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Optimizing Weed Management in Polythene Nursery-raised Cashew (*Anacardium occidentale* L.) Seedlings: Implications for Seedling Morphology, Transplanting Vigour and Soil Fungal Community Structure

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Abstract

Background: Weed management in nursery crop production is frequently neglected by farmers, posing a significant threat to seedling quality, growth and transplanting success. In cashew (*Anacardium occidentale* L.) nurseries, weeds compete aggressively with seedlings for light, nutrients and water, and may harbour

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pathogens detrimental to seedling health, yet the optimal manual weeding frequency remains inadequately defined.
Aim: The study investigates the effects of varying manual weeding frequencies on cashew seedling morphology, transplanting vigour, root characteristics and soil fungal community structure.
Study Design: A Completely randomized design (CRD) was adopted, having six treatments, each replicated three times: weed-free (WF), weedy-check (WC), once-weekly (1W), once-in-two-weeks (2W), once-in-three-weeks (3W) and once-in-four-weeks weeding (4W).
Place and Duration of Study: The study was conducted at Akinyele Local Government Area, Ibadan, Oyo State for three months.
Methodology: Cashew nut biotypes were sown in polybags (25 cm × 12.5 cm) with 2 mm-sieved topsoil. Morphological parameters were assessed biweekly from 1 MAS. Destructive sampling at 3 MAS was conducted. Seedling vigour was rated on a five-point scale at 12 WAS. Soil fungi were assessed using standard procedures.
Results: WC recorded the smallest leaf area (31.39 cm^2) at 12 WAS while 4W (45.77 cm^2) was the largest. WC (2.8) recorded the lowest vigour. Tap root length was significantly greater in 2W (18.2 cm) than WC (14.6 cm). Peak weed density occurred at 2–4 WAS. Initial topsoil recorded the highest fungal CFU. *Aspergillus niger* and *A. fumigatus* were ubiquitous, while *Fusarium oxysporum* and *Trichoderma viride* varied with weeding frequency.
Conclusion: The critical weed interference period was 2–4 WAS, beyond which cashew canopy development naturally suppressed weed regeneration. Weeding frequency selectively shaped soil fungal community composition. Once-in-four-weeks weeding is recommended as a practical, agronomically sound strategy sustaining acceptable seedling quality while minimizing nursery labour demands.

Keywords: Anacardium occidentale; weed management; seedling vigour; Soil fungal community; manual weeding.

1. Introduction

The cashew tree, scientifically known as *Anacardium occidentale* L belongs to the *Anacardiaceae* family of plants as mango (Awodun et al., 2015). It is an evergreen tree native to Brazil, but now grown widely in tropical countries of the world such as Nigeria. In Nigeria's agricultural sector, it plays a crucial role and significantly contributes to the country's economic growth (Olukunle, 2023). According to Ogunwolu *et al*., (2020), this non-oil export crop is well-known, lucrative and supports foreign exchange earnings. Many stakeholders engaged in the production, processing and other stages of the cashew nut value chain depend financially on exporting the nuts. Its dense foliage makes it useful for controlling erosion, providing windbreaks and improving degraded soil (Nduka *et al*., 2015, Altland, 2005, Deen et al., 2003).

According to Essien *et al*. (2021), cashew trees are mostly propagated from seeds, which can be seeded directly in the field, in nursery beds or perforated nursery bags. However, cashew growers in Nigeria frequently employ the technique of growing cashew seedlings in nursery polythene bags (Agele and Agbona, 2008).

One of the major constraints encountered in the nursery is the management of weeds (Yu and Marble, 2022). As a result of an ideal growing environment such as well-drained and moist potting soil, newly potted cashew plants in the nursery tend to be vulnerable to weed infestation (Norcini *et al*., 2010). In the nursery setting, weeds compete fiercely with cashew seedlings for vital resources such as light, nutrients and water, which negatively impacts the seedlings' growth and development. In addition, weeds can also act as possible habitats for pathogens or insects, which raises the possibility of infestation or disease transmission to cashew seedlings.

Crop morphological development has been observed to be impacted by weeds (Swanton and Murphy, 1996; Siddiqui *et al*., 2024, Garau et al., 2009). Nevertheless, it is important to recognize that the root systems of crops also play a substantial role in the successful establishment of nursery crops in the field (Sánchez-Blanco *et al*., 2014). Unfortunately, the focus is often directed primarily toward the shoot system, leading to an oversight of the crucial contribution made by the roots.

Weeds can change the soil environment by competing with crops for nutrients, water and sunlight, leading to alterations in the composition and activity of the soil microbial community (Massenssini *et al*., 2014). It is therefore important to observe the influence of weeding periods on soil microbes.

To protect cashew seedlings, it is critical to manage weed infestation effectively, which calls for prompt and suitable weed management procedures. Some of the measures that are effective in reducing weed-related problems in cashew nurseries are mulching, manual weeding and regular monitoring. Adopting good weed management practices enables cashew growers to raise healthy seedlings, enabling successful establishment and future growth in the field. Therefore, it is important to scientifically study the effect of weeds on young cashew seedling morphology, root systems and nursery soil used. This study's objective is to:

1. Observe the influence of varying durations of manual weeding on cashew seedling morphology, vigour and root systems.
2. Investigate the most appropriate time to weed cashew seedlings in the nursery.
3. Observe the effect of different weeding periods on soil fungal community.

2. Methodology

2.1 Experimental Design, Weeding Treatment and Experimental Setup

The experimental study was conducted in a nursery located within Akinyele Local Government Area, Ibadan, Oyo State, Nigeria within 3 months. A completely randomized design (CRD) was employed, comprising six treatments each replicated three times. The treatments were: weed-free (WF), weedy check (WC), once-weekly weeding (1W), once-in-two-weeks weeding (2W), once-in-three-weeks weeding (3W) and once-in-four-weeks weeding (4W). Medium-sized cashew (*Anacardium occidentale* L.) nut biotypes were sown at a depth of 4 cm in polybags measuring 25 cm × 12.5 cm, filled with topsoil sieved to 2 mm fineness. Each polybag was punctured at the base to ensure adequate drainage and prevent waterlogging. Each treatment comprised 10 seedlings per replicate, giving a total of 60 seedlings per replication and 180 seedlings across all three replications. Seedlings were irrigated every two days throughout the experimental period.

2.2 Data Collection

Growth parameter data collection commenced at one month after sowing (1 MAS) and was conducted at biweekly intervals thereafter. Parameters recorded included plant height (cm), stem diameter (mm), number of leaves per plant and leaf area (cm^2). Seedling vigour was assessed at three months after sowing (3 MAS) using a five-point rating scale ranging from 1 (poor) to 5 (excellent), as previously described by Olasan *et al*. (2018). At the termination of the experiment, destructive sampling was carried out on all seedlings. Each plant was carefully uprooted and separated into shoot and root fractions. Fresh shoot weight (FSW) and fresh root weight (FRW) were immediately recorded using a precision balance and tap root length (TRL) was measured with a ruler. Root morphology was scored using a scale adapted and modified from Olasan *et al*. (2018), where 1 = scanty, 2 = moderate and 3 = fibrous. Plant material was subsequently oven-dried to constant weight at 70°C to determine dry shoot weight (DSW) and dry root weight (DRW). Weed species present within each polybag were identified and documented throughout the experimental period.

2.3 Soil Sampling and Microbial Analysis

An initial topsoil sample was collected prior to sowing to characterize the baseline physicochemical properties of the experimental soil. At experiment termination (3 MAS), soil samples were collected from each treatment for microbial analysis. For each sample, 1 g of soil was aseptically weighed and suspended in 9 ml of sterile distilled water to produce a uniform soil suspension. The suspension was agitated for 30 minutes to homogenize and serial dilutions were prepared at 10^{-3} and 10^{-5}, with each dilution replicated three times. One milliliter aliquots from each dilution were inoculated onto 15 ml of sterilized, cooled Potato Dextrose Agar (PDA) amended with 10% lactic acid solution to inhibit bacterial contamination. Inoculated plates were incubated at room temperature for 5–7 days to permit fungal colony development, after which colony counts were recorded. Pure cultures of morphologically distinct fungal colonies were subcultured onto fresh PDA plates for identification.

2.4 Statistical Analysis

All data were subjected to one-way Analysis of Variance (ANOVA) using GenStat statistical software. Treatment means were separated using the Least Significant Difference (LSD) test at a probability level of $p \leq 0.05$.

3. Results and Discussion

Weed identification is a critical prerequisite for effective weed management, as knowledge of species composition provides insight into the biological characteristics and competitive potential of the weed community (Naidu, 2012). In nursery systems, topsoil used for filling polybags typically contains viable weed seeds originating from the collection site, which germinate and establish under the warm and moist conditions that favour seedling production. The weed species recorded in the polybag nursery during this study are presented in Table 1. The identified species comprised *Synedrella nodiflora*, *Portulaca oleracea*, *Talinum triangulare*, *Laportea aestuans*, *Chromolaena odorata* and *Tridax procumbens*, all classified as broadleaf weeds and *Eragrostis tremula*, classified as a grass weed. All species identified are recognized as tropical weeds (Akobundu and Agyakwa, 1998). Tropical weed species are well documented as aggressive competitors with crop plants for essential resources including light, water and soil nutrients (Zimdahl, 2004; Hakim et al., 2013). Their co-occurrence with cashew seedlings in the polybags therefore underscores the necessity for timely and effective weed control measures in the nursery, particularly during the early stages of seedling establishment when competition pressure is most detrimental to growth.

Table 1. Weeds identified during the experiment

S/N	Weed Species		
	Common Name	**Scientific Name**	**Life Cycle**
1	Synedrella	*Synedrella nodiflora*	Annual
2	Common Purslane	*Portulaca oleracea*	Annual
3	Water leaf	*Talinum triangulare*	Perennial
4	Tropical Nettleweed	*Laportea aestuans*	Annual
5	Siam Weed	*Chromolaena odorata*	Perennial
6	Love grass	*Eragrostis tremula*	Annual
7	Tridax	*Tridax procumbens*	Annual
8	Worm Bush	*Spigelia antelmia*	Annual

Characterization of the physical and chemical properties of nursery soil prior to use is essential for informed management decisions regarding seedling production. The physicochemical properties of the soil used in this study, determined before sowing and treatment application, are presented in Table 2. Textural analysis classified the soil as sandy clay loam and the pH value of 4.36 indicated a strongly acidic reaction. Using the soil fertility rating criteria of Chude *et al*. (2012), the soil's organic carbon and total nitrogen contents were found to be very low, available phosphorus (P) was low, while exchangeable potassium (K), magnesium (Mg) and calcium (Ca) were rated very high.

Table 2. Physicochemical properties of the topsoil

Parameters	Values	Class/Level
Chemical Properties		
pH (1:2 H_20)	4.36	Strongly Acidic
Organic Carbon (g kg^{-1})	1.74	Very Low
Total Nitrogen (g kg^{-1})	0.36	Very Low
Available P (mg kg^{-}1)	5.13	Low
K (cmol kg^{-}1)	1.01	Very High
Mg (cmol kg^{-}1)	2.60	Very High
Ca (cmol kg^{-}1)	5.40	Very High
Soil Properties		
Sand		
Clay		
Silt		
Textural Class	Sandy Clay Loam	

The low levels of organic carbon, nitrogen and available phosphorus recorded in this soil have direct implications for seedling nutrition and weed management. Weeds are well documented as deep-rooted, aggressive scavengers of soil nutrients, capable of depleting available nutrient reserves rapidly when left uncontrolled. Given the already limiting levels of key nutrients recorded in the pre-sowing soil analysis, competition from weeds would further compromise the nutrient availability to cashew seedlings. These findings therefore provide a strong agronomic justification for the implementation of timely and effective weed management practices in the nursery, to minimize weed-crop competition for the limited nutrient resources present in the soil.

The effects of weed management treatments on the growth parameters of cashew seedlings are presented in Table 3. No significant differences were observed among treatments for plant height, number of leaves and stem diameter throughout the observation period. However, a notable difference was recorded in leaf area at 12 weeks after sowing (WAS), where the Weedy Check (WC) treatment produced the smallest mean leaf area (31.39 cm²) compared to the once-in-three-weeks weeding (3W; 43.56 cm²) and once-in-four-weeks weeding (4W; 45.77 cm²) treatments, indicating that even infrequent weeding intervals positively influenced leaf area development in cashew seedlings.

Although no significant difference in plant height was recorded among treatments, WC recorded the shortest mean plant height (25.50 cm) at 12 WAS, suggesting a suppressive trend attributable to uncontrolled weed competition. Interestingly, WC recorded the highest number of leaves (18.8) at the same period; however, the corresponding leaf area data indicate that these leaves were considerably smaller than those produced under weeded treatments. This pattern suggests that prolonged weed interference promoted the production of numerous but poorly developed leaves, likely as a stress response to resource competition.

These observations are consistent with documented evidence that weed competition adversely affects both the morphological and physiological development of crop plants (Hakim et al., 2013). In the context of nursery management, the suppression of plant height and leaf area in unweeded cashew seedlings is of particular concern, as these parameters are direct indicators of seedling vigour and transplanting readiness. Furthermore, given the established interrelationships among plant growth parameters (Sher et al., 2013), early suppression of height and leaf area development in unweeded seedlings may have cascading negative effects on other growth attributes over time.

Table 3. Growth parameters of cashew seedlings as influenced by weeding periods

Treat	**Growth Parameters**											
	Plant Height (cm)			**No. of Leaves**			**Stem Diameter (mm)**			**Leaf Area (cm^2)**		
	4WAS	**8WAS**	**12WAS**	**4WAS**	**8WAS**	**12WAS**	**4WAS**	**8WAS**	**12WAS**	**4WAS**	**8WAS**	**12WAS**
WF	20.62	24.65	27.37	7.3	9.8	14.0	4.90	5.00	5.50	38.34	39.89	38.59
WC	19.90	23.22	25.50	8.5	12.5	18.8	4.30	5.13	5.50	44.32	43.90	31.39
1W	18.58	23.25	25.88	7.2	9.8	17.2	4.73	5.12	5.90	37.14	38.51	37.94
2W	21.63	24.82	27.18	8.3	10.0	13.3	4.72	5.17	5.57	42.80	43.46	39.02
3W	21.02	25.23	27.60	7.0	9.3	13.7	4.25	4.47	5.12	42.77	42.70	43.56
4W	21.37	26.00	28.97	6.7	9.0	11.5	4.58	5.03	5.63	4.01	40.78	45.77
LSD	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**	**9.900**

Note: ns= Not significant; WAS= Weeks after sowing; WF= Weed-free; WC= Weedy check; 1W= Once in a week weeding; 2W= Once in two weeks weeding; 3W= Once in three weeks weeding; 4W= Once in 4 weeks weeding

Beyond the assessment of individual growth parameters, the overall performance of seedlings under different weed management treatments was evaluated visually using a seedling vigour scoring scale, which provides a holistic measure of plant growth and general condition. While no significant differences were recorded among treatments for plant height, number of leaves, stem diameter and leaf area throughout the experimental period with the exception of leaf area at 12 weeks after sowing (WAS) (Table 3), visual vigour assessment conducted at 12 WAS prior to transplanting revealed notable treatment-related differences (Fig. 1). Using the vigour scoring scale adopted from Olasan *et al*. (2018), the Weedy Check (WC) treatment recorded the lowest mean vigour score of 2.8, rated as below fair and was significantly different from all weeded treatments, namely Weed-free (WF; 4.8), once-weekly weeding (1W; 4.7), once-in-two-weeks weeding (2W; 4.8), once-in-three-weeks weeding (3W; 4.7) and once-in-four-weeks weeding (4W; 4.8), all of which approached an excellent rating.

These results demonstrate that sustained weed interference from sowing to the point of transplanting significantly compromised the overall vigour of cashew seedlings, even in instances where individual growth parameter measurements did not reflect statistically significant differences among treatments. This underscores the sensitivity of holistic visual assessment in detecting subtle but biologically meaningful treatment effects that may be overlooked by individual parameter analysis alone. Seedling vigour is a critical determinant of post-transplanting establishment and field survival and poor vigour at the nursery stage has been associated with reduced crop stand and diminished early growth performance in the field (Farooq *et al*., 2007; Sarangi *et al*., 2015). Representative photographs of WC and WF seedlings at 12 WAS are presented in Plates 1, 2 and 3.

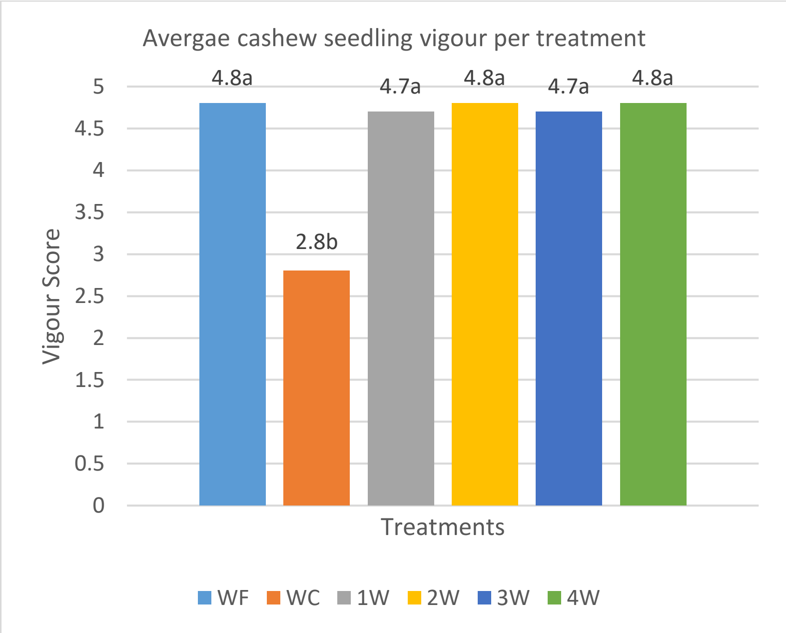

Fig. 1. Cashew seedling vigour per treatment at 12 weeks after sowing

Note: WF= Weed-free; WC= Weedy check; 1W= Once in a week weeding; 2W= Once in two weeks weeding; 3W= Once in three weeks weeding; 4W= Once in 4 weeks weeding. Treatment(s) with the same letter are not significantly different

Plate 1. Unweeded cashew seedlings overgrown with weeds at 12 weeks after sowing in the nursery

Plate 2. Healthy weed-free cashew seedlings at 12 weeks after sowing in the nursery

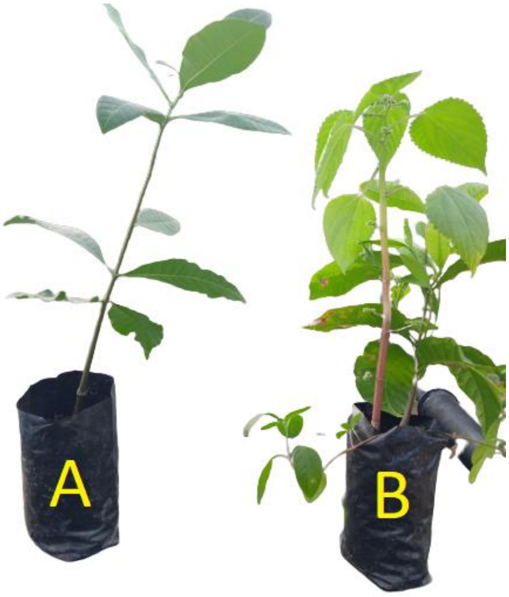

Plate 3. Healthy weed-free cashew seedling (A) and unweeded cashew seedling at 12 weeks after sowing (B)

At 12 WAS, seedlings were carefully uprooted and separated into shoot and root fractions for destructive sampling and biomass assessment. The results of the measured destructive parameters are presented in Table 4. The Weedy Check (WC) treatment recorded the lowest values across all measured parameters, including tap root length (TRL; 14.6 cm), fresh shoot weight (FSW; 6.14 g), dry shoot weight (DSW; 1.92 g), fresh root weight (FRW; 1.43 g) and dry root weight (DRW; 0.59 g). However, no significant differences were observed between WC and the other treatments for most parameters, with the exception of TRL, where the once-in-two-weeks weeding treatment (2W; 18.2 cm) recorded a significantly greater tap root length than WC (14.6 cm). No significant differences were observed among WF, 1W, 2W, 3W and 4W for any of the shoot or root destructive parameters assessed.

Of additional note, WC produced the most fibrous root system among all treatments, although the difference was not statistically significant. This observation may be attributed to the response of cashew seedlings to sustained nutrient competition imposed by the co-existing weed community. Increased fibrous root proliferation under competitive conditions is a recognized plant adaptation strategy, as competition for limited soil nutrients has been shown to stimulate lateral and fibrous root development as plants seek to expand their nutrient acquisition capacity (Brassard *et al*., 2009). Furthermore, prolonged physiological stress resulting from resource competition has also been implicated in altered root architecture and biomass partitioning (Franco *et a*l., 2011). Collectively, these findings confirm that extended periods of uncontrolled weed interference can significantly impair the root and shoot development of cashew seedlings, with implications for transplanting success and early field establishment (Hakim *et al*., 2013).

Table 4. Cashew seedling destructive sampling at 12 weeks after sowing

Treat	Destructive Sampling					
	RS	**TRL (cm)**	**FSW (g)**	**DSW (g)**	**FRW (g)**	**DRW (g)**
WF	1.7	17.2	6.24	2.58	1.54	0.75
WC	2.7	14.6	6.14	1.93	1.43	0.59
1W	1.7	14.9	7.55	2.65	1.71	0.76
2W	2.2	18.2	7.09	2.60	1.76	0.79
3W	2.0	15.8	7.63	2.84	1.61	0.78
4W	2.3	17.4	6.88	2.65	1.52	0.72
LSD	**ns**	**2.87**	**ns**	**ns**	**ns**	**ns**

Note: ns= Not significant; WF= Weed-free; WC= Weedy check; 1W= Once in a week weeding; 2W= Once in two weeks weeding; 3W= Once in three weeks weeding; 4W= Once in 4 weeks weeding; RS= Root score; TRL= Tap root length; FSW= Fresh shoot weight; DSW= Dry shoot weight; DRW= Dry root weight

Weed count is a quantitative measure of weed density within a defined sampling unit. In conventional field studies, weed enumeration is typically conducted using a quadrat; however, given the individual polybag format of this nursery experiment, weeds were manually counted per polybag at each sampling interval to obtain accurate weed density data.

The mean weed count recorded in the Weedy Check (WC) treatment across the observation period is presented in Fig. 2. Peak weed density was recorded at four weeks after sowing (4 WAS) with a mean of 13 weeds per polybag, followed by a progressive decline at 5 WAS (11), 6 WAS (9) and 7 WAS (8), before stabilizing at a mean count of 7 from 8 WAS through to 12 WAS. Two principal factors are attributed to this observed decline in weed density in the unweeded treatment. First, the mechanical force of irrigation water displaced young, tender weed seedlings during the early establishment phase. Second, canopy formation by the developing cashew seedlings progressively shaded the soil surface, suppressing weed emergence and survival at later growth stages. This observation is consistent with documented evidence that weed establishment and growth are significantly suppressed under developing crop canopies (Dass *et al*., 2017).

Mean weed counts for the periodically weeded treatments are presented in Figs. 3–6. In the once-weekly weeding treatment (1W; Fig. 3), weed density remained consistently low throughout the observation period, with a maximum mean of 2 weeds recorded at 2 WAS and a mean of 1 weed at 12 WAS. In the once-in-two-weeks weeding treatment (2W; Fig. 4), the highest mean weed count of 7 was recorded at 2 WAS, declining to 2 at both 4 and 6 WAS, 1 at 8 and 10 WAS and zero at 12 WAS. The once-in-three-weeks weeding treatment (3W; Fig. 5) recorded a peak mean weed count of 12 at 3 WAS, declining sharply to 2 at 6 and 9 WAS and 1 at 12 WAS. The once-in-four-weeks weeding treatment (4W; Fig. 6) recorded a peak mean of 9 weeds at 4 WAS, with no weeds recorded at 8 WAS and a mean of 1 at 12 WAS.

A consistent pattern was observed across all treatments (Figs. 2–6): peak weed density occurred between 2 and 4 WAS, followed by a marked and sustained decline in subsequent weeks regardless of weeding frequency. Notably, this decline was also recorded in the unweeded WC treatment following 4 WAS, indicating that factors beyond mechanical weeding including canopy suppression and intraspecific weed competition contributed to natural weed density reduction over time. These findings collectively indicate that the critical period of weed interference in cashew nursery polybags occurs between 2 and 4 WAS. Effective weed management within this window is therefore essential to minimize competitive pressure on cashew seedlings from emergence through to transplanting, which typically occurs at a maximum of 12 WAS.

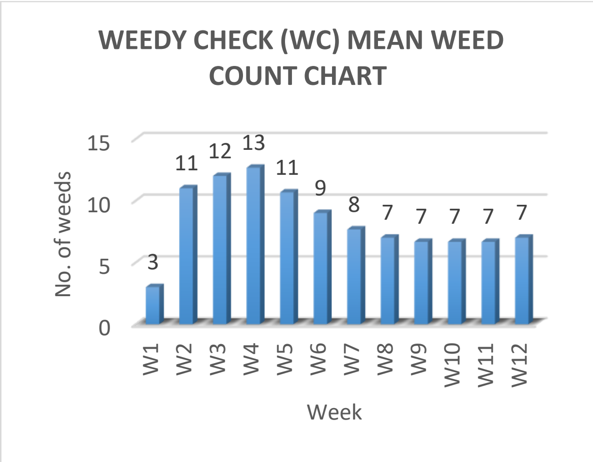

Fig. 2. Weedy check mean weed count
Note: W= week

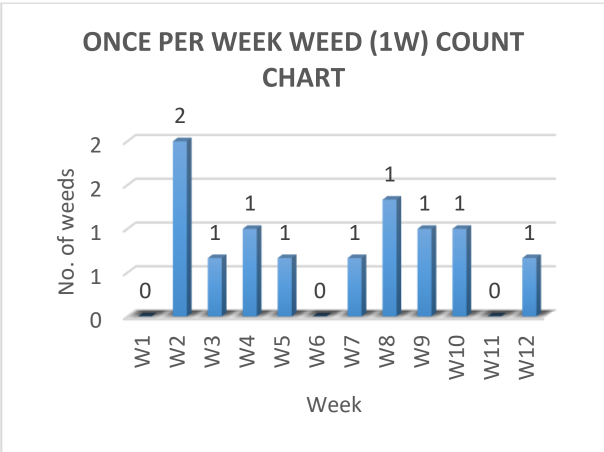

Fig. 3. Once per week mean weed count
Note: W= week

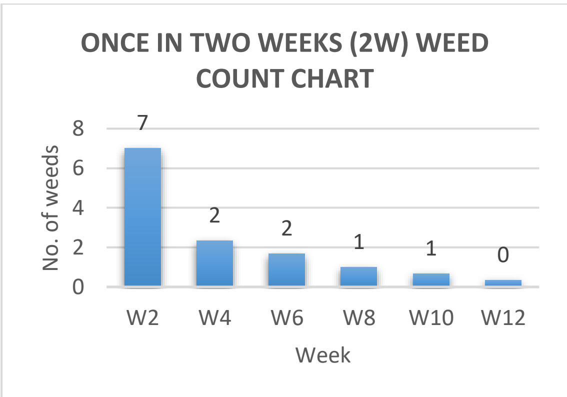

Fig. 4. Once in two weeks mean weed count
Note: W= week

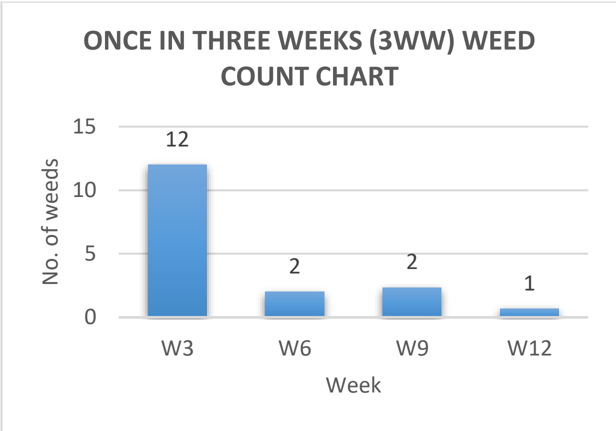

Fig. 5. Once in three weeks mean weed count
Note: W= week

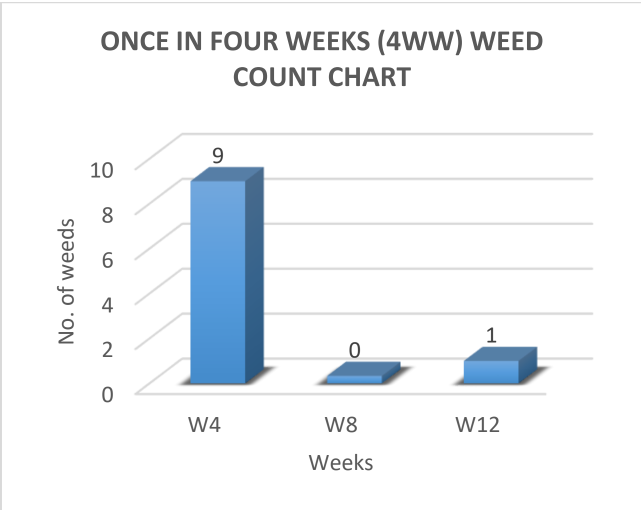

Fig. 6. Once in four weeks mean weed count
Note: W= week

The Initial Topsoil (IS) recorded the highest fungal CFU at both dilution levels (19.4 × 10^4 and 8.4 × 10^6), reflecting the undisturbed, organic-matter-rich state of the soil prior to nursery management. Saprotrophic fungi are most closely associated with higher soil nutrient levels due to their functional role in organic matter decomposition and nutrient cycling (Wu *et al*., 2019). Once soil was transferred into polybags and subjected to weeding, fungal populations declined across all treatments, consistent with the disruptive effect of management on established fungal communities.

Among weeding regimes, the Weed-free (WF) treatment recorded the lowest CFU at ×10^4 (6.8), as the absence of weeds eliminated organic inputs from root exudates and decomposing biomass that sustain soil fungi. Weeds tend to have positive interactions with soil microorganisms through their rhizospheric contributions (Massenssini *et al*., 2014). The Weedy Check (WC) correspondingly recorded higher counts (8.2 × 10^4; 5.2 × 10^6) than WF, confirming weed-driven microbial stimulation. Periodically weeded treatments (1W–4W) recorded intermediate values, suggesting moderate weeding frequency better preserved a functional soil fungal community. Soil physical disturbance from weeding significantly alters fungal community structure and reduces nutrient levels supporting fungal establishment (Wang *et al*., 2017). Confined nursery conditions with repeated soil disturbance discourage beneficial fungal communities, potentially selecting for opportunistic species (Marčiulynienė *et al*., 2021) that may compromise cashew seedling health.

Table 5. Colony forming unit of fungi in the treatments soil sample

Treatments	Cfu x10^4	Cfu x10^6
1W	10.2	4.4
2W	8.0	4.4
3W	10.0	4.2
4W	9.2	4.4
WF	6.8	6.6
WC	8.2	5.2
IS (Control)	19.4	8.4

Note: Cfu = colony forming unit; WF= Weed-free; WC= Weedy check; 1W= Once in a week weeding; 2W= Once in two weeks weeding; 3W= Once in three weeks weeding; 4W= Once in 4 weeks weeding; IS= Initial topsoil sample (Control)

From Table 6, it is evident that *Aspergillus niger* and *A. fumigatus* are present across all treatments, highlighting their resilience and adaptability to different weeding regimes as they have also been observed to influence good soil health when present in moderate form (Nayak *et al*., 2020). Other fungi such as *A. tamarii* and *A. nidulans* show varied presence depending on the treatment, indicating the influence of specific weeding practices on fungal diversity in the soil. *Aspergillus* spp. which belongs to the phylum *Ascomycota* is the most dominant microorganism in this study which is related to the findings of Xiao *et al*., (2022) who stated that fungi that belong to *Ascomycetes, Basidiomycetes* are predominant in soils under different weeding regimes.

Table 6. Occurrence of Fungi across Treatment

Fungi	Treatments					
	W1	W2	W3	W4	WF	WC	IS (Cont.)
A.niger	+	+	+	+	+	+	+
A.fumigatus	+	+	+	+	+	+	+
A.nidulans	+	-	-	-	+	-	+
A.flavus	+	-	-	-	-	-	-
A.tamarii	+	+	+	+	-	-	-
A.terreus	-	+	-	-	-	+	-
A.carbonarius	-	-	+	+	-	+	-
A.candidus	-	-	-	-	-	+	-
A.ochraceus	-	-	-	-	+	-	-
P. Oxalicum	+	+	-	-	-	-	-
F.oxysporium	+	+	-	-	-	-	-
T.viride	-	+	-	-	-	-	-
R.stolonifer	-	-	-	-	-	-	+

**+/- (presence/absence) WF= Weed-free; WC= Weedy check; 1W= Once in a week weeding; 2W= Once in two weeks weeding; 3W= Once in three weeks weeding; 4W= Once in 4 weeks weeding; IS= Initial topsoil sample (Control)*

4. Conclusion

This study examined the influence of varying manual weeding frequencies on the morphological development, seedling vigour, root characteristics and soil fungal community dynamics of cashew (*Anacardium occidentale* L.) seedlings raised in nursery polythene bags.

Weeding frequency exerted a selective influence on cashew seedling growth. Leaf area was positively influenced by weeding intervals of once in three weeks (3W) and once in four weeks (4W), while plant height, number of leaves and stem diameter were not significantly affected by any weeding treatment. For root development, tap root length responded positively only to once-in-two-weeks weeding (2W), while shoot and root biomass parameters were unaffected by weeding frequency. Seedling vigour assessment provided the most sensitive measure of cumulative weed interference. Unweeded seedlings recorded significantly lower vigour scores, compromising their market value and post-transplanting survival, while all weeded treatments produced seedlings of acceptable quality, affirming that any form of regular weeding is agronomically superior to leaving nursery seedlings unmanaged.

Weed density data consistently identified the critical period of weed interference as 2–4 weeks after sowing (WAS), beyond which weed regeneration declined substantially across all treatments. Weeding at four-weekly intervals is therefore encouraged throughout the 2–3 month nursery phase as a strategy to maintain seedling quality and also minimize weeding labour demands.

Different weeding frequencies significantly influenced the abundance and diversity of soil fungal communities. The undisturbed initial topsoil recorded the highest fungal colony forming units (CFU), while the Weedy Check (WC) recorded higher CFU than the Weed-free (WF) treatment, attributed to the additional organic substrate from decomposing weed biomass supporting saprophytic fungal activity. Periodically weeded treatments maintained intermediate fungal populations. *Aspergillus niger* and *A. fumigatus* were ubiquitous across all treatments, confirming their dominance as soil saprophytes, while potentially pathogenic taxa including *Fusarium oxysporum* and the biocontrol agent *Trichoderma viride* occurred variably with weeding frequency, confirming that weeding practices selectively shape soil fungal community composition in cashew nurseries.

A weeding frequency of once every four weeks is recommended as a practical and agronomically sound management strategy for cashew polythene bag nursery production.

Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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Competing Interests

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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