Plant Architectural Arrangements to Improve Production and Quality of Brazilian Spinach

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Abstract. Brazilian spinach (*Alternanthera sissoo*) is an extremely nutrient-rich leafy vegetable plant species native to Brazil and South America. It packs high amounts of carotenoids, vitamin C, vitamin K, folic acid, iron, and calcium. Brazilian spinach leafy vegetable is a low-growing perennial that forms a neat stack of up to 30 cm high, rather than spread out on the mat. COver 2 months growth leaf become small, fibrous taste, and grow horizontally that cause pest investment. Brazilian spinach is an annual herb that can be increased of quality and production by pruning. Pruning of Brazilian spinach is carried out at the Screenhouse on the seedbed in Karangploso from May to August 2022. Pruning to arrangements the plant architecture were carried out by leaving 1 internode, 2 internodes, 3 internodes, and 4 internodes on the stem and control, each repeated 4 replications with 5 treatment with 6 plant samples in each treatment. Observations were made on the number of main stem, the number of axilary branches, the number of leaves, the length of the main stem, the number of internodes, the fresh weight of the plant, and the fresh weight of the leaves. Plant architecture create using Corel Draw, and the observation of the pest attacks percentage was carried out by calculating the percentage of attacks of Spodoptera sp., and Bemicia tabaci attacks. Organoleptic test on 16 respondents on color, scent, texture, flavor, and overall appearance category. The results showed that the arrangement of plant architecture by pruning effected on the agronomic character of the plant, the percentage of Spodoptera sp. And Bemicia tabaci attacks, and consumer preferences for the consumption of spinach. Pruning by leaving 3 internodes showed the best growth and yield of plants, while the preference for spinach consumption criteria was found in spinach with 4 internode pruning.

Keywords: Agronomy characters · Brazilian spinach · Consumption criteria · Pest percentage · Pruning

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1 Introduction

Brazilian spinach (*Alternanthera sissoo*) is an extremely nutrient-rich leafy vegetable plant species native to Brazil and South America. It packs high amounts of carotenoids, vitamin C, vitamin K, folic acid, iron, and calcium [1] Another important matter of consideration is of growing Brazilian spinach is very easy and convenient. Brazilian spinach leafy vegetable is a low-growing perennial that forms a neat stack of up to 30 cm high, rather than spread out on the mat. This growth habit makes it a handy plant for edging paths, especially in partial shade because it is quite a shade tolerant [2]. The plant is tolerated in full sun to medium shade. This soft plant can grow up to 30 cm tall with leaves about 2.0–3.5 cm wide. Brazilian spinach that reaches a height of 30 cm tends to grow sideways and results in the growth of new branches that have leaf sizes less than 2.0 cm. While the leaves that grow will become old and taste hard if consumed.

Pruning is a common way to regulate plant architecture while increasing crop production, especially in annual fruit and vegetable crops. In addition to affecting the production and health of plants, pruning with plant architectural arrangements can maintain plant life so that plants can grow longer. Pruning is generally done on the plant branches, internodes, or the main stem of the plant. Pruning is common in vegetable crops, such as tomatoes to reduce the number of flowers formed, to produce tomatoes with large fruit [3, 4], or reduce the incidence of attack. Wilt disease [5], or stimulate the formation of vegetative shoots so that the leaf space that produces photosynthate is wider so that the quality of the fruit produced will also be better [6, 7]. According to [8] that pruning on okra plants can stimulate the formation of buds and branching, where more branches, will stimulate the growth of the flowers that come out. Pruning on Brazilian spinach is generally done by taking the top of the plant by leaving the plant part about 10 cm from the ground or by taking the young branches and leaving the old branches. This results in irregular plant growth and different growth processes between plant branches. The growth of different branches resulted in differences in the size of the leaves formed. An assessment of the pruning method on Brazilian spinach has never been done to obtain maximum production results, including those related to the health of Brazilian spinach and the taste of Brazilian spinach for consumption. So, in this paper, we will discuss the effect of setting plant architecture by pruning on the quantity and quality of Brazilian spinach production.

2 Methodology

The study was conducted from May to August 2022 in a seedbed of screen house with an average temperature of 17 °C to 27.6 °C, and air humidity of 96% [9]. The screen house located at an altitude of ± 496 m above sea level. The study was arranged based on a randomized block design with 5 treatments and 4 replications with 6 samples in each treatment. The size of the experimental plot is 1.5 x 1 cm. Ant pruning once when the plant is 30 cm (± 2 months) tall, leaving several internodes of the plant with the following details (A) Control, (B) Leaving 1 internode, (C) Leaving 2 internodes, (D) Leaving 3 internodes, (E) Leaving 4 internodes. Leaves on the stems/branches of treatment plants were removed include for control plants. Plant maintenance is done by watering every

2 times a day or when the plants were dry, fertilization is done at the beginning of treatment, 2, 4, and 6 weeks after treatment. Pest control is done manually by taking pests that attack plants. Plant architecture was observed at the end of the observation by drawing plant growth patterns according to predetermined standard criteria. While the observations of agronomic characters conducted on several characters as follows:

a. Number of main stem

The number of main branches is measured at the main stem that is formed after pruning, with the characteristics of the branch being directly connected to the base of the stem. The number of main branches is measured at intervals of once a week.

b. Number of axilary branches

The number of sub-branches is measured by counting the number of branches attached to the main branch or branches growing on the trunk internodes. The number of branches is measured at intervals of once a week.

c. Number of leaves

The number of leaves is measured by counting the entire leaf of the plant that grows with the criteria of having a leaf size for consumption or approximately having a minimum size of 3 cm long and 4 cm wide.

d. Main stem length

The length of the main branch was measured by measuring the length from the base of the stem (near the base of the root) to the longest part of the stem. The main branch is a stem that grows horizontally from the soil surface.

e. Number of nodes

The number of nodes is measured by counting the number of nodes on each stem, both in the main branch and in the sub-branches.

f. The wet weight of the plant

The wet weight of the plant was measured by weighing all parts of the plant immediately after harvest.

g. The wet weight of the leaf

Leaf wet weight was measured by weighing all the leaves on the plant according to the criteria immediately after harvest.

In addition to morphological characters, the percentage of plant pests attacks was also recorded, such as:

a. Percentage of Caterpillar (*Spodoptera sp.*) attack

The percentage of caterpillar attacks was measured by counting the number of plants attacked by caterpillars in all sample plants.

b. Percentage of aphids (*Bemicia tabaci*) attack

The percentage of aphids attacks was measured by counting the number of plants infected with aphids in all sample plants.

The organoleptic test on brazil leaves conducted 16 respondents. The results of the organoleptic test were analyzed descriptively. While the agronomic data were analyzed by ANOVA using the Rstudio program, the significant difference in the analysis results was further tested using the Tukey test with a 5% confidence level. The plant architecture is done with Corel Draw software.

3 Result and Discussion

3.1 The Impact of Plant Architecture Arrangement on Plant Morphology

Several morphological characteristics affected plant growth include the addition of the main stem, the number of axilary branches, the number of leaves, the number of internodes, the length of the main stem, and the canopy. Pruning effectively affects the meristematic parts of the plant. In Brazilian spinach, it is known that the meristematic part is found on the soft stem. Brazilian spinach is a dicotyledonous plant that does not have a cork cambium on its stem, and its cambium activity is quite low affect less phloem and xylem are produced. As a result, the stems of herbaceous dicotyledonous plants look smaller while compared to dicotyledonous plants in general. The part of the stem that grows earlier has more cambium accumulation, pruning treatment based on the number of internodes formed will have a significant effect.

Based on observations, it was found that the highest number of main stems was found in plants that were cut leaving 1 internode, and the least was found in control plants that were not pruned. Control plants will lengthen the main stem resulting only 1 main stem that grow too long and dry until die. Meanwhile, pruning by leaving 1 internode produces more meristematic spots compared to other treatments, which are usually only found on the main stem internode. The longest main stem length was found in control plants that were not pruned, while the second length was found in 4 internode pruning, then 3 internodes, 2 internodes and the shortest was 1 internode (Table 1). The length of the main stem in the control plants experienced continuous long growth followed by an increase in the number of axilary branches on the main branch. When compared between pruned plants, 4 internode pruning showed a faster main stem growth than other pruning. This is because at 4 pruning the longer main stem growth allows the plant to immediately form new branches/axilary branches from the remaining internodes during pruning, while the pruned part will cause a new growing spots with a new main stem. Conversely, the shorter position of internodes, the longer ability to form new branches, so the plants tend to be shorter.

The highest number of axilary branches formed on the main stem by pruning showed that were not significantly different in the control plants and the pruning of 3 internodes. Following by pruning of 1,2, and 4 internodes. The number of branches is affected by the length of the main stem. By the data on the number of axilary branches in the control treatment, which is the length of the main stem is longer than the others. While the number of axilary branches in 3 internodes pruning has the second largest number of branches even though the main stem length is the third longest. It cause the internodes on the axilary branches that are formed on the main branch at 3 internodes pruning have a shorter distance, allowing the formation of more branches. The number of internodes, show that the control plants have the highest number of internodes. This was followed by the pruning of 3 internodes, 4 internodes, and 2 internodes that were not significantly different (Table 1). While pruning 1 internode has least number of internodes. This result is following by [1] where in Brazilian spinach the internodes will grow on the main stem or axilary branches. So the longer of the main branch, the more internodes are formed. In addition, the shorter internode distance on the main stem allows the formation of more internodes.

The leaves on the Brazilian spinach plant grow on the stems, axilary branches, and internodes. Control plants had the highest number of leaves, followed by the pruning of 3 internodes. Meanwhile, pruning of 2 internodes, 4 internodes, and 1 internode showed results that were not significantly different (Table 1). The number of leaves on the control plants was the highest even though the size tended to be small, while the number of leaves on the 3 internode pruning tended to have the same size on every part of the plant. Because the length of the main stem, the number of axilary branches, and the number of internodes of the control plants were the highest, the number of leaves was also the highest. Meanwhile, plants with 3 internode pruning had the second largest number of axilary branches which not significantly different from the control, the second largest number of internodes, and the third longest stem length, and had the second highest number of leaves after control plants. The plant canopy is influenced by the character of the length of the main stem, the number of main stems, the number of axilary branches, the number of internodes, and the number of leaves. The widest plant canopy was found in control plants, followed by pruning of 3 internodes, and 4 internodes. Meanwhile, plants with 1 internode and 2 internode pruning had the smallest canopy (Table 1).

The highest wet weight of the plant was found in the control treatment, following pruning 4 internodes, 3 internodes and 2 internodes that were not significantly different, and the smallest found at pruning 2 internodes. Meanwhile, the wet weight of the leaf which is the highest production component in Brazilian spinach was obtained in the control treatment, then pruning 4 internodes, 3 internodes, and 1 internode, that were not significantly different, then the smallest found in pruning 2 internodes (Table 1). From these results, it can be said that the control plants had the highest yield, while the least was pruning 2 internodes.

Pruning significantly affects the architectural form of the plant. Following the statement that the architecture of each plant species is uniquely specified through the activities of indeterminate and determinate meristems [10]. Indeterminate meristems are replenishing reservoirs of undifferentiated plant cells needed for continued plant growth. In aerial tissues, these indeterminate meristems establish the placement of leaves, the position of nodes and branches, and internode distances. This reiterative vegetative growth arises from a single point and is referred to as monopodial growth. Cells of determinate meristems differentiate to form the reproductive structures of inflorescences and flowers. Because the apical meristem terminates in this case, the most proximal axillary bud must be released from apical dominance to continue the species-specific body plan. This is referred to as sympodial growth.

Pruning in addition to affecting the shape of the canopy, also affects the speed of growth, the number of branches and branches formed, differences in the direction of growth of the main stem and branches, to the presence of flowers. Grouped the types of plant architecture in tropical forests into 4 categories based on: (1) the growth process, (2) the branching process, (3) the morphological differentiation of axes, and (4) the position (lateral vs. terminal) of reproductive structures [11, 12].

Table 1. The results of observations of agronomic characters with various pruning methods

Treatments	Number of main stems	Number of axilary branches	Number of leaves	Main stem length	Number of internodes	Canopy	The wet weight of the plant	The wet weight of the leaf
A	1 d	40.8 a	1068.6 a	114.9 a	409.4 a	56.4 a	991.70 a	333.80 a
B	9 a	24.8 b	451.6 c	50.4 d	134.4 c	25.4 c	384.32 c	160.74 b
C	7 c	24.6 b	557.0 c	61.0 d	156.6 b	27.2 c	244.90 d	85.40 c
D	8 b	34.2 a	720.8 b	80.3 c	166.2 b	54.2 ab	417.32 c	166.04 b
E	7 c	20.6 b	495.8 c	99.4 b	159.0 b	46.4 b	524.32 b	190.14 b

Explanation: (A) Control, (B) Cut internode 1, (C) Cut internode 2, (D) Cut internode 3, (E) Cut internode 4. The letters behind the numbers indicate that there is a difference between each treatment.

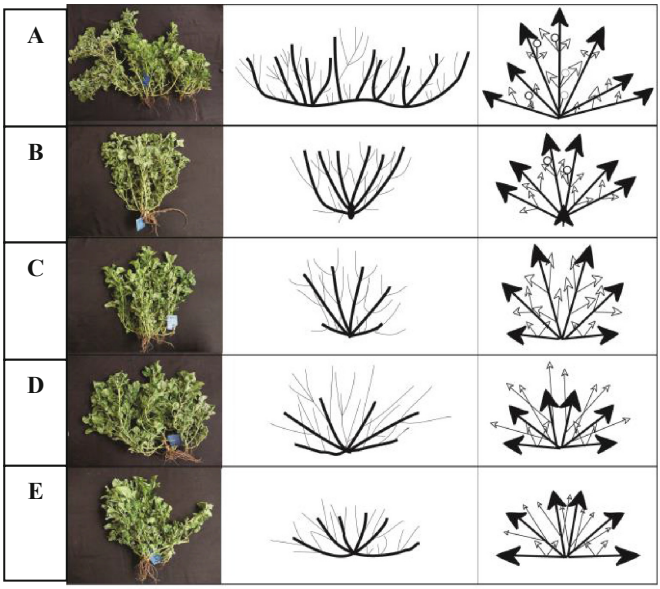

Fig. 1. Plant architecture due to pruning effect. Note: black arrows = stopped main branch growth, white arrows = indeterminate growth of sub-branches, and white circles = inflorescence. A = control; B = 1 internode; C = 2 internodes; D = 3 internodes; E = 4 internodes.

3.2 The Impact of Plant Architecture Arrangement on the Percentage of Spodoptera Sp and Bemicia Tabaci Attacks

Regarding the effect of plant architecture on colonization and damage by leaftying caterpillars of Quercus alba showed that the arrangement of plant architecture binds the branching of plants so that it affects the plant canopy which has an impact on the regulation of plant leaf attachment, indicating that the arrangement of plant architecture can minimize contact between plant leaves so that reduce leaftying caterpillar attacks [13]. The results of observations of the arrangement of plant architecture through pruning of Brazilian spinach against *Spodoptera* and *Bemicia* attacks showed that control plants had the highest percentage of attacks. Meanwhile, the lowest percentage of *Spodoptera* attacks was found in 3 internode pruning and the lowest *Bemicia* attack was found on all pruned plants (Figs. 2 and 3).

Control plants had the highest attack because the plants grew very densely, the leaves covered each other and created a good ecosystem for the growth of the two pests. *Spodoptera* will lay their eggs on the underside of the leaves and invisible until adult caterpillars that eat plant leaves. In addition, the underside of the plant leaves is a hiding place for leaf caterpillars. While the *Bemicia tabaci* will attach their eggs and spend the pupa period on the underside of the leaves. Causes yellowish spots on the leaves due to the uneven distribution of chlorophyll. In addition, adult *Bemicia* will cause whitish to blackish patches on plant leaves. The damage caused by these two pests resulted in reduced production of Brazilian spinach plants. By the standard for spinach grades [14], consumption of spinach leaves should be protected from serious damage by pests that cause the plants to change color drastically, the presence of insects on the leaves of plants that are infested to cause damage, free from white spots or other plant diseases that cause damage. Can reduce the quality of consumption crops, and finally not rot.

Damage to plant leaves also reduced photosynthetic yields caused in the inhibition of plant growth. This can be seen in the control plants which have a small number of leaves and size of branches, although there are many. Leaf size for consumption on control plants also tended to be small when compared to leaves on pruned plants. That case caused the decrease in photosynthate due to caterpillar attacks on Populus deltoids resulted in a decrease in the number of shoots and branching [15]. The large leaf size also causes attacks by *Anacampsis niveopulvella* [16]. In this case, the broad leaves

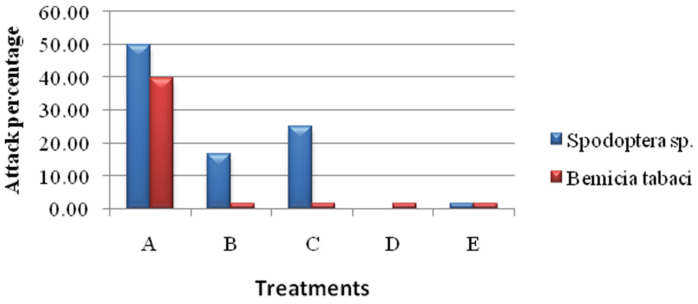

Fig. 2. Percentage of attack *Spodoptera sp.* And *Bemisia tabaci.*

Fig. 3. Attack of *Spodoptera sp.* (a) and *Bemisia tabaci* (b) on Brazilian spinach leaf

synergize with the closure between the leaves of the plant which resulted in an increased attack of the leaf caterpillar *Spodoptera sp* on the Brazilian spinach control plant.

3.3 The Impact of Plant Architecture Arrangement on the *Appearance of Brazilian Spinach Leaves Consumption*

It has been explained previously that plant architecture affects plant growth, in this case including affecting plant leaf growth. In plants whose leaves are taken for consumption, the accuracy of harvesting age and plant visuals affect the intensity of consumption, and affecting the nutritional value of the food. Pruning affects to shape of the architecture of the plant and will affect the age of the growing leaves. The results of an organoleptic survey of 16 respondents showed that leaf color and leaf aroma were most favored at 1 internode pruning, and leaf texture, taste, and general appearance at 4 internode pruning (Fig. 4).

The color and aroma of the leaves were most preferred at 1 internode pruning, indicating the color of the leaves was fresh dark green and the aroma was savory (no unpleasant smell). While the texture, taste, and overall appearance were obtained at 4 internodes pruning with a texture that was neither soft nor hard, with a neutral (not bitter) taste. Respondents from the age range of 20–55 years chose the leaves on 4 internodes pruning had the criteria for consumption.

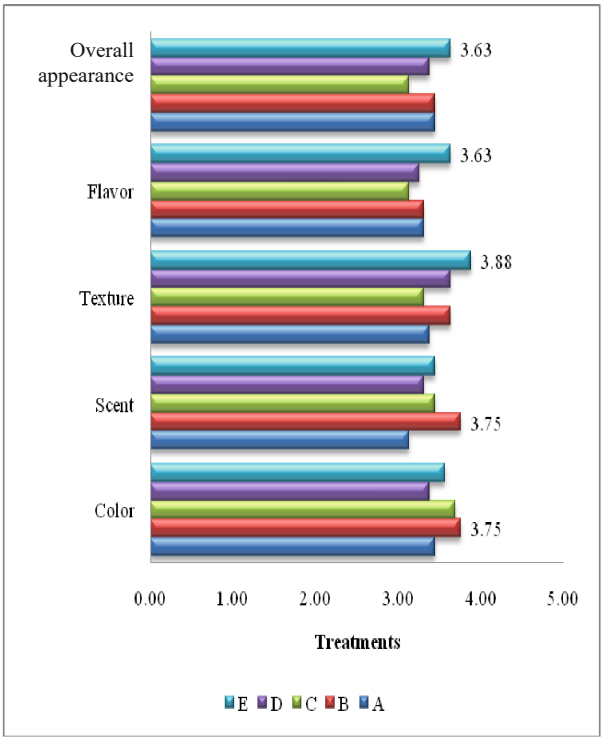

Fig. 4. The results of the organoleptic test of the brazil spinach pruning

4 Conclusion

Arrangement of plant architecture by pruning affects the agronomic character of the plant, the percentage of *Spodoptera sp.* And *Bemicia tabaci* attacks, in line with consumer preferences for consuming spinach. Pruning by leaving 3 internodes showed the best plant growth and yield, while the preference for the consumption spinach criteria was found in spinach with 4 internode pruning.

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