Effect Of Agricultural By-Products As Substrates For H'mong Cucumber Seedlings Under Greenhouse Conditions

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Abstract

Circular agriculture is the agricultural production process in a closed cycle, which the waste and by-products of one process are the input to the other production process, through the application of technical advances and biotechnology. Thus, agricultural production will exploit and use resources economically and efficiently, minimizing post-harvest losses, especially reducing and eliminating wastes that pollute the environment, protecting ecosystems and human health.

The objective of this study was to examine the effect of mixing several types of available materials such as rice husk ash, coconut coir, canna residue, peat, chicken droppings, pig feces and cow feces, which can be found freely in Vietnam. Klasmann was the control treatment in this experiment. The crops tried was the H'mong cucumber - an indigenous cucumber variety of the ethnic minorities in the Northern mountainous region of Vietnam. The effect of the substrate on H'mong cucumber seedling growth was found to be disparate depending on the species. Our results suggested that, in comparison with the treatment of Klassmann, the experimented media showed positive effects on the growth of H'mong cucumber seedlings. Treatment 2 (T2) with a mixture of 25% RHA + 25% CC + 25% CR + 25% CKD gave the great values of physical characterization, particle size, bulk density, total porosity, aeration porosity and water-holding porosity. Additionally, nutrient concentrations were determined. To evaluate the effect of mixing ratio of substrates on H'mong cucumber seedling growth, stem length, leaf area, dry weight - fresh weight of aerial and root biomass.

Keywords: Rice husk ash, coconut coir, canna residue, substrate, chicken droppings.

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INTRODUCTION

Cucurbitaceae plants cucumber (*Cucumis sativus* L.) and watermelon (*Citrullus lanatus*) are common substrate crops (Frasetya et al., 2018; Lou and Wehner, 2016). Cucumber, one of the most important economic vegetable crops cultivated broadly throughout the world (Frasetya et al., 2018), is mainly grown in tropical and subtropical regions (Lata et al., 2018). Cucumber is the primary source of vitamins and minerals for the human body. Its extract has strong biological activity, which can effectively promote the metabolism of human body (Obel et al., 2022).

One of the most important issues impacting the success of vegetable growing to produce quality saplings. The substrate component is very important for saplings. The physical properties and chemical component have both a considerable influence on plant growth rate of seedlings (Babaj et al., 2008). Although seedling production is used widely by a number of countries, the scale of seedling production in terms of the appropriate media and mixtures have not been reached. The researcher gathered on the usefulness of seedlings growing regional organic waste (Sevgican et al., 1999; Gul et al., 1990). Substrate is usually made from a mixture of organic materials and inorganic materials (Atiyeh et al., 2000). Peat, due to advantageous physical characteristics and high cation exchange capacity is used extensively (Raviv et al., 2002). Farmers sometimes devised saplings substrate, but they cannot manage about the weed seeds, diseases and pests (Beckett et al., 1999).

According to the Ministry of Agriculture and Rural Development of Vietnam (MARD), annually the biomass by-products from main crops such as rice, maize, sugarcane, vegetables of all kinds can provide the equivalent of about 43 million tons of organic matter, 1.8 million tons of urea nitrogen, 1 6 million tons of single superphosphate and 2.2 million tons of potassium sulfate. This is considered a huge number to compensate for nutrients in the soil and use it for crops in agricultural cultivation. However, these nutrients are almost wasted and there are no incentive mechanisms for reuse. In the livestock industry, only 23% of waste can be used to produce organic fertilizers, the rest is wasted and has not been used to provide input materials for farming and animal husbandry in linked chains. cyclic. This not only pollutes the environment but is also economically wasteful (MARD, 2021).

Quality saplings; must have a balanced stem-root ratio, should have a high degree of total dry matter, nodes interval should be short, stem should be thick, leaves should be green and thick, it must have sufficient root growth, all parts must be strong and healthy, such as specific color characteristics must be conspicuous, should not be too young or old and all the seedlings should be consistency (Murat et al., 2019). Quantitative indicators of these criteria have been explored in this study. Therefore, the substrate of seedling should be the ideal combination enough to accommodate such a request. Prepared seedlings substrate can be benefical for others, although it is useful for a plant. In this respect to satisfy the demand of a big chunk of vegetables by making various preparations are needed to determine the ideal seedling substrate or separately optimal substrate for each type of sapling. This study; preparing seedlings of different environments, with different types of H'mong cucumber seedling quality, by determining their effects on seedling growth and development were studied to determine the most suitable substrate.

MATERIAL AND METHODS

(1) Materials

In this study, the plant material "H'mong" cucumber variety was used, which was collected from Tua Chua district, Dien Bien province, Vietnam.

All of agricultural by-products were collected by HDT Agriculture Joine Stock Company (Thai Nguyen provice, Vietnam). Rice husks were made by the hydrothermal carbonization at 200^0C with 10% acid citric as a catalyst (Velazquez-Maldonado et al., 2019).

Mix 2 kg of lime powder with 100 liters of water, put each by-product (coconut coir, peat, canna residue, chicken manure, pig manure and cow manure) in a separate lime water tank,

soak for 7 days. After that, drain the lime water and soak it in clean water for about 1 day (3 times).
After that, spread the by-products into layers (separate) about 30 - 50 cm high, then use Trico-DHCT (108 spores/gram) at a dosage of 500g with 500 liters of water evenly on the compost piles (humidity reaches 60%), then use plastic wrap to cover the pile for 30 days.

(2) Experimental design

The type of material on the properties of seedling growing media is effective. Therefore, selecting one group of various materials in the desired size and mixed in suitable proportions multiple materials can be accessed on the intended properties. As the seedling growing media: rice husk ash (RHA), coconut coir (CC), peat, canna residue (CR), chicken droppings (CKD), pig feces (PF) and cow feces (CF) materials were used. Klasmann was used as control application. The material used seedling growth medium mixture and the mixture ratios are given in Table 1.

Table 1. Mixing ratio of the seedling substrate used in the experiment.

Treatment	Meterial mixtures
T1	25% RHA + 25% CC + 25% CR + 25% PF
T2	25% RHA + 25% CC + 25% CR + 25% CKD
T3	25% RHA + 25% CC + 25% CR + 25% CF
T4	25% RHA + 25% CC + 25% CR + 25% peat
T5 (C.T)	Klasmann (Gesste, Germany)

(2) Management

Experiments were organized under greenhouse conditions in Center for Training and Research on Plant and Animal Breeding (C.P.A), Thai Nguyen University of Agriculture and Forestry (T.U.A.F), Thai Nguyen city, Vietnam (21°35'40.6"N 105°48'31.0"E).
The experiments were designed with five treatments and three replications. Each replication was prepared as one tray with 50 holes. One seed was sown per hole. The seeds were irrigated to meet their demand during the growing period. The irrigation scheduling and water volume were arranged similarly for all treatments. Also, fertilization was not performed on seedlings growing medium.

(3) Physico-Chemical Analysis

WHC, TPS, WHP, and APS of seedling substrates were determined with the ring knife method (Zhang and Sun, 2017). The pH and EC of the seedling substrates were analyzed using Hanna HI5521-02 meter (Woonsocket, RI, U.S.A).
Bulk density (BD): 232-mL polystyrene permeameters were used in this determination. Samples were saturated with running water for 24 h, placed in the permeameters and dried in an oven at 65 °C until constant weight. N was determined for the individual materials by the micro Kjedhal method and P with the vanadate-molybdate-yellow method. Total K, Ca content was obtained by means of the flamometry technique, and Mg by atomic absorption spectrophotometry according to the official Mexican standard PROY-NOM-021-RECNAT-2000 (Carlos et al., 2021). Micronutrients, including iron (Fe), zinc (Zn), and manganese (Mg) were measured with an inductively coupled plasma atomic emission spectroscopy (ICP-AES) after extraction with 0.1 N hydrochloric acid solvent (Atiyeh et al. 2001; Truong, Wang, and Kien 2017; Abid et al. 2018).

(4) Seedling growth

The seeds were considered to have germinated after radicle emergence. Germinating seeds and the emergence of saplings were counted daily and expressed as a percentage of the total number of planted seeds. After sowing, the germination results were expressed as the number of seedlings in comparison with the number of sown seeds. The height of plants was measured in 5, 7 and 10 days after sowing (DAS). Stem diameter and seedling biomass were examined after 21 days of sowing. At the final step of the experiment, 10 seedling plants per replication were harvested randomly. In order to investigate fresh weight, they were then separated into sample groups of shoots and roots.

Root volume (cm^3) was determined by submerging the root in a measuring cup with water. To estimate the dry weight of the shoots and roots, and the concentration of total macro and micronutrients in the shoots, these samples were dried in an oven at 60 °C for 48 h (Atiyeh et al. 2001; Truong, Wang, and Kien 2017; Abid et al. 2018). The concentrations of total macro- and micronutrients, including N, P, K, Ca, Fe, Zn, and Mg, in the shoot of cucumber seedlings were determined as presented above.

(5) Statistical analysis

All data were statistically analyzed using SAS 9.1 software (SAS Institute Inc.Cary, NC, USA). The data were subjected to one-way analysis of variance (ANOVA), and the means were compared for significance by the least significant difference (LSD) test at P < 0.05. All the analyses were performed in triplicate.

RESULTS

(1) Physico-Chemical Analysis of the substrates

After mixing the agricultural by-products together according to the respective ratios of each treatment (follow Table 1), we analyzed the physico – chemical criteria of the substrates. The pH of growing media are showed that ranged from 6.5 – 6.82, which was within the appropriate threhold for seedling growth. The EC in all treatments, exception of T1, were withing the desirable range of cucumber seedlings (2.19 – 3.16 mS/cm). For the WHC, the value was higher for T2, T4, T5 (68.59; 71.02 and 73.15%) than for the other treatments and was highest for T1 (86.35%). As showed in table 2, the BD of this experiment ranged 0.15 – 0.42 g/cm^3, the lowest were T4, T5 (0.15 – 0.17 g/cm^3) and the highest for T2 (0.42 g/cm^3), it has been regarded as ideal for the seedling substrates (Feng and Zhang, 2021). Porosity as an essential physical property of the media, which reflects the water holding capacity and the exchange of gas and effects to the amount and frequency of watering in seedlings cultivation (Huet et al., 2012), it can be seen that WHC and TPS in these treatments have a favorable correlation with each other. The value of TPS, MW and APS in Treatment 1 obtained significantly higher values in comparison to those of other treatments.

Table 2. Chemical and physical characteristics of the experimented substrates

Treatment	pH (1:10)	EC (mS/cm)	WHC (%)	Bulk density (BD) (g/cm^3)	Total porosity (TPS) (% volume)	Mass wetness (MW) ($g.g^{-1}$)	Aeration porosity (APS) (% volume)
T1	6.50 b	1.14 c	86.35 a	0.21 b	86.00 a	2.84 a	15.95 b
T2	6.60 b	3.16 a	68.59 bc	0.42 a	80.25 bc	2.31 b	17.24 a
T3	6.82 a	2.22 b	65.15 c	0.25 b	82.16 b	2.16 b	17.69 a
T4	6.78 a	2.19 b	71.02 b	0.17 c	65.91 c	1.85 c	10.34 c
T5	6.80 a	2.30 b	73.15 b	0.15 c	85.54 a	2.10 b	12.89 bc
LSD 0.05	0.05	0.34	5.87	0.08	17.32	0.44	2.21

EC, electrical conductivity; WHC, water holding capacity; LSD, least significantly difference. Means followed by the same letters do not significantly differ (p<0.05).

2) Seedlings growth

After 5 days after sowing (DAS), the germination rate of the other treatments ranged between 87.71 – 93.58%, in which T2 gave the highest germination rate, followed by group T1, T5 and finall T3, T4, with 95% confidence. At 7 DAS, the germination rate in all the treatments stopped and there was no change at 10 DAS. T2 presented the highest number of germinated seeds with 95. 64%; T1 and T5 continuosly obtained the high germination rate around 92.33 – 92.89%, at the bottom of the ranking, T3 and T4 reached 90.12 – 90.97% respectively. Thus, it could be seen that the time the cucumber seedlings live in the pot in the period of 5-7 DAS will give the maximum germination rate, and not more than 10 days.

Table 3. The germination rate of H'mong cucumber in treatments at different DAS

Treatments	5 days	7 days	10 days
T1	91.46 b	92.89 b	92.89 b
T2	93.58 a	95.64 a	95.64 a
T3	87.71 c	90.12 c	90.12 c
T4	88.13 c	90.97 c	90.97 c
T5	90.89 b	92.33 b	92.33 b
LSD 0.05	6.15	4.73	4.73

LSD, least significantly difference. Means followed by the same letters do not significantly differ (p<0.05).

Table 4 showed that the different types of subtrates had significant effected on morphological charateristics and growth of H'mong cucumber seedlings in 21 DAS. T2 recorded the highest plant height compared to the others in 21 DAS (13.92 cm). The mean seedling heights in T1, T3 and T5 were 12.04; 11,87 and 11.37 respectively. The number of leaf in all treatments fluctuated between 2.90 – 3.80 leaves. The value of shoot weight in both fresh and dry samples in T2 gave the highest results with 8.73 and 1.11 g/plant respectively; following were T5 and T1 with values of fresh/dry 6.21 – 6.42/0.54 – 0.60 g/plant and T3, T4 were the lowest with 2.90 – 3.20/0.37 – 0.43 g/plant. For the criterion of root volume, all of these treatments obtained similar values, fluctuated from 1.04 – 10.09 cm^3/plant, with a confidence level of 95%.

Table 4. Effect experimented substrate on morphological characteristics and growth of H 'mong cucumber seedlings in 21 days after sowing

Treatments	Plant height (cm)	Leaf number (leaf)	Shoot weight ($g.plant^{-1}$)		Root volume ($cm^3.plant^{-1}$)
			Fresh	Dry	
T1	12.04 b	3.50 a	6.42 b	0.60 b	1.06 a
T2	13.92 a	3.80 a	8.73 a	1.11 a	1.09 a
T3	11.87 b	3.20 a	5.15 c	0.43 c	1.04 a
T4	10.26 bc	2.90 ab	4.56 bc	0.37 c	1.06 a
T5	11.37 b	3.30 a	6.21 b	0.54 b	1.07 a
LSD 0.05	1.31	1.05	1.18	0.24	0.20

LSD, least significantly difference. Means followed by the same letters do not significantly differ (p<0.05).

The composition of the main macro and micronutrients of H'mong cucumber stems in 5 treatments after 21 DAS are significantly different, which are summarized in Table 5. It can be seen that the Nitrogen, Phosphorus, Potassium, Magnesium and Zinc contents in T1 and T2 were higher than the other treatments.

Table 5. Concentration of macro-micronutrients in the shoot of H'mong cucumber seedlings after 21 days of sowing

Treatments	N	P	K	Ca	Mg	Mn	Fe	Zn
	$g.kg^{-1}$ dry weight					$mg.kg^{-1}$ dry weight		
T1	37.6 a	0.75 a	93.49 a	2.64 c	6.03 a	116.79 d	779.55 c	18.36 a
T2	37.8 a	0.90 a	94.72 a	4.24 b	5.89 a	222.66 a	680.64 d	20.11 a
T3	17.4 c	0.65 a	63.79 b	4.39 b	3.96 b	164.6 bc	932.11 b	15.17 b
T4	16.0 c	0.67 a	51.79 c	2.77 c	3.06 d	177.44 b	991.53 a	16.09 b
T5	28.4 b	0.91 a	58.32 bc	4.80 a	3.65 c	143.52 c	566.0 e	18.63 a
LSD 0,05	2.34	0.26	6.88	1.93	2.34	22.38	35.58	1.78

LSD, least significantly difference. Means followed by the same letters do not significantly differ (p<0.05).

DISCUSSION

In horticulture, the germination rate indicates how many seeds of a particular species will germinate in a given time period. It is a measure of germination time and is usually expressed as a percentage. For example, a germination rate of 85% means that about 85 out of 100 seeds will be able to germinate under the right conditions in the given time period. Germination rate is useful in calculating the amount of seeds needed given a given planting area or desired number of plants. For physiologists and seed scientists, germination rate is the reciprocal of the amount of time it takes for germination to complete, starting from seed sowing.

In the germination stage, the internal physiological activity of seeds will be influenced by the internal - external environment and curb factors (Yang and Zhang, 2022). Under the conditions of sufficient moisture, oxygen, temperature, and light, dicotyledon plants can be constructed by seeds utilizing the carbohydrates and proteins stored in the endosperm for hydrolysis and photosynthesis. Absorption of water is the first step in the seed germination process. The protoplasm of dried seeds is in a gel state with a low metabolic level, and most of the water exists as bound water with a low content. After the seeds absorb water, on the one hand, the protoplasm changes from the gel state to the sol state, and the metabolism level is improved. On the other hand, the spornioderm swells and softens by absorbing water, which helps oxygen pass through the spornioderm, enhances the respiration of the embryo, and facilitates the emergence of radicles from the seed. Consequently, the germination status of cucumber seeds was affected by the WHC and porosity of the seedling substrates. In addition, the substrate has low BD that means it is too loose and poor water retention, which are detrimental to seedlings root fixation (Feng and Zhang, 2021). The value of BD and germination rates in table 2 and 3 in T3 is a clear evidence for this statement. ‘

The growth and development of plants are reflected in the quantity of biomass (Yang and Zhang, 2022). And the physical and chemical bv bvvc cproperties of seedling substrates are closely related to the growth of both the parts of a seedling that are above and below the ground (Feng and Zhang, 2021). In the table 4, the biomass of H'mong cucumber seedlings can be raised by adding cattle manures.. A study explained that pre-mixing animal manures with agro-wastes followed by composting increased the P availability to plants (Tüzel et al. 2020). Basically, various manures provide good nutritional content to plants when applied in combination with soil-less substrates (Vivek and Duraisamy 2017).

CONCLUSION

In this season, H'mong cucumber thrived best on the mixture of 25% RHA + 25% C + 25% CR + 25% CKM. Incorporating the agricultural by-products improved the physicochemical properties of the seedlings substrates, creating better growth environments for growing H'mong cucumber. The germination rate in 7 DAS was 95.64%; the shoot weight in both fresh and dry samples in T2 gave the highest results with 8.73 and 1.11 g/plant respectively and Nitrogen, Phosphorus, Potassium, Magnesium and Zinc contents in T2 were higher than the other treatments.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the author(s).

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AUTHOR CONTRIBUTIONS

Nguyen Quynh Anh assisted in conducting the experiments, performed the statistical analysis and data visualization and wrote the manuscript. Ha Duy Truong designed and conducted all of the experiments and wrote the manuscript. All authors have read and aprproved of the final manuscript.

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