               |
| T4:T1+ Trichoderma #2      | 1.55 b                      | 23.43  | 27.90       | 40.28      | 18.5   | c      |                               |
| T5:T1+ Trichoderma #3      | 2.29 ab                     | 20.24  | 27.45       | 37.65      | 20.8   | b      |                               |
| T6:T1+ Trichoderma #4      | 2.75 a                      | 21.85  | 26.91       | 36.83      | 23.2   | a      |                               |
| Probability (p)            | 0.078                       | 0.767  | 0.960       | 0.383      | 0.000  |        |                               |
| CV (%)                     | 28.94                       | 21.77  | 10.31       | 7.61       | 9.02   |        |                               |

Notes: p<0.01, p<0.05, 0.05<p<0.1, and p>0.1 are significant at 1%, 5%, 10%, and not significant; numbers in one column with the same letters or without letters are not significantly different with LSD test.

Kumar et al. (2017) showed that several Trichoderma spp. isolated from the rhizosphere were able to produce IAA, siderophore, and solubilize phosphate, increase maize growth as well as proline and phenol contents in both normal and saline conditions. The concentrations of P and K in the shoots at the R1 growth phase were at sufficient levels, whereas N was deficient (Table 3). This was in line with the P and K levels in the soil which were high and low N (Table 4). The sufficient levels of N, P, K in groundnut shoots at the flowering (R1 phase) according to Jones et al. (1991) are 3.50-4.50% of N, 0.20-0.35% of P, and 1.70-3.00% of K, and according to Singh et al. (2010) are 3.14-3.54% of N, 0.31-0.38% of P, and 1.84-1.97% of K. In groundnuts, the highest absorption rate for N occurs during the R1-R4 phases, P during the R2-R4 phases, and K in the R4 phase (Silva et al., 2017). Low levels of N in both soil and plants caused the chlorophyll content

![Electrical Conductivity graph](image-url)
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The chlorophyll content index (CCI) was also low (28.50-35.20) at 27 DAP and 40 DAP. However, CCI became relatively normal at 70 DAP (Figure 2). The increase of CCI was in accordance with the decrease in soil EC. These results indicated that the current Trichoderma tested was promising to improve vegetative growth of groundnuts cultivated on saline soil, and this effect might be related to its ability to induce resistance to salinity and also to produce a growth stimulant.

Table 3. N, P, K and Na concentrations in groundnut shoots at R1 phase grown in saline soil, Tuban, 2019.

| Treatments          | N (%) | P (%) | K (%) | Na (%) |
|---------------------|-------|-------|-------|--------|
| T1:69 kg N/ha       | 1.64  | 0.50  | 2.68  | 0.48 b |
| T2:T1+36 kg P₂O₅/ha| 1.78  | 0.45  | 2.54  | 1.17 ab|
| T3:T1+ Trichoderma #1| 2.12 | 0.47  | 2.70  | 1.55 a |
| T4:T1+ Trichoderma #2| 1.79 | 0.46  | 2.55  | 1.66 a |
| T5:T1+ Trichoderma #3| 1.66 | 0.45  | 2.51  | 0.92 ab|
| T6:T1+ Trichoderma #4| 1.57 | 0.46  | 2.53  | 0.64 b |

Probability (p) 0.294 0.801 0.973 0.040
CV (%) 16.11 9.22 14.41 40.84

Notes: p<0.01, p<0.05, 0.05<p<0.1, and p>0.1 are significant at 1%, 5%, 10%, and not significant; numbers in one column with the same letters or without letters are not significantly different with LSD test.

Table 4. Concentrations of N, P, K and Na in saline soil when groundnut plants at the R1 phase, Tuban, 2019.

| Treatments          | N total (%) | P₂O₅ (ppm) | Exch-K (cmol/kg) | Exch-Na (cmol/kg) |
|---------------------|-------------|------------|------------------|------------------|
| T1:69 kg N/ha       | 0.15        | 87.1 a     | 1.15             | 3.76             |
| T2:T1+36 kg P₂O₅/ha| 0.13        | 67.7 b     | 1.12             | 3.99             |
| T3:T1+ Trichoderma #1| 0.15   | 84.1 a     | 0.95             | 3.56             |
| T4:T1+ Trichoderma #2| 0.14   | 76.8 ab    | 1.05             | 3.98             |
| T5:T1+ Trichoderma #3| 0.17   | 90.3 a     | 1.20             | 3.86             |
| T6:T1+ Trichoderma #4| 0.16   | 88.4 a     | 1.09             | 3.87             |

Probability (p) 0.222 0.059 0.666 0.525
CV (%) 11.91 10.27 16.79 7.68

Notes: p<0.01, p<0.05, 0.05<p<0.1, and p>0.1 are significant at 1%, 5%, 10%, and not significant; numbers in one column with the same letters or without letters are not significantly different with LSD test.

Several researchers have reported the ability of Trichoderma to stimulate plant growth by producing hormones and other organic compounds, helping to absorb nutrients and reducing the influence of abiotic stresses including salinity stress (Berg et al., 2014; Bisen et al., 2016; Lee et al., 2016; Guler et al., 2016; Cripps-Guazzone et al., 2016; Zhang et al., 2019). The Trichoderma used in this current study did not show a positive effect on N, P, K uptake, but instead increased Na uptake.

Yield and yield attributes

The treatments did not significantly affect yield and yield attributes but significantly affected the percentage of plant population at harvest and harvest index (Table 5). This shows that N fertilization is important for groundnut grown on saline soils with low N and high P, and this result is in line with a study conducted by Taufiq et al. (2018).

![Figure 2. Chlorophyll content index (CCI) of groundnut leaves cultivated on saline soils in six treatments. Tuban, 2019. (T1:69 kg N/ha, T2:T1+36 kg P₂O₅/ha, T3:T1+Trichoderma #1, T4:T1+Trichoderma #2, T5:T1+Trichoderma #3, T6:T1+Trichoderma #4)](attachment:image)
### Table 5. The effect of fertilization and *Trichoderma* inoculation on groundnut yield attributes of Hypoma 1 cultivar on saline soil, Tuban, 2019.

| Treatments          | Plant population at harvest (%) | Weight of 100 seeds (g) | HI) | Number per plant | Weight of pod and seed (g/10 plants) | Yield (kg/ha) |
|---------------------|---------------------------------|-------------------------|-----|------------------|--------------------------------------|--------------|
|                     |                                 |                         |     | Branches         | Mature pods | Young pods | Fresh pods | Dry pods | Dry seed | Fresh pods | Dry pods | Dry seed |
| T1: 69 kg N/ha      | 57.5 bc                         | 47.58                   | 0.34 a | 5.8 | 10.7 | 5.2 | 189.4 | 111.7 | 68.2 | 2.048 | 1.053 | 511.1 |
| T2: T1 + 36 kg P2O5/ha | 63.3 bc                        | 46.96                   | 0.36 a | 6.6 | 13.0 | 4.6 | 211.3 | 122.3 | 73.8 | 1.904 | 0.901 | 482.4 |
| T3: T1 + *Trichoderma* #1 | 59.7 bc                        | 45.52                   | 0.33 a | 6.6 | 11.8 | 5.0 | 198.8 | 113.0 | 68.7 | 1.778 | 0.857 | 389.6 |
| T4: T1 + *Trichoderma* #2 | 55.8 c                         | 40.34                   | 0.27 b | 7.5 | 10.7 | 6.1 | 188.8 | 102.3 | 59.2 | 1.809 | 0.816 | 348.8 |
| T5: T1 + *Trichoderma* #3 | 70.9 ab                        | 45.84                   | 0.30 a | 6.1 | 10.4 | 5.0 | 180.6 | 104.1 | 64.0 | 2.059 | 0.992 | 493.0 |
| T6: T1 + *Trichoderma* #4 | 79.2 a                         | 42.55                   | 0.33 a | 6.5 | 12.0 | 5.1 | 184.3 | 104.8 | 63.3 | 1.741 | 0.826 | 416.5 |
| Probability (p)     | 0.005                           | 0.259                   | 0.098 | 0.247 | 0.204 | 0.683 | 0.694 | 0.521 | 0.347 | 0.849 | 0.693 | 0.485 |

Notes: p<0.01, p<0.05, 0.05<p<0.1, and p>0.1 are significant at 1%, 5%, 10%, and not significant; numbers in one column with the same letters or without letters are not significantly different with LSD test; 1) variance analysis use transformed-data by √x; 2) HI=harvest index, calculated based on 10 plant samples.
Seed treatments with the current \textit{Trichoderma} had no positive effect on groundnut yield. Plant population at harvest in the treatments using \textit{Trichoderma} #4 (T6) and \textit{Trichoderma} #3 (T5) was higher than the other treatments. Plant population at treatments with \textit{Trichoderma} #2 (T4) was lower than the other treatments, and also had the lowest harvest index (Table 5), and this might be related to high Na concentrations in the plants (Table 3) which caused the death of the plants.

A higher percentage of plant population at harvest indicates lower crop mortality due to the salinity. These results suggest that \textit{Trichoderma} #4 and \textit{Trichoderma} #3 are potential to be used for improving groundnut growth on saline soil. The yield significantly correlated with the number of mature pods and weight of 100 seeds, but it did not significantly correlate with plant population, even though plant population was significantly different among the treatments (Table 6).

Table 6. Correlations between yield and yield attributes of groundnut cultivated on saline soil (n = 36), Tuban, 2019.

| Variables                          | Plant height (cm) | NMP | PTP | 100 seeds weight (g) |
|------------------------------------|-------------------|-----|-----|----------------------|
| Number of matured pods/plant (NMP)| 0.074             |     |     |                      |
| Plant population at harvest (PTP, %)| 0.562**           | 0.197|     |                      |
| Weight of fresh pods (kg/ha)       | 0.144             | 0.394*| 0.094| 0.658**              |
| Weight of dry pods (kg/ha)         | 0.109             | 0.381*| 0.097| 0.663**              |
| Weight of dry seeds (kg/ha)        | 0.119             | 0.327*| 0.132| 0.591**              |

Notes: * and **: significant at 5% and 1%, respectively.

The number of branches was normal, i.e. 5-6 branches/plants, but the number of mature pods was only 11.4 pods/plant or 42.7% of the cultivar potential when this cultivar was planted on nonsaline soil. The highest yield was around 2.0 t/ha of fresh pods and 1.1 t/ha of dry pods or equal to 47.8% of the average yield of Hypoma 1 cultivar on non-saline soil, or about 30% of the potential yield. In a greenhouse experiment, Hypoma 1, Hypoma 2, Takar 1, Tuban, Kancil, Bison, Singa, Talam 1, Domba, and Panther cultivars did not produce pods at the EC >4.44 dS/m although those cultivars were able to survive at the EC of 10.38 dS/m (Taufiq et al., 2015). The highest pod yields (fresh pods) of Hypoma 1 and Domba cultivars on saline soil in Tuban and Lamongan with the ECs of 11.06-13.90 dS/m during the dry season in 2015 were 1.78 t/ha and 1.13 t/ha, respectively (Taufiq et al., 2016). The highest fresh pod yield of Hypoma 2 cultivar on saline soil in Lamongan with the ECs of 11.0-14.5 dS/m during the dry season in 2016 was 3.99 t/ha (Taufiq et al., 2017), and on saline soil with the ECs of 13.3-18.4 dS/m in 2017 yielded 1.31 t/ha in Tuban and 2.96 t/ha in Lamongan (Taufiq et al., 2018). This shows that the effect of salinity on decreasing cultivar yield is very significant.

\textbf{Conclusion}

An application of NP fertilizers on high salinity soils (EC 8.80-15.91 dS/m) with low N and high P had no significant effect to all variables observed compared to those of N fertilization. Seed treatments with \textit{Trichoderma} increased plant height and reduced plant death as indicated by a higher percentage of plant population at harvest compared to those of without inoculation. Among the four \textit{Trichoderma}, strains of #3 and #4 showed more effective plant growth improvement than the other two counterparts based on the shoot dry weights at the R1 phase, plant heigh and percentage of plant population at harvest. The positive effects of \textit{Trichoderma} #3 and #4 could be due to their ability to promote plant growth as well as to induce plant resistance against salinity stress. This result suggested that applications of \textit{Trichoderma} as seed treatment had a promising effect of alleviating salinity stress. This research was the first trial conducted in the field, and therefore, it needs to be further investigated, including \textit{Trichoderma} formulations and application techniques.

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