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Growth and biomass production of *Gongronema latifolium* (Benth) using substrate mix with biochar inclusion and pinching regimes in southeast Nigeria

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Abstract

This research demonstrated the possibility of growing and producing *Gongronema latifolium* using various substrate mixes and pinching regimes. The greenhouse experiment was conducted at the Research and Teaching Farm of the School of Agriculture and Agricultural Technology, Federal University of Technology Owerri, Nigeria, during the 2023 late-season farming period. The experiment followed a 4 x 3 factorial design in a Completely Randomized Design (CRD) and was replicated thrice. The factors were four substrate mixes (sawdust/poultry manure/biochar mix in the ratios of 3:2:0, 3:2:1, 3:2:2, and 3:2:3) and three pinching regimes (2, 4, and 6 weeks after transplanting). The substrates (sawdust, poultry manure, and ground biochar) were procured, composted, and cured for 2 weeks before mixing. The measurements were made in volume (v:v:v:v). The substrate mix was introduced into perforated black polybags of 11 cm x 13 cm size and 1 mm thickness. The filled polybags were watered and allowed 2 days for thoroughly binding the substrate mix. Seedlings from the nursery trays were then transplanted into the polybags filled with the substrate mix. Seedlings transplanted at 6 weeks of age were pinched with fingernails at the tip of the plant below the second leaf at 2, 4, and 6 weeks after transplanting, as per the experimental design. Staking, water application, and weeding were carried out at appropriate times. Data on growth and biomass production were collected. Growth and biomass production results showed significant ($P<0.05$) differences. Substrate mixes of 3:2:3 and 3:2:2 optimally improved growth and biomass production (number of leaves, leaf area, vine length, branches, and fresh and dry shoot weight). Pinching regimes at 4 and 6 weeks produced more leaves and branches, resulting in a larger quantity of fresh and dry shoot biomass of *G. latifolium*. Furthermore, the interactions of 3:2:3 + 6 weeks and 3:2:2 + 4 weeks recorded optimal leaves and fresh and dry biomass yields. As shoots and leaves are the economically significant components of the plant, pinching regimes at 4 and 6 weeks and the 3:2:3 + 6 weeks and 3:2:2 + 4 weeks are advised for farmer adoption. This method can increase vegetable output and assist in lowering world poverty.

Key words: Greenhouse, sawdust/poultry manure/ biochar, substrates mix, pinching, fresh and dry biomass, *Gongronema latifolium,*

Introduction

Gongronema latifolium is a climbing shrub with broad heart-shaped leaves with serrated edges that have a distinctively sharp, bitter and slightly sweet taste. The soft hairy stems produce exudates and milky latex. It is member of the Asclepiadaceae family of plants. Commonly grown in southern Nigeria, it is called Utazi there; the Yorubas call it Arokete (Ugochukwu *et al.*, 2003). Mostly found in the rainforest zone of Nigeria and other tropical African nations, this edible nutritious/medinal plant is also found in Used are fruits, seeds, leaves, roots and bark. Important medicinal plant, vegetable, and spice G. latifolium is Promising hypoglycaemic activities have been shown by a variety of pharmacological tests; also intriguing antibacterial, antioxidant, anti-inflammatory, heptoprotective, anti-asthmatic, anti-ulcer, analgesic, and antipyretic activities (Afolabi, (2007). It is used mostly as a vegetable and spice in Nigeria; nevertheless, domestication is necessary and will remain vital as well. Sometimes it is grown to guarantee its continuous availability and sustainable preservation. According to Olympoiou (1999), ideal substrate should play four main functions: (i) should act as a reservoir for plant nutrients; (ii) should hold enough water; (iii) should provide good aeration; and (iv) should provide physical support for good plant development and growth. Though sand provides good physical support and aeration, some of the soilless media may not support all the functions; that is, sand is quite poor in nutrient and water supplying capacity (Csaba, 1995). Mostly organic, container substrates consist of peat moss, pine bark, coconut fiber (coir), and composted materials (Chen and Wei, 2018).

To attain the right balance of air and water holding capacity for the plants to be grown as well as for the long-term stability of the medium, growing media are often formulated from a mix of different raw materials (Grunert *et al.*, 2008). Some growing substrates of economic potential are sand, perlite, vermiculites, polystyrene, foam resins; others are peat of many types, barks of various origin, sawdust, pumice grape marc, straw bales and rock wools found in a variety of formations used by the greenhouse growers, sold as commercial preparation, or recommended by research institute (Chen *et al.*, 2008). Every substrate has unique qualities and generally differs from one another. Successful soilless growing of horticultural depends on these variations between growing media. Different studies have shown consistent findings showing that the pinching treatment reduces vine length (Naafe *et al.,* 2022; Eve *et al.,* 2016) in butternut. High rates of infrastructure development, urbanization, and industrialization have over time raised demand for land. This then lowers food production and security's degree.

This study aimed to find how pinching and soilless media affect number of leaves, leaf area, vine length, wet and dry biomass, growth and biomass generation of *G. latifolium* (Benth) under Southeast Nigerian substrate mix and pinching regimes.

Materials and methods

Experimental site and design: The experiment was carried out at the Green House Unit of the Teaching and Research Farm, School of Agriculture and Agricultural Technology, Federal University of Technology, Owerri. The site is located at 5°27'N, 5°23'N and 7°21'E, 7°49'E Latitude and Longitude (with an elevation 55 meters above mean sea level (MSL) using a Global Positioning System Receiver). An experiment was conducted in 2023 to test the combination of poultry droppings, sawdust and biochar in growing *G. latifolium* at different ratios of these materials.

The experiment was in a completely randomized design (CRD) consisting of a 3 × 4 factorial of 12 treatment combinations. It involved 3 pinching regimes (2, 4, 6 weeks) x 4 soilless growth media (sawdust, mixture of poultry droppings/biochar ratios at 3:2:0, 3:2:1, 3:2:2 and 3:2:3) with 3 replications.

Mature capsule pods of *G. latifolium* were purchased from Okigwe Outstation, National Institute of Horticulture, Imo State, Nigeria. Seeds were removed from capsules and placed on laboratory bench at room temperature for 2 days before broadcasting. They spent six (6) weeks being nursed in nursery trays with composted sawdust. We watered them three times a week.

Substrate mix – procurement and preparation: Sawdust was obtained from *Gmelina arborea* tree–Owerri Sawmill Industrial Estate, Imo state. It was laid underneath some shade and composted for 4 weeks. Water was poured weekly to speed the composting. Fresh poultry droppings were obtained from the Poultry Unit of the Research and Teaching Farm of the University and were also air cured for 4 weeks under shade before use. The logs of *Gmelina arborea* were burnt by anaerobic method and then they were ground by the milling machine. Curing of sawdust and poultry manure was done for four (4) weeks after composting. Instead of composting biochar, it is supposed to be watered and stored in a sack for 7 days to bind together.

Analysis of the substrates in laboratory: Content of minerals Ca, K, Na, P, and N was determined using the Multiple Nutrient Extraction Method (Novozamsky A83). Samples were allowed to dry in an electric air oven at 65 °C for 8 h then milled in a Thomas-Willey mill to pass through a 0.5 mm sieve. The milled samples were placed in sample bottles for analysis.

The method of mineral element extraction used was wet-acid multiple nutrient digestion. Five mL multiple nutrient extraction reagent (H_2SO_4-selenium-salicylic acid solution) was added to 0.2 g of the sample and the mixture was allowed to stand for 24 hours. The samples were then placed on a hot plate at 32°C and kept for 2 hours under fume cupboard. Then, 5 mL of 75% perchloric acid was added and the samples were heated at 80°C until complete digestion, issuing perchloric acid vapors. The digests were cooled to room temperature, followed by the addition of 10 mL of distilled water, heated for complete dissolution. Purpose of Mineral AnalysisThe digests were placed in a 50 mL volumetric flask for mineral analysis.

The EDTA complexometric titration method (Tel and Hagarty, 1984) was used to determine Ca and Mg. Flame photometric method was used to determine potassium (K) and sodium (Na) (Vogel, 1962). Determination of phosphorus (P) was carried out using Yellow Molybdate Spectrophotometric method (Nwosu *et al.*, 2009) while nitrogen (N) contents were measured using the semi-micro Kjeldahl method (AOAC, 1990).

Table 1. Physical and chemical properties of the media

Parameter	Poultry manure	Sawdust	Biochar
pH in water	7.61	7.76	9.98
Organic carbon	25.24	33.19	1.38
Organic matter	43.51	58.26	2.38
N%	2.37	1.19	0.028
P%	1.08	0.485	0.285
K%	3.11	0.308	4.95
Ca%	3.22	2.41	6.48
Mg%	4.70	1.128	2.25
Na%	0.48	0.477	0.534
Colour	Black	Brownish	Grayish dark
Texture	Granule	Grain size	Coarse

The *G. latifolium* seeds were sown in nursery trays and watered regularly. Six weeks after sowing (WAS), the seedlings were transplanted to a depth of 5 cm into 6 kg of various substrate mixes, which were filled with sawdust, poultry manure, and biochar according to respective ratios (3:2:0, 3:2:1, 3:2:2, and 3:2:3). These mixtures were placed into perforated black polybags of 11 cm x 13 cm size and 1 mm thickness. The seedlings were then pinched at the tip, below the second leaf, using fingernails at 2, 4, and 6 weeks after transplanting. For cultural practices, the plants were irrigated using watering cans, weeds were hand-picked, and staking was done with Indian bamboo sticks at the appropriate time.

The number of leaves was calculated by counting the leaves at 0, 2, 4, and 6 weeks after pinching (WAP). Leaf area was determined by measuring the mean length and width of the leaf blades, as well as the mean number of leaves for each treatment combination and replication. The leaf area was then calculated using a constant value of 0.75 (Egharevba *et al.*, 1976). Vine length was measured using a meter rule at 0, 2, 4, and 6 WAP. The number of branches was physically counted at 0, 2, 4, and 6 WAP, and the number of roots was counted similarly. Fresh weight was calculated by removing the sample plant from the polybag, washing it with running tap water to remove dirt, and weighing it with a digital balance at 6 WAP. Dry weight was determined by drying the washed sample in an oven at 60-70°C and weighing it with a digital balance at 6 WAP.

A test for significant differences among treatment means was performed using the least significant difference at P=0.05.

Results

Effect of substrate mix and pinching regime on the number of leaves: At 3, 6, and 9 weeks after pinching (WAP), the 3:2:3 and 3:2:2 substrate mixes recorded more leaves than the 3:2:0 and 3:2:1 mixes, respectively (Table 2). The inclusion of biochar in the various mixes, based on their properties (Table 1), improved leaf production. Pinching at 6 weeks produced a higher number of leaves than pinching at 2 and 4 weeks, respectively. When the crop is at the peak of its growth (6-12 weeks), pinching increases the number of leaves produced. Interactions between pinching and substrate mix also showed a significant ($p<0.05$) effect. At 9 WAP, the interaction of 3:2:3 + 6 weeks resulted in a higher number of leaves compared to other interactions (Table 2).

Table 2. Effect of substrate mix and pinching regime on number of leaves of *G. latifolium* at 3, 6 and 9 weeks after pinching (WAP)

Media	3 WAP				6 WAP				9 WAP			
	2	4	6	Mean	2	4	6	Mean	2	4	6	Mean
3:2:0	9.33	12.00	12.67	11.33	13.33	14.00	16.67	14.67	16.67	20.00	25.33	20.67
3:2:1	9.33	12.00	15.33	12.22	13.33	18.00	20.67	17.33	17.33	22.00	26.67	22.00
3:2:2	11.33	14.67	24.67	16.89	16.00	21.33	37.33	24.89	20.67	26.00	26.67	31.11
3:2:3	13.33	18.00	22.67	18.00	18.67	23.33	28.67	24.89	24.00	31.33	46.00	33.78
Mean	10.83	14.17	18.83		15.33	19.17	25.83		19.67	24.83	36.17	
LSD(0.05) Substrate mix				2.03				2.97				3.61
LSD(0.05) Pinching				1.75				2.57				3.13
LSD(0.05) S x P				3.51				5.15				6.26

Note: 3:2:0 – Sawdust/Poultry manure/Biochar mix; 3:2:1– Sawdust/Poultry manure/Biochar mix; 3:2:2 – Sawdust/Poultry manure/Biochar mix; 3:2:3 – Sawdust/Poultry manure/Biochar mix. WAP– Weeks after pinching; LSD (0.05) – Least Significant Different; S x P – Substrate x Pinching.

Table 3. Effect of substrate mix and pinching regime on leaf area (cm^2) of *G. latifolium* at 3, 6 and 9 weeks after pinching

Media	3WAP				6WAP				9WAP			
	2	4	6	Mean	2	4	6	Mean	2	4	6	Mean
3:2:0	3.39	8.28	6.24	5.97	5.58	7.94	8.30	7.28	7	13	654	224
3:2:1	1.94	6.73	15.39	8.02	2.01	11.13	22.15	11.76	3	18	37	19
3:2:2	2.03	7.36	23.85	11.08	2.91	9.75	32.36	15.00	4	12	45	20
3:2:3	3.81	19.76	17.34	13.63	4.79	25.05	26.41	18.75	7	30	39	25
Mean	2.79	10.53	15.71		3.82	13.47	22.31		5	18	195	
LSD(0.05) Substrate mix				4.32				4.54				311.8^{ns}
LSD(0.05) Pinching				3.74				3.93				270.0^{ns}
LSD(0.05) S x P				7.49				7.87				540.0^{ns}

Table 4. Effect of substrate mix and pinching regime on vine length (cm) of at 3, 6 and 9 weeks after pinching (WAP)

Substrate	3WAP				6WAP				9WAP			
	2	4	6	Mean	2	4	6	Mean	2	4	6	Mean
3:2:0	6.20	5.90	5.17	5.76	6.67	6.47	6.23	6.46	6.97	7.20	8.07	7.41
3:2:1	4.93	6.00	6.83	5.92	5.43	6.40	7.70	6.51	5.97	7.60	10.50	8.02
3:2:2	4.70	6.70	7.40	6.29	5.63	7.13	9.23	7.33	6.13	8.13	15.00	9.76
3:2:3	4.97	7.53	7.70	6.70	5.37	9.10	9.50	7.99	5.90	10.47	14.63	10.33
Mean	5.22	6.53	6.78		5.77	7.27	8.17		6.24	8.35	12.05	
LSD(0.05) Substrate mix				1.05ns				1.10				1.34
LSD(0.05) Pinching				0.91				0.96				1.16
LSD(0.05) S x P				1.81ns				1.91				2.30

Effect of substrate mix and pinching regime on leaf area cm^2): Substrate mix, pinching, and their interactions had a significant effect at various periods (Table 3). The substrate mix was significant at 3 and 6 weeks after pinching regarding leaf area. Leaf area was significantly broader in plants with the 3:2:3 mix compared to those with the 3:2:1 and 3:2:0 mixes, respectively. Leaf area development determines light interception and is also an important factor in evaluating plant productivity. Pinching at 6 weeks significantly improved leaf area more than pinching at 2 and 4 weeks, respectively, at 3 and 6 weeks after pinching. The 3:2:2 + 6-week interaction significantly produced broader leaves compared to plants in 3:2:2 + 2 weeks, respectively, at 3 and 6 weeks after pinching. At 6 weeks after pinching, no significant differences were recorded among all the treatments and their interactions.

Effect of substrate mix and pinching regime on vine length (cm): Significant differences were recorded in the media at 6 and 9 weeks after pinching (Table 4). At both 6 and 9 weeks after pinching, the 3:2:3 mix significantly produced longer vine lengths than the 3:2:0 mix, but did not significantly differ from the 3:2:2 mix. Pinching significantly affected vine length from 3 to 9 weeks after pinching. Pinching at 6 weeks significantly produced longer vine lengths than pinching at 2 and 4 weeks, respectively. A reduction in vine length was observed when pinching was done at 2 and 4 weeks, as recorded in this study. Substrate mix and pinching regimes significantly affected the vine length of *G. latifolium* at 6 and 9 weeks after pinching. Interactions between 3:2:3 + 6 weeks of pinching resulted in longer vines than 3:2:3 + 2 weeks at 6 weeks after pinching. At 9 weeks, the 3:2:2 + 6 weeks interaction produced longer vine lengths than the 3:2:3 + 4 weeks interaction.

Effect of substrate mix and pinching regime on the number of branches: At 9 WAP, the 3:2:3 mix significantly increased the number of branches in *G. latifolium* compared to the 3:2:2, 3:2:1, and 3:2:0 mixes, respectively (Table 5). Pinching significantly affected the number of branches at 3 and 6 WAP. No significant effect was recorded in their interactions. At 3 WAP, pinching at 4 and 6 weeks significantly produced more branches than pinching at 2 weeks. At 9 WAP, pinching at 6 weeks significantly resulted in more branches than pinching at 2 weeks.

Effect of substrate mix and pinching regime on biomass: Media and pinching significantly affected biomass, number of roots, and root length (Table 7). Interactions showed significant differences in fresh and dry biomass at various pinching regimes. The 3:2:3 substrate mix produced larger fresh biomass than the 3:2:1 and 3:2:0 mixes, respectively. Pinching at 6 weeks produced heavier fresh biomass than pinching at 2 weeks. Dry biomass in the

Table 5. Effect of substrate mix and pinching regime on number of branches at 3, 6 and 9 weeks after pinching (WAP)

Media	3WAP				6WAP				9WAP			
	2	4	6	Mean	2	4	6	Mean	2	4	6	Mean
3:2:0	1.00	2.00	2.00	1.67	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
3:2:1	1.00	2.00	2.00	1.67	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
3:2:2	1.67	2.00	2.00	1.89	2.00	2.00	2.67	2.22	2.00	2.00	3.00	2.33
3:2:3	1.33	2.00	2.00	1.78	2.33	2.33	8.67	4.44	2.33	3.33	3.67	3.11
Mean	1.25	2.00	2.00		2.08	2.08	3.83		2.08	2.33	2.67	
LSD(0.05) Substrate mix				0.23^{ns}				3.26^{ns}				0.49
LSD(0.05) Pinching				0.20				2.82^{ns}				0.40
LSD(0.05) S x P				0.40^{ns}				5.64^{ns}				0.84^{ns}

Table 6. Effect of substrate mix and pinching regime on biomass at 9 weeks

Media	Fresh weight (g)				Dry weight (g)			
	2	4	6	Mean	2	4	6	Mean
3:2:0	1.03	1.41	0.86	1.10	0.33	0.44	0.29	0.35
3:2:1	0.93	1.11	2.56	1.53	0.29	0.32	0.75	0.45
3:2:2	1.69	1.71	3.93	2.44	0.44	0.50	0.92	0.62
3:2:3	2.09	2.86	2.02	2.32	0.51	0.71	0.50	0.57
Mean	1.44	1.77	2.34		0.39	0.49	0.62	
LSD(0.05) Substrate mix				0.71				0.16
LSD(0.05) Pinching				0.61				0.14
LSD(0.05) M x P				1.23				0.27

Table 7. Effect of substrate mix and pinching regime on root parameters at 9 weeks

Media	Number of roots				Root length (cm)			
	2	4	6	Mean	2	4	6	Mean
3:2:0	17.00	19.00	21.00	19.00	4.50	5.47	5.93	5.30
3:2:1	16.67	24.00	20.67	20.44	3.87	5.83	4.57	4.76
3:2:2	22.00	26.67	35.65	28.11	4.90	6.27	7.43	6.20
3:2:3	27.00	29.33	40.33	32.22	4.57	6.57	7.67	6.27
Mean	20.67	24.75	29.42		4.46	6.03	6.40	
LSD(0.05) Substrate				4.77				0.73
LSD(0.05) Pinching				4.13				0.63
LSD(0.05) S x P				8.26^{ns}				1.27^{ns}

3:2:2 mix was significantly larger than in the 3:2:0 and 3:2:3 mixes. The interactions of 3:2:2 + 6 weeks and 3:2:3 + 4 weeks respectively, significantly recorded larger fresh biomass than other interactions.

The interactions of 3:2:2 + 6 weeks and 3:2:3 + 6 weeks produced significantly ($p<0.05$) larger dry biomass. The number of roots in the 3:2:3 and 3:2:2 mixes were significantly higher than in the 3:2:1 and 3:2:0 mixes, while pinching at 6 weeks recorded a higher number of roots than pinching at 4 and 2 weeks, respectively. Root length in the 3:2:3 and 3:2:2 mixes was significantly ($p<0.05$) longer than in the 3:2:1 and 3:2:0 mixes.

Discussion

The inclusion of biochar in the various mixes, based on their properties improved leaf production (Table 1). Yang and Zang (2022) reported an increase in chlorophyll content in the ornamental plant *Centaurea cyanus* L. in response to BC supplementation compared to control plants. Biochar gradually releases nutrient elements, preventing their leaching during watering. The inclusion of biochar in sawdust + poultry mix (4:2 and 4:3, respectively) improved the number of leaves, plant height, and root length of *Bryophyllum pinnatum* (Peter-Onoh *et al.*, 2019). Pinching at 6 weeks resulted in a higher number of leaves than pinching at 2 and 4 weeks, respectively. When the crop reaches the peak of its growth (6–12 weeks), pinching increases the number of leaves produced. Substrate mix has recently been proven to be a suitable substitute for soil in vegetable crop production. Rashika and Karuppaiah (2025) found a combination of garden soil, burnt rice husk, FYM, and cocopeat is the most effective and sustainable alternative for improving the yield, growth, and quality of *Dracaena reflexa* cv. Song of India cut foliage.

Measurement of leaf area is crucial for improving crop performance and increasing crop yield due to its photosynthetic functions. Biochar application can increase pH in acidic soils, improve soil organic carbon, enhance nutrient holding capacity due to functional groups, reduce the adverse effects of heavy metal adsorption, and increase the nutrient elements supplied by the BC (Chang *et al.*, 2021). Leaves convert absorbed sunlight into organic matter in green plants through photosynthesis, providing nutrients for their physiological functions (Koester *et al.*, 2014). Furthermore, when the leaves are narrow, they affect chlorophyll content, which in turn reduces yield, especially in leafy vegetables.

According to Anand *et al.* (2014), the physiological activation caused by pinching treatment directs more photosynthate to the lower parts of the vines, thereby reducing the length of the vine. The increased number of branches due to pinching might be attributed to the breaking of apical dominance and the sprouting of auxiliary buds, as observed in this study. Pinching significantly affected the plant height of okra by removing apical parts, reducing height, and increasing lateral branches and flowers. Pinching prevented apical dominance and stimulates the growth of the lower parts of tomato plants (Iannotti, 2009; Central Coast Gardening, 2010). Pinching, a pruning technique, involves removing the apical bud and a few leaves to promote secondary and tertiary sprouting (Patel *et al.*, 2017).

Pinching controled plant height, enhances plant width, and increasedc the number of branches (Olasantan, 2001). Garcia and Martinez (2019) demonstrated that pinching sunflower cultivars at the right time increased yield by 3–4 times, as it boosts the number of smaller sunflower heads, resulting in increased profits for growers.

Choi *et al.* (2018) reported that growing medium mixes comprising 20% pine bark and 80% BC (by volume) boosted fresh and dry weights in chrysanthemum (*Chrysanthemum nankingense*) compared to the control (without BC). Similarly, biochar application increased vegetable yields by 4.7% to 25.5% compared to conventional farmer practices (Vinh *et al.*, 2014). A study by Lehmann *et al.* (2011) showed that biochar contains high levels of essential nutrients, including P, N, C, CEC, and has a more neutral pH. Pinching at 6 weeks produced larger dry biomass than pinching at 2 weeks. Biochar has a multifunctional role, including greenhouse gas sequestration, improving soil properties, enhancing seed germination, boosting crop yield and quality, and increasing crop tolerance to abiotic and biotic stress (Ji *et al.*, 2022).

A healthy root system helps establish transplants in the growing media, which is influenced by media properties (Nair and Carpenter, 2016). The development of the root system directly affects the transplant's ability to obtain nutrients from the media (Bu *et al.*, 2022). The principles of growing plants in substrate mixes are similar to growing plants in soil. Growing *G. latifolium* in pots/containers can serve as a source of food and be used as an ornamental plant for landscaping and environmental beautification. Each substrate has specific properties and usually differs from others. These differences in substrate mixes must be considered for successful soilless cultivation of horticultural crops. The sawdust/poultry manure/biochar mix (3:2:3) provided the best conditions for effective growth of *G. latifolium*, followed by the 3:2:2 mix. Additionally, pinching at 6 weeks and 4 weeks enhanced the production of branches and leaves. The interaction of sawdust/poultry manure/biochar mix and pinching at 6 weeks (3:2:3 + 6 weeks) provided the most favorable condition for vegetative growth of *G. latifolium*, followed by the 3:2:2 + 4 weeks interaction. These practices can be applied to other herbaceous climbing shrubs, boosting vegetable production

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