The application of NPK fertilizer boosts the nutrient uptake status and biomass production of *Vernonia amygdalina*

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Abstract. *Susanto D, Amirta R. 2020. The application of NPK fertilizer boosts the nutrient uptake status and biomass production of* Vernonia amygdalina. *Nusantara Bioscience 12: 114-119.* Vernonia amygdalina Delile is a medicinal plant introduced in Indonesia. This study aims to determine the nutrients absorption status and growth of *V. amygdalina* plants planted with a spacing of 1x1 m. The study used a complete randomized block design with NPK compound fertilizer treatment with five doses of fertilizer namely 0 g (without fertilizer) as a control, 40 g, 80 g, 120 g, and 140 g, three blocks each group consisted of 10 plants so that in total there were 150 plants. The results showed that NPK fertilizer increased growth and the biomass of *V. amygdalina*. The best growth of *V. amygdalina* plant was achieved in plants applied with 160g per plant NPK fertilizer in which the average of stem diameter and plant height were 6.69 ± 0.930 cm and 611.67 ± 12.71 cm, while the estimated biomass yield was 407 tons.ha-1. The most nutritional elements accumulated in plant biomass was the calcium (1279.49 kg.ha^{-1}), followed by magnesium (1167.0642 kg.ha^{-1}), phosphorus (536.64 kg.ha^{-1}), potassium (419.71 kg.ha^{-1}) and nitrogen (134.4 kg.ha^{-1}). We propose that these base nutrients are highly necessary for the cultivation of *V. amygdalina* as biomass feedstock or medicine plant.

Keywords: Biomass, NPK, nutrients uptake, *Vernonia amygdalina*

INTRODUCTION

Vernonia amygdalina Delile is one of the non-endemic plant collections from Cibodas Botanical Gardens, Cianjur, Indonesia originated from China, which was then firstly planted on 31 October 2009 (Lailaty and Nadhifah 2017). This plant is a small shrub, which has been widely planted by people in Indonesia, especially in East Kalimantan due to its potents as medicinal plants (Duarte and Silva 2013). This plant has potential as an antidiabetic drug (Atangwho 2014; Mustofa et al. 2020), antimalarial drug (Lailaty et al. 2016). It also contains antioxidative and chemopreventive properties (Farombi and Owoeye 2011; Asante et al. 2016; Okoduwa et al. 2017), antioxidants (Atangwho 2013), antibacterial (Uzoigwe and Agwa 2011), antifungal (Yusoff et al. 2018; Praptiwi et al. 2020). Moreover, this plant can be used as food supplements for chicken (Mandey et al 2010). Amirta et al. (2016) reported that *V. amygdalina* is woody plant that fastly grow, so that it is a prominent biomass plant to substitute the use of fossil fuels to produce heat and energy.

This plant can be propagated by stem cuttings (Ehiagbonare 2007; Anjula et al. 2014; Susanto et al. 2019a; Ma'rufah and Aziz 2019) and tissue culture (Eveline-Kong et al. 2016; Mey-Yin and Sani. 2018). The need of nutritional elements i.e cadmium and Lead to the soil affected the growth of 1-year-old *V. amygdalina* in terms of plant height, number of leaves, and number of branches, and stem diameter at the end of the experiment (Edegbai and Anoliefo 2019), whereas Nursuhaili et al. (2019) report that administration of basic N fertilizers or basic fertilizers without N can be applied to *V. amygdaline*. In other parts, organic fertilizer such as chicken manure can be given at a dose of 2 tons per hectare, once a month. The effect of the reproductive phase on micronutrients has been reported by Musa et al. (2011), while the ability to accumulate heavy metals by *V. amygdalina* has been reported by Ikhajiagbe and Shittu (2016). On the other hand, the effect of water stress on *V. amygdalina* seedlings has also been reported by Osinaike et al. (2019). As an introduced plant that has spread widely in Indonesia, the information about this plant in terms of growth, biomass production and nutrient accumulation are not well known, yet. Therefore, the focus of this study was to determine the growth and nutrient accumulation of the *V. amygdalina* biomass by administering NPK compound fertilizer. This is of importance to investigate the accumulation status of nutrient elements in this plant biomass, which is necessary for large scale cultivation purposes.

MATERIALS AND METHODS

Study area
The research area is located at the coordinates S 00°17'18.2 "and E 117°14'39.5", in Suka Damai Village, Muara Badak Sub-district, Kutai Kertanegara District, East Kalimantan Province, Indonesia (Figure 1). Planting was carried out from January 2018 to June 2019. Analysis of plant growth was carried out in the Plant Physiology

Laboratory of the Faculty of Mathematics and Natural Sciences, while analysis of soil nutrient elements and plant biomass in the Soil ScienceLlaboratory of the Faculty of Forestry, Mulawarman University, Samarinda, East Kalimantan, Indonesia.

Procedures

Seedling and land preparation

The stem cuttings were taken from the *V. amygdalina* plant collection from the Plant Physiology laboratory, Faculty of Mathematics and Natural Sciences, Mulawarman University. Stem of *V. amygdalina* with a uniform diameter, a length of 50 cm, planted into a polybag, and placed in a moist place. Three-month-old seedlings are ready to be moved to planting plots in the field.

Grasses that grow on the ground were cleaned manually, then made planting holes with a width of 30 cm and a depth of 30 cm. Spacing of 1m x 1m on an area of 360 m2. Before planting, the soil at the study site was sampled at a depth of 0-30 cm at four points. Soil composite samples were taken to the laboratory for analysis of its nutrient content

Figure 1. Map of research area in Suka Damai Village, Muara Badak Sub-district, Kutai Kartanegara District, East Kalimantan Province,Indonesia (Susanto et al.2019b).

Experimental design

The study design used a Complete Randomized Block Design, which consisted of five NPK fertilizer treatments, namely 0 g (without fertilizer as a control), 40 g, 80 g, 120 g, and 160 g respectively with 3 blocks, every 10 replications and total are 150 plants. Fertilization was done two weeks after planting with commercial NPK fertilizer by YARA, Oslo Norway: N (16%), P (16%), K (16%), Mg (1.5%) and 5% Ca (5%) (Susanto et al. 2019a).

Planting method

Plants from stem cuttings are placed in prepared holes. The plant and the media are taken from the polybag carefully by tearing it with a knife. They are placed in holes and covered with soil. Two weeks after planting, each plant is fertilized using NPK fertilizer according to the stated concentration.

Plant growth measurement

Stem diameter, stem height, and the biomass of aerial part plants were measured as plant growth parameters. To analyze the chemical properties, leaf samples were collected in a composite from each treatment.

Soil analysis

Soil chemical dan physical properties analysis consisted of pH, base saturation, cation exchange capacity, and bulk density. Nutrient concentrations such as total N (using Kjeldahl method), available P (using Bray method), and available K, Ca, and Mg (using spectrophotometrically) were measured at the laboratory (Susanto et al. 2019b).

Analysis of nutrient concentration of plant components

The Kjeldahl method (extraction, distillation, and titration) using to measure the total nitrogen concentrate. Phosphorus content was measured using a spectrophotometer at a wavelength of 470 nm. Potassium, calcium, and magnesium were measured with Atomic Absorption Spectrophotometer. To calculate the total macronutrient elements, including N, P, K, Ca and Mg accumulated in the three components in the stand, the dry weights of the three components were multiplied by their nutrient concentrations (Susanto et al. 2016).

Data analysis

Data were analyzed statistically using ANOVA to determine the significant difference between treatments and followed by Duncan's Multiple Range Test or DMRT (P = 0.1). All statistical tests used SPSS 23.0 (SPSS Inc. USA).

RESULTS AND DISCUSSION

Soil chemical properties in the study area

The chemical properties of the soil at this study site showed that the soil is acidic, the cation exchange capacity is low, the base saturation is high. Nitrogen, phosphorus, and potassium nutrients have low concentrations, while calcium and magnesium nutrient elements have high concentrations (Table 1). Zulkarnain et al. (2014) reported

that bulk density soils ranged from 0.70-1.38 g.cm^{-3}, while Paranoan (2019) reported that the soil in Kutai Kartanehgara District is acidic (pH 4.57-4.64), base saturation in the surface horizon content is moderate (41.30%) and in the subsoil varies from low to very low (30.27 - 18.93%). On the other hand, Susanto et al. (2019) reported that Soil in Muara Badak Sub-district, Kutai Kartanegara District is acidic, low cation exchange capacity (4.20), low base saturation, low available nitrogen, and low available potassium.

Growth characteristics of *Vernonia amygdalina*

ANOVA test showed that NPK compound fertilizer application affected the growth of stem diameter and plant height of *V. amygdalina*. The application of 160 g fertilizer per plant showed statistically significant from the control group and the administration of 40 g fertilizer. Applying 80 g and 120 g fertilizer was statistically not significant from the control group and 160 g on stem diameter. In plant height growth, applying 40 g, 80 g, 120 g, and 160 g fertilizers were statistically significant from the control group. The application of 40 g fertilizer was statistically significant from application 80 g, 120 g, and 160 g. (Table 2). Study conducted by Payne (2011) showed no effect between plant spacing and plant height, wet weight, and dry weight of *V. amygdalina* plants. Susanto et al. (2019a) reported that at the age of 6 months after planting, several types of tropical shrub plants accumulated a lot of potassium, followed by nitrogen and phosphorus in the leaves. Kemka-Evans et al. (2014) reported that epidermal characters are of taxonomic importance in the classification and delimitation of the four taxa among the three species of *Vernonia*. On the other hand, Duarte and Silva (2013) reported that the leaf anatomy of *V. amygdalina* has stomata on both leaf surfaces so that it is more effective in absorbing CO_2 gas for photosynthesis. Osinaike et al. (2019) reported that the best and favorable growth environment for *V. amygdalina* is watered every day. The amount of water available for plants will affect the rate of photosynthesis.

Table 1. The effect of fertilizer treatment on growth of basal stem diameter, stem height *V. amygdalina*. Values followed by the same letter within the same column do not differ significantly (p<0.10)

Fertilizer	Basal diameter (mm)	Height Stem (cm)
0 g	3.89±0.671[a]	423.33±8.82[a]
40 g	4.88±0.104[a]	473.33±14.53[b]
80 g	5.35±0.104[ab]	553.33±24.17[c]
120 g	5.43±0.121[ab]	561.67±20.88[c]
160 g	6.69±0.930[b]	611.67±12.71[d]

Nutrient concentration in biomass of *Vernonia amygdalina* aerial parts

Nitrogen, phosphorus, calcium, and magnesium nutrients in stems have higher concentrations compared to leaves, while the concentration of potassium nutrients in stems is lower than in leaves. The highest nutrient concentrations in the stem are calcium (2.65-2.99%), followed by magnesium (2.08-2.80%), phosphorus (1.31-1.98%), potassium (1.01-1.21%) and low levels are nitrogen (0.28-0.37). The highest concentration of nutrients in the leaves is potassium (1.22-1.32%), followed by calcium (0.99-1.15%), magnesium (0.57-0.75%), phosphorus (0.14-0.34%) and the lowest is nitrogen (0.24-0.32) %) (Figure 2). Previous studies have shown that *V. amygdalina* leaves contain Calcium 145 mg, Phosphorus 0.7 mg / 100 g dry weight (Sodimic et al. 2006). Edegbai and Anileofo (2019) reported that *V. amygdalina* was more uptake of lead than cadmium. On the other hand, Musa et al. (2011) reported that the concentrations of Fe, Mg, Ca, and K decreased during the reproductive phase, however, the reduction of Mg was observed only with the applied nitrogen fertilizer. Tjhia et al. (2018) reported that the leaf concentrations of N, P, and K were higher in vegetative than in generative stage. Leaf nitrogen content increases chlorophyll a content, phosphorus is positively correlated with carotenoids, whereas potassium nutrient elements increase anthocyanin and chlorophyll a, chlorophyll b, and carotenoid content at the vegetative growth stage of V. amygdalina plants. Carotenoids, chlorophyll a, chlorophyll b, anthocyanins are pigments that play a major role in plant photosynthesis. Fast-growing species Macaranga gigantea, endemic in Kalimantan has a nitrogen concentration of 1.51-1.89%, phosphorus 0.14-0.16%, and potassium 0.28-0.38% in leaf organs, which is lower than the nutrient concentrations of N, P, and K in leaf *V. amygdalina* (Susanto et al. 2016; Susanto et al. 2017).

The biomass production of *Vernonia amygdalina*

ANOVA test showed that NPK compound fertilizer application increased biomass production of *V. amygdalina* plant. The application of 160 g fertilizer gave the highest biomass yield and statistically significant from the control group, application 40 g, 80 g, and 120 g fertilizer. The highest biomass production in the application of 160 g fertilizer (407.55 tons.ha^{-1}), followed by 80g (232.69 tons.ha^{-1}), 120 g (181.42 tons.ha^{-1}), 40 g (166.34 tons.ha^{-1}), and lowest in the control group (121.46 tons.ha^{-1}) (Figure 3). *Macaranga gigantea* plants treated with NPK fertilizer 120 g per plant (age 1 year) produced the highest biomass of 1,813 tons.ha-1. The production of *V. amygdalina* biomass is much higher (one hundredfold) compared to the production of *Macaranga gigantea* plant biomass, which is a fast-growing endemic plant from the island of Kalimantan (Susanto et al. 2017; Susanto et al. 2018).
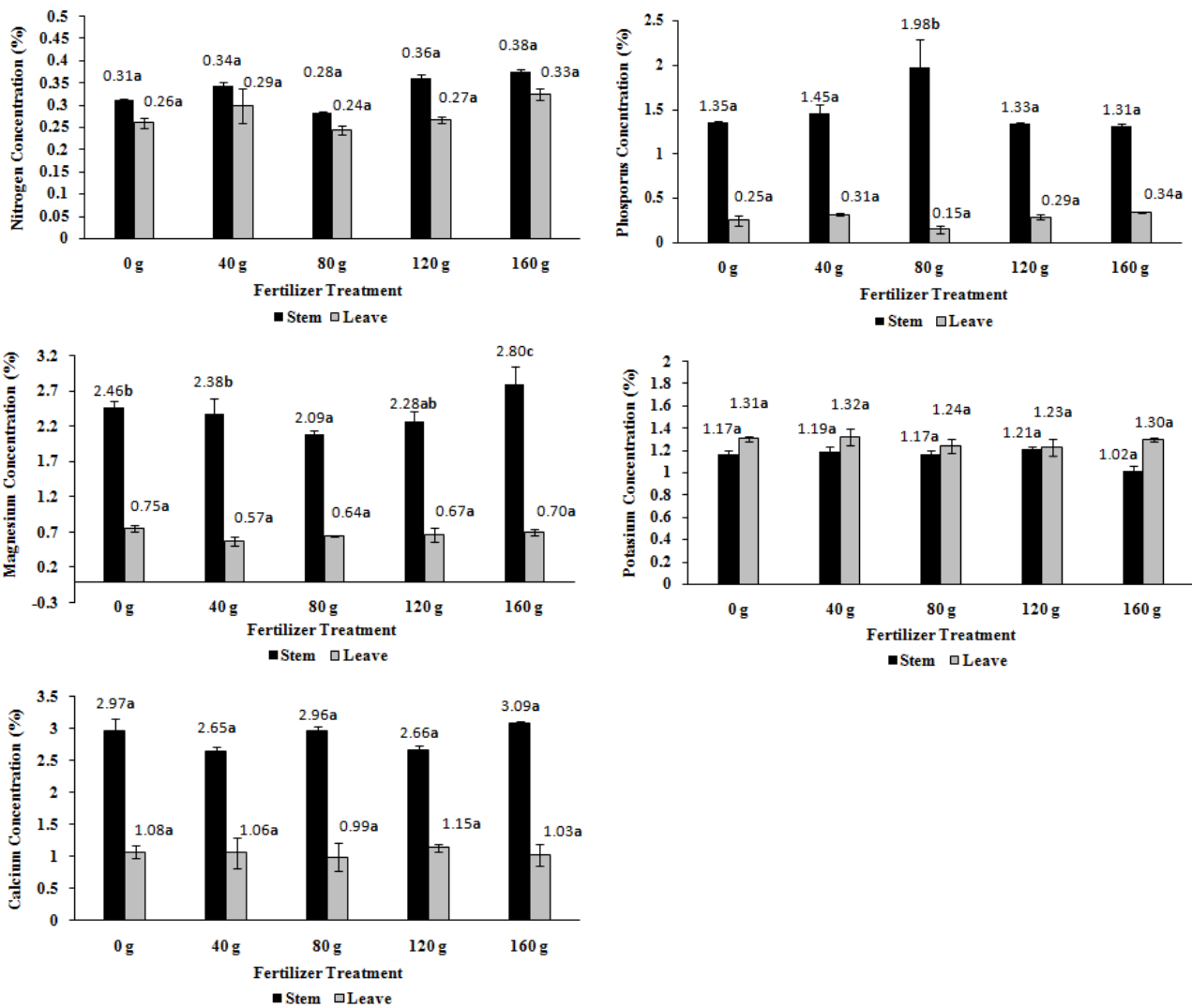
Figure 2. Effect of fertilizer treatment on concentration of N, P, K, Ca and Mg on sample trees of *Vernonia amiqdalina*
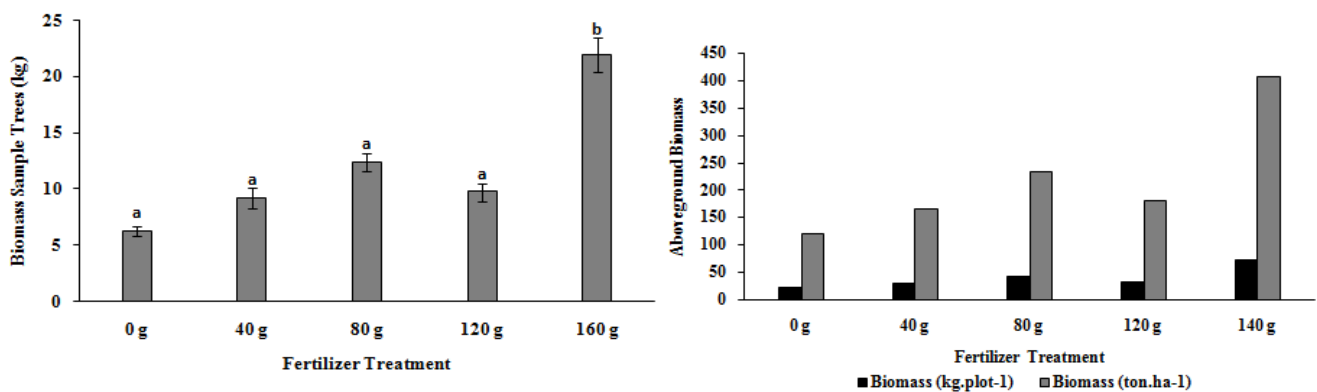

Figure 3. Biomass production of *Vernonia amygdalina* (A) on sample trees, (B) estimation per plot and per hectare
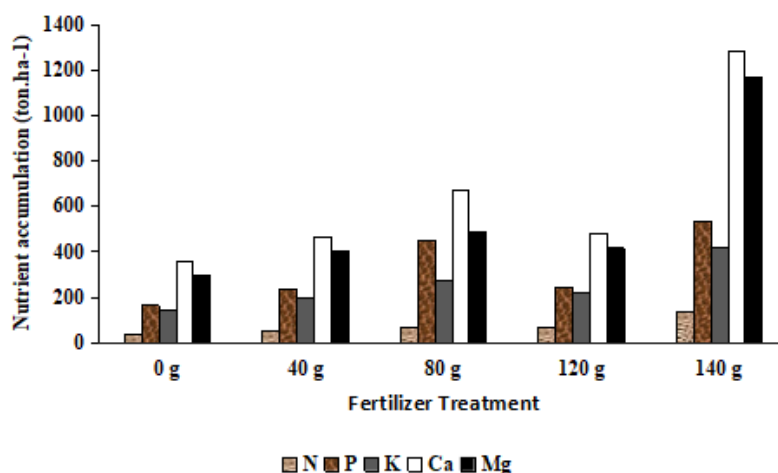
Figure 4. Estimation nutrient content accumulated in aboveground biomass of *Vernonia amygdalina*

Nutrient uptake of *Vernonia amygdalina*

Nutrients absorbed by plants will accumulate in the biomass component. The most nutrient elements that accumulate in *V. amygdalina* biomass are calcium, followed by magnesium, phosphorus, potassium and the lowest is nitrogen. The highest calcium nutrient accumulation in biomass was 1279.49 kg.ha^{-1} in the treatment of 160 g fertilizer and the lowest was 361.42 kg.ha^{-1} in the control group without fertilizer application. The highest magnesium nutrient accumulation in the treatment of 160 g fertilizer is 1167.0642 kg.ha^{-1} and the lowest in the control group is 299.26 kg.ha^{-1}. The highest accumulation of phosphorus nutrient elements was 536.64 kg.ha^{-1} and the lowest was 164.12 kg.ha^{-1}, while the highest accumulation of potassium nutrient elements was 419.71 kg.ha^{-1} and the lowest was 141.41 kg.ha^{-1}. In another part, the highest accumulation of nitrogen nutrient elements was 134.4 kg.ha^{-1} and the lowest was 37.83 kg.ha^{-1} (Figure 4). Studies conducted on the *Macaranga gigantea* plant which is a fast-growing and endemic type of Borneo, showed that *M. gigantea* at the age of 1 year accumulated nitrogen nutrients 5.37 kg.ha^{-1}, phosphorus 14.35 kg.ha^{-1} and potassium 40.21 kg.ha^{-1}, calcium 4.27 kg.ha^{-1}, Magnesium 2.17 kg.ha^{-1} in the treatment of NPK or 120 g per plant (Susanto et al. 2017). Based on the comparison of the above data it can be seen that *V. amygdalina* plants absorb more nutrients than *M. gigantea* plants. This is thought to be caused by soil conditions, plant spacing, and genetic growth of *V. amygdalina* plants that grow fast and are able to absorb large amounts of nutrient elements, and produce a lot of biomass.

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