Waste and Biomass Valorization (2023) 14:2367–2374
https://doi.org/10.1007/s12649-022-01995-4

ORIGINAL PAPER

Exploratory Research on the Adoption of New Organic Wastes for Production of Greenhouse Cucumber in Soilless Culture

Majid Basirat[1] · Seyed Majid Mousavi[1] · Farhad Dehghani[2] · Mohammad Hossein Davoudi[1]

Received: 19 May 2022 / Accepted: 19 November 2022 / Published online: 6 December 2022

Abstract

Purpose Soilless culture and using organic wastes can increase not only yield but also quality and safety of fresh produce and thus meet the demands of modern society.

Methods In order to study the effect of new organic-based soilless media including aged wood bark, composted date palm woody wastes, and a mixture of 70% cocopeat + 30% perlite as the control on yield, quality, and nutritional status of greenhouse cucumber, this study was conducted as randomized complete blocks design with three replications.

Result Based on the results, the average daily yield was not significantly affected by the studied organic wastes. Although aged wood bark had the highest total yield, the number of fruit and average fruit weight compared to other treatments; however, there was no significant difference between the three-growing media in terms of yield parameters. The nitrate content of fruit in all treatments was lower than the permissible limit. Furthermore, regardless of the type of growing media, the accumulation of nitrate in fruit peel was greater than in the fruit flesh by 3–7 times.

Conclusion In general, it is concluded that both aged wood bark and composted date palm woody wastes may be considered as the alternative options for cocopeat and perlite.

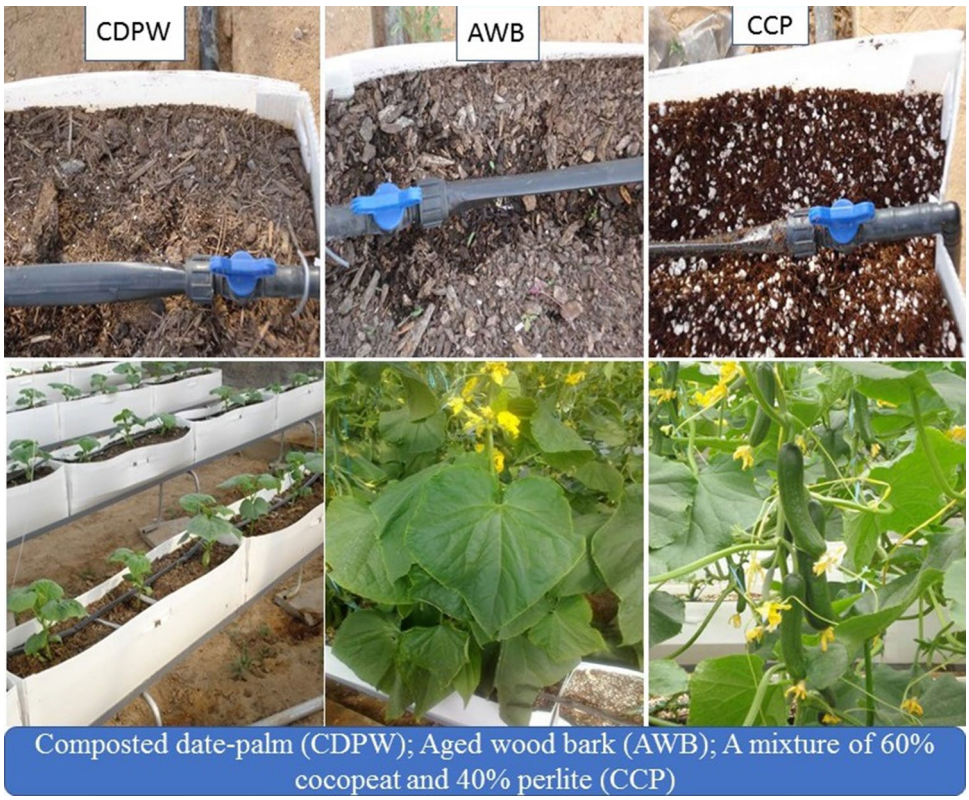
✉ Majid Basirat
majid_basirat@yahoo.com

✉ Seyed Majid Mousavi
majid62mousavi@gmail.com

[1] Soil and Water Research Institute, Agricultural Research Education and Extension Organization (AREEO), Karaj 31779-93545, Iran

[2] National Salinity Research Center, Agricultural Research, Education and Extension Organization (AREEO), Yazd, Iran

Graphical Abstract



Keywords Soilless culture · Organic wastes · Greenhouse cucumber · Yield · Fruit quality

Statement of Novelty

Because of plant protection problems with soil-borne pathogens and soil limiting factors, utilizing substrate-based agriculture is a logical alternative to the current soil-based production approach. Soilless culture can increase not only yield but also quality and safety of fresh produce and thus meet the demands of modern society. In Iran, aged wood bark and date palm woody wastes are abundant materials in the wood industry and date palm orchards. They are huge residual wastes in the environment which are mostly burned for disposal. Therefore, in this research, two internally prepared growing media from wood and palm wastes are compared with a mixture of cocopeat and perlite in respect to effects on yield, nutritional status, and nitrate content of greenhouse cucumber.

Introduction

Using organic wastes in order to protect natural resources and create more benefits in agriculture production chains are attractive topics in environmental policies. On the other side, soilless culture is a technical approach to increase yield in greenhouses and the quality of products is the hot spot issue and stockholders are approaching to use of organic materials to produce healthy and fresh crops. In Iran, aged wood bark and date palm woody wastes are abundant materials in the wood industry and date palm orchards. Both of them are huge residual wastes in the environment which are mostly burned for disposal [4]. Because of plant protection problems with soil-borne pathogens and soil limiting factors such as soil salinity and pH, soil and groundwater pollution with nitrate and pesticides, soil compaction, and poor drainage, the plants on the soil show different disorders. Also, weed control cannot be avoided [9]. Therefore, it is needed to treat soil using different methods which are either too expensive or too polluting to the soil and/or groundwater [13].

Therefore, utilizing substrate-based agriculture is a logical alternative to the current soil-based production approach throughout the world. Soilless or hydroponics culture is known as one of the cultivated techniques for better function, water use efficiency as well as high quality and quantity crops. There are different hydroponic systems, the substrate-culture, water-culture, and aquaponics.

Table 1 Some properties of the used zeolite and vermicompost

	pH (1:10)	EC(dS/m) (1:10)	Nitrogen (%)	Phosphorous (%)	Potassium (%)	Calcium (%)
Zeolite	9.2	2.1	0.003	0.001	0.64	0.84
Vermicompost	7.2	2.3	1.48	0.38	0.86	1.1

A substrate culture system with trickle irrigation was used in this research. Currently, most of the growing media used in hydroponic greenhouses are imported, such as cocopeat and peat moss, which has increased the production costs and indicates the need for an alternative media from domestic resources. Also, at present, there is no domestic alternative in the country, and growers are forced to use high-priced imported types. Moreover, the use of soil along with other factors such as lack of proper rotation in greenhouse productions has led to the spread of many diseases in the greenhouses that require growing media with physicochemical properties equivalent to cocopeat types.

The selection of a specific material as a substrate is correlated with its availability, cost, and local experience with its use [17]. Such substrates substitute the soil because the natural soils are often poorly suited for cultivation and contain chemical, physical, or biological constraints [2]. The substrate plays a vital role to support the plant and provides air, water, and nutrients to the roots. In addition, it must not contain pathogens and should not be phytotoxic [1].

Cucumber (*Cucumis sativus* L.) is one of the main crops cultivated in greenhouses because of its short growing cycle and its high economic value in off-season harvest [5], it is the fourth most important vegetable crop after tomato, cabbage, and onion in Asia [8]. In Iran, due to the lack of substitutes, the use of cocopeat-perlite mixes has been a priority for greenhouse owners. Therefore, in this research, two internally prepared growing media from wood and palm wastes are compared with a mixture of cocopeat and perlite in respect to effects on yield, nutritional status, and nitrate content of greenhouse cucumber.

Materials and Methods

In order to investigate the effect of different growing media on greenhouse cucumber, an experiment was conducted as a randomized complete block design with three replications in the greenhouse environment of Yazd Agricultural and Natural Resources Research and Education Center, Yazd, Iran in autumn and spring on greenhouse cucumber. In this experiment, which was conducted in a soilless open system, 3 growing media including (1) a mixture of 60% cocopeat and 40% perlite (CCP) as the positive control (2) Aged wood bark (AWB) processed and enriched with vermicompost and zeolite (3) Composted date-palm (CDPW) enriched with vermicompost and zeolite were studied. A natural clinoptilolite-zeolite powder (0.3–0.5 mm with purity > 95%) supplied by Afrand Tusca Co., Tehran, Iran, was used for this work [11, 12]. The ratio of mixes is 90% CDPW + 5% vermicompost + 5% zeolite and 80% AWB + 15% vermicompost + 5% zeolite, which according to the studies conducted at Soil and Water Research Institute, Karaj, Iran [3], this ratio has an appropriate ratio of coarse pores for aeration and drainage. While the medium has good water retention, it also provides good drainage. Also, in order to sterilize the growing media a 10% bleach soak was used for 20 min followed by multiple rinses of tap water. The growing media has a pH close to neutral and good cation exchange capacity (CEC), as well (Table 2).

The raw materials were obtained from date palm trees (*Phoenix dactylifera*), and the Mazafati variety. According to Basirat and Davoudi's method [4], the longleaf was separated and crushed to a very small size. Short fibers are sieved in 0.5–8.0 mm sizes. A pile (1.5 × 2.5 m) was prepared; it was

Table 2 Some important properties of the growing media

Growing media	CEC (meq/l)	OC (%)	C/N (-)	EC (dS/m)	pH (-)	BD[a] (g/cm^3)	PD[b] (g/cm^3)	TP[c] (%)	AFP[d] (%)	WHC[e] (%)
CCP	61	43	72	1.2	6.98	0.13	0.70	91	24	58
CAWB	61.5	21.3	22.6	0.96	7.02	0.43	0.75	86	20.2	65.7
CDPW	61.7	23.5	13.6	1.07	7.16	0.19	0.74	27	47	51.5

[a]Bulk density

[b]Particle density

[c]Total porosity

[d]Air filled porosity

[e]Water holding capacity

incubated with 3.75 kg urea per one cubic of the substrate and kept constant in ambient moisture and turned for eight weeks. Two mixes were prepared by adding different rates of zeolite and vermicompost as amendments. Vermicompost was prepared in pits with dimensions of 1 × 0.75 × 1 m. The pit was filled with a layer of gravel sands to limit the earthworms' exit. The out layer of the pit was filled with farming soil, slurry cow manure, and a 10 cm thick layer of straw respectively. The rest of the pit was filled with cow manure with 200 earthworms (*Eisenia foetida*) were put in the growing media. To retain the moisture content, water was sprinkled during the procedure. Harvesting was done on the 60th day, and the worms were separated from the vermicompost. The young worms and cocoons were separated from the soil using 3 mm sieves. The nutrient analysis of vermicompost and zeolite is presented in Table 1.

Containers with dimensions of 30 × 25 × 30 cm were used. They were placed on metal bases with a height of 45 cm, and in order to facilitate the drainage, some pumice was placed on their floor. Then, the growing mixes were placed into the containers as the growing media. Before the experiment, the mixes, especially cocopeat, were water-leached in order to homogenize and reduce their salinity (EC) [6]. The physical properties such as bulk density, total porosity, air-filled porosity (AFP), particle density (PD), water holding capacity, and chemical properties such as C/N ratio, pH and EC, Nitrogen, Phosphorus, Potassium, and Calcium, cation exchange capacity, and organic carbon of the growing medias were determined [18] (Tables 1 and 2).

The materials used in the growing media must have appropriate physical and chemical properties and in addition to providing suitable growth conditions for the plant, they must maintain their desired properties over time. Tables 1 and 2 show some important properties of the growing media, vermicompost, and zeolite used in this experiment.

The greenhouse cucumber hybrid seeds variety Pepino of Fito Semillas Barcelona, Spain. which is a mostly single flower and was more suitable for the autumn season were planted in seedling boxes according to and then were placed in the greenhouse under optimal environmental conditions including a temperature of 22–24 °C during the day and 18 °C at night, a photoperiod of 14 h light/10 h dark, the light intensity of 8000–8500 Photosynthetic Photon Flux Density (PPFD), and relative humidity of 70% [5]. After 15 days, the seedlings were transferred to carton plasts containing the growing media with three plants per carton plast.

The Composition of the Nutrient Solution Using for Fertigation

One of the important points in determining the composition of nutrient solution used in soilless growing media is the quality of irrigation water. Table 3 shows the results of the analysis of the irrigation water. The composition of the nutrient solution was different in different stages of development, so three types of compounds were used for the early stages of growth, flowering and early fruit formation, and the stages of maximum production. The amounts (gr per 1000 L of water) and types of fertilizer salts used to make 3000 L of nutrient solution in the fruit production stage are as follows: KNO_3 40, $Ca(NO_3)_2 + 4H_2O$ 1020, Fe EDDHA 33.3, HNO_3 200, NH_4NO_3 20, $MgSO_4 + 7H_2O$ 390, K_2SO_4 407, NH_4NO_3 6.65, $ZnSO_4 + 7H_2O$ 3.05, H_3BO_3 3.35, $MnSO_4 + 4H_2O$ 4, $CuSO_4 + 5H_2O$ 1, $MoO_4(NH_4)$ 0.66, KNO_3 30, KH_2PO_4 184, NH_4HPO_4 50.

This volume was made for three days and due to dilution, all the salts were dissolved in it. The fertigation was done at specified intervals by drip irrigation, i.e., on average every hour for 5 to 7 min, and ranged between 7 am to 7 pm. The electrical conductivity and pH of the solution were controlled every day before irrigation and modified if necessary. Nitric acid was used to control the acidity. Due to the fact that the greenhouse was under cultivation during the spring growing period, the accumulation of solutes in the growing media was removed by leaching once every two weeks.

In the beginning stage of growth, the amounts of nitrogen and phosphorus were increased, and in the flowering stage, the amounts of phosphorus were increased again, and in the stage of fruiting and re-harvesting, the ratio of nitrogen and phosphorus decreased and the amount of potassium

Table 3 The chemical analysis of the irrigation water and the effluent in the studied growing media

Parameter	Irrigation water								
	EC (dS/m)	pH	Na^+	Ca^{2+}	Mg^{2+}	Cl^- (meq/lit)	CO_3^{2-}	HCO_3^-	SAR
Amount	0.48	7.9	1.1	2.7	0.96	1.2	0	2.7	0.8
Properties of the effluent in the studied growing media									
Growing media	EC (dS/m)	pH (−)	N (ppm)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Fe (ppm)	Mn (ppm)
CCP	2.14	7.80	42	6.97	94	211.7	70.7	0.34	0.025
CAWB	2.63	7.72	98	10.72	61	329	65	0.27	0.020
CDPW	2.49	7.64	91	16.10	61	417	68.3	0.35	0.036

increased as much as possible [5]. In order to control the conditions of the root environment and consider the interaction between the type of growing media and the plant on the composition of the effluent from different substrates, this effect was investigated by analyzing the chemical composition of the effluent. During the growing season, pruning, pest control, and foliar spraying (observing deficiency symptoms or leaf analysis results) were carefully performed.

Harvesting, Sampling, and Analyzing

Harvesting and the related measurements were performed once every 2 or 3 days. During the experiment, quantitative and qualitative characteristics of fruits including the number of fruits, total yield, and concentration of nitrate in fruit (once in the eighth step of harvesting) of each treatment were measured. For leaf sampling (in the eighth step of harvesting), a sample was taken from the fifth leaf at the end of the bushes for analysis.

Fruit sampling was performed in each of the treatments and then nitrate content was measured. To sample cucumber fruit, 15 healthy fruits were harvested from the treatments. After transferring to the laboratory, the fruits were washed with distilled water and prepared for analysis by standard methods. In order to measure the concentration of nitrate, the post-reduction calorimetric method (Di Azo method) was used. Based on this method, 50 ccs of 2% acetic acid was added to 0.5 gr of the milled sample. After half an hour of shaking and passing through filter paper of 10 ml, 0.5 g of the mixed powder (citric acid compound, manganese sulfate monohydrate, sulfanilamide, N-1-naphthyl ethylene diamine Dihydrochloride, and zinc powder in certain proportions were added to the resulting and stirred for 30 s. It was then passed through filter paper and read at a wavelength of 540 nm by a spectrophotometer [16]. Finally, after analysis of variance (ANOVA) of the data to determine significant treatment effects, mean separation was done using Duncan's multiple range test (DMRT). All statistical results were considered significant at $P \leq 0.05$. The figure was created by EXCEL.

Results and Discussion

The measured parameters in the water (Table 3) indicate its appropriate quality for use in the preparation of the nutrient solution. Due to the interaction effects between the type of growing media and plant on the composition of the effluent, this effect was investigated by analyzing the composition of the drainage (Table 3). The EC and pH of the effluent were not affected by the media. The higher concentration of calcium and magnesium in the output solution compared to the initial nutrient solution is related to the lower rate of absorption of these nutrients compared to the rate of water absorption and evaporation.

Influence of Different Growing Media on Yield and Yield Components of Cucumber

The changes in the average daily yields in different treatments are shown in Fig. 1, which indicates that there is no significant difference during the experiment.

Also, the effect of different growing media on yield and yield components of cucumber (Table 4) showed that there is no significant difference among the growing media however; Aged wood bark (CAWB) had the highest total yield, the number of fruits, and the average weight of fruit compared to other treatments. The previous studies reported that cocopeat and perlite were suitable growing media for some plants, especially for vegetables [5, 20, 21]. Though,

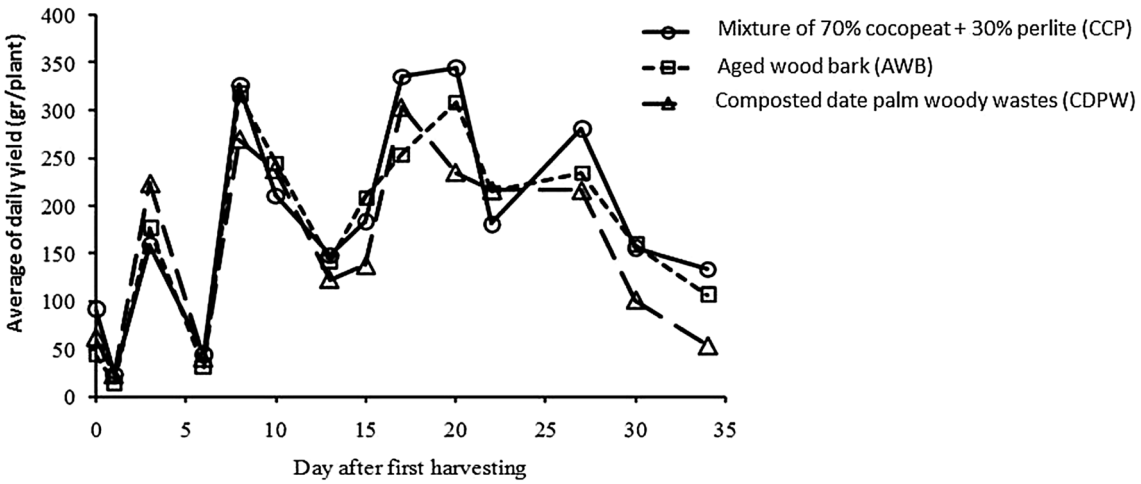


Fig. 1 Changes in the average of daily yield during harvest in different growing media

Table 4 Means comparison of the effect of different growing media on yield and yield components of cucumber

Growing media	Average weight per fruit (g)	Average number of fruit per plant	Total yield (g per plant)
CCP	81.39a	24.33a	1970.0a
CAWB	86.91a	25.00a	2160.8a
CDPW	81.83a	23.42a	1911.6a

Means in the same column followed by the same letter are not significantly different according to DMRT at ($P \leq 0.05$)

recent studies have shown that there are some new growing media, which due to their physicochemical properties provide a better growing media for plants. The amount of CEC in CAWB and CDPW was higher than CCP (Table 2). This factor relates to the buffer capacity of nutrients, which has a vital role in plant supplements. However, some studies have reported that there is no significant difference between CCP and the newer growing media such as CDPW in terms of growing indices [10, 14].

The previous study on assessment of different date palm based mixes for soilless culture reported the CDPW [date palm substrate (90%), vermicompost (5%) and zeolite (5%)] in terms of cation exchange capacity, particle density, total porosity, bulk density, water holding capacity and electrical conductivity in the same cluster as coir substrate, as the superior growing media, which it is confirmed by the present study [4].

Influence of Different Growing Media on the Chemical Composition of Plant Tissues

The results showed that nutrients content of the leaf is significantly affected by the type of growing media. CAWB and CDPW accumulated higher concentrations of N, P, K, and Cu compared to CCP. While Mg and Zn content of leaf in CCP was more than in other growing media (Table 5). The superior growing media in terms of Ca, Fe, Mn, and B content of leaf was CDPW and it was respectively followed by CCP and CAWB.

The leaf concentrations of P, Ca, Mg, Fe, Mn, Cu, and B in the studied growing media were at the optimum level but the concentrations of N and K were at the toxicity level [7]. The high N and K content of leaves is likely related to the chemical composition of the using nutrient solution and relatively insufficient drainage for exiting the extra concentrations of N and K from the containers. The notable point of this study was the effect of CCP on the Zn content of leaf, which was in the toxicity range reported by de Kreij et al. [7] while, CAWB and CDPW caused an optimum accumulation of Zn in leaf (i.e., the optimum range of Zn is 20–100 mg/kg). These results are in line with those obtained by Basirat and Davoudi [4] about CDPW.

In general, with the exception of Zn changes, it was observed that the growing media had a similar effect on the nutritional status of cucumber leaf, which refers to their nearly similar properties, and therefore they had not created any significant difference in the nutritional status of the cucumber leaf. The levels of nutrient absorption of plants in the two treatments were significantly higher than CCP, while the CEC is similar among them (Table 2). The results showed that the type of growing media had no significant effect on the content of nitrate in the flesh and peel of cucumber ($P < 0.05$) (Table 6). However, regardless of the type of growing media, the accumulated nitrate in the peel was significantly higher ($P < 0.05$) than the accumulated content in the flesh. The nitrate content of the cucumber peel was about 3 to 7 folds higher than the flesh. This result is in line with those obtained by Stachniuk et al. [19]. Therefore, separating the peel can significantly reduce the risks of high nitrate accumulation in the fruit. Another notable result of this study is that the total content of nitrate in fruit was significantly lower than the maximum permissible rate (15 mg

Table 5 Nutrients content of leaves in different growing media

Growing media	N	P	K	Ca	Mg	Fe	Zn	Mn	Cu	B
	%					mg/kg				
CCP	5.16a	0.643a	4.16a	1.25a	0.508a	78.85a	122.3a	42.6a	14.8a	49b
CAWB	5.48a	0.784b	4.28a	1.23a	0.393a	73.55a	92.4b	30.0b	18.8b	47a
CDPW	5.69a	0.727b	4.49a	1.89b	0.491ab	89.75b	80.5b	48.6a	16.7b	52b
	Nutrient standards in cucumber leaves (de Kreij et al. 1992)									
	N	P	K	Ca	Mg	Fe	Zn	Mn	Cu	B
	%					mg/kg				
Deficiency level	< 1.8	< 0.2	< 2	< 1	< 0.15	< 50	< 15	< 15	< 3	< 20
Optimum level	2.5–4.5	0.3–0.7	2.5–4	2.5–5	–	50–300	20–100	60–400	8–20	30–70
Toxicity level	> 4.5	> 1	> 4	-	> 2.5	> 300	> 100	> 400	> 30	> 70

Table 6 Concentration of nitrate in fruit affected by different growing media

Growing media	Concentration of nitrate in cucumber flesh (mg per 100 g fresh weight)	Concentration of nitrate in cucumber peel (mg per 100 g fresh weight)	Total nitrate (mg per 100 g fresh weight)
CCP	1.06a	5.46a	2.18a
CAWB	2.37a	7.78a	3.68a
CDPW	1.25a	9.49a	3.29a

Means in the same column followed by the same letter are not significantly different according to DMRT at ($P \leq 0.05$)

per 100 g fresh weight of fruit). This may be due to the quality of the using growing media, and the likely balance of nutrients in the nutritional formulation. The high concentration of nitrate was related to the non-efficient management of plant nutrition in the greenhouse, due to excessive use of urea and nitrate fertilizers and also livestock manures [15].

Conclusion

Numerous studies reported that cocopeat and perlite are popular growing media for soilless culture in greenhouses in different regions. The results of the present work showed that a mixture of 60% cocopeat and 40% perlite (CCP), aged wood bark (AWB), and composted date-palm enriched with vermicompost and zeolite (CDPW) did not have any significant differences in the nutritional and yield status of greenhouse cucumbers which likely refers to their nearly similar properties. Although, the nutrients use efficiency is more than conventional media. Thus, considering the low cost, availability, and abundance of wastes of date palm and aged wood bark in the region, these wastes may be considered efficient substituents to the conventional growing media such as cocopeat and perlite for greenhouse plants such as cucumber in Iran.

Acknowledgements The authors wish to express their sincere thanks to Soil and Water Research Institute, Agricultural Research Education and Extension Organization (AREEO), Karaj, Iran for providing research facilities.

Author Contributions Supervision, Conceptualization, and Methodology were performed by MB. Visualization, Investigation, Writing-Original draft preparation, Reviewing and Editing were performed by SMM. Investigation and data Curation were performed by FD. Resources were supported by Mohammad Hossein Davoudi. All authors read and approved the final manuscript.

Funding The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

Data Availability The datasets generated during and/or analyzed during the current study are not publicly available due to personal reasons but are available from the corresponding author on reasonable request.

Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

References

1. Al-Far, A.M., Tadros, M.J., Makhadmeh, I.M.: Evaluation of different soilless media on growth, quality, and yield of cucumber ("*Cucumis sativus*" L.) grown under greenhouse conditions. Aust. J. Crop Sci. **13**(8), 1388–1400 (2019)
2. Asaduzzaman, M., Saifullah, M., Mollick, A.S.R., Hossain, M.M., Halim, G.M.A., Asao, T.: Influence of soilless culture substrate on improvement of yield and produce quality of horticultural crops. Soilless culture-Use of substrates for the production of quality horticultural crops. INTECH **45**, 1–32 (2015)
3. Basirat, M.: Investigating the possibility of producing soilless culture medium from domestic sources for several greenhouse crops. Final report of research, Id number of 45665. Soil and Water Research Institute, Karaj, Iran. (In Persian) (2015).
4. Basirat, M., Davoudi, M.H.: Assessment of different date-palm based mixes for soilless culture. J. Solid Waste Technol. Manag. **46**(3), 314–320 (2020)
5. Basirat, M., Mousavi, S.M.: Effect of foliar application of silicon and salicylic acid on regulation of yield and nutritional responses of greenhouse cucumber under high temperature. J. Plant Growth Regul. (2022). https://doi.org/10.1007/s00344-021-10562-5
6. Basirat, M., Mousavi, S.M., Abbaszadeh, S., Ebrahimi, M., Zarebanadkouki, M.: The rhizosheath: a potential root trait helping plants to tolerate drought stress. Plant Soil **445**(1), 565–575 (2019)
7. de Kreij, C., Sonneveld, C., Warmenhoven, M.G., Straver, N.A.: Guide values for nutrient element contents of vegetables and flowers under glass. 3rd Ed (1992).
8. Eifediyi, E.K., Remison, S.U.: Growth and yield of cucumber (*Cucumis sativus* L.) as influenced by farmyard manure and inorganic fertilizer. J. Plant Breed. Crop. Sci. **2**(7), 216–220 (2010)
9. Hussain, A., Iqbal, K., Aziem, S., Mahato, P., Negi, A.K.: A review on the science of growing crops without soil (soilless culture)-a novel alternative for growing crops. Int. J. Agric. Crop Sci. **7**(11), 833 (2014)
10. Mohamadi Ghehsareh, A., Hematian, M., Kalbasi, M.: Comparison of date-palm wastes and perlite as culture substrates on growing indices in greenhouse cucumber. Int. J. Recycl. Organic Waste Agric. (2012). https://doi.org/10.1186/2251-7715-1-5
11. Mousavi, S.M., Motesharezadeh, B., Hosseini, H.M., Alikhani, H., Zolfaghari, A.A.: Root-induced changes of Zn and Pb dynamics in the rhizosphere of sunflower with different plant growth

promoting treatments in a heavily contaminated soil. Ecotoxicol. Environ. Saf. **147**, 206–216 (2018)
12. Mousavi, S.M., Motesharezadeh, B., Hosseini, H.M., Alikhani, H., Zolfaghari, A.A.: Geochemical fractions and phytoavailability of zinc in a contaminated calcareous soil affected by biotic and abiotic amendments. Environ. Geochem. Health **40**(4), 1221–1235 (2018)
13. Petre, S.N., Pele, M., Draghici, E.M.: Influence of perlite and jiffy substrates on cucumber fruit productivity and quality. J. Agric. Sci. **7**(8), 185 (2015)
14. Samiei, L., Khalighi, A., Kafi, M., Samavat, S., Arghavani, M.: An investigation of substitution of peat moss with palm tree celluloid wastes in growing aglaonema (*Aglaonema Commutatum* Cv Silver Queen). Iran. J. Agric. Sci. **36**(2), 503–5105 (2005). ((**in Persian**))
15. Sanai Ostovar, A., Khoshgoftarmansesh, A.H., Mirzapour, M.H.: Some quality characteristics and nutritional status of greenhouse cucumber in Qom province. J. Hydrol. Soil Sci. **14**(4), 15 (2010). ((**In Persian**))
16. Singh, J.P.: A rapid method for determination of nitrate in soil and plant extract. Plant Soil **110**, 137–139 (1988)
17. Sorin, P., Pele, M., Draghici, E.M.: Study on the influence of substrate culture on the production of cucumbers in unconventional system. Sci. Papers. Ser. B **20**, 255–258 (2015)
18. Sparks, D.L., Page, A., Helmke, P., Loeppert, R., Soltanpour, P., Tabatabai, M., Johnston, C., Sumner, M.: Methods of Soil Analysis. Soil Science Society of America, Madison (1996)
19. Stachniuk, A., Szmagara, A., Stefaniak, E.A.: Spectrophotometric assessment of the differences between total nitrate/nitrite contents in peel and flesh of cucumbers. Food Anal. Methods **11**(10), 2969–2977 (2018)
20. Subramani, T., Gangaiah, B., Baskaran, V., Swain, S.: Effect of soilless growing media on yield and quality of tomato (*Solanum lycopersicum* L.) under tropical island condition. Int. J. Curr. Microbiol. Appl. Sci. **9**(5), 2084–2090 (2020)
21. Waiba, K.M., Sharma, P., Sharma, A., Chadha, S., Kaur, M.: Soilless vegetable cultivation: a review. J. Pharmacogn. Phytochem. **9**, 631–636 (2020)