Effect of harvesting age of chicory (Cichorium intybus) on the pattern of planting intercropping dwarf elephant grass in the second regrowth on production and quality

N Zaini, A M Tilova, N Umami, C Hanim, A Astuti and B Suwignyo

Department of Animal Nutrition, Faculty of Animal Science, Universitas Gadjah Mada, Jl. Fauna No. 3, Bulaksumur, Yogyakarta, Indonesia

E-mail: naifiatul.umami@ugm.ac.id

Abstract. The research was conducted to evaluate the effects of harvesting age in the second regrowth of chicory (Cichorium intybus) in intercropping pattern with dwarf elephant grass (Pennisetum purpureum cv. Mott) on productivity and quality. Chicory seeds were spread on the interspatial land between the dwarf elephant grass on a 2.5×2.5 m² plot, with 1×1 m² of the distance between each dwarf elephant grass. Plants were harvested on the day- 30, 45 and 60 by defoliation 10 cm above the soil surface. Each treatment had 3 replications, totaling 9 plots. The variable measured in the study were production (dry and organic matter) and nutrient contents (dry matter, organic matter, extract ether, and crude fiber). Data were analyzed using a one-way analysis of variance. Significant data were evaluated on Duncan's New Multiple Range Test (DMRT). The results of the study showed that plants that were cut later had the highest production and nutrient contents (P<0.05). Groups harvested at later cutting ages had higher dry matter production (chicory and dwarf elephant grass). However, chicory and dwarf elephant grass on older harvesting also had higher crude fiber (13.07% and 26.87%). Crops harvested at 60 days in the second regrowth demonstrated the most improved yield.

1. Introduction
Chicory (Cichorium intybus L.) is a plant species belonging to the Asteraceae family, the Chicory plant contains important compounds such as inulin, a bitter sesquiterpen lactone, coumari, flavonoids, and vitamins, and has anti-hepatotoxic activity [1]. Chicory has a single leaf and will multiply the leaves after the first harvest. Chicory plants have thick hollow stems and will harden after reaching lengths of up to 600 mm [2]. Non-legume plants such as forbs can increase the supply of soil nitrogen by using deep roots that can bind nitrogen far below the soil surface. Chicory which is one of the forbs plants has a deep-rooting capacity to access soil nitrogen from the soil reaching 1.2 m, deeper compared to plants that have shallow-rooting [3]. The annual dry matter (DM) yield of chicory is smaller (5.6 ton/ha) than lucerne (28.7 ton/ha) and red clover (12.5 ton/ha). Yet, the in vitro dry matter digestibility of puna chicory is higher (903 g/kg) than Lancelot plantain (780 g/kg) [4].

The use of monoculture systems in forage management has caused nonoptimal plant growth and productivity. One way to improve the quality of feed is by introducing foreign plants that have more advantages compared to plants in Indonesia. Intercropping systems are able to have positive impacts on pest control and aggregate yields that are larger or more stable per unit area [5]. This system can also be used for land conservation, reducing the risk of failure and increasing soil fertility [6].
Intercropping planting between forbs and Odot grass has its advantages. Elephant dwarf grass has a short cutting life of 45 days after the first regrowth [7]. Elephant dwarf grass has the advantage of a strong and deep root system on elephant dwarf grasses that will be able to streamline the use of nitrogen from the deepest soil layers, so as to improve the physical condition of the soil [8]. Dwarf elephant grass is one of the superior grasses because of its high quality, palatability, and easiness in plant management.

One of the means to enhance Chicory production is by managing the harvesting age. Deciding the right harvesting age is one of the approaches to acquire maximal yield.

2. Materials and method
The experiment was conducted in 2019 in the research field of Universitas Gadjah Mada, Yogyakarta. The research was conducted in a split-plot experiment with 3 times replicated of 3 treatments, summing 9 plots in total (3 plots for each group). The plotting for each treatment was determined randomly. The treatments of the experiment included three harvests in main plots (30 days, 45 days, and 60 days), while the cutting interval (first and second regrowth) served as the subplot.

For the field preparation, 5 tons/ha manure and 200 kg/ha urea were used to provide the required soil nutrients. These fertilizers were broadcasted on the soil surface and subsequently incorporated into the soil by a tractor machine. Another 200 kg/ha urea was spread on the soil surface before and after cutting. After preparation and before the seeding, the field was irrigated to ensure proper germination. The study was performed on a 2.5x2.5 m² plot. Elephant dwarf grass stems were planted until the height reached 10–15 cm. Chicory seeds were spread between dwarf grasses which grew with 1x1 m² space between each grass. Data were collected on the first and second regrowth and harvesting were done 3 times, namely at the age of 30, 45, and 60 days. However, data used in this study were obtained from the second regrowth.

Data were measured in two stages. The first stage was in the field condition and included production to know dry matter and organic matter production. The second stage was in the laboratory such as proximate analysis. Finally, data were analyzed by using a one-way analysis of variance on the SPSS.

3. Results and discussion
In this research, biomass production and quality of *Cichorium intybus* dan *Pennisetum purpureum* cv. Mott were studied. The biomass production comprises dry matter production and organic matter production. Meanwhile, the quality observed includes dry matter, organic matter, extract ether, and crude fiber. Dara was collected in the second in different harvesting ages with the intercropping plant. Research results on the production and nutrient of chicory and dwarf elephant grass different harvesting ages with intercropping plant patterns are presented in table 1.

3.1. Dry matter production
The results showed that the different ages of cutting produced a significant effect (P<0.05) on the production of dry matter (table 1). Data comparison between three cutting ages of chicory and dwarf elephant grass demonstrated that increasing age of crop cutting also increased the production of dry matter, namely the highest cutting age of 60 days (1.03 tons/ha and 3.55 tons/ha, respectively). Increased dry matter production at 60 days cut might be as a result of intercropping land which able to improve soil conditions, so that the later the crop is cut increases the soil nutrients availability [9].

The intercropping system is able to improve land-use efficiency, increase the efficiency of fertilizer, and can improve soil physical and chemical properties, so as to minimize the risk of failure [10]. Chicory grazed at 48 days had a total dry matter production of 0.83 tons/ha, while at 39 days it declined to 0.80 tons/ha [11]. Dry matter production of elephant grass with a cutting age of 60 days reached 4,659 kg/ha, higher than elephant grass cut on 30 and 45 days, 1,879 kg/ha and 3,569 kg/ha respectively.
The 3rd International Conference of Animal Science and Technology  
IOP Conf. Series: Earth and Environmental Science 788 (2021) 012173  
doi:10.1088/1755-1315/788/1/012173

Table 1. Production and nutrient value of Chicory and dwarf elephant grass in the second regrowth.

| Species          | Variables                          | Harvesting ages |
|------------------|------------------------------------|-----------------|
|                  |                                    | U1              | U2              | U3              |
| Chicory          | Dry matter production (ton/ha)     | 0.57±0.57c      | 0.69±0.44d      | 1.03±0.66e      |
|                  | Organic matter production (ton/ha) | 0.46±0.44c      | 0.59±0.02d      | 0.81±0.05e      |
|                  | Dry matter (%)                     | 9.73±1.00c      | 10.18±0.83d     | 10.58±0.44d     |
|                  | Organic matter (%)                 | 80.59±0.00c     | 82.31±0.45d     | 82.95±0.81c     |
|                  | Extract ether (%)                  | 3.33±0.61c      | 4.11±0.43d      | 4.81±0.31e      |
|                  | Crude fiber (%)                    | 11.23±1.46c     | 12.01±0.13cd    | 13.07±0.41d     |
| Dwarf elephant   | Dry matter production (ton/ha)     | 1.46±0.40c      | 2.05±0.47d      | 3.55±0.12e      |
| grass            | Organic matter production (ton/ha) | 1.17±0.32c      | 1.71±0.39d      | 2.98±0.09e      |
|                  | Dry matter (%)                     | 18.35±0.54c     | 19.85±2.03      | 20.15±0.53c     |
|                  | Organic matter (%)                 | 80.20±0.00c     | 83.32±0.30d     | 83.85±1.26d     |
|                  | Extract ether (%)                  | 1.60±0.20c      | 1.84±0.36c      | 2.18±0.25d      |
|                  | Crude fiber (%)                    | 24.79±0.53c     | 25.95±0.54c     | 26.87±0.20d     |

Superscripts on the same row indicate a significant difference between groups (P-value<0.05).

U1: Harvesting age of 30 days; U2: Harvesting age of 45 days; U3: Harvesting age of 60 days

3.2. **Organic matter production**

Statistical evaluation revealed that chicory planted on intercropping patterns and cut on different ages had significant differences (P-value<0.05) on organic matter production. The highest average of chicory and elephant dwarf grass organic matter production were observed on groups cut on day-60, 0.81 tons/ha and 2.98 tons/ha, respectively. The improved biomass production might be due to the later cutting age, the water content would decrease. Chicory organic material production at the cutting age of the second regrowth is 12.74 ton/ha/year [12]. Whereas the production of organic matter of elephant grass that is intercropping with Seca and Siratro can increase production by up to 11% [13]. Increasing the production of both plant species is possible because intercropping can increase soil nitrogen by 10% so that nutrient supply is fulfilled.

3.3. **Dry matter value**

Different cutting ages altered the dry matter content of chicory significantly (P-value<0.05). Intercropping planting patterns with appropriate cutting age and planting spacing, plants may improve plant ability in absorbing nutrients from the soil, so that crop competition can be minimized. Non-legume plants such as forb can increase the supply of soil nitrogen by using deep roots that are able to bind nitrogen far below the soil surface because it has a deep rooting system reaching 1.2 m, deeper compared to plants that have shallow-rooting [3]. Chicory harvested at 30 days of cutting has a dry matter content of 8.19% [12].

The dry matter content of dwarf elephant grass was not significantly altered by different harvesting ages. The dry matter content of U1, U2, and U3 groups was 18.35, 19.85, and 20.15%, respectively. Meanwhile, the dry matter production of dwarf elephant grass respectively increased. It might be caused by the fact that plant intercropping can competitive each plant but the dwarf elephant grass could not utilize absorption nutrients from soil because they do not have a deep-root system.

3.4. **Organic matter value**

The results showed that the different cutting ages produced a significant effect (P<0.05) on the organic matter production of chicory and dwarf elephant grass. The highest organic matter at the cutting age of 60 days was 82.95% chicory and 83.85% for dwarf elephant grass. This might be due to the higher percentage of stems compared to leaves, besides the longer cutting life, it will affect the plant's organic matter content increases. The percentage of chicory organic material harvested in the second regrowth at 28 days was 81.37% [12]. Whereas elephant grass intercropped with Arachis pintoi has a higher organic matter of 890 g/kg DM than monoculture planted of 875 g/kg DM in the second grazing [13].
3.5. Extract ether value
Extract ether of chicory and odot grass with intercropping planting patterns at different harvesting ages yielded were significantly different (P-value<0.05). The highest extract ether of chicory and odot grass were observed on the U3 group compared to U1 and U2 (4.81% vs 3.33 and 4.11%) and (2.18% vs 1.60 and 1.84%) respectively. This is presumably because the extract ether increases as the plant getting older, while the water content decreased. At the age of 30 days, chicory cuts have younger leaves while at the age of 60 days and 45 days the plant has begun to pick old leaves so it has a higher extract ether [15]. Chicory extract ether content in the root part is 1.69% while in the leaf part is 3.68%. At the age of 30 days, the extract ether of chicory is 2.08% [11], whereas the extract ether content of odot grass on 50 days of cutting was 2.28% higher [16].

3.6. Crude fiber value
The crude fiber of chicory and odot grass with intercropping planting patterns at different harvesting ages were significantly different (P value<0.05). The highest crude fiber in chicory and odot grass was witnessed on the U3 group compared to U1 and U2 (13.17% vs 11.42 and 12.27%) and (27.05% vs 25.98 and 24.97%) respectively. This might be due to the increased plant wall content which is indicated by the harder plant stems as the later harvesting age. Odot grass harvested at the age of 50 days has a crude fiber content of 32.35% [11].

4. Conclusion
Based on this study, it can be concluded that the harvesting ages increased the production and nutrient value of *Cichorium intybus* intercropped with dwarf elephant grass. The overall results of this experiment indicate that harvesting ages 60 days were the best-selected harvesting age.

References
[1] Panahandeh J, Abdollahi S, Kazemnia H D and Mahna N 2012 Effects of plant density on root yield and leaf area in chicory (*Cichorium intybus L*) *Acta. Hortic.* 932 427–30
[2] Lee J M, Nivonne R H, Elena M K M and Cameron E F 2015 Management strategies for chicory (*Cichorium intybus*) and plantain (*Plantago lanceolata*): Impact on dry matter yield, nutritive characteristics and plant density *J. Crop. Pasture. Sci.* 66 168–83
[3] Pirhofer-Walzl K, Eriksen J and Rasmussen J 2012 Effect of four plant species on soil 15N- access and herbage yield in temporary agricultural grasslands *Plant. Soil.* 371 313–25
[4] Matt A S, Maria L, Marvin H, Hall and Gerald F E 2003 Nutritive value of chicory and english plantain forage *Crop. Sci.* 43 1797–804
[5] Brooker R W, Bennett A E, Cong W, Daniell T J, George T S, Hallett P D, Hawes C, Iannetta P P M, Jones H G, Karley A J, Li L, McKenzie B M, Pakeman R J, Paterson E, Schob C, Shen J, Squire G, Watson C A, Zhang C, Zhang F, Zhang J and White P J 2015 Improving intercropping: a synthesis of research in agronomy, plant physiology and ecology [Research Review] *New. Phytologist.* 206 107–17
[6] Ceunfin S, Prajinto D, Suryanto P dan Putra E T S 2017 Penilaian kompetisi dan keuntungan hasil tumpang sari jagung kedelai di bawah tegakan kayu putih *J. Pertan. Konserv. Lahan Kering* 2 1–3
[7] Bilal A Q 2009 Effect of molasses and corn as silage additives on the characteristics of mott dwarf elephant grass silage at different fermentation periods *Pakistan. Vet. J.* 29 19–23
[8] Thorup-Kristensen K 2006 Effect of deep and shallow root systems on the dynamics of soil inorganic N during 3-year crop rotations *Plant. Soil.* 288 233–48
[9] Prihandana R, Noerwijjan K and Adinurani P G D Setyaningsih, Setiadi S dan Hendroko R 2007 Bioetanol Ubi Kayu: Bahan Bakar Masa Depan (Jakarta: Agromedia)
[10] Matthews P N P, Kemp P D and Austin G M 1990 The effect of grazing on the growth and reproductive development of chicory *Proceedings Agronomy Science of New Zealand* (New Zealand) pp 41–3
[11] Lounglawan P, Wassana L and Suksombat S 2014 Effect of cutting interval and cutting height on yield and chemical composition of King Napier grass (Pennisetum purpureum x Pennisetum americanum) APCBEE Procedia 8 27–31

[12] Umami N, Wiratih I, Agus A and Suhartanto B 2019 Growth and production of Cichorium intybus in the second regrowth with different planting densities in Yogyakarta IOP Conf. Ser. Earth Environ. Sci. 387 012098

[13] Njoka-Njiru E N, Njarui M G, Abdulrazak S A and Mureithi J G 2006 Effect of intercropping herbaceous legumes with napier grass on dry matter yield and nutritive value of the feedstuffs in semi-arid region of Eastern Kenya Agricultural tropica et subtropica Agric. Trop. Subtrop. 39 255–67

[14] Crestani S, Filho H M N R, Miguel M F, Almeida E X and Santos F A P 2013 Steers performance in dwarf elephant grass pastures alone or mixed with Arachis pintoi Trop. Anim. Health. Prod. 45 1369–74

[15] Nwafor I C, Shale K and Achilonu M C 2017 Chemical composition and nutritive benefits of chicory (Cichorium intybus) as an ideal complementary and alternative livestock feed supplement J. Sci. World 1–11

[16] Wati W S, Mashudi dan Irsyamawati A 2018 Kualitas silase rumput odot (Pennisetum purpureum cv. Mott) dengan penambahan Lactobacillus plantarum dan molasses pada waktu inkubasi yang berbeda J. Nutr. Ternak Trop. 1 45–53