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# Evaluation of socio-economic characteristics and management attributes of ornamental seedlings' nursery operators in Lilongwe City, Malawi

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Small-scale ornamental nurseries play an increasingly important role in urban greening and landscaping in rapidly urbanising African cities, yet their socioeconomic characteristics and management practices remain poorly documented. Socioeconomic characteristics, nursery operations, and chemical properties of the growing media were surveyed in Lilongwe, Malawi to assess conditions associated with potential seedling quality outcomes, based on established literature. A cross-sectional survey was conducted across 60 nurseries: 54 privately owned and 6 institutional, using a pre-tested semi-structured questionnaire. Composite potting media samples were collected from each nursery and analysed for pH, organic carbon, organic matter, nitrogen, phosphorus, potassium, and magnesium using standard laboratory methods. Substantial differences were found in the operational characteristics of different types of nurseries. For example, institutional nurseries generally had older, more educated employees with more extensive horticultural experience; they had a more consistent source of clean water; and, as a result, they were more likely to implement best-practice techniques such as root pruning and hardening-off. Conversely, 81.5% of privately operated nurseries did not receive formal training; 63% of these nurseries experienced problems with their water supply; and it is apparent that many are not using root pruning and/or hardening-off. The single largest chemical finding from this study was a universal potassium deficiency in potting medium across all 60 nurseries, regardless of whether they were owned/operated as private or public institutions. This reflects a long-standing issue: the inability to provide adequate potassium levels in local soils due to the inherent potassium-poor nature of locally available soils, combined with Malawi's historical reliance on fertilizer formulations that contain little or no potassium. Additionally, private nurseries showed higher percentages of slightly alkaline pH values and lower percentages of organic carbon than institutional nurseries. These results demonstrate that two primary issues face growers of

ornamental seedlings in urban Malawi: inadequate management practices and/or poorly managed growing substrates, primarily in privately owned areas, which may have implications for seedling quality, according to established nursery science literature.

#### KEYWORDS

growth medium formulation, nursery management, seedling morpho-physiological quality attributes, standard seedling management attributes, urban landscape

## 1 Introduction

Socioeconomic and management attributes of nursery operators play a crucial role in determining the quality of seedlings. A good-quality seedling possesses well-balanced morphological and physiological characteristics, including a sturdy stem, an adequate height–diameter ratio, a well-developed and non-deformed root system, healthy foliage free from pests and diseases, and sufficient nutrient reserves, all of which enhance survival and establishment after transplanting (Takoutsing et al., 2014). In nursery science, seedling quality is commonly evaluated based on morphological, physiological, and health-related attributes that predict survival and post-transplant performance. These include stem diameter, height–diameter ratio, shoot-to-root balance, root system architecture, nutrient reserves, and freedom from pests and diseases (Gregorio et al., 2010; Takoutsing et al., 2014; Nyoka et al., 2018). In recent years, increased attention has been given to the role of nursery management practices, operator capacity, and growth media characteristics in shaping attributes associated with seedling quality, particularly in small-scale and urban nursery systems.

Growth media properties also play a central role in shaping seedling quality-related attributes. Appropriate pH, organic carbon content, and balanced nutrient availability support root growth, nutrient uptake, and photosynthetic efficiency, whereas sub-optimal media conditions can constrain seedling development and predispose seedlings to stress (Hussain et al., 2023; Yang et al., 2024). Collectively, these studies demonstrate that socio-economic characteristics, nursery management practices, and chemical properties of growth media are key determinants of seedling quality attributes. In studies where seedling traits are not directly measured, these factors are commonly interpreted as indicators with potential implications for seedling performance based on established nursery science literature.

A substantial body of research has examined small-scale nursery systems in sub-Saharan Africa, particularly in forestry and agroforestry contexts. Studies conducted in Cameroon, Malawi, and other African countries have evaluated seedling quality, nursery management practices, and operator capacity using descriptive surveys combined with assessments of seedling morphological attributes (Gregorio et al., 2010; Takoutsing et al., 2014; Nyoka et al., 2018). These studies have demonstrated that management practices, operator training, and resource availability strongly influence seedling quality and subsequent field performance. For example, Takoutsing et al. (2014) showed that seedling quality in small-scale nurseries in Cameroon was closely

associated with irrigation regimes, growth media composition, and operator training. Similarly, Nyoka et al. (2018) documented significant variation in morphological seedling quality across nurseries in Malawi.

Although these studies demonstrate that researchers have long been interested in small-scale nursery systems in sub-Saharan Africa, most have focused on tree seedlings for use in forestry and agroforestry systems. Therefore, very few studies have examined ornamental plant production in small-scale urban nurseries. However, small-scale ornamental nurseries now play an increasingly important role in urbanized regions of Africa by producing the plants used for landscape purposes, urban greening initiatives, and private garden plantings. Only recently have studies begun to examine this emerging sector of urban agriculture. For example, Mwavu et al. (2024) reported that roadside nurseries in Kampala are making significant contributions to urban biodiversity conservation and to the livelihoods of urban residents. Likewise, Mukubu Pika et al. (2024) examined the diversity and management characteristics of small-scale ornamental nurseries in Kinshasa. They concluded that they are critical components of urban horticulture and green infrastructure. Studies in West Africa have also demonstrated that ornamental nursery businesses can be a source of income for both urban and peri-urban households and that these businesses face challenges such as limited training, inadequate infrastructure, and limited access to markets (Adeduntan, 2015; Asiedu, 2025).

However, empirical evidence on the socioeconomic characteristics, management practices, and growth media conditions of small-scale ornamental nurseries in many African cities remains limited, particularly in Southern Africa. Previous research in Malawi has generally focused on evaluating the quality of tree seedlings in forest and agroforest nurseries (Nyoka et al., 2018), thereby leaving a gap in understanding how small-scale ornamental nurseries operate in urban contexts. Given the rapid pace of urbanization in cities like Lilongwe, it is necessary to understand the operational characteristics and management practices of small-scale ornamental nursery operators to meet the growing demand for ornamental plants. Understanding these characteristics will help improve nursery management practices, enhance urban horticulture systems, and ensure high-quality planting materials for urban landscaping and green infrastructure development.

Although it has been documented that socio-economic and management variables significantly affect the quality of seedlings grown in ornamental nurseries, little is known about how these attributes affect ornamental nurseries in Lilongwe City, Malawi. To

address this lack of knowledge, this research conducted a cross-sectional survey of 60 ornamental nurseries (54 private and 6 institutional) to determine their socio-economic attributes, grower management practices, and the chemical composition of growth media. The overall objective of this study was to characterize the socio-economic profile and management practices of growers operating ornamental nurseries in Lilongwe City, Malawi, and to assess how these practices could affect the quality of seedlings produced, drawing on the existing literature in the field. Specifically, the study sought to: (i) describe the socio-economic characteristics of institutional and private growers operating in ornamental nurseries; (ii) record management practices of relevance to ornamental seedling production; and (iii) assess the chemical compositions of growth media being utilized across all nurseries and explore how these could impact seedling quality. Given the limited empirical evidence available on urban ornamental nurseries in sub-Saharan Africa, especially in rapidly growing cities like Lilongwe, this study should be considered an initial exploratory assessment of ornamental nursery systems in an urban African setting.

## 2 Materials and methods

### 2.1 Study sites

Data were collected in nurseries located in both urban and peri-urban areas of Lilongwe District. The chemical analyses of the potting medium were conducted at the Lilongwe University of Agriculture and Natural Resources (LUANAR) Soil Science Laboratory. The study was conducted from November 2024 to January 2025.

### 2.2 Study design and sampling

The study employed a combination of cross-sectional and quantitative research approaches (Kilani and Kobziev, 2016; Wang and Cheng, 2020). The cross-sectional research approach was appropriate for the study because it was conducted at a single point in time. A quantitative approach aligned to describe and provide nursery's socio-economic and management insights by utilising numerical data obtained through close-ended questions in a questionnaire and laboratory potting medium chemical properties analyses. A mixed sampling approach combining purposive and probability-based techniques was employed. Lilongwe District was purposively selected because it is one of Malawi's major urban centers with high demand for ornamental plants and a relatively high concentration of nurseries.

The study did not use statistical power analysis to determine the sample size, as the design was intended as an exploratory, descriptive assessment rather than a hypothesis test. At the time of the study, there was no formal registry of ornamental nurseries in Lilongwe District. During the preliminary listing exercise conducted in consultation with city authorities, extension officers, and local nursery operators, approximately 72 operational private ornamental nurseries were identified in Lilongwe District at

the time of the study. Approximately 75% of the listed private nurseries ( $n = 54$ ) were randomly sampled from the population of private nurseries in the study area. Response consistency across sampled nurseries on key variables increased during the survey process, suggesting that additional surveys would be unlikely to yield new or different information beyond that observed for the descriptive variables of interest. The collected data appeared to have reached a point of "information saturation," supporting the adequacy of the final sample size for the research's exploratory objectives.

On the other hand, this listing identified a limited number of functional institutional nurseries. Due to their small number, all functional institutional nurseries ( $n = 6$ ) were purposively included in the study. This combined approach ensured the inclusion of all institutional nurseries while maintaining randomness among private nurseries.

According to Nyoka et al. (2018), institutional nurseries are owned and run by colleges, NGOs, and the government, whereas individuals operate private nurseries. The study had fewer institutional nurseries than private nurseries, with only six functional and capable of providing the required data.

### 2.3 Data collection

Prior to administering the main survey, the questionnaire underwent pre-testing with 5 nursery owners to evaluate whether all items were clear and relevant, and to gauge each respondent's comprehension. As a result of comments received during the pre-test, a few minor changes were made to each item to clarify wording, make it easily understandable to all respondents regardless of educational background, and ensure that the questions and sections had a logical flow. A pre-tested and adjusted semi-structured questionnaire was used to collect data through interviews with nursery operators. Composite potting medium samples were collected from each nursery using 8 x 11-inch zip-lock plastic bags for laboratory chemical analyses. Each nursery used a similar potting media for all plant species produced there; hence, the composite potting media was representative of all species in each nursery. About 1 Kg of potting media was collected from each nursery from a pool of prepared, ready-to-use potting mix, which was then processed to remove extraneous materials and air-dried to remove moisture. In total, 60 composite potting media samples were analysed, corresponding to one sample per nursery (6 institutional and 54 private). Laboratory analyses were conducted in quadruplicate to ensure analytical accuracy; however, results are presented as categorical classes relative to critical nutrient thresholds rather than as continuous measurements. Chemical property analyses were conducted according to standardized methods (Table 1) previously used by Kamanga et al. (2024). The critical values used for interpreting soil chemical properties were based on soil fertility guidelines commonly used for crop production in Malawi (Omuto and Vargas, 2018).

### 2.4 Data analysis

The analysis was done using the R statistical package, version 4.4.3. Descriptive statistics, including frequencies and percentages, were generated and presented in tables to illustrate patterns and

TABLE 1 Analytical methods used for determining the chemical properties of potting media samples collected from surveyed nurseries.

Chemical variable	Units of measurement	Method
pH (water)	pH	1:1 (soil-H <sub>2</sub> O)
Organic carbon and matter	%	Walkley and Black
Total N	%	Kjeldahl method
Available P	mg/kg	Mehlich 3 method, spectrophotometry
Exchangeable K, Ca, Mg	mg/kg	Mehlich 3 method, spectrophotometry
Cu, Zn	mg/kg	1 M NH <sub>4</sub> Cl, spectrophotometry

provide further insight into the sample characteristics. Because there were only a few ( $n=6$ ) institutional nurseries, no inferential statistical comparisons between institutional and private nurseries were made. Therefore, descriptive statistics were used to depict patterns in the socioeconomic characteristics and management practices of the surveyed nurseries. Trends across nursery types should therefore be viewed as illustrative rather than statistical.

### 3 Results

Because so few institutional nurseries were surveyed ( $n = 6$ ), the percentage values for this group should be interpreted cautiously. In many cases, a change from one or two nurseries will result in a large percentage change. As a result, we present comparisons between institutional and private nurseries as representative patterns rather than as statistically significant differences.

#### 3.1 Demographic profiles of the nursery operators

Demographics of nursery owners/managers, as per Table 2, are shown below. Male operators predominated across both nursery types, accounting for 66.7% in institutional and 88.9% in private nurseries. Institutional nurseries were generally managed by older individuals, with 66.7% operated by individuals aged 40 years or older, whereas private nurseries had a much younger demographic profile, with 40.7% managed by individuals aged 18–25. There were also notable disparities in terms of the education of the owners/managers of the two types of nurseries. All of the owners/managers of the institutional nurseries had completed their MSCE. On the other hand, there was a variety of educational backgrounds among the owners/managers of the private nurseries: 33.3% were primary school leavers, 14.8% held JCE, 14.8% held PSLCE, whereas only 3.7% held tertiary certificates. These age and educational profile differences between the two types of nursery owners/managers reflect the relatively formalized employment practices at institutional nurseries compared to the relatively informal routes of entry into private nursery operation.

#### 3.2 Nursery background attributes

Table 3 shows nursery background characteristics. All institutional nurseries had been operational for more than 10 years, while experience among private nurseries was more varied: 37% had operated for over 10 years, 29.6% for 6–10 years, and a further 29.6% for 2–5 years. Overall, 83.3% of all nurseries had been in operation for six or more years, indicating a generally experienced sector. A clear structural difference emerged in market orientation. All institutional nurseries served established clientele, including NGOs, private companies, or both, while all private nurseries relied entirely on random individual customers. This distinction in customer base is relevant to the accountability and quality feedback mechanisms to which each nursery type is subject.

#### 3.3 Operational challenges and effects

The most frequently cited operational challenges are provided in Table 4. More than three-quarters of respondents to this survey (83.4%), including nearly all (96.3%) private nurseries and almost half (50%) of institutional nurseries, indicated that they had a significant operational challenge; and that, as a result of these challenges, their ability to provide high-quality seedlings was impacted. Commonly reported challenges included seasonal drying of water sources, low seedling market prices, inadequate tools, seedling theft, and limited market access. An anomalous pattern is worth noting: while 96.3% of private nurseries acknowledged that operational challenges affect seedling quality, only 3.7% reported receiving customer complaints related to stunted seedling growth. This contrasts with institutional nurseries, where 66.7% reported stunted growth, yet only 50% acknowledged the quality-related implications of these challenges.

TABLE 2 Demographic profiles of the nursery operators ( $n = 60$  nurseries; 54 private and 6 institutional).

Variable	Institutional (%)	Private (%)	Mean (%)
<b>Gender</b>			
Female	33.3	11.1	22.2
Male	66.7	88.9	77.8
<b>Age</b>			
18 – 25	0	40.7	20.4
26 – 40	33.3	37	35.2
Above 40	66.7	22.2	44.5
<b>Education*</b>			
JCE	0	14.8	7.4
MSCE	100	33.3	66.7
Primary school leaver	0	33.3	16.7
PSLCE	0	14.8	7.4
Tertiary certificate	0	3.7	1.9

\*JCE, Junior Certificate of Examination; MSCE, Malawi School Certificate of Education; PSLCE, Primary School Leaving Certificate of Education.

TABLE 3 Nursery background characteristics (n = 60 nurseries; 54 private and 6 institutional).

Variable	Institutional (%)	Private (%)	Mean (%)
<b>Year in operation</b>			
1 year ago	0	3.7	1.9
2–5 years ago	0	29.6	14.8
6–10 years ago	0	29.6	14.8
Over 10 years ago	100	37	68.5
<b>Purpose</b>			
For sale and own use	100	0	50
For income generation	0	100	50
<b>Major Customers*</b>			
NGOs	33.3	0	16.7
Private Companies	33.3	0	16.7
NGOs & Private Companies	33.3	0	16.7
Random individuals	0	100	50

NGOs, Non-Governmental Organizations.

TABLE 4 Operational challenges (n = 60 nurseries; 54 private and 6 institutional).

Variable	Institutional (%)	Private (%)	Mean (%)
<b>Customer complaints</b>			
None	33.3	74.1	53.7
Stunted growth	66.7	3.7	35.2
High mortality rate	0	22.2	11.1
<b>Challenges</b>			
No	33.3	0	16.7
Yes	66.7	100	83.4
<b>Do challenges affect quality of seedlings</b>			
Yes	50.0	96.3	73.15
No	50.0	3.7	26.85

This apparent contradiction, whereby private nurseries self-report quality concerns yet receive few complaints, while institutional nurseries receive more complaints despite lower self-reported concern, is a notable finding that warrants further consideration.

### 3.4 Seedlings' growth media aspects

Table 5 shows the characteristics of growth media. Soil was the predominant potting medium in both nursery types, used by 66.7% of institutional and 77.8% of private nurseries, with the remainder combining soil with river sand. Institutional nurseries relied on soil mainly derived from forests for their soils, whereas private nurseries relied on multiple sources to provide soils to their plants; namely, self-produced compost (33.3%), forest soil (29.6%), dambo land (22.2%), farmland (11.1%), and soil from dump sites (3.7%). This diversity of sources among private nurseries introduces considerable variability in

baseline chemical properties, as reflected in the chemical analyses reported in Section 3.5. Manure application was near-universal (98.2%) and consistently rated as effective across both nursery types.

### 3.5 Chemical quality of the potting medium across nurseries

Chemical characteristics of substrates for plant growth in nurseries are shown in Table 6. The most significant chemical characteristic across all measured parameters was that potassium was present at very low concentrations (<2.0 ppm) in every one of the 60 tested nurseries, with no exceptions recorded in either institutional or private nurseries. This is unique to potassium, since the levels of other nutrients measured varied across different types of nurseries; this suggests a common source of the potassium deficiencies found in all the tested samples and does not appear to be due to management practices used by the operators of the individual nurseries.

In addition to potassium levels, there were clear differences in pH and organic carbon between the two types of nurseries. A large proportion of institutional nurseries have optimal pH (66.7%), whereas a smaller but still considerable proportion of the private nursery samples were in the slightly alkaline range (7.5–8.5). In contrast, a larger proportion of the private nursery samples contained very low levels of organic carbon (<2%) than the institutional samples, which all contained high levels of organic carbon (>2%). Nitrogen, phosphorus, and magnesium levels were generally satisfactory to extremely high across both institutional and private nurseries, suggesting that these nutrients are not limiting factors in the current system.

TABLE 5 Seedlings' growth media aspects (n = 60 nurseries; 54 private and 6 institutional).

Variable	Institutional (%)	Private (%)	Mean (%)
<b>Growth media type</b>			
Soil	66.7	77.8	72.3
Soil and River sand mixture	33.3	22.2	27.8
<b>Soil Source</b>			
Forest soils	66.7	29.6	48.2
Own produced compost	33.3	33.3	33.3
Dambo lands	0	22.2	11.1
Dumpsite	0	3.7	1.9
From farmlands	0	11.1	5.6
<b>Manure Use</b>			
Yes	100	96.3	98.2
No	0	3.7	1.9
<b>Manure Effectiveness</b>			
Not effective	0.0	0.0	0.0
Very effective	66.7	85.2	76
Extremely effective	33.3	14.8	24.1

TABLE 6 Nursery potting medium chemical properties (n = 60 nurseries; 54 private and 6 institutional).

Parameters	Critical values	Institutional (%)	Private (%)	Mean (%)
<b>pH</b>				
Slightly acidic	5.5–6.5	0.00	7.41	3.71
Ideal	6.5–7.5	66.67	25.93	46.30
Slightly alkaline	7.5–8.5	33.33	66.67	50.00
<b>Organic carbon (%)</b>				
Low	<2	0.00	66.67	33.34
High	>2	100.00	33.33	66.67
<b>Organic matter (%)</b>				
Low	<1.5	0.00	3.70	1.85
Medium	1.5–4.0	0.00	81.48	40.74
High	>4.0	100.00	14.81	57.41
<b>Nitrogen (%)</b>				
Low	0.08–0.10	0.0	0.0	0.0
High	0.20–0.30	0.00	74.07	37.04
Very high	>0.30	100.00	25.93	62.96
<b>Phosphorus (ppm)</b>				
Low	6–10	0.0	0.0	0.0
High	46–65	11.11	0.00	5.56
Medium	11–25	25.93	0.00	12.97
Moderately high	26–45	33.33	33.33	33.33
Very high	>65	29.63	66.67	48.15
<b>Potassium (ppm)</b>				
Very low	<2.0	100.00	100.00	100.00
<b>Magnesium (ppm)</b>				
Low	2.5–5.0	0.0	0.0	0.0
Very high	>25.0	100.00	100.00	100.00

Laboratory analyses were conducted in quadruplicate to ensure analytical accuracy; however, results are presented as categorical classes relative to critical nutrient thresholds rather than as continuous measurements.

### 3.6 Water source and irrigation frequency

Table 7 presents water management attributes across nurseries. All institutional nurseries had access to permanent water sources, utilising a diversified supply from boreholes, rivers, and wells in equal proportions. Private nurseries were heavily reliant on wells (88.9%), with only 37% reporting permanent water availability, 37% depending on temporary sources, and 25.9% on semi-permanent sources. The difference in water supply reliability affected how these nurseries irrigated their plants. Institutional nurseries are irrigated daily for each seedling. Of private nurseries, 51.9% irrigated based solely upon how the seedling plant's growth media looked; 37% of private nurseries irrigated each day; and the remaining private nurseries irrigated only during periods of time they could classify as semi-permanent or temporary water conditions. All institutional nurseries are irrigated daily on a schedule. In contrast, only 37% of private nurseries follow the same daily schedule, and 51.9% irrigate only after they see visual signs that the growth media needs watering.

TABLE 7 Water management attributes (n = 60 nurseries; 54 private and 6 institutional).

Variable	Institutional (%)	Private (%)	Mean (%)
<b>Water source</b>			
Borehole	33.3	0	16.7
River	33.3	11.1	22.2
Well	33.3	88.9	61.1
<b>Water source reliability</b>			
Permanent	100	37	68.5
Semi-permanent	0	25.9	13
Temporary	0	37	18.5
<b>Watering frequency</b>			
Daily	100	37	68.5
Weekly	0	11.1	5.6
When growth medium appears dry	0	51.9	26

### 3.7 Hardening off

The results of the hardening-off are shown in Table 8. It is very apparent from the results that there is a large disparity in how both types of nurseries use hardening-off; specifically, 66.7% of institutional nurseries use some form of hardening-off before they sell plants or transplant them into the garden, as opposed to only 29.6% of private nurseries that use any form of hardening-off on their seedlings. The remaining 70.4% of private nurseries do not use hardening-off on their seedlings. Among those that practiced hardening-off, the combined reduction in water and shading was the dominant method in private nurseries (87.5%). In contrast, in institutional nurseries it was evenly divided between this approach and reduced watering alone. However, institutional nurseries almost equally used either the combination of the methods above (reduced watering and reduced shading) or just reduced watering (50% each). Private nurseries tended to use longer hardening-off durations than institutional nurseries, with 62.5% applying hardening for three weeks compared with two weeks in institutional nurseries.

### 3.8 Pest and disease management

All 60 nurseries experienced pest and/or disease pressure (Table 9). Regardless of whether they were a public or private nursery, insect pests were the most common pest category, and fungi were the most common disease category. The use of chemical-based control measures was the primary method used by both public (100%) and private (88.9%) nurseries to manage the pest and disease pressures. All of the nurseries that responded to the survey rated their control methods as effective, very effective, or extremely effective.

### 3.9 Seedling pruning systems and management

The most notable difference between institutional and private nurseries was in their use of root pruning (Table 10). All

institutional nurseries used some form of root pruning, whereas a significant majority of private nurseries (74.1%) did not. There were, however, no differences in the use of shoot pruning between the two groups (66.7% in the institutional group vs. 77.8% in the private group), suggesting that shoot pruning is a more universally accepted method and is therefore more commonly used by both types of nurseries, regardless of educational background (Table 10). Where root pruning was practiced, the primary criterion was species-based, and it was conducted predominantly once per month, with the stated purpose of preventing seedlings from growing into the ground.

### 3.10 Seedling propagation facilities and access to nursery management training

The seedling propagation facility and training information are provided in Table 11. All institutional nurseries had formal propagation equipment (greenhouses, lath houses, and propagation tunnels); however, none of the private nurseries have access to these facilities. All private nurseries relied solely on natural tree shade for seedling protection. In contrast, institutional nurseries used all three forms of shade (commercial shade cloth, grass-thatched shelters, and natural shade) in almost equal amounts. 81.5% of private nursery managers have received training on seedling management, whereas 66.7% of institutional nursery managers have received training on seedlings. In addition to receiving peer training, institutional managers received it equally from Colleges and Peers, whereas private managers received it most frequently from peers (60%) and NGOs (40%). The low level of training received by private nursery managers has been a consistent theme when viewing the previous management practices discussed in this section.

TABLE 8 Seedlings hardening-off practices (n = 60 nurseries; 54 private and 6 institutional).

Variable	Institutional (%)	Private (%)	Mean (%)
<b>Hardening off</b>			
Yes	66.7	29.6	48.2
No	33.3	70.4	51.9
<b>Hardening method</b>			
Reduced watering	50.0	12.5	56.25
Reduced watering + shading	50.0	87.5	93.75
Reduced shading	0.0	0.0	0.0
<b>Hardening duration</b>			
1 week or less	0	37.5	18.75
2 weeks	100	0	50.0
3 weeks	0	62.5	31.25

TABLE 9 Pest and disease management (n = 60 nurseries; 54 private and 6 institutional).

Variable	Institutional (%)	Private (%)	Mean (%)
<b>Pest and disease prevalence</b>			
Yes	100	100	100
<b>Major pests</b>			
Insects	100	100	100
<b>Major diseases</b>			
Fungal	100	81.5	90.8
Bacterial	0	7.4	3.7
Viral	0	11.1	5.6
<b>Pest and control methods</b>			
Spraying chemicals	100	88.9	94.5
Cultural practices	0	11.1	5.6
<b>Control Effectiveness</b>			
Not effective	0.0	0.0	0.0
Very effective	33.3	66.7	50
Extremely effective	33.3	18.5	25.9
Effective	33.3	14.8	24.1

TABLE 10 Seedling pruning systems and management (n = 60 nurseries; 54 private and 6 institutional).

Variable	Institutional (%)	Private (%)	Mean (%)
<b>Root pruning</b>			
Yes	100	25.9	63
No	0	74.1	37
<b>Root pruning criteria</b>			
Based on species	100	57.1	78.55
Based on container size	0	14.3	7.15
Based on growing conditions	0	28.6	14.3
<b>Root pruning frequency</b>			
Once a month	100	85.7	92.85
Once a fortnight	0	14.3	7.15
<b>Root pruning purpose</b>			
To avoid seedlings growing into the ground	100	100	100
<b>Shoot pruning</b>			
Yes	66.7	77.8	72.3
No	33.3	22.2	27.8
<b>Shoot pruning criteria</b>			
Based on species	50	85.7	67.85
Based on growing conditions	50	14.3	32.15
<b>Shoot pruning frequency</b>			
Once a month	100	95.24	97.62
Once a week	0.0	4.76	2.38
<b>Shoot pruning purpose</b>			
Reduce excessive growth	50	90.5	70.25
Ease handling + uniformity	50	4.75	27.38
Ease handling	0	4.75	2.38

## 4 Discussion

This study provides an exploratory baseline characterization of the socio-economic attributes, management practices, and chemical properties of growth media in ornamental plant nurseries in Lilongwe City, Malawi, the first systematic survey of this sector in an urban sub-Saharan African context. Prior research in Malawi focused primarily on tree seedlings in both forestry and agroforestry nurseries (Nyoka et al., 2018). That earlier work found considerable variability in morphological seedling quality, attributed to variations in both the training of the person operating the nursery, the management of the operation, and the quality of the growing medium (substrate) used. This current research builds on that base, confirming that many of the structural limitations identified by Nyoka et al. (2018) still exist in Lilongwe's ornamental nursery sector, with some being more severe for private operators than for public ones. Management constraints, lack of training, and physical infrastructure issues were also observed in the ornamental nursery sectors in other African cities

TABLE 11 Propagation facility, seedlings shading, and training aspects (n = 60 nurseries; 54 private and 6 institutional).

Variable	Institutional (%)	Private (%)	Mean (%)
<b>Propagation facility</b>			
Yes	100	0	50
No	0	100	50
<b>Transplant shade</b>			
Yes	100	85.2	92.6
No	0	14.8	7.4
<b>Shade kind</b>			
Commercial shade cloth	33.3	0	16.65
Constructed shed with grass thatch	33.3	0	16.65
Natural	33.3	100	66.65
<b>Training</b>			
Yes	66.7	18.5	42.6
No	33.3	81.5	57.4
<b>Trainer</b>			
College	50.0	0.0	25.0
Peer	50.0	60.0	55
NGO	0	40.0	40.0

(Mwavu et al., 2024; Mukubu Pika et al., 2024; Adeduntan, 2015; Asiedu, 2025), suggesting that the trends described in this study reflect a larger geographic trend in Africa.

The distinctions in how institutional and private nursery operators operated were influenced by broader structural factors arising from Malawian socioeconomic conditions. Institutional nurseries operate in formally defined employment environments with greater structure for recruiting and training employees. Therefore, it is logical that all institutional nursery operators hold an MSCE and that 66.7% of them have been formally trained. Conversely, the majority of private nursery operators functioned primarily as an informal means of generating income. It was reasonable to conclude that the high percentage of private nursery operators under 25 (40.7%) reflected limited formal employment opportunities in urban Malawi rather than a preconceived plan to develop a career path.

Additionally, the demographics and training profiles of private nursery operators explained the management gaps observed among them, including lower use of root pruning, hardening off, and irrigated systems in private nurseries compared to institutional nurseries. Furthermore, the majority of the private nurseries relied solely on individual customers, thus eliminating potential quality feedback loops that could have promoted future improvement through institutional clients. The absence of formal training among 81.5% of private operators, therefore, appears to be a major factor associated with the management gaps observed throughout this study, a finding consistent with Takoutsing et al. (2014) and Nyoka et al. (2018), who identified operator training as

an important determinant of management quality and seedling performance in small-scale African nursery systems.

An analytically important finding of this study is the apparent contradiction between private nurseries' self-reported awareness of quality problems and the near-absence of customer complaints reported by private nurseries. While 96.3% of private nurseries acknowledged that operational challenges affect seedling quality, only 3.7% reported stunted growth, compared with 66.7% in institutional nurseries. This difference is likely due to the limitations of private nurseries' customer base (individual buyers in an informal market). Buyers who purchase informally do not have the same level of horticultural expertise to recognize quality issues, such as inadequate root structure or physiological stress symptoms. As a result, these buyers may find seedlings that appear acceptable for purchase despite underlying quality deficiencies. In this case, the fact that no buyers have complained about the seedlings should not be taken as evidence that they are of sufficient quality. Instead, it is an aspect of informal markets that lacks reference standards by which to measure quality.

Among all chemical parameters assessed, the finding that potassium levels were very low (<2.0 ppm) across all 60 surveyed nurseries, with no exceptions in either nursery type, represents one of the most important results of this study. Unlike other nutrients, which varied between nursery types and reflected management differences, the potassium deficiency appears systemic, implicating the substrate sources themselves rather than operator-specific practices.

The predominant sources of potting media reported in this study, including forest soils, composts, and dambo soils, are known to have low potassium-supplying capacity, as tropical soils in Southern Africa often exhibit potassium depletion due to long-term leaching losses (Omuto and Vargas, 2018). This finding is likely due to an older national agricultural heritage. Historically, fertilizer recommendations in Malawi often lacked potassium in major formulations (e.g., 23:21:0), contributing to long-term potassium depletion in soils (Malawi Government, 2021; Kohler, 2020). The organic amendments applied by 98.2% of nurseries in this study are unlikely to replenish potassium adequately unless derived from potassium-rich plant materials. Since all surveyed nurseries showed potassium-deficient substrates regardless of management practices, addressing this constraint requires deliberate potassium amendment of potting media and the development of standardised growth media formulations with balanced nutrient composition.

While most of the institutional samples were at the optimal pH level for their type of sample, a total of 66.7% of the samples from private nurseries were somewhat alkaline (pH levels 7.5-8.5), which can limit nutrient availability, impact the ability to grow roots, and affect chlorophyll production (Yang et al., 2024). Additionally, while all institutional samples had greater than 2% organic carbon, 66.7% of the private samples contained less than 2%, which can reduce the substrate's ability to retain water and release nutrients (Hussain et al., 2023). Furthermore, the majority of samples from both types of nurseries were grown using soil-based potting media (i.e., they were "soil-only" samples), and although many studies have shown that mixed-substrate potting media can result in better plant performance than potting media made of a single component (e.g. Xu et al., 2024), this limitation also exists as a result of the use of soil-only samples.

While these results are consistent with those of Nyoka et al. (2018), who reported that variations in seedling quality among Malawian nurseries were largely due to differences in substrate quality, the water management practices of each nursery also represent an additional constraint. While institutional nurseries had reliable access to water and were irrigated daily, the majority of private nurseries relied on wells and, as a result, did not always have reliable access to water; irrigation at these nurseries was typically based on visual signs of dryness in the potting media. Inconsistent water supply has been shown to suppress root biomass, reduce shoot extension, and impair nutrient uptake (Xue et al., 2016), with consequences compounded by the low adoption of hardening-off (29.6%) and root pruning (25.9%) among private nurseries, both practices that are widely recommended to reduce transplant shock and improve root system development (Shu-aib Jakpa and Hardi, 2021; Korbik et al., 2025).

Overall, the findings of this research indicate that there is a structural constraint to ornamental nursery operations in Lilongwe, in addition to a purely technical constraint. The manner in which nursery managers employ specific management techniques (such as irrigation scheduling, root-pruning, hardening-off, and substrate selection) is determined by the broader socio-economic context, which includes the availability of training, finances, infrastructure, and market characteristics. Institutional nurseries have an advantage over private nurseries due to their stability and access to training, whereas most private nurseries operate within informal market systems and lack formalized technical assistance. These structural issues help account for the ongoing management deficiencies experienced by private nursery operators and thus demonstrate the necessity of coordinated approaches that combine technical training with broader institutional support mechanisms.

## 5 Study limitations

Several limitations must be acknowledged when interpreting the findings of this study. Most fundamentally, morphological and physiological seedling quality attributes were not directly measured in this study. Consequently, interpretations regarding seedling quality should be understood as inferred implications based on established nursery science literature rather than empirically demonstrated causal relationships within the present dataset. The central causal chain, that the identified management and substrate deficiencies translate into lower-quality seedlings, therefore remains empirically unconfirmed and represents an important direction for future research. Beyond this, response bias cannot be ruled out, as nursery operators may have reported practices they know are recommended. The survey was conducted during the period when rainfall occurs in Malawi (November 2024 through January 2025). That is the time of year when the most water is available in Malawi, so irrigation challenges are likely greater during the dry seasons. There may be a sampling bias due to survivorship, as the survey's sampling frame was based on local authorities and extension services, thereby excluding informal nurseries operating outside formal networks. Therefore, the management deficits reported in this study are from relatively established nursery operations, not from the most limited segments of the nursery industry.

## 6 Recommendations and implications

Based on the socio-economic characteristics, nursery management practices, and growth media properties observed in this study, targeted policy and capacity-building interventions are recommended to strengthen nursery management practices relevant to high-quality ornamental seedling production in Lilongwe City. Priority should be given to private nursery operators through structured training programs coordinated by city, municipal, and town councils in collaboration with agricultural extension services and non-governmental organizations, focusing on water management, hardening-off, root pruning, pest and disease monitoring, and growth media formulation. Policy measures that facilitate access to reliable water sources for urban nurseries, such as integrating them into municipal water planning and supporting small-scale water infrastructure, would enable more consistent irrigation practices.

In addition, the development, formal adoption, and dissemination of standardized guidelines for ornamental nursery growth media covering nutrient balance, pH ranges, and organic carbon content could be institutionalized through local regulatory frameworks and extension advisory services to address recurrent constraints such as low potassium levels and sub-optimal media conditions. Strengthening extension support and regulatory engagement, including nursery registration, periodic technical inspections, and voluntary accreditation or certification schemes, would further incentivize compliance with recommended practices. Collectively, the implementation of these policy-oriented measures has important implications for urban landscaping and public green space development by improving seedling establishment, reducing post-transplant losses, and supporting more sustainable and resilient urban horticulture systems in rapidly urbanizing cities such as Lilongwe.

## 7 Conclusion

This study assessed the socio-economic characteristics, nursery management practices, and chemical properties of potting media used by institutional and private ornamental plant nurseries in Lilongwe City, Malawi, and discussed their potential implications for seedling quality. Firstly, the results showed apparent differences in the socio-economic profiles of nursery operators, with institutional nurseries generally having more experienced and better-trained personnel than private nurseries. Regarding nursery management practices, most nurseries practiced shoot pruning; however, substantial gaps were observed among private nurseries, such as limited access to training, unreliable water sources, irregular irrigation practices, and low adoption of hardening-off and root-pruning practices. These management attributes are widely reported in the literature as essential factors influencing seedling performance after transplanting.

Furthermore, chemical analyses revealed that potting media used by most nurseries had high levels of nitrogen, phosphorus, and magnesium, but consistently low levels of potassium. In addition, a considerable proportion of private nurseries used growth media with slightly alkaline pH and low organic carbon content, conditions that may limit nutrient availability and uptake.

Although pest and disease prevalence were commonly reported across nurseries, this study did not quantify severity or incidence levels. Therefore, conclusions regarding pest and disease impacts are limited to reported presence and management approaches rather than measured effects on seedlings.

In conclusion, these findings identify critical management and substrate-related constraints, particularly among private nurseries, that may affect seedling quality. Addressing these gaps through targeted training, improved water access, and standardized formulation of growth media could strengthen nursery management practices and support high-quality ornamental seedling production in urban Malawi.

## Data availability statement

The original contributions presented in the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author.

## Ethics statement

The studies involving humans were approved by Research Ethics Committee (REC), Lilongwe University of Agriculture and Natural Resources (LUANAR). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

## Author contributions

JS: Data curation, Formal Analysis, Investigation, Software, Visualization, Writing – original draft. SK: Supervision, Writing – review & editing. VM: Funding acquisition, Resources, Supervision, Validation, Writing – review & editing. RK: Conceptualization, Funding acquisition, Methodology, Resources, Software, Supervision, Validation, Writing – review & editing.

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## Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Generative AI statement

The author(s) declared that generative AI was used in the creation of this manuscript. We acknowledge the use of generative AI tools, specifically Grammarly and ChatGPT 2.0, in enhancing the clarity of this manuscript.

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