Growth and production of Cilembu sweet potatoes (*Ipomoea batatas* L.) varieties in the highlands with potassium fertilizer and pruning treatments

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**Abstract.** The efforts to increase the productivity of sweet potatoes is applying of potassium and pruning treatments. The objective of the study was to evaluate the effect of potassium fertilizer and pruning treatments on the growth and production of Cilembu sweet potato varieties in the highlands (1.340 m above sea level). The study was conducted at “Balai Penelitian Tanaman Sayuran” (*Vegetable Crops Research Institute*), Tongkoh Village, Berastagi – Tanah Karo on September 2018 - March 2019, using a factorial randomized block design. The first factor was potassium fertilizer (0; 7; 14 and 21 g KCl/plant) and the second factor was pruning (without pruning; pruning till 3 tendrils; pruning till 2 tendrils and pruning till 1 tendril). The result of the research showed the treatment of potassium (7-21 g/plant) significantly increased the tuber size compared to without potassium fertilizer. The combination of 7 g KCl/plant and pruning till 2 tendrils treatments significantly increased the length of the main tendrils at 10-11 week after planting and tuber length per sample. While the combination of 14 g KCl/plant and pruning till 3 tendrils treatments produced the highest tuber weight per plot.

1. Introduction

Sweet potato (*Ipomoea batatas* L.) is classified as food plant that high economic value and has many benefits, because it contains high carbohydrates and nutrients such as vitamin A (especially in cultivars with orange tuber), thiamin, riboflavin, vitamin C, vitamin E, β-carotene, iron (Fe), calcium (Ca), phosphorus (P) and potassium (K) which is very useful for health. Sweet potatoes also contain protein and fat in low concentrations in tubers, while the leaves are rich in protein, vitamins and minerals [1].

Sweet potato can grow in various soil conditions, so it is good developed in various marginal areas as a support for food diversification. Data from the Central Bureau of Statistics showed that sweet potato production in Sumatera Utara in 2016 was 91,531 ton with a harvest area of 6,378 ha and productivity of 14.35 ton/ha, an increase from 2015 of 4.7%. However, there was a decline in total production and the harvested area which previously amounted to 122,362 ton with a harvest area of 8,952 ha. Sweet potato production can be increased by fertilizing. Fertilizer application with proper in the composition and implementation is very influential for increasing plant production [2].

The main problems in production of sweet potato are generally due to inaccurate cultivation techniques, application of cropping patters and crop distribution processes. Selection of sweet potato
varieties and fertilizers are alternatives to increase the production and quality of sweet potatoes. Until now, sweet potatoes are generally used as food, therefore the quality of the plant, yield and adaptation have been given more attention. Several superior adaptive clones have been released, such as Sari, Cilembu, Beta 1, Antin-1, Daya, A82, Jago, and others [3].

Cilembu is one of the special types of sweet potato because of the tuber, when it baked, will emit a kind of sticky, sweet, and honey-sugar liquid. Therefore, Cilembu tubers are also called "honey" tubers. The tubers, in general, are sweet, but the sweet taste of Cilembu tubers is sweeter and stickier with honey sugar compared with other clones [4].

One of the inorganic fertilizers needed by sweet potato plants that can improve growth and development, especially tubers, is potassium (K). Potassium is one of the essential nutrients that play a very important role in the photosynthesis process to form new organic compounds which will be translocated to the tuber/storage organ [5].

Besides applying K fertilizer, improving cultivation techniques by pruning is an effort to increase sweet potato production. Pruning is an effort to reduce unimportant plant parts to optimize plant parts that are important for growth and production [6]. Stem pruning aims to inhibit the continuous vegetative growth of plants hence the assimilate which produced by plants will be more concentrated on the generative development of plants [7]. Previous research stated that the pruning treatment on sweet potato plants has an effect in increasing stem length, number and length of secondary branches, number and length of primary branches, and number of shoot cuttings measuring 25 cm [8].

Based on these backgrounds, this research aimed to evaluate the effect of potassium fertilizer and pruning treatments on the growth and production of Cilembu sweet potato in the highlands.

2. Materials and methods

2.1. Research site and materials
The research was conducted at Tongkoh Vegetable Research Institute, Berastagi, Sumatera Utara (± 1340 meters above sea level) from October 2018 to March 2019. The result of soil analysis were presented in table 1.

| Parameter | Result analysis | Unit    | Analysis method          |
|-----------|-----------------|---------|--------------------------|
| Ca-exch   | 4.76            | me/100g | Ammonium Acetate pH 7    |
| CEC       | 16.49           | me/100g | Ammonium Acetate pH 7    |
| K-exch    | 0.90            | me/100g | Ammonium Acetate pH 7    |
| Mg-exch   | 1.36            | me/100g | Ammonium Acetate pH 7    |
| Na-exch   | 0.16            | me/100g | Ammonium Acetate pH 7    |
| P-Bray    | 80.21           | mg/kg   | Spectrophotometry        |
| C-Org     | 2.94            | %       | Walkley & Black          |
| N-Kjehl    | 0.51            | %       | Kjehl - Spectrophotometry|
| pH-H2O    | 5.80            | %       | Electrometry             |

Source: PT. Socfin Indonesia -Medan (2020)

The materials used were sweet potato shoot cuttings of Cilembu variety, KCl, Urea and TSP fertilizers, water and other materials that support this research. The tools used are hoes, knives/cutters, samples labels, gauges, analytical scales, watering can, and other supporting tools.

2.2. Design experiment and management of crop
The research use a factorial randomized block design with 2 factors. The first factor was K fertilizer dose, consists of 4 levels (K₀: 0 g KCl/plant (control); K₁: 7 g KCl/plant (220 kg KCl/ha); K₂: 14 g
KCl/plant (440 kg KCl/ha); K3: 21 g KCl/plant (660 kg KCl/ha). The second factor was pruning, consists of P0: without pruning; P1: pruning till 3 tendrils; P2: pruning till 2 tendrils; P3: pruning till 1 tendril.

The research was started with soil cultivation to a depth of 20 cm, then a plot was made with a length of 200 cm, 100 cm wide, a height of 30 cm with 50 cm spacing between blocks and a distance between the plots of 30 cm. A drainage ditch as deep as 30 cm was made around the area to avoid stagnant water around the research area. The land that had been made of treatment plots was then mixed with compost (5 t/ha).

The seedlings used were sweet potato shoot cuttings of Cilembu variety, originating from Tiga Raja Village with a length of 20-25 cm and relatively the same seed size. KCl fertilizer was given based on the dose by burying it about 5 cm near the plant and covered with soil. Fertilization was carried out at 2 and 5 weeks after planting (WAP) the sweet potato cuttings.

Basic fertilization was carried out one week after planting. Fertilizer was applied based on the recommendation of the Indonesian Agricultural Research and Development Center according to the recommended dosage for sweet potato fertilizer, namely Urea 200 kg/ha (40 g/plot) and TSP 100 kg/ha (20 g/plot). Fertilization is done by burying and covered again with the soil.

Shoot cuttings were planted perpendicular to the base of the cuttings immersed (1/3 of the cuttings) hence 2/3 of the cuttings were above the ground, the spacing used was 30 cm. Each hole was planted with 1 cutting, each bed was planted with 6 sweet potato cuttings. Pruning was carried out according to the treatment at 8 WAP and kept under control hence new tendrils did not appear again. Plant maintenance included watering, stitching, lifting stems, weeding, controlling the pests and diseases and also harvesting. Watering was done every day, at morning or evening depending on weather conditions. Stitching was carried out on 1 WAP, with the aim of replacing damaged/non-growing cutting. Lifting the stem aimed to prevent the formation of small tubers was carried out every week of observation. Weeding was done to control weeds around the plots and blocks. Weeding was carried out according to the conditions in the field at 2,5,7 and 11 WAP.

Pest and plant disease control was carried out manually by removing the existing pests on plants and replacing plants which affected by the disease with transplanting plants, while plants which affected by disease before harvesting were not replaced with transplanting plants. Insecticides and fungicides spraying were not carried out because the pests in the field were classified as 'having not reduced production yields' or were not detrimental. Pest controls was done manually. Spraying of insecticides and fungicides is not carried out because the pest in the field are not classified as reducing production yields or are harmful. Harvesting was done when the sweet potato reached 20 WAP (5 months) old with the harvest criteria can be seen with the color of the leaves starting to turn yellow and then falling off. Sweet potato plants can be harvested when the yams are old (physiologically ripe).

The observed variables included length of the main tendrils, length of tubers/sample, shoot dry weight, tuber weight per sample, tuber weight average and tuber grading. The average tuber weight is calculated by dividing the tuber weight by number of tubers. Fresh tuber grading refers to SNI 01-4493-1998 with the following criteria: class A (tuber weight > 200 g/tuber); class B (tuber weight > 100 - 200 g/tuber); class C (tuber weight 75-100 g/tuber).

2.3. Data analysis
Data were analyzed using the Analysis of Variance. If the Analysis of Variance results showed a significant effect, then proceed with the Mean Difference Test based on the Duncan Multiple Range Test (DMRT) at the level of α = 5%.
3. Results and discussion

3.1. Results

3.1.1. Main tendril length. The interaction of potassium fertilizer and pruning treatments had a significant effect on the length of the main tendrils at 10 and 11 WAP. The combination of 7 g KCl/plant fertilizer with pruning till 2 tendrils treatments (K1P2) was the best treatment combination in increasing the length of the Cilembu sweet potato main tendrils at 10 and 11 WAP, 58.52 cm and 65.51 cm, respectively. While the combination of 21 g KCl/plant fertilizer with pruning till 1 tendril treatments (K3P1) was the lowest treatment combination in increasing the length of the main sweet potato tendrils at 10 and 11 WAP (Table 2).

Table 2. Main tendril length of sweet potato 10-11 WAP with application of potassium fertilizer and pruning

| WAP | Potassium fertilizer (g KCl/plant) | Pruning | Main tendril length (cm) | Mean |
|-----|-----------------------------------|---------|--------------------------|------|
|     | Without pruning (P0) | Pruning till 3 tendrils (P1) | Pruning till 2 tendrils (P2) | Pruning till 1 tendril (P3) |
| 10  | K0(0) | 46.50def | 52.58abcd | 47.79def | 42.03fg | 47.22 |
|     | K1(7) | 48.44def | 44.68efg | 58.52a | 57.15ab | 52.20 |
|     | K2(14) | 47.71def | 46.41def | 50.86bcde | 39.64g | 46.16 |
|     | K3(21) | 56.31abc | 49.81cde | 51.35abcde | 50.09cde | 51.89 |
| Mean | 49.74 | 48.37 | 52.13 | 47.23 |
| 11  | K0(0) | 52.84cde | 56.21bcd | 51.46cde | 46.45ef | 51.74 |
|     | K1(7) | 55.00bcd | 48.30def | 65.51a | 63.53ab | 58.08 |
|     | K2(14) | 54.38bcde | 48.14def | 54.18bcde | 41.63f | 49.58 |
|     | K3(21) | 60.13abc | 53.94cde | 52.78cde | 51.18cde | 54.51 |
| Mean | 55.58 | 51.65 | 55.98 | 50.70 |

Note: The number followed by the same letter and time of observation shows that it is not significantly different based on Duncan Multiple Range Test (DMRT) at the level of α = 5%

This is because pruning sweet potato plants can break apical dominance, so that the development of the plant stems is inhibited. While the application of 7 g KCl/plant increased the length of the tendrils because potassium plays a role in the photosynthesis process which affects plant growth as indicated by the increase in the length of main tendrils.

This is in line with Novianti [8]; Jayanti et al. [9]; Netsay et al [10] which stated that pruning resulted in shorter average growth of stem than without pruning and vice versa. Pruning sweet potato plants can break the apical dominance. Thus inhibiting the development of the plant stem. The main stem of the plant contains food reserves hence plants with a higher main stem will have more food reserves. This food reserve is a source of energy; hence plants with more food reserves will have better plant growth.

3.1.2. Tuber length, shoot dry weight, tuber weight per plot, average tuber weight. The interaction between potassium fertilizer and pruning treatments had a significant effect on tuber length and tuber weight per plot. Potassium fertilizer and pruning treatments and also the combination between them had no significant effect on tuber length, shoot dry weight, tuber weight per plot and average tuber weight. The combination of K fertilizer (7 g KCl/plant) and pruning till 2 tendrils treatments resulted in the highest tuber length per sample (table 3).
This fact shows that there is a link between potassium fertilizers and pruning in increasing the production of Cilembu sweet potato. K fertilizer in plants plays a role in increasing cell turgor activity to help the process of closing and opening the stomata and translocation of photosynthate from leaves to all parts of the plant, which ultimately affects plant weight [11].

In this research, the highest tuber weight per plot was obtained at 14 g KCl/ha of K fertilizer and pruning till 3 tendrils treatments. This is reasonable because the application of K as much as 14 g KCl/plant will have an impact on increasing the rate of photosynthesis, following the function of K which plays an important role in photosynthesis, and assimilate translocation. Pruning till 3 tendrils

Table 3. Tuber length, shoot dry weight, tuber weight per plot, average tuber weight of Cilembu sweet potato tuber with application of potassium fertilizer and pruning

| Treatment | Tuber length (cm) | Shoot dry weight (g) | Tuber weight per plot (g) | Average tuber weight (g) |
|-----------|------------------|----------------------|--------------------------|--------------------------|
| Potassium fertilizer (g KCl/plant) | | | | |
| K₀ (0) | 24.78 | 96.96 | 3666.88 | 133.96 |
| K₁ (7) | 27.33 | 119.72 | 4391.25 | 156.72 |
| K₂ (14) | 23.93 | 118.89 | 4576.25 | 155.89 |
| K₃ (21) | 25.52 | 125.77 | 4348.63 | 162.77 |
| Pruning (P) | | | | |
| P₀ (without pruning) | 24.87 | 117.70 | 4295.50 | 154.70 |
| P₁ (pruning till 3 tendrils) | 26.15 | 103.05 | 4138.75 | 140.05 |
| P₂ (pruning till 2 tendrils) | 26.37 | 125.55 | 4557.50 | 162.55 |
| P₃ (pruning till 1 tendrils) | 24.16 | 115.04 | 3991.25 | 152.04 |
| K x P | | | | |
| K₀P₀ | 23.20cd | 117.37 | 3197.50 d | 154.37 |
| K₀P₁ | 28.13ab | 89.06 | 4160.00 abc | 126.06 |
| K₀P₂ | 25.81abcd | 94.41 | 4280.00 abc | 131.41 |
| K₀P₃ | 21.97d | 87.00 | 3030.00 d | 124.00 |
| K₁P₀ | 23.34cd | 99.11 | 4420.00 abc | 136.11 |
| K₁P₁ | 28.21ab | 99.34 | 3310.00 cd | 136.34 |
| K₁P₂ | 29.08a | 146.80 | 5135.00 a | 183.80 |
| K₁P₃ | 28.70a | 133.63 | 4700.00 ab | 170.63 |
| K₂P₀ | 23.75bcd | 118.01 | 5020.00 a | 155.01 |
| K₂P₁ | 23.73bcd | 115.11 | 5220.00 a | 152.11 |
| K₂P₂ | 26.60abc | 136.97 | 4530.00 abc | 173.97 |
| K₂P₃ | 21.65d | 105.48 | 3535.00 bcd | 142.48 |
| K₃P₀ | 29.20a | 136.31 | 4544.50 ab | 173.31 |
| K₃P₁ | 24.54abcd | 108.71 | 3865.00 abc | 145.71 |
| K₃P₂ | 23.99bcd | 124.04 | 4285.00 abc | 161.04 |
| K₃P₃ | 24.34bcd | 134.04 | 4700.00 ab | 171.04 |

Note: The number followed by the same letter and column shows that it is not significantly different based on Duncan Multiple Range Test (DMRT) at the level of α = 5%
allow the sweet potato plant to produce enough leaves hence the photosynthetic capacity increases [12].

Therefore, there is a link between the role of K and pruning. K is also a nutrient that functions to form and stimulate protein synthesis, translocation of carbohydrates, stimulate root growth and development, increase root turgor pressure, increase nutrient absorption. N metabolism, carbohydrate metabolism, regulate the utilization of various main nutrients, and activate various enzymes [5,13-17].

3.1.3. Tuber grading. K fertilizer treatment significantly increased tuber grading for class A and C. while pruning treatment had no significant effect on tuber grading. K fertilizer treatment as much as 7-21 g KCl/ha significantly increased the grading of tuber grade A, but decreased tuber grade C (table 4).

| Grade | Potassium fertilizer (g KCl/plant) | Pruning | Mean |
|-------|-----------------------------------|---------|------|
|       | Without pruning (P0) | Pruning till 3 tendrils (P1) | Pruning till 2 tendrils (P2) | Pruning till 1 tendrils (P3) |
| Grade A | K0 (0) | 2.50 | 3.00 | 2.50 | 2.00 | 2.50b |
|        | K1 (7) | 3.50 | 3.50 | 4.00 | 4.00 | 3.75a |
|        | K2 (14) | 5.00 | 3.00 | 2.50 | 2.50 | 3.25ab |
|        | K3 (21) | 4.50 | 4.00 | 3.50 | 3.50 | 3.88a |
| Mean   | 3.88 | 3.38 | 3.13 | 3.00 |      |
| Grade B | K0 (0) | 1.50 | 2.50 | 3.00 | 1.50 | 2.13 |
|        | K1 (7) | 3.00 | 1.00 | 2.00 | 1.50 | 1.88 |
|        | K2 (14) | 1.50 | 3.00 | 2.50 | 1.00 | 2.00 |
|        | K3 (21) | 2.50 | 2.00 | 2.00 | 2.50 | 2.25 |
| Mean   | 2.13 | 2.13 | 2.38 | 1.63 |      |
| Grade C | K0 (0) | 2.00 | 2.50 | 2.00 | 3.00 | 2.38a |
|        | K1 (7) | 1.50 | 2.00 | 1.00 | 1.50 | 1.50b |
|        | K2 (14) | 1.50 | 1.50 | 1.50 | 1.50 | 1.50b |
|        | K3 (21) | 1.00 | 1.00 | 1.50 | 1.00 | 1.13b |
| Mean   | 1.50 | 1.75 | 1.50 | 1.75 |      |

Note: The number followed by the same letter and column at the same parameter shows that it is not significantly different based on Duncan Multiple Range Test (DMRT) at the level of α = 5%

This is because tuber grading is carried out based on the height of the tuber weight. while tuber weight describes the ability of a plant to translocate assimilate to the storage organ portion of the total assimilate obtained. K fertilizer plays a very important role in carbohydrate metabolism which determines the size of the tubers [17]. K nutrient plays a very vital role in influencing tuber formation and weight because it serves to stimulate the formation of protein and carbohydrates as important constituents of tubers (sweet potatoes) and root development for plants [18]. Therefore, in this research, the grade A tuber grading increased along with the increase in K fertilization.

4. Conclusions
The treatment of potassium (7-21 g/plant) significantly increased the tuber size compared to without potassium fertilizer. The combination of 7 g KCl/plant and pruning till 2 tendrils treatments significantly increased the length of the main tendrils at 10-11 week after planting and tuber length per
sample. While the combination of 14 g KCl/plant and pruning till 3 tendrils treatments produced the highest tuber weight per plot.

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