

# Growth of Tropical Alfalfa (*Medicago sativa* cv. Kacang Ratu BW) under Drought Stress

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**Abstract.** Tropical alfalfa (*Medicago sativa* cv. Kacang Ratu BW) has potential as a high-quality forage source in tropical regions. This study aimed to observe the response of tropical alfalfa to drought stress by examining plant growth. The experiment employed a Nested Design with two factors: irrigation frequency (P0, P1, P2, and P3) and cutting age (20 and 30 days). Observed variables included plant height, growth rate, and number of branches. Results indicated no significant differences ( $P>0.05$ ) across all variables at different levels of drought stress and cutting ages. These findings indicate the potential of tropical alfalfa to be cultivated in drought-prone tropical environments. This study provides a scientific basis for developing of more effective management strategies in alfalfa cultivation in the tropics, which may contribute to the increased availability of high-quality feed throughout the year for farmers in the region.

**Keywords:** Drought stress, Growth, Tropical alfalfa

## 1 Introduction

The leguminous plant known as alfalfa (*Medicago sativa* L.) has excellent potential for use as a premium animal feed ingredient. This plant is well known for having a high crude protein content, readily digested fiber, and several vital vitamins and minerals [1]. However, as a plant that typically thrives in temperate regions, adapting alfalfa to tropical environments poses a unique challenge, particularly in the context of increasingly intense global climate change.

Alfalfa, which has begun to be cultivated in tropical regions [2], shows superior growth and nutrient content and can compete with subtropical varieties, creating opportunities for its recognition as a new tropical alfalfa variety [3]. The Indonesian Ministry of Agriculture officially recognized this variety, Kacang Ratu BW, registered with the Plant Variety Protection and Agricultural Licensing Center under number 929/PVHP/2021. Research on tropical alfalfa (*Medicago sativa* cv. Kacang Ratu BW) has significantly progressed since 2010 [4].

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Climate change has increased the frequency and intensity of droughts in various regions, including tropical areas such as Indonesia [5]. This makes drought stress one of the main limiting factors in the growth and productivity of alfalfa in tropical regions. Therefore, understanding the response of tropical alfalfa to various levels of drought stress becomes crucial to optimizing the cultivation of this plant in facing climate change challenges.

This study aims to investigate the growth of tropical alfalfa in response to different levels of drought stress, represented by varying irrigation frequencies. Additionally, this research observes the impact of cutting age on the plant's growth. In the context of livestock production, this research holds significant importance. Alfalfa is a crucial component in livestock production systems [3]. The availability of high-quality forage throughout the year is an important challenge for farmers, especially in tropical areas prone to climatic fluctuations [6]. By understanding the response of tropical alfalfa to drought stress, this research can provide a scientific basis for developing more effective management strategies for alfalfa cultivation in tropical regions.

## **2 Materials and Methods**

### **2.1 Materials**

The study was conducted over three months, from September to November 2023, at the Forage and Pasture Research Field, Faculty of Animal Science, Universitas Gadjah Mada, Yogyakarta, Indonesia. Field equipment included a 5 m measuring tape for plot and plant height measurements, soil preparation tools (sickle, hoe, tiller), and hoses for plant watering. The study materials comprised regrowth-sixth tropical alfalfa plants, regosol soil, and water.

### **2.2 Methodology**

Plant growth measurements were conducted weekly using a Nested Design. The first factor was irrigation frequency with watering intervals of 1 day (P0) as a control, 2 days (P1), 4 days (P2), and 6 days (P3). The second factor was the cutting age after the sixth regrowth, consisting of 20-day and 30-day cutting ages. The observed variables included plant height, growth rate, and branch count.

Plant maintenance activities included watering to field capacity, weeding, and pest and disease control. Watering to field capacity meant providing water until the soil was saturated, with excess water allowed to drain. Field capacity refers to the maximum amount of water soil can hold against gravitational pull. Weeding was carried out regularly to clear weeds and loosen the soil carefully to avoid damaging plant roots. Pest and disease control were performed mechanically by removing pests like caterpillars and grasshoppers, which only attacked a few plants.

### **2.3 Measured variables**

#### **2.3.1 Plant height**

Plant height was measured from the plant base at soil level to the tip of the plant using a ruler in centimeters (cm). This measurement aimed to gauge plant growth vigor and development under environmental conditions.

### 2.3.2 Growth rate

The growth rate refers to the speed at which a plant grows over a specific period. It is measured through changes in plant height, leaf count, plant mass, or other growth parameters over a given interval, usually expressed in growth units per day or week.

### 2.3.3 Number of branches

The number of branches was determined by counting the productive lateral branches, which can produce shoots or flowers and contribute to overall plant productivity.

## 2.4 Data analysis

The data obtained were statistically analyzed using Nested Design analysis, followed by Duncan's Multiple Range Test (DMRT) if a significant difference was observed at a confidence level of  $\alpha = 0.05$ , using SPSS version 26.

## 3 Results and Discussion

### 3.1 Agroclimatic conditions

Based on data from the Yogyakarta Climatology Station, climate conditions from September to November 2023 at the research location indicated average temperatures ranging from 18.4°C to 35.6°C with humidity between 66-84%. Rainfall from September to early November was recorded at 0 mm/month. The monthly average duration of sunshine reached 7.5 hours. This aligns with previous research that indicated optimal subtropical alfalfa growth at temperatures around 20°C, while tropical alfalfa can thrive even at temperatures reaching 48°C [15].

### 3.2 Plant height

Plant height is a growth indicator used to measure the response of plants to the treatments applied in an experiment. It represents a variable that can indicate the vegetative growth activity of a plant. The height of tropical alfalfa under different drought stresses is shown in Table 1.

**Table 1.** Average plant height of tropical alfalfa under different drought stresses (cm)

Irrigation Frequency	Cutting Age	
	20 days	30 days
P0	59.78±7.51	72.78±3.38
P1	55.89±4.59	69.67±3.54
P2	57.61±6.84	70.33±2.59
P3	61.61±6.07	69.67±4.42

Note: P0, Daily irrigation; P1, Irrigation every 2 days; P2, Irrigation every 4 days; P3, Irrigation every 6 days.

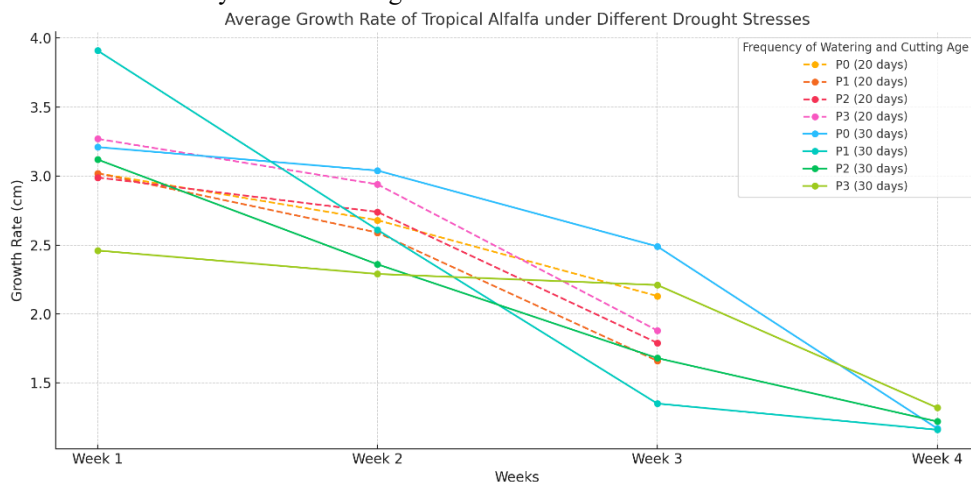
Analysis revealed that different cutting ages and irrigation frequencies, such as P0, P1, P2, and P3, did not significantly ( $P > 0.05$ ) affect the plant height of tropical alfalfa under drought stress (Table 2). This result is higher than the previous research [7], which reported alfalfa height of 44.78 cm at 60 days of age and 50.63 cm at 80 days of age. Furthermore, previous

studies [3] showed that tropical alfalfa harvested at 3 weeks and 4 weeks of age reached heights of 10.42 cm and 30.11 cm, respectively.

This occurs because alfalfa has adaptive mechanisms that enable the plant to survive even under drought conditions. Alfalfa has a deep root system and efficient water use, enabling it to access water from deeper soil layers even when irrigation is not performed regularly [6]. Alfalfa roots typically grow deeper than other plants, reaching up to 16 feet (4.87 m) into the soil [8]. This deep root system creates channels that help retain soil, increase water infiltration and biological activity in the root zone, and improve nutrient cycling. Additionally, alfalfa exhibits drought tolerance due to its ability to reduce evaporation and increase water use efficiency under dry conditions [9]. Plants that have undergone six regrowths have deeper roots, making them more resilient to drought stress. The depth of alfalfa roots increases linearly with age, from 3 to 12 years, with an average increase of 35,3 cm per year. Based on this data, the root depth of alfalfa at 10, 20, and 30 years is estimated to reach 613 cm, 966 cm, and 1319 cm, respectively [10].

### 3.3 Growth rate

The growth rate of alfalfa refers to the speed at which the alfalfa plant grows. The growth rate data in this study is shown in Figure 1.



Note: P0, Daily irrigation; P1, Irrigation every 2 days; P2, Irrigation every 4 days; P3, Irrigation every 6 days.

**Figure 1.** Average growth rate of tropical alfalfa under different drought stresses

Based on the analysis, there were no significant differences in the growth rate of tropical alfalfa across different irrigation frequencies and cutting ages. Although there were variations in average plant height with each treatment, the overall decrease in height did not show statistically significant differences ( $P > 0.05$ ). The declining pattern across all treatments tended to be similar, where initial growth appeared promising in the first weeks but then gradually decreased over time, especially at longer cutting ages.

These results indicate that although there are slight variations in alfalfa's response to irrigation frequency under drought conditions, the overall impact on growth rate is not statistically significant. This suggests that tropical alfalfa has a relatively similar adaptive capacity in coping with drought stress regardless of the irrigation frequency. This aligns with previous findings [2], which noted that alfalfa's average height or growth rate in the first

week after cutting increased between 2-5 cm per day. However, as the flowering process began, the plant's growth gradually declined in the third and fourth weeks.

### 3.4 Number of branches

The number of branches refers to the total number of branches formed from the main stem of a plant. These branches develop from buds that emerge on the main stem and contribute to the plant's overall growth and development. The number of branches in tropical alfalfa under different drought stresses is shown in Table 2.

**Table 2.** Average number of branches of tropical alfalfa under different drought stresses (count)

Irrigation Frequency	Cutting Age	
	20 days	30 days
P0	23.22±3.42	23.67±3.32
P1	20.89±2.52	25.11±3.85
P2	22.56±3.09	24.56±3.13
P3	24.44±2.60	25.33±3.24

Note: P0, Daily irrigation; P1, Irrigation every 2 days; P2, Irrigation every 4 days; P3, Irrigation every 6 days.

Based on the data above, no significant differences ( $P > 0.05$ ) were found in the number of branches of tropical alfalfa across different irrigation frequencies at different cutting ages. The data shows that the number of branches in P0 varied from 20.89±2.52 to 24.44±2.60 for the 20-day cutting age, while for the 30-day cutting age, the number of branches ranged from 23.67±3.32 to 25.33±3.24. Although other irrigation frequencies, such as P1, P2, and P3, showed different numbers of branches, the same trend occurred in all treatments, with no statistically significant changes observed.

This indicates that tropical alfalfa shows a similar response to drought stress conditions, without a meaningful effect of irrigation frequency on the number of branches produced. The process of branch formation in tropical alfalfa under different irrigation frequencies involves a series of complex physiological and morphological responses. Initially, alfalfa produces a primary shoot. As the plant grows, it develops apical and axillary meristems that have the potential to form new branches [11]. The plant can also divert resources from branch growth to develop deeper root systems in search of water. Additionally, plant hormones such as auxin and cytokinin play essential roles in regulating apical dominance and lateral branching, and the balance of these hormones can change in response to water stress [12].

## 4 Conclusion

This study shows that tropical alfalfa (*Medicago sativa* cv. Kacang Ratu BW) exhibited no significant differences in plant height, growth rate, and number of branches at various irrigation frequencies and cutting ages. This plant demonstrates good adaptability to drought stress. The results of this study indicate that tropical alfalfa has the potential to be cultivated in tropical environments that often experience drought and can provide knowledge in effective cultivation strategies in the tropics.

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