Asian Journal of Plant Sciences

ISSN 1682-3974

science alert

ANSInet
an open access publisher
http://ansinet.com

OPEN ACCESS Asian Journal of Plant Sciences

ISSN 1682-3974
DOI: 10.3923/ajps.2024.15.21

Research Article
Morphology Characteristic and Biomass Production of Sunn Hemp (*Crotalaria juncea* L.) at Different Cutting Time

[1]Mayang Salsabillah Dewanti, [2]Bambang Suhartanto and [2]Yogi Sidik Prasojo

[1]Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta 55281, Indonesia
[2]Department of Animal Nutrition and Feed Science, Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta 55281, Indonesia

Abstract

Background and Objective: Sunn hemp (*Crotalaria juncea* L.) is a fast-growing legume that can produce high biomass in a short time. It is commonly used as a green manure, fiber source and cover crop. It was also drought-resistant and adaptable in a wide range of soil. Sunn hemp rich in nitrogen and carbon content. Therefore, sunn hemp may be a potential forage option for supplementing livestock feed while also delivering nitrogen into low-fertility soils. This study aimed to investigate the morphology characteristics and biomass production of sunn hemp at different cutting times. **Materials and Methods:** The study was conducted using a Completely Randomized Design (CRD) with three replications. Treatments consisted of three cutting times (8, 10 and 12 weeks). The following parameters observed were morphological characteristics (plant height, number of leaves, leaf length and width, stem diameter and number of branches) and biomass production. Data were analyzed using Analysis of Variance (ANOVA) and continued with Duncan's Multiple Range Test ($p<0.05$). **Results:** The cutting times had a significant effect ($p<0.05$) on morphology characteristics such as plant height, number of leaves, leaf length and width, stem diameter, number of branches and biomass production. The plant height, the number of leaves, leaf length and width, stem diameter, number of branches and biomass production were increased in line with the increase of the cutting times. The best results were found at 12 WAP of cutting time, which is before the plant bloom. **Conclusion:** The morphology characteristics and biomass production of sunn hemp increased as the cutting time increased.

Key words: Biomass production, cutting time, fiber source, morphology, sunn hemp

Citation: Dewanti, M.S., B. Suhartanto and Y.S. Prasojo, 2024. Morphology characteristic and biomass production of sunn hemp (*Crotalaria juncea* L.) at different cutting time. Asian J. Plant Sci., 23: 15-21.

Corresponding Author: Yogi Sidik Prasojo, Department of Animal Nutrition and Feed Science, Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta 55281, Indonesia Tel/Fax: (0274) 513363

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Forages are beneficial and crucial in livestock production systems. It provides good sources of macro and micronutrients for animal production and supports soil fertility, water supply security and air quality preservation. Therefore, improving the nutritional content of grasses and other fodder crops is crucial to boosting animal productivity and ensuring the production of high-quality food. It is also important to develop new forages that can be utilized effectively, as well as to use animals in a way that minimizes waste. Hence, the utilization of locally available feedstuffs from plant sources becomes crucial for sustainable livestock. *Crotalaria juncea* L., widely known as sunn hemp or Orok-orok in Indonesia, is an annual legume that originated from India and has a wide distribution in the tropic and subtropic areas in the world. In recent years, it has become popular as a sustainable crop due to its ability to improve soil fertility and suppress weeds. This plant grows well in a wide range of soil, but the optimal growth is on good fertility and drainage soil with neutral pH or between 5.0 to 8.5 where phosphorus and calcium are available[1]. Sunn hemp is a fast-growing legume, high-yielding crop that is rich in nitrogen and carbon content. It is commonly used as a cover crop and green manure, because of its capability to produce high accumulation of nitrogen through a nitrogen fixation process with the help of *Rhizobium* bacteria which are in the root nodules of this plant. The stems are fibrous and semi-woody, it has tall habits and small leaves, with seeds of various colors packed in pods[2]. The biomass dry matter yield produced by sunn hemp is around 18 to 27 ton ha^{-1} [3] and able to fix the equivalent of 70 to 130 kg N/ha/year[4]. Due to several characteristics, including high biomass output, ability to control weed growth, increase in soil organic matter, symbiotic relationships and effective nitrogen fixation for the plant, it has significant economic significance. Therefore, the usage of sunn hemp can be useful according to the cutting time.

Plants interact with their surroundings through their phenotype. Morphology is important in the natural sciences and studying the phenotypic diversity of an organism is essential to understanding plant patterns and processes. The morphology characteristic and biomass production of the plant should depend on cutting time as a growth stage on legume plants[5]. Determining the right cutting time including the cutting height level can significantly affect the quality and quantity of biomass produced by plants[6,7]. Generally, the cutting time of sunn hemp is determined by the stage of development of the plant, that is when the plant reaches its peak of growth. The recommended cutting period for sunn hemp is usually from 60 to 100 days after planting, depending on its intended use[8]. If used as green manure, cutting time is usually around 60 to 70 days after planting, when the plants reach their maximum height and before the flowers bloom. At this stage, sunn hemp has a high nitrogen content in plant tissue and is capable of producing significant biomass[9]. If the aim is for seed production, cutting time can be delayed until up to 100 days after sowing when the sunn hemp will flower and produce protein-rich seeds. Green biomass production from sunn hemp planted in the pre-monsoon period in India was 22 to 27 ton ha^{-1}, while in Thailand when grown as green manure after rice, a high-quality yield of 2 ton ha^{-1} was obtained in 6 to 8 weeks[10].

Recent studies in Indonesia have focused on the use of sunn hemp as a green manure and cover crop. Little information was known about sunn hemp in Indonesia, especially for morphological characteristics, biomass production and potential use as feed at different cutting times. In addition to providing information regarding optimal cutting times, growers need a simple approach to evaluate the potential biomass and total N from sunn hemp. However, it is necessary to determine the right cutting time to increase biomass yield which depends on plant morphology. This would be very valuable for farmers who might want to grow sunn hemp in Indonesia for feeding use. This study aims to investigate the effect of cutting time on the morphological characteristics and biomass production of sunn hemp.

MATERIALS AND METHODS

Study area: This research was conducted from the beginning of February until April, 2023. Cultivation, irrigation and morphological investigations were carried out at Research Farm of the Laboratory of Forage and Pasture Science (S 7°46'4.55860" and E 110°23'10.30870"), while laboratory analysis was conducted in the Laboratory of Forage and Pasture Science, Faculty of Animal Science, Universitas Gadjah Mada, Sleman, Yogyakarta.

Procedures

Experimental design: This study was conducted using a Completely Randomized Design (CRD) which consisted of three cutting-time treatments (8, 10 and 12 weeks). Every treatment was replicated 3 times.

Soil analysis: The soil in the research area was sampled before cultivation time for the soil chemical and physical properties analysis. The type of soil in the research area is regosol, while the chemical contents of the soil were shown in Table 1.

Table 1: Soil characteristics at the experimental site

Soil parameter	Value
pH (H_2O)	7.3
C-organic (Te %)	2.15
N-total (%)	0.17
P available (ppm)	15
K available (cmol kg^{-1})	0.48
C/N (%)	12.65
pH (H_2O)	7.3

Regosol soils originate from the natural processes of weathering, erosion and deposition that act on parent materials such as rocks and sediments. It has a relatively coarse texture, often containing a significant proportion of sand that makes it a good drainage property. The chemical properties of the soil at this study site showed that the phosphorus and potassium nutrients had a moderate concentration, while the nitrogen and C-organic were low (Table 1). Regosol soil fertility can be increased by suitable land management strategies that emphasize increasing organic matter content, nitrogen levels and soil structure. Table 1 showed that the soil has a neutral pH (7.3) which supported the optimum growth of sunn hemp. Sunn hemp can grow well in the soil with 5-8.4 pH but the growth will be impeded if the soil has an acid pH. The results of the chemical soil analysis in Table 1 showed that in general, the soil has a low to medium fertility level. This is indicated by the moderate content of phosphorus (15 ppm) and potassium (0.48 cmol kg^{-1}), as well as the low C-organic content (2.15%) and nitrogen (0.17%). Low C-organic content indicates that the amount of organic matter in the soil is low. The C-organic content of the soil besides being able to determine the value of the soil's cation exchange capacity (CEC) also greatly determines the addition of nutrients it contains such as N, P, K, Ca, Mg, S and microelements.

Cultivation and plant management: The land was processed using a manual tractor and applied with organic fertilizer obtained by cattle, then divided into 18 plots. The size in each plot was 1×1.5 m with an interval of 0.5 m between plots. Sunn hemp seeds are planted on the land with a depth 2-3 cm and a spacing row of 20×25 cm[11,12]. Planting was done by making a hole, which consisted of 1 seed in every hole so that each plot contained as many as 20 plants. Irrigation was done twice, in the morning and afternoon. According to da Silva *et al.*[2] sunn hemp requires adequate moisture for germination and establishment. It can tolerate drought conditions but performs best with regular rainfall or irrigation. Weeding was manually done by using hand every week until the plants were 8 weeks old.

Morphological measurements: The morphology characteristics measured were plant heights, number of leaves, leaf length and width, stem diameter and number of branches. Morphological measurement was carried out at 8, 10 and 12 weeks of cutting time. Plant height was measured from the base of the stem to the tallest part of the plant using a roll meter. The number of leaves was counted on fully developed leaves using a manual counter. The leaf length and width were measured using a ruler. The number of primary branches was measured by counting the number of branches contained in the stem of the plant using a manual counter. The stem diameter was measured by using a digital caliper.

Cutting and yield measurement: Cutting the plant was done at 8, 10 and 12 weeks after planted (WAP). Sunn hemp in every plot was cut on the main stem approximately 15 cm from the soil surface. The total fresh weight of the plant in every plot was taken immediately after cutting using a measuring balance. Approximately 1000 g of the plants were sampled and put into a paper bag whose weight was known, then dried in the oven at 55°C for 72 hrs until it reached the constant weight to obtain the dry weight. The dried samples were ground to pass through a 1 mm sieve using Willey Mill and then stored individually inside the sealed plastic bag based on the treatment. Samples from each cutting time were subjected to determine the dry matter using the AOAC[13] methods, by drying the samples in the oven at 105°C for 24 hrs until they reached the constant weight. To determine the total dry matter weight, the total fresh weight of the plot is divided by sub-sample fresh weight and multiplied by sub-sample dry weight.

Data analysis: Data were analyzed statistically using Analysis of Variance (ANOVA) and followed by Duncan's Multiple Range Test (DMRT) with a 95% significance level. All statistical tests used SPSS 23.0 (SPSS Inc., USA).

RESULTS AND DISCUSSION

Agroclimatic condition: The average precipitation in February, 2023 which was at the beginning of plantation and investigation was higher (375.1 mm) than any other months during the investigation in March and April, 2023 (243.7 and 100.9 mm, respectively). On the other hand, the temperature in February, 2023 was 25.9°C which was slightly lower than that in March and April, 2023 (26.5 and 26.8°C, respectively) (Fig. 1). The agro-climatic conditions during the plant cultivation were ideal for plant development. Sunn hemp first cultivation was in India at 1500 meters above sea level (m.a.s.l.) area with an average temperature of 15 to 27°C. In Brazil, sunn hemp grows well in the area with an average temperature of 18 to 27°C[14].

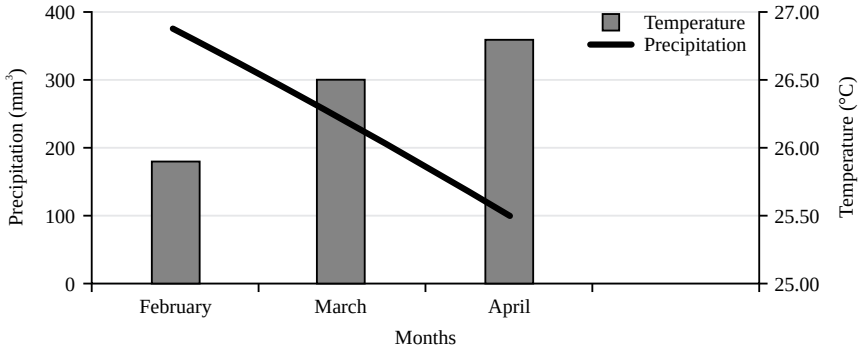

Fig. 1: Temperature and precipitation data at research area

Morphology characteristics: Morphological characteristics including plant heights, number of leaves, leaf length and width, stem diameter and number of branches are important parameters to determine plant growth and development. The growing process are influenced by environmental factor including cutting time. The cutting time significantly increased the plant height, number of leaves, leaf length and width, stem diameter and number of branches. Table 2 showed that the highest plant height at 12 WAP of cutting time was 261.53 cm. Plant height at 12 WAP was higher ($p<0.05$) than that of 10 and 8 WAP (243.33 and 192.67 cm, respectively) (Table 2). The result was higher than Tripathi *et al.*[10], where the plant height in 12 WAP was only 238.3 cm tall. These results were as expected, due to the difference of plant growth stage. Plant height is the result of cell division and elongation during the vegetative phase, so the sunn hemp is cut older will produce the highest plant height[15]. The cutting height of the plant may affect the regrowth system, whereas soybean plants that were harvested by cutting 12 cm above the ground and at the vegetative stage tended to have a higher number of nodes with regenerated leaflets on the main stem[6].

The number of leaves increased as increasing the cutting time. The number of leaves at 12 WAP was higher ($p<0.05$) than that of 10 and 8 WAP (337 and 196 leaves, respectively) (Table 2). It was observed that the number of leaves increased as cutting time increased. Increasing the age of sunn hemp in the vegetative phase causes the plant to allocate more energy towards the growth of the leaves to capture sunlight to carry out photosynthesis. This causes an increase in leaf production at later growth stages as the plant ages. The number of leaves is also related to plant height, the taller a plant, the more leaves it has.

Leaf length at 12 WAP (20.21 cm) was longer ($p<0.05$) than at 10 and 8 WAP (19.31 and 17.55 cm, respectively). The width of the sunn hemp leaves at 12 WAP (5.43 cm) was wider ($p<0.05$) than at 10 WAP and 8 WAP (5.30 and 4.91 cm, respectively) (Table 2). The longer the cutting time, the longer and wider the leaves will be, because the time used by plants to carry out photosynthesis is increasing. Photosynthate produced during the photosynthesis process will be broken down again through the respiration process and produce the energy needed by cells to carry out activities such as cell division and enlargement which causes leaves to reach the maximum length and width[16]. The stem diameter of sunn hemp at 12 WAP (1.80 cm) was higher ($p<0.05$) than that of 10 and 8 WAP (1.46 and 1.18 cm, respectively) (Table 2). The highest diameter was found at 12 WAP of cutting time. This result was higher than the report of Yimlamai *et al.*[17] which found that sunn hemp diameter at 17 WAP was only 1 cm. Growth in plant diameter is closely related to the rate of photosynthesis. The total leaf area in plants that are active in carrying out photosynthesis will affect the photosynthate that will be produced[18], so the longer the cutting time is, the more photosynthate is produced and accumulated in the stem so that the stem diameter increases. The number of branches of the sunn hemp at 12 WAP (38.67) was higher ($p<0.05$) than that at 10 and 8 WAP (31.67 and 15.00, respectively) (Table 2). This shows that the longer the harvest age, the more branches will be produced, because plants have a lot of time to photosynthesize and cause the accumulation of photosynthetic results to an increasing number of branches. The more the number of branches causes the total leaf area to increase (height).

Biomass production: Table 3 showed that the cutting time factor had a significant effect ($p<0.05$) on the fresh weight production of sunn hemp. Fresh weight production at 12 WAP (43.24 ton ha^{-1}) was higher ($p<0.05$) than that at 10 WAP and 8 WAP (33.54 and 22.48 ton ha^{-1}, respectively). The longer the

Table 2: Average plant height, number of leaves, length and width of leaves, stem diameter and number of branches of sunn hemp with different cutting times

	Cutting time (weeks after planted)		
Variable	8	10	12
Plant height (cm)	192.67±3.78[a]	243.33±5.69[b]	261.53±7.23[c]
Number of leaves	196.00±23.39[a]	336.67±8.62[b]	458.00±61.87[c]
Leaf length (cm)	17.66±0.13[a]	19.31±0.11[b]	20.21±0.13[c]
Leaf width (cm)	4.91±.25[a]	5.30±0.08[b]	5.43±0.09[c]
Stem diameter (cm)	1.18±0.03[a]	1.46±0.03[b]	1.80±0.15[c]
Number of branches	15.00±2.64[a]	31.67±2.08[b]	38.67±6.66[c]

[a,b,c]Different superscripts on the same line show significant differences ($p<0.05$)

Table 3: Average biomass production of sunn hemp with different cutting time

	Cutting time (WAP)			
Variable	8	10	12	Mean
Fresh yield (ton ha^{-1})	22.48±1.27[a]	33.54±0.99[b]	43.24±1.72[c]	33.08±9.07
Dry matter yield (ton ha^{-1})	3.11±0.15[a]	8.42±0.25[b]	10.78±0.51[c]	7.44±3.41

[a,b,c]Different superscripts on the same line show significant differences ($p<0.05$)

cutting time, the production of fresh weight will be higher. The highest fresh weight production of sunn hemp was at 12 WAP, which was 43.24 ton ha^{-1}. This result was higher than Tripathi *et al.*[10], where green biomass production of sunn hemp planted during the pre-monsoon period in India is 22-27 ton ha^{-1}, while in Thailand, it reaches 2 ton ha^{-1} in 6-8 WAP. The longer the cutting time, the higher the fresh weight production of the sunn hemp because the longer the cutting time will give more time for the plants to carry out photosynthesis. Keraf *et al.*[19] suggested that the upper part of the crop increased with increasing harvesting time, because the more time available for plants to photosynthesize, the more photosynthetic material accumulated in the plant tissue. Manuhuttu *et al.*[20] stated that plant fresh weight (canopy) is a combination of the development and increase of plant tissue such as the number of leaves, leaf area and plant height which are influenced by water content and nutrient content in the cells of plant tissue.

Table 3 showed that the cutting time factor had a significant effect ($p<0.05$) on the dry matter production of sunn hemp. The dry matter production of plants at 12 WAP (10.78 ton ha^{-1}) was higher ($p<0.05$) than that at 10 WAP and 8 WAP (8.42 and 3.11 ton ha^{-1}, respectively). This result was higher than the report of Srisaikham and Lounglawan[21] which found that the dry matter production of sunn hemp was only 4.2 ton ha^{-1} in 7 WAP. The longer the cutting time, the higher the dry matter production of sunn hemp. The higher plants age, the results of photosynthetic activity besides being used for growth are also stored as food reserves so that the content and production of dry matter increases as the cutting time increases. The increase in the percentage of dry matter in forage was also caused by a decrease in the percentage of water content in old plants. Young plants tend to have a higher water content, so the percentage of dry matter is low. Legume plants such as soybean in Prasojo *et al.*[22] also show the same trend as sunn hemp water content characteristics. The young plant of the soybean plant has a higher water content than the older plant.

Sunn hemp productivity increases with the increasing of cutting time which is partly due to the timing of sunn hemp planting and changes characterized by increased accumulation of nutrients from the soil. In this study, the variation in the yield of each crop suggests that many factors might have an impact, such as planting sunn hemp at varying densities, creating differences in growth. In addition, other factors can affect the yield of the sunn hemp crop, such as plant species, soil integrity, environmental conditions and cutting time.

CONCLUSION

The morphological characteristics and biomass productions of sunn hemp were increased in line with the increase of the cutting times. The cutting time at 12 WAP gives the best result on morphology characteristics and biomass production of sunn hemp. These results indicate that sunn hemp can perform good productivity based on the morphological characteristics and biomass production during the rainy conditions in Indonesia. Future research should investigate the nutrient value of the sunn hemp at different cutting times to give further information about the quality of the sunn hemp that will be very helpful for feeding use.

SIGNIFICANCE STATEMENT

This research aimed to determine the morphological characteristics and biomass production of sunn hemp at different cutting times. The result showed that the cutting times had a significant effect on morphology characteristics and biomass production. The morphological characteristics and biomass productions were increased in line with the increase in the cutting times. These results can be beneficial for researchers and farmers to choose the appropriate cutting time for sunn hemp as a forage or for other purposes. Future research should investigate the nutrient value of the sunn hemp at different cutting times to give further information about the quality of the sunn hemp that will be very helpful for feeding use.

ACKNOWLEDGMENT

The authors are very thankful to Universitas Gadjah Mada which already supports this research by providing funding through the Final Project Recognition Grant Universitas Gadjah Mada Number 5075/UN1.P.II/Dit-Lit/PT.01.01/2023.

REFERENCES

1. Wang, C.L. and Y.L. Dai, 2018. First report of sunn hemp fusarium wilt caused by *Fusarium udum* f. sp. *crotalariae* in Taiwan. Plant Dis., 102: 1031-1031.
2. da Silva, B.N.P., T.E. Masetto and L.C.F. de Souza, 2022. Changes in the physiological potential of sunn hemp seeds during storage. Pesqui. Agropecu. Trop., Vol. 52. 10.1590/1983-40632022v5272687.
3. Wanapat, M., P. Totakul, B. Viennasay and M. Matra, 2021. Sunnhemp (*Crotalaria juncea*, L.) silage can enrich rumen fermentation process, microbial protein synthesis, and nitrogen utilization efficiency in beef cattle crossbreds. Trop. Anim. Health Prod., Vol. 53. 10.1007/s11250-021-02628-z.
4. Garzon, J., J.M.B. Vendramini, M.L. Silveira, P. Moriel and H.M.S. da Silva *et al*., 2021. Harvest management and genotype effects on sunn hemp forage characteristics. Agron. J., 113: 298-307.
5. Prasojo, Y.S., G. Ishigaki, M. Hashiguchi and R. Akashi, 2021. Effect of different growth stages on biomass weight and forage quality of different growth type soybean (*Glycine max*). Asian J. Plant Sci., 20: 256-262.
6. Prasojo, Y.S., G. Ishigaki, M. Hashiguchi, M. Muguerza and R. Akashi, 2021. Evaluation of regrowth ability of soybeans for forage utilization under two-cutting systems. Aust. J. Crop Sci., 15: 1452-1458.
7. Shortnacy, L.K.W., C. Eberle and S. Paisley, 2023. Sunn hemp biomass accumulation, regrowth, and nutritive value in response to harvest time and cutting height. Crop Forage Turfgrass Manage., Vol. 9. 10.1002/cft2.20215.
8. Shavkatovna, N.M., 2022. The effect of sowing time and rate on grain and hay yield of *Crotalaria juncea* plant. Br. J. Global Ecol. Sustainable Dev., 9: 63-69.
9. Kaneko, M., N. Kato, I. Hattori, M. Matsuoka and J.M.B. Vendramini, 2023. Seeding and harvesting times and climate conditions are important for improving nitrogen and fiber contents of green manure sunn hemp. Sustainability, Vol. 15. 10.3390/su15097103.
10. Tripathi, M.K., B. Chaudhary, S.R. Singh and H.R. Bhandari, 2013. Growth and yield of sunnhemp (*Crotalaria juncea* L.) as influenced by spacing and topping practices. Afr. J. Agric. Res., 8: 3744-3749.
11. Krüger, M., T. van Eeden and D. Beswa, 2022. *Cannabis sativa* cannabinoids as functional ingredients in snack foods-historical and developmental aspects. Plants, Vol. 11. 10.3390/plants11233330.
12. Liu, M., M.T. Ale, B. Kołaczkowski, D. Fernando, G. Daniel, A.S. Meyer and A. Thygesen, 2017. Comparison of traditional field retting and *Phlebia radiata* Cel 26 retting of hemp fibres for fibre-reinforced composites. AMB Express, Vol. 7. 10.1186/s13568-017-0355-8.
13. AOAC, 2005. Official Methods of Analysis of AOAC International. AOAC International, Rockville, Maryland, ISBN: 9780935584752.
14. Ahmed, A.T.M.F., M. Zahidul Islam, M.S. Mahmud, M.E. Sarker and M. Reajul Islam, 2022. Hemp as a potential raw material toward a sustainable world: A review. Heliyon, Vol. 8. 10.1016/j.heliyon.2022.e08753.
15. Lastdrager, J., J. Hanson and S. Smeekens, 2014. Sugar signals and the control of plant growth and development. J. Exp. Bot., 65: 799-807.
16. Sitorus, U.K.P., B. Siagian and N. Rahmawati, 2014. Response in growth of cocoa seedlings (*Theobroma cacao* L.) on giving boiler ash and urea fertilizer at nursery [In Indonesian]. J. Agroekoteknologi Universitas Sumatera Utara, 2: 1021-1029.
17. Yimlamai, P., T. Ardsamang, P. Puthson, P. Somboon and B. Puangsin, 2023. Soda pulping of sunn hemp (*Crotalaria juncea* L.) and its usage in molded pulp packaging. J. Bioresour. Bioprod., 8: 280-291.
18. Jiao, Y., K.J. Niklas, L. Wang, K. Yu, Y. Li and P. Shi, 2022. Influence of leaf age on the scaling relationships of lamina mass vs. area. Front. Plant Sci., Vol. 13. 10.3389/fpls.2022.860206.
19. Keraf, F.K., Y. Nulik and M.L. Mullik, 2015. The effects of nitrogen fertilization and plant's age on the quality and production of kume grass (*Sorghum plumosum* var. Timorense) [In Indonesian]. J. Peternakan Indonesia, 17: 123-130.

20. Manuhuttu, A.P., H. Rehatta and J.J.G. Kailola, 2014. The effect of bioboost biological fertilizer concentration on increasing the production of lettuce plants (*Lactuca sativa*. L) [In Indonesian]. Agrologia, Vol. 3. 10.30598/a.v3i1.256.
21. Srisaikham, S. and P. Lounglawan, 2021. Nutrient yield of brown hemp and its utilization as protein source in concentrate on Brahman×Thai-native cattle performances. Chiang Mai Univ. J. Nat. Sci., Vol. 20. 10.12982/CMUJNS.2021.006.
22. Prasojo, Y.S., M. Niimi, M.M. Rahman, G. Ishigaki and R. Akashi, 2022. Effect of soybean (*Glycine max* L. Merr) intercropping into rhodesgrass (*Chloris gayana* Kunth.) on dry matter yield, crude protein, and silage characteristics grown in Southwest Japan. J. Anim. Plant Sci., 32: 460-465.