Amelioration and variety selection to increase shallot yield in peatlands

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Abstract. Productivity can be achieved by improving fertility and using adaptive varieties. The research aimed to determine the effect of ameliorant types and onion varieties on soil properties and shallot yield in peatlands. The research was carried out on degraded peatland in Kalampangan, Palangkaraya, Central Kalimantan from April to September 2017. The experiment was arranged using a factorial randomized block design with four replications. The first factor was the ameliorants type (A1 = 100% manure, A2 = 50% rice husk biochar + 50% manure, A3 = 50% rice husk ash + 50% manure, and A4 = compost formulated from 40% weeds + 40% manure + 20% agricultural lime). The second factor was the shallot variety of Bima and Bauji. Observation variables included available P, exchangeable K, plant growth and yields. Manure was better than others for increasing the availability of P and K. The highest yield of shallot obtained by Bauji variety which applied ameliorant 100% manure. Shallot yields in peatland were more influenced by ameliorant type than varieties so the ameliorant was very important for the success of shallot development in peatland. The Bauji variety is quite adaptive in peatlands, so it can be recommended for larger development.

1. Introduction

The area of peatlands in Indonesia is currently predicted to reach 14.93 million ha [1]. Peat soil is formed slowly due to the accumulation of organic matter in shallow lakes, and then slowly overgrown by wetland vegetation [2]. Peat contains a mixture of organic compounds which have high molecular weight characteristics such as humic acid, cellulose, lignin, peptides, and fat. Peat also has organic material with low molecular weight such as amino acids, alkaloids, carbohydrates, and other types of sugars [3]. Peat soils generally have low pH level, base saturation, macronutrients (K, Ca, Mg, P), micronutrients (Cu, Zn, Mn and B), and high cation exchange capacity (CEC) [4]. Amelioration plays a role in improving peat soil fertility through increasing pH and nutrient availability, and reducing levels of organic acids and toxic ions [5]. There has been a lot of research on amelioration in peatlands to increase their productivity. However, the effectiveness of amelioration depends on the type of fixing agent, the dosage used, and the level of maturity of the peat. The provision of chicken manure, oil palm empty bunches (OPEFB) compost, and rice husk ash did not change the pH criteria except for the application of lime [6]. The provision of husk ash and mineral soil had a very significant effect on pH, total N, availabilities of P and K, CEC, and base saturation of peat soils [7]. Ameliorant type and dosage affect the growth and NPK nutrients uptake by sweet corn plants [8]. Giving 10 t ha\textsuperscript{-1} dolomite can increase pH, available P, exchangeable K, Ca and Mg as well as onion yields in peatlands [9]. Ripe compost can increase shallot production in peat soils [10].
The problem in cultivating shallots on peatlands apart from soil fertility is the attack of plant pests, especially during the rainy season. Suhardi [11] reported that the cause of cultivation failure of shallot in the rainy season is mostly due to the high incidence of disease. In order to minimize the yield gap, it is necessary to test the adaptation of new superior varieties of shallots which have high adaptation and production in peatlands. Variety selection is very important because if it is not suitable with the agro-ecosystem it will cause low yields [12]. The research aimed to determine the effect of ameliorant types and shallot varieties on soil properties, and shallot growth and yield in peatlands.

2. Materials and methods

2.1. Materials
The materials needed in this research included: shallot tubers of Bauji and Bima Arjuna varieties, manure, dolomite, rice husk biochar, rice husk ash, compost, fertilizers (urea, SP-36, and KCl), herbicides, insecticides, fungicides, chemical materials for soil analysis, and stationery kits.

2.2. Methods
The research was conducted on degraded peatlands in Kalampangan Village, Sebagau District, Palangkaraya District, during the rainy season (July-November 2017). Initially, the land was cleared of shrubs using the glyphosate herbicide and cutting down the dead shrubs. The existing stump was removed so that the land was neat and level. After the land was cleared and flattened, raised beds and trenches (according to the treatment) were 1.2 m wide and 10 m long according to the experimental plot. The peatlands used had sapric maturity levels with the following soil properties; pH-H2O 4.65, pH-KCl 3.38, EC 0.082 mS cm⁻¹, organic C 56.6%, available P 22.18 ppm, exchangeable K 0.851 cmol(+) kg⁻¹, Ca 5.225 cmol(+) kg⁻¹, and Mg 4.469 cmol(+) kg⁻¹ [13].

The study used a factorial randomized block design and the treatments were replicated 4 times. The first factor was ameliorant type, namely A1 = 100% manure, A2 = 50% rice husk biochar + 50% manure, A3 = 50% rice husk ash + 50% manure and A4 = compost formulated from 40% weeds + 40% manure + 20% agricultural lime. The second factor was shallot variety, namely A = Bima variety and B = Bauji variety.

Ameliorant material was given at 2 weeks before planting with a dose of 10 t ha⁻¹. The basic fertilizers in the form of Urea, SP36 and KCl were spread and then stirred evenly with the soil 2-3 days before planting with doses of 100 kg N, 120 kg P2O5, and 150 kg K2O ha⁻¹. Supplementary fertilization was conducted 2 times by ½ dose each. The first supplementary fertilization in the form of urea and KCl fertilizers as much as 150-200 kg ha⁻¹ and K as much as 50-100 kg K2O ha⁻¹ or 100-200 kg KCl ha⁻¹ was carried out at the age of 10-15 days after planting and the second one was at the age of 1 month after planting.

Preparation of shallot seeds was done by cutting the ends of the seedlings and applying fungicides. The cutting of the end of the shallot tuber was done on the seedling tuber whom storage life is less than 2 months. The purpose of cutting the end of the tuber was to accelerate the growth of buds and stimulate the growth of the later tuber [14,15]. Before planted, the tubers were given or mixed with Dithane M-45 of 10 g kg⁻¹ tubers, then fermented for 12 hours. Planting the shallot tubers was done by inserting the shallot tubers into the planting hole at a distance of 20 cm x 15 cm with a movement such as twisting a screw so that the end of the tuber looks flat with the soil surface. Watering was done evenly every morning and afternoon.

Weed were controlled by weeding at least twice, each on 10-15 days old and before additional fertilization. Pest and disease control were controlled by using fungicides and insecticides every 2 weeks for prevention.

Shallot harvesting was carried out when the plants ages were 65 days old. Shallot plants are ready to harvest when the tubers have formed and come out of the soil surface, 60% of the stems are soft, more than 80% of the plants fall, and the leaves turn yellow. Harvesting should be done in dry soil and sunny weather to prevent tuber blight in the warehouse. Furthermore, the tubers are dried under direct
sunlight until they are quite dry (1-2 weeks) until they reach a moisture content of approximately 80% (tuber loss of 25-40%). After drying, the shallots are stored by hanging the shallots in a special warehouse at a temperature of 25-30°C and low humidity (±60-80%).

Observation of the periodic soil properties on pH H₂O, EC, and available P and K was carried out by taking periodic soil samples at 4 and 8 weeks after planting. Observations of plant growth included plant height and number of leaves. At the end of the observation, the weights of the shallot tubers and onion production per ha were observed. Data of observation variables were analyzed in the form of analysis of variance followed by the Duncan 5% test.

3. Results and discussion

3.1. Soil characteristics

The type of ameliorant treatment affected the soil properties which were observed at 4 and 8 weeks after planting (WAP). The highest pH value was shown by ameliorant treatment A4 followed by A2 (figure 1a). The highest EC was in treatment A4 and the lowest was A2 (figure 1b). Treatment A4 of compost ameliorant consisting of 40% weed + 40% manure + 20% dolomite, significantly increased soil pH which was higher than other ameliorants. The addition of lime in compost can increase the pH of peat soils. Lime provides a supply of OH⁻ to the soil solution and reacts with H⁺ to become water (H₂O) causing the H⁺ level to decrease and increase the soil pH [16]. The increase of EC on A4 treatment, it can be caused by the addition of lime to the compost, because giving lime is able to break down peat particles into smaller ones. Changes in the physical properties of peat can increase the EC of peatlands [17].

![Figure 1. Soil pH (a) and EC (b) due to ameliorant treatment on Bima and Bauji onion varieties.](image)

The available P on all treatments increased at 4 weeks after planting compared to baseline, then decreased at 8 weeks. This condition proves that the addition of ameliorant and inorganic fertilizers can significantly increase the available P. The highest available P concentration was indicated by the treatment of manure ameliorant (A1) (figure 2a). Manure has high base saturation [18] such as Ca and Mg which can act as a phosphate-binding cation bridge in the reactive site of peat material. The P element plays a role in translating photosynthetic products into plant tubers so that the tuber weight increases [19].
Figure 2. Available soil P (a) and K (b) due to ameliorant treatment on Bima and Bauji onion varieties.

The treatment A1 (100% manure) increased the highest soil K availability (figure 2b). Availability of K on 8 WAP was higher than that of 4 WAP. This is due to the addition of K fertilizer for 1 month. The addition of K nutrients either from inorganic or organic fertilizers can increase soil K content. The addition of compost takes longer to increase the K content because it requires decomposition and mineralization processes. Apart from the addition of K fertilizer, the availability of K in peat soils is also influenced by the process of decomposition and mineralization of peat soil. [20] reported that decomposition and mineralization processes in peat soils affect the availability of K in peat soils. Potassium is a monovalent cation, an element that is mobile and not strongly bound (non-covalently) by organic matter. According to the opinion of Gorham and Jannsens [21], K is a nutrient that is mobile horizontally and leached to the lower layers. Bohn et al. [22] also stated that K is a relatively mobile element in peat soils that are prone to leaching.

3.2. Growth and yield of shallots
There is interaction between ameliorant types and varieties on plant height observed at 2, 4 and 8 WAP (figure 3a), and on the number of leaves at 28 and 48 WAP (figure 3b). The ameliorant treatment of A3 on Bima variety had the highest effect on plant height (figure 3b), while the number of tillers of A1 treatment on Bima variety had the highest effect (figure 3b).

Figure 3. Effect of soil ameliorant and varieties on plant height (3a) and number of leeks (3b).
Towards the tuber yield, the type of soil repairer and varieties showed significant differences. It appears that the Bauji variety gives higher yields than Bima. The type of fixing agent A1 gives a better effect on the shallot yield than other types of soil amendment (figure 4).

Note: bars followed by the same number are not significantly different based on the 5% LSD test.

**Figure 4.** Effect of ameliorants and varieties on tuber diameter (a) and shallot yield (b).

According to Havlin *et al.* [23], the P element plays a role in the formation of the cell nucleus, cell division and multiplication, and essential in the process of photosynthesis and carbohydrate metabolism as a regulatory function for the sharing of photosynthetic results between the source and reproductive organs. Giving P fertilizer of 120 kg P₂O₅ ha⁻¹ can increase water conductivity on stomata, plant height, tuber diameter, P uptake and fresh weight per clump of shallots [24, 25]. If the K element is sufficient, it can provide optimal growth of shallots and show good results. Munawar [26] stated that plant growth and yield are closely related to the availability of nutrients that are absorbed by plants used in plant metabolic processes. The formation of shallot bulbs is related to increasing plant metabolic processes. Setiyowati and Hastuti [27] stated that tuber enlargement was caused by cell enlargement which was more dominant than cell division.

According to Sumarni *et al.* [28] genetic factors determine the number of shallot tillers compared to fertilization factors. Putrasamedja and Suwandi [29] reported that shallot production is influenced by genetic and environmental factors. Sinaga *et al.* [30] stated that the adaptability of a variety having one type of genotype having the ability to control morphological and physiological traits to adapt to the environment. The yield of Bauji variety on the peatlands of West Kalimantan was 8.13 t ha⁻¹, while the Super Philip was 6.50 t ha⁻¹ [12].

4. Conclusions
The type of ameliorant affects the pH, available P and exchangeable K of peat soil, and shallots growth and production. The application of 100% manure ameliorant gave the highest P nutrient availability. The plant height and number of leaves of the Bima shallot variety were higher than the Bauji variety, but the tuber size in the Bauji variety was bigger than that of the Bima variety. The ameliorant of 100% manure gave the significant high yield of shallots in both varieties. The highest shallots yield was achieved by Bauji variety with 100% manure, so that the treatment can be recommended to be developed in a wider area.

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