Organic fertilizer dosages and biofilmed biofertilizer formula on nitrogen uptake and shallot yields in slightly acid soil

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Abstract. Research aims to study the effect of organic fertilizer dosages and Biofilmed Biofertilizer formula on nitrogen uptake and shallot yield in Alfisols. Field experiment was conducted at Sukosari Village, Jumantono, Karanganyar district, Central Java, Indonesia. The experimental design used was Randomized Completely Block Design with two factors namely dose of organic fertilizers (D0, D1, D2) and Biofilmed biofertilizer formula (F0, F1, F2, F3). Each combination treatment repeated three times. Variables observed included N-uptake, plant fresh and dry weight, number and diameter of bulb, and shallot yield. Data was analyzed by F test at 95% of level confidence, followed by Duncan Multiple Range Test (DMRT) if any significant influence. The result showed that organic fertilizer doses influence significantly on bulb weight, while the interaction of organic fertilizer dose and biofertilizer formula influence N uptake. Highest bulb weight achieved by the use of 20 tons ha⁻¹ organic fertilizer (62.9 g clump⁻¹), increase 348.65% from control treatment (14.04 g clump⁻¹). The highest N-uptake was taken from the treatment combination of 10 tons ha⁻¹ organic fertilizer and biofertilizer formula F₁ (0.17 gr N/clumps), increase 183.33% from control treatment (0.06 g clump⁻¹).

1. Introduction
Shallot is a vegetable commodity that is used as a spice seasoning and traditional medicine for maagh, diabetes, and cholesterol. Shallot has a high economic value. Although production continues to increase, this production has not been able to meet the increasing demand annually [1]. Red shallot development is necessary to improve and meet national demand.

On the other hand, Alfisols is a marginal land that spread in Indonesia which can be used for shallot cultivation to increase its production. However, this soil has characteristics of acid pH, low organic matter content, shallow solum, high Aluminium (Al) and iron (Fe) levels and macro nutrient deficiencies, especially nitrogen. The lack of N-availability in Alfisols often results in low shallot yields.

Nitrogen in acid soils is widely available in the form of volatile and lichable nitrates. This has become one of the limiting factors of achieving optimal shallot yield. Nitrogen is an essential nutrient that involve as a constituent of amino acids and chlorophyll that are important in the process of photosynthesis, so nitrogen deficiency can inhibit growth and produced small tubers [2].
Lack of nutrient availability for plants can be overcome by fertilization. Inorganic fertilizers can provide macro nutrients quickly [3] but the use of excessive inorganic fertilizers can damage the soil structure. Inorganic fertilizers can cause the soil more compact, incapable of holding water and nutrients due to the residue left behind by cementation, so it is necessary to use fertilizers that can improve the nature of soil chemistry, physics, and biology.

Biofilmed biofertilizers are biological fertilizers that can be used as biodecomposers in the manufacture of organic fertilizers. Organic materials decomposed with biofilmed biofertilizer has the advantage of containing functional microbes from synergistic plant roots, and forming a thin layer of microbial consortia so as to increase nutrient availability through N fixation, P and K solubilization and inhibit the growth of Fusarium oxysporum fungus [4]. The study was aimed to determine the dosage of organic fertilizer decomposed with biofilmed biofertilizer which increased N uptake and the shallot yield in Alfisols.

2. Materials and methods

The study was conducted from April to June 2016, on Alfisols of Jumantono, Karanganyar. Soil and plant tissue analysis was conducted at Soil Chemistry and Soil Fertility Laboratory, Faculty of Agriculture, Sebelas Maret University, Surakarta. Shallot seeds used were varieties of Bima Brebes. The materials used were biofilmed biofertilizer inoculum, organic fertilizer decomposed with biofilmed biofertilizer, pest and disease control materials, SP-36 fertilizer, KCl, urea, ZA, PDA and NA media as well as chemicals for physical and chemical properties analysis of the soil. The experiment design used was Completely Randomized Block Design (CRBD) with two factors: organic fertilizer dosages (D0 = 0 ton / ha, D1 = 10 ton / ha, D2 = 20 ton / ha) and biofilmed biofertilizer formula as biodecomposer (F0 = formula without biofilmed biofertilizer, F1 = formula 1 of biofilmed biofertilizer. Formula 2 (F2) of biofilmed biofertilizer was formula 1 without nitrogen fixing bacteria (FP1). Formula 3 (F3) was commercial biodecomposer. Composition of Biofilmed Biofertilizer Formula 1 is phosphate solubilizing bacteria (PSB) (isolate TBH 18, PBH), phosphate solubilizing fungus (PSF) (Aspergillus niger, isolate YD 17), potassium solubilizing bacteria (isolate PPH 7), sulphur oxidizing bacteria (SoB) (isolate HBH12), Beauveria, Trichoderma sp., JPF (JPF isolates), Aspergillus japonicas (AJU isolates), nitrogen fixing bacteria (FP1), liquid media composition (coconut water 10 L, rice water 5 L water, ½ L molasses, SP-36 20 gr, KCl 10 gr and urea 10 gr). Composition of organic material to make organic fertilizer were 20 kg of chicken manure, 20 kg dung, phosphate rock 5 kg, feldspar 1 kg, 0.5 kg sulphur, and dolomite 2 kg, 1.5 kg ash). All organic material were mixed evenly with the decomposer inoculum formula and made the water content ranges from 40-60% by adding water, then incubated for 2 weeks before used for treatment. The data were analyzed using F test at 95% level confidence, followed by Duncan Multiple Range Test (DMRT) test if any significant differences.

3. Result and discussion

3.1. Selected soil chemical properties and texture

The research was conducted in April-June 2016 located at Alfisols Jumantono, Karanganyar at 193 m altitude, rainfall and average temperature was 194,3 mm/month and 27,7°C. Shallot is a short-lived plants, optimally cultivated at an altitude of 0-450 m above sea level. Shallot is suitable to be grown in loamy sand textured soil with high organic content (> 2%), cation exchange capacity> 16 (cmol (+) / kg), good drainage and pH 6-7,8, air temperature between 25-32°C, 100-200 mm/month rainfall, low humidity and long irradiation more than 12 hours [5]. Based on the growing requirements for the shallot, it is necessary to apply the decomposed organic materials biofilmed bifertilizer to improve soil chemical properties such as pH and organic materials to support the growth and the results of shallot. The use of decomposed organic materials biofilmed biofertilizer in Alfisol soil is thought to be more favorable, because the acid soil properties can help improve dissolution of natural phosphate rock and feldspar to be readily available for plants.
The characteristics of ready-to-use organic fertilizer is a C / N ratio <20, neutral pH, blackish brown color, fine fertilizer texture and odorless [7]. Based on the quality standard that has been determined and viewed from the content of nutrient (Table 1 and Table 2), the organic fertilizer is feasible to be used. C / N ratio of less than 15 means that the fertilizer mineralization rate is greater than the immobilization so that nutrients are available to the plant.

3.2. Nitrogen uptake of shallot

| Parameter | F0 | F1 | F2 | F3 | MOA |
|-----------|----|----|----|----|-----|
| Water content (%) | 18.0 | 14.8 | 15.5 | 15.5 | 15-25% |
| N (%) | 2.2 | 2.3 | 1.3 | 1.9 | (N + P2O5 + K2O min 4% |
| P (%) | 0.2 | 0.3 | 0.3 | 0.3 | |
| K (%) | 1.6 | 1.7 | 1.7 | 1.2 | |
| Organic C (%) | 21.4 | 19.5 | 19.8 | 18.5 | min 15% |
| pH | 8.39 | 7.39 | 7.55 | 8.11 | 4-9 |
| C/N Ratio | 9.7 | 8.5 | 15.0 | 9.8 | 15-25 |

The results showed that the interaction of organic fertilizer dosage and biofilmed biofertilizer formula significantly affected the N Shallot absorption (Figure 1). The highest N uptake resulted from the treatment combination of 10 tons ha⁻¹ organic fertilizer and F1 (0.17 gram N cluster⁻¹). Formula 1 is biofilmed biofertilizer with N-fixing microorganisms, P and K solvents and sulfur oxidizers. The high

![Figure 1](image-url)
absorption resulting from the treatment is suspected of microbial activity fixing free N, and P and K solubilizer that capable of increasing nutrient availability for plants, either through N fixation of air by N fixing bacteria, or dissolving P and K from the fertilizer used i.e. phosphate rock as a source of P and feldspar as the source of K. In addition, although the addition of fertilizer doses can increase the total N of the soil, but not necessarily increase the availability of nitrate and ammonium that can be absorbed by plants, this results in the absorption of between 10 and 20 tons/ha of fertilizer has no significant difference. Not only the high nutrient content matters, the nutrient balance of N, P, K is also important, because it is capable of affecting the results of the treatment given either encouraging, inhibiting or not responding to the growth and development of the plant. N uptake from NPK treatment was lower than organic fertilizer use, as assumed in soil acid pH, N is absorbed in the form of nitrate while urea (one of NPK fertilizer) when applied to the soil turns into ammonium carbonate so that N uptake is low.

### 3.3. Shallot growth and yield

![Figure 2. Effect of organic matter dosage decomposed by biofilmed biofertilizer on shallot plant height in Alfisols](image)

Plant height is the most easily observed growth indicator. The results showed that the dosage of organic fertilizer had significant effect on the height of shallot plant (Figure 2). The use of organic fertilizer 10 tons/ha can increase the height of shallot. Dose of 20 tons/ha increased plant height that was not significantly different with the dose of 10 tons/ha. This is allegedly due to the increasing use of higher doses of manure that can increase the height of shallot, because the higher fertilizer doses brought higher availability of nutrients [8,9]. There is an association between N uptake and plant growth ($r = 0.682$). The more optimal the N is absorbed by the plant the better the growth. Nitrogen acts as a constituent of amino acids, protoplasm and chlorophyll so that optimal absorption of N is capable of supporting the photosynthesis process and the N deficiency lead to inhibited growth, dwarf and even dead.

![Figure 3. Effect of organic matter decomposed by biofilmed biofertilizer on shallot bulb number in Alfisols](image)
The number of tillers formed will result in a larger number of bulbs [10,11]. The results showed that the dose of organic fertilizer had significant effect on the number of shallot bulbs, but the dosage and formula interaction and biofilmed biofertilizer formula had no significant effect (Figure 3). The use of decomposed organic fertilizer with biofilmed biofertilizer increases the number of bulb. The absence of nutrient input to the control treatment resulted in the plant that not getting enough nutrient supply to support the growth and formation of tillers [12]. There was a correlation between adding doses of fertilizer usage with increasing number of bulb (r = 0.464). The addition of fertilizer with the right dose at the beginning of growth will support the formation of tillers on shallot which will affect the number of bulbs produced, so if the formation of the number of tillers will be obstructed that decreasing the number of bulbs fromed [13].

![Figure 4](image.png)

**Figure 4.** Effect of organic matter decomposed by biofilmed biofertilizer on shallot bulb fresh weight in Alfisols

As with the number of tubers, the dose of organic fertilizer had a significant effect on the weight of shallot bulbs, but the dosage and formula interactions and biofilmed biofertilizer formulations had no significant effect (Figure 4). The use of organic fertilizer up to 20 ton ha\(^{-1}\) still shows the increase shallot yield, maybe because of low level of indigenous soil organic matter, so that the availability of macro and micro nutrients is low. Tuber weight is strongly influenced by the availability of macro and micro nutrients in the soil, if the availability of macro and micro nutrients is low then the tuber yield will decrease while the application of organic fertilizer into the soil can increase the availability of nutrients in the soil. The low weight of shallot bulbs is due to the large number of tubers but the low nutrient uptake, resulting in low photosynthate yield but high distribution so the tubers produced are small and light [14,15]. There is a correlation between the plant height and the weight of bulb produced (r = 0.620), where in plants with good growth describes the results is also good, because the metabolism process goes well so high assimilate obtained and support the formation of large and heavy bulbs.

### 3.4. Tuber diameter

Tuber diameter is one of the quality parameters of red shallot. Where the greater the diameter of the bulbs, the better the quality shallot tuber classification in general havea several ways. According to the shallot bulb classification uses diameters measured by the calipers using the criteria when the diameter is <1.5 cm are class C, 1.5-1.8 cm are class B and class A > 1.8 cm.

The result of the diameter of the shallot bulb in Table 3. shows that in average, tuber yield has small diameter, this can be seen from the result of the multiplication of tubers into the class B and C. The nutrient uptake on the shallot is low and the lot of bulb formed suspected to cause small diameter produced. Low nutrient uptake results in lower photosynthetic processes, resulting in low assimilate yields and inability to support large diameter bulbs, whereas large numbers of bulbs lead to more distribution of photosynthesis results [16,17]. Along with the increased doses of organic fertilizer given the greater the diameter of the tubers produced. This is because the increased dose of fertilizer is able to increase the availability and uptake of nutrients by the Shallot, especially the element K. K element on the shallot plays a role in the formation, enlargement and elongation of bulbs. Potassium is
important in tuber formation, since it is a catalyst in the translocation of photosynthetic yields and the ability of plants to form bulbs and increase bulbs is determined by the ability of plants to form assimilates and to translocate the assimilates from the leaves to the bulbs [10]. There is a correlation between N uptake and the bulb diameter \( r = 0.647 \) where the more optimal the plant absorbs the N element, the larger the bulb diameter is formed. Absorption of N is the absorption regulator of P and K, in the red Shallot that lacks of P, only small tubers formed, because one of the P functions in the red Shallot is the enlargement in tuber formation.

### Table 3. Classification of Shallot bulb

| Treatment | Value | Class |
|-----------|-------|-------|
| F0D0      | 1.8   | B     |
| F0D1      | 1.64  | B     |
| F0D2      | 1.63  | B     |
| F1D0      | 1.25  | C     |
| F1D1      | 1.66  | B     |
| F1D2      | 1.58  | B     |
| F2D0      | 1.29  | C     |
| F2D1      | 1.65  | B     |
| F2D2      | 1.68  | B     |
| F3D0      | 1.28  | C     |
| F3D1      | 1.66  | B     |
| F3D2      | 1.69  | B     |
| NPK       | 1.35  | C     |

Description : Classification based on [18]

### 4. Conclusion

The combination treatment of 10 ton ha\(^{-1}\) organic fertilizer and formula 1 biofertilizer able to increase N uptake of 0.17 gram N cluster\(^{-1}\), (183.3%) compared to 0.06 gram N cluster\(^{-1}\) of control treatment. The application 20 ton ha\(^{-1}\) of organic fertilizer increase shallot yield (bulb weight) to 348.6% (62.99 gr clump\(^{-1}\)) compared to control treatment (14.04 g clump\(^{-1}\)). The increase of shallot bulb yield is still linear with the increase of fertilizer dose up to 20 ton ha\(^{-1}\) allegedly because of low soil organic matter content.

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