



Effect of spent tea powder as an alternative growth substrate for amaranth and mustard microgreens

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DOI: <https://doi.org/10.66856/ijbs.2026.11.4.11244>

Abstract

Microgreens are short-cycle crops whose establishment and productivity are strongly influenced by the growing substrate. Repurposing used tea powder as a growing medium for microgreens, is one of the approaches in addressing both the need for sustainable substrates and waste management. The present study evaluated the growth performance of *Amaranthus tricolor* (red amaranth) and *Brassica juncea* (mustard) microgreens cultivated using spent tea powder (TP), cocopeat (CP), and a 1:1 combination of cocopeat and tea powder (CP + TP). Germination was assessed using cotton, TP, CP and CP + TP. Shoot and root growth, fresh weight, dry weight and moisture content were evaluated in microgreens cultivated on CP, TP and CP + TP. Germination of *A. tricolor* was highest on cotton and TP (100.00 ± 0.00%), whereas *B. juncea* showed maximum germination on CP + TP (93.33 ± 3.33%). TP produced the highest shoot length in both *A. tricolor* (3.97 ± 0.15 cm) and *B. juncea* (8.37 ± 1.63 cm). The longest root in *B. juncea* was recorded on CP + TP (3.00 ± 1.32 cm). TP also produced the greatest fresh and dry biomass in both species. Moisture content was highest in TP-grown *A. tricolor* (89.10 ± 0.36%) and CP + TP-grown *B. juncea* (87.73 ± 0.44%). The results demonstrate that spent tea powder is a promising alternative growing substrate for microgreen production, particularly for enhancing shoot growth and biomass, while the CP + TP combination may be advantageous for root development in *B. juncea*.

Keywords: Microgreens, tea waste, cocopeat, *Amaranthus tricolor*, *Brassica juncea*, germination, shoot growth, root growth, biomass

Introduction

Microgreens are young edible seedlings harvested at an early stage of development and are increasingly cultivated because of their short production cycle, low space requirement and suitability for controlled and urban production systems (Poudel *et al.*, 2023) [11]. Their consumption has increased due to their high nutritional and functional value, as they are rich in phytochemicals, vitamins, and minerals (Kyriacou *et al.*, 2016) [7]. Successful microgreen production depends greatly on the physical and chemical characteristics of the growing medium (Li *et al.*, 2021). Substrate properties such as water-holding capacity, aeration, porosity, nutrient availability and root support directly influence germination and subsequent seedling growth. Growing in soil is common amongst household and green-house farmers. Soil growing with small quantity of fertilizer can provide microgreens with naturally occurring nutrients. However, growing in soil makes microgreens susceptible to soil-borne bacterial infections. Furthermore, soil content on microgreens is unappealing to customers. Using soil-based media to grow microgreens may require washing off the dirt from it after harvesting (Enssle, 2020) [3]. Cocopeat is widely used as a soilless growing medium because of its favourable water-retention and physical properties (Awang *et al.*, 2009) [1]. However, the increasing generation of organic wastes has encouraged the investigation of low-cost waste-derived substrates. Daily human consumption generates massive volumes of organic waste across homes, local tea shops, and commercial hotels, where large quantities of processed tea residue, known as spent tea powder, are continuously discarded after

extraction (Miao *et al.*, 2023) [9]. Its fibrous organic matter and residual nutrients suggest potential for use as a component of growing media, thereby providing an opportunity for waste valorization and sustainable crop production (Nguyen *et al.*, 2022) [10].

Amaranthus tricolor (red amaranth) and *Brassica juncea* (mustard) are fast-growing species suitable for microgreen production. Their rapid germination and short harvest period make them useful models for evaluating alternative growing substrates. However, substrate suitability may differ between species because of differences in seed size, root development, water uptake and growth characteristics. The present study therefore focused specifically on the growth performance of *A. tricolor* and *B. juncea* microgreens grown using spent tea powder, cocopeat and their combination. Germination, growth pattern, shoot length, root length, fresh weight, dry weight and moisture content were evaluated to determine the suitability of spent tea powder as an alternative growing substrate.

Materials and Methods

Plant material

Healthy seeds of *Amaranthus tricolor* L. and *Brassica juncea* (L.) Czern. used for the experiment were collected from Organic Bazar seed store. Healthy and disease-free seeds were selected and used for the cultivation of microgreens.

Preparation of growth substrates

Spent tea powder was collected from households and nearby tea shops. The collected material was washed repeatedly

with water to remove residual sugar, milk and other impurities and was subsequently dried under direct sunlight for two days. Commercial cocopeat was used as the conventional substrate. Three cultivation treatments were prepared: cocopeat (CP), tea powder (TP), and cocopeat + tea powder (CP + TP). The combined substrate consisted of cocopeat and tea powder mixed in a 1:1 proportion.

Germination experiment

Germination was evaluated using four substrate treatments: cotton (CT), tea powder (TP), cocopeat (CP), and cocopeat + tea powder (CP + TP). Ten healthy seeds were sown in each Petri plate and three independent replicates were maintained. The plates were initially maintained under dark conditions for two days to facilitate germination and were subsequently kept under normal light conditions. Light watering was provided as required. Germination percentage was recorded three days after sowing.

Microgreen cultivation

For the growth experiment, seeds were uniformly sown on CP, TP and CP + TP substrates placed in cultivation trays. The trays were maintained under dark conditions during the initial germination period and subsequently transferred to normal growing conditions. Regular watering was provided throughout the experimental period. Growth was monitored at 1, 3 and 7 days after sowing. Microgreens were harvested at the appropriate growth stage.

Measurement of growth parameters

Shoot length was measured from the base of the shoot to the shoot tip. Root length was measured from the base of the hypocotyl to the tip of the primary root. Measurements were recorded in centimetres using a graduated ruler. Fresh weight was recorded immediately after harvest using a digital balance. For dry weight determination, harvested microgreens were dried until constant weight and weighed again. Moisture content was calculated from the difference between fresh and dry weights using the formula:

$$\text{Moisture content (\%)} = [(\text{Fresh weight} - \text{Dry weight}) / \text{Fresh weight}] \times 100$$

Statistical analysis

The experiment was conducted with three independent replicates ($n = 3$) for each treatment. The values represent the mean of germination rate, fresh weight, dried matter yield and shoot height $\pm$ SE (standard errors). Statistical analysis of the growth-related data was performed using IBM SPSS Statistics Version 26.0.

Results and Discussion

Germination performance

Germination varied among substrates and between the two microgreenspecies. *A. tricolor* exhibited 100.00 % germination on both cotton and tea powder (Fig 1). Germination on CP + TP was $90.00 \pm 0.00\%$, while cocopeat recorded $83.33 \pm 3.33\%$. In *B. juncea*, the highest germination was recorded on CP + TP ($93.33 \pm 3.33\%$), followed by TP ($90.00 \pm 0.00\%$), CP ($83.33 \pm 3.33\%$) and cotton ($73.33 \pm 3.33\%$) (Fig 1) (Table 1). Thus, tea powder supported excellent germination in *A. tricolor*, while the combined substrate was most favourable for *B. juncea* seed establishment.

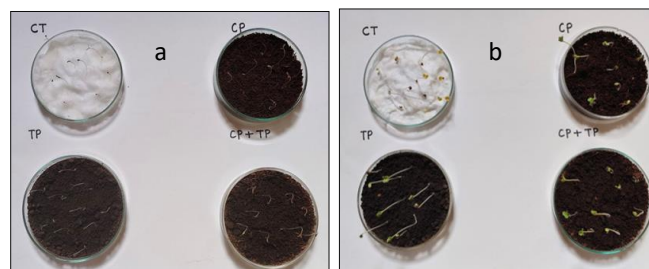


Fig 1: Germination of (a) red amaranth and (b) mustard seeds under different substrate treatments three days after sowing

Table 1: Germination percentage (%) of amaranth and mustard under different substrates

Substrate	Amaranth (%)	Mustard (%)
Cotton	100.00 ± 0.00	73.33 ± 3.33
Tea powder	100.00 ± 0.00	90.00 ± 0.00
Cocopeat	83.33 ± 3.33	83.33 ± 3.33
CP + TP	90.00 ± 0.00	93.33 ± 3.33

Growth pattern during seedling development

Growth observations at 1, 3 and 7 days after sowing showed progressive development of seedlings in all substrate treatments. On day 1, the seedlings were primarily in the establishment and early growth phase. Radicle emergence and shoot initiation were evident on day 3. On day 7, differences in shoot height and root development among the substrates became more pronounced. The tea powder treatment showed rapid shoot development in both species, indicating favourable conditions for early seedling growth. In *B. juncea*, the CP + TP treatment produced particularly strong root development by the later growth stage. The increasing divergence in growth with time suggests that the effect of substrate properties became more evident as seedlings developed beyond germination. Substrate moisture, aeration and physical support are important during this period because growing seedlings depend increasingly on the root system for water and mineral acquisition. The present observations therefore indicate that the influence of a substrate should be evaluated not only at germination but throughout the early growth period.

Shoot and root length

The growth parameters of *A. tricolor* and *B. juncea* showed considerable variation among the different substrates (Table 2). In *A. tricolor*, the highest shoot length was observed in the tea powder treatment (3.97 ± 0.15 cm), followed by the CP + TP treatment (3.50 ± 0.20 cm). The lowest shoot length was recorded in the cocopeat treatment (3.20 ± 0.61 cm). Root length in *A. tricolor* ranged from 1.13 ± 0.55 cm to 2.27 ± 0.45 cm, with the maximum value observed in TP (1.33 ± 0.31 cm) and the minimum value in the CP + TP treatment (1.13 ± 0.55 cm).

In *B. juncea*, the maximum shoot length was observed in the tea powder treatment (8.37 ± 1.63 cm), followed by the CP + TP treatment (6.83 ± 0.93 cm). The lowest shoot length was recorded in cotton (5.07 ± 1.17 cm). The highest root length in *B. juncea* was observed in the CP + TP treatment (3.00 ± 1.32 cm), followed by the tea powder treatment (2.77 ± 0.59 cm). The lowest root length was recorded in cocopeat (0.80 ± 0.61 cm). The results indicate that tea powder treatment enhanced shoot growth in both microgreen species, whereas the combined substrate (CP + TP) promoted root development in mustard microgreens.

Table 2: Shoot length and root length of amaranth and mustard under the three cultivation substrates

Species	Substrate	Shoot length (cm) Mean $\pm$ SE	Root length (cm) Mean $\pm$ SE
Amaranth	TP	3.97 $\pm$ 0.15	1.33 $\pm$ 0.31
	CP	3.20 $\pm$ 0.61	1.23 $\pm$ 0.06
	CP + TP	3.50 $\pm$ 0.20	1.13 $\pm$ 0.55
Mustard	TP	8.37 $\pm$ 1.63	2.77 $\pm$ 0.59
	CP	5.07 $\pm$ 1.17	0.80 $\pm$ 0.61
	CP + TP	6.83 $\pm$ 0.93	3.00 $\pm$ 1.32

Fresh weight, dry weight and moisture content

Fresh and dry biomass also differed substantially among substrates (Fig. 2 and 3). In *A. tricolor*, tea powder produced the highest fresh weight (18.60 $\pm$ 0.51 g), followed by CP (15.41 $\pm$ 0.42 g), while CP + TP recorded the lowest fresh weight (11.29 $\pm$ 0.38 g). Dry weight followed a similar pattern, with the highest value on TP (2.02 $\pm$ 0.05 g), followed by CP + TP (1.92 $\pm$ 0.04 g) and CP (1.79 $\pm$ 0.06 g) (Table 3).

In *B. juncea*, tea powder produced a markedly greater fresh weight (21.21 $\pm$ 0.63 g) than CP + TP (15.04 $\pm$ 0.47 g) and CP (4.76 $\pm$ 0.24 g). Dry weight was also highest on TP (2.98 $\pm$ 0.08 g), followed by CP + TP (1.84 $\pm$ 0.05 g) and CP (0.69 $\pm$ 0.03 g). The consistently higher biomass on tea powder indicates that this substrate supported greater vegetative productivity under the conditions of the experiment (Table 3).

Moisture content varied according to both species and substrate. *A. tricolor* showed the highest moisture content on TP (89.10 $\pm$ 0.36%), followed by CP (88.36 $\pm$ 0.41%), while CP + TP recorded 82.93 $\pm$ 0.52%. In *B. juncea*, the highest moisture content was recorded on CP + TP (87.73 $\pm$ 0.44%), followed by TP (85.92 $\pm$ 0.39%) and CP (85.52 $\pm$ 0.48%) (Table 3). The difference between species suggests that water accumulation and retention were influenced by both substrate properties and species-specific water uptake and growth.



Fig 2: Growth of amaranth microgreens grown on different substrates a. cocopeat (CP), b. tea powder (TP), and c. cocopeat + tea powder (CP + TP) on 7th day of sowing



Fig 3: Growth of mustard microgreens grown on different substrates a. cocopeat (CP), b. tea powder (TP), and c. cocopeat + tea powder (CP + TP) on 7th day of sowing

Table 3: Fresh weight, dry weight and moisture content of amaranth and mustard microgreens under different substrates

Microgreen	Substrate	Fresh weight (g) Mean $\pm$ SE	Dry weight (g) Mean $\pm$ SE	Moisture (%) Mean $\pm$ SE
Amaranth	CP	15.41 $\pm$ 0.42	1.79 $\pm$ 0.06	88.36 $\pm$ 0.41
	TP	18.60 $\pm$ 0.51	2.02 $\pm$ 0.05	89.10 $\pm$ 0.36
	CP + TP	11.29 $\pm$ 0.38	1.928 $\pm$ 0.04	82.93 $\pm$ 0.52
Mustard	CP	4.76 $\pm$ 0.24	0.69 $\pm$ 0.03	85.52 $\pm$ 0.48
	TP	21.21 $\pm$ 0.63	2.98 $\pm$ 0.08	85.92 $\pm$ 0.39
	CP + TP	15.04 $\pm$ 0.47	1.84 $\pm$ 0.05	87.73 $\pm$ 0.44

The results obtained indicate that the type of growing medium, and plant species significantly influenced the growth and biometric parameters of microgreens. Considering the growth parameters collectively, tea powder was the most effective substrate for shoot elongation and biomass production in both *A. tricolor* and *B. juncea*. The effect was particularly pronounced in *B. juncea*, where tea powder produced both the longest shoots and the greatest

fresh and dry weights. In contrast, the CP + TP treatment was particularly favourable for root development in *B. juncea* and produced the highest moisture content in that species. The enhanced growth observed on tea powder may be associated with the physical and organic characteristics of the processed tea residue. The growth pattern indicates that its influence was evident from the early seedling stages and became more pronounced by day 7. The response of *B.*

juncea to CP + TP suggests that combining substrates can modify the physical growing environment and may provide a more suitable balance for root development.

The agronomic potential of tea industry residues is well-documented in several crops. Seed priming and spraying with aqueous tea leaf extract have been shown to enhance germination efficiency and overall plant performance (Bhattacharya *et al.*, 2025) ^[2], whereas compost tea improves germination percentage, root/shoot elongation, and leaf production in green gram (Suganthi and Jayanandhan, 2015) ^[12]. Furthermore, tea waste amendments increase height in pea plants (Wazir *et al.*, 2018) ^[13] and boost vegetative growth in tomatoes due to their high nitrogen and organic matter levels (Kondo *et al.*, 2004) ^[6]. Utilizing spent tea extracts and tea-derived composts provides a practical strategy to restore soil organic matter and support eco-friendly agriculture (Gurav and Sinalkar, 2013; Gammoudi *et al.*, 2021) ^[4, 5]. The present study reinforces the feasibility of repurposing spent tea powder as a sustainable growing medium for microgreen production, though species-specific evaluations remain essential.

Conclusion

The present study demonstrates that spent tea powder can serve as an effective alternative growing substrate for *A. tricolor* and *B. juncea* microgreens. Tea powder supported 100% germination in red amaranth, high germination in mustard, the greatest shoot length in both species, and the highest fresh and dry biomass. The cocopeat and tea powder combination produced the highest germination in mustard and the greatest root length and moisture content in this species. The growth response therefore depended on both species and substrate composition. Among the substrates tested, tea powder was particularly promising for rapid shoot growth and biomass production, while cocopeat and tea powder combination showed advantages for root development in mustard microgreens. The findings highlight the significant potential of spent tea powder as a practical growing medium for microgreen production, supporting efforts to enhance food security and environmental sustainability. Further research is recommended for a deeper understanding and optimization for microgreen production.

Acknowledgement

The authors are thankful to the Head, Department of Botany, University of Kerala, for providing necessary facilities for doing this work.

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