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Substitution of synthetic n fertilizer with wedelia (*Wedelia trilobata* L.) compost on Chinese water spinach (*Ipomoea reptans* Poir) cultivation

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Abstract
The objective of this study was to determine the combination dose of N-synthetic fertilizer and wedelia compost for Chinese water spinach (*Ipomea reptans* Poir) growth and yield. Field research was carried out from May to June 2020 in Sambirejo Village, Selupu Rejang District, Rejang Lebong Regency, Bengkulu, Indonesia, at an altitude of ±1100 m above sea level. The study employed a completely randomized design (CRD) with a single treatment factor, namely a combination of synthetic N fertilizer and wedelia compost dosage. The treatments have included combination of 200 kg/ha urea and no compost; 160 kg/ha urea and 6 tons/ha compost; 120 kg/ha urea and 12 tons/ha compost; 80 kg/ha urea and 18 tons/ha compost; 40 kg/ha urea and 24 tons/ha compost; and 30 tons/ha compost. Each treatment was repeated three times. The application of 160 kg/ha urea + 6 tons/ha compost and 120 kg/ha urea + 12 tons/ha compost resulted more in Chinese water spinach fresh weight per plant, and fresh weight per plot than the 40 kg/ha urea treatment. + 24 tons/ha of compost and 30 tons/ha of compost. The stem diameter and greenness of Chinese water spinach leaves did not differ between plants fertilized only with urea and compost or with a mixture of urea and compost at various doses. Therefore conjunctive use of compost and inorganic fertilizer made it possible to reduce inorganic fertilization.

Keywords: compost, organic fertilizer, water spinach, wedelia

Introduction

Water spinach is an annual plant cultivated in both the tropics and the subtropics. Fertilization is among the essential activities that must carry out to grow water spinach plants to produce high-quality crops and increase yields. Fertilization is the process of applying nutrients to plants to grow and develop. Fertilizers commonly used in plant cultivation are both synthetic and organic fertilizers.

In conventional agricultural activities, increasing the availability of nutrients for plants is often accomplished by applying synthetic fertilizers to the soil. In water spinach, urea fertilizer is commonly utilized. The application of 200 kg/Ha Urea resulted in the highest productivity for water spinach, according to Simangunsong et al. (2018) [23]. However, the continual and unsuitable or excessive use of synthetic fertilizers has a detrimental influence on the ecosystem and can cause land degradation. Organic fertilizers are required to restore the function of the soil for plants and reduce the dependence on synthetic fertilizers such as urea. Organic fertilizers are produced from natural resources such as plants, waste, sawdust, manure, and other byproducts (Hartatik et al., 2015) [7]. Organic fertilizers can improve the soil's physical, chemical, and biological qualities (Simanungkalit et al., 2006) [24]. Manure, compost, guano fertilizer, and hummus are some well-known organic fertilizers. Organic fertilizer is composed of organic materials with various bases. According to Zalna et al. (2018) [27], the highest yield of cow dung bokashi application on water spinach was at a dose of 30 tons/ha.

Compost is the product of the incomplete decomposition of a mixture of organic materials, which can be accelerated artificially by various microbes in warm, humid, aerobic, and anaerobic environmental conditions (Diaz et al., 2007) [4]. According to Rukmana (2007) [19], organic waste such as plant wastes (straw, stems, branches), household waste, livestock manure (cows, goats, chickens, ducks), husk charcoal, kitchen ash, and others are sources of compost. In addition to these materials, weeds can be used as raw materials in compost production (organic fertilizer).

Wedelia is a broadleaf weed (Wedelia trilobata). Wedelia is a weedy wild plant that invades cultivated soil. Wedelia has been used as a source material for organic fertilizers, either as liquid fertilizer or compost. The experiment findings indicated that using Wedelia compost could improve the soil's physical, biological, and chemical properties while also providing nutrients to plants. According to Setyowati et al. (2008) [21], the highest yields of Wedelia organic fertilizer application on mustard greens were obtained at a dose of 23 tons/ha, with a nutrient content equivalent to N in urea at a dose of 16 kg/ha. Wedelia compost has an N content of 3.2%. Organic fertilizers are frequently combined with synthetic fertilizers in cultivated plants to meet plant nutritional needs and produce an optimal growing environment (Dayanti et al., 2018; Kurnia et al., 2019; Prasetyo et al., 2020) [3, 10, 17,18]. Organic fertilizers maintained nutrient delivery and crop productivity at levels comparable to inorganic fertilizers. The advantages of organic amendments were evident even when they only contained a small part of the overall qua

-ntity of nutrients supplied, indicating that some of the beneficial effects of integrated fertilizer approaches may occur in the short term (Lazcano *et al*., 2013) [11]. Organic fertilizers alone resulted in lower N concentrations in leaves and fruits than inorganic fertilization. Compost and inorganic fertilizer combination generated higher yields and better fruit quality than either inorganic treatment applied alone. Soils with combined fertilization also had greater microbial biomass C, basal respiration, and dehydrogenase activity than inorganic soils. Using compost and inorganic fertilizer together reduced inorganic fertilization by roughly 40% while maintaining fruit quality and quantity and improved soil properties (Hernández *et al*. 2014) [8]. Yang *et al*. (2015) stated that after 22 years of combined application of inorganic fertilizers and crop residuals, the soil organic carbon and crop yields significantly increased.

The disadvantage of solid organic fertilizer is that it requires a considerable quantity for application; hence transportation costs are higher. Furthermore, the nutrient content is low, and it is usually inadequate to meet the needs of plants. Compared to synthetic fertilizers, organic fertilizers require more time for nutrients to be available to plants (Parnata, 2010) [15]. According to Setyowati *et al*. (2010) [20], organic fertilizers should be used in conjunction with synthetic fertilizers to fulfill the nutrient requirements of plants, reduce negative environmental impacts, and create better-growing conditions. Aside from their weaknesses, organic fertilizers have the following advantages: they contain macro and micronutrients, reduce the cost of purchasing synthetic fertilizers, reduce waste, reduce air pollution, increase soil fertility, improve soil character and structure, and increase soil microbial activity, and improve harvest quality. This study aimed to determine the best combination of N fertilizer (Urea) and Wedelia compost for water spinach growth and yield.

Material and Methods

Research Site

The research was carried out on upland from June to July 2020 in Sambirejo Village, Selupu Rejang District, Rejang Lebong Regency, Bengkulu, Indonesia, at an altitude of ±1100 m above sea level.

Research Design

The study used a completely randomized design (CRD) with one treatment factor, namely the ratio of the combined dose of synthetic N fertilizer (urea) and Wedelia compost, which was consisted of:

P1 = 200 kg/ha urea
P2 = 160 kg/ha urea + 6 ton/ha Wedelia compost
P3 = 120 kg/ha urea + 12 ton/ha Wedelia compost
P4 = 80 kg/ha urea + 18 ton/ha Wedelia compost
P5 = 40 kg/ha urea + 24 ton/ha Wedelia compost
P6 = 30 ton/ha Wedelia compost

Each treatment was carried out three times for 18 experimental plots in the study.

Wedelia Composting Process

Bahan dan cara pembuatan pupuk kompos tusuk konde dapat dilihat pada Lampiran 2.

Plot Preparation

Before planting, the area was cleared of weeds and plant litter. Additionally, the land is plowing to a 15-20 cm depth. The experimental plots are 100 cm × 100 cm (length x width), with a plot height of 20 cm, a distance of 50 cm between plots, and 50 cm between replications.

Fertilizer Application, Planting, and Harvesting

TSP fertilizer with a dose of 200 kg/ha and KCl 100 kg/ha was applied before planting by spreading it on the soil surface. Wedelia compost was applied one week before planting, and synthetic N fertilizer was applied two weeks after planting by spreading evenly over the plots. Water spinach seeds were sown at a 3-4 cm depth and a spacing of 10 cm x 10 cm. Each planting hole is sown with 2-3 water spinach seeds and then covered with topsoil. Plants that do not germinate and grow are replaced by planting seeds one week afterward. Irrigation was conducted every day to keep the soil moist. Weed control was conducted two weeks after planting. Pest and disease control is carried out organically, without chemical pesticides.

Thirty days after sowing, the crop was harvested. Healthy growth and fresh leaves are the physical characteristics of ready-to-harvest water spinach plants. Water spinach was harvested by pulling the plant and its roots out of the soil.

Observed Variables

The variables observed were plant height (cm), leaf number, stem diameter (mm), leaf greenness, crop fresh and dry weight, and crop weight per plot.

Data Analysis

The data were statistically analyzed using Analysis of Variance (ANOVA) with F 5%. The significantly different data were then tested further with the least significant difference test (LSD) to compare treatment responses.

Results and Discussion

Research Site

The pH of the soil where the research was conducted was 5.67, with N content of 0.38 %, P= 14.57 ppm, K= 0.37 me/100, and a C-organic= 4.79 %. According to the Balai Penelitian Tanah (2005) standards, the soil pH is slightly acidic, the total nitrogen content is moderate, the P content is high, the K level is moderate, and the organic carbon content is high. These findings imply that the soil at the research site is relatively fertile.

Water Spinach Growth Pattern

Plant growth is described as the increase in volume and/or mass of the plant, with or without the generation of different structures such as organs, tissues, cells, or cell organelles. Growth is frequently related to development (specialization of cells and tissues) and reproduction (production of new individuals) (Fosket, 1994). Plant metabolism promotes an increase in the size of plant organs, which is influenced by environmental factors such as water, sunlight, and soil nutrient content (Taiz and Zieger, 2002). The growth of water spinach which includes plant height, stem diameter, and leaves number at aged 2 to 5 WAP, is presented in Figures 1, 2, and 3.

The study's findings revealed that the height of water spinach increased fast from the age of 2 WAP to 4 WAP. According to Taiz and Zieger (2002), plant growth increases with plant age. However, the plant height didn't change significantly after the age of 4 WAP. The increase in plant height is slowing because the water spinach has reached harvest age at 4 MST.

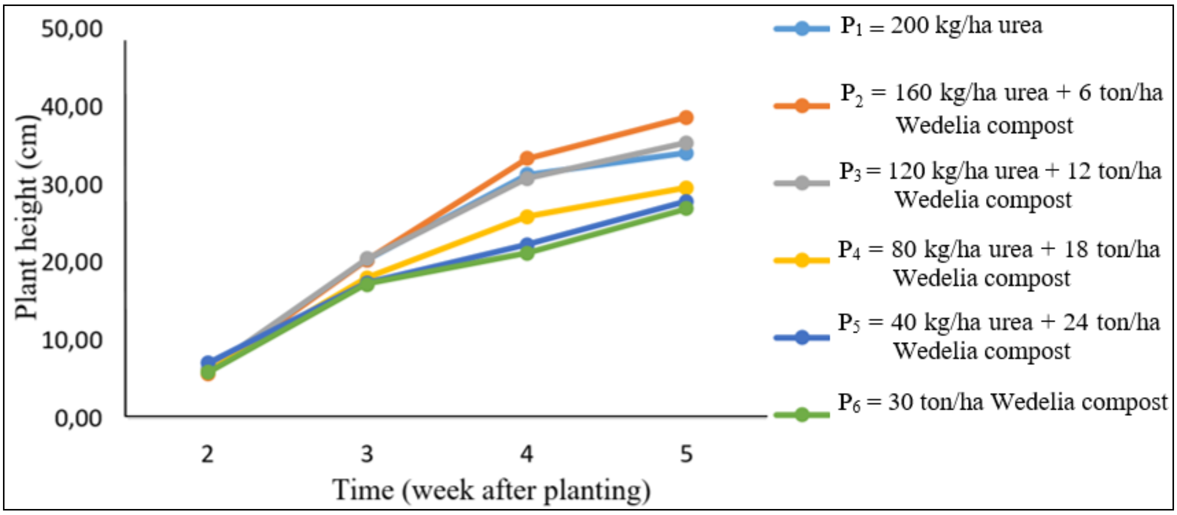

Fig 1: Height of water spinach in various N fertilizer and Wedelia compost combinations at 2-5 WAP

The results also showed that an increase in stem diameter and number of leaves followed the same trend as plant height growth (Figures 2 and 3). Kresna *et al*. (2016) described a similar growth pattern in which the stem diameter and number of leaves of water spinach continued to increase until the age of 5 WAP.

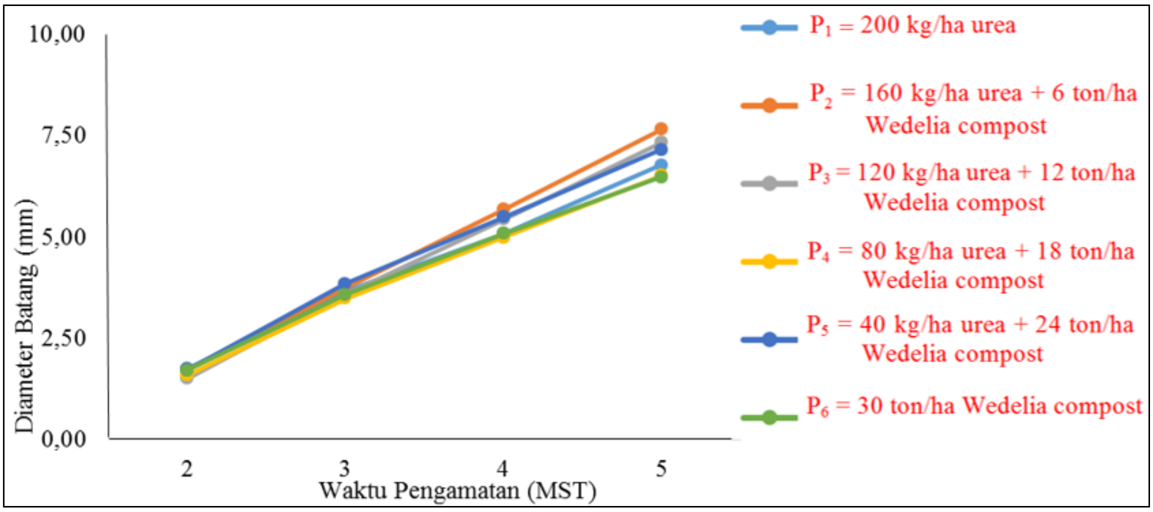

Fig 2: Stem diameter of water spinach in various N fertilizer and Wedelia compost combinations at 2-5 WAP

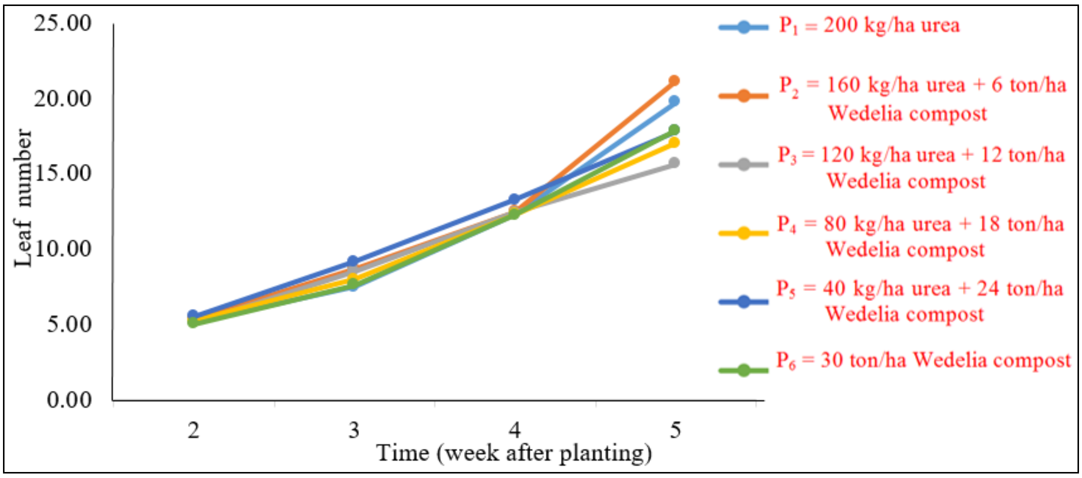

Fig 3: Leaf number of water spinach in various N fertilizer and Wedelia compost combinations at 2-5 WAP

Analysis of Variance

Table 1 summarizes the results of the analysis of the variance of the effect of the combined dose of synthetic N fertilizer and Wedelia compost on the observed variables.

Table 1: Summary of analysis of variance

Variables	F-calc	F-table 5%	CV (%)
Plant height	15,56*	3,11	6,34
Stem diamater	1,23 ^{ns}	3,11	10,47
Leaf number	5,07*	3,11	8,29
Leaf greeness	2,32 ^{ns}	3,11	4,87
Fresh weight per plant	3,66*	3,11	17,94
Dry weight per plant	1,74 ^{ns}	3,11	24,82
Fresh weight per plot	7,79*	3,11	12,84

Note: * = significantly different, ^{ns} = not significantly different, CV = Coefficient Variation

The combination dose of synthetic N fertilizer with Wedelia compost significantly affected plant height, the number of leaves, plant fresh weight, and fresh weight per plot but had no effect on stem diameter, leaf greenness, and plant dry weight (Table 1).

Effect of Treatment on Growth Components of Water Spinach

The diameter of the stem and the greenness of the leaves did not differ significantly with different doses of synthetic N fertilizer when combined with Wedelia compost. However, the results showed that the application of % urea + % compost resulted in greater stem diameter of 7.65 mm. In contrast, 100 % urea + zero percent compost application resulted in higher greenery of the leaves, 36.68% (Table 2).

Table 2: Effect of treatment on the growth of water spinach

Treatment	Plant height (cm)	Stem diameter (mm)	Leaf number	Leaf greenness
100 % urea + 0 % compost	34.20 b	6.78	19.74 ab	36.68
80 % urea + 20 % compost	38.71 a	7.65	21.09 a	35.66
60 % urea + 40 % compost	35.46 ab	7.32	15.61 c	35.15
40 % urea + 60 % compost	29.71 c	6.52	16.99 c	32.81
20 % urea + 80 % compost	27.92 c	7.15	17.78 bc	34.03
0 % urea + 100 % compost	27.00 c	6.48	17.84 bc	33.31

Note: the numbers followed by the same letter in the same column do not differ significantly. Dose of 100% urea = 200 kg/ha, dose of 100% compost = 30 ton/ha

Plant height (38.71 cm) was higher when % urea + % compost was applied than when only urea (34.20 cm) or wedelia compost was applied (27.00 cm). The combinations of % urea + 20% compost and 60 % urea + 40% compost yielded higher plants than the combinations of % urea + 60% compost and % urea + 80% compost (Table 2).

According to the results of this study, the application of a combination of % urea + % compost and % urea + % compost produces the availability of nutrients, particularly nitrogen (N), which is available for plants and the growing environment, such as better soil structure, when compared to other treatments. Plant vegetative growth, as measured by plant height growth, is influenced by nitrogen, according to Perwitasari *et al.* (2012). Higher nitrogen-containing nutrients will enhance vegetative growth. The findings of this study are similar to the results of Muntashilah et al. (2015) [14], who reported that increasing the amount of N applied to the soil increased the height of water spinach plants.

Plants' N requirements can be met through fertilization. Urea is one of the synthetic organic fertilizers with a high percentage of nitrogen (46%). However, the nutrient content of N in Urea is easily lost, so if it is not calculated, the N requirement of water spinach is not met throughout the growth phase. Furthermore, the loss of N from urea to the environment, particularly growth media in the form of nitrate and ammonium, might impair soil health. As a result, organic matter should be added to compensate for N loss and ameliorate the growing media. According to Muktamar et al. (2022) [13], considerable amounts of N released by urea hydrolysis can be immobilized by soil microorganisms. Organic fertilizers can improve the soil's physical, chemical, and biological qualities. However, because the nutrients in organic fertilizers are relatively low, high doses will be required to increase plant productivity if only organic fertilizers are utilized. As a result, organic fertilizers should be used with synthetic fertilizers. As a result, organic fertilizers must be used in conjunction with inorganic fertilizers to ensure that N is also available to plants and improve the growing medium.

Plant height was positively correlated with the number of leaves. The taller the plant, the more leaves it will have. Table 2 reveals that the application of % urea + % compost produced the most leaves, namely 21.09 leaves, significantly different from the other treatments except the application of 100% urea. As a result, the compost-added growing media is optimal for root development, and N is available to plants. According to Djamaan (2006), N is absorbed by plant roots and utilized by plants for vegetative growth, including leaf formation. Furthermore, Taiz and Zieger (2002) stated that N's application in plants stimulates the growth of photosynthesis-related organs, specifically leaves. Plants that get a supply of N will form broader leaves and produce more leaves.

Effect of Treatment on Water Spinach Yield

Applying a combination of synthetic N fertilizer plus Wedelia compost at various doses did not affect plant dry weight. However, 80% urea + 20% compost treatment resulted in a more plant dry weight of 1.58 g. (Table 3).

Table 3: Effect of treatment on the yield of water spinach

Treatment	Plant fresh weight (g)	Plant dry weight (g)	Plant fresh weight/plot (kg)
100 % urea + 0 % compost	14,50 ab	1,17	2,23 ab
80 % urea + 20 % compost	18,79 a	1,58	2,50 a
60 % urea + 40 % compost	18,54 a	1,42	2,40 a
40 % urea + 60 % compost	14,92 ab	0,79	1,90 bc
20 % urea + 80 % compost	12,67 b	1,08	1,70 cd
0 % urea + 100 % compost	11,46 b	0,88	1,43 d

Note: the numbers followed by the same letter in the same column do not differ significantly. Dose of 100% urea = 200 kg/ha, dose of 100% compost = 30 ton/ha

Increased plant fresh weight was obtained by treatments with 80% urea + 20% compost, 100% urea + 0% compost, 60% urea + 40% compost, and 40% urea + 60% compost, compared to treatments with 100% compost or 80% compost + 20% urea (Table 3). As a result, the growing media must be supplemented with compost and N for water spinach to grow optimally. If synthetic N is not added, nutrients obtained from only compost are often inadequate for plant development. Leghari *et al*. (2016) [12] stated adding N may increase the development of stems, branches, and leaves. N increases the synthesis of carbohydrates to protein. Thus, cell division accelerates, stem and branch development increases, and the plant's fresh weight gets bigger. Plant fresh weight relates to plant fresh weight per plot. The higher the fresh weight per plant, the greater the fresh weight per plot. Sibarani *et al*. (2015) [22] reported that an increase in fresh weight per plant of water spinach is followed by an increase in fresh weight per plot.

This research indicated that the application of 80% urea + 20% compost resulted in the highest fresh weight per plant and plot. The treatment of % compost and % urea + % compost resulted in a lower fresh weight per plot (Table 3).

In general, the data indicated a trend toward increasing compost by over 20% and decreasing urea below 80%, a gradual decrease in water spinach yields. Compost dosage of more than 20%, even when balanced with urea fertilizer, the N from both fertilizers is not yet available to plants in sufficient amounts. Compost-derived nitrogen is not as readily available as manufactured nitrogen. Thus, compost must be applied at the appropriate period to provide time for decomposition, ensuring that the N contribution to plants is accessible at the proper time. Compost is required in the soil to enhance its structure, allowing the soil to become more permeable and the roots to grow appropriately to absorb nutrients (Prasetyo, 2020) [17, 18].

Conclusion

The findings indicated that applications of 80% urea + 20% compost and 60% urea + 40% compost resulted in greater plant height and fresh weight than treatments with 20% urea + 80% compost or 100% compost without synthetic N. There was no significant difference in stem diameter or leaf greenness amongst treatments.

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