

Productivity of Butterfly Pea (*Clitoria ternatea* L.) Influenced by Urea Fertilizer Rates and Harvest Ages in Kulon Progo, Yogyakarta, Indonesia

Wardi Wardi^{1,2}, Nafiatul Umami^{2*}, Asih Kurniawati², Bambang Suhartanto², Chusnul Hanim², and Zen Adyatama²

¹Research Center for Animal Husbandry, National Research and Innovation Agency, Bogor, Indonesia

²Faculty of Animal Science, University of Gadjah Mada, Yogyakarta, Indonesia

*Corresponding author email: nafiatul.umami@ugm.ac.id

Abstract. Butterfly pea (*Clitoria ternatea* L.) is leguminous species that contain high nutritional values. This study aimed to determine the effect of the rate of urea fertilizer and harvest age on the productivity of butterfly pea forage. This research used a split-plot design consisting of urea rates (0, 100, and 200 kg/ha) and harvest ages (30, 45, and 60 days after planting or DAP) with three replications. The variables observed were morphological growth (plant height, stem diameter, number of leaves, and number of branches), and productivity of forage biomass (fresh weight, dry weight, and crude protein). The data obtained were analyzed using ANOVA and the means were separated by using Duncan's Multiple Range Test (DMRT). The interaction between fertilizer rates and harvest ages was shown ($p < 0.05$) on stem diameter, number of leaves, number of branches, and fresh weight of butterfly pea. The increased rates of fertilizer and harvest ages significantly affected ($p < 0.05$) in the morphological growth and productivity of butterfly pea biomass. The application of urea fertilizer increased plant length from 10.59 to 17.16%, stem diameter from 12.12 to 24.24%, number of leaves from 15.40 to 28.20%, and number of branches from 81.82 to 190.91% compared to control. It was concluded that the morphological growth and productivity of forage biomass increased with fertilizer rates and harvest ages. Treatment of 200 kg/ha urea and harvest age of 60 DAP produced the highest morphological and productivity.

Keywords: *Clitoria ternatea*, harvest ages, morphology, productivity, urea fertilizer

Abstrak. Kembang telang (*Clitoria ternatea* L.) merupakan salah satu jenis leguminosa yang memiliki nilai gizi tinggi. Penelitian ini bertujuan untuk mengetahui pengaruh dosis pupuk urea dan umur panen terhadap produktivitas hijauan kembang telang. Penelitian ini menggunakan rancangan petak terbagi yang terdiri dari kadar urea (0, 100, dan 200 kg/ha) dan umur panen (30, 45, dan 60 hari setelah tanam atau HST) dengan tiga ulangan. Variabel yang diamati adalah pertumbuhan morfologi (tinggi tanaman, diameter batang, jumlah daun, dan jumlah cabang), produktivitas biomassa hijauan (bobot segar, bobot kering dan protein kasar). Data yang diperoleh dianalisis menggunakan ANOVA dan dilanjutkan dengan menggunakan Duncan's Multiple Range Test (DMRT). Dosis pemupukan dan umur panen menunjukkan interaksi ($p < 0,05$) terhadap diameter batang, jumlah daun, jumlah cabang dan bobot segar hijauan kembang telang. Aplikasi pupuk urea meningkatkan panjang tanaman dari 10,59 menjadi 17,16%, diameter batang dari 12,12 menjadi 24,24%, jumlah daun dari 15,40 menjadi 28,20% dan jumlah cabang dari 81,82 menjadi 190,91% dibandingkan dengan kontrol. Peningkatan takaran pemupukan dan umur panen hijauan kembang telang berpengaruh nyata ($p < 0,05$) terhadap pertumbuhan morfologi dan produktivitas biomassa hijauan. Disimpulkan bahwa pertumbuhan morfologi dan produktivitas biomassa hijauan kembang telang meningkat seiring dengan peningkatan takaran pemupukan dan umur panen. Hijauan kembang telang pada perlakuan urea 200 kg/ha dengan umur panen 60 HST memiliki morfologi dan produktivitas tertinggi.

Kata kunci: *Clitoria ternatea*, umur panen, morfologi, produktivitas, urea

Introduction

Feed quality plays the ultimate role in fulfilling livestock's nutritional demand, growth, development, production, and reproduction. Forage is the primary source of feed for ruminants.

Therefore, forage feeds must have good quality, high digestibility, high palatability, and be continuously available (Umami et al., 2019). Legumes are good fodder crops in terms of high protein, productivity, adaptability to various

environmental conditions, and good growth rates. The butterfly pea is a leguminous plant that livestock favor for its high nutritional content. The butterfly pea is a perennial plant, hence undergo defoliation several times a year. Based on a research by Jamil et al. (2018) butterfly pea leaves contain 30% crude protein and 14% crude fiber. Also, Purba (2020) reported that butterfly pea can grow well on all types of soil and is resistant to dry conditions. Sutedi (2013) explained that forage production of butterfly pea is 25 to 29 tons/ha at 42 days of defoliation, containing 21.5% protein. High nutrition in butterfly peas are in the form of 27% crude fiber and 19%, in which seeds contain the most protein (Al-Snafi, 2016).

Plant growth is an indicator of plant production, and therefore good development will produce high productivity. Growth parameters such as plant height, number of leaves, stem diameter, and number of branches correlate with plant biomass production. Several factors affecting plant growth and development include internal factors (genetic) and external factors (nutrient content, irradiation intensity, water content, and temperature). Bui et al. (2015) explained that additional nutrients incorporated into the growing media are needed to increase growth and biomass production. Plant growth development is influenced by nutrients absorbed from the soil, such as nitrogen. Urea fertilizer is a common type of fertilizer used when the plant is at the vegetative phase. Applying the right fertilization level is essential during the cultivation of feed crops. Direct fertilization of urea on plants has several advantages, including high absorption of nutrients that stimulates faster plant regrowth and affects plant production. Harvest ages affect most of the chemical constituents and gas kinetic parameters related to the stems. The leaves of this legume are the least affected part by the aging process (Abreu et al.,

2014). Also, harvest ages affect the nutrient content of the plant, which can affect the digestibility of the material. The older the plant, the greater the ratio of stems to leaves. In addition, the older the plant, the higher the proportion of biomass and the lower the nutrient content (Prasojo et al., 2021). Therefore, it is important to evaluate the productivity of butterfly peas by identifying different harvest ages.

Wafi et al. (2020) reporting that the use of NPK fertilizer in butterfly peas planted in ultisol soil types can increase root length and fresh production of biomass. Furthermore, research conducted by Arnawa et al. (2017) the application of bio-slurry fertilizers with different doses on butterfly peas can improve the agronomic parameters of plants. However, there is little to no research related to the fresh production of biomass and agronomy of butterfly pea forage that uses urea fertilizer on the grumusol soil type in Kulon Progo. This study aims to determine the effect of urea fertilizer rate and harvest ages on the productivity of butterfly pea forage

Materials and Methods

This research was conducted at Kembang village, Nanggulan sub-district, Kulon Progo district, Special Region of Yogyakarta Province of Indonesia from May to October 2021. The proximate analysis was carried out at the Semarang Veterinary Center Laboratory and soil nutrient analysis at the Laboratory of Agriculture Technology Research Center in Yogyakarta.

Experimental Design

This study used a split-plot design consisting of three rates of urea fertilization (0, 100, and 200 kg/ha) as the main plot (A) and three harvest ages (30, 45 and 60 days) as the subplots (B), each performed with three replications, 3x3x3, making up 27 treatments planted in plots of land

Sites Preparation

Land preparation for planting sites began with clearing the land and loosening the soil using a hoe. The ground of the area was prepared in conventional, plowed, and plotted before the seedling. There were 27 plots of experimental land, measuring 75 cm x 75 cm each, with an interval of 75cm between every plot.

Seeding and Planting

Land preparation for planting sites began with clearing the land and loosening the soil using a hoe. The ground of the area was prepared in conventional, plowed, and plotted before the seedling.

Fertilization

Fertilizer was given after the butterfly peas were planted according to their respective treatments, namely A1 0 kg/ha, A2 100 kg/ha, and A3 200 kg/ha. After being converted to the area and the number of plants, the fertilizer level for A1 was 0 grams/plant, A2 5.6 grams/plant, and A3 11.25 grams/plant. Three levels of urea fertilizer (0, 100, and 200 kg/ha) were applied to each treatment one week after being transplanted to the field. Each treatment of urea fertilizer was replicated three times using a split-plot design.

Maintenance

Preparation begins with the prior cleaning of the sites and the land is processed using a hoe to loosen the soil. Weeding was carried out carefully to avoid damage to the root system of the butterfly pea. Watering was done twice, in the morning at 07.00 and the afternoon at 16.00, on non-rainy days. The harvest ages were 30, 45, and 60 days after planting (DAP)

Sampling Procedure and Observed Parameters

Plant morphology measurements were carried out before defoliation on a weekly basis. All plants

in each plot were measured and the results were recorded. Plant measurements included plant length, stem diameter, and the number of branches and leaves. The length of the plant was measured from the soil surface to the tallest leaf by covering all the leaves until they were perpendicular. The stem diameter was obtained by reading the number indicated by the caliper at the base stem. The number of branches was tallied by counting the number of branches on every plant stem. The number of leaves was recorded by counting all the leaves that had fully opened. Harvesting was carried out three times at the age of 30, 45, and 60 DAP. The plant stem was cut, leaving about 10 cm from the soil surface (Syamsuddin et al., 2016). Production measurements were carried out at harvest ages 30, 45, and 60 DAP. Biomass yield production was determined by converting fresh weight into kg DM ha⁻¹ (Astuti et al., 2020).

Agroclimatic Condition

The secondary data were weather conditions, climate, humidity, and temperature on the land of Kembang Village, Nanggulan District, Kulon Progo Regency, Yogyakarta province, collected from the meteorology, climatology, and geophysics agency, geophysics station Yogyakarta province. Kulon Progo Regency is situated between 7° 38'42" to 7° 59'3" south latitude and 110° 1'37" to 110° 16'26" east longitude. The geographical borders of Kulon progo were Magelang Regency to the north, Indian Ocean to the south, Purworejo Regency to the west, and Sleman and Bantul regencies to the east. The northern part was plateau/menorah hill with an altitude of 500-1000 meters above sea level, consisting of Girimulyo, Nanggulan, Kalibawang, and Samigaluh subdistricts (Statistics of Kulon Progo Regency, 2021). The average temperature of the site was 28 to 33°C with 78 to 80% humidity. The rainfall throughout 2020 ranged from 2.80 to 270.10 mm/monthly, and the duration of sunlight

exposure was 50.21 to 87.46% (Meteorological, Climatological, and Geophysical Agency, 2021).

Soil Nutrient Analysis

Soil analysis was performed before treatment by taking 1 kg of soil in the main plot randomly on A1, A2, and A3. The soil test was analysed at the Yogyakarta Agricultural Technology Research Center Laboratory to determine the available nutrients. The pH value was analysed using a pH meter (Sulaeman et al., 2005) and the total nitrogen was calculated using the Kjeldahl method that converts nitrogen in the form of $(\text{NH}_4)_2\text{SO}_4$ (Utami and Handayani, 2003). The C-organic values were determined using the Walky and Black method (Djuwanti, 2007) and the P-value using the Bray method. Phosphates in the acidic state will be bound as Fe and Al-phosphate compounds that are difficult to dissolve. NH_4F contained in the Bray extractor will form a compound with Fe & Al and liberate the 3-PO_4 ions (Sulaeman et al., 2005). K-available and P-available were analysed using the Morgan Wolf method (Sulaeman et al., 2005).

Chemical Analysis

The samples (dried, ground, and composited in one plot) were analyzed for chemical composition including dry matter (DM), organic matter (OM), and crude protein (CP) (AOAC, 2005). For DM analysis (AOAC, 2005), around one gram of the sample was oven-dried at the temperature of 105°C overnight until constant weight. DM content was calculated with the following formula: $\text{DM} = 100 - [\text{Weight after oven-dried (g)} / \text{Weight before oven-dried (g)}] \times 100\%$. For OM analysis (AOAC, 2005), the dry sample was then furnace at 600°C for 2 hours until constant weight. The content of OM was calculated as 100% minus ash content on which ash with the following formula: $\text{OM} = \{[\text{Weight before oven-dried (g)} - \text{Weight after furnace } 600^\circ\text{C (g)}] / \text{Weight before oven-dried (g)}\} \times 100\%$ For CP analysis (AOAC,

2005), the sample was digested in a Kjeldahl tube with the following step. Around 0.5 g of sample was added with catalyst of one gram of CuSO_4 and two grams of K_2SO_4 and 20 ml of concentrated H_2SO_4 for degradation. The results of degradation were diluted with 75 ml of aquadest and homogenized. Erlenmeyer 300 ml was prepared and filled with 60 ml of borax solution and indicator mix. The tube that has been filled with the results of destruction and indicator mix is installed in the distillation apparatus and the 50 ml of NaOH flow. The distillate was titrated with 0.1 N HCl until changed color. The content of CP was calculated with the following formula: $\text{CP} = \{[(\text{Number of HCl sample (ml)} - \text{Number of HCl blank (ml)}) \times \text{N} \times 0.014 \times 6.25] / \text{Sample weight}\} \times 100\%$.

Statistical Analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences software (SPSS) version 23.0 with a significant level of 5%. Data normality was evaluated using the Kolmogorov-Smirnov test while the homogeneity of variance among treatments was examined using Levene's test. Data were calculated using analysis of variance (ANOVA) with a split-plot and followed by Duncan's Multiple Range Test (Astuti, 1980).

Results and Discussion

Research Site Conditions

The type of soil in this study was grumusol. Grumusol soil has a very high coefficient and contraction, so if there is no irrigation, this type of soil will dry up, expand and crack. In addition, the problem with using grumusol soil has low nitrogen levels and impacts plant growth. Fertilization is incorporating particular materials to improve soil's nutrients as well as physical, chemical, and biological properties to support better plant growth. Purba (2020) states that butterfly peas can grow well on all types of soil, withstand dry

conditions, and grow best in the sun. The selected location with dry conditions was ideal for this study, despite changes in land, conditions, and climatology. Proper fertilization will produce good soil conditions, especially for the growth of butterfly pea plants. Soil conditions at the study site after fertilization based on soil analysis tests are shown in Table 1. The application of urea fertilizer has increased the available K-nutrients from 7.57 to 28.65% (Table 1). The pH conditions were relatively the same, and the highest urea level of 0 kg/ha compared to 100 kg/ha and 200 kg/ha. Soil conditions in the study indicate that this location is suitable for developing butterfly pea plants. Referring to Oguis et al. (2019), the plant is easy to grow in a variety of habitats and is used for rotational cultivation to help regenerate soil nitrogen, as a fodder crop, or as a source of new phytochemicals. Butterfly peas can thrive in all types of soil and dry conditions.

Plant Morphology Growth

Table 2 showed significant interaction ($p < 0.05$) between fertilizer rate and harvest age on stem diameter, number of leaves, and number of branches. The highest results were observed from the application of 200kg/ha fertilizer with 60 DAP. Based on this study, the rates of fertilization had a significant ($p < 0.05$) on the length, stem diameter, number of leaves, and number of branches. The application of urea fertilizer increased plant length from 10.59 to 17.16%, stem diameter from 12.12

to 24.24%, number of leaves from 15.40 to 28.20%, and the number of branches from 81.82 to 190.91% compared to the control (Table 2). This is due to the nitrogen element in urea fertilizer absorbed by plants with function for vegetative growth (lengths, branches, leaves, and diameters) related to the process of defense of cells and meristem tissues. The nitrogen element in urea absorbed by plants is used to form the lengths, the number of leaves, the number of branches, and the diameter of the stem, so it will increase with the level of urea fertilizer applied. In addition, these conditions indicate that the plant gets good nutrients, water, and sunlight. The presence of nitrogen is very important in plant development because it plays a role in the photosynthesis process, ultimately affecting the improvement of plant morphological growth. Sembiring et al. (2021) reported that one of the factors is nitrogen which acts as an essential substance that affects the morphological growth of butterfly peas. Arnawa et al. (2017) stated that the butterfly pea plant is in a vegetative growth phase where the absorption of nutrients in the soil is to carry out the process of cell division and enlargement. The number of leaves and branches increased as the level of fertilizer increased. Dianita and Abdullah (2011) stated that a nitrogen function is for the growth of vegetative parts of nitrogen for growth of plants vegetative plants such as plant height, number of leaves, stem diameter, and number of branches.

Table 1. Chemical characteristics of soil at the location of *Clitoria ternatea L.*

Parameters	Treatment of urea fertilizer (kg/ha)		
	0	100	200
pH (H ₂ O)	7.12	6.88	6.98
DHL (μs/cm)	155.00	143.00	217.00
C-organic (%)	2.30	2.22	2.90
N-total (%)	0.23	0.20	0.30
K available (ppm)	185.00	199.00	238.00
P available (ppm)	8.00	9.00	7.00

The soil analysis performed at Laboratory of Agriculture Technology Research Center in Yogyakarta

Table 2. Morphological Growth of *Clitoria ternatea* L. at fertilization rates with at different harvest ages

Plant Morphology growth	Harvest ages (days)	Urea fertilization level treatment (kg/ha)			Average
		0	100	200	
Plant length (cm)	30	83.40±4.00	94.58 ±7.24	101.31±4.39	93.09±9.12 ^x
	45	110.92±3.51	122.29±5.47	129.72 ±4.20	120.97±8.68 ^y
	60	127.57±6.84	139.22±5.47	146.12±3.67	137.64±9.40 ^z
	Average	107.30±19.80 ^a	18.67±20.05 ^b	125.72±19.95 ^c	
Stem diameter (cm)	30	0.55± 0.01 ^k	0.61±0.03 ^{kl}	0.67±0.04 ^l	0.61±0.06 ^x
	45	0.65± 0.03 ^l	0.74±0.02 ^m	0.80±0.03 ^{mn}	0.73±0.07 ^y
	60	0.78± 0.04 ^m	0.85±0.01 ⁿ	0.99±0.07 ^o	0.87±0.10 ^z
	Average	0.66±0.10 ^a	0.74±0.11 ^b	0.82±0.14 ^c	
Number of leaves	30	164.58±20.96 ^k	194.00±7.63 ^l	220.81±22.69 ^m	193.13±29.09 ^x
	45	381.02±24.31 ⁿ	461.32±39.94 ^o	525.64±74.02 ^p	455.99±76.50 ^y
	60	605.92±21.29 ^q	672.84±27.12 ^r	727.31±60.29 ^s	668.69±63.07 ^z
	Average	383.84±92.08 ^a	442.72±209.24 ^b	491.25±226.2 ^c	
Number of branches	30	9.77±1.07 ^k	10.83±0.53 ^{kl}	12.48±1.91 ^l	11.02±1.41 ^x
	45	17.98±0.99 ^m	20.55±0.23 ⁿ	22.47±0.56 ^o	20.33±2.03 ^y
	60	30.47±1.97 ^p	32.23±0.38 ^q	34.92±1.34 ^r	32.54±2.28 ^z
	Average	19.40±9.11 ^a	21.20±9.28 ^b	23.29 ±9.77 ^c	

Different superscript on the same line shows significant differences ($p < 0.05$); Different superscript on the same line and column show significant interaction ($p < 0.05$); Different superscript on the same column shows significant differences ($p < 0.05$)

Gomez and Kalamani (2003) stated that the height of the pea flower that is maintained properly can reach 90 to 162 cm. Butterfly peas at different doses of bio-slurry fertilizer showed plant height between 184.76 to 227.42 cm.

Butterfly pea plants had a significant ($p < 0.05$) growth morphology (plant length, number of leaves, number of branches, and stem diameter) when harvested 30, 45, and 60 days after planting (DAP) on Defoliation time increased plant length from 29.94 to 47.85%, the number of leaves from 135.75 to 246.11%, the number of branches from 10.53 to 21.05%, and stem diameter from 19.67 to 42.62% compared to control (Table 2). This was because plant morphology grew as the crop matured from the vegetative phase to the generative and flowering phases. As the plant matures, there are more processes of cell division, meristem tissue, and the photosynthesis of products. Cell tissues grow by increasing the length of the plant, the number of leaves, the number of branches, and the diameter of the stem

circle. The accumulation of plant vegetative growth can help the formation of chlorophyll in the leaves in order to accelerate the rate of photosynthesis. The higher the photosynthesis rate, the more photosynthate is produced and hence increase the plant length, the size of the large stem circle, and the number of leaves and branches increases. This is in line with Sembiring et al. (2021) the development of growth in height, leaves, branches, and stems is closely related to the process of cell division. Prakoso et al. (2018) the increase in plant age showed an increase in the number and size of cells. that the growth of height, leaves, branches, and stems is closely related to the process of cell division. Prakoso et al. (2018) reported that plant maturity demonstrates an increasing number and size of cells. Forage plants harvested at an older age can produce more leaves because they are in the vegetative phase. Rizqiani et al. (2007) explained that in the vegetative period, the number of branches increased.

Table 3. Productivity (tons/ha) of *Clitoria ternatea* L. at fertilization rates at different harvest ages

Productivity (tons/ha)	Harvest ages (days)	Urea fertilization level treatment (kg/ha)			Average
		0	100	200	
Fresh weight	30	14.79±1.84 ^a	16.18±2.45 ^b	17.07±3.50 ^c	16.02±2.53 ^d
	45	46.90±4.46 ^e	55.12±10.54 ^f	56.15±9.95 ^g	52.71±8.76 ^h
	60	108.18±7.80 ^m	117.48±4.71 ^{mn}	125.93±11.25 ^o	117.19±10.56 ^p
	Average	56.62±41.34 ^a	2.92±44.64 ^b	66.38±48.37 ^c	
Dry matter weight	30	3.10±0.53	3.50±0.41	3.64±0.83	3.44±0.59 ^x
	45	9.68±1.17	12.30±2.59	12.17±2.02	11.38±2.16 ^y
	60	23.08±3.28	25.28±1.13	27.43±2.77	25.29±2.91 ^z
	Average	11.95±8.99 ^a	13.76±9.60 ^b	14.41±10.58 ^c	
Crude protein dry weight	30	0.66±0.12	0.83±0.15	0.87±0.21	0.78±0.17 ^x
	45	2.03±0.28	2.77±0.67	2.88±0.50	2.56±0.60 ^y
	60	4.79±0.80	5.72±0.38	6.27±0.78	5.59±0.88 ^z
	Average	2.49±1.87 ^a	3.11±2.17 ^b	3.34±2.41 ^c	

Different superscripts on the same line show significant differences ($p < 0.05$); Different superscripts on the same line and column show significant interaction ($p < 0.05$); Different superscripts on the same column show significant differences ($p < 0.05$)

Morsy and Awadalla (2017) reported that butterfly peas that was given different doses of phosphorus fertilizer at 80 days of harvest age reported a plant height of 87.22 to 91.51 cm. Nasim and Pa'ee (2021) reported that the butterfly pea plant had the highest plant height of 44 cm at the age of 14 days with the addition of 200 mM NaCl.

Biomass Productivity

Statistical results (Table 3) showed a significant interaction ($p < 0.05$) between fertilizer rate and harvest age on fresh weight. The application of fertilizer rate of 200kg/ha with 60 DAP had the highest fresh weight productivity (125.93 tons/ha), while the lowest was the fertilizer rate of 0 kg/ha with 30 DAP (14.79 tons/ha). Based on this study, the differences in fertilizer rates and harvest ages had a significant ($p < 0.05$) effect on the productivity (tons/ha) of butterfly pea forages. The addition of urea fertilizer levels significantly increased the productivity of dry matter, fresh matter, and crude protein in butterfly peas (*Clitoria ternatea* L.). The application of urea fertilizer increased the productivity of butterfly pea forage compared to the control (Table 3). The productivity of fresh forage was 200 kg/ha (17.24%) and 100 kg/ha (11.13%) compared to the

control. Dry weight productivity increased by 200 kg/ha (20.59%) and 100 kg/ha (15.15%) compared to control. Crude protein productivity is 200 kg /ha (34.14%) and 100 kg/ha (24.90%) compared to the control. This is because the high nitrogen (N) content in urea fertilizer can increase the nitrogen content in the soil and the intake of nitrogen elements needed by plants.

Nitrogen nutrients, water, and sunlight impact the photosynthesis process and stimulate a higher yield of photosynthesis products which spread throughout the plant. Therefore, the fresh weight, dry weight, and total crude protein weight of forage increase. The amount of chlorophyll on the leaves will increase the results of photosynthesis, where chlorophyll is obtained from the element nitrogen. This is because the nitrogen content influences it in urea for the formation of compounds such as crude protein in butterfly pea plants. Nitrogen is an important element in the development of leaves and the formation of crude protein in plants. Sembiring et al. (2021) stated that nitrogen nutrients play a crucial role in forming new cells, cell elongation, and tissue thickening which ultimately increases the productivity of fresh and dry-weight of butterfly peas. Rizqiani et al. (2007) reported that plants

need nitrogen nutrients to carry out metabolic processes in the vegetative period, so the maximum photosynthesis process ultimately increases plant productivity. The carbohydrate and protein produced will be more abundant and spread throughout the plant so that the dry weight of the forage will increase. Nitrogen availability affects crop biomass production (Umami et al., 2019; Utomo et al., 2019).

As for the dry weight production at different harvest ages treatments. Harvest ages increased dry weight production 45 DAP (11.30 kg/ha) and 60 DAP (25.29 kg/ha) compared to control (3.44 kg/ha). This is because of the plants in the vegetative phase. Harvest ages also affect the water content of the plant. Plants cut at shorter or younger ages have higher water content than older plants. Nitrogen availability affects plant biomass production; the older the plant, the higher the organic matter content of the plant (Umami et al., 2019; Utomo et al., 2019). Harvest ages increased crude protein production by 45 DAP (2.56 kg/ha) and 60 DAP (5.59 kg/ha) compared to the control (0.78 kg/ha). This is because the age of the plant affects the yield of crude protein levels (%) which is the basis for determining crude protein production, besides that the harvest at a young age can affect the ratios of stems, and leaves of plants compared to older plants. Karim et al. (1991) (Umami et al., 2019; Utomo et al., 2019). Karim et al. (1991) conveyed that the age of the plant affects the ratio of leaves to stems, and in turn, the ratio of leaves to stems will affect crude protein level. Harvesting ages at 35 days on butterfly pea plants produced a crude protein of 273.3 g/kg dry matter (Abreu et al., 2014).

Conclusions

Applying urea fertilizer rates could increase plant height, number of leaves, number of branches, stem diameter, and the productivity of

butterfly peas. The growth of plant morphology and productivity increased in line with the age of harvest. Butterfly pea forage harvested after 200 kg/ha urea treatment with 60 DAP had the highest morphological growth and productivity

Acknowledgment

This work was supported by research assistance from the Indonesian Agency for Agricultural Research and Development of the Ministry of Agriculture Republic Indonesia (IAARD, 2021) in collaboration with Universitas Gadjah Mada.

References

- Abreu, MLC, RAM Vieira, NS Rocha, RP Araujo, LS Glória, AM Fernandes, PD de Lacerda, AG Júnior, and A Gesualdi. 2014. *Clitoria ternatea* L. as A Potential High Quality Forage Legume. Asian-Australasian Journal of Animal Sciences. 27(2):169–178.
- Al-Snafi, AE. 2016. Pharmacological Importance of *Clitoria ternatea*- a review. IOSR Journal Pharmacy. 6(3):68–83.
- AOAC. 2005. Official Methods of Analysis. (18th ed.). Association of Officiating Analytical Chemists.
- Arnawa, IW., IW Suarna, and IG Mahardika. 2017. Growth and Yield of Butterfly Pea (*Clitoria ternatea* L.) on Various Level of Water Content and Bio-slurry Fertilizers. Pastura. 7(1):41–46.
- Astuti, D, B Suhartanto, N Umami, and A Irawan. 2020. Effect of Density Between Intercropped Sorghum and Stylosanthes on Biomass Production and Quality Under Varying NPK Fertilizer Application Rates. Journal of Crop Science and Biotechnology. 23(3):197–205.
- Astuti, M. 1980. Desain Penelitian dan Analisis Statistik [Experimental Design and Statistical Analysis]. Gadjah Mada University Press, Yogyakarta.
- Bui, F., MA Lelang, and RI Taolin. 2015. Effect Of Planting Media Composition and Polybag Size on Tomato Growth and Yield (*Lycopersicon esculentum*, Mill). Savana Cendana Jurnal Pertanian Konservasi Lahan Kering. 1(1):1–7.
- Danita, R and L Abdullah. 2011. Effect of Nitrogen Fertilizer on Growth Characteristics and Productivity of Creeping Forage Plants For tree-pasture integrated system. Journal of Agricultural Science and Technology. 1(8):1118-1121.

- Djuwanti, S., HB Pulunggono, and Suwarno. 2007. Pengaruh Pemberian Bahan Organik Fosfat Alam Terhadap Aktifitas Fosfatase dan Fraksi P Tanah Latosol Di Dermaga, Bogor. *Jurnal Tanah dan Lingkungan*. 9(1): 10-15.
- Gomez, SM., and A Kalamani. 2003. Butterfly pea (*Clitoria ternatea*): A Nutritive Multipurpose Forage Legume For The Tropics. *Pakistan Journal of Nutrition*. 2(6):374–379.
- Hartutik, Soebarinoto, PT Fernandez, and S Ratnawaty. 2012. Evaluation of Legume Herbs Nutritive Value As a Ruminant Feed and Nitrogen Supply on Soil in West Timor, Indonesia. *Pakistan Journal of Agricultural Research*. 25(4):323–331.
- Jamil, N., MNM Zairi, A Nasim, and F Pa'ee. 2018. Influences of Environmental Conditions to Phytoconstituents in *Clitoria ternatea* (Butterfly Pea Flower). *Journal of Science and Technology*. 10(2):208-228.
- Jelantik, I., T Nikolaus, C Penu, G Malelak, and I Benu. 2019. Forage Production and Nutritive Value of (*Clitoria ternatea*) Harvested at 60, 75 and 90 Days After Planting. *Pastura*. 8(2):76–80.
- Karim, AB., ER Rhodes, and PS Savill. 1991. Effect of Cutting Height and Cutting Interval on Dry Matter Yield of *Leucaena leucocephala* (Lam) De Wit. *Agroforestry Systems*. 16(2):129-137.
- Meteorological, Climatological, and Geophysical Agency. 2021. Badan Meteorologi, Klimatologi, dan Geofisika online. BMKG.
- Morsy, ASM., and A Awadalla. 2017. Growth, Forage Yield and Quality of *Clitoria* (*Clitoria ternatea*) as Affected by Dates and Methods of Sowing and Phosphorus Fertilizer Under Toshka Region Condition. *Middle East Journal Agriculture Research*. 6(2):506–518.
- Nasim, NM., and F Pa'ee. 2021. Evaluating Physiological Responses of Butterfly Pea, *Clitoria ternatea L. var. Pleniflora* to Salt Stress. *IOP Conference Series: Earth and Environmental Science*. 736(1):012039.
- Oguis, GK., EK Gilding, MA Jackson, and DJ Craik. 2019. Butterfly Pea (*Clitoria ternatea L.*) a Cyclotide-bearing Plant With Applications in Agriculture and Medicine. *Frontiers in Plant Science*. 10(1):1–3.
- Prakoso, DI., D Indradewa, and E Sulistyanyingsih. 2018. Pengaruh Dosis Urea Terhadap Pertumbuhan dan Hasil Kedelai (*Glycine max L. Merr.*) Kultivar Anjasmoro. *Vegetalika*. 7(3):16–29.
- Prasojo, YS., G Ishigaki, M Hashiguchi, M Muguerza, and R Akashi. 2021. Evaluation of Regrowth Ability of Soybeans for Forage Utilization Under Two-Cutting Systems. *Australian Journal of Crop Science*. 15(12):1452–1458.
- Prayoga, IK., F Fathul, and Liman. 2018. Pengaruh Perbedaan Umur Panen Terhadap Produktivitas (Produksi Segar, Produksi Bahan Kering, serta Proporsi Daun dan Batang) Hijauan Indigofera zollingeriana. *Jurnal Riset dan Inovasi Peternakan*. 2(1):1–7.
- Purba, EC. 2020. Kembang Telang (*Clitoria ternatea L.*): Pemanfaatan dan Bioaktivitas. *Jurnal Pendidikan, Matematika dan Sains*. 4(2):111–124.
- Rizqiani, NF., A Ambarwati, and NW Yuwono. 2007. Pengaruh Dosis dan Frekuensi Pemberian Pupuk Organik Cair Terhadap Pertumbuhan dan Hasil Buncis (*Phaseolus vulgaris L.*) Dataran Rendah. *Jurnal Ilmu Tanah dan Lingkungan* 7:43-53.
- Sarmita, F., ED Hastuti, and S Haryanti. 2011. Pertumbuhan Legum Pada Ketinggian Yang Berbeda. *Bioma: Berkala Ilmiah Biologi*. 13(2):67–72.
- Sembiring, SDBJ., N Ginting, S Umar, and S Ginting. 2021. Effect of Eco Enzymes Concentration on Growth and Production of Kembang Telang Plant (*Clitoria ternatea L.*) as Animal Feed. *Jurnal Peternakan Integratif*. 9(1):36–46.
- Statistics of Kulon Progo Regency. 2021. Kulon Progo Regency in Figures For 2021.
- Sulaeman, Suparto, and Eviati. 2005. Analisis Kimia Tanah, Tanaman, Air, dan Pupuk. *Petunjuk Teknis*. Balai Penelitian Tanah. Badan Penelitian dan Pengembangan Pertanian Departemen Pertanian. Bogor.
- Sutedi, E. 2013. Potensi kembang telang (*Clitoria ternatea L.*) sebagai tanaman pakan ternak. *Wartazoa*. 23(2): 51-62.
- Syamsuddin, S, T Saili, and A Hasan. 2016. Hubungan Pemberian Pupuk Kandang Sapi Dengan Peningkatan Legum *Clitoria ternatea* Sebagai Hijauan Pakan Ternak. *Jurnal Ilmu Teknologi Peternakan Tropis*. 3(2):81–86.
- Umami, N., A Abdiyansah, and A Agus. 2019. Effects of Different Doses of NPK Fertilization on Growth and Productivity of *Cichorium intybus*. *IOP Conference Series: Earth and Environmental Science*. 387(1):012097.
- Umami, N., YS Prasojo, and MS Haq. 2022. Morphological Characteristics and Biomass Production Brassica rapa var. Marco During the Dry Season. *Animal Production*. 24(1) :31-36.
- Utami, SNH., and S Handayani. 2003. Sifat Kimia pada Estisol Sistim Pertanian Organik. *Jurnal Ilmu Pertanian*. 10(2): 63-69.
- Utomo, R., CT Noviandi, N Umami, and A Permadi. 2019. Effect of Composted Animal Manure as Fertilizer on Productivity of *Azolla pinnata* Grown in

- Earthen Ponds. Journal of Biological Sciences Original Research Paper. 19(4):232-236.
- Wafi, H., S Sowmen, Q Aini, and E Yulita. 2020. Pemanfaatan waretha sebagai bakteri pelarut posfat dan pupuk npk terhadap akar dan produksi *clitoria ternatea* di ultisoL. Pastura, 10(1), 10-22.
- Winata, NASH., K Karno, and S Sutarno. 2012. Pertumbuhan dan Produksi Gamal (*Gliricidia sepium*) Dengan Berbagai Dosis Pupuk Organik Cair. Animal Agriculture Journal. 1(1):797-807.
- Zulchi, T., A Husni, and Fransiska. 2020. Hasil Ploidisasi Kembang Telang (*Clitoria ternatea L.*) Terhadap Produksi Biomas. Prosiding Seminar Nasional Teknologi Peternakan dan Veteriner Virtual 2020. Puslitbangnak Litbang Kemntan. Bogor.