Effects of different doses of NPK fertilization on growth and productivity of *Cichorium intybus*

N Umami, A Abdiyansah and A Agus
Department of Animal Nutrition, Faculty of Animal Science, Universitas Gadjah Mada, Jl. Fauna No. 3, Bulaksumur, Yogyakarta, Indonesia

Correspondence author: nafiatul.umami@ugm.ac.id

**Abstract.** This research was aimed to investigate the effects of different doses of NPK fertilization on growth and productivity of *Cichorium intybus*. The study was carried out in the farm facility of Faculty of Animal Science Universitas Gadjah Mada. There were three treatments: 0 kg/ha (P0), 45 kg/ha (P1), and 60 kg/ha (P2) (3 replications for each). Seeds were planted in a plot of 1 x 1.5 m. Fertilization was performed once prior to cultivation period (day-15). The height and length of plants were recorded once a week for 30 d. Defoliation was conducted when the plant’s height reached 5 cm (day-30). Data observed including plant’s height and length, number of leaves, fresh production, dry matter (DM) and organic matter (OM) production. Data were evaluated by using one-way ANOVA and followed by Duncan’s New Multiple Range test for significant difference. The results showed that P2 significantly increased (P<0.05) the fresh, DM, and OM of *Cichorium intybus*, resulting 260.8 tons/ha/year of fresh production, 35.53 tons/ha/year of dry matter, and 28.12 tons/ha/year of organic matter. To conclude this study, the increasing dose of NPK fertilized is able to increase the fresh, DM, and OM production of *Cichorium intybus*.

1. **Introduction**
Ruminant productivity is influenced by the availability of sufficient feed ingredients and high-quality feed – either forage or concentrate. Ruminant usually requires more forages than concentrate in term of quantity. An increasing ruminant population requires more forage available that meets the standard of both quantity and quality. Unfortunately, during dry season, forage scarcity is commonly faced by farmers in Indonesia. This condition forces farmers to explore more potential forages that both intently cultivated and uncultivated to provide feeds for their animals.

Forages as animal feed should comply these following requirements: high quality, high palatability, and continuously available. Thus, a forage introduction is necessary considered to improve forage quality. Forages from other countries/regions are imported as it has more superiorities compared to local forages, mainly on its resistance and quality. It usually has higher productivity and quality – thus also called as hybrid [1]

*Cichorium intybus* grows well in the pasture land and even in unmanaged land. The lightweight of its seed, easily spread by wind or bird, enable it to flourish [2]. *Cichorium intybus* can be cultivated by sowing the seeds and can serve as a mean to suppress the growth of weeds. *Cichorium intybus* is perfectly suitable as ruminant feed due to low fiber and high non-structural carbohydrate. It also can be an alternative to enhance the milk production of goat [3].
*Cichorium intybus* provides high crude protein and less structural carbohydrate. It is best growing in the fertile and drainage area. It is one of salt-resistant plants [13]. The most noticeable characteristic of *Cichorium intybus* include wooden stem, up to 2 m of height, taproot system, branched, has long jagged leaves with a few of smooth bristles. The flower of *Cichorium intybus* can reach 2 to 4 cm large, colored blue, purple, white, or pink – depending on its origin. The leaf itself contains sulfuric and phosphorous salt derived from sodium, magnesium, potassium, and nitrate potassium. The plant also contain bitter glycoside called Chicorine [4].

It has been known that fertilization is one of common practices to enhance the growth and productivity of plants by providing nutrient required by the plants. Fertilization is significant way to improve plant productivity and soil quality. The right fertilization practice will not only improve the productivity, but also ensure the production stability on an intensive agriculture system [5].

NPK fertilizer contains both macro and micro nutrients required by plants that include Nitrogen (N), Phosphorous (P), and Potassium (K). It is applicable, easy absorbed by the plant, and more economical [8]. Nitrogen plays important role in plant growth since it will support the vegetative development and growth that include leaf, stem, and root. It is also a building factor of the protein in plant. The Nitrogen availability affects the plant biomass production [15]. Phosphor is used in the synthesis of protein, fat, and bean. It also has significant role in Adenosine diphosphate (ADP) transformation into Adenosine triphosphate (ATP) [6]. Potassium acts on photosynthesis by enabling facilitate the CO₂ to entrancethrough stomata, photosintate transport, water and sugar, and protein and sugar synthesis [4]. Potassium acts as an enzyme activator that involved in plant metabolism. The Potassium deficiency will lead to energy deficiency that results in poor harvest [7].

This study was performed to investigate the effects of different levels of NPK fertilization on growth and productivity of *Cichorium intybus*. It was presumed that the increasing level of NPK fertilizer given will enhance the *Cichroidium intybus* growth and production. This study was expected to provide source of information regarding the best dose of NPK fertilizer for *Cichorium intybus*.

2. Material and methods

2.1. Materials

This study was carried out for 5 months (November 2018 to March 2019) at the Forage Facility, Laboratory of Forage and Pasture, Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta. Primary data were supported by the secondary data including the result of soil analysis at Laboratory of Soil Science, Faculty of Agriculture, Universitas Gadjah Mada. Rainfall intensity, temperature, and humidity were also obtained from Agency of Meteorology, Climatology, and Geophysics to support the primary data. Instruments and tools used on this study included hoe, sickle, sample bag, metric tape, weight analytical scale with 0.0001 gram of degree of accuracy, digital scale, scissor, and plastic rope. Materials used on this study were water, *Cichorium intybus* seeds, and Mutiara-brand NPK fertilizer (6,6,6).

2.2. Methods

2.2.1. General. It was intended to prepare the soil that will enable the seedling to grow well. The land preparation consisted of 2 main activities: weed control and soil propagation. The area was cleared out by removing all weeds and plants. The area was then plowed and watered. After 1 week, the soil was then subjected to another plowing and watering, before in total 9 plots with an area of 1 x 1.5 m were made on it. Plantation was performed on the plots that had been prepared before. Seeds of each plant was weighed by using analytical balance (4.5 g of *Cichorium intybus* for each plot). The seeds were spread and covered with soils. The seeds were spread 7 to 10 cm from inner side of the plot. The experiment design of this study was one-way completely randomized design – with 3 different doses of NPK fertilizer as the treatments: 0 kg/ha (P0); 45 kg/ha (P1); and 60 kg/ha (P2). There was 0.5 m spacing between plots to ease the control and prevent any puddle. To decide the level of fertilizers
being placed in a plot, the height of each plot was considered. It was intended to avoid the fertilizer being washed out and moved to another plot during watering. The cultivation included watering and weeding. To maintain the moisture content, the grass was watered twice a day (07:00 a.m. and 04:00 p.m.) in a sunny day. Weeding was carried out by removing any weeds on the surrounding of the grass to remove any factors that may perturb the growth of the *Cichorium intybus*. Plants that reached 50 days old or already flowered were harvested by using sickle – 10 to 15 cm cut above the soil surface. The yields were then weighed – representing the fresh production, and then covered in sample bag to undergo further analysis (dry matter and organic matter assessment). The plants were harvested when it reached 49 days old (7 weeks) – counted since the seedling. Biomass production was observed based on the fresh and dry matter production. Fresh production was calculated by converting the fresh weight into ton/ha unit. Dry matter production was obtained by converting the weight of the plant into ton/ha unit and multiplied by the percentage of dry matter.

2.2.2. Statistic. All data were statistically evaluated by using one-way analysis of variance for completely randomized design. The difference among groups were then subjected to Duncan’s New Multiple Range Test (DMRT). Statistical analysis was conducted by using computer program – Statistical Product and Service Solution [8].

3. Results and discussion

3.1. Productivity of the plants

Plant growth and productivity can be improved by fertilization treatment. A Different nutrient availability can cause a competition among plants in acquiring the nutrients. Thus, fertilization can be a mean to provide nutrients that come from external environment. Some distinct differences of plant height and leaf width are presented in Figure 1 - 3.

![Figure 1. Plant height (20 days old)](image1.jpg)

![Figure 2. Plant height (30 days old)](image2.jpg)
Figure 3. (a) leaf length and width – 1 week; (b) leaf length and width – 2 weeks; (c) leaf length and width – 3 weeks; (d) leaf length and width – 4 weeks; (e) leaf length and width – 5 weeks; (f) leaf length and width – 6 weeks.

Plant height, leaf width, and leaf number of *Cichorium intybus* (50 days old) that received different level of NPK fertilizer (0, 45, and 60 kg/ha) can be seen on Table 1.

Table 1. Plant height (cm), leaf width (cm), and number of leaf (leaf) on 50 days after planting

| Variable                  | Treatment | Average   |
|---------------------------|-----------|-----------|
|                           | P0        | P1        | P2        |           |
| Plant height (cm)         | 47.32±0.66 | 48.83±1.39 | 52.56±2.28 | 49.57±2.71 |
| Leaf width (cm)           | 8.35±0.42  | 7.66±0.37  | 7.74±0.35  | 7.91±0.46  |
| Number of leaf (leaf)     | 14.93±1.00 | 15.67±1.52 | 18.47±0.92 | 16.36±1.91 |

Superscripts on the same row indicate significant differences among groups (P<0.05).

A statistical analysis showed that difference level of NPK fertilizer had significantly improved the plant height and number of leaves of *Cichorium intybus* (P<0.05) – but not the leaf width. The plant height of group that received 60 kg/ha (P2) was higher compared to other groups (52.56 cm vs 47.32 cm and 48.83 cm). The results showed that increasing the level of fertilization improved the nutrient availability (Nitrogen, Phosphorous, and Potassium), and as a result the plant growth and productivity were greater. Increasing the fertilization level – mainly Nitrogen – can improve the plant’s vegetative development and growth (stem and root). Nitrogen is also an essential component on the plant protein. Nitrogen availability affects the plant production and furthermore increasing the biomass production [9].

3.2. Nutrient composition

Dry and organic matter of *Cichorium intybus* that received different level of NPK fertilizer and harvested on day 50 are shown on Table 2.
Table 2. Dry and organic matter content of *Cichorium intybus* on 50 days after sowing

| Variable            | Treatment | Average  |
|---------------------|-----------|----------|
|                     | P0        | P1       | P2       |         |
| Dry Matter (%)      | 9.60±1.17<sup>a</sup> | 13.12±1.42<sup>b</sup> | 15.73±0.16<sup>c</sup> | 12.82±2.82 |
| Organic Matter (%)  | 82.28±0.17<sup>a</sup> | 80.55±0.70<sup>b</sup> | 81.49±0.09<sup>b</sup> | 81.44±0.83 |

<sup>abc</sup> superscripts on the same row indicate significant differences among groups (P<0.05)

The results indicated that the fertilization on this study had significant effects (P<0.05) on dry and organic matter contents. P2 resulted higher dry matter (15.73%) compared to P0 and P1 groups (9.60 and 13.12%). Administering NPK fertilizer exceeds the plant’s requirement will lead to faster growth and change its nutrient composition. Meanwhile, insufficient fertilization will cause non-optimal growth – corresponding to the less fresh production. Hence, a precise quantity of fertilizer to be given to the plant should be deliberately concerned. Different levels of fertilization can change the dry and organic matter production. Nitrogen is a main limiting factor for plant since it is water-soluble and it may cause the deficiency more prevalent. Moreover, Nitrogen is also a building factor of protein, chlorophyll, and nucleic acid that will support the plant productivity as a source for forages. It also supports the soil microorganisms that eventually will benefit the soil itself. Dry and organic matter content of a plant depends on the proportion of cell wall and content of the plant. If the cell wall is greater than its content, the dry matter content will be higher [5].

3.3. Biomass Production

The dry and organic matter productions of *Cichorium intybus*, harvested on day-50 are shown on Table 3.

Table 3. Dry and organic matter productions of *Cichorium intybus* receiving different level of fertilization (kg/ha)

| Variable            | Treatment | Average  |
|---------------------|-----------|----------|
|                     | P0        | P1       | P2       |         |
| Dry Matter (kg/ha)  | 21.34±4.00<sup>a</sup> | 23.68±1.90<sup>b</sup> | 25.96±2.28<sup>c</sup> | 23.66±2.73 |
| Organic Matter (kg/ha) | 18.49±3.45<sup>a</sup> | 19.95±2.18<sup>b</sup> | 21.45±1.72<sup>c</sup> | 19.71±2.42 |

<sup>abc</sup> superscripts on the same row indicate significant differences among groups (P<0.05)

The application of 60 kg/ha of NPK fertilizer (P2) was able to produce more dry matter and organic matter of *Cichorium intybus* compared to P0 and P1 (P<0.05). It indicated that increasing the level of fertilization will provide nutrients in the soil that eventually increase the plant growth and development. Insufficient nutrients availability in the soil will result in deprived plant growth [10]. NPK fertilizer increased the dry matter of production of a plant [11].

4. Conclusion

As a conclusion of this study, NPK fertilizer applied to *Cichorium intybus* is able to increase vegetative growth and production of plant biomass. Application of NPK fertilizer with a level of 60 kg/ha on *Cichorium intybus* can increases the fresh production, dry and organic matter production. Production of *Cichorium intybus* can be improved by increasing the levels of NPK fertilized applied.

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