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EFFECT OF SHOOT PRUNING INTERVAL AND DOSAGE OF POTASSIUM FERTILIZER ON GROWTH AND YIELD OF YAM BEAN (PACHYRHIZUS EROSUS L.)

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ABSTRACT

A study was conducted in Baratan village, district of Patrang, Jember, East Java, on the effects of shoot pruning intervals and potassium fertilizer dosages on the growth and yield of yam bean (Pachyrhizus erosus L.). Pruning of the plant shoot was done six weeks after planting, 50 cm above the soil surface. Three levels of shoot pruning treatment were: no pruning (control), shoot pruning every 7 days, and shoot pruning every 14 days. The dosages of potassium fertilizer were: 0, 75, 150, 225, and 300 kg ha1 of K2O. The experimental design adopted was the completely randomized block design (CRBD) with three replications. The results showed that pruning of shoots every 7 days with potassium fertilizer at 225 kg ha-1 gave the best effect on leaf area index, tuber diameter, tuber fresh weight, tuber dry weight, and total plant fresh weight and dry weight, respectively. Those values were 6.1; 18.88 cm; 468.56 g, 89.05 g, 710.32 g, and 143.54 g, respectively. There was an increase of 289, 175, 392, 362, 247, and 223 percent again without pruning and potassium fertilizer (control) treatments. Pruning shoots every 7 days with 300 kg ha-1 potassium fertilizer resulted in the highest tuber carbohydrate content, which was 44.99 percent higher than the control treatment (no pruning and potassium fertilizer application).

Keywords: Growth, Yam Bean, Potassium Fertilizer, Shoot Pruning Interval, Yield

1. INTRODUCTION

Yam bean (*Pachyrrhizus erosus* L.) is a perennial plant belonging to the Leguminose family that originates in Central America Oluwole et al. (2021). Under the soil's surface, the plant produces root swellings or round fleshy tubers with a similar crisp texture and apple-like flavor. It is an underground starchy root that is one of the most widely cultivated edible root vegetables in Central America, South Asia, the Caribbean Islands, and regions of South America near the Andes Gbenga-Fabusiwa (2021), George et al. (2020). In Indonesia, the yam bean has been widely

farmed in Sumatra, Java, Nusa Tenggara, Sulawesi, Bali, and Kalimantan. Even though it has a lot of industrial potential, yam bean is only used as a fresh food in Indonesia Krisnawati et al. (2018).

The tubers of yam beans are particularly low in calories, with only 35 calories per 100 grams. However, it includes high-quality dietary fiber; around 13% of the root pulp is composed of fiber Baiyeri et al. (2018). Yam bean is a source of oligo-fructose inuline; inuline is a zero-calorie, sweet, inert carbohydrate that is not metabolized by the human body, making the tuber a great sweet snack for diabetics and dieters Crespo et al. (2020). Fresh yam bean tubers are high in vitamin C, containing around 20.2 mg per 100 g. Vitamin C is a water-soluble anti-oxidant that protects the body from the damaging effects of free radicals, consequently preventing cancer, inflammation, and viral cough and cold disorders. In addition to B-complex vitamins, yam beans contain folates, riboflavin, pyridoxine, pantothenic acid, and thiamine. Additionally, it contains essential minerals, including magnesium, copper, iron, and manganese Rana and Mamatha (2017).

Yam bean is a shrub that begins flowering four weeks after being planted. Flowers are reproductive organs that convert photosynthetic assimilates into seeds Afolabi et al. (2019). The passage of photosynthate to the flower will decrease the flow of photosynthate to other organs, such as the tuber. The shoot was pruned to remove reproductive organs and unneeded branches in order to limit photosynthate absorption by unneeded organs and optimize the leaf distribution, maximizing the efficiency of the photosynthetic process Nie et al. (2021), Suchocka et al. (2021).

Potassium's primary function is to establish the proper ionic environment for metabolic processes in the cytosol and to regulate many processes, including growth regulation. Potassium ions (K^+) are required by plants for protein synthesis and for the opening and closing of stomata, which is regulated by the proton pump to make surrounding guard cells either turgid or flaccid Oosterhuis et al. (2014). Potassium is also required for photosynthesis, protein synthesis, the activation of certain enzymes, phloem solute transfer of photoassimilates into storage organs, and the maintenance of cation-anion balance in the cytosol and vacuole Zörb et al. (2014). Multiple studies have demonstrated that potassium boosts early development, enhances protein production, and improves water utilization efficiency. Potassium is also essential for the vigor, lifespan, and winter hardiness of numerous plants, in addition to enhancing their resistance to diseases and insects Hasanuzzaman et al. (2018). To determine the maximum development and production of yam bean, it is crucial to understand the influence of shoot-pruning intervals and the optimal potassium fertilization dose.

2. MATERIALS AND METHODS

The research was conducted in Baratan village, Patrang district, and Jember, Indonesia. This was a factorial experiment with a completely random block design and three replications. Six weeks following transplantation, the shoots and bloom primordia were pruned. No pruning, pruning every 7 days, and pruning every 14 days were the shoot pruning variables. The potassium fertilizer doses were as follows: 0, 75, 150, 225, and 300 kg ha^{-1} of K_2O.

To speed germination, yam bean seeds were immersed in clean, warm water for 24 hours. The size of the experimental plot was 2 m × 2 m. In the experimental plot, germinated seedlings were transplanted into shallow soil holes (5 cm deep) with 25 cm × 25 cm planting spacing. Following the treatments, the soil was

fertilized with urea at a rate of 100 kg N h^{-1}, superphosphate (SP 36) at a rate of 100 kg P_2O_5 h^{-1}, and potash muriate at K_2O doses.

One-third of the fertilizer was administered as base fertilizer (before plant transplanting), and the remaining one-third was applied six weeks later. Six weeks after transplantation, at a height of 50 cm above the soil surface, the first pruning was performed. The weeding and watering were properly conducted.

The harvesting of tubers started four months after sowing. Leaf area index, tuber diameter, tuber fresh weight, tuber dry weight, total plant fresh weight, and total plant dry weight were observed as parameters. The data about the observed parameters were evaluated using analysis of variance, followed by Duncan's multiple range test (5%) Laxminarayana (2017).

3. RESULTS AND DISCUSSION

The shoot pruning interval and potassium fertilizer doses had a significant effect on the parameters measured. Shoot pruning interval treatment with an interval of 7 days and potassium fertilizer application of 225 kg $K_2O.ha^{-1}$ gave the best results on leaf area index (LAI) as high as 6.14, whereas the lowest LAI (1.93) was reached by the combination of no pruning treatment and fertilizer application of 75 kg $K_2O.ha^{-1}$ Figure 1. Pruning treatment could increase the number of branches and stimulate flush formation; pruning once a week gave a higher leaf area index on all dosages of potassium combination.

Figure 1

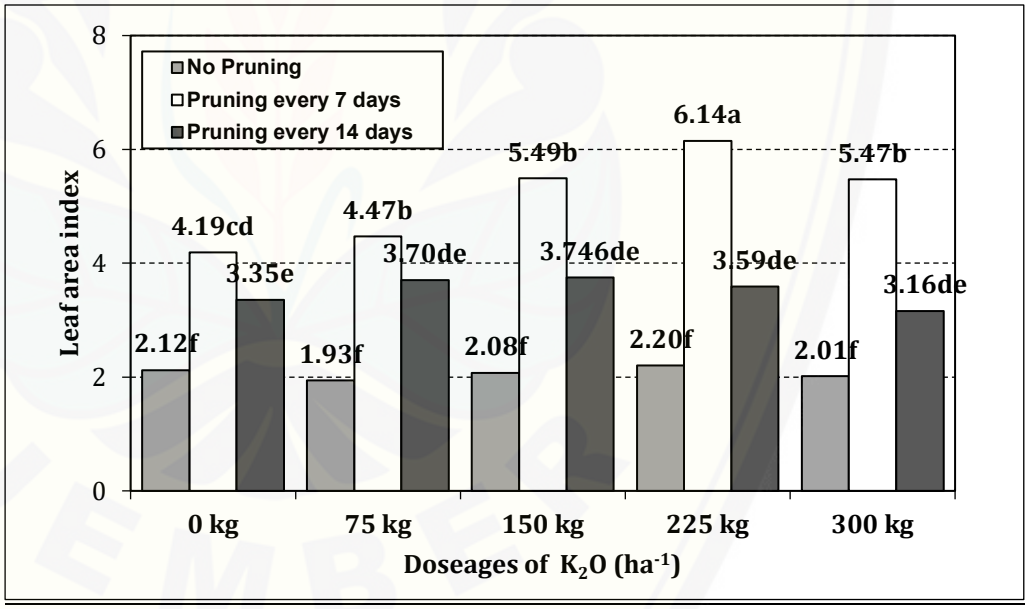

Figure 1 Effect of Pruning Intervals and Dosages of Potassium Fertilizer on Leaf Area Index

No-pruning plants yield the smallest tuber diameter. The smallest tuber diameter was found with no pruning and no potassium application, which resulted in a diameter of 10.76 cm. The greatest tuber diameter was found with once-week pruning combined with 225 kg K_2O ha^{-1} application, resulting in a tuber diameter value of 18.88 cm, or a 175.46 percent increase over the control treatment (no pruning and no potassium fertilizer). It did not differ significantly from a 7-day pruning interval with 300 kg K_2O ha^{-1} and a tuber diameter of 17.85 cm Figure 2. The yield of yam bean tubers can potentially be increased by pruning the sink-

reproductive organ, which aims to turn the flow of assimilates to tubers so that the size of the tubers will be bigger Fitsum et al. (2019) .

Figure 2

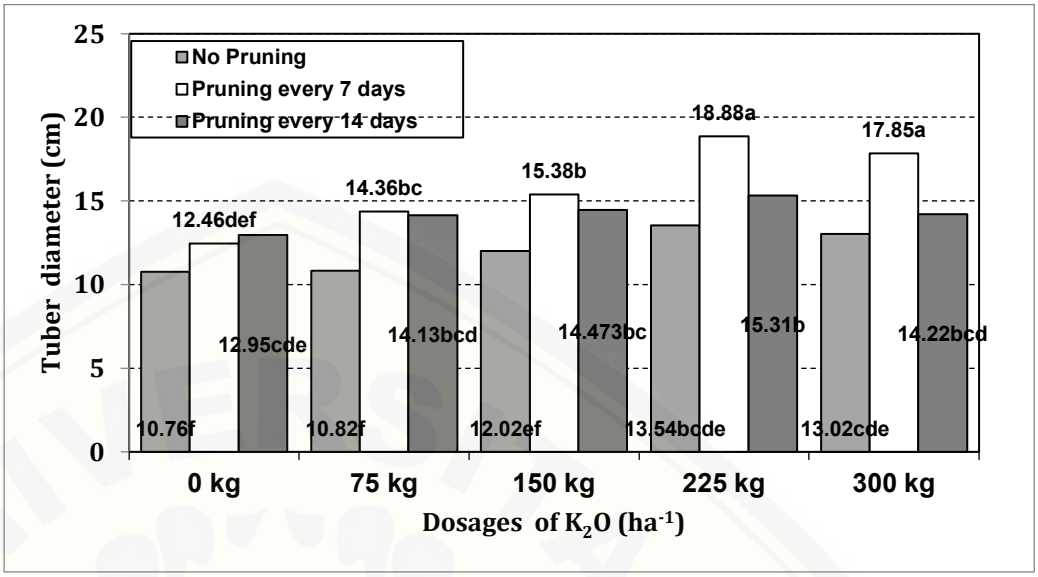

Figure 2 Effect of Pruning Intervals and Dosages of Potassium Fertilizer on Tuber Diameter

Shoot pruning once a week and 225 kg K_2O ha^{-1} fertilizer application yield the highest tuber fresh weight of 486,56 g $plant^{-1}$, or a 407.4% increase over no pruning and no potassium fertilizer, which yield the lowest tuber fresh weight of 119.43 g $plant^{-1}$ Figure 3. Pruning can increase the yield of yam tubers and based on the results of Rizky et al. (2013) research, it shows that there is a significant difference between the average value of yam bean plants that are not pruned and those that are. The productivity of yams per hectare of 27 genotypes with reproductive pruning treatment ranged from 7.55 t ha^{-1} to 19.73 t ha^{-1}, with yams weighing 226.5 g to 592 g on average.

Figure 3

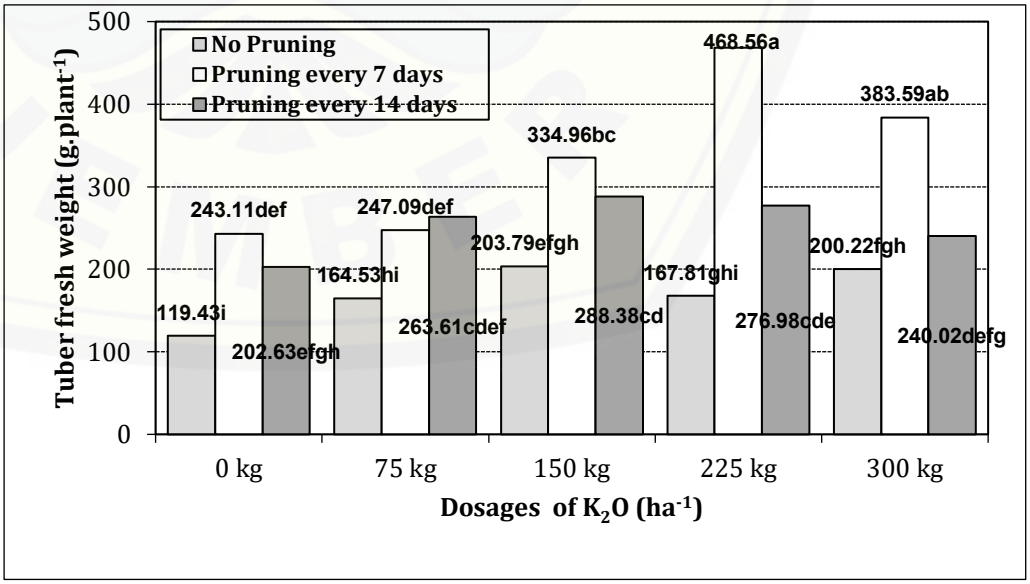

Figure 3 Effect of Pruning Intervals and Dosages of Potassium Fertilizer on Tuber Fresh Weight

The practice of pruning in this experiment increased the yield by about 85.94% compared to the set of experiments without pruning (average weight of tuber: 110–403 g, yam yield: 3.67–13.43 t ha^{-1}). This can be explained by the fact that the effect of pruning is seen as one of the real evidences of competition between sink organs in plants Baïram et al. (2019). As a result, trimming one of the sinks increases the likelihood of other sinks gaining more assimilates, especially if the sinks removed are strong sinks, such as reproductive sinks Dingkuhn et al. (2020). Pruning could increase the yield of the plant, as found by Mardhiana et al. (2017) in their research about the effect of pruning versus no pruning on the quality and yield of cucumber. The result shows that the potential yield was higher in pruned cucumber than in those treated with no pruning.

Potassium fertilization has a very important role in tuber yielding in many plants. 100 kg of K_2O ha^{-1} on potatoes resulted in the largest tuber (679 g) or an increase of 10% compared to no potassium fertilizer Figure 4. Uke et al. (2015) investigated the effect of tuber sizes and potassium dosages on the growth and production of Shallots var. Lembah Palu showed that the dosage of K fertilizer significantly affected all growth parameters except the number of tillers and leaf area, as well as all yield parameters, namely the number of bulb tubers, diameter of tubers, fresh weight of tubers, dry weight of tubers, and production where fertilizer doses of 100 kg K ha^{-1} and 250 kg K ha^{-1} show higher yields than other treatments.

Figure 4

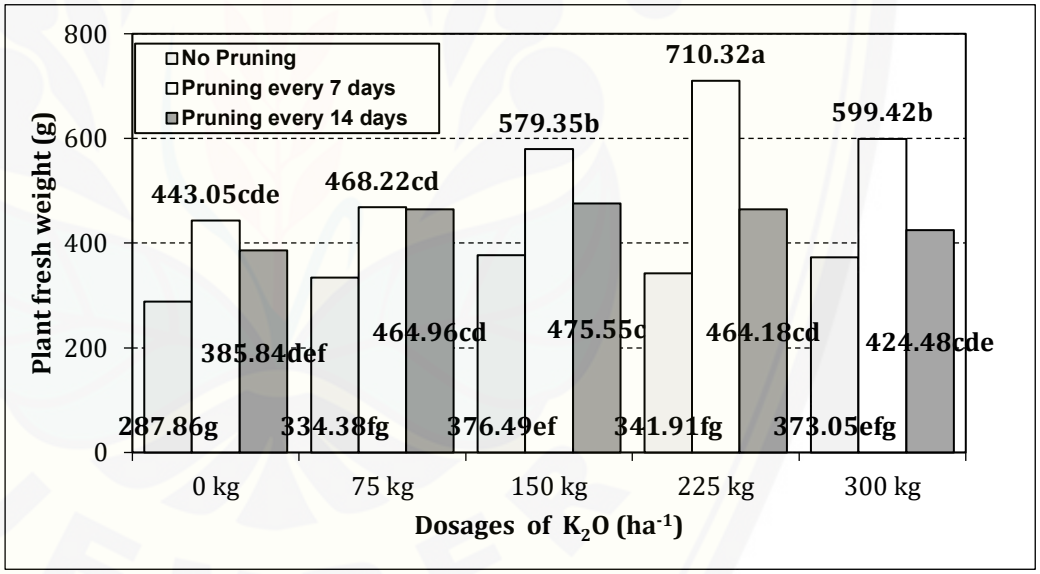

Figure 4 Effect of Pruning Intervals and Dosages of Potassium Fertilizer on Plant Fresh Weight

Ndereyimana et al. (2021) showed that there was an interaction of branches pruning and potassium fertilization on fruit weight, fruit length, fruit diameter, and fruit water content of melon. When a branch is pruned at the 20th internode, it has a big effect on the weight, length, diameter, water content, thickness, softness, and total sugar content of the fruit. Potassium fertilizer 40 g K_2O $plant^{-1}$ gave the best results on fruit weight, fruit length, fruit diameter, fruit water content, fruit thickness, fruit softness, and total sugar content. Pruning has an important role to increase fruiting and plant nutrient status Tyagi et al. (2017). Robinson (2011) found that pruning and thinning could increase the yield of apple. The plant growth increased as the severity of pruning increased, but the fruit set, and yield decreased

due to more vegetative growth Albarracín et al. (2017). Pruning resulted in stimulation of emission of vegetative shoots and reduction of flowering Cruz et al. (2011). The leaf nutrient status was also affected by the different pruning intensities. Leaf nitrogen and potassium contents increased with the increase in severity of pruning, whereas leaf calcium content was found to decrease Kaith et al. (2011).

Figure 5

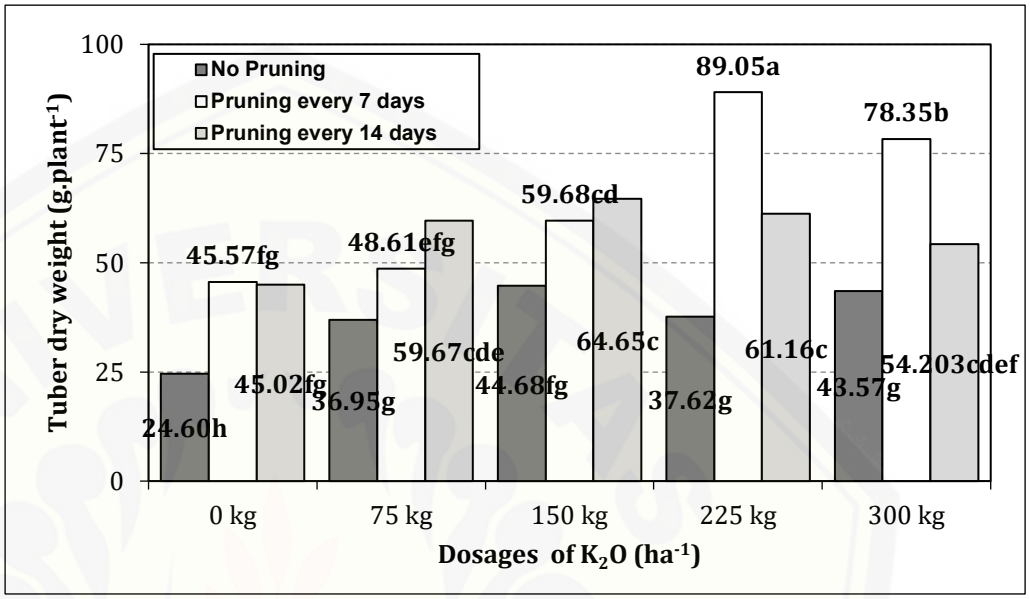

Figure 5 Effect of Pruning Intervals and Dosages of Potassium Fertilizer on Tuber Dry Weight

High potassium levels (225 kg K2O ha-1) and intensive pruning every 7 days resulted in the maximum tuber dry weight (89.05 g per plant) of yam beans Figure 5. Intensive pruning might reduce production by inhibiting flower formation and robust vegetative growth Kaith et al. (2011). Due to its essential role in plant physiology, potassium (K) is required in high concentrations; it also contributes to nutrition and photosynthetic electron translocation Tränkner et al. (2018). K2SO4 was found to increase potato tuber dry matter Bhattarai and Swarnima (2016).

Potassium plays a crucial role in the regulation of plant water status and ionic concentrations within plant tissues such as stomata Hasanuzzaman et al. (2018). Due to the increased cell strength generated by potassium deficiency, stress can be better tolerated. Potassium also regulates the flow of nutrients and sugar from the leaf to the tuber Ahmad and Maathuis (2014), Engels et al. (2012). The application of 150 kg ha-1 K2O fertilizer tends to enhance yield, the proportion of process-grade tubers, and the organic acid content of potato cultivars Tenggo and Krespo Wibowo et al. (2014).

In conjunction with a dose of 225 kg K2O ha-1, seven-day pruning maximizes plant dry weight (143.54 g) Figure 6. The development of floral and axillary buds is inhibited by intensive trimming Cooper and Saeed (1949) A flower is a potent sink; hence blossom removal will convert photosynthate into another sink, in this case the plant's body or tubers, resulting in larger tubers with a high carbohydrate content. Appropriate pruning can transport photosynthate from leaves to roots and a particular organ, allowing the plant to create glucose stores in the roots Génard et al. (2008)

Figure 6

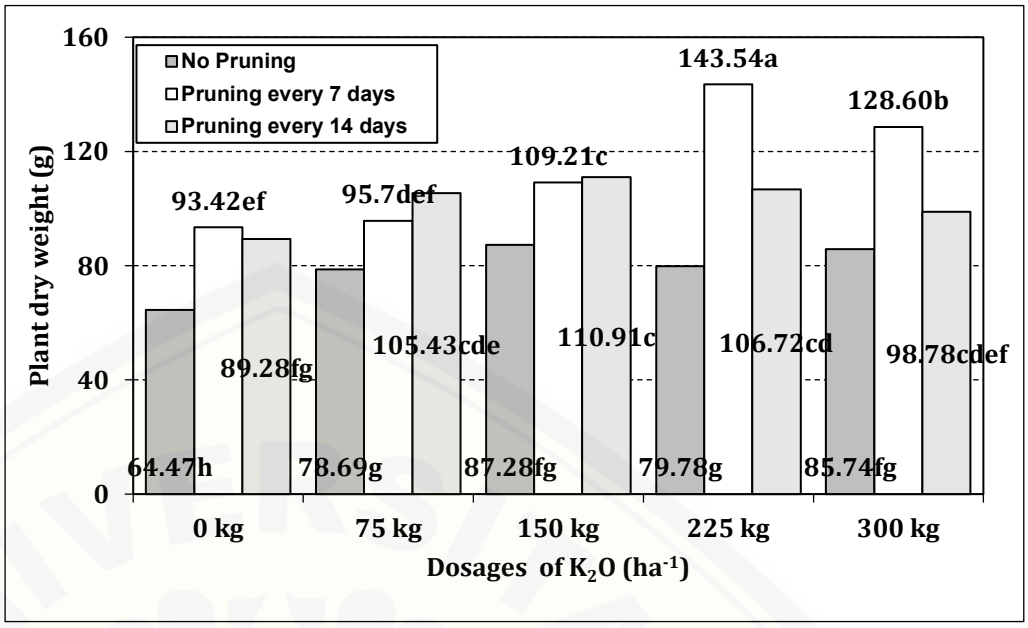

Figure 6 Effect of Pruning Intervals and Dosages of Potassium Fertilizer on Plant Dry Weight

Potassium plays a crucial function in plant physiological processes such as the movement of photoassimilates into storage organs such as tubers via the phloem solute transport system De Schepper et al. (2013). The greatest tuber carbohydrate content was 44.99 percent Figure 7 when shoots were pruned every 7 days with potassium fertilizer (300 kg ha1 of K2O), a 605 percent increase compared to no pruning and potassium fertilizer administration.

Figure 7

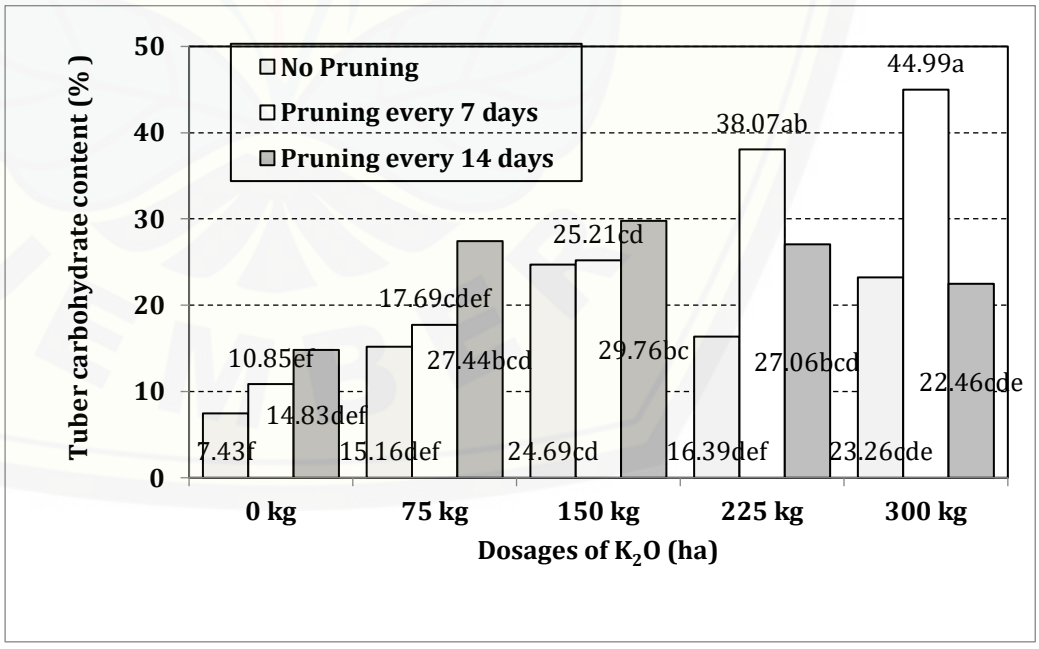

Figure 7 Effect of Pruning Intervals and Dosages of Potassium Fertilizer on Tuber Carbohydrate Content

4. CONCLUSION

Leaf area index, tuber diameter, tuber fresh weight, tuber dry weight, and total plant fresh weight and dry weight were all positively impacted by a potassium (K2O) fertilizer dose of 225 kg ha-1 when combined with weekly shoot pruning intervals of 7 days for yam beans. The tuber carbohydrate content, measured as a percentage of dry weight, was found to be highest when yam beans were pruned for their shoots once every seven days and 300 kg ha-1 of potassium (K2O) fertilizer was applied.

CONFLICT OF INTERESTS

None.

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