Effects of different levels of defoliation on growth and production of *Cichorium intybus*

H O Parjana, N Umami, B Suhartanto, N Suseno, C Hanim, A Astuti, A Agus and A M Tilova

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

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

Abstract. The study was conducted to evaluate the growth and production of cichory (*Cichorium intybus* L.) on different levels of defoliation. Experiments were carried out at forage facilities owned by Laboratory of Animal Forages and Pasture at Faculty of Animal Science UGM. One-way completely randomized design was employed on the experiment, with a follow up of Duncan Multiple Range Test on statistically different results. Variables observed on this study are vegetative phase-growth and biomass production. Chicory (aged 7 months; and on 8th regrowth) were planted on 1 x 1.5 m² plots, with 3 replication. Defoliation treatments were performed on different levels, i.e., 2.5 cm, 5 cm, and 10 cm above the ground surface. Chicory were cut on day-21. All data obtained from the experiment were subjected to variance analysis. The results showed that different levels of defoliation affected plant length, leaf length, leaf width, number of buds, and biomass production significantly (P<0.05). The highest biomass production was observed on *Cichorium intybus* which defoliated on the 10 cm above the ground surface, yielding 13.40 ton/ha fresh production, 1.09 ton/ha dry matter (DM), and 0.88 ton/ha organic matter (OM). According to this study, defoliation on 2.5 cm above the ground surface produced smaller growth and biomass production than groups defoliated on 5 and 10 cm, yet showed the highest number of buds.

1. Introduction

Ruminant feeds can be generally categorized into 2 main class, i.e., forages and concentrate, with forages serve as the main feed. The rise on the population of ruminant must be supported with the sufficient feed supply. Forages can be further divided into 3 categories, i.e. grass, legume, and forbs. Forbs are groups of plant that cannot be classified as either grass or legume, has no woody stem, and are in bush-shaped. Forbs contain high level of minerals which is considered to deliver benefits for animal growth [1].

One of forbs that complies quality, quantity, and adaptability requirements is chicory (*Chicorium intybus*), which is a subtropical bush-shaped annual plant. Chicory can flourish in the well- or even poor-managed lands. Furthermore, the light weight chicory seeds ease its dissemination, to produce new plants [2].

Chicory are usually used as vegetables, medicine, and animal forage [3]. Chicory has high digestibility as a feedstuff. Its high level of pectin content alters the intestinal morphology and microbiota [4]. Substitution of fiber from grains with chicory suppress the feed cost and prevent the supply conflict arise from the grain consumption by human and limited grain production [5].
A good management practice determines the success rate of plant production improvement. A right level of defoliation is expected to deliver optimal plant growth [6]. Post defoliation plant growth is influenced by the carbohydrate and energy storage in the uncut stem [6]. Stem is considered as the growth axis that support the structure of above-ground parts, i.e. leaves, flowers, and fruits [8]. Therefore, this study aimed to evaluate the effects of different levels of defoliation on vegetative-phase growth and biomass production of Cichorium intybus.

2. Materials and methods
The experiment on this study was carried out for 4 weeks at forage facility owned by Laboratory of Animal Forage and Pasture in Faculty of Animal Science Universitas Gadjah Mada, which is located in Sleman, Yogyakarta Special Regions. Tools and instruments used on this study were hoe, pole, shovel, scissor, 50 cm ruler (0.1 cm of accuracy), digital balance, analytical balance (0.001 ram of accuracy), stationeries, blender, plastic bag, silica disk, 55°C oven, 105°C oven, desiccator, clamp, and 550°C furnace. Materials used on this study were regosol-type soil, Cichorium intybus (aged 7 months), NPK fertilizer 16-16-16, animal manure-based organic fertilizer, newspaper, and lipid-free filter paper.

Cichorium intybus (aged 7 months, on 8th regrowth) were planted on 1x1.5 cm² plots, and divided into 3 groups of treatment-different levels of defoliation: 2.5 cm (D1), 5 cm (D2), and 10 cm (D3) above the ground surface. Each treatment was replicated 3 times, yielding 3 plots for each treatments. Plotting was carried out randomly. Defoliation was performed on day-21 since the first defoliation treatment. Chicory were cut according to defoliation treatments. Data on vegetative phase-growth, i.e. plant height, plant length, leaf length, leaf width, number of leaves, and number of buds were recorded. Biomass production were evaluated according to fresh, dry matter, and organic matter productions. Fresh production was determined by weighing the harvested yield and converted into ton/ha unit. Dry matter production was calculated by multiplying fresh production (ton/ha) by dry matter content. Meanwhile, fresh production (ton/ha) was multiplied with organic matter content to obtain organic matter production. Dry and organic matter assessments were performed according to AOAC methods [9].

All data obtained on this study, i.e. vegetative phase-growth and biomass production were analyzed on one-way completely randomized design variance analysis. Statistical differences between groups were evaluated with Duncan’s Multiple Range Test. Statistical evaluation was performed on computer software of Statistical Product and Service Solution (SPSS) version 13.0.

3. Results and discussion
3.1. Growth
Plant growth can be influenced by the management, i.e., defoliation. According to table 1, different levels of defoliation altered plant height, plant length, leaf length, leaf width, and number of buds significantly (P<0.05). Meanwhile, number of leaves was not affected.

Statistical analysis demonstrated that different levels of defoliation delivered significant difference on plant height (P<0.05). D2 and D3 groups had taller plant height, 32.02 cm and 34.57 cm respectively, than D1 group (20.87 cm) (P<0.05). Factors affecting regrowth include nutrient storage on the uncut part after defoliation [6]. Greater nutrient storages accelerate the vegetative phase plant growth.

Different levels of defoliation altered plant length significantly (P<0.05). Groups defoliated on 5 cm and 10 cm above the ground had longer plant length than group cut on 2.5 cm above the ground surface, 33.38 cm and 37.17 cm vs 21.97 cm respectively. Point of defoliation above the ground surface affected a plant regrowth [6], as higher nutrient storages improved the growth rate of a plant.

Statistical analysis showed that defoliation treatments on this study affected leaf length of chicory significantly (P<0.05). D2 and D3 groups had longer leaf than D1 group, 22.27 cm, 22.69 cm, and 14.17 cm respectively. The increment of leaf area is influenced by remaining carbohydrate and energy storage on the stem after cutting [7]. Higher level of defoliation above the ground surface represents the greater nutrient storage, thus affecting the vegetative phase growth.

Statistical evaluation showed that levels of defoliation on this study affected leaf width of chicory significantly (P<0.05). Wider leaf was observed on groups cut on 5 cm and 10 cm above the ground,
3.25 cm and 3.15 cm respectively, compared to group cut on 2.5 cm above the ground surface (1.90 cm). Defoliation causes the loss of apical dominance which can exhibit the synthesis of cytokinin hormone. Cytokine stimulates the cell division, forming new buds-resulting in the decreased leaf widening [10]. Low level defoliation caused increasing buds formation and decreasing leaf widening.

Statistical analysis demonstrated that different levels of defoliation did not alter the number of leaves of chicory. Number of leaves of D1, D2, and D3 groups were 37.86, 24.83, and 18.07 respectively. Leaf formation is affected by composition of growth hormone, i.e. auxin and cytokinine on the plant. Other factors influencing the formation and growth of axillar bud into leaf are environment, mainly physical factor of light, the length of photoperiod and temperature of incubation [11].

Number of buds on this study were influenced significantly by different levels of defoliation (P<0.05). D1 group was observed to have greater number of buds (4.43) than D3 group (0.37) (P<0.05). Lower level of defoliation above the ground surface accelerates the formation of new buds. New buds are formed from the loss of apical dominance, thus the vertical growth is inhibited. The disappearance of meristem cells at the top of the plant exhibit the growth of the plant to the sides, i.e. branch development or lateral buds [10, 12].

Table 1. Average of vegetative growth on different levels of defoliation

| Variables           | Defoliation levels | Average  |
|---------------------|-------------------|----------|
|                     | D1                | D2       | D3       |
| Plant height (cm)   | 20.87±2.47a       | 32.02±1.27b | 34.57±4.12b | 29.15±6.78  |
| Plant length (cm)   | 21.97±3.09a       | 33.38±2.02b | 37.17±4.60b | 30.84±7.46  |
| Leaf length (cm)    | 14.17±0.74a       | 22.27±1.81b | 22.69±2.76b | 19.71±4.49  |
| Leaf width (cm)     | 1.90±0.26a        | 3.25±0.36b | 3.15±0.14b | 2.77±0.69   |
| Number of leaves    | 37.86±2.45        | 24.83±8.32 | 18.07±2.84 | 26.92±6.30  |
| Number of buds      | 4.43±1.68         | 3.21±1.88b | 0.37±0.32a | 2.67±2.20   |

ab different superscripts on the same row denote statistical difference (P<0.05)

3.2 Production

Chicory production is determined by calculating the fresh, dry matter, and organic matter productions, which presented on the table 2. According to the result on this study, different levels of defoliation significantly altered fresh, dry matter, and organic matter productions of chicory (P<0.05).

Fresh production of chicory on this study were altered significantly by different levels of defoliation (P<0.05). Fresh production of group D1 was significantly smaller (5.81 ton/ha), than D2 and D3 groups, 11.22 ton/ha and 13.40 ton/ha respectively. Fresh production of plant is influenced by the plant height and number of leaves-greater surface area of leaves increase the fresh production [13]. According to statistical analysis, the plant height, leaf length, and leaf width of chicory defoliated on 2.5 cm above the ground surface were reduced significantly compared to other groups.

Statistical analysis showed that significantly difference on the dry matter production was observed among different groups of treatments on this study (P<0.05). D2 and D3 groups had greater dry matter production, 0.89 ton/ha (DM 8.00±0.99%) and 1.09 ton/ha (DM 8.12±0.37%) respectively, than D1 group (0.49 ton/ha; DM 8.43±0.95%). Dry matter production is positively correlated to the fresh and organic matter production. Increasing fresh production is followed by increasing dry matter production [14].

Different levels of defoliation were observed influencing the organic matter production of chicory on this study (P<0.05). D2 and D3 groups had greater organic matter production, 0.72 ton/ha (DM 80.33±0.95%) and 0.88 ton/ha (DM 80.82±1.57%) respectively, than D1 group (0.40 ton/ha; DM 81.55±1.74%). High organic matter content is enhanced by high dry and organic matter production [14].
Table 2. Average of fresh, dry matter, and organic matter productions of chicory on different levels of defoliation.

| Variables                     | Levels of defoliation | Average    |
|-------------------------------|------------------------|------------|
|                               | D1         | D2        | D3        |
| Fresh production (ton/ha)     | 5.81±1.46a  | 11.22±1.79b | 13.40±0.71b | 10.14±3.59 |
| Dry matter production (ton/ha)| 0.49±0.11a  | 0.89±0.11b | 1.09±0.10b | 0.82±0.28  |
| Organic matter production (ton/ha) | 0.40±0.10a  | 0.72±0.11b | 0.88±0.10b | 0.67±0.23  |

*ab* different superscripts on the same row denote statistical difference (P˂0.05)

*ns* not significant

4. Conclusion

According to the result on this study, vegetative phase growth of chicory, i.e., plant height, plant length, leaf length, leaf width, number of leaves, and number of buds could be improved by defoliation on 10 cm above the ground surface. Biomass production of chicory, i.e. fresh, dry matter, and organic matter production on this study were also improved by defoliation on 5 cm above the ground surface.

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