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Evaluation of Mango Waste Compost Effect on Nut Germination, Rootstock and Scion Growth of Cashew (*Anacardium occidentale* L.) in the Nursery

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ABSTRACT

Background: Cashew (*Anacardium occidentale* L.) is a major economic important crop in tropical regions, particularly in West Africa. In Côte d'Ivoire, it is the second most important export product after cocoa, making a significant contribution to farm income and the fight against rural poverty. However, the production of vigorous, homogeneous seedlings remains a major challenge for the sustainable development of this crop. The aim of the study was to assess the effect of mango vaste compost on nut germination and the growth parameters of cashew rootstocks and scions in the nursery.

Methods : In a Fisher block design, five doses of compost were tested: no-compost control (T_0); 1/4 compost + 3/4 soil (T_1); 1/3 compost + 2/3 soil (T_2); 1/2 compost+1/2 soil (T_3); 100% compost (T_4). Analysis of variance revealed a significant difference (p<0.0001) between treatments for the parameters studied. Tukey's post-test was used to compare means.

Result: The compost treatments performed better than control. However, treatments T_2 and T_3 resulted in faster nut germination and more efficient plant recovery. Also, the most vigorous plants in terms of height, diameter, number of leaves and spread were obtained with T_2 and T_3. Treatments T_0 (control) and T_4 (compost alone) were less effective than the other treatments.

Key words: Cashew tree, Compost, Germination, Plant growth, Substrate.

INTRODUCTION

Cashew (*Anacardium occidentale* L.) is native to South America, in the central region of Brazil (Azonkpin *et al*., 2025). It is a fruit tree widely cultivated in South and Central America, Asia and Africa (Chen *et al*., 2023; Katou *et al*., 2024). It is grown mainly for its nut, which is a source of income for many people (Yeboah *et al*., 2023; Babatunde *et al*., 2023). Africa is the world's leading producer of raw cashew nuts, accounting for over 58% of global production, followed by Asia with 38% (FAOSTAT, 2023). The main cashew nut production zone is located in West Africa. This region accounts for almost 45% of African nut production, led by Côte d'Ivoire, the world's leading producer and exporter (Thiocone, 2024).

Initially introduced to Côte d'Ivoire for environmental reasons, in particular to combat deforestation and soil degradation (Silué, 2020), cashew is now the country's second most important export product after cocoa (World Bank, 2025). Given the increase in field prices, annual cashew nut production has risen from 380,000 tonnes in 2010 to over 1.2 million tonnes in 2023, representing 40% of world supply, with exports estimated at over $800 million (World Bank, 2025). Despite this increase in production, the average yield of Ivorian orchards remains low. This is due to the use of low-performance planting material and unsuitable cultivation practices. Indeed, farmers' plantations are seeded with low-performance nuts. However, seed multiplication has a number of drawbacks, including heterogeneous production, a high rate of atypical plants and low yields. As a result, according to Koné (2010), the increase in Ivorian cashew production is due to an increase in the area under cultivation, rather than an improvement in orchard yields. In the medium to long term, this extensive agriculture will contribute to the reduction of arable land.

Aware of this threat, several studies have been carried out to promote intensive cashew cultivation. One of the

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solutions proposed by research is the multiplication of plant improved material taken with advanced agronomic pratices. This technique helps to maintain the genetic integrity of the mother tree to be propagated and to create homogeneous orchards healthy seedling (Djaha *et al*., 2012). One of the main factors in successful grafting is the quality of the substrate. Indeed, a good nutritional composition of the nursery substrate promotes the production of vigorous plants, through the higher availability of mineral elements. In addition, research in India has also shown that fertilizing the nursery substrate with a biofertilizer improves the dry matter content of cashew seedlings (Shankarappa *et al*., 2017). To date, there is little scientific information on use of organic amendments of cashew nursery substrate in Côte d'Ivoire. The general aim of the present study is to improve the cashew tree's technical itinerary through the production of vigorous seedlings in the nursery. Specifically, it aims to evaluate the effect of different doses of mango waste compost on the growth of cashew rootstocks and scions.

MATERIALS AND METHODS

The experiment was carried out at the research station of the National Agricultural Research Center of Ferkessédougou, located in the Tchologo region of northern Côte d'Ivoire during the dry season of the year 2024. The characteristics of site soil are described in Table 1.

In this study, compost was produced from mango waste (spoiled fruit, leaves and pits). These inputs were chosen for their local availability and high nutrient content. Compost production was inspired by the Orlina *et al*. (2023) method, which uses a ratio of 40% nitrogen source and 60% carbon source. Chicken droppings, rich in nitrogen, were introduced into the pile to facilitate degradation of the carbon-rich mango waste. Thanks to its richness in decomposer micro-organisms, chicken droppings accelerate the decomposition of lignocellulosic compounds contained in the waste, promote compost formation and improve its maturity (Zhang and Sun, 2018).

Peanut shells were incorporated into the pile to promote aeration and limit compaction. The waste materials were placed in alternating layers. All the waste was watered and then covered with a semi-permeable tarpaulin. Watering was repeated at every three days for three months. After this period, watering was carried out as required. The pile was turned at every 15 days interval to homogenize and aerate it. Six months after installation, the pile had shrunk considerably and was now black in color. The compost samples obtained were air-dried and then were crushed using a mortar and pestle, sieved using a standard soil sieve of less than 2 mm. One (1) kilogram of representative sample was taken and sent to the Environnement et Agroalimentaire laboratory in Abidjan for physico-chemical analysis. These chemical analyses were used to determine the mineral composition of the compost (Table 2). The organic matter (OM) content was calculated by multiplying the carbon content by 1.72. The compost obtained was tested on cashew trees in the nursery according to a Fisher block design, comprising five treatments with three replicates. Cashew nuts were used to produce rootstocks. The scions came from the LAZ 330 genotype, selected for its good productivity and vigour. The treatments were as follows:

T_0: Substrate composed of 100% soil.
T_1: Substrate composed of 1/4 compost and 3/4 soil.
T_2: Substrate composed of 1/3 compost and 2/3 soil.
T_3: Substrate composed of 1/2 compost and 1/2 soil.
T_4: Substrate composed of 100% compost.

Substrates composed of sand and/or compost were used to fill nursery pot. Each bag was labelled according to the proportion of compost it contained (treatment). A single nut was sown per pot. After sowing, nursery pot were watered twice a day. Three weeks after emergence, the plants were grafted. The experiment lasted for three months.

Data collection

The following data were collected for the study

Germination parameters

After sowing the nuts, the pots were observed daily to record the germination time. Germination rate was determined 14 days after sowing, according to the formula:

$$\text{Germination rate} = \frac{\text{Number of sprouted nuts}}{\text{Number of nuts sown}} \times 100\%$$

Growth parameters

Two weeks after germination, the height of each plant in each treatment was carefully measured using a graduated ruler. Measurements were taken from the crown to the apex. The diameter at the crown of each plant was measured with a caliper. The number of leaves were counted on each plant. Leaf area was calculated using the Bonhomme *et al*. (1982) equation:

$$\text{Leaf area (cm}^2\text{)} = (L \times l) \times 0.75$$

Where,
L= Leaf length.
L= Leaf width.

Plant vigor was determined using Alexandre's (1977) formula:

$$\text{Vigor (H/D)} = \frac{\text{Height}}{\text{Neck diameter}}$$

Post-grafting recovery parameters

At two weeks post-grafting, the plants were observed daily to record the recovery date (appearance of the first bud). Then, one month after emergence, the recovery rate was also calculated using the following formula:

$$\text{Germination rate} = \frac{\text{Number of sprouted nuts}}{\text{number of nuts sown}} \times 100\%$$

Growth parameters were also recorded on cashew seedlings one month after grafting.

Statistical analysis

Data were processed using Microsoft Excel 2016 for entry and graph generation of germination and seedling recovery rates. One-way ANOVA followed by Tukey's HSD test was used to assess the effects of treatments on cashew germination, seedling recovery and growth. Differences were considered significant at $p<0.05$. Statistical analyses were performed in R 4.2.1.

Table 1: Soil characteristics at the study site.

Parameters	
Chemical soil parameters	Contents
pH eau	6.45
MO (mg kg^{-1})	2.57
Calcium (Cmol kg^{-1})	952
Cation exchange capacity (CEC) (meq 100 g^{-1})	7.15
Magnesium (cmol kg^{-1})	145.5
Potassium (cmol kg^{-1})	99.67
Sodium (cmol kg^{-1})	13.83
Nitrogen (%)	0.071
Phosphorus (mg Kg^{-1})	8.00
Physical soil parameters	
Sand (%)	39.66
Silt (%)	46.96
Cly (%)	1338

Source: Akanza, P.K. and N'Da. (2018).

Table 2: Chemical composition of compost.

Parameters	Teneurs
pH	7.38
Organic carbon (%)	1.82
Potassium (%)	0.86
Nitrogen (%)	1.03
C/N	12.45
Phosphorus (%)	15.3

RESULTS AND DISCUSSION

Temperature and pH variation during composting

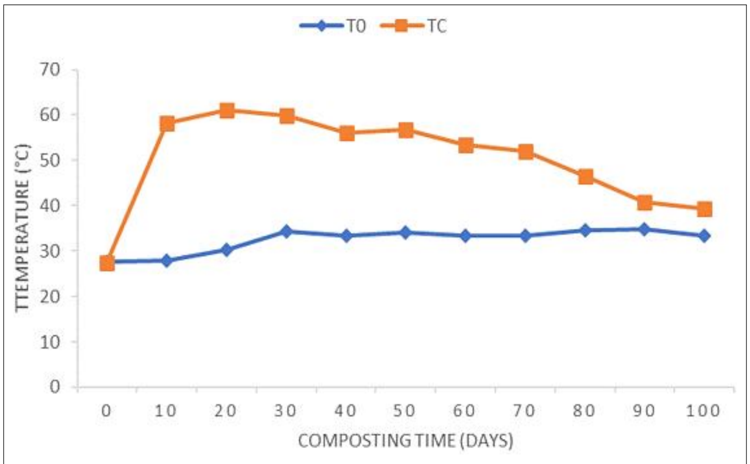
The temperature of the compost heap (T_C), in contrast to the ambient temperature (T_0), rose rapidly from the second day after its formation (60°C) and remained constant for 30 days (Fig 1). After this date, a gradual decrease in temperature was observed, reaching 38°C after three months. The pH of the compost heap showed a characteristic variation with time. During the first four weeks after the heap was placed, the pH remained high, fluctuating between 8.2 and 8.5 (Fig 2). After this date, a gradual decrease in pH was observed, reaching a value of around 7.2 at the end of the composting process.

Effect of substrate composition on nut germination and seedling recovery after grafting

Analysis of variance revealed a significant difference ($p<0.0001$) between treatments regarding nut germination and recovery dates in cashew grafts (Table 3). In general, treatments with compost performed better than those without. However, the 1/3 compost treatment had the shortest germination and recovery times. The control treatment without compost (T_0) and the treatment with 100% compost substrate (T_4) resulted in later germination. In terms of germination and resprouting rates, all treatments had germination and resprouting rates in excess of 50% (Fig 3 and 4).

Effect of substrate composition on rootstock and scion growth

Analysis of variance showed a highly significant difference ($p<0.0001$) between treatments in cashew growth parameters in the nursery. Treatments T_2 and T_3 produced large-sized, large-diameter seedlings for both rootstocks



T_0= Ambient temperature; T_C= Compost temperature.

Fig 1: Temperature changes during the composting process.

(Table 4 and 5) and scions (Table 6). The number of leaves per plant, leaf area and rootstock spread were also higher in treatments T_2 and T_3. In this study, the plants had a height/ diameter (H/D) ratio of less than 80, indicating balanced growth and satisfactory vigour.

Growth of cashew trees by treatment

Fig 5 and 6 show the growth dynamics of cashew trees. In general, plants in substrates with compost grew faster than those in substrates without compost. However, the best growth in height was obtained with treatments T_2 and

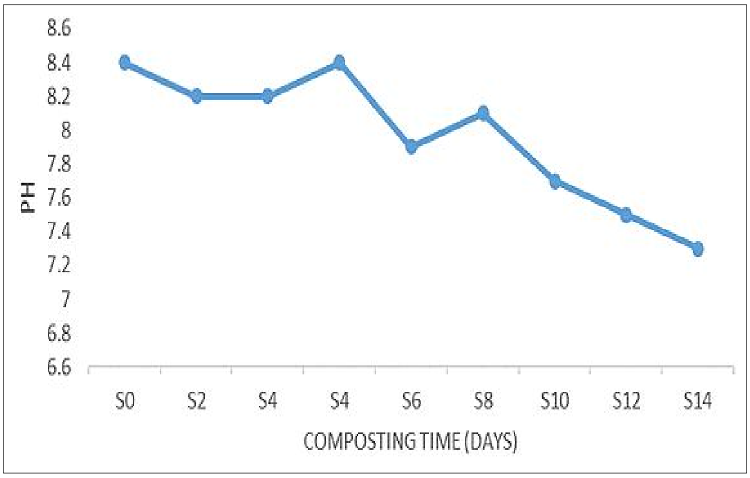


Fig 2: Changes in compost pH over time.

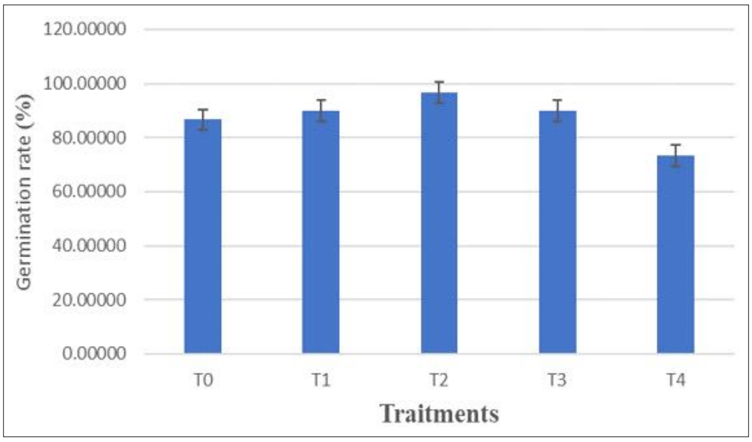


Fig 3: Cashew nut germination rate.

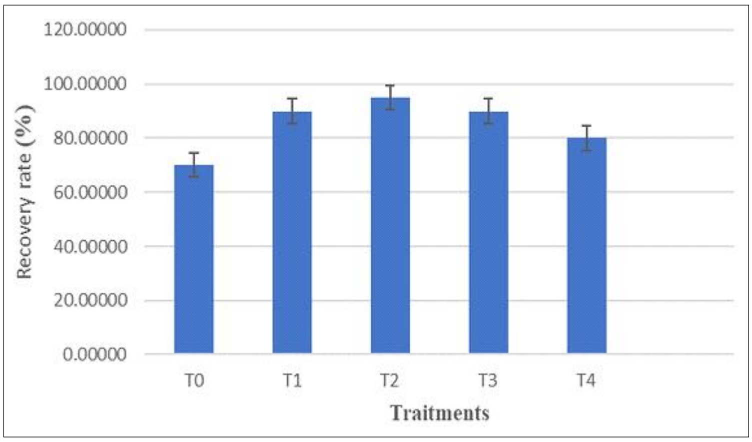


Fig 4: Recovery rate after grafting.

T_3. The best growth in diameter was observed in treatments T_1 and T_2.

The high temperature observed in the pile constitutes the thermophilic phase of composting, during which pathogens and weed seeds are eliminated. Temperature monitoring is a relevant indicator of microbial activity and high temperatures are characteristic of high microbial activity. Pan *et al*. (2022) showed that germination of Leucaena leucocephala (white leadtree) seeds was significantly reduced when compost was heated to 70°C for several days. The compost also showed a pH close to neutral (7.2) after three months. This value reflects the stabilization of the compost and attests to its maturity. Previous studies confirm that composts considered mature have a pH between 6.5 and 7.5 (Zhang and Sun, 2018; Adhikari *et al*., 2020). The decrease in pH could be an indicator of compost stabilization and signs of maturation. The results of work by Oueld Lhaj *et al*. (2024) showed that initial pH values in composts were recorded at 7.42, 7.10 and 7.10, respectively, subsequently decreasing to 6.61, 6.80 and 5.90 at the end of the process.

Regarding the effect of compost on nut germination and cashew growth, analysis of variance revealed a significant difference (p<0.0001) between the treatments

Table 3: ANOVA results for germination and recovery dates after grafting.

Traitments	Germination date	Grafting recovery date
T_0	18.033±2.075c*	19.433±1.654c*
T_1	16.466±2.080bc	17.133±1.382b
T_2	12.866±1.279a	15.566±2.979a
T_3	14.166±1.895b	17.966 ±2.965b
T_4	16.600±3.113c	20.633±3.458d
Probability	<0.0001	<0.0001

*Column means with the same letter do not differ significantly at the 5% level (Turkey test).T_0 : compost in proportion 0%, T_1: Compost in proportion 1/4; T_2: Compost in proportion 1/3, T_3: Compost in proportion 1/2; T_4: Compost in proportion 100%.

Table 4: Effect of compost on rootstock height, diameter and number of leaves per plant.

Traitments	Height (cm)	Diameter (cm)	Number of leaves per plant
T_0	13.11±0.83a*	0.34±0.06a	6.63±2.04a*
T_1	19.06±1.76b	0.35±0.07ab	7.90±0.80b
T_2	22.55±1.90d	0.51±0.08b	9.67±1.35d
T_3	21.07±2.16c	0.38±0.06ab	8.83±1.62cd
T_4	20.34±1.99bc	0.37±0.06ab	7.77±0.94b
Probability	<0.0001	<0.0001	<0.0001

*Column means with the same letter do not differ significantly at the 5% level (Turkey test).T_0: Compost in proportion 0%, T_1: Compost in proportion 1/4; T_2: Compost in proportion 1/3, T_3: Compost in proportion 1/2; T_4: Compost in proportion 100%.

Table 5: Effect of compost on leaf area, spread and vigour of rootstocks.

Traitments	Leaf area (cm²)	Spread (cm)	Vigor of rootstocks
T_0	27.46±6.37a	16.25±2.94a	39.69±6.89a
T_1	39.62±5.00b	19.57±1.98b	55.63±10.53b
T_2	47.73±5.23c	23.46±1.44d	45.27±8.67a
T_3	47.34±7.16c	22.20±1.19cd	57.32±10.84b
T_4	43.64±6.59bc	21.34±2.91c	55.95±10.32b
Probability	<0.0001	<0.0001	<0.0001

*Column means with the same letter do not differ significantly at the 5% level (Turkey test).T_0: Compost in proportion 0%, T_1: Compost in proportion 1/4; T_2: Compost in proportion 1/3, T_3: Compost in proportion 1/2; T_4: Compost in proportion 100%.

Table 6: Effect of compost on graft height, diameter and number of leaves.

Traitments	Height (cm)	Diameter (cm)	Number of leaves	Canopy
T_0	19.56±1.46a*	0.44±0.05a	4.13±0.73a*	18.03±1.03b
T_1	27.11±2.40c	0.68±0.08d	5.33±0.84b	20.08±1.13c
T_2	28.15±2.71cd	0.74±0.07e	6.87±1.07c	20.67±1.33c
T_3	29.24±1.94d	0.50±0.04b	6.20±1.03c	15.86±1.12a
T_4	24.86±1.72b	0.60±0.07c	5.20±1.16b	19.88±1.52c
Probability	<0.0001	<0.0001	<0.0001	<0.0001

*Column means with the same letter do not differ significantly at the 5% level (Turkey test).T_0: Compost in proportion 0%, T_1: Compost in proportion 1/4; T_2: Compost in proportion 1/3, T_3: Compost in proportion 1/2; $_T4$: Compost in proportion 100%.

applied. Treatments with compost performed better than those without. However, the 1/3 compost + 2/3 soil treatment had the minimum shortest germination and plant recovery time, followed by the 1/2 compost + 1/2 soil treatment. This could be due to the fact that the quantity of compost contained in these treatments would have maintained an optimal quantity of water allowing good rehydration of the nuts. According to Bouzid (2024), the first stage of germination is characterized by high tissue hydration through water absorption, leading to seed swelling. The germination phase comprises a sequence of events, beginning with imbibition and ending with radicle emergence. The germination process is strongly influenced by the interaction between environmental factors and the genetic make-up of the plant species (Carrera-Castaño *et al*., 2020). Also, the mineral elements provided by the compost would have been beneficial in stimulating germination and recovery of the plants after grafting.

Nitrate has been shown to promote the lifting of seed dormancy and subsequent germination in many plant species (Arc *et al*., 2013). Kouamé *et al*. (2023) in their study showed that, incorporating sawdust compost into the substrate accelerated the germination of Framiré seeds compared to the control without compost. The control treatment (T_0) and the 100% compost substrate treatment (T_4) resulted in later germination. This could be linked to the poor material content of the sand and poor aeration in the pure compost, which could limit seed oxygenation. According to Thajeel and Al-Bayati (2026), vegetative growth was poor in untreated Swiss chard (*Beta vulgaris* var. *cicla* L.) compared to plants receiving 20 g·L^{-1} of organic fertilizer. Also, Orlina *et al*. (2023) in their study showed that exposure of seedlings to a higher concentration of nutrients can impair their development. The work of Sarwar *et al*. (2024) has shown that substrates balanced in organic matter and sand favor rapid seed emergence, in contrast to overly compact or poor environments. Similarly, Sciendo (2021) has highlighted the importance of substrate porosity in aeration and oxygen availability for the embryo. The results indicate that the treatments consisting of 1/3 compost +2/3 soil (T_2) and 1/2 compost+1/2 (T_3) promoted better overall growth of cashew rootstocks and scions. This performance

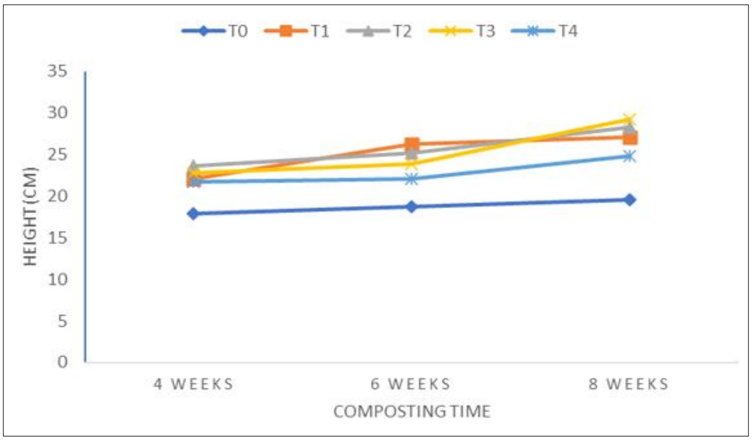


Fig 5: Evolution of graft height over time.

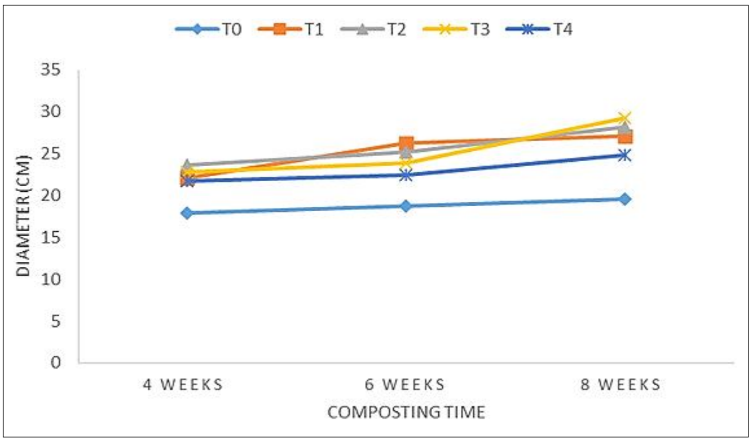


Fig 6: Evolution of graft diameter over time.

could be explained by the fact that this proportion represents the optimal dose for this type of compost, thus promoting the gradual availability of nutrients to the plants. Consistent with the present findings, Singh and Misal (2022) reported that maize growth was significantly enhanced by the application of organic inputs such as vermicompost, applied either alone or in combination with inorganic fertilizers. Hendrik *et al*. (2025) reported that incorporating crop residues into agricultural fields contributes to soil fertility restoration, erosion control and enhanced crop productivity. Also, recent studies confirm the importance of the compost/soil ratio in improving substrate properties and plant growth. Manrique-Vega and Alvarado-Sanabria (2023) showed that incorporating 12.5% to 25% compost into the soil improved the growth of plant species, with better availability of nitrogen and phosphorus to the plant. According to Hassan *et al*. (2023), moderate doses of compost, combined with mineral soil or biochar, promote plant growth while limiting nutrient loss. Also Ain *et al*. (2025) showed in their study that the 50% compost substrate showed a considerable reduction in fresh and dry plant weight. In their view, this indicates that the large amount of compost in the solution was highly toxic to the plants.

However, the T_0 control treatment produced the smallest plants compared with the other treatments. This result could be due to the low level of fertility of the substrate, which could not provide the plants with nutrients. This is confirmed by the results of the chemical analysis of the soil used, indicating a sandy texture, low acid pH, high C/N, nutrient deficiencies (nitrogen, potassium, calcium, organic matter). Abebe *et al*. (2023) reported that plants grown in substrates with low organic matter content showed superficial root growth and low biomass accumulation, compared with those grown on compost-enriched substrates. The relatively low values of the height/diameter ratio suggest that, although the substrate was poor, it provided a minimum supply of nutrients to cashew trees at the initial stage of their growth, promoting thickening of the crown while allowing some elongation of the stem. This may be explained by the fact that cashew plants in the juvenile stage are less demanding in terms of nutrients. Ngom *et al*. (2024) in their study showed that cashew plants grown in a poor substrate (T_0) had an H/D ratio below 80, indicating balanced growth between height and diameter.

CONCLUSION

The study showed that incorporating compost into the substrate significantly influenced germination, recovery and growth of rootstocks as well as growth of cashew scions in the nursery. Treatments containing 1/3 compost + 2/3 soil (T_2) and 1/2 compost + 1/2 soil (T_3) favored faster germination, efficient recovery and good seedling growth. The no-compost control treatment (T_0) and the compost-only treatment (T_4) performed less well, respectively due to the poor substrate and excessive density of pure compost, which limits oxygenation and can induce nutrient stress.

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Disclaimers

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Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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