Effect of planting densities and fertilization levels on the production and quality of Chicory (*Cichorium intybus*) in Yogyakarta, Indonesia

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Abstract. This study was aimed to determine the growth, production, and nutrient content of *Cichorium intybus* planted in different planting densities and fertilization levels in Yogyakarta, Indonesia. The study was arranged on factorial randomized design (3 x 3) with two factors: level of fertilization (0, 45, and 60 kg/ha) and planting density (2, 3, and 4 g of seeds/m²); with 6 replications – aggregating 54 plots. Chicory seeds were spread on 1 x 1.5 m² plots with 20 cm of bedding height and 30 cm of distance between plots. NPK fertilizer was given when plants reached 15 days old. Plants were harvested at day-50 by cutting them 10 cm above the soil surface. The observation was performed on these following variables: growth (plant height, plant length, and leaf width), production (dry and organic matter production), and nutrient value (crude protein, dry and organic matter contents). All data were statistically evaluated using of the SPSS computer program. Significant treatments were subjected to Duncan's new multiple range test (DMRT). The study shows that plants which received the greatest amount of fertilizer had the highest growth, production, and nutrient value (P-value <0.05). Higher planting density compensated the plant height, leaf width, number of leaves, dry and organic matter contents (P-value <0.05). However, it escalated the dry and organic matter production (P-value <0.05). The plant that received 60 kg/ha of fertilizer and planted in 3 g/m² density demonstrated the most improved yield.

1. Introduction

Aside from management factors, other factors causing poor ruminant production in Indonesia are the volatility of feed quantity, quality, and continuity. It is associated with the fact that more than 90% of ruminant feed comprises forages – consumed daily as much as 10 to 15% per body weight – and the rest is supplied with feed concentrate and feed supplement [1]. Therefore, forage availability is becoming a considerable factor to support and enhance the ruminant productivity.

Forages can be classified into 3 groups: grass, legume, and forbs. Forbs is a class that does not belong either to grass and legume, with bush-shaped and un-woody stems that indirectly affecting the productivity of pasture land and soil quality. Forbs contain a high number of mineral, that can positively improve animal growth. One of the forbs is Chicory. Chicory (*Cichorium intybus*) is known...
as traditional herbs that possess great potency as a feed with high quality during the dry season. Chicory has been being widely used for centuries as animal feed. This plant holds high crude protein and less structural carbohydrate. Chicory grows well on fertile and drainage area. It can stand the high salt level [2]. However, it yields small biomass. This study was performed to evaluate the effects of different planting densities and fertilization levels on morphological values and biomass production of \textit{Cichorium intybus}.

2. Material and Methods

This study was carried out at research farm and Laboratory of Forage and Pasture, Faculty of Animal Science Universitas Gadjah Mada. Nutrient content in the soil is ; Carbon (C) 1.87%, Organic matter (OM) 3.23%, N total 0.20%, P total 0.22%, K total 0.10%, C/N ratio 9.35, and pH 7.12. The study was designed in split-plot design with main plot is levels of NPK fertilization (0, 45, and 60 kg/ha) and sub plot is planting densities (2, 3, and 4 g/m$^2$). Each treatment was replicated 6 times, and total plot is 54. The NPK fertilizer (16:16:16) used was Mutiara branded. Chicory seeds were obtained from Cropmark Seed Company New Zealand. Seeds were cultivated on 1 x 1.5 m$^2$ plots with 20 cm of bed height, 30 cm of space between plots. NPK fertilization was performed when the plants reached 14 days old by spreading it to the plots.

The plants were harvested at day-50 by cutting the stem 10 cm above the soil surface. The observation was carried out for plant growth (plant height, plant length, and leaf width) on fourth defoliation. The yields were then dried in 55 °C ovens (Memmert GmbH + Co. KG, Germany) and ground by using Wiley mill (Thomas Scientific, USA) with 1 mm screening. Chemical analysis was performed according to AOAC method [3]. All data were evaluated by using analysis of variance for completely randomized factorial on SPSS version 18 computer software (IBM, USA). Significant treatments were subjected to further evaluation on Duncan’s new multiple range tests (DMRT) with 5% significance rate.

3. Result and Discussion

3.1 Growth

Overall, different levels of NPK fertilization and planting density influence significantly the growth of \textit{Cichorium intybus} (P-value <0.05). The data are shown in table 1. Different levels of fertilization caused significant alteration on plant growth (P-value <0.05). Group, given with 60 kg/ha dosage, had the highest plant height (37.03 cm), compared to 0 and 45 kg/ha groups (34.08 and 35.74 cm respectively). The planting density affects significantly on plant height (P-value <0.05). Plant height of group on 2 gram/m$^2$ density was higher (39.65 cm) compared to 3 and 4 gram/m$^2$ groups (34.65 and 32.61 cm, consecutively).

The statistical analysis shows that different levels of fertilization provided significant effects on plant height (P-value <0.05). Plant height on 0 kg/ha of planting density group is smaller (5.22 cm), compared to 45 and 60 kg/ha groups (5.53 and 5.91 cm respectively). The higher level of fertilization given to the plants led to the higher plant height obtained. The result demonstrated that increasing levels of NPK fertilization could provide more Nitrogen, Phosphorous, and Potassium nutrient that used to improve plant growth. Increasing the fertilization level, mainly Nitrogen will help in speeding up the vegetative growth and development (leaf, stem, and root) and serving as essential protein precursor for plants [4]. Nitrogen availability plays important roles in improving plant productivity to increase biomass production.

The statistical analysis showed that different levels of fertilization affected the number of leaves significantly (P-value <0.05). The fewest number was observed on 0 kg/ha group (12.54), compared to 45 and 60 kg/ha groups (13.34 and 14.37 consecutively). Treatments of different planting density affected the leaf width significantly (P-value <0.05). Leaf width of \textit{Cichorium intybus} planted on 2 gram/m$^2$ density was wider (6.33 cm) compared to 3 gram/m$^2$ group (5.33 cm) and 4 gram/m$^2$ group (4.96 cm). As a consequence of high planting density, the plant would have shorter height. It is associated with the photosynthesis process in which it will be reduced on high planting density groups.
since the sunlight entrance is compromised. Low planting density causes less competition among plants [5]. Besides, the plants will also have more space to enable photosynthesis taking place optimally and its products will be translocated to all parts of the plant.

Table 1. Effects of different levels of NPK fertilization and planting density on the growth of *Cichorium intybus*

| Levels of NPK fertilization | Planting Densities | Average |
|-----------------------------|--------------------|---------|
|                             | 2 g/m²             | 3 g/m²  | 4 g/m²  |          |
| Plant Height                |                    |         |         |          |
| 0 kg/ha                     | 37.17 ± 0.06       | 33.37 ± 0.16 | 31.71 ± 0.21 | 34.08 ± 2.43<sup>a</sup> |
| 45 kg/ha                    | 39.51 ± 0.41       | 35.43 ± 0.45 | 32.31 ± 0.11 | 35.74 ± 3.14<sup>b</sup> |
| 60 kg/ha                    | 42.31 ± 0.21       | 35.26 ± 0.21 | 33.53 ± 0.45 | 37.03 ± 4.03<sup>c</sup> |
| Average                     | 39.65 ± 2.23<sup>c</sup> | 36.48 ± 1.03<sup>c</sup> | 32.51 ± 0.84<sup>p</sup> |
| Plant width                 |                    |         |         |          |
| 0 kg/ha                     | 5.72 ± 0.22        | 5.11 ± 0.11 | 4.81 ± 0.11 | 5.22 ± 0.43<sup>a</sup> |
| 45 kg/ha                    | 6.41 ± 0.11        | 5.31 ± 0.11 | 4.90 ± 0.11 | 5.53 ± 0.67<sup>b</sup> |
| 60 kg/ha                    | 6.91 ± 0.11        | 5.61 ± 0.12 | 4.83 ± 0.13 | 5.91 ± 0.78<sup>c</sup> |
| Average                     | 6.33 ± 0.53<sup>c</sup> | 5.33 ± 0.23<sup>c</sup> | 4.96± 0.21<sup>p</sup> |
| Number of Leaves            |                    |         |         |          |
| 0 kg/ha                     | 14.81 ± 0.27       | 12.31 ± 0.11 | 10.53 ± 0.58 | 12.54 ± 1.88<sup>a</sup> |
| 45 kg/ha                    | 17.16 ± 0.15       | 12.51 ± 0.44 | 10.37 ± 0.15 | 13.34 ± 3.02<sup>b</sup> |
| 60 kg/ha                    | 18.51 ± 0.43       | 14.33 ± 0.15 | 10.31 ± 0.11 | 14.37 ± 3.56<sup>c</sup> |
| Average                     | 16.83 ± 1.64<sup>c</sup> | 13.04 ± 0.99<sup>c</sup> | 10.41 ± 0.32<sup>p</sup> |

<sup>a,c</sup>: Different superscripts at the same column indicate significant differences (P<0.05).

3.2 Production

As an overview, the different levels of NPK fertilization and planting densities had significant effects on the *Cichorium intybus* production (P-value <0.05). The data of *Cichorium intybus* production can be seen in Table 2. An application of NPK fertilizer with different levels affected the dry matter production (kg/ha/year) significantly (P-value <0.05). Dry matter production on 60 kg/ha group (18.94 kg/ha/year) was observed as the highest number compared to 0 and 45 kg/ha groups (16.52 and 18.18 kg/ha/year, respectively). The higher level of fertilization resulted from increased DM production. NPK fertilization can improve the nutrient value since it provides the nutrients required by the plants [6]. The results demonstrated that an increased level of multiple fertilizer application (NPK) would provide soil nutrients to support the plant growth and development, producing increased organic matter.

Statistical analysis confirmed that planting density was responsible for a significant difference in DM production (P-value <0.05). Different level of fertilization was also observed affecting the organic matter (OM) production (P-value <0.05). Organic matter production on 0 kg/ha group was smaller (15.93 kg/ha/year) compared to 45 and 60 kg/ha groups (17.81 and 18.64 kg/ha/year, respectively). Plant density was also confirmed had a significant effect (P value<0.05) on OM production of chicory. Planting density of 2 gram/m² produced smaller OM (16.10 kg/ha/year) compared to 3 and 4 gram/m² (17.48 and 18.64 kg/ha/year). Higher planting density increases the biomass production per area, although the biomass production/year is undergone reduction [7]. It may be caused by the population per plot is greater, thus the producing greater weight accumulation.
Effects of different levels of NPK fertilization and planting density on *Cichorium intybus* production

| Levels of NPK fertilization | Planting Density | Average |
|----------------------------|------------------|--------|
|                            | 2 g/m²           | 3 g/m² | 4 g/m² |
| Dry Matter Production (kg/ha/year) |             |        |        |
| 0 kg/ha                    | 15.83 ± 0.17     | 16.42 ± 0.36 | 17.33 ± 0.49 | 16.52 ± 0.72<sup>a</sup> |
| 45 kg/ha                   | 16.81 ± 0.11     | 18.21 ± 0.34 | 19.53 ± 0.25 | 18.18 ± 1.21<sup>b</sup> |
| 60 kg/ha                   | 17.07 ± 0.02     | 19.04 ± 0.02 | 20.73 ± 0.15 | 18.94 ± 1.58<sup>c</sup> |
| Average                    | 16.57 ± 0.57<sup>p</sup> | 17.89 ± 1.18<sup>q</sup> | 19.19 ± 1.52<sup>r</sup> |

Nutrient Value

The nutrient value of *Cichorium intybus* were presented in Table 3. According to Table 2, DM value was confirmed significantly affected by different level of fertilization (P-value <0.05). Smaller DM was observed on 0 kg/ha group (9.12%) compared to 2 and 3 gram/m² (11.14 and 13.13%, consecutively). Application of 45 kg/ha NPK fertilizer produced smaller DM (11.14%) compared to 60 kg/ha group (13.13%).

### Table 3. Effects of different levels of NPK fertilization and planting density on nutrient value of *Cichorium intybus*

| Levels of NPK fertilization | Planting densities | Average |
|----------------------------|--------------------|--------|
|                            | 2 g/m²             | 3 g/m² | 4 g/m² |
| Dry Matter (%)             |                    |        |        |
| 0 kg/ha                    | 9.56 ± 0.25        | 8.51 ± 0.38 | 7.63 ± 0.15 | 8.57 ± 0.87<sup>a</sup> |
| 45 kg/ha                   | 13.63 ± 0.15       | 10.33 ± 0.25 | 9.46 ± 0.15 | 11.14 ± 1.91<sup>b</sup> |
| 60 kg/ha                   | 15.71 ± 0.11       | 13.43 ± 0.21 | 10.27 ± 0.21 | 13.13 ± 2.38<sup>c</sup> |
| Average                    | 12.97 ± 2.71<sup>c</sup> | 10.76 ± 2.17<sup>c</sup> | 9.12 ± 1.18<sup>p</sup> |
| Organic Matter (%)         |                    |        |        |
| 0 kg/ha                    | 82.61 ± 0.36       | 80.56 ± 0.19 | 81.47 ± 0.16 | 81.55 ± 0.92<sup>a</sup> |
| 45 kg/ha                   | 83.31 ± 0.11       | 81.33 ± 0.15 | 80.93 ± 0.15 | 81.86 ± 1.11<sup>b</sup> |
| 60 kg/ha                   | 83.61 ± 0.11       | 81.63 ± 0.16 | 81.24 ± 0.18 | 82.17 ± 1.13<sup>c</sup> |
| Average                    | 83.18 ± 0.48<sup>q</sup> | 81.17 ± 0.51<sup>p</sup> | 81.21 ± 0.27<sup>p</sup> |
| Crude Protein (%)          |                    |        |        |
| 0 kg/ha                    | 24.33 ± 0.15       | 23.36 ± 0.16 | 22.43 ± 0.31 | 23.38 ± 0.84<sup>a</sup> |
| 45 kg/ha                   | 25.63 ± 0.21       | 24.36 ± 0.23 | 23.37 ± 0.15 | 24.46 ± 0.99<sup>b</sup> |
| 60 kg/ha                   | 26.23 ± 0.15       | 25.21 ± 0.10 | 24.47 ± 0.16 | 25.31 ± 0.78<sup>c</sup> |
| Average                    | 25.41 ± 0.85<sup>r</sup> | 24.31 ± 0.81<sup>p</sup> | 23.42 ± 0.91<sup>p</sup> |

The statistical analysis showed that planting density had significant effects (P-value <0.05) on the DM value. Dry matter of 4 gram/m² was observed smaller (9.12%) compared to 2 and 3 gram/m².
groups (12.97 and 10.76% respectively). Planting density of 2 gram/m² showed the higher DM (12.97%) compared to 3 gram/m² group (10.76%).

Statistical analysis confirmed that planting density influenced the DM value significantly (P-value <0.05). Dry matter value of 4 gram/m² was observed smaller (9.12%) compared to 2 and 3 gram/m² (12.97 and 10.76%). The planting density of 2 gram/m² showed higher DM (12.97%) compared to 3 gram/m² group (10.76%).

The higher fertilizer given was followed with higher DM value produced. Nitrogen fertilizer given to the plant is a main limiting factor for plant since its deficiency is more prevalence due to its high solubility; its function as precursor for protein, nucleic acid, and chlorophyll – thus can boost the forage productivity and support the growth of soil bacteria whose positive impacts for soil fertility [8]. DM and OM value depends on the proportion on the constituent of the cell wall and cell content of the plant [9]. If the constituent of the cell wall is higher compared to its content, The DM produced is becoming higher.

Organic matter of groups on 2 gram/m² density was higher compared to 3 and 4 gram/m² groups (81.17 and 81.21%). The organic matter between 3 and 4 gram/m² groups was observed not significantly different (81.17 vs 81.21%). Organic matter (OM) of chicory on first regrowth is 83.88%. *Cichorium intybus* contains crude protein, ranging from 24 to 26% [10].

4. Conclusion
Based on this study, it can be concluded that the use of NPK fertilizer increased the growth, production, and nutrient value of *Cichorium intybus*. The most appropriate level of NPK fertilizer is 60 kg/ha/cut. Higher planting density increased its DM and OM production, yet reduced the growth and nutrient value. The most appropriate density is the use of seeds 3 gr/m².

Acknowledgement
Authors thank Universitas Gadjah Mada that has funded this study through “Graduating Paper Recognition Grant 2019” and Faculty Grant scheme, and to Dr. Tim Cookson and Brian Thorington from New Zealand who provided constructive advice during the study.

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