Biomass Production AND Nutrient FROM Crotalaria JUNCEA L. AS Green Manure IN Different Planting Distance AND Age OF Harvest

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Abstract: The purpose of research is to determine the biomass production and nutrient content of Crotalaria juncea L. as green manure used different planting distance and age of harvest. The study was conducted in Bontouse village, Tanasitolo Wajo district, South Sulawesi, Indonesia from December 2017 to July 2018. The study used a factorial two-factor in Randomized Block Design. The first factor is planting distance (J) with three levels: J_1 = 5 cm x 20 cm; J_2 = 10 cm x 20 cm and J_3 = 15 cm x 20 cm. The second factor is the age of harvest C. juncea (U) with four levels: U_1 = 15 days; U_2 = 30 days; U_3 = 45 days and U_4 = 60 days. Each treatment unit was made plot measuring 200 cm x 200 cm, each treatment unit was repeated three times. The results was showed that the average biomass production of C. juncea was around 3.638.21g/m^2 or 36.382.08 kg ha^{-1} on planting distance J_1 = 5 cm × 20 cm, significantly different from J_2 = 10 cm × 20 cm and J_3 = 15 cm × 20 cm. The age of harvest C. juncea U_4 = 60 days has average of the heaviest biomass about 6.680.28g/m^2 or 66.802.78 kg / ha^{-1} and significantly different from the treatment of U_1 = 15 days, U_2 = 30 days and U_3 = 45 days. Production and nutrient content of C. juncea on the use of planting distance J_1 = 5 cm × 20 cm produced the highest nitrogen about 1.570.06 kg/ha^{-1}, the highest phosphorus production of 80.05 kg / ha-1 and the highest potassium production of 1,398.58 kg/ha^{-1}. Age of harvest U_4 = 60 days produces the highest average nitrogen production about 2954.84 kg/ha^{-1}, the highest average production of phosphorus 151.51 kg /ha^{-1} and the highest average production of potassium is 2044.61 kg/ha^{-1}.

Index Terms: Crotalaria juncea, biomass, green manure, nutrient, planting distance

1 INTRODUCTION

Green manure as important alternative increasing soil quality and plant nutrition (White and Brown, 2010). The material of green manure come from cover crop or waste of harvest. Cover crops meaning crops grown to cover the land to protect the soil from erosion, loss plant nutrients through leaching and runoff. The another reason is cover crops useful for weed suppression, carbon sequestration, and integrated pest management. Cover crops protect water quality by reducing losses of nutrients, pesticides, or sediment from agricultural fields. Soil erosion leads to reductions in soil quality and productivity (Yadav et al., 2000; Dabney et al., 2001). Utilization of green manure increasing the content of organic matter and soil nutrients. This condition such as physical, chemical and biological properties of the soil to be more suitable for plant growth. Commonly plant material was used as source of green manure. Green manure used in the soil in two from: fresh material or after decomposition process. Some plants often used as a cover crop of green manure such as: quick stick (Gliricidia sepium), white leadtree (Leucaena leucocephala), Sesbania rostrata, Crotalaria spp., and Mucuna pruriens (Odhiambo, 2010; Yuliana et al., 2013; Sumarni, 2014; Pereira et al., 2016). Crotalaria spp. family Leguminosae or Fabaceae as potential plant as green manure.

The plant produces many of biomass, containing higher water and nitrogen inside cell tissue. Approximately 90 species of Crotalaria spp. spread in the world wide except Antarctic. The one of famous species as the source of green manure is Crotalaria juncea L. (Abawi and Widmer, 2000; Bhardwaj et al., 2005). C. juncea contain higher nitrogen approximately 3.27%, lowest lignin and polyphenol approximately 7.42% and 0.78%, respectively. C. juncea has properties that easily decomposed into organic matter, as cover crop, produces minerals contain humus will improve soil structure and be able to nourish the soil (Balkcom and Reeves, 2005; Ambrosano et al., 2013; Cherr et al., 2016; Subaedah et al., 2016). The findings of research from Marla et al. (2008); Djajadi (2011); Curto et al., (2015); Patel and Dhillon (2017) reported that in addition to providing fertility to the soil, C. juncea useful plant that rapidly reduces the population of pathogenic nematode on plant such as Meloidogyne incognita infect cultivated plants i.e. tomato. Commonly in decomposition process, tissue of youngest plants decomposed quickest. There are contain more water and soft textures (Baitsaid et al., 2018). C. juncea growth is very fast. In short time can produce more biomass used as green manure. The biomass playing role adding organic matter to the soil (Sutejo, 2002 and Schomberg et al., 2007). Sainju and Sing (2001) and Subaedah et al. (2004) suggested that the application of forage plants or green manure as organic material increasing total nitrogen content of soils up to 60%, increase ability cation exchange capacity to 24%, and enhance C-organic soil to 25% compared without the treatment of organic matter in plantation. Paul et al., (2001); Ruffo et al., (2004); Sumarni (2014); Syahri et al., (2016); Adekiya et al. (2019) reported the results of their research that green manure derived from C. juncea improve soil quality including: physical properties in the form of aggregate stability, chemistry (organic matter, nitrogen, phosphorus and cation exchange capacity) and soil biology (inhibit development of soil borne pathogens). Sharma et al. (2017) reported that green manure from C. juncea contain more organic and decomposer materials such as Trichoderma

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sp. They has an important role as biocontrol agents for pathogenic microbes in the soil. According to Odhiambo and Bomke (2001); de Oliveira et al., (2007) and Ossom et al., (2010) reported that C. juncea improve the productivity of cultivated plants on dry land because able reserve water used by plants such as taro and sweet potato. In research without C. juncea application resulted lowest production.C. juncea as leguminous playing an important role as green manure as soil organic material in fresh form and processed products such as compost and liquid organic fertilizer. Compost made from C. juncea can be used as an alternative to anorganic fertilizer. In the future application of anorganic fertilizer can be reduced or eliminated (Odhiambo, 2010, Murungu et al., 2011, Sukartono et al., 2011 and Ziblim et al., 2013). C. juncea in the fresh form carried out by planting in monoculture and intercropping. Monoculture system by planting one month after harvesting the crops then immersed in the soil during soil cultivation. C. juncea in the form of processed products such as compost must be propagated monoculture using seeds. C. juncea in fresh and processed products can not be known precisely the results of biomass and content of the nutrients. Based the reason above, the purpose of research is to determine the biomass production and nutrient content of C. juncea as green manure at different planting distance and age of harvest.

2 METHODOLOGY

2.1 Site of Research

The research activities was conducted in Bontouse village, Tanasitolo Wajo district, South Sulawesi, Indonesia from December 2017 to July 2018. The materials and equipment used such as : C. juncea seeds, label, raffia ropes, nylon ropes, cultivator, scales, scissors, plastic bag and stationery. The study was arranged using a Factorial two-factor in Randomized Block Design. The first factor as planting distance (J) used three levels : J_1 = 5 cm x 20 cm, J_2 = 10 cm x 20 cm and J_3 = 15 cm x 20 cm; the second factor is the age of harvest green manure (U) used four levels: U_1 = 15 days, U_2 = 30 days, U_3 = 45 days and U_4 = 60 days. The combination of treatments given are: J_1U_1 = 5 cm x 20 cm + age of harvest 15 DAP (Day After Planting); J_1U_2 = 5 cm x 20 cm + age of harvest 30 DAP; J_1U_3 = 5 cm x 20 cm + age of harvest 45 DAP; J_1U_4 = 5 cm x 20 cm + age of harvest 60 DAP; J_2U_1 = 10 cm x 20 cm + age of harvest 15 DAP; J_2U_2 = 10 cm x 20 cm + age of harvest 30 DAP; J_2U_3 = 10 cm x 20 cm + age of harvest 45 DAP; J_2U_4 = 10 cm x 20 cm + age of harvest 60 DAP; J_3U_1 = 15 cm x 20 cm + age of harvest 15 DAP, J_3U_2 = 15 cm x 20 cm + age of harvest 30 DAP; J_3U_3 = 15 cm x 20 cm + age of harvest 45 DAP; J_3U_4 = 15 cm x 20 cm + age of harvest 60 DAP.

2.2 Preparation and Management of C. juncea

The land was processed by applying cattle manure and divided into three replications. In each replication, the plot measurement 200 cm x 200 cm were made for each treatment unit. Each replication consists of 12 plots and total 36 plots. C. juncea planting is grow with planting distance according to the treatment. Maintenance of C. juncea is carried out until harvest with replanting, weeding and irrigation. C. juncea harvest is carried out according to the treatment by pulling the plant including all parts of the plant (roots, stems, and leaves) will be used in the research activities.

2.3 The Observation of C. juncea

Parameters was observed in the activity are: weight of C. juncea biomass and nutrient content. Biomass weight is obtained based on harvest time according to the treatment. C. juncea harvest was chopped, then weighed to obtain weight of C. juncea biomass. To find out the nutrient content of C. juncea, chopped from the roots, stems and leaves are taken as 250 g. The sample bring to the Laboratory of Soil, Plant, Fertilizer and Water, South Sulawesi Agricultural Research and Development Agency. This a best place analyzed macro nutrient content of C. juncea such as : nitrogen, phosphorus and potassium.

2.4 Data Analysis

All of the data were tabulated and analyzed of variance (ANOVA) followed by Least Significant Difference with α = 5%.

3 RESULT AND DISCUSSION

3.1 Biomass Production of C. juncea

The results of observations of C. juncea biomass production are presented in Table 1 below:

Table 1. *The Average Biomassa of C. juncea*

Planting Distance (cm)	Mean	Age (Day)				Average	$LSD_{0.05}$
		15 (u_1)	30 (U_2)	45 (U_3)	60 (U_4)		
5 × 20 (J_1)	g/m^2	470.42	2296.17	4299.25	7487.00	3638.21^a	522.397
	4 g/m^2	(1881.67)	(9184.67)	(17197.00)	(29948.00)	(14552.83)	
	Kg/ha	(4704.17)	(22961.67)	(42992.50)	(74870.00)	(36382.08)	
10 × 20 (J_2)	g/m^2	233.83	1105.75	4011.00	6490.08	2960.17^b	
	4 g/m^2	(935.33)	(4423.00)	(16044.00)	(25960.33)	(11840.67)	
	Kg/ha	(2338.33)	(11057.50)	(40110.00)	(64900.83)	(29601.67)	
15 × 20 (J_3)	g/m^2	246.83	1281.00	3168,00	6063.75	2689.90^b	
	4 g/m^2	(987.33)	(5124.00)	(12672,00)	(24255.00)	(10759.58)	
	Kg/ha	(2468.33)	(12810.00)	(31680,00)	(60637.50)	(26898.96)	
Average	g/m^2	317.03^d	1560.97^c	3826.08^b	6680.28^a		
	4 g/m^2	(1268.11)	(6243.89)	(15304.33)	(26721.11)		
	Kg/ha	(3170.28)	(15609.72)	(38260.83)	(66802.78)		
$LSD_{0.05}$	603.2117						

Numbers in the same column followed by same letters are not significantly different (LSD α=0.05).

The use of different planting distance and age of harvest C. juncea has a significant effect, while their interaction does not significantly affect the weight of C. juncea biomass. The results of C. juncea biomass production in Table 1 was showed the treatment planting distance J_1 = 5 cm × 20 cm resulted the heaviest average of C. juncea biomass (3.638.21 g/m^2 or 14.552.83 g/4 m^2 or 36,382.08 kg/ha) and significantly different from planting distance J_2 = 10 cm × 20 cm and J_3 = 15 cm × 20 cm. Treatment of plant age U_4 = 60 days harvest the heaviest average of plant biomass (6.680.28 g/m^2 or 26.721.11 g/4 m^2 or 66.802.78 kg/ha) and significantly different from the age of U_1 = 15 days, U_2 = 30 days and U_3 = 45 days. The results of further test analysis was showed that the highest C. juncea biomass achievement was obtained at planting distance J_1 = 5 cm × 20 cm. The planting distance is the tightest of the various crop treatment. In general, planting distance affect plant populations with denser spacing means that the plant population will increase. According to Feichtinger et al. (2004) and Daudu et al. (2016) suggested that increasing plant populations in normal condition,without competition between plants, it is expected that production per unit area will also be higher. It will cause increasing in plant biomass. Based Good Agriculture Practices in the field, Mosjidis et al. (2007) and Tripathi et al. (2013) reported that sowing seed of C. juncea at the planting distance 30 × 10 cm at 30 days after sowing is effective increasing the seed yield of C. juncea. According to Habte et al. (2013), Mendonca and Schiavinato (2005) described that biomass is defined as the total amount of living material based the time at certain area. Magdalena et al. (2013) state that biomass includes constituting the majority of living organisms that contain a lot of liquid. Hansch and Mendel (2009) and Pereira et al. (2016) suggested that measurement of total plant biomass is a good parameter can be used as an indicator of plant growth. Based on the fact that estimated plant biomass is relatively easy to measure and is an integration of almost all events experienced by plants before.

3.2 Nutrient Production of C. juncea

3.2.1 Nitrogen Content

Nitrogen production from C. juncea at different planting distance and plant age is very significant, while the interaction of both does not significantly affect the nitrogen production of C. juncea. Table 2 was showed the average nitrogen production of C. juncea.

Table 2. *The Average of Nitrogen Production from C. juncea (kg ha^{-1})*

Planting Distance (cm)	Age (Day) 15 (U_1)	30 (U_2)	45 (U_3)	60 (U_4)	Average	$LSD_{0,05}$
5 × 20 (J_1)	220.25	965.75	1814.41	3279,83	1570.06^a	187.417
10 × 20 (J_2)	138.85	433.29	1579.57	2879.09	1257.70^b	
15 × 20 (J_3)	116.12	547.94	1255.63	2705.60	1156.32^b	
Average	158.41^d	648.99^c	1549.87^b	2954.84^a		
$LSD_{0,05}$	216.4104					

Numbers in the same column followed by same letters are not significantly different (LSD α=0.05).

Table 2 was showed that treatment planting distance J_1 = 5 cm × 20 cm produces the highest average of nitrogen approximately 1,570.06 kg ha^{-1} and significantly different from planting distance J_2 = 10 cm × 20 cm and J_3 = 15 cm × 20 cm. Treatment of plant age at U_4 = 60 days produced the highest average nitrogen about 2954.84 kg ha$_{-1}$ and significantly different from the treatment of plant age U_1 = 15 days, U_2 = 30 days and U_3 = 45 days. Odhiambo (2010) and Han et al. (2011) findings was showed soil with threated of C. juncea having the highest amount of mineral nitrogen after 16 weeks of incubation. The amount of mineral nitrogen ranged from 121 to 170 more higher than other legumes such as Mucuna pruriens. The cumulative amounts of nitrogen from the legume residues mineralized recovered as mineral nitrogen in soil after 16 weeks of incubation ranged from 21 - 41% (92 - 121 mg kg^{1}). Mineralization rate from C. juncea relative constant, k value was significantly correlated to the residue nitrogen content, nitrogen net mineralized , C/N ratio and lignin/N ratio. Results from this study indicated that C. juncea contribute significant amounts of nitrogen for uptake by plants, with release nitrogen at a faster rate. High clay content in soil slowed down nitrogen mineralization. Decomposition and nutrient release from leguminous biomass were monitored by sampling at 30, 60, 90, 120, 150 and 180 days after installing litter bags. In general, Crotalaria spectabilis and Canavalia ensiformes showed higher decomposition and nutrient release rates and they are the most promising for the dry region and poor soil nutrition (Thonnissen et al., 2000 and Pereira et al., 2016).

3.2.2 Phosphorus Content

Phosphorus (P) is essential mineral for all living organisms in nature. Plants must have phosphorus for normal growth and maturity. Phosphorus plays a role in photosynthesis, respiration, energy storage and transfer, cell division, cell enlargement and several other processes in plants. Phosphorus is one of the major plant nutrients in the soil. It is a constituent of plant cells, essential for cell division and development of the growing tip of the plant. For this reason it is vital for seedlings and young plants (Jeranyama et al., 2000 and Mabuza et al., 2016). Han et al. (2011) reported that nutrient release such as from leaf litter in an apple orchard system can contribute a significant portion of the nutrient requirement for apple production. Beside litter, cover crops such as C. juncea has potential as green manure improving soil health. Accounting for this nutrient contribution in the annual fertilizer management is important to avoid excess application, optimize net returns, and maintain sustainable production systems. Production of phosphorus derived from C. juncea in different planting distance treatments significantly affected the treatment of plant age, while the interaction of the both doesnot significantly affect the phosphorus production of C. juncea. Table 3 was showed the average phosphorus production of C. juncea.

Table 3. *The Average of Phosphorus Production from C. juncea (kg ha^{-1})*

Planting Distance (cm)	Age (Day) 15 (U_1)	30 (U_2)	45 (U_3)	60 (U_4)	Average	$LSD_{0,05}$
5 × 20 (J_1)	13.78	56.69	83.05	166.67	80.05^a	10.751
10 × 20 (J_2)	9.13	24.18	98.71	149.59	70.40^{ab}	
15 × 20 (J_3)	7.37	38.75	73.74	138.27	64.53^b	
Average	10.09^d	39.87^c	85.17^b	151.51^a		
$LSD_{0,05}$	12.4141					

Numbers in the same column followed by same letters are not significantly different (LSD α=0.05).

Table 3 was showed that planting distance J_1 = 5 cm × 20 cm produced the highest average of phosphorus production (80.05 kg ha^{-1}) but was not significantly different from J_2 = 10 cm × 20 cm. There are significantly different from J_3 = 15 cm × 20 cm (J3). Treatment of plant age U_4 = 60 days produces the highest average production of phosphorus (151.51 kg ha^{-1}) and significantly different from plant age U_1 = 15 days, U_2 = 30 days and U_3 = 45 days. Murungu et al., (2011) reported that C. juncea stems had 65% dry weight remaining after 132 days while just over 10% of Mucuna sp. and C. juncea leaves remained. There was no mineral contribution to maize growth by cover crops. However, in incubation studies, Mucuna sp. mineralized 60 mg nitrogen kg^{-1} and 3.2 mg phosphorus kg^{-1} and C. juncea mineralized 45 mg nitrogen kg^{-1} and 3.5 mg phosphorus kg^{-1}. This suggested that weeds and/or leaching may have impacted negatively to nutrient flow from decaying cover crops species to maize during the long winter fallow period. Kahiluoto et al. (2012) and Subaedah et al. (2014) reported that field studies have indicated that plant-available phosphorus supply is the main determinant of the performance of arbuscular mycorrhiza of crops. Presence arbuscular mychorriza as supply of phosphorus help plant maintaining and increasing their development. Ziblim et al. (2013) repoted that Mucuna pruriens recorded higher mean levels of percentage nitrogen, phosphorus, percentage organic carbon and soil pH except in potassium where the mean added level was higher than Crotalaria juncea. There was no significant difference in the soil amendment potentials of M. pruriens and C. juncea. M. pruriens is recommended to be used as a fallow crop since it has an added advantage of serving as a cover crop to control soil erosion.

3.2.3 Potassium Content

Commonly NPK fertilizer contain Nitrogen, Phosphorus and Potassium (K_2O). Although similar symbol with phosphorus, potassium has many different roles in plants. For example, in photosynthesis on plant, potassium regulates the opening and closing of stomata, and therefore regulates CO_2 uptake. Potassium triggers activation of enzymes and is essential for production of Adenosine Triphosphate (ATP) (Han et al., 2011). C. juncea production potassium at different planting distance and plant age is very significant, while the interaction of both does not significantly affect the production of C. juncea. Table 4 was showed treatment planting distance J_1 = 5 cm × 20 cm produced the highest average of potassium production (1398.58 kg ha^{-1}) and significantly different from J_2= 10 cm × 20 cm and J_3 = 15 cm × 20 cm.

Table 4. *The Average of Potassium Production from C. juncea (kg ha^{-1}).*

Planting Distance (cm)	Age (Day) 15 (U_1)	30 (U_2)	45 (U_3)	60 (U_4)	Average	$LSD_{0,05}$
5 × 20 (J_1)	307.01	930.72	1920.42	2436.18	1398.58a	160.588
10 × 20 (J_2)	194.54	424.46	1898.59	1798.66	1079.06b	
15 × 20 (J_3)	154.82	569.76	1492.80	1898.98	1029.09b	
Average	218.79d	641.65c	1770.60b	2044.61a		
$LSD_{0,05}$	185.4308					

Numbers in the same column followed by same letters are not significantly different (LSD α=0.05).

The treatment of plant age at U_4 = 60 days resulted in the highest average production of potassium (2044.61 kg ha^{-1}) and significantly different from U_1 = 15 days, U_2 = 30 days and U_3 = 45 days. The analysis at Table 4 was showed that C. juncea treated at planting distance J_1 = 5 cm × 20 cm, the plants produced highest nitrogen production (1.570.06 kg ha^{-1}); highest phosphorus production (80.05 kg ha^{-1}) and highest potassium production (1.398.58 kg ha^{-1}). Treatment plant age U_4 = 60 days produced highest nitrogen (2,954.84 kg ha^{-1}), highest phosphorus (151.51 kg ha^{-1}), and highest potassium production (2,044.61 kg ha^{-1}). In the age of 60 days is the optimal age formation of these elements inside C. juncea plant tissue. Mosjidis et al. (2007) state that C. juncea is one of the Leguminoceae plants has nodules on roots contain rhizobium bacteria catch free nitrogen in the atmosphere. According to Yadav et al. (2000) state that the conversion of free nitrogen from atmosphere to ammonia is mediated by the enzyme nitrogenase. The amount of nitrogen that is converted to ammonia is highly dependent on the physical, chemical and biological conditions of the soil. It was showed at the age of 60 days, the complete a series of metabolic processes including number content of nitrogen, phosphorus, potassium, C-Organic and C / N has reached optimal levels in C. juncea. The use of green manure from leguminous can improve number of nutrients into the soil through decomposition and nutrient release from biomassa. The findings of research showed Crotalaria spectabilis and Canavalia ensiformes has a higher decomposition and nutrient release rates. For greater persistence of residue in the soil, C. juncea is more recommended (Pereira et al., 2016).

CONCLUSION

The conclusion of the research is :

1. Average of the heaviest biomass production of C. juncea about 3.638.21 g/m^2 or 36.382.08 kg ha^{-1} at planting distance J_1 = 5 cm × 20 cm and significantly different from planting distance J_2 = 10 cm × 20 cm and J_3 = 15 cm × 20 cm.
2. The age of harvest C. juncea at U_4 = 60 days obtained an average of the heaviest biomass of 6.680.28 g/m^2 or 66.802.78 kg ha^{-1} and significantly different from the age of harvest U_1 = 15 days, U_2 = 30 days and U_3 = 45 days.
3. Production and nutrient content of C. juncea on the use of planting distance J_1 = 5 cm × 20 cm produces the highest nitrogen production (1.570.06 kg ha^{-1}), the highest phosphorus production (80.05 kg ha^{-1}) and the highest production of potassium (1.398.58 kg ha^{-1}).
4. Treatment age harvest U_4 = 60 days produces the highest average nitrogen production (2954.84 kg ha^{-1}), highest average phosphorus production (151.51 kg ha^1) and the highest average potassium production (2044.61 kg ha^{-1}).

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