Role of compost derived from rice straw and tithonia in improving chemical fertility of Regosol on onion cultivation.

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Abstract. Regosol, a suboptimal land, is rarely cultivated due to its low water retention and nutrient content. It is needed organic matter to improve the soil physical, chemical, and biological properties. A research conducted in glasshouse and soil laboratory was aimed to find out the best doses of compost derived from rice straw and tithonia to improve soil chemical properties of Regosol as well as onion production. There were 9 levels of compost doses (0; 2.5; 5.0; 7.5; 10.0; 12.5; 15.0; 17.5; and 20.0 ton ha\textsuperscript{-1}) applied to soil with three replications. The experimental units were allocated based on Completely Randomized Design (CRD). Crop data resulted were statistically analyzed using F-test and then continued using Least Significance Difference (LSD) at 5\% level of significance if F-calculated > F-table. The result showed that compost application up to 20 ton ha\textsuperscript{-1} did not significantly affect chemical properties of Regosol as well as onion production. The highest weight of onion bulb was found at application of 7.5 t compost ha\textsuperscript{-1}, however the highest N, P, and K uptake was found at doses 20 t compost/ha\textsuperscript{-1}. Therefore, it was needed further study to determine the appropriate compost doses for optimal onion production in Regosol.

1. Introduction
Beach area, area near to the sea, is mostly dominated by Regosols. This soil order has bad soil properties either the physical, chemical, or biological properties. Regosol, especially subordo Psamment is a kind of suboptimal land in low elevated land. In Indonesia, this soil order had an area approximately 831,000 ha [1], and [2]. Which is distributed in Padang city, Padang Pariaman and West Pasaman regions. It has low soil productivity, but it can be used for agriculture if it can be well managed.

Soil texture of Regosol is dominated by sand fraction, therefore, it has good aeration and drainage. However, it has low plant available water as well as bad soil chemical properties especially less amount of plant nutrients because the nutrients are easy to leach. Moreover, the Regosol had less soil organic matter (SOM) content [3]. Therefore, the soil physical, chemical, and biological properties must be improved before using it for crop cultivation. One way to do the effort is by OM application.

A type of OM that had been used widely for either various crops or many soil types was compost derived from rice straw (JP) and tithonia (Tt). Both materials were mixed with ratio 1:1 during composting. The raw materials of the compost, both JP and Tt, are excessively available in nature, especially in wet tropical region such as in West Sumatra. However, the materials are not optimally used, even JP was used to burn by farmers after harvest. Therefore, composting JP is important to keep OM in soils.
In composting process, it takes time for JP to decompose, because it has high lignin and cellulose percentage [4], with the C/N ratio was 56.90 and C/P ratio was 195.43. To accelerate the composting process, it need to add easily decomposed OM, such as tithonia (Tithonia diversifolia) which is mixed to JP. Tithonia has C/N ratio 13.96 and C/P ratio 154.48 [5]. This type of plant is known as green manure which can grow in many places from low to high altitude.

Reported that incorporation of fresh tithonia (2.5 t/ha) combined with Urea fertilizer application (150 kg/ha) resulted in 8.08 t/ha dry seed yield [6]. Previously, application of JP for 20 t/ha and P fertilizer for 60 kg SP-36/ha could improve some physical properties of Regosols, especially the bulk density (BD), aggregate stability index (ASI), and porosity of the soil [7] and the found that Ti considered as green manure has chemical composition as following: 3.43% N; 0.31% P; 4.16% K, 1.14% Ca; 0.78 Mg, and low cellulose and lignin content [8]. Therefore, explained that fresh Tt contained organic acids, such as 7.36 ppm benzoic acid; 13.90 ppm propionic acid, and 118.75 ppm of citric acid [9].

Furthermore, reported that compost derived from JP and Tt contained higher nutrients (0.63% N; 0.34% P; 0.89% K; and 39.18% C) than compost from JP only. Compost from JP and Tt with ratio 1:1 was very good to provide enough OM on farming land, as well as could safe synthetic fertilizer need [5]. It had been proved in the research that application of 7.5 t/ha compost JP+Ti (1:1) had improved soil chemical properties of Inceptisols and wheat growth [10]. The continued to study the residue effect of the compost on wheat growth. He found that the compost still had effect on crop growth and could substitute 50% of synthetic fertilizer need[11]. Then, also applied JP+Ti compost (1:1) on Ultisols, they found that the highest corn production was found under 7.5 t/ha compost application [12]. Applied the compost JP+Ti (1:1) on Oxisol for Kopay chili cultivation [13]. The highest chili production after 8 harvest periods was also found at 7.5 t/ha compost application. Based on the results above, the compost was also tried to apply to Regosol for onion cultivation.

Onion is a type of vegetable which needs to increase the production in Indonesia. Based on data released [14] of Indonesia, the onion was still imported up to 2,755,000 ton, which increased by 93,000 ton compared to year 2012. Increase in import meant that the demand was high but supply was less, even though the onion production increased every year. The problem of low total onion production could be anticipated by extending area for onion cultivation.

Onion was a kind of vegetation prioritised to increase the yield in GP2T Program (in 2016) and in UPSUS (in 2017), either under government or non-government funding. Then, [15] reported that yield of some onion varieties could reach 15 t/ha on low land. The cultivation and production in Regosol was interested to study. The research was aimed to determine the best dosage of compost derived from JP and Tt (1:1) for improving chemical properties of Regosol and production of onion.

2. Materials and Methods
This research was in form of experiment conducted at glasshouse and soil laboratory Agriculture Faculty, Andalas University Padang, Indonesia from April to September 2018. Soil (Regosol) was taken from top soil (0-20 cm soil depth) in Ulakan Tapakis, West Sumatra, Indonesia. Onion bulb used for this research was Bima Brebes variety. During composting process, the materials (JP+Ti) was added with Stardec as bio-activator to accelerate the decomposition process. Composting process took time for 2 months.

The treatment consisted of 9 dosage of compost (0.0; 2.5; 5.0; 7.5; 10.0; 12.5; 15.0; 17.5; and 20.0 ton/ha) with 3 replications. Each experimental unit was allocated using completely randomized design. Soil (Regosol) was measured the water content either at wind dry as well as at field capacity prepared. Soil was put for 5 kg (based on dry weight) into each pot (27 pots). The soil in each pot was added with compost as the treatment dosages, then incubated for 2 weeks. After that the incubated soil was sampled for soil chemical analyses of Regosol after compost application.

The bulbs chosen for this research were the bulbs having bright color, normal size and form as well as without any damage (5 g weight in average). The bulbs were incorporated into soil as the bulb height, and then covered with a thin layer of soil. Fertilizer applied was 200 kg SP-36/ha, 100 kg KCl/ha, 75 kg Urea/ha (half recommendation). Synthetic P application was applied 3 days before showing,
while N and K were applied at 2 weeks and 4 weeks after showing for half dosage each. The onion was harvested at 2 month age. The bulbs were dry under shading.

Initial and after incubation soil properties were analysed for the pH (using pH meter), organic-C (wet oxidation), total-N (digestion), available P (Bray I), CEC and basic cations especially K, Ca, Na, and Mg (leaching with NH4OAC 1N pH 7). Parameters analysed were amount of seedlings/pot, wet and dry weight bulb/pot. For analyses need, onion leaves and bulbs were oven dried at 65°C, and then weighed and ground. Then, it was analysed for N, P, K content and then calculated for the nutrients absorption by the bulbs and leaves.

Data resulted were compared to the soil chemical criteria (for soil characteristics) and statistically analysed for the variance using F-test and then continued using HSD at 5% level of significance if the F-calculated > F-table (for the crop).

3. Results and Discussions

3.1. Chemical Characteristics of Compost and the Effect on Regosol

Compost JP and Tt (1:1) produced had good quality and fulfilled SNI 19-7030-2004 (Table1).

| Parameter | Unit      | Concentration |
|-----------|-----------|---------------|
| pH        | %         | 7.41          |
| Tot-Cl    | %         | 32.91         |
| Tot-N     | %         | 1.87          |
| Tot-P     | %         | 0.26          |
| Tot-K     | %         | 0.76          |
| Tot-N     | %         | 0.43          |
| Tot-C     | %         | 0.17          |
| Tot-Mg    | %         | 0.68          |
| CEC       | Cmol/kg   | 37.45         |
| C/N       | -         | 17.59         |

Compost having chemical characteristics as in Table 1, incubated into Regosol for 3 weeks at several dosages was found to increase the pH values as the compost dosages increased. The pH values changed from acid to slightly acid as the compost applied increased from 0.0 to 0.25 t/ha, then pH value of the soil reached neutral as the compost applied up to 20.0 t/ha (Table 2).

Based on Table 2, soil organic-C did not change the criteria except after application of 20 t compost/ha, but it was not optimal yet. Then soil C/N ratio, CEC, and basic cations, base saturation were still considered low. However, interestingly, increasing soil CEC by compost application decreased the base saturation. Increase in soil CEC was due to increasing OM applied.

Increasing compost JP and Tt (1:1) applied was not able to improve P-available, total-N, and basic cations of Regosol good growth of onion. This was due to the fact that OM applied had low nutrients content (Table 1), even though it had fulfilled SNI 19-7030-2004. Therefore, soil chemical characteristics did not meet the crop need.
### Table 2. Characteristics of Regosol at initial and after compost JP+Tt (1:1) incubation

| Compost Dosage (ton/ha) | pH | H₂O Org.-C | C/N | P-avail. | CEC | K-exch. | Ca-exch | Mg-exch | Na-exch | Base-Sat. | Soil Chemical Properties |
|-------------------------|----|-----------|-----|----------|-----|---------|---------|---------|---------|-----------|-------------------------|
| Initial                 | 5.90 | 0.28 | 0.01 | 28.0 | 4.47 | 4.62 | 0.22 | 0.88 | 0.24 | 0.36 | 36.80 | m= acid; am= rather sour; s=medium; r=low; sr=very low; t=high; |
| 0.0                     | 6.40 | 0.36 | 0.02 | 18.0 | 5.46 | 4.90 | 0.25 | 0.99 | 0.26 | 0.48 | 40.41 |
| 2.5                     | 6.64 | 0.57 | 0.04 | 14.25 | 7.02 | 6.53 | 0.30 | 1.05 | 0.26 | 0.50 | 32.31 |
| 5.0                     | 6.68 | 0.70 | 0.05 | 14.00 | 8.59 | 9.38 | 0.33 | 1.05 | 0.30 | 0.50 | 24.41 |
| 7.5                     | 6.68 | 0.73 | 0.06 | 12.17 | 10.99 | 10.06 | 0.35 | 1.10 | 0.30 | 0.61 | 23.46 |
| 10.0                    | 6.72 | 0.76 | 0.07 | 10.85 | 12.19 | 10.61 | 0.37 | 1.10 | 0.35 | 0.63 | 23.09 |
| 12.5                    | 6.74 | 0.85 | 0.09 | 9.44 | 14.01 | 11.42 | 0.39 | 1.15 | 0.41 | 0.66 | 22.85 |
| 15.0                    | 6.91 | 0.92 | 0.10 | 9.20 | 15.26 | 12.24 | 0.50 | 1.20 | 0.43 | 0.66 | 22.79 |
| 17.5                    | 6.99 | 0.95 | 0.12 | 7.92 | 16.30 | 12.38 | 0.61 | 1.22 | 0.45 | 0.92 | 25.85 |
| 20.0                    | 7.10 | 1.17 | 0.15 | 7.80 | 17.77 | 12.78 | 0.61 | 1.28 | 0.47 | 1.20 | 27.86 |

3.2. Effect of compost JP dan Tt (1:1) on onion production

Crop growth was supported by nutrients available in the soils. Crop growth can be describes through its seedlings and dry matter which related to nutrients uptake of the crops.

![Average number of bulbs per hill](image-url)

**Figure 1.** Amount of average bulbs produced at several dosages of JP+Tt compost (1:1) on Regosol.
Based on Figure 1, dosage of compost did not give significant amount of onion bulbs produced. The highest amount of bulbs was found under 12.5 t/ha compost application, then it was followed by dosages 17.5 and 7.5 t/ha. Optimal fresh and dry bulb weights were found under 7.5 t/ha compost application. Data for bulbs were not match to the leaf dry weight, the highest leaf dry weight was found under application of 12.5 t compost/ha.

Table 3. Fresh and dry bulb weight as well as dry weight onion leaves from Bima Brebes variety as compost JP+Tt (1:1) on Regosol

| Compost Dosage (t/ha) | Fresh Weight | Dry Weight | Dry Leaves Weight |
|-----------------------|--------------|------------|-------------------|
|                       | g/polybag    |            |                   |
| 0.0                   | C            | 3.84 C     | 0.78 e            |
| 2.5                   | Be           | 5.90 Be    | 0.83 e            |
| 5.0                   | Ab           | 7.65 Ab    | 1.01 e            |
| 7.5                   | A            | 10.78 A    | 1.03 e            |
| 10.0                  | ab           | 8.68 ab    | 1.68 bc           |
| 12.5                  | A            | 9.15 ab    | 4.20 a            |
| 15.0                  | ab           | 9.46 ab    | 2.45 b            |
| 17.5                  | ab           | 9.30 ab    | 1.69 bc           |
| 20.0                  | A            | 10.71 A    | 2.79 b            |

Note: Numbers followed by the same small letter within column based on LSD at 0.05 level of significance.

Either bulb and leave weight or number of bulb produced correlated to nutrient absorption. Based on Table 4, the highest nutrient uptake by onion and significantly different from the others was found under 20 t/ha compost application. However, N nutrient uptake by leaves did not correlate to the N uptake by the bulbs. The highest N uptake by leaves was found under 12.5 t/ha compost, while the P and K uptake by both leaves and bulbs was the highest and significantly different from the others under 20 t/ha compost applied.

Table 4. Nutrient N, P, and K uptake by onion as affected by compost JP+Tt (1:1) application on Regosol

| Compost Dosage (t/ha) | N Uptake Bulb | Leaf | P Uptake Bulb | Leaf | K Uptake Bulb | Leaf |
|-----------------------|---------------|------|---------------|------|---------------|------|
|                       | g/polybag     |      |               |      |               |      |
| 0.0                   | 0.28 h        | 0.13 e| 1.23 h        | 0.33 d| 0.28 g        | 0.28 g|
| 2.5                   | 0.55 gh       | 0.45 e| 1.97 gh       | 0.63 d| 0.45 fg       | 0.42 fg|
| 5.0                   | 0.84 fg       | 0.74 e| 3.60 fg       | 1.30 cd| 0.61 ef       | 0.51 fg|
| 7.5                   | 1.22 ef       | 1.23 de| 5.10 ef       | 1.63 cd| 0.82 de       | 0.63 ef|
| 10.0                  | 1.42 de       | 2.39 cd| 6.43 de       | 2.23 cd| 0.89 d        | 0.83 de|
| 12.5                  | 1.75 ed       | 7.27 a| 7.50 ed       | 2.87 cd| 1.02 cd       | 1.02 d |
| 15.0                  | 1.90 e        | 3.62 bc| 8.83 e        | 4.37 bc| 1.15 bc       | 1.51 c |
| 17.5                  | 2.47 b        | 3.05 bc| 11.40 b       | 6.63 b | 1.31 b        | 1.94 b |
| 20.0                  | 3.39 a        | 4.42 b| 15.10 a       | 11.30 a| 1.68 a        | 2.63 a |

Note: Numbers followed by the same small letter within column based on LSD at 0.05 level of significance.

Indicator of onion production needed is weight of the bulbs harvested. Based on data resulted, it can be concluded that optimal dosage of compost JP+Tt (1:1) for onion cultivation at Regosol was 7.5
t/ha. Even though the highest number of bulbs was found under 12.5 t/ha but the size was smaller, therefore the weight was lower.

4. Conclusions
Application of compost JP+Tt (1:1) was able to improve chemical characteristics of Regosol. Optimal dosage of compost found was 7.5 t/ha which produced 13.56 g/polybag fresh and 10.78 g/polybag dry onion bulbs.

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