Comparison of brazilian spinach plant (*Alternanthera sissoo*) cultivation techniques in wiremesh tower garden and conventional land

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Abstract. A city depends on the area of the village around the city, which has food providers. One of the problems in urban areas is converting agricultural land to non-agricultural land, causing a lack of agricultural areas in the city. This study aims to determine the effectiveness of the Wiremesh Tower Garden (WTG) cultivation method compared to the conventional method and determine Brazilian spinach's growth response and yield when grown vertically on WTG. This research was conducted at the Experimental Garden and Laboratory of the Agrotechnology Study Program, Faculty of Science, Engineering, and Design, Universitas Trilogi, from August to November 2022. WTG and conventional cultivation were placed in an area with the same size plot to be compared fairly. WTG was set by a distance of 60 cm each other with five replications, and conventional cultivation was carried out on five beds with a size of 1 x 2 m2. Brazilian spinach cultivation using WTG showed lower results compared to conventional cultivation. However, based on production variables, WTG was still recommended because WTG's land use still needs to be optimal. The best planting position on WTG was the peak, followed by the top, middle and bottom positions based on production variables.

1 Introduction

A city will have a dependence on the village area around the city, which basically has a food provider [1]. One of the problems faced in urban areas is the conversion of agricultural land to non-agricultural land, causing a reduction in agricultural areas in a city. Therefore, the availability of food in urban areas is decreasing, which is feared to threaten food security in the household sphere. In an effort to increase food security in households, it is necessary to innovate plant cultivation technology, which is currently known as urban farming.

Urban farming is defined as the processing, distribution, and farming of various commodities, such as food, livestock, and vegetables, that are included outside and within the urban suburbs [2]. The importance of urban farming increases when there is an economic crisis that affects the security of the country [3]. Food safety that is prioritized for the middle and lower urban communities will be an important issue in the future. This application encourages independence in food procurement on a household scale. In today's trend,

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innovations from technological advances and thinking in the agricultural sector are growing rapidly. Various urban farming methods have many techniques, such as aquaponics, verticulture, and hydroponics, but each cultivation technique has its weaknesses and advantages.

Land use efficiency is one of the things that is considered in urban farming because there is only a small amount of land owned by the community in urban areas. In addition, most of the land and space available in urban areas are in the form of pavement. Therefore, an idea arose to develop another plant cultivation technique called Wiremesh Tower Garden (WTG). Wiremesh Tower Garden Perforated iron for the needs of agricultural cultivation techniques that are commonly used as a buffer for planting media, and the shape of WTG is unique because the cultivation technique is between the holes Wiremesh [4]. Wiremesh Tower Garden is a cultivation technique that is planted vertically with a size of 2 cm which is shaped like a tube, coated with black plastic that is perforated and the middle part is given a used mineral water bottle as a plant care such as watering [5]. Wiremesh Tower Garden is a solution for Urban Farming-based plant cultivation.

Brazilian spinach is a plant that belongs to the family Amaranthaceae which originated from the South American continent and has high antioxidant activity [6]. Brazilian spinach, according to [7], is an annual plant that can grow for a long time in the yard and then have beauty in the form of its leaves. Brazilian spinach is also interpreted as a plant that can be consumed or called an edible plant so that it can be used as a raw material in processing products such as smoothies, chips, salads, and food colouring. Brazilian spinach has high flavonoids and iron, making it good for people with anaemia [8].

The lack of information related to the cultivation of Brazilian spinach standards requires research related to this. Therefore, this study aims to determine the effectiveness of Wiremesh Tower Garden compared to conventional methods in Brazilian spinach cultivation for urban farming and to determine the growth response and yield of Brazilian spinach when grown vertically in WTG. The results of this research are expected to introduce Brazilian spinach to the community, especially the city community by applying the right cultivation technology according to the land or space they have.

2 Methodology

This research was conducted in the Experimental Garden and Laboratory of the Agrotechnology Study Program, Faculty of Science, Engineering, and Design, Trilogi University, Pancoran, South Jakarta, from August to November 2022. The tools used in this study are hoes, chicken wire/strainers (wire mesh), cutter, wire scissors, trash bag, duster, padlock, ruler, stationery, tarpaulin, cable ties, used mineral water bottle size 1.5 liters, camera, and digital calipers. The materials used are Brazilian spinach seeds, lembang soil, Karyana manure, and burnt husks.

This research was carried out using a Randomize Block Design (RBD) with two treatments, namely vertical planting techniques using wiremesh tower garden (WTG) and conventional (beds). In order to see the effectiveness of the WTG technique, the two cultivation techniques are carried out in the same area of land, which is 3 m x 6 m each.

The planting distance in the WTG is 12 x 12 cm to the side with a distance between levels of 15 cm; in one WTG, there are four planting positions: the bottom, middle, top, and peak. The inter-WTGs are arranged at a distance of 60 cm so that in one bed, there are 1 m x 2 m and 3 WTGs in one plot. The treatment was repeated five times until there were 15 WTGs. Each WTG took as many as 12 sample plants from each planting position to be observed. Meanwhile, the planting of Brazilian spinach on conventional land uses a planting distance of 15 cm x 15 cm on a 1 x 2 m bed. The treatment was repeated five times. Each bed is a

replicate, and each replicate is observed in 6 sample plants. Each planting hole, both in WTG and conventional techniques, is filled with one seedling cutting of a uniform size.

2.1. Trial Procedure

This research began with preparing planting material (cuttings) so that they have the same conditions, namely by planting several Brazilian spinach seedlings according to the needs of experimental treatment with the same height and age. Then, planting preparations are carried out using two cultivation techniques: conventional land preparation, which involves making treatment beds and WTG, and planting media in WTG according to the treatment. Planting is carried out simultaneously after all the planting materials and treatment locations are ready. After planting is complete, the next stage is to carry out plant care and observations according to the variables that have been determined.

2.2. Observation Variables

1. Plant Height (cm). Plant height was measured from base to highest shoot, starting at 1 Week After Transplanting (WAT). Then, it is measured by a 30 cm ruler. Observations are carried out one time a week until harvest.
2. Leaf width (cm). Leaf width was measured from the center of the leaf. The leaf to be measured is at the position of the fourth leaf from the shoot, and the leaf width measurement is 3 cm from the base of the leaf. Measurements start at 1 MST. Observations are carried out one time a week until harvest.
3. Number of leaves (pieces). Calculation of the number of leaves when the leaves have grown perfectly. Then, the number of planting leaves is calculated once a week until harvest.
4. Number of branches (pieces). The number of branches is calculated by the number of planting branches once a week until harvest.
5. Stem diameter (mm). The stem diameter measured 3 cm from the surface of the plant. The calculation of the stem diameter is carried out at 1 MST until harvest. The diameter of the stem was measured by a digital caliper.
6. Fresh harvest weight (grams). Harvesting occurred at 30-40 DAP (Days After Planting). Crop yields are weighed using digital scales.

2.3. Data Analysis

The data from the observation results were analyzed using the STAR (Statistical Tools for Agricultural Research) application. If there is a significant difference in the treatment, a further test is carried out with the Duncan Multiple Range Test (DMRT) at an error level of 5%.

3 Discussion

3.1 General Conditions of Research

Based on data from the weather station located in the Trilogi University Experimental Garden, the average rainfall in the field at the time of the study in September reached 1005,160 mm, October 1005,467 mm, and November 1006,428 mm. The temperature in the field during the study in September averaged 29.9°C, October 29.6°C, and November reached 27.7°C. Temperatures in September and October are included in the hot temperature,

while in November, they are included in the standard temperature. The obstacle faced during the study was the presence of weeds; these obstacles only existed in conventional treatment, while weeds did not grow much in the WTG treatment. This is one of the advantages of WTG has. Weed control is carried out manually, i.e., uprooted or cleaned by hand.

3.2 Growth of Brazilian Spinach Plants

The Brazilian Spinach plant is a leafy vegetable, so its vegetative character is an important variable. In this study, the vegetative characteristics observed are plant height, number of leaves, branches, leaf width, and stem diameter. These characteristics affect the quality of Brazilian Spinach production. Based on the results of data analysis on plant height, stem diameter, number of leaves, and leaf width between those planted with cultivation techniques using WTG and conventional, almost all variables gave significantly different results, except for the variable number of plant branches that showed no significant difference in results. The response of Brazilian spinach plants grown with the WTG technique tends to grow less than conventional techniques.

3.3 Plant Height

The height of the Brazilian spinach plant is an important factor in production. This plant is harvested, sold, and consumed along with its stems. The taller the plant, the greater the production of this commodity. The height of the plants in the first week of planting did not show a significant difference between those planted in WTG and those planted conventionally. However, in the second week onwards, there was a significant difference in plant height (Table 1). Brazilian spinach planted on conventional land horizontally has a higher plant height than when planted vertically in the Wiremesh Tower Garden.

Table 1. Average growth height of Brazilian spinach plants (cm) on differences between conventional cultivation techniques and WTG

Treatments	**Weeks After Transplanting**			
	1	2	3	4
Conventional Planting	4.50	8.06 a	13.03 a	21.73 a
Wiremesh Tower Garden	4.77	7.39 b	12.23 b	18.26 b

These results show that the best treatment to produce the optimum height of Brazilian spinach is by using the conventional technique horizontally compared to the cultivation technique using WTG. Allegedly, conventional plant cultivation treatments provide optimal growing space for Brazilian spinach plants. Conventional cultivation can provide flexibility for cultivated plants to grow and develop and will give higher yields on plant height than vertical cultivation [9].

The height of Brazilian Spinach plants in the first week showed no real difference because the condition of the seedlings used did have the same height to maintain the uniformity of planting material. Different growing space conditions make each plant adapt so that in the following weeks, there can be a significant difference in plant height. The appropriate growing space will affect the height of the plant because there is no competition for nutrients between plants, so nutrients are sufficient, and the light is filled properly [10].

The plant cultivation technique using WTG is a modification of the vertical culture technique so that there is a possibility of a difference in the height response of plants between plants placed in the bottom, middle, top, and top positions. The average height of Brazilian spinach plants grown using WTG can be seen in Table 2. It turns out that the position of the plant has or does not have a significant effect on the height of the Brazilian Spinach plant.

Table 2. Comparison of Brazilian Spinach plant height (cm) based on planting position in WTG

Planting Position in WTG	Weeks After Transplanting			
	1	2	3	4
Peak	5.40 a	7.34 a	13.10 a	19.80 a
Top	4.60 b	7.06 b	12.54 b	18.56 b
Middle	4.40 b	6.82 c	12.30 b	18.38 b
Bottom	4.00 b	6.74 c	11.78 c	17.62 c

The comparison of the height of Brazilian spinach plants can be seen in (Table 2) that in week four there was a real difference in the lower and top planting positions, namely 17.62 and 19.80. The comparison can prove that the peak position has an optimal plant height growth due to the intensity of sunlight affecting various processes in plant growth and development, including transpiration and especially photosynthesis [11].

3.4 Stem Diameter

The large stem diameter of Brazilian spinach can support plant growth and produce optimal production. Therefore, the diameter of the rod is important to observe. Cultivation of Brazilian Spinach plants with conventional techniques and WTG yielded significantly different results against stem diameter variables in the second, third, and fourth weeks. The stem diameter of Brazilian Spinach becomes smaller and smaller when grown using the WTG technique (Table 3).

Table 3. Average growth of Brazilian spinach diameter (mm) on the difference between conventional cultivation techniques and WTG

Treatments	**Weeks After Transplanting**			
	1	**2**	**3**	**4**
Conventional Planting	3.03	3.72 a	4.50 a	4.87 a
Wiremesh Tower Garden	3.12	3.12 b	3.90 b	4.31 b

The conventional treatment of Brazilian spinach cultivation techniques provides a larger stem diameter when compared to the cultivation technique in WTG. We suspected that conventional cultivation areas are more effective for plants to grow more optimally because the plant gets enough sunlight.Tthe growth of plant diameter is closely related to the rate of photosynthesis [12]. The total width of the leaves in plants that are active in the photosynthesis process will affect the photosynthesis that will be produced. During the vegetative growth phase, the results of photosynthesis can be used by plants to increase the diameter of the stem, the growth of new branches, and the growth of plant height [13].

Table 4. Comparison of Brazilian Spinach stem diameter (mm) based on planting position in WTG

Planting Position in WTG	Weeks After Transplanting			
	1	2	3	4
Peak	2.90	3.56 a	4.30 a	4.52 a
Top	2.86	3.50 a	4.12 a	4.18 ab
Middle	2.60	3.08 b	3.90 b	4.14 ab
Bottom	2.38	2.60 c	3.72 b	3.84 b

Treatment use of WTG has not been able to give better results on the diameter of the stem. We suspected that the cultivation area in WTG is less effective for plants to grow more optimally; in addition, external factors, namely the environment, will also affect the growth of stem diameter. Environmental factors must be met for plants so that they can grow optimally and complete their life cycle to produce their best potential [14]. Some spinach plant populations in the treatment WTG are not getting morning sunlight; if there is a lack of sunlight absorbed by the plant, it will cause the rate of photosynthesis to decrease and will cause photosynthesis to decrease [15].

3.5 Number of Leaves

Variable leaf numbers in Brazilian spinach plants with conventional cultivation and WTG yielded significantly different results in the first and third weeks. The best results were found in conventional treatment, with an average number of leaves in the first week 7.57 and the third week 32.97 (Table 5).

Table 5. Average growth of the number of leaves of Brazilian spinach plants (pieces) on differences between conventional cultivation techniques and wiremesh tower garden

Treatments	Weeks After Transplanting			
	1	2	3	4
Conventional Planting	7.57 a	22.40	32.97 a	62.70
Wiremesh Tower Garden	6.50 b	21.00	29.17 b	61.30

Conventional cultivation gives better results than WTG. Allegedly, the growing space provided by conventional treatment is better. The optimal growing space will affect the number of leaves due to the rate of photosynthesis that runs well. Leaves are one of the main components in plant growth for the photosynthesis process, so they affect leaf growth, including the number of leaves, leaf width, and leaf fresh weight [16].

Brazilian spinach plants that are cultivated with conventional treatment will get the same intensity so that they can absorb sunlight evenly. Contras with the treatment of WTG because some parts lack sunlight, especially morning sunlight. Even though the morning sun is the best light for vegetable crops, including the Brazilian spinach plant, morning sunlight is the best light not only for plants but for all living things [17]. Morning sunlight can produce vitamin D for plants, which is beneficial for the photosynthesis process, so sunlight is one of the important factors in plant growth [18].

Table 6. Comparison of the number leaves of Brazilian spinach based on planting position in Wiremesh Tower Garden

Planting Posistion in WTG	Weeks After Transplanting			
	1	2	3	4
Peak	7.20	20.40 a	20.12	63.60 a
Top	7.20	19.00 b	29.00	58.20 b
Middle	7.00	17.60 c	27.80	57.40 b
Bottom	6.80	16.40 d	24.60	55.60 b

3.6 Leaf Width

Conventional and WTG cultivation treatments gave significantly different results against leaf width variables at weeks two, three, and four. The best results were found in conventional

cultivation treatment, with an average of 2.81 in the second week, 3.40 in the third, and 3.83 in the fourth (Table 7).

Table 7. Average growth of Brazilian spinach leaf width (cm) on the difference between conventional cultivation techniques and wiremesh tower garden

Treatments	Week			
	1	2	3	4
Conventional Planting	2.24	2.81 a	3.40 a	3.83 a
Wiremesh Tower Garden	2.20	2.50 b	3.12 b	3.59 b

Leaf width is one of the indicators of plant growth which illustrates the rate of photosynthesis in plants, including light absorption. The wider the leaves of the plant, the more sunlight can be absorbed by the plant [19]. Conventional cultivation has better results when compared to WTG; these results prove that the nutrient absorption of Brazilian spinach plants is better so that it affects the formation of chlorophyll, which has an important role in photosynthesis. An important nutrient in the photosynthesis process is nitrogen (N) nutrients. Leaves that have more chlorophyll content will also cause the photosynthesis process to increase [20].

The distance of the planting population will influence the width of the leaves of Brazilian spinach, and this can be one of the factors for the width of the leaves of spinach plants in conventional treatment. WTG cultivation has a more stretched planting distance. A looser spacing would result in a larger leaf width than a dense spacing [21]. Stretched planting distance will have a low level of nutrient competition [15]. Low nutrient competition between plants will cause the nutrient and water content absorbed by plants to be more optimal.

Table 8. Comparison of Brazilian spinach leaf width (cm) based on planting position in WTG

Planting Position in WTG	Weeks After Planting			
	1	2	3	4
Peak	2.80 a	2.50 a	2.80 a	3.86 a
Top	2.60 a	2.42 ab	2.60 b	2.86 b
Middle	2.00 b	2.34 bc	2.54 bc	2.98 b
Bottom	2.00 b	2.24 c	2.44 c	2.84 b

3.7 Number of Branches

Explain why the number of branches is important to observe! Conventional and WTG cultivation treatments showed no significant difference in the variable number of branches from the first week to the fourth week. The average growth of the number of branches was almost the same and showed no real difference, so the difference in growth from each week for conventional treatment and wire mesh tower garden was not noticeable. The best average yield for the best number of branches was found in the conventional treatment. However, the difference in results was not significantly different from the WTG treatment (Table 9).

The treatment with conventional and WTG methods showed no significant difference in the number of branch variables between the first and fourth weeks. Brazilian spinach may adapt to both cultivation methods, and the nutrients absorbed by the plant are optimal so that the growth of spinach plants is maximized. Nutrients that plants optimally absorb will then be used to develop branches derived from axial shoots, which causes the growth of shoots to be faster to allow the formation of stem branches [22].

Table 9. Average growth of the number of branches of Brazilian spinach on conventional treatment and Wiremesh tower garden

Treatments	Weeks After Transplanting			
	1	2	3	4
Conventional Planting	1.83	2.34	3.57	7.67
Wiremesh Tower Garden	1.93	2.43	3.43	7.37

3.8 Brazilian Spinach Production

Brazilian spinach is a leafy vegetable that can be harvested anytime for consumption. Brazilian spinach in this study was harvested at the age of one month and harvested twice. Harvesting was done by cutting the main stem and leaving the main stem about 3 cm. Crops are separated between treatments and weighed using digital scales. Brazilian Spinach production is determined by fresh weight at the time of harvest. The results of ANOVA showed that the cultivation techniques had no significant effect on the weight of fresh harvest. However, conventional cultivation techniques tend to produce a more considerable harvest weight than WTG (Table 10).

Table 10. Average harvest fresh weights on conventional and WTG treatments of Brazilian spinach plants

Treatments	First Period Harvest Weight (kg)	Second Period Harvest Weight (kg)
Conventional Planting	2.22	2.46
Wiremesh Tower Garden	2.11	1.66

Conventional cultivation and WTG yield equally good results on the harvest weight in the first and second harvests. In addition, conventional cultivation techniques tend to increase harvest weight in the next harvest period. Meanwhile, cultivation techniques using WTG tend to decrease. Due to the increasingly limited nutrients that WTG can provide, the production of Brazilian spinach plants will decrease in the next period. The weight of crop harvest is influenced by plant height, number of leaves, and leaf width. There is a genuine relationship between plant height, number of leaves, and leaf width; thus, increasing these components will increase the crop harvest weight [23].

Table 11. Average harvest weight in the treatment of Wiremesh Tower Garden planting position on Brazilian spinach plants

Planting Position in WTG	Harvest Weight (grams)
Peak	87.06 a
Top	51.51 b
Middle	43.87 b
Bottom	25.17 c

Table 11 shows that the treatment of WTG's planting position affects the weight of Brazilian spinach plants. The peak position treatment of 87.06 grams showed the best plant weight. The peak position gets enough sunlight compared to the other positions. The higher intensity of sunlight, the higher growth in spinach plants because spinach is a plant that requires full light for physiological activities in photosynthetic activities, so the distributed photosynthetic are highly dependent on the intensity of light utilized by plants optimally [24].

4 Conclusion

The conventional cultivation technique of Brazilian spinach plants shows better growth at almost all growth observation variables, except for the number of branches variable. However, the variable harvest weight in the two cultivation techniques showed no significant difference, so the Brazilian spinach cultivation technique using WTG was considered quite effective in urban farming practices. The planting position in WTG influences the growth and production of Brazilian spinach plants. The best position to grow Brazilian spinach in the WTG technique is the peak position, while the bottom is the lowest for all observation variables.

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