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Residual Effect of NPK Fertilizer towards Plant Growth and Corm Yield of Indonesian Konjac (*Amorphophallus muelleri* Blume) on Vertisol Soil

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Abstract
Indonesian konjac (Amorphophallus muelleri Blume) naturally grows on forest under the shade of the trees. However, this crop has become an important commercial tuber crop due to the whay the tuber crops, Indonesian konjac has been cultivated by employing the relatively high input in cultural practices, especially the use of fertilizer. NPK fertilizer has been commonly used to cultivate Indonesian konjac to produce high yield of corm. The present study was undertaken to evaluate the residual effect of NPK fertilizer on growth and corm yield of Indonesian konjac. Vertisol soil previously unfertilized (A), previously fertilized with 100 kg NPK/ha (B) and previously fertilized with 200 kg NPK/ha (C) were used to grow Indonesian konjac. The Indonesian konjac grown on each soil (A, B or C) was fertilized with 0 kg NPK/ha, 150 kg NPK/ha and 300 kg NPK/ha. Thus, the study used 9 treatments, and each treatment was replicated three times. All data obtained were analyzed by employing the standard deviation from 3 replicates. The results of the present study revealed that NPK fertilizer addition did not increase plant height, shoot diameter, shoor dry weight, corm diameter, corm thickness and corm fresh weight of Indonesian konjac grown on Vertisol soil previously unfertilized, previously fertilized with 100 kg NPK/ha or previously fertilized with 200 kg NPK/ha. Thus, the results of the present study suggest that Vertisol soil is fertile and addition of NPK fertilizer is not necessary to grow this kind of konjac.

Keywords: Indonesian konjac, vertisol, fertilizer, growth and corm yield

INTRODUCTION

Among tuberous crops, Indonesian konjac (*Amorphophallus muelleri* Blume), known as porang, is considered the most beneficial crop and has become an important commercial commodity in Indonesia (Al Hamdhan, 2020). The corm has been exported to several countries and has driven relatively high market prices (Abriyani, 2012; Ahmad, 2019; Al Alawi, 2017; Gesha, 2019). Konjac corm contains high amounts of glucomannan (Ariesta et al., 2019; Wardani et al., 2021), which has been linked to various health benefits such as blood sugar reduction and improved metabolic parameters (Cheang et al., 2017; Mardiah & Rahmawati, 2019; Soedarjo, 2015). The high market value of konjac has resulted in higher income for farmers compared to other tuber crops like cassava and sweet potato (Huda, 2021).

In its natural forest habitat, konjac grows under shaded trees with nutrients sourced from the soil. However, under commercial cultivation, intensive management practices such as fertilizer application are commonly employed to improve plant growth and yield. Several studies have shown that fertilizer significantly increases growth and yield in various crops, including rice, tomato, soybean, onion, long bean, and cassava (Hidayanto, 2019; Hariyadi et al., 2018; Phoppy et al., 2017; Hendarto et al., 2021; Lestari & Palobo, 2019; Purwanto et al., 2019; Taufiq et al., 2020). Fertilizer application has also been shown to positively affect konjac growth, especially in less fertile soils such as podsolic types (Santosa et al., 2016).

Konjac is typically harvested after the third year of cultivation when it reaches commercial corm size (3–5 kg). To support such growth, fertilizer is frequently applied during the first year and sometimes continuously in subsequent years (Santosa et al., 2016; Soedarjo et al., 2020; Soedarjo, 2021). However, the necessity of repeated fertilizer application beyond the first year remains unclear. Therefore, this research aims to assess the residual effect of fertilizer and determine whether additional fertilization is required in the second and third years of konjac cultivation.

Previous studies by Setyowati et al. (2020) and Arifin et al. (2021) emphasized the importance of initial fertilization in nutrient-deficient soils like Ultisols and Inceptisols, which are common in Indonesian agriculture. These studies demonstrated improvements in plant height, leaf number, and early corm development. However, they did not investigate the long-term effects of the initial fertilization on subsequent years. The present study fills this gap by exploring fertilizer residue effects on growth and yield during the second and third years of konjac farming. Scientifically, the findings contribute to understanding residual nutrient dynamics in tuber crops; practically, they guide farmers toward cost-effective and environmentally sustainable fertilizer management in konjac farming.

The objective of this study is to determine whether repeated fertilizer applications are necessary in each growing season or whether residual soil nutrients can sufficiently support konjac growth in subsequent years. The benefits of this research are both scientific and practical: scientifically, it contributes to the understanding of residual nutrient dynamics in tuberous crops; practically, it offers guidance to farmers and agronomists on optimizing fertilizer use, reducing production costs, and promoting environmentally sustainable konjac farming practices in Indonesia.

METHOD

Soil and Plant Preparation

Vertisol soil used in the present research work was obtained from Kendalpayak Experimental Station, Malang-East Java, Indonesia. The soil was taken from as deep as 20 cm. The soil was previously used for fertilizer research on Konjac at the rates 0 kg NPK ha^{-1} (A), 100 kg NPK ha^{-1} (B) and 200 kg NPK ha^{-1} (C) which was conducted as pot experiment in the glass house from November 2019 to April 2020. After harvest, the soils A, B and C were used for evaluating the residual effect of NPK fertilizer application on Konjac plant in the present experiment.

Each soil from A, B and C was pooled, crushed and sieved through 0.5 mm sieve. Then, the soil of as much as 7.5 kg from each soil (A, B and C) was put into a polyethlylene bag (15 x 30 cm). Prior to konjac sowing, the soil was watered to field capacity in accordance with the methodology described by Soedarjo et al. (2020) and Soedarjo (2021).

The research used local variety of konjac bulbil which was obtained from Probolinggo regency, East Java, Indonesia. Bulbil was germinated on wet sand and the seedlings were used as planting material. Selection of Konjac seedling was done to obtain approximately uniform size of Konjac seedling (height and shoot diameter) and healthy konjac seedlings. The weight of bulbil used in the study was approximately 20 $\pm$ 0.76 g. One konjac seedling from the uniform germinated bulbil was transplanted to each soil (A, B and C).

Konjac plants on each soil A, soil B and soil C were fertilized with 0 kg NPK ha^{-1}, 150 kg NPK ha^{-1} and 300 kg NPK ha^{-1} as treatments, respectively. Thus, the combination treatments used in the present study were A0, A150 and A300 (indicates soil A fertilized with 0 kg NPK ha^{-1}, 150 kg NPK ha^{-1} and 300 kg NPK ha^{-1}, B0, B150 and B300 (indicates soil B fertilized with 100 kg NPK ha^{-1} treated with 0 kg NPK ha^{-1}, 150 kg NPK ha^{-1} and 300 kg NPK ha^{-1}), C0, C150 and C300 (indicates soil C fertilized with 200 kg NPK ha^{-1} treated with 0 kg NPK ha^{-1}, 150 kg NPK ha^{-1} and 300 kg NPK ha^{-1}).

Exprimental Design

The present observation was done in the net house (approximately 60% shading) of Indonesian Legume and Tuber Crops Research Institute (ILeTRI) from November 2020 to May 2021. Each treatment was laid out in randomized block design and was replicated three times.

Plant height, shoot diameter, shoot dry weight, corm diameter, corm thickness and fresh weight of corm were measured to evaluate the residual effect of NPK fertilizer. Previously described measurement of plant height, shoot diameter and corm diameter was employed by Soedarjo et al. (2020) and Soedarjo (2021). After harvest, oven-dried shoot, fresh weight of corm were weighed. All data of each observation was analyzed by employing Standard Deviation from three replicates.

RESULTS AND DISCUSSION

Effect of NPK Fertilizer on Plant Height

Plant heights of Konjac at 40 days after sowing (DAS) and at 60 DAS grown on previously unfertilized Vertisol soil were similar among the NPK fertilizer treatments (Figs. A and B). When grown on vertisol soil B or C, the plant heights of konjac were not significantly different among NPK fertilizer treatments. The result of the present study indicates that Vertisol soil obtained from Kendalpayak experimental station was fertile enough to support normal growth of konjac, since fertilization of 150 kg NPK ha^{-1} and 300 kg NPK ha^{-1} on Vertisol soil B or Vertisol soil C did not increase konjac plant height.

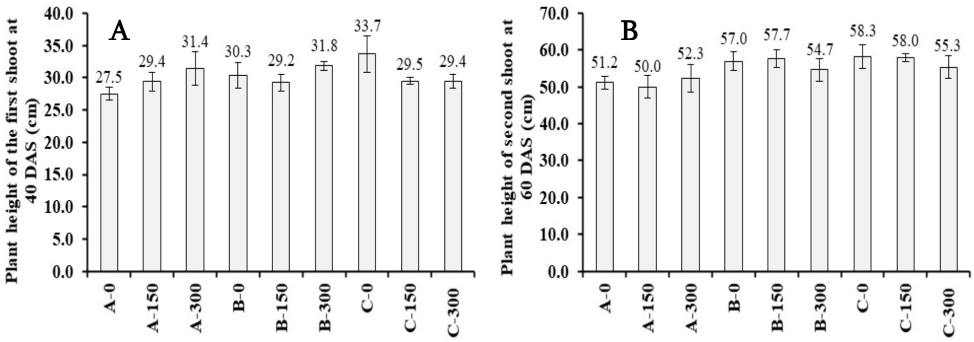

Figure 1. Effect of NPK fertilizer on plant height of the first shoot at 40 DAS (A) and on plant height of the second shoot at 60 DAS (B). Letters A, B and C as well as numbers 0,150 and 300 on X axis are described in Material and Method

Effect of NPK Fertilizer on Shoot Diameter

The first (main) shoot diameter of konjac measured at 40 DAS did not vary between NPK fertilizer treatments on soil previously unfertilized (soil A), on soil previously fertilized with 100 kg NPK ha^{-1} (soil B) or on soil previously fertilized with 200 kg NPK ha^{-1} (soil C). Likewise, the second shoot of Konjac measured at 70 DAS was similar among the fertilizer treatments on each soil previously fertilized with 100 kg NPK ha^{-1} or on soil previously fertilized with 200 kg NPK ha^{-1}. The result of the present study indicates that the fertility of vertisol soil used in the current study could support the normal growth of konjac measured in term of shoot diameter. The result also suggests that the residual effect of NPK fertilizer was not significant since the shoot diameter of konjac plants on soil previously unfertilized, fertilized with 100 kg NPK ha^{-1} or 200 kg NPK ha^{-1} (Figs. 2A and 2B) were comparable when the soils were not fertilized

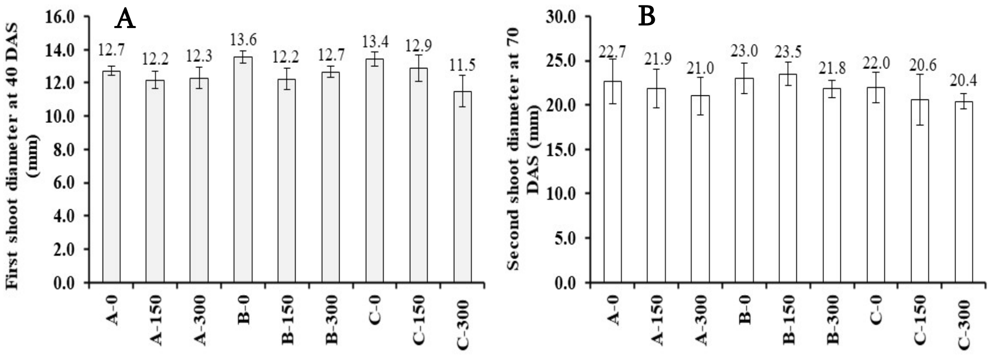

Figure 2. Effect of NPK fertilizer on the first shoot diameter at 40 DAS (A) and on second shoot diameter of the second shoot at 70 DAS (B). Letters A, B and C as well as numbers 0,150 and 300 on X axis are described in Material and Method

Effect of NPK Fertilizer on Shoot Dry Weight

Shoot dry weights (shoot and leaves) of konjac at harvest as depicted on Figure 3 were comparable among fertilizer treatments. This result suggests that the NPK fertilizer addition on vertisol soils previously unfertilized (soil A), or fertilized with 100 kg NPK ha^{-1} (soil B), or fertilized with 200 kg NPK ha^{-1} (soil C) did not promote the growth of konjac. The absence effect of NPK fertilizer on shoot dry weight was similar to the absence effect of NPK fertilizer on plant height (Figs. 1A and 1B) and on shoot diameter (Figs 2A and 2B). Since konjac plants did not show nutrient deficiency symptoms among the NPK fertilizer treatments, vertisol soils used in the present study is considered to be fertile enough to support the normal growth as measured in plant height, shoot diameter and shoot dry weight.

Effect of NPK Fertilizer on Corm Diameter and Corm Thickness

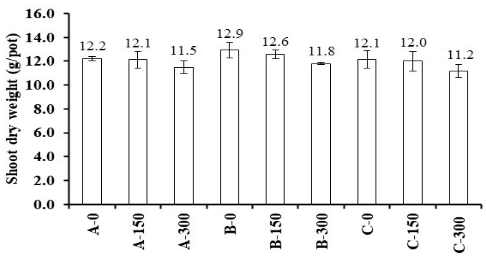

Figure 3. Effect of NPK fertilizer on shoot dry weight. Letters A, B and C as well as numbers 0,150 and 300 on X axis are described in Material and Method.

Corm diameter and corm thickness at harvest was displayed on Figures 4A and 4B, respectively. The effect of fertilization with NPK on corm diameter and corm thickness of konjac grown on vertisol soils previously unfertilized (soil A), fertilized with 100 kg NPK ha^{-1} (soil B) or 200 kg NPK ha^{-1} (soil C) was similar (not significant). The growth of Konjac measured shoot dry weight among the NPK fertilization was in parallel to plant height, shoot diameter (Figs. 1A, 1B, 2A, 2B and 3). Similar growth of konjac among NPK treatments was followed by similar corm diameter and corm thickness.

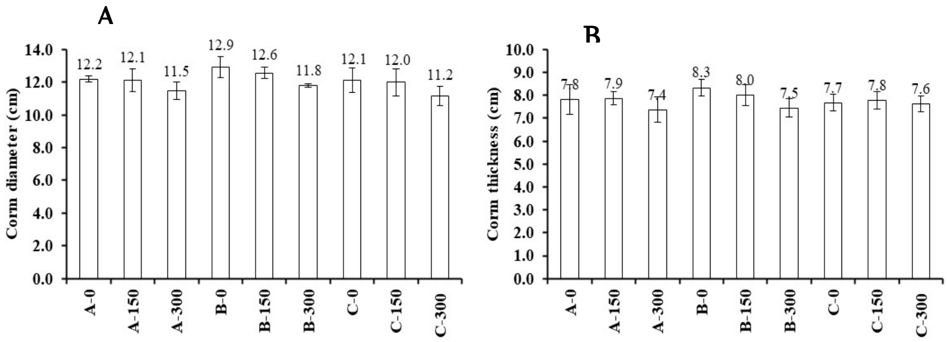

Figure 4. Effect of NPK fertilizer on corm diameter (left) and on corm thickness (right). Letters A, B and C as well as numbers 0,150 and 300 on X axis are described in Material and Method

Effect of NPK Fertilizer on Fresh Weight of Corm

The fresh weight of corms as a result of NPK fertilization on konjac grown on vertisol soil previously unfertilized (A), fertilized with 100 kg NPK ha^{-1} (B) or fertilized with 200 kg NPK ha^{-1} (C) were depicted on figure 5. The figure revealed that addition of 150 kg NPK/ha did not cause an increase to fresh weight of corm when the konjac was grown on vertisol soil previously unfertilized (soil A), fertilized with100 kg NPK ha^{-1} (soil B, fig.5 right). Further increase of NPK addition (300kg NPK ha^{-1}) caused significantly lower fresh weight of corm yield on each vertisol soil (A, B and C), indicating the negative effect of 300 kg NPK ha^{-1}. The appearances of corm yield look to be comparable among the NPK treatments on each vertisol soil when fertilized up to 150 kg NPK ha^{-1} (Fig 5 left). Figure 5 (left) also showed slightly smaller appearances of corm when fertilized with 300 kg NPK ha^{-1}. The present study shows that the normal and similar growth of Konjac measured in plant height (Fig. 1), shoot diameter (Fig. 2) and shoot dry weight (Fig. 3) was accompanied by the comparable corm diameter (Fig. 4A), corm thickness and fresh weight of corm (Fig. 4B). Previous studies (20, 21) showed that good plant growth of konjac was found to be in parallel to optimum fresh weight of corm yield.

Since NPK fertilization on vertisol soil did not affect better plant growth and higher fresh weight of corm yield, the present study suggests that NPK fertilizer addition is not needed to grow konjac on vertisol soil.

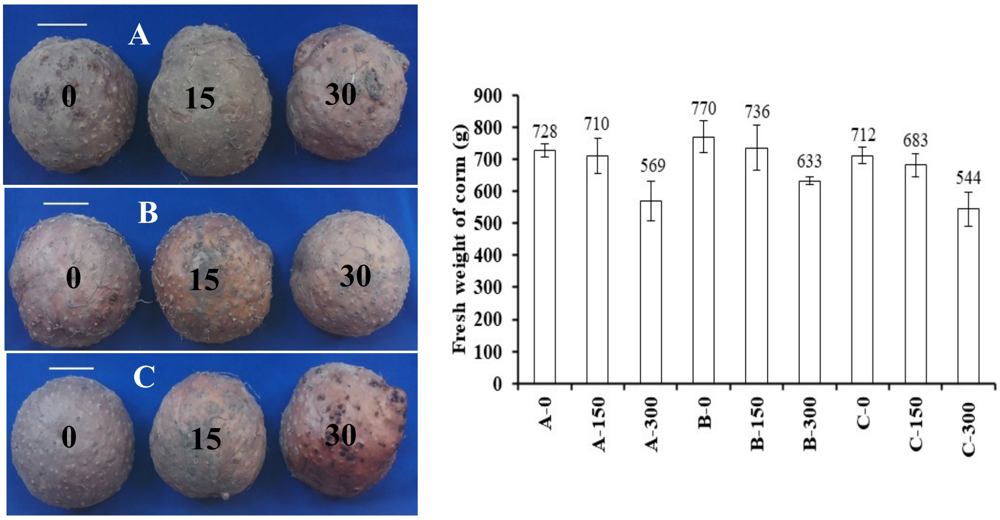

Figure 5. Effect of NPK fertilizer on fresh weight of corm. Letters A, B and C as well as numbers 0,150 and 300 (left and right) are described in Material and Method

CONCLUSION

Application with NPK fertilizer up to 300kg NPK ha^{-1} on vertisol soil previously unfertilized (soil A), fertilized with 100 kg NPK ha^{-1} (soil B) or fertilized with 200 kg NPK ha^{-1} (soil C) did not significantly improve the plant growth of konjac, measured in plant height, shoot diameter and shoor dry weight. Corm diameter, corm thickness and corm fresh weight of corm, as an indicator of corm yield, were also comparable among the NPK fertilizer treatments. The results indicate that vertisol soil used in the present study is considered to be fertile for konjac cultivation. Therefore, the present study suggests that it is not necessary to apply NPK fertilizer on konjac grown on vertisol soil.

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