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The Role of *Trichoderma viride* in Valorization of Date Palm Fiber Wastes as an Alternative Growing Media to Coco Peat for Cucumber Seedlings Production

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PRODUCTION of vegetable seedlings is considered one of the most important factors control the success cultivation of vegetables worldwide. Seedlings stage is a crucial period in vegetables growing, ensuring high productivity. The growing media of seedling is a vital component of seedlings production cost, especially the coco peat. In the current study, date palm fiber (DPF) waste was evaluated to be an alternative growing substrate to coco peat to reduce the cost of seedlings production. Along with this general aim, *Trichoderma viride* was also investigated in valorization of DPF as an alternative growing media to coco peat in cucumber seedlings production. DPF media was mixed with vermiculite (VC) at different ratios (i.e., 75:25, 50:50, and 25:75) compared to the control. These mixtures were enriched with and/or without *T. viride* to make eight treatments which included: control (coco peat and vermiculite 1:1), 75 % DPF + 25 % VC, 50 % DPF + 50 % VC, and 25 % DPF + 75 % VC in presence or absent of *T. viride* for all mixtures. The findings reveal the efficiency of using DPF media in the germination and growth of cucumber seedlings. There are no significant differences due to all DPF mixtures on both total germination rate and germination index in comparing to commercial growing media (control) in presence or absent of *T. viride*. The best seedlings quality traits were resulted by all DPF mixtures including root length, stem diameter, chlorophyll content, while coco peat media recorded the tallest seedlings and biggest leaf area. *T. viride* application increased the quality of growing media and showed the highest percentage of survival rate and lowest disease severity percentage of damping off caused by *Rhizoctonia* spp. Also, different DPF mixtures with VC showed the lowest cost of growing media compared to commercial media which had the highest costs. The application of *T. viride* promoted the growth of cucumber seedling roots and increased the bioavailability of different nutrients in rhizosphere of growing media along with the uptake by roots. Further research is needed to be applied to other different vegetable seedlings as well.

Keywords: Agro-wastes; Chlorophyll content; Seedling traits; Media cots; Photosynthesis efficiency; *Rhizoctonia* spp.

1. Introduction

Agro-wastes, particularly agricultural residues and agro-industrial by-products represent a valuable resource for several agro- and biotechnological applications such as industrial bio-products (Wibisono et al. 2025), composting (Bayoumi et al., 2019; Liu et al. 2025), wastewater treatment (Kumari et al. 2025), soil remediation (Yang S et al. 2025), cosmetic (Khiri et al. 2025) and medicine applications (Chai and Chen 2023). Composting agro-wastes to be used as growing substrates presents a sustainable alternative to growing media, which can provide the horticultural seedlings with the needed nutrients (Picca et al. 2025). Many common types of plant-derived wastes are addressed to be utilized in preparing growing media such as garden or nursery wastes, crop residues (Noor et al. 2024), and spent mushroom substrate (Wang et al. 2024), as bio-based peat alternatives including compost, wood fiber, and other agricultural wastes (Liu et al. 2024; Hashemi et al. 2024; Van Gerrewey et al. 2024; Liu et al. 2025). The vegetable nursery industry seeks to develop and facilitate different possible substrate or mixture alternatives to coco peat as sustainable and eco-friendly growing media, with an emphasis on the circular economy approach (Gallegos-Cedillo et al. 2024a). Therefore, the valorization of agro-, agro-industrial and food wastes for preparing growing media is a crucial and global issue in nurseries sector

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(Zhang et al. 2024; Korba et al. 2025; Xie et al. 2025). Among agro-wastes, date palm fiber is a promising agro-waste that can be utilized as an alternative growing media to peatmoss (Shalaby et al. 2025).

As an old cultivated plant, date palm is considered a bountiful source of glucose, sucrose, carbohydrates, and proteins along with several by-products can be utilized in the agri-food sector (Di Salvo et al. 2024). Date palm wastes have several applications in many sectors such as bioethanol production (Al-Rajhi and Abdelghany 2023), biomedical applications (Dhahi et al. 2024), polymer composites (Bouzidi et al. 2024), improving soil properties (Kavvadias et al. 2024), producing biochar-based fertilizers (Mihoub et al. 2024; Rehali et al. 2025), removing pollutants from aqueous environments (Siva Kumar et al. 2023; Al-Zoubi et al. 2025), sustainable construction (Khrissi and Tilioua 2025), bioactive components (Barathikannan et al. 2025), solar steam generation (Salem et al. 2025), and producing nanomaterials like nano-cellulose (Raza et al. 2025). Unlimited quantities of non-harvestable wastes or byproducts can be produced from date palm cultivation, which should be valorized for utilization in many industries (Khrissi and Tilioua 2025). The use of date palm fiber (DPF) waste as eco-friendly and sustainable growing substrate in the nursery industry is of a great challenge that was investigated by researchers (e.g., Abid et al. 2018; Elabed et al. 2022; Aydi et al. 2023; Ghouili et al. 2023; Qaryouti et al. 2023). It is reported that DPF is considered a promising growing medium alone or mixing with vermiculite for vegetable seedlings production (Shalaby et al. 2025).

The genus *Trichoderma* plays crucial and significant roles in the agriculture sector and human health (Taha et al., 2020; Tyśkiewicz et al. 2022; Harman 2024; Ribeiro Dos Santos and Lima Dos Santos 2025). These roles range from reducing crop losses, promoting plant growth, the ability to biofortify crops and/or biodetoxify wastewater or soils (García-Latorre et al. 2025). This genus can stimulate plant growth by enhancing phyto-hormones, producing antioxidants and having promising antimicrobial potential by emitting volatile organic compounds and enzymes as well as enhancing the potential of plant host defense (Ferreira et al. 2024; Cournault et al. 2025). Few studies were reported on the co-application of DPF and *Trichoderma* with focus on different themes such as the bioconversion process of DPF by *Trichoderma* (Elsayed et al. 2021), and removing pollutants from water (Jassim and Al-Shammari 2023; Elsayed et al. 2025). Although, the promising application of *Trichoderma* spp. in enhancing plant growth under different growing media (Traversari et al. 2024), promoting the growth of horticultural seedlings depends on *Trichoderma* inoculum and substrate type (Marín-Guirao et al. 2016).

As far as we know, this is the first report focused on applying *T. viride* to promote the utilization of DPF as an alternative growing media to coco peat by forming new mixtures from DPF and vermiculite. Therefore, the current study highlights the possible application of mixing DPF with vermiculite in presence and absent of *T. viride* forming different growing media as an alternative to coco peat for growing cucumber seedlings. Different vegetative seedlings growth, nutrients uptake, photosynthetic parameters, and seedlings quality against damping off caused by *Rhizoctonia* spp. were evaluated. To what extent can DPF be utilized as growing media instead of coco peat? What is the role of *T. viride* in enhancing the suggested growing media?

2. Materials and Methods

2.1. Trial design and treatments

The trial was processed at Horticulture Department Farm, Faculty of Agriculture, Kafrelsheikh University, during March 2025 under greenhouse conditions. The current research focuses on the valorization of date palm fiber (DPF) wastes to be alternative growing media to coco peat for producing vegetable seedlings in nurseries. DPF wastes were collected and dried as well as grinded (Figure 1). The basic chemical analyses of date palm fiber wastes after grinding can be found in Table 1. The DPF media was mixed with local media (vermiculite) by volume to create eight preferred treatments producing completely locally growing media without coco peat (Figure 2) and each treatment has six replicates (i.e., trays) as follows:

<u>I. Treatments in absent of *Trichoderma viride*</u>

1- Control, (coco peat: vermiculite; 1:1)

2- Utilization of 75 % DPF + 25 % VC

3- Utilization of 50 % DPF + 50 % VC

4- Utilization of 25 % DPF + 75 % VC

<u>II. Treatments in presence of *Trichoderma viride*</u>

5- Control (coco peat: vermiculite; 1:1)

6- Utilization of 75 % DPF + 25 % VC

7- Utilization of 50 % DPF + 50 % VC

8- Utilization of 25 % DPF + 75 % VC

Table 1. Basic chemical analyses of date palm fiber (DPF) wastes after grinding.

pH	EC (dS m^{-1})	Nutrient concentration (ppm)									
(1:5)	(1:10)	N	P	K	Ca	Cu	Fe	Na	Mg	Mn	Zn
6.02	5.56	6400	137.4	9325	1516	12.5	1675	1835	5500	30.6	986

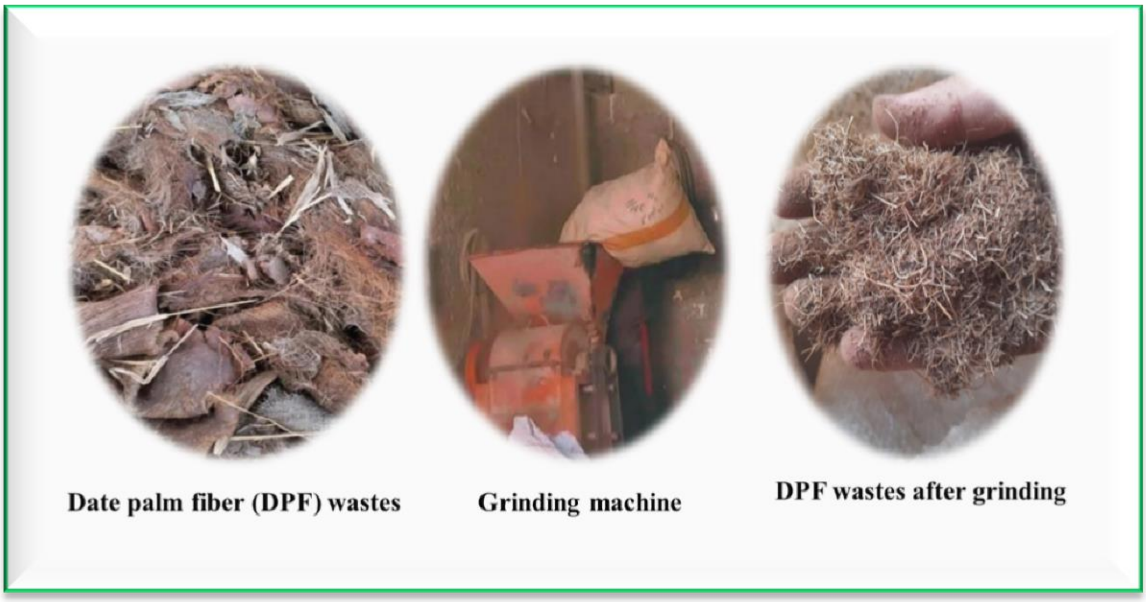

Fig. 1. The main three steps for producing growing media from date palm fiber waste including air drying the wastes after collecting and then grinding to be ready for mixing.

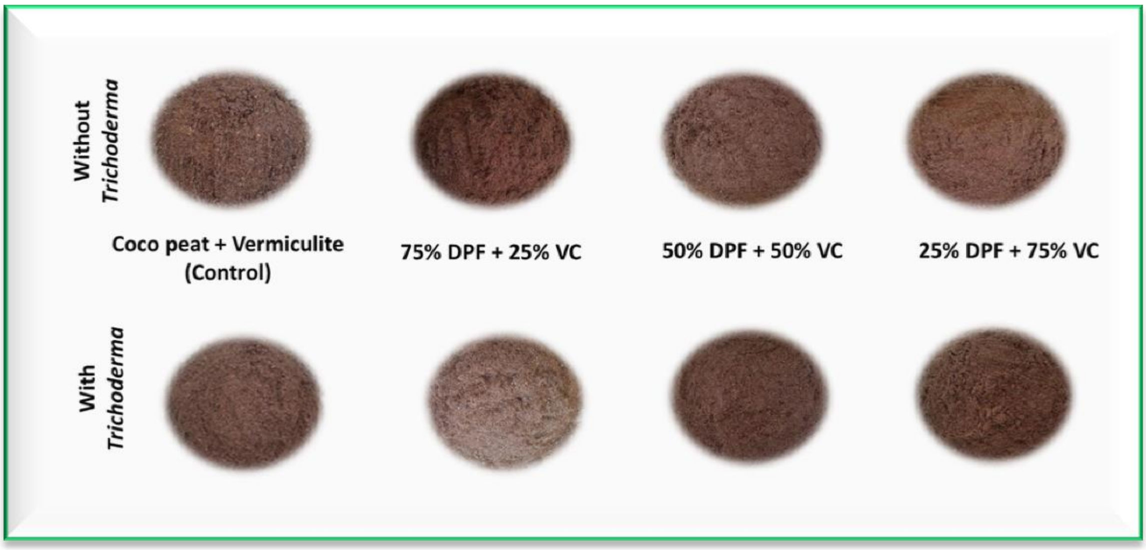

Fig. 2. The possible mixed growing media between DPF and vermiculite in presence and absent of *Trichoderma viride*.

2.2. Chemical analyses of different DPF mixtures

The DPF waste media was analyzed to measure EC and pH as well as selected nutrients (i.e., N, P, K, Ca, Cu, Fe, Na, Mg, Mn, and Zn) at the Central Laboratory for Environmental Studies, Kafrelsheikh University according to **Sparks et al. (2020)** as shown in Table (1). Also, the values of pH and EC were measured in different DPF mixtures after well mixing and preparing different treatments and before seed sowing directly (Table 2). General agricultural practices in vegetables nursery were applied to each growing mixture substrate during the mixing and before sowing the seeds by adding 500 g of N:P:K fertilizer (20:20:20) for each mixture substrate (enough to fill out 100 seedling trays). A coco peat and vermiculite substrate (1: 1 v/v) was used as the control substrate due to its widespread use in vegetable crop nurseries worldwide, despite being the most expensive component (1975 LE/100 trays) compared to the other substrates under study. The chemical characteristics of all the growing media were measured at the end of the experiment according to **Sparks et al. (2020)** using a pH meter (model 3510, Jenway, Staffordshire, UK) and an EC meter (model MI 170, Italy), respectively.

Table 2. Analyses of treatments after mixing with prepared media and before seeds cultivation.

Treatments	pH (1:5)	EC (1:10) (dS m^{-1})
Without *Trichoderma viride*		
Control	6.14	1.10 d
75% DPF + 25% VC	6.89	4.62 a
50% DPF + 50% VC	6.95	3.40 b
25% DPF + 75% VC	7.32	1.84 cd
With *Trichoderma viride*		
Control	6.13	1.20 d
75% DPF + 25% VC	6.91	4.97 a
50% DPF + 50% VC	6.97	3.49 b
25% DPF + 75% VC	7.30	2.30 c

DPF: date palm fiber; VC: vermiculite

2.3. Trichoderma application

Pure cultures of *Trichoderma viride* was obtained from the Plant Pathology Research Institute, Sakha Agricultural Research Station, Agricultural Research Center (ARC), Kafr El-Sheikh, Egypt. Pure cultures of *T. viride* were cultivated on potato dextrose broth (PDB) media under sterile conditions. *T. viride* isolate was incubated in PDB at 28 ± 2 °C for 10 days. To prepare spore suspensions, sterile distilled water was added to the culture flasks, and then well blended using the mixer and mixed directly with the growing media number 5, 6, 7 and 8. Spore concentrations for *T. viride* were adjusted using a hemocytometer to approximately 1×10^7 spore ml^{-1}. *Trichoderma* suspension was supplemented to growing media (from 5 to 8 treatments) at the rate of 10 ml suspension per each 1-liter media during their preparation.

2.4. Seeds sowing in trays

The seedling trays (Styrofoam trays, 104 cells) were sterilized with formalin (39%), then air-dried (2 days), and then filled with the studied mixtures of growing media, the cucumber seeds were sown, covered with the same mixture, and then all trays were suitably irrigated. Daily irrigation was carried out or as needed after whole germination. Regarding the agrochemicals, a solution of 1.5 g N:P:K (19.19.19) in 1.0 liter was added to each tray for fertilization 12 days after sowing. Seeds sowing done on 12th March 2025, with daily observing involving counting the number of germinated seeds each day until the germination rate stabilized (after 7 days), to calculate the germination parameters (Esechie, 1994). Seeds were considered germinated when the hypocotyls appeared above the surface of the medium. We did not identify any pathogens during the study period for cucumber seedlings. The following germination parameters were recorded:

$$\text{1- Germination rate (\%)} = \frac{\text{Number of germinated seeds}}{\text{Total number of tested seeds}} \times 100$$

$$\text{2- Germination index} = \left(\frac{G1}{1}\right) + \left(\frac{G2}{2}\right) \ldots\ldots + \left(\frac{Gx}{x}\right)$$

Where: G = germination on each subsequent day after placement,

1, 2; x = corresponding day of germination

2.5. Seedlings growth traits

Twenty-one days after sowing the cucumber seeds, the following vegetative growth traits were measured, seedling height (cm; measured from the surface of the growing medium to the shoot apex), number of leaves (excluding cotyledons), stem diameter (mm), measured with a caliper, leaf area per plant (cm^2), by leaf area meter (CID Bio-Science, CI-202 Portable Laser, Washington, USA), roots length (cm), fresh masses of shoots and roots (per seedling), and dry masses of shoots and roots (recorded after drying at 65 °C for 48 hours).

2.6. Chlorophyll content and photosynthesis efficiency

The chlorophyll content (SPAD) or chlorophyll index was measured using the chlorophyll-meter (Minolta, Tokyo, Japan), according to **Yadava (1986)**, after 21 days. The seedlings were kept in a dimly lit place for 30 min before measurement. Photosynthetic efficiency (Fv/Fm) was recorded using a portable chlorophyll fluorometer (OS-30p, Opti-Sciences, Hudson, NH, USA). The lowest fluorescence (F_0) for photosynthetic photon flux density values were measured after 30 min in the dark for the same leaves, and the maximal fluorescence (Fm) values were measured using light of < 0.1 and 3500 µmol m^{-2} s^{-1} for the same leaves. According to **Dewir et al. (2005)**, the photochemical efficiency of PSII (Fv/Fm) was recorded. The previous parameters were recorded using three seedlings and were taken from the leaves under the leaf chamber. Each treatment included three single leaves as three replications.

2.7. Disease severity and survival rate

Disease severity of natural infection with damping off of *Rhizoctonia* spp. disease infected cucumber seedlings was assessed and monitored at 15 days after sowing date. Also, survival rate (%) was calculated according to the following equation:

$$\text{Survival rate \%} = (\text{number of germinated seeds} - \text{number of seedlings that died after germination}) \times 100$$

2.8. Statistical analyses

The data were tabulated in completely randomized design (CRD) and statistically analyzed using the one-way-ANOVA of the CoStat package program (Computer Program Analysis, Version 6.303; CoHort Software, CA, USA). Duncan’s multiple range test at a 5% level of probability was employed to identify significant differences in the means of the treatments (Snedecor and Cochran 1989).

3. Results

3.1. Mixture costs of growing media

The cost of filling 100 Styrofoam seedling trays (104 cells) for each mixture of the growing media is presented in **Table 3**. In presence of *T. viride*, the growing medium of coco peat and vermiculite (1:1) is considered the most expensive one (1975 LE), followed by coco peat and vermiculite (1:1) in absent of *T. viride* (1875 LE). The growing media of DPF mixed with vermiculite recorded the lowest cost ranged from 340 to 490 LE in absent and presence of *T. viride*, respectively.

Table 3. The relative cost and composition of the growing media used in the current study.

Growing media	Growing media composition	Relative cost (LE/100 trays)
Without *Trichoderma viride*		
Control (commercial)	Coco peat: vermiculite (1:1)	1875
75% DPF + 25% VC	75 % Date palm fibers + 25 % vermiculite	340
50% DPF + 50% VC	50 % Date palm fibers + 50 % vermiculite	365
25% DPF + 75% VC	25 % Date palm fibers + 75 % vermiculite	390
With *Trichoderma viride*		
Control (commercial)	Coco peat: vermiculite (1:1)	1975
75% DPF + 25% VC	75 % Date palm fibers + 25 % vermiculite	440
50% DPF + 50% VC	50 % Date palm fibers + 50 % vermiculite	465
25% DPF + 75% VC	25 % Date palm fibers + 75 % vermiculite	490

Note: 1 USD ≈ 50.58 Egyptian pound (LE) during March 2025; DPF= date palm fibers; VC= vermiculite

3.2. Effects of growing media on germination characteristics

The germination parameters (i.e., rate and index) of cucumber seeds can be noticed in **Table 4**. There are no significant differences among all studied growing media including the presence and absent of *T. viride*. It is obvious that the germination rate ranged from 98.4 to 100%, whereas the germination index ranged from 1.02 to 1.52 for all studied growing media. This means that the suggested growing media (with different ratio from DPF and VC) did not differ significantly from the commercial growing media (control). The highest germination index of cucumber (1.52 and 1.37) was recorded by the growing medium 75% DPF + 25% VC in absent and presence of *T. viride*, respectively. On the other hand, the highest germination rate (99.5 and 100%) was recorded by the commercial and 25% DPF + 75% VC, respectively in absent and presence of *T. viride*. The mixture of 25% DPF + 75% VC was achieved the highest germination rate (100 %) to be better than the standard growing media of coco peat and VC in presence of *T. viride*.

Table 4. The seed germination parameters of cucumber under different growing media mixtures in presence and absent of *T. viride*.

Growing substrates	Germination rate (%)	Germination index
Without *Trichoderma viride*		
Control (commercial)	99.5 a	1.14 a
75% DPF + 25% VC	98.7 a	1.52 a
50% DPF + 50% VC	98.8 a	1.11 a
25% DPF + 75% VC	99.2 a	1.16 a
With *Trichoderma viride*		
Control (commercial)	99.1 a	1.02 a
75% DPF + 25% VC	99.4 a	1.37 a
50% DPF + 50% VC	98.4 a	1.02 a
25% DPF + 75% VC	100.0 a	1.11 a
F. test	NS	NS

3.3. Vegetative growth parameters of cucumber seedlings

Selected vegetative growth parameters were evaluated including root length (cm), leaf area per plant (cm^2), number of leaves per seedling, stem diameter (mm), seedling length (cm), as well as the fresh and dry weights of roots and shoots of cucumber seedlings (**Tables 5 and 6**). From the data in these Tables, it is obvious that all previous parameters have a significant positive correlation except number of leaves per seedling. One more comment regarding the role of *T. viride*, all studied parameters recorded the higher values in presence of *T. viride* compared to the absent. The role of *T. viride* can be noticed in the **Figures 3 and 4** through the most desirable features of cucumber seedlings. These features include the strong growth of seedlings, particularly the growth of root system and their volume along with the vegetative growth in the presence of *T. viride*. It is logic to notice that the commercial growing media (coco peat and vermiculite) has the best and higher values of studied parameters.

Table 5. Vegetative growth traits of cucumber seedlings response to date palm fiber media mixtures and *T. viride* .

Growing media	Seedling length (cm)	Stem diameter (mm)	No. of leaves /seedling	Leaf area/plant (cm^2)	Root length (cm)
Without *Trichoderma viride*					
Control (commercial)	12.05 a	3.47 a	2.2 a	162.2 bc	7.65 b
75% DPF + 25% VC	7.25 d	2.48 c	1.5 a	140.5 e	5.34 d
50% DPF + 50% VC	9.1 c	2.78 b	2.1 a	150.8 d	6.65 c
25% DPF + 75% VC	9.4 c	2.84 b	2.0 a	158.6 c	7.32 b
With *Trichoderma viride*					
Control (commercial)	10.75 b	3.68 a	2.3 a	169.5 a	8.51 a
75% DPF + 25% VC	8.50 c	2.68 b	1.5 a	155.4 c	6.15 c
50% DPF + 50% VC	8.58 c	2.82 b	2.2 a	157.7 c	7.28 b
25% DPF + 75% VC	9.95 bc	2.88 b	2.3 a	164.3 b	8.55 a
F – test	**	*	NS	**	**

Table 6. Effect of date palm fiber media mixtures and *T. viride* as growing substrates on fresh and dry weights for shoots and roots of cucumber seedlings.

Growing media	Shoot fresh weight (g)	Root fresh weight (g)	Shoot dry weight (g)	Root dry weight (g)
Without *Trichoderma viride*				
Control (commercial)	1.76 b	0.472 b	0.171 b	0.0296 c
75% DPF + 25% VC	1.04 f	0.198 g	0.091 e	0.0212 f
50% DPF + 50% VC	1.13 f	0.278 f	0.114 d	0.0242 e
25% DPF + 75% VC	1.25 de	0.394 cd	0.117 d	0.0262 d
With *Trichoderma viride*				
Control (commercial)	1.98 a	0.538 a	0.188 a	0.0480 a
75% DPF + 25% VC	1.20 e	0.309 e	0.112 d	0.0242 e
50% DPF + 50% VC	1.22 e	0.332 d	0.120 cd	0.0274 d
25% DPF + 75% VC	1.44 c	0.406 c	0.125 c	0.0312 b
F – test	**	**	*	**

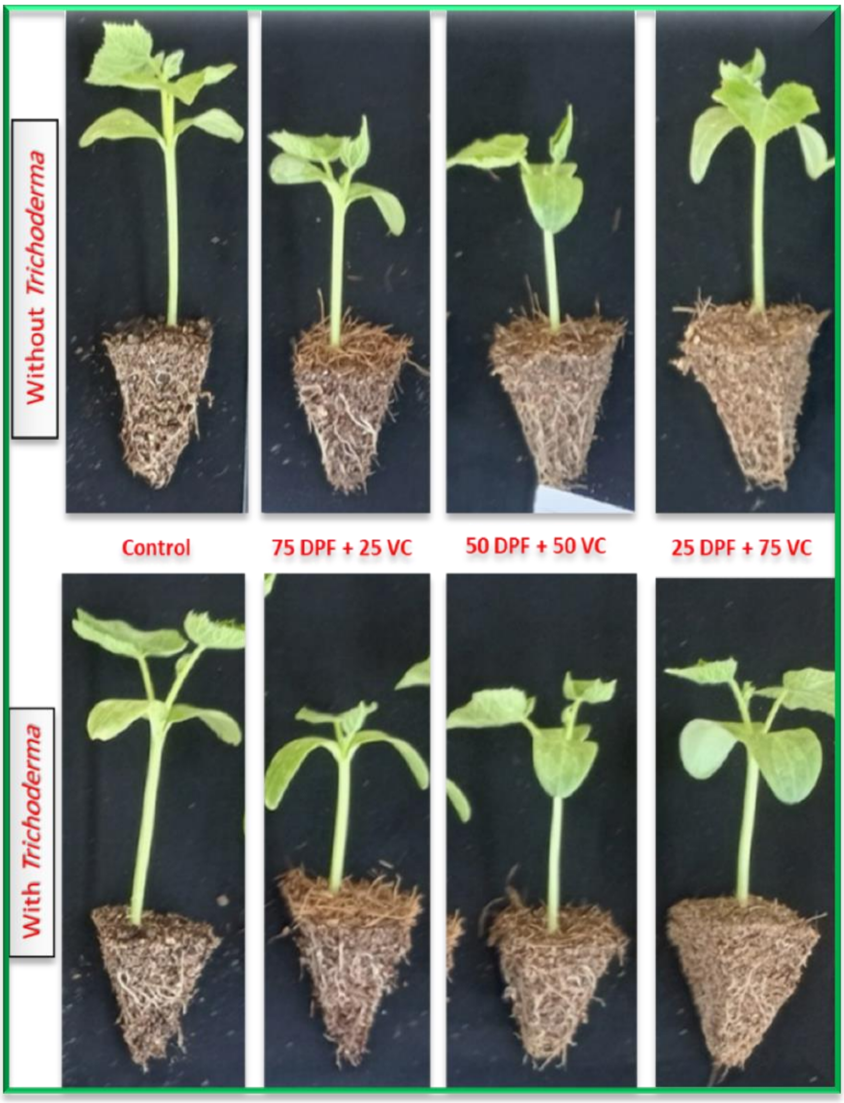

Fig. 3. An overview on the cucumber seedlings growth as influenced by date palm fiber media mixtures and *T. viride* as growing substrates.

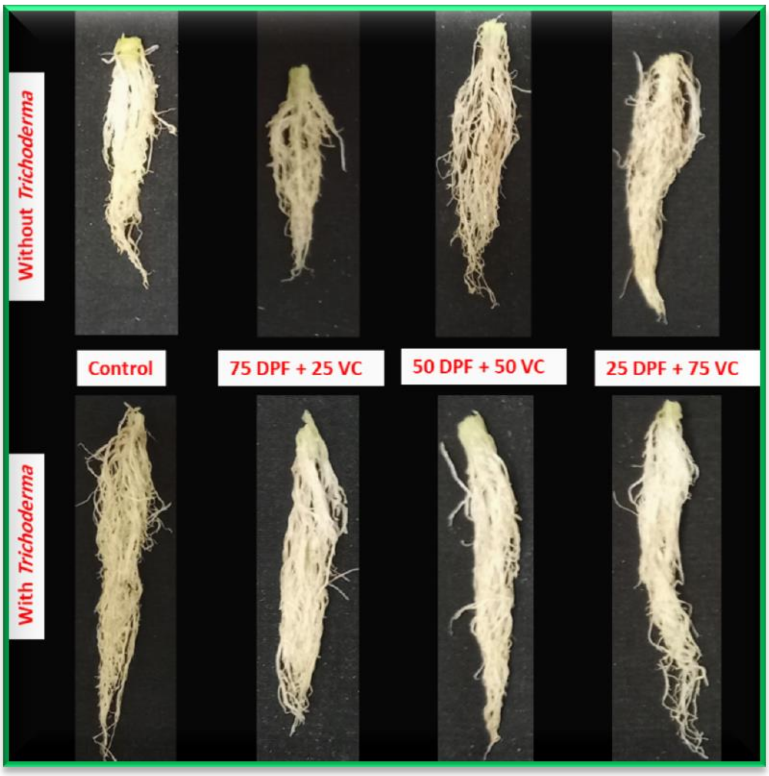

Fig. 4. An overview of the roots growth of cucumber seedlings as influenced by date palm fibers media mixtures and *T. viride* as growing substrates.

3.4. Photosynthetic parameters of cucumber seedlings

To distinguish between the suggested growing media, selected photosynthetic parameters including chlorophyll content (as SPAD values), and photosynthesis efficiency (as Fv/Fm ratio) were measured and evaluated. The results of the correlational analysis are set out in **Table 7**. There was a significant positive correlation between the suggested growing media mixtures and *T. viride*. In general, the commercial growing medium as a standard medium was recorded the highest values of studied photosynthetic parameters, with priority to presence of *T. viride*. Concerning the suggested mixtures from DPF and VC, it is preferable increasing the DPF up to 75% with decrease of VC up to 25% even in presence or absent of *T. viride*.

Table 7. Effect of date palm fiber media mixtures and *T. viride* as growing substrates on chlorophyll content and photosynthesis efficiency of cucumber seedlings .

Growing media	Chlorophyll content (SPAD)	Photosynthesis efficiency (Fv/Fm)
Without *Trichoderma*		
Control (commercial)	12.09 a	0.709 a
75% DPF + 25% VC	11.15 b	0.649 c
50% DPF + 50% VC	9.42 d	0.644 c
25% DPF + 75% VC	8.65 e	0.657 c
With *Trichoderma*		
Control (commercial)	12.86 a	0.693 b
75% DPF + 25% VC	11.50 b	0.656 c
50% DPF + 50% VC	10.16 c	0.652 c
25% DPF + 75% VC	10.04 c	0.672 c
F – test	**	*

3.5. Disease severity and survival rate

Table 8 compares the results obtained from the disease severity of *Rhizoctonia* damping –off and survival percentages of cucumber seedlings. From this data, it could be noticed that different combinations from DPF and VC resulted in the lowest value of survival percent compared to the commercial growing medium, whereas the opposite trend is remarkable for the disease severity. Strong evidence of disease severity was found when applied *T. viride*, where the presence of *T. viride* reduced this disease severity to be a near value to the commercial growing media (1.1 %) with non-significant differences among all treated growing media with *T. viride*. This evidence also is obvious from **Figure 5**, where the same trend can be noticed for the survival seedlings (%) when treated by the *T. viride*.

Table 8. Effect of date palm fiber media mixtures and *T. viride* as growing substrates on survival plants and disease severity percentages of cucumber seedlings.

Growing media	Survival seedlings (%)	Disease severity (%)
Without *Trichoderma viride*		
Control (commercial)	99.0 a	9.6 d
75% DPF + 25% VC	93.8 b	13.2 c
50% DPF + 50% VC	90.8 c	21.5 b
25% DPF + 75% VC	87.6 d	34.4 a
With *Trichoderma viride*		
Control (commercial)	99.7 a	1.1 e
75% DPF + 25% VC	98.0 a	2.4 e
50% DPF + 50% VC	97.9 a	2.3 e
25% DPF + 75% VC	97.0 a	3.5 e
F – test	**	**

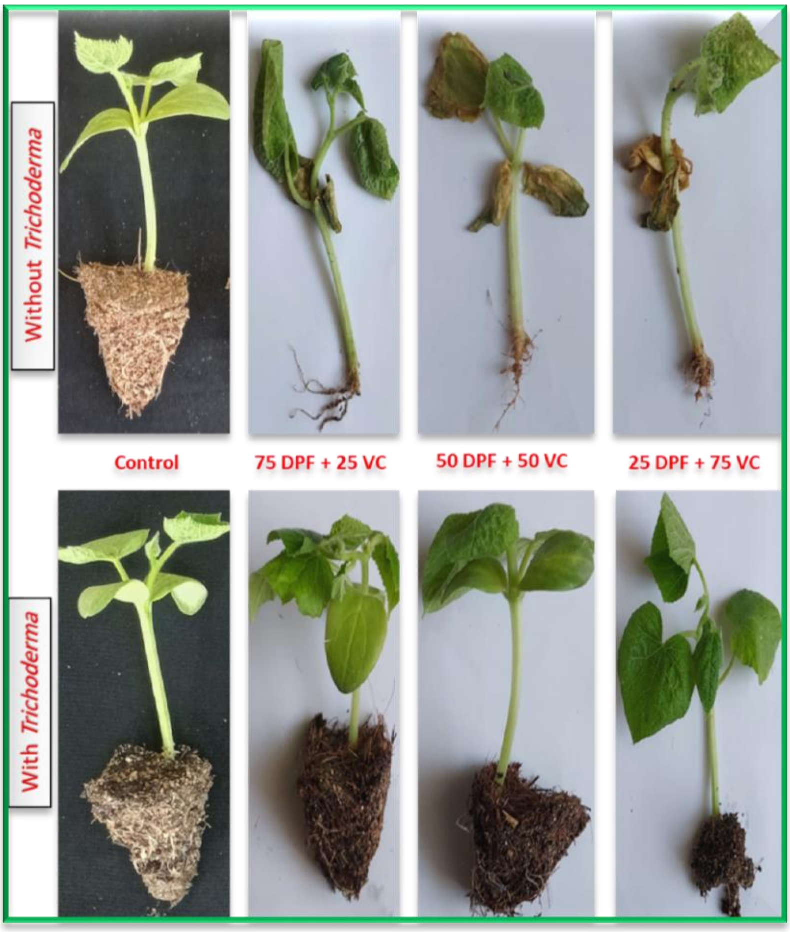

Fig. 5. Effect of date palm fibers media mixtures and *T. viride* as growing substrates on disease severity percent of cucumber seedlings.

3.6. Nutrients uptake by cucumber seedlings

At the end of the experiment, all studied growing media were collected and analyzed (**Table 9**). This table is quite revealing in several ways. First, unlike the other Tables, this Table includes the chemical analyses of studied growing media (mainly pH, EC, contents of Cu, K, Fe, Mn, and Zn). Second, the pH values in all studied growing media were higher than those values before starting the study, whereas all values of EC were decreased in all studied growing media by more than 50% from the starting value. Third, a clear benefit of *T. viride* in enhancing the uptake of all studied nutrients (mainly Cu, Mn, and Zn) in cucumber seedlings compared the absent of this fungus in growing media could not be identified in this Table. The opposite trend can be noticed after treatment with *T. viride* for the Fe content in growing media.

Table 9. Chemical analyses of the different media treatments at the end of the experiment .

Treatments	pH (1:5)	EC (dS m^{-1}) (1:10)	Cu (ppm)	K (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)
Without *Trichoderma viride*							
Control (commercial)	8.46	0.588 b	0.468 f	254 e	74.4 a	10.64 c	4.76 c
75% DPF + 25% VC	8.45	0.589 b	1.484 b	324 ab	10.48 b	12.92 b	17.6 a
50% DPF + 50% VC	8.76	0.514 b	1.148 c	317 b	11.08 b	9.56 d	10.8 b
25% DPF + 75% VC	9.20	0.348 d	0.960 d	293 c	10.36 b	7.28 e	3.84
With *Trichoderma viride*							
Control (commercial)	8.50	0.511 bc	0.556 e	273 d	69.6 a	10.88 c	4.48 c
75% DPF + 25% VC	8.50	0.634 a	1.660 a	359 a	10.48 b	18.8 a	18.0 a
50% DPF + 50% VC	8.82	0.566 b	1.168 c	342 a	10.48 b	9.08 d	12.8 b
25% DPF + 75% VC	9.03	0.421 c	0.996 d	287 c	10.64 b	7.56 e	2.93 d
F-test	------	**	*	**	**	**	**

DPF, date palm fibers, VC, vermiculite

4. Discussion

The quality production of vegetable seedlings depends on many factors including plant genotypes or varieties, the environmental conditions (lighting, temperature, biotic/abiotic stress), and applied agro-management practices (mainly growing media or substrate types, tray types, irrigation and agro-chemical applications). An initial objective of the current study was to identify the role of *T. viride* in promoting cucumber seedlings using different growing media. The present work also was designed to determine the possibility to utilize the DPF growing medium as alternative to coco peat under cucumber seedlings production. The third question in this research was to what extent both *T. viride* and DPF growing media can control the quality of producing cucumber seedlings?

With respect to the first research question concerning growing medium, it is well-known that coco peat and vermiculite is the best and ideal growing medium used in the commercial nursery industry (Gallegos-Cedillo et al. 2024a). To find the suitable constituents of growing media in nurseries, the utilized substrates should improve the chemical and physical properties of growing media as well as enhancing the biological attributes by promoting seedling growth, nutrition, and protection (Gallegos-Cedillo et al. 2024b). Otherwise, this commercial growing medium is expensive and needs hard currency in Egypt, which leads to find and develop the proper growing media. In the present study, different combinations from DPF and VC (ratios from 25-75%) were investigated on the agronomic and economic levels. On the economic level, different utilized growing media from DPF and VC were significantly lower in their cots (up to 80%) compared to coco peat medium. The cost of coco peat medium was 1975 LE to produce 100 trays, whereas this cost was only 340 LE in case of DPF and VC growing medium. Growing media of DPF and VC were recorded promising attributes, which included high germination rate (up to 100%), desirable seedling properties (mainly root system, seedling length, and the volume of rooting system). As an eco-friendly and sustainable growing substrate, many studies reported about using DPF in the nursery culture industry (e.g., Abid et al. 2018; Elabed et al. 2022; Aydi et al. 2023; Ghouili et al. 2023; Qaryouti et al. 2023). Recently, Shalaby et al. (2025) highlighted the utilization of DPF as a promising growing medium mixing with vermiculite (1:1) for vegetable seedlings production (cucumber, lettuce and tomato). In our study, all mixed DPF and VC growing media were accepted for preparing growing media and the mixture ratio depends on the purpose of such mixture. The observed decrease in EC (1.84 dS m^{-1}) could be attributed to prefer the mixing ratio to be 25% DPF + 75% VC and neutral pH value (7.32), which led to the highest germination rate (100%) particularly in presence of *T. viride*. Whereas, the ratio 75% DPF + 25% VC is preferable to achieve the survival percent (98%) of cucumber seedlings against *Rhizoctonia* damping –off. The reason for this is not clear but it may have something to do with the role of applied *T. viride* as biofertilizer and biocontrol agent. A general comparison between coco peat and DPF can be listed in **Table 10**.

Table 10. The main differences between coco peat and date palm fiber as a growing media.

Items	Coco peat	Date palm fibers
Source	Made from coconut husks (byproduct of coconut industry)	Made from shredded date palm frond and midrib
Physical structure	Fine, soft, uniform texture, spongy, dust-like when dry, retains water	Coarser, fibrous strands, stringy, improves drainage and root penetration
Water management	Very high (holds 8–10x its weight), risk of overwatering if not mixed with perlite/sand	Moderate (drains faster than coco peat), less waterlogged and better for arid climates
Aeration, root development	Good, but can compact over time; encourages fine root growth but can become dense	Excellent (fibrous structure improves airflow), promotes stronger root systems due to air pockets
pH level	Slightly acidic to neutral (5.5–6.5), suits most plants (e.g., tomatoes, lettuce, herbs).	Alkaline (7.0–8.5), ideal for date palms, olives, and desert plants.
Decomposition	Cellulose (43%), and lignin (38%)	Cellulose (20%), and lignin (45%)
Nutrient content	Low in NPK but high cation exchange capacity (CEC, that holds nutrients well)	Proper NPK content (6400, 137, 9325 ppm)
Disease resistance	Natural antifungal properties due to the lignin content	High resistance due to lignin and tannins
Sustainability	Renewable (coconut waste)	Renewable (date palm waste in arid regions)
Cost and availability	Expensive and widely available globally	Cheap and limited availability as common in Middle East and North Africa
Suitable for	Moisture-loving plants, seedlings, hydroponics	Drought-resistant plants, seedlings, date palms, cacti, alkaline soil

A strong relationship between *Trichoderma* spp. and growth of seedlings has been reported in the literature. With respect to the second research question, *T. viride* has become a sustainable strategy to promote the growth and development of vegetable seedlings by reducing the applied agrochemicals. In the present study, to what extent can *T. viride* make a difference in growth of cucumber seedlings under different combinations of DPF and VC? It is interesting to note that in all different growing media of this study was shown a positive response to applied *T. viride*. The most distinguished results due to applied *T. viride* may include the following findings:

1- The only higher germination rate (100 %) of studied growing medium (i.e., 25% DPF + 75% VC) than the commercial medium was happened after treatment with *T. viride*,

2- All studied parameters were better when seedlings of cucumber treated by *T. viride*, including the vegetative trails, photosynthetic parameters, and uptake of nutrients,

3- The higher values of survival seedlings (up to 98 %), and lower values of disease severity (up to 2.3%) were obtained after applying the studied *T. viride*,

4- The possible explanations for these findings may back to the role of *T. viride* as biocontrol agent against the studied pathogen (*Rhizoctonia* spp.), and as biofertilizer by supporting root systems by nutrients, enhancing photosynthetic activity, and producing strong seedlings,

5- The high-quality seedlings of cucumber mainly depend on the morphological (seedling height, diameter, and root system) and physiological (uptake of water and nutrients, photosynthetic activities, and tolerance to stresses) attributes (Ferreira et al. 2024), and

6- The suggested mechanisms of *T. viride* may include the direct attack fungal pathogens using lytic enzymes (chitinases, glucanases, and proteases); production of toxic metabolites (e.g., peptaibols, gliovirin); secreting antimicrobial compounds (trichodermin, gliotoxin and harzianic acid); producing the phytohormones (auxins, IAA and cytokinins); solubilizing nutrients (phosphate, Fe, micronutrients); enhancing disease resistance through jasmonic acid /ethylene pathways, and pathogenesis-related proteins; protecting against abiotic stress such as osmolytes, antioxidant and enzymes (**Figure 6**).

Concerning the last question on to what extent both *T. viride* and DPF growing media can control the quality of producing cucumber seedlings? What are the main criteria of the produced seedling quality? To what extent can *T. viride* promote the cucumber seedlings production using DPF medium? In this section, it is somewhat surprising that no certain growing medium from DPF and VC can be noted to achieve and give the best values in the studied parameters. Contrary to expectations, this study did not find a significant difference between all studied mixtures from DPF and VC. However, the observed role of *T. viride* in this study was highly significant.

As far as we know, this is the first report about the role of *T. viride* in producing strong cucumber seedlings from DPF and VC media. These findings support previous research into this brain area which links *Trichoderma* and seedlings production. To answer the previous questions, possible explanations for this might be discovered as follows:

1- The success in producing high cucumber productivity mainly depends on how to produce high quality of cucumber seedlings. Producing high quality of cucumber seedlings is crucial issue for ensuring high plant growth rate, high yield productivity, and high crop resistance to phytopathogens and diseases. The high production of cucumber should start from having high quality seedlings to avoid poor-quality ones, which may lead to reduce crop and productivity,

2- High-quality seedlings are controlled by certain key characteristics including strong stem, healthy leaves, good root system, uniform growth and appropriate height (not long seedling). These previous factors can impact the seedlings quality through the following key factors seed quality, growing medium, irrigation, light, temperature, nutrients, and spacing of seedlings,

3- High-quality cucumber seedlings need ensuring proper growing conditions (mainly growing media) to maximize the yield and reduce any problems later in the growing season. In the present study, *T. viride* significantly supported producing desirable seedlings having intensive root system, not long seedling, high germination rate, stem diameter, high photosynthetic activity, high survival seedlings, and lower disease severity, and

4- The current study was succeed to find an economic, suitable and ecofriendly growing media for cucumber seedlings producing using different combinations of DPF and VC, which can save more than 80% from costs, more tolerant to disease (*Rhizoctonia* spp.) and strong.

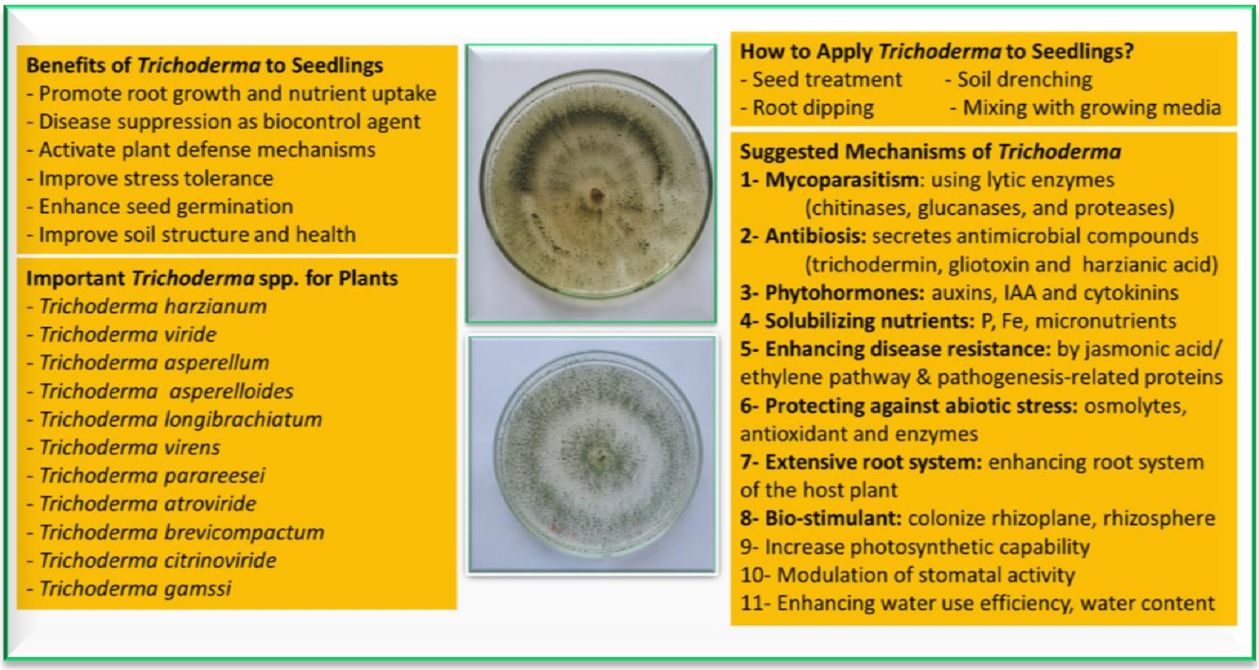

Fig. 6. The suggested mechanism of *Trichoderma viride* in promoting cucumber seedlings (Sources: Khan et al. 2023; Akbari et al. 2024; Contreras-Cornejo et al. 2024; Jin and Alberti 2025; Yang Y et al. 2025).

5. Conclusions

The current study evaluated the possibility to produce an alternative growing medium to the global common one (i.e., coco peat and vermiculite) through different mixtures from DPF and VC for cucumber seedlings production. The reason behind this hypothesis was to overcome the expensive of the global standard growing medium from coco peat by utilization of the very cheap agro-wastes from DPF in combination with VC. The new suggested growing media from DPF and VC can save more than 80% from the production cost of cucumber seedlings. The suggested growing media were valorized by application of *T. viride*, which promoted the germination rate of cucumber seeds and other properties of produced seedlings. Surprisingly, no differences were found in the germination rate of cucumber seeds between the suggested growing media and coco peat medium. The producing cucumber seedlings in presence of *T. viride* were strong enough to transfer to the open field based on the suggested mechanism in enhancing the seedling growth by the dual action of *T. viride* as biofertilizer and biocontrol agent. These findings are somewhat surprising given the fact that coco peat growing medium is the most widely used medium in producing vegetable seedlings all over the world but expensive. The morphology of producing seedlings supports these hypotheses through the strong root system, the intensive roots, and shorter seedling length along with promoting the survival rate and photosynthetic parameters. As far as we know, this is a first report evaluated the application of *T. viride* to promote the utilization of DPF as an alternative growing media to coco peat by forming new mixtures from DF and vermiculite. However, more research on this topic needs to be undertaken before the association between DPF and VC, as several questions remain unanswered at present.

Declarations

Ethics approval and consent to participate

Author Contributions: All authors helped prepare the MS and agree to publish it.

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