Growth and production of *Cichorium intybus* in the second regrowth with different planting densities in Yogyakarta, Indonesia

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**Abstract.** This study was aimed to evaluate the growth and production of *Cichorium intybus* in the second regrowth with different planting densities in Yogyakarta, Indonesia. *Cichorium intybus* were cultivated by spreading the seeds on a 1x1.5 m plots with different planting density as treatments: 2 g/m², 3 g/m², and 4 g/m² – then named as D1, D2, and D3 groups respectively. Each treatment had 3 replications. Fertilization was performed once, on the day-15. The plant’s height and length were observed weekly for 30 days. *Cichorium intybus* were defoliated 5 cm above the soil surface on the day-28. Variables observed on this study include plant’s height and length, number of leaves, leaf width, number of plants, dry and organic matter production. All data were evaluated by using one-way analysis of variance on the SPSS. Significant differences among groups were then subjected to further analysis – Duncan’s New Multiple Range Test. Different planting densities significantly alter number of plants, dry matter production, and organic matter production (P<0.05). The group with highest planting density has higher number of plants (198.33 ± 22.50) compared to D1 and D2 groups (108.66 ± 6.50 and 155.66 ± 8.02). Meanwhile, *Cichorium intybus* on D1 group had higher plant height (37.5 ± 0.6 cm) compared to D2 and D3 groups (31.77 ± 1.18 and 31.49 ± 0.92 cm). Based on this study, the *Cichorium planted* on 4 g/m² of density results in highest production.

1. **Introduction**

As forage serves as main feed source for ruminants, its improvement both on quality and quantity is necessary to enhance the ruminant production. Forage can be classified as either grass, legume, or forbs. Forbs are type plants that do not belong to grass or legume group, non-woodyen with bush shaped and indirectly affecting the productivity of the pasture land and soil quality. Forbs contain numerous minerals that can be beneficial for animal growth[1].

Chicory is one of plants in the forbs group. Chicory (*Cichorium intybus*) is traditional herbs that potentially can be a feed source - yielding a great amount with high quality in dry season [10]. It has been widely used as animal feed. Its leaf and flower are commonly served as vegetable salad, while its root alternately used as coffee substitute[2].

One of means to enhance Chicory production is by managing the planting density. Deciding the right plant density is one of approaches to acquire maximal yield. It also affects the competition among plants in obtaining soil nutrients [3].
This study was performed to evaluate the effects of planting density on morphology and biomass production of *Cichorium intybus*. The *Cichorium intybus* introduction, hopefully, will enrich the biodiversity and improve the forage quality in Indonesia.

2. Materials and methods

This study was conducted at the Laboratory of Forage and Pasture Faculty of Animal Science, Gadjah Mada University that is located in Sleman, Yogyakarta Special Region. Tools and instruments used on this study include hoe, pole, plastic rope, plastic bucket, shovel, sickle, digital balance, analytical balance, scissors, stationery, metric tape, silica disc, furnace, oven, blender, newspaper, desiccator, clamp, and ruler. The materials include regosol soil, *Chicorium intybus*, fertilizer, and water.

The study was performed on 1x1.5 cm² of *Cichorium intybus*-planted land that had been harvested with 5 cm above soil surface-length of base still intact. There were 3 different number of seeds spread on each plot: 2, 3, and 4 gram/m². These treatments were then named as group D1, D2, and D3 respectively. Each treatment were 3 times replicated – summing 9 plots in total (@ 3 plots for each group). The plotting for each treatment were randomly picked. Thus, each row and column host different planting density.

Data observed on this study include plant height and length, leaf width, number of leaf, and biomass production (fresh, organic, and dry matter production). Experiment design on this study was split plot design – planting density as the main plot, while the cutting interval (first and second regrowth) as second plot. This study evaluated some variables: plant morphology (plant height and length, leaf width, and number of leaf). Plant height was obtained by measuring the length of plant base to the highest point of the plant. Plant length was measured from the plant base to the end of leaf. Biomass production (fresh weight, dry and organic matter values) of *Cichorium intybus* were also evaluated.

3. Result and discussion

On this research, growth and biomass production of *Cichorium intybus* were studied. The plant growth observed include plant height (cm), plant length (cm), and leaf width (cm), number of leaf, and number of plant. Meanwhile, biomass production comprise the dry matter (DM) production (ton/ha/year) and organic matter (OM) production (ton/ha/year). Data were collected in the second regrowth. The growth and biomass production of *Cichorium intybus* cultivated in different planting density in the second regrowth phase are shown on Table 1.

| Variable                              | D1        | D2        | D3        |
|---------------------------------------|-----------|-----------|-----------|
| Plant height (cm)                     | 37.55±0.60 | 31.77±1.18 | 31.49±0.92 |
| Plant length (cm)                     | 38.86±4.43 | 35.52±1.58 | 36.56±3.20 |
| Leaf width (cm)                       | 5.08±0.81  | 4.90±0.35  | 5.97±0.59  |
| Number of leaf                        | 11.3±3.20  | 9.08±1.12  | 11.52±1.54 |
| Number of plant                       | 108.66±6.50 | 155.66±8.02 | 198.33±25.50 |
| Dry matte production (ton/ha/year)   | 15.66±2.51 | 15.86±0.83 | 16.53±3.39 |
| Organic matter production (ton/ha/year) | 12.74±2.08  | 12.85±0.60  | 13.48±2.63  |
| Dry matter value (%)                  | 8.19±0.06  | 7.98±0.06  | 7.84±0.64  |
| Organic matter value (% DM basis)     | 81.37±0.69 | 80.34±1.06 | 81.62±0.87 |

Notes
Superscripts on the same row indicates significant difference (P value <0.05).
D1: 2 g/m² of planting density
D2: 3 g/m² of planting density
D3: 4 g/m² of planting density
3.1. *Plant height*
Plant height was obtained by measuring the length of plant base to the highest point of the plant. The statistical analysis shows that planting density significantly changed the plant height (P value <0.05). The height *Cichorium intybus* on the D1 was significantly higher (P value <0.05) compared to D2 and D3 (37.55 cm vs 31.77 and 31.49 cm). It might be a result of the different level of competition to acquire soil nutrients on each group. Less planting density will lead to less competition among plants to obtain soil nutrients. Besides, it also provide more space to enable photosynthesis taking place optimally – its products will then translocated to various plant parts, mainly used for growth [4].

3.2. *Plant length*
It was measured from the plant base to the end of leaf. D1 group had longer plant length (38.86 cm) compared to D2 and D3 groups (35.52 and 36.56 cm) (P value <0.05). The higher planting density corresponds for the more competition among plants to absorb nutrients from the soil. High planting density will lead to intra and inter-species competitions. The main competition include acquiring sunlight, soil nutrients, and water [5]. Plants cultivated in less-dense area will have fewer competition to acquire nutrients and have more space to facilitate optimal photosynthesis [4].

3.3. *Leaf width*
The leaf width was obtained by measuring the distance between sides of the widest leaf surface. The statistical analysis confirmed that the different planting density did not significantly modulate the leaf width. The average leaf width on D1, D2, and D3 were 5.08, 4.90, and 5.97 cm. Planting density likely to change the competition among plants. Less density allows weed to grow more flourish. High planting density affects the individual growth, since it prevent vegetative growth – reducing the photosynthesis rate and leaf development – that will have impact on declining yield [6].

3.4. *Number of leaf*
The planting density did not significantly modulate the number of leaf of *Cichorium intybus*. It might be caused by the fact that leaves on all groups were overlapping each other. Thus, they could not utilize the sunlight optimally. When leaf overlapping happened, plants would respond by reducing the leaf development [7]. Intensity of sunlight is a significant factor for plant growth that can be seen based on the number of leaf [8].

3.5. *Number of plant*
The number of plants on each plant were counted – representing the number of plant data. The planting density significantly changed the number of plant (P value <0.05) of *Cichorium intybus*. D1 group had significantly fewer plants (108) compared to D2 and D3 (155 and 198). It was a result from the different number of seeds spread on each groups (2, 3, and 4 gram of seed per m²).

3.6. *Dry matter production (ton/ha/year)*
The dry matter production of chicory was not significantly altered by the planting density. D1, D2, and D3 produced 15.66, 15.86, and 16.53 ton/ha/year of dry matter. Meanwhile, the dry matter value of chicory on those groups were 8.19, 7.08, and 7.84% respectively. Dry matter of chicory in the first regrowth is 8.17% [5]. Chicory planted in October and harvested in March produce 13.8 ton/ha/year of dry matter. Hence, the dry matter production on this study is smaller than previous reports [9].

Compared to other groups, D1 produced higher average of dry matter – the greater number of plants on D1 might cause this result. The higher planting density can improve the biomass production [10]. High planting density indeed improve the biomass production per area unit. However, the drop occurred on biomass production per plant [3]. It is caused by the greater population per area unit, thus, the accumulation of it will result in greater weight.
3.7. Organic matter production (ton/ha/year)
The statistical analysis confirmed that the organic matter production of chicory among groups on this study were not significantly different. The average organic matter production of D1, D2, and D3 are 12.74, 12.85, and 13.48 ton/ha/year. Meanwhile, the organic matter percentage are 81.37, 80.34, and 81.11%. The organic matter percentage of chicory in the first regrowth is 83.88% [5]. The different system give different result of production [4].

4. Conclusion
Planting density of 2 g / m² resulted in the highest average plant height compared to other treatments. Planting density of 4 g / m² produces the highest average number of plants compared to other treatments. Planting density of 4 g / m² has the highest average DM production compared to 2 g / m² and 3 g / m² density. The morphology of chicory plants is higher at low densities, while biomass production is higher at high densities. Planting density affects plant height and number of plants, BK production and BO chicory production, but planting density does not affect leaf width, plant length, and number of leaves of chicory plants.

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