Application of *Trichoderma*-Enriched Compost on Shallot Productivity and Storability in East Lombok, West Nusa Tenggara

(Pemanfaatan Kompos Diperkaya Trichoderma pada Produktivitas dan Daya Simpan Bawang Merah di Lombok Timur, Nusa Tenggara Barat)

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ABSTRACT. Research on the benefits of *Trichoderma*-enriched compost (*Tricho-compost*) to improve soil fertility and yield of some vegetables has been widely reported. The objective was to study the effect of Tricho-compost application on productivity and storability of shallot. The experiment was laid out in a randomized block design at Labuan Lombok Village, Pringgabaya, East Lombok District, West Nusa Tenggara Province, during June to August 2017. There were five treatments with three replications, i.e., T1 = no fertilizer (control), T2 = 10 t/ha compost, T3 = NPK (250 kg/ha NPK, 150 kg/ha Urea, and 150 kg/ha SP-36), T4 = T3 + T2, and T5 = T3 + 10 t/ha Tricho-compost. The results showed that shallot with T5 treatment produced higher weight at 20, 40 and 60 days after planting (DAP), fresh weight at 40 and 60 DAP, and dry yield. The plant height, fresh weight and dried yield were higher in T5 than those of plants in T4 for 3.7%, 8.7%, and 8.3%, respectively. Weight lost in T5 was 2.7% lower than T4 after storing for 90 days, indicating T5 shallot had better storability. These data indicated the potential of Tricho-compost to improve growth, yield, and storability of shallot.

Keywords: *Allium cepa ascalonicum*; Productivity; Storability; Tricho-compost; Tropical dryland

Shallot (*Allium ascalonicum* L.) is one of the most important vegetable in Indonesia as it is the main ingredient in various culinary and preferred for its distinct flavour that persists after cooking when compare to onion (*Allium cepa* L.). Increasing demand showed at the yearly consumption growth lifted 7.33% from 2.570 kg/cap/year in 2017 to 2.758 kg/cap/year in 2018. On the other hand, growth of national shallot production was lower at 2.26% while the shallot harvested area reduced 0.88% from 158.171 ha to 156.799 ha in the same periode (Pusat Data dan Sistem Informasi Pertanian 2019).

One of shallot main producers in Indonesia is West Nusa Tenggara (NTB) Province. The harvest area of shallot in NTB is about 19.275 ha with annual production is 211.803,70 tonnes (BPS NTB 2015). Shallot is propagated vegetatively with short growth cycle at about 60 to 120 days depend on variety and environment (Woldetsadik, Gertsson & Ascard 2003). About 17.711 households cultivates shallot in dryland area of East Lombok (1,344 ha), Sumbawa (3,340 ha), Dompu (666 ha), and Bima Districts (13,884 ha) (BPS 2013).

Low soil fertility and water availability is the major obstacle to grow shallot in dryland area (Suriadi et al. 2018). Moreover, farmers prefer to grow shallot during dry season to get optimum solar radiation, lower incidence of disease, and better yield. On the other
hand, shallots require a constant supply of moisture throughout the growing season. Increasing soil organic matter by adding organic fertilizer is the key solution to improve soil fertility, water retention, favourable microclimate, and conserving soil biota (Allison 1973; Brady 1984). Shallot production in East Lombok District is very intensive because farmers irrigate using deep well water. Annually, shallot is cultivated two to three times, excluding during the rainy season (November to February) to avoid excess of rainfall. First season usually start about March to April, next on June to July, and last on September to October (Adnyana & Rahayu 2016; Rahayu & Mardian 2016).

Dryland shallot farming in NTB is a feasible business at B/C ratio about 0.66 for East Lombok District area (Adnyana & Rahayu 2016), whenever the productivity is above 5 tonnes/ha at minimum price IDR 7,500/kg (Rahayu & Mardian 2016). In attempt to obtain high yield, shallot grower are strongly depending on chemical fertilizer and pesticide that closely related to some disease and pest resistant. Therefore, adding organic fertilizer that acts as biocontrol is necessary for sustainable shallot production on dryland are of NTB Province. Thicho-compost is one of promising organic fertilizer that acts both increasing soil fertility and biological agent. Tricho-compost is the material that results when spores of *Trichoderma* sp. used in the composting process (Rahman & Birkey 2005). *Trichoderma* sp. is antagonistic fungus that inhibits the growth of several pathogens (Wahyuno, Manohara & Mulyo 2009). These antagonistic activities include competition, parasitism, predation or formation of toxins such as antibiotics (Harman 2000). Various research results show the benefits of *Trichoderma* sp. as a biological fertilizer on various crops such as caiisin (Yudha, Soesanto & Mugiastuti 2016), strawberries (Dwiastuti, Fajri & Yunimar 2016), soybeans (Marianah 2013), garlic (Mahdizadehnaraghi et al. 2015; Oliveira, Margarida & Borges 1984), onion (Latifah, Kustantinah & Soetanto 2011), and paper (Wahyuno, Manohara & Mulyo 2009).

Commercial products containing *Trichoderma* sp. is available at market, including at government institution such as Balai Besar Peramalan Organisme Pengganggu Tanaman (BBPOTP) in Karawang of West Java that produce and regularly distribute *Trichoderma* sp. to Balai Proteksi Tanaman Pangan dan Hortikultura (BPTP) at each provincial level. Tricho-compost produced at Balai Pengkajian Teknologi Pertanian (BPTP) of NTB by following typical method by Rahman & Birkey (2005). The study aims to evaluate the effect of *Trichoderma*-enriched compost on productivity and storability of shallot grown in East Lombok.

**MATERIALS AND METHODS**

**Times and Place**

An on-farm experiment was carried out at June to August 2017 at Labuhan Lombok Village, Pringgabaya Subdistrict, East Lombok District, West Nusa Tenggara (NTB) Province (S 8°30'47.74 “x 116°39’17.56”, 57 m above sea level) during dry season.

**Research Methodology**

The experimental area is characterized as tropical dryland with average annual rainfall of about 976 mm per year and in average 87 rainy days. Although there was no rainfall recorded during experiment, irrigation done using farrow irrigation system from deep water pumped. The soil was sandy loamy in texture with pH about neutral at 6.52 and mean annual temperature of about 35°C with range of 33°C maximum to 20°C minimum (BPS 2018).

Shallot of *Trisula* cultivar used in this study is high yielded (6.5–23.21 tonnes ha⁻¹) suitable for low latitude (6–85 m above sea level) and number of bulb about 5-8 with weight 39–93.3 g plant⁻¹ (Hortikultura 2012). Shallot was planted on alluvial soil, the experiment was arranged in Randomized Block Design with three replications. There were five treatments, i.e., 1 = control (no fertilizer), T2 = 10 t/ha compost, T3 = NPK (250 kg/ha NPK, 150 kg/ha Urea, and 150 kg/ha SP-36), T4 = T3 + 10 t/ha compost, and T5 = T3 + 10 t/ha Tricho-compost. In total there were 15 plots area sized 150 m² (10 m x 15 m) that consisted of five rows in 20 cm apart with 15 cm spacing in row.

*Trichoderma* sp. was obtained from Agens Hayati Laboratory of Balai Besar Peramalan Organisme Pengganggu Tanaman (BBPOTP) by Balai Proteksi Tanaman Pangan dan Hortikultura (BPTP) of Dinas Pertanian of West Nusa Tenggara Province, however futher information about spesific strain of *Trichoderma* was not mentioned clearly. Next, BPTPH prepared the rice media colonized *Trichoderma* sp. with average density was 24.21 x 10⁶spore/mg. Futhermore, Tricho-compost made at Balai Pengkajian Teknologi Pertanian (BPTP) of West Nusa Tenggara Province.

*Trichoderma*-enriched compost was made using 2.5 kg of rice colonized by *Trichoderma* sp. and mixed with 50 kg organic fertilizer Petroganik® produced by PT. Petrokimia Gresik with registration number 095/ORGANIK/BSP/IX/2005. Petroganik® contains of minimum 12.5% C-organik, 10-5-25 C/N ratio, 4–12% maximum moisture content, pH at 4–8. After initial mixing, the compost was incubated for two weeks. Every 4–5 days, the mixing was watered and mixed (Figure 1a).
Tricho-compost was applied as base fertilizer with NPK and SP-36 at the time of plowing soil. While Urea was applied for second and third fertilizer at age 15 and 45 days after planting (DAP). The bulb tip was cut 2/3, then sprayed with fungicide, and dried for 3 days before planting. Shallot cultivation system referred to the technical guidance on shallot integrated plant management (Sumarni & Hidayat 2005).

Fifteen sample plants were selected randomly from central rows of each plot. Data were collected for parameter on plant height, number of leaf, fresh weight, and number of tiller at 20, 40, and 60 DAP. Fresh yield from 1 m$^2$ was weighted at harvest (about 40 plant/m$^2$), and the results were then converted to yield per hectare with 30% coefficient correction for land use effectiveness (Balitsa 2019). Dry yield is weight after storage which is measured when reaching constant weight after sun dried for 7–10 days. Bulb lost weight, diameter, and length were measured after storage for 90 days. Trial statistical evaluation results of data were done using STAR ver.2.0.1 (IRRI 2014).

**RESULTS AND DISCUSSION**

**Fresh and Dry Yield**

Yield of shallot was significantly affected by fertilizer treatments for both fresh and dry weight.
Table 1. Effect of fertilizer on shallot plant height, leaf number, and tiller number at 20, 40, and 60 DAP grown on Alluvial tropical dryland of East Lombok (Pengaruh pupuk terhadap tinggi tanaman bawang merah, jumlah daun, dan jumlah anakan pada 20, 40, dan 60 HST tumbuh di lahan kering tropis Alluvial Lombok Timur)

| Treatments (Perlakuan) | Plant height (Tinggi tanaman), cm | Leaf number (Jumlah daun) | Tiller number (Jumlah anakan) |
|------------------------|----------------------------------|--------------------------|-----------------------------|
|                        | 20 | 40 | 60 | 20 | 40 | 60 | 20 | 40 | 60 |
| T1                     | 26.94 | 31.57 b | 30.73 c | 13.60 | 22.53 | 21.07 c | 3.00 | 3.20 b | 5.20 |
| T2                     | 27.75 | 36.37 b | 33.00 c | 13.27 | 22.47 | 18.80 c | 3.13 | 4.13 ab | 5.13 |
| T3                     | 28.17 | 44.43 a | 41.20 b | 16.00 | 27.67 | 32.40 a | 3.20 | 5.47 a | 6.40 |
| T4                     | 29.63 | 46.07 a | 45.73 a | 13.47 | 25.67 | 26.60 b | 3.20 | 4.73 a | 5.60 |
| T5                     | 30.41 | 47.63 a | 47.50 a | 15.53 | 26.67 | 30.80 ab | 3.20 | 5.07 a | 5.47 |
| CV (%)                 | 14.95 | 18.10 a | 14.01 ab | 30.70 | 34.95 | 28.78 ab | 32.36 | 34.16 a | 33.35 |

Values within a column followed by the same letters are not significantly different by DMRT at 5% level. T1 = control (no fertilizer), T2 = 10 t/ha compost, T3 = inorganic fertilizer (250 kg/ha NPK, 150 kg/ha Urea, and 150 kg/ha SP-36), T4 = T3 + 10 t/ha compost, and T5 = T3 + 10 t/ha Tricho-compost. DAP = days after planting.

Although there was no significant difference between T5 and T4, Tricho-compost in T5 was likely beneficial to increase dry yield at average 0.90 t/ha. According to Shoresh, Harman & Mastouri (2010), *Trichoderma* sp. stimulates plants to absorb nutrients, improve fertilizer efficiency, and stimulate crops to be more resistant to biotic and abiotic damage. Parasitic character in the *Trichoderma* sp. could attack and absorb nutrient from other fungus, than slower their growth or caused dead (Purwantisari 2009). Research by Latifah, Kustantinah & Soesanto (2011) reported the ability of *T. harzianum* from many isolate that could reduced *Fusarium oxysporum* development to 43.85%. While Deden & Umiyati (2017) who reported the lower number of disease caused by *F. oxysporum* at about 1.87–1.90% on shallot aged 4 and 5 weeks.

Yield potential of *Trisula* cultivar ranged between 6.50 to 23.21 tonnes per hectare (Hortikultura 2012). This study reached the similar yield at T4 and T5 where NPK was supplemented with 10 t/ha compost and 10 t/ha Tricho-compost applied, respectively. This data indicating the optimum environment for growth of shallot created when organic fertilizer added. Organic fertilizer largely attributes to improve soil organic matter, soil physical, chemical, and microbial properties, and nutrient availability and uptake as well (Allison 1973). Thus soil permeability and stable aggregates also improved (Satyanaraya & Prasar 2002), mainly in the top 40 cm of soil where 90% non-branching root of shallot concentrated (Brewster 1994). This better yield was contribution of better vegetative growth such as higher plant height, leaf number, and tiller number (Table 1). In line with this result, Rahayu & Berlian (2005) also concluded that higher carbohydrate reflected by bigger bulb when plant grow taller, higher leaf number, strong, and compact.

**Plant Height, Leaf Number, and Tiller Number**

Fertilizer treatment showed significant difference (p<0.05) of plant height at 40 and 60 DAP (Table 1). At 20 DAP, the plant height was ranged from 29.94 cm (T1) to 30.41 cm (T5). At 40 DAP, plant height increase between 31.57 cm (T1) to 47.63 cm (T5). During this growth period, plant height at T3 where only synthetic fertilizer applied was statistically similar to T4 and T5. At 60 DAP, the plant height was ranged between 30.73 cm (T1) to 47.50 cm (T5). Without organic fertilizer, plant height at T3 was significantly grow lower compare to T4 and T5. Although there was no significant difference between T4 (45.73 cm) and T5 (47.50 cm), Tricho-compost improve shallot height at about 3.7% taller compare to T4.

The number of leaves per plant showed no significant variation by application of treatment at 20 and 40 DAP, where the lowest number of leaves recorded in T2 and the highest at T3 for both growth stages. T3 was consistently obtained the highest number of leaves until 60 DAP at 32.40 which was similar to T5 (30.80) and followed by T4 (26.60). In contrast to number of leaf, number of tiller was significantly different only at 40 DAP. The highest number of tiller obtained at T3 which was similar to the rest of treatment except at T1. *Trichoderma* sp. plays an important role in the process of decomposition of organic compounds and it is capable of spreading by moving water flow brought nutrient...
closer to the root (Azwan et al. 2018). Under favourable environment and optimal nutrient availability, leaf expand optimally which increase the amount of solar radiation intercepted, nutrient uptake, photosynthesis, and transpiration rates, in turn will produce more splits and bigger bulb (Begum et al. 1990).

Average height of Trisula cultivar is 39.92 cm, number of leaf of about 28–39 per plant, and about 5–8 tillers (Hortikulutra 2012). The result of the current study is in agreement with some research finding. Effect of T. harzianum and T. koningii as fertilizer at some dosage (0–2.5 ml/liter) for three shallot varieties that reported by Deden & Umiyati (2017) was significantly improve plant height, leaf number, plant biomass, and dry bulb yield of Bima, Illolos, and Sunenep cultivars. The results is in line with research finding for other Allium such as reported by Mahdizadehnaraghi et al. (2015). He reported the effect of bioformula Trichoderma harzianum, T. Asperellum, and Talaromyces to increase plant height and bulb weight for both fresh and dry yield of garlic (Mahdizadehnaraghei et al. 2015).

**Fresh Weight, Weight Lost, and Bulb Size**

Analysis of variance showed that average fresh weight was affected by fertilizer treatment at 20 and 60 DAP (Table 3). At early vegetative stage, the highest fresh weight at 20 DAP was recorded T2 (9.17 g plant⁻¹) with no significant difference to other treatments except T4 (6.37 g plant⁻¹). Although similar to other treatment, T5 grow higher biomass at early generative stage (40 DAP), and when harvested at 60 DAP, the fresh weight was significantly the highest (67.44 g plant⁻¹). Benefit of Tricho-compost also showed on the smaller weight lost on T5 (5.20 g plant⁻¹) compare to T4 (5.96 g plant⁻¹) at about 2.7%. Sing & Sing (2003) reported that large size bulbs exhibited the highest weight loss compare to smaller sized bulbs. Derajew, Fikreyohannes & Bereje (2017) who reported that highest weight lost and bulbs rotting were observed when the highest...
Table 2. Effect of fertilizer on shallot fresh weight at 20, 40, and 60 DAP, weight lost after 90 days, bulb diameter, and bulb length grown on Alluvial tropical dryland of East Lombok (Pengaruh pupuk terhadap bobot segar bawang merah pada 20, 40, dan 60 HST, susut bobot setelah 90 HST, diameter umbi, dan pertumbuhan panjang umbi pada lahan kering tropis Alluvial Lombok Timur)

| Treatments (Perlakuan) | Fresh weight (Bobot segar), g plant⁻¹ | Weight lost after 90 days (Susut bobot setelah 90 HST) | Bulb diameter (Diameter umbi) | Bulb length (Panjang umbi) |
|------------------------|---------------------------------------|------------------------------------------------------|-------------------------------|-----------------------------|
|                        | 20  | 40 | 60/harvest | g plant⁻¹ | 90 HST        | cm | cm |
| T1                     | 7.77 ab | 12.32 | 46.76 bc | 8.13 a       | 1.91 ab | 2.58 a |
| T2                     | 9.17 a | 15.26 | 39.40 c  | 2.31 d       | 1.65 bc | 2.52 a |
| T3                     | 8.39 a | 18.14 | 53.81 ab | 3.29 cd      | 1.53 c  | 2.48 a |
| T4                     | 6.37 b | 17.39 | 61.57 a  | 5.96 ab      | 2.01 a  | 2.55 a |
| T5                     | 7.37 ab | 18.50 | 67.44 a  | 5.20 bc      | 1.59 c  | 2.28 b |
| CV (%)                 | 32.83* | 39.17 | 36.31**  | 72.30**      | 21.67** | 9.50** |

Values within a column followed by the same letters are not significantly different by DMRT at 5% level. T1 = control (no fertilizer), T2 = 10 t/ha compost, T3 = inorganic fertilizer (250 kg/ha NPK, 150 kg/ha Urea, and 150 kg/ha SP-36), T4 = T3 + 10 t/ha compost, and T5 = T3 + 10 t/ha Tricho-compost, DAP = days after planting.

farmyard manure (30 t/ha⁻¹) and widest intra-row spacing (15 cm) applied. *Trichoderma* sp. is avirulent to host plants that can enhance the plant resistance to some pathogenic fungi (Harman et al. 2004). *Trichoderma* sp. that isolated from shallot and applied to caisin plant effectively reduce the above ground disease to 50% and underground disease to 34.48%, and decreased the volume disease caused by *P. brassicae* at about 72.73% (Yudha, Soesanto & Mugiastuti 2016).

Significant difference in bulb size (diameter and length) was observed between treatments. Bulb size of shallot in T4 was significantly the biggest at average 2.01 cm in diameter and 2.55 cm in length, while the smallest size was in T5 with 1.59 cm in diameter and 2.28 cm length. Without *Trichoderma*, shallot produced a larger bulb in short term effect. According to Mukherjee, Horwitz, & Kenerley (2012), *Trichoderma* produced some metabolites (secondary metabolites) that could be toxic to plants, and further studies to characterize genetic and metabolit profiling of strain need to be done. However, based on variety description (Hortikultura 2012), *Trisula* bulb seizes 1.0–2.5 cm in diameter and 2–3 cm in length. Medium bulb size that ranged between 1.5 – 1.8 cm is generally has better quality and more economic for vegetative propagation (Sumarni & Hidayat 2005). Moreover, the size of ideal marketable shallot is of about 3–4 cm in diameter (Krontal, Kamenisky & Rabinowith 2000).

**CONCLUSION AND RECOMMENDATIONS**

This study quantify increase of shallot fresh weight at 8.7% and dry yield at 8.3% with application of *Trichoderma*-enriched compost. Next, its weight lost after stored for 90 days was lower by 2.7% compared when using only the compost. In addition, uniform medium bulb size puts more value for shallot bulb seed. In general, additional organic fertilizer, with or without *Trichoderma* sp. increases shallot production compared to when only chemical fertilizer applied. However, without chemical fertilizer (treatment in control and compost only) caused growth (plant height, leaf number, and fresh weight) of shallot less optimal which then produce the lowest yield.

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