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Research Article

Effects of Different Soilless Growing Media on the Growth and Development of Tobacco Seedlings

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To prevent reliance on a single finite source of the medium in raising tobacco nurseries, there arose a need to evaluate alternative media based on materials already available on farms. An experiment was set to evaluate the effects of different soilless growing media on the growth and biomass of flue-cured leaf tobacco seedlings. The design used was a randomized complete block design with three replications. The treatments were 100% pine bark (control), 50% cattle manure + 50% sand, 100% coal rubble, 100% compost manure, 50% pine bark + 50% sand, 100% cattle manure, 75% coal rubble + 25% sand, 75% cattle manure + 25% sand, 50% compost manure + 50% sand, and 75% compost manure + 25% sand. The results showed that increased seed emergence and survival percent were observed in the following media; 50% pine bark + 50% sand, 75% coal rubble + 25% sand, 75% compost manure + 25% sand, 100% coal rubble, 100% compost manure, and 50% compost manure + 50% sand, these treatments were not statistically different from 100% pine bark (control). The stem length and diameter of tobacco seedlings were superior in the medium with 100% compost manure when compared to all other treatments including pine bark. Increased transplantable percent of tobacco seedlings were in 50% pine bark + 50% sand and 100% compost manure, significantly higher than 100% pine bark (control). Most treatments that used cattle manure had significantly lower seed emergence percent, survival percentage, and transplantable percent of tobacco seedlings. Therefore, tobacco growers are recommended to use the growing medium with compost manure and should avoid using cattle manure when raising tobacco seedlings in seed beds.

1. Background and Introduction

In Zimbabwe, the cultivation of tobacco in the fields begins with the transplanting of tobacco seedlings from tobacco nurseries. Therefore, seedling production and nursery management are important because they influences final crop establishment in the field. Results from research studies elsewhere showed that a growing medium contributes significantly to the production of an ideal transplant and is also a major factor that influences seed germination, seedling emergence, seedling growth and the quality of a seedling [1–6]. For most of the past decades, most tobacco farmers were producing tobacco seedlings through the use of the conventional system which involves the use of soil as the growing medium. Soil used for producing tobacco seedlings required the use of methyl bromide as a fumigant to control soilborne diseases and insect pests, which includes root-knot nematodes. However, in 2015, the use of methyl bromide was globally phased out following its negative impact on the ozone layer, hence, contributing to global warming.

In an effort to effectively do away with methyl bromide, the Tobacco Research Board (TRB) introduced a new system of raising tobacco seedlings without the use of soil or fumigation called float tray technology as a way to avoid the use of fumigants like methyl bromide [7]. The hydroponic system of raising tobacco seedlings is an excellent and proven way of propagating seedlings. The seedlings produced are morphologically and biologically uniform, well-hardened, drought tolerant, with an additional flexibility in planting. The root system is vigorous and it enables the seedlings to take off faster and withstand extended periods without water in the field. Researchers have reported better seedling growth and quality in soilless cultures [8]. In addition, soilless cultures are therefore considered more advantageous materials for growing seedlings than soil cultivation [7]. Different types of soilless growing mediums are known and used by farmers utilizing the float tray technology in Zimbabwe, and this includes sphagnum moss, peat moss, pine bark, reed and sedge, humus or muck, perlite, vermiculite, calcined clays. Pine bark is perhaps the most desirable and predominant growing medium which is widely used in tobacco seedling production due to its reasonable cost when compared to other soilless growing mediums and also possesses suitable chemical and physical properties for propagating and growing plants [9].

However, there is a potential threat arising from the existence of increasing and ongoing damage to pine plantations, mainly by deforestation prior to processing of pine trees into red timber, veld fires, and bark stripping by wild animals. Furthermore, there is a high demand for pine bark media, therefore, its production for future use might not be achieved but would only lead to uncertainty of unavoidable inconsistence, skewed availability, and unsustainable production of tobacco seedlings. In addition, some small-scale tobacco growers in Zimbabwe are suffering from a scarcity of pine bark coupled with high unaffordable costs. This has been the most challenge to growers interested in adopting the float tray system and has resulted in only 30% of the small-scale holder farmers using the system [10].

Therefore, research of other alternative soilless growing mediums for use in float systems in tobacco seedling production is imminent [2]. Locally made materials such as crushed coal rubbles, organic composted materials and livestock manure could be used as alternative growing media in float tray system when raising tobacco seedlings. Coal rubble can be collected at the farm from tobacco barns after coal is burnt prior to tobacco leaf curing. The rubbles are then crushed and sieved to acceptable particle sizes (4–6 mm) for use as a medium. Furthermore, organic compost is a more sustainable and environmentally sound alternative growing media that can be derived from yard debris waste, plants or animal waste and is utilized in nursery production in hydroponics. Livestock manure, particularly manure from cattle, can be easily available at the farm and can be collected from the cattle kraal and used as a growth medium. In addition, sand components can be extracted from a nearby river and can be added to the growing medium to improve its aeration and drainage features.

Development of a new growing medium which is cost-effective, sustainable and that result in healthy tobacco seedlings has the potential to increase yield and profit for tobacco farmers [11]. Most tobacco farmers in Zimbabwe are failing to reach the potential yield and quality of tobacco for the nation and the globe [11]. One of the reasons to low productivity and substandard quality of tobacco is due to poor seedlings from the nurseries. Poor tobacco seedlings are usually susceptible to insect pests, nematodes, and diseases [12]. In addition, poor tobacco seedlings fail to utilise nutrients in the soil efficiently resulting in low yields and substandard grade [13]. Therefore, the study entails to evaluate the effect of different soilless growing media on the growth and biomass of flue-cured leaf tobacco seedlings.

2. Materials and Methods

2.1. Experimental Design and Treatments. The experiment was laid out in a randomized complete block design (RCBD) with three replicates. The treatments used in the experiment were growing media components in percentages by volume viz 100% pine bark (control), 50% cattle manure + 50% sand, 100% coal rubble, 100% compost manure, 50% pine bark + 50% sand, 100% cattle manure, 75% coal rubble + 25% sand, 75% cattle manure + 25% sand, 50% compost manure + 50% sand, and 75% compost manure + 25% sand.

2.2. Construction of Float Tray Beds for Raising Tobacco Seedlings and Preparation of the Growing Media. The study was carried out commencing with ground levelling and the construction of three floating beds measuring 11.5 m length wise and 0.97 m in width. The two brick-coarse determined the height of beds walls. Three beds were constructed; each bed was subdivided into ten plots by a 2-brick coarse wall high, and the entire beds were lined with a 250 μ black plastic sheeting longer than the inside dimensions of the beds to allow for the plastic to be laid over the top of the walls to hold the plastic in place. The plots were treated with termite poison before laying the plastic to prevent the chances of seedling damage by termite infestations. The ponds were then filled with water to a recommended depth of about 12 cm to 15 cm throughout to effectively flatten the plastic against the walls of the beds.

The pine bark used in the experiment was obtained from Tobacco Research Board (Kutsaga research station) as TRB Gromix Plus. Coal rubbles used in the experiment were collected from tobacco barns after coal was burnt as a source of heat energy during the tobacco leaf curing process. The coal rubbles were thoroughly washed with clean water to remove excess ash, and then, sun dried for crushing using a builder's rammer. The crushed coal rubbles were sieved with a 4–6 mm sieve with some extensive shaking. Cattle manure used in the experiment was collected from the cattle kraal in the Beatrice area and left for 60 days to decompose. Cattle manure was sieved through a 4–6 mm sieve after some extensive shaking. Compost manure used in the experiment was collected from the composting site in the farm yard after the debris and tree twigs were composted for a period of twelve months. River sand used in the experiment was collected from a nearby river and was sieved to a 6 mm particle size and also to get rid of stones and twigs.

2.3. Experimental Procedure. The growing medium was then thoroughly mixed with water on a flat working surface before being packed in float trays. The trays with media were lifted to a height of about 20 cm above the flat surface and gently dropped twice to slightly compact the media in the trays so as to avoid the media to be wicked by water when floated in the ponds. Refilling of trays with soilless media was done after each and every drop, and the trays were floated in the ponds for at least two to three days to allow capillary action to take place. The trays were dibbled using a dibble board at the centre of each cell. Pelleted tobacco seeds (cultivar-T76) were sown using a seeder. The sowing process was done to ensure that each float tray cell has a single seed, giving 242 seeds per tray. A $200\,\mu$ transparent plastic was used to cover each bed at a height of 20 cm from the surface to control temperatures, avoid heat from direct sunlight and also protect the beds from contamination.

Split application of Kutsaga Float Fert (20 : 10 : 20) as basal fertilizer was done with three rates of 25, 50, and 75 $mg{\cdot}L^{-1}$ at 7, 21 and 35 days after sowing (DAS) respectively. Ammonium nitrate (34.5% N) was applied to pond water as top dressing at the rate of 100 $mg{\cdot}L^{-1}$ of water at 42 days after sowing. Tobacco seedling leaves were clipped at their tips to ensure seedling uniformity. The beds were covered during the night to avoid seedling exposure to very low night temperatures and were uncovered during the day when the temperatures were between 25°C and 32°C. Bulb thermometers were used to monitor temperature changes in the seedbed.

2.4. Data Collection and Data Analysis. From 14 to 28 DAS, the emergence percent of tobacco seeds were determined by dividing the number of seedlings emerged per plot by the number of seedlings emerged per plot multiplied by 100. Seedling survival counts were done at the termination of the experiment, thus 92 DAS. The survival percentage of tobacco seedlings was determined by dividing the total plants survived per plot and total plants emerged per plot multiply by 100. The number of transplantable plants was established by counting tobacco seedlings that had desirable transplantable characteristics at termination of the experiment and dividing it by the total plants that survived and multiplying it by 100. Stem height and thickness were measured at the termination of the experiment (92 DAS). Using a ruler, stem height (cm) was measured as the distance between the root crown and the apical meristem. The stem thickness (cm) was measured using a veneer calliper at a position just above the root crown. To determine the dry matter of the roots and shoots, tobacco seedlings were cut just above the root crown to separate the roots and the shoots. The roots and shoots were oven dried at 70°C for 72 hours. After drying, the roots and the shoots' dry mass were measured using a digital scale. Root: shoot dry weight ratio was determined by dividing the dry matter of roots and shoots. The data were subjected to analysis of variance (ANOVA) using Genstat 18th edition. Separation of means was done using the least significant difference (LSD) tests at the 5% level of significance. Pearson correlation and regression analyses on measured variables were done using Microsoft Excel 2010.

Table 1: The effect of soilless growing media on seed emergence percentage (%) of tobacco.

Treatments	14 DAS	21 DAS	28 DAS
100% pine bark (control)	65.43^{bc}	92.70^{cd}	93.13^{c}
50% cattle manure + 50% sand	43.93^{a}	73.70^{a}	74.67^{a}
100% coal rubbles	80.77^{cd}	87.10^{bcd}	88.27^{bc}
100% compost manure	67.50^{bc}	89.57^{bcd}	92.13^{bc}
50% pine bark + 50% sand	70.40^{bcd}	92.27^{cd}	93.67^{c}
100% cattle manure	59.97^{ab}	84.03^{bc}	84.73^{b}
75% coal rubbles + 25% sand	88.70^{d}	93.70^{d}	94.33^{c}
75% cattle manure + 25% sand	39.93^{a}	73.70^{a}	74.80^{a}
50% compost manure + 50% sand	65.97^{bc}	83.33^{b}	87.30^{bc}
75% compost manure + 25% sand	74.83^{bcd}	92.17^{cd}	93.00^{c}
p value	<0.003	<0.001	<0.001
CV%	18.5	5.9	5.4
LSD	20.82	8.8	8.087

Least significant difference (LSD) tests at the 5% level of significance. See 2.4 data collection and data analysis.

Table 2: The effect of soilless growing media on survival and transplantable (%) of tobacco seedlings.

Treatments	Survival%	Transplantable%
100% pine bark	56.3^{c}	86.33^{e}
50% cattle manure + 50% sand	34.7^{b}	0^{a}
100% coal rubbles	79.0^{de}	48.5^{c}
100% compost manure	94.6^{f}	91.4^{ef}
50% pine bark + 50% sand	81.6^{e}	93.7^{f}
100% cattle manure	8.1^{a}	0^{a}
75% coal rubbles + 25% sand	72.4^{d}	41.3^{b}
75% cattle manure + 25% sand	11.8^{a}	0^{a}
50% compost manure + 50% sand	82.2^{e}	80.2^{d}
75% compost manure + 25% sand	91.6^{f}	86.8^{e}
p value	<0.001	<0.001
CV%	6.8	5.6
LSD	7.191	5.106

Least significant difference (LSD) tests at the 5% level of significance. See 2.4 data collection and data analysis.

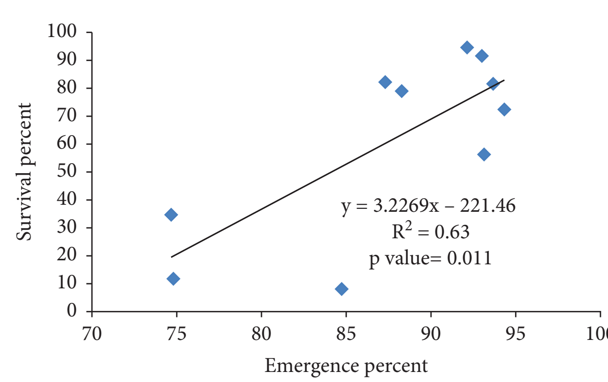

Figure 1: The relationship between survival percent and emergence percent of tobacco seedlings.

2.5. Results

2.5.1. The Effect of Soilless Growing Media on Seed Emergence, Survival Percent, and Transplantable Percent of Tobacco Seedlings. There were significant differences ($p < 0.05$) in soilless growth media on the seed emergence of tobacco. Generally, the emergence percent of seedlings increased from 14 DAS to 28 DAS (Table 1). At 28 DAS, 75% coal rubble + 25% sand, 50% pine bark + 50% sand, 75% compost manure + 25% sand, 100% compost manure, 100% coal

Table 3: The effect of soilless growing media on stem height and thickness of tobacco seedlings.

Treatments	Stem height (cm)	Stem thickness (cm)
100% pine bark	13.3d[e]	0.39[bc]
50% cattle manure + 50% sand	6.2[b]	0.46[cd]
100% coal rubbles	8.87[c]	0.32[a]
100% compost manure	17.07[g]	0.41[cd]
50% pine bark + 50% sand	12.83[d]	0.33[ab]
100% cattle manure	4.2[a]	0.64[e]
75% coal rubbles + 25% sand	8.33[c]	0.29[a]
75% cattle manure + 25% sand	4.63[a]	0.48[d]
50% compost manure + 50% sand	14.43[ef]	0.42[cd]
75% compost manure + 25% sand	15.5[f]	0.42[cd]
p value	<0.001	<0.001
CV%	6.3	10.1
LSD	1.137	0.073

Least significant difference (LSD) tests at the 5% level of significance. See 2.4 data collection and data analysis.

rubbles, 50% compost manure + 50% sand, and 100% pine bark (control) had the highest emergence percent of tobacco seedlings. The media with 50% cattle manure + 50% sand, which did not statistically differ from 75% cattle manure + 25% sand, had the lowest emergence percent of tobacco seedlings.

Significant differences ($p < 0.05$) in soilless growth media on survival percent of tobacco seedlings were identified (Table 2). The medium with 100% compost manure and 75% compost manure mixed with 25% sand had the highest seedling survival percent; both treatments were superior to 100% pine bark (control). The treatments, 100% cattle manure and 75% cattle manure + 25% sand, had the lowest survival percent of seedlings, both treatments were inferior to 100% pine bark (control). A positive correlation between emergence percent and survival percent existed and the regression between the two variables was significant (Figure 1)

Similarly, there were significant differences ($p < 0.05$) in soilless growth media on the transplantable percent of tobacco seedlings (Table 2). The media with 50% pine bark + 50% sand and 100% compost manure had the highest transplantable percent of tobacco seedlings; both treatments were superior to 100% pine bark (control). The medium with 50% cattle manure + 50%, 100% cattle manure and 75% cattle manure + 25% sand and had the lowest transplantable percent of tobacco seedlings when compared to 100% pine bark (control) (Table 2).

2.5.2. The Effect of Soilless Growing Media on Stem Height and Thickness of Tobacco. There were significant differences ($p < 0.05$) in soilless growth media on stem height and thickness of tobacco seedlings (Table 3). The medium with 100% compost manure had the highest stem length of tobacco seedlings when compared to 100% pine bark (control). The media with 100% cattle manure and 75% cattle manure + 25% had the shortest stem length of tobacco seedlings, both treatments were inferior to 100% pine bark (control).

The medium with 100% cattle manure had the highest stem thickness of tobacco seedlings when compared to 100% pine bark (control). The stem thickness of seedlings in 50% cattle manure + 50% sand were comparable to 50% compost manure + 50% sand, 75% compost manure + 25% sand, 100% compost manure, and 100% pine bark (control) with an average stem thickness (Table 3). The media with 75% coal rubble + 25% sand and 100% coal rubble had the lowest stem thickness, both treatments were inferior to 100% pine bark (control).

2.5.3. The Effect of Soilless Media on Roots, Shoots, Total Dry Mass and Root: Shoot Ratio of Tobacco Seedlings. Significant differences ($p < 0.05$) in soilless growth media on roots, shoots, and total dry mass of tobacco seedlings were identified (Table 4). The medium with 100% compost manure had the highest roots, shoots and total dry mass than 100% pine bark (control). The medium with 100% coal rubble had the lowest roots, shoots and total dry mass, and this treatment was not statistically different from 75% coal rubbles + 25% sand except on shoot dry mass. Similarly, there was a significant difference ($p < 0.05$) in soilless growth media on the root: shoot ratio of tobacco seedlings (Table 4). The highest root: shoot seedling dry weight ratio of tobacco was revealed in the medium with 100% coal rubble, and 75% coal rubble + 25% sand. The media with 100% pine bark, 50% pine bark + 50% sand and 75% compost manure + 25% sand had the lowest root-to-shoot ratio of seedling dry weight of tobacco.

2.5.4. Correlation and Regression Analyses of Measured Variables. Table 5 shows correlation and regression analyses between the measured variables, indicating the direct effects of different soilless media on tobacco seedlings. Correlation and regression analyses showed that transplantable percent and stem height; stem thickness and root dry mass; stem thickness and total dry mass; root dry mass and total dry mass; root dry mass and root: shoot ratio were significantly correlated. Similarly, shoot dry mass and total dry mass; total dry mass and root: shoot ratio, were positively correlated ($p < 0.05$). In contrast, the relationship between transplantable percent and shoot thickness; transplantable percent and root dry mass; transplantable percent and total dry mass or root: shoot was not significantly correlated.

Table 4: The effect of soilless growing media on roots, shoots, and overall dry matter of tobacco seedlings.

Treatments	Root Dry mass (g)	Shoot Dry mass (g)	Total Dry mass (g)	Root: shoot Ratio
100% pine bark	1.25d	0.98c	2.20c	0.43a
50% cattle manure + 50% sand	0.98c	1.13d	2.24c	0.57b
100% coal rubbles	0.30a	0.80a	0.95a	0.73c
100% compost manure	1.56e	1.32f	3.29f	0.53b
50% pine bark + 50% sand	0.70b	0.82a	1.37b	0.51ab
100% cattle manure	1.28d	1.22e	2.77e	0.54b
75% coal rubbles + 25% sand	0.32a	0.88b	1.09a	0.70c
75% cattle manure + 25% sand	1.13cd	1.21e	2.59de	0.56b
50% compost manure + 50% sand	0.93bc	1.11d	2.16c	0.57b
75% compost manure + 25% sand	1.28d	1.12d	2.53d	0.50ab
p value	<0.001	<0.001	<0.001	<0.001
CV%	14.9	3	6.7	9.1
LSD	0.248	0.053	0.245	0.09

Least significant difference (LSD) tests at the 5% level of significance. See 2.4 data collection and data analysis.

Table 5: Correlation and regression analyses of measured variables.

		Transplantable Percent	Stem Height	Shoot Thickness	Root DM	Shoot DM	Total DM	Root: shoot Ratio
Transplantable	R	1.0	0.95	0.55	0.10	0.24	0.06	0.34
Percent	p value		<0.001	0.098	0.78	0.50	0.87	0.34
Stem height			1.0	0.43	0.08	0.01	0.16	0.38
				0.21	0.43	0.99	0.66	0.28
Stem thickness				1.0	0.63	0.73	0.70	0.38
					0.048	0.02	0.02	0.28
					1.0	0.85	0.96	0.79
						0.001	<0.001	0.006
Shoot dry mass						1.0	0.96	0.41
							<0.001	0.26
Total dry mass							1.0	0.63
								0.05
Root: shoot ratio								1.0

Likewise, stem height and stem thickness; stem height and any measured dry mass or root: shoot ratio did not show significant relationship.

2.6. Discussion

2.6.1. The Effect of Soilless Growing Media on Seed Emergence, Survival Percent, and Transplantable Percent of Tobacco Seedlings. The medium with 100% compost manure had the highest seed emergence percent of tobacco (Table 1). This might have been attributed to the high wettability of compost manure and its ability to hold more water. As a result, the dormant dry seeds of tobacco had access to enough water for imbibition, followed by bursting of the seed coat and eventual growth of small emerging seedlings. Amending the media with compost manure could have improved the total porosity of the media, thereby increasing its aeration and the amount of oxygen required for germination. There was no statistical difference between 100% compost manure and 100% pine bark in the emergence percent of tobacco seedlings, implying that the former growing medium can be used as a substitute for raising tobacco seedlings in nurseries. In contrast, poor seed emergence was observed where cattle manure was used as a growing medium. This could be attributed to the poor wettability of cattle manure that reduces the moisture needed for germination. Tobacco seed is very small and requires a medium that can release moisture frequently to support germination. In addition, cattle manure harbour substantial amount of ammonia and this gas causes toxicity that adversely reduces or delays seed germination [14, 15].

Similarly, the medium with 100% compost manure had the highest survival percent of tobacco seedlings when compared to 100% pine bark. Perhaps, this could be attributed to the highest emergence percentage of tobacco seedlings. In this study, a significant positive correlation between seed emergence percent and survival percent existed (Figure 1). In addition, compost manure has high organic matter and nutrient content suitable to support early plant growth [16]. Organic matter in compost manure enhances aeration, water retention, and improved fertilizing capacity, which are critical factors in plant growth. According to Chong [17], organic composts tend to have ideal physical properties such as porosity and aeration properties comparable to those of pine bark and peat, which are ideal for seedling production and propagation. The medium with 100% cattle manure had the lowest survival percent of tobacco seedlings when compared to 100% pine bark (control). This is partly attributed to poor emergence of seed that was sown in 100% cattle manure. In addition, high salt content due to NH_3 and NH_4^+-N and alkaline pH have phytotoxic effects of growth on the seedlings [18]. Cattle manure may contain contaminants such as organic chemicals, trace elements and heavy metals such as Cu and Zn, which increase the death of seedlings [17, 18].

The use of compost manure increased the transplantable percent of tobacco seedlings and was superior to the use of 100% pine bark (control). This is an indication that compost manure is ideal for production of tobacco nursery, presumably because they had good physical and chemical properties such as acceptable water retention and holding capacity, reduced bulk density and high porosity, optimum pH and high CEC that enhanced optimum growth of ideal seedlings, thus, the substrates are potential alternatives to pine bark [19]. The medium with 100% cattle manure reduced the transplantable percent and this could be attributed to reduced stem elongation caused by inherent chemical and physical properties of this growing medium. One of the attributes that significantly contributed to the selection of seedlings ideal for transplanting is stem length. Koga and Rukuni [19] reported similar results in regard to using cattle manure as a growing medium resulting in poor quality of seedlings of tobacco.

2.6.2. Response of Stem Height and Thickness of Tobacco Seedlings to Different Soilless Media. Seedlings from the medium with 100% compost manure had elongated stem length and were thicker in comparison to 100% pine bark (control), making the medium more suitable for use in tobacco nurseries. The superiority of the medium could probably be attributed to its capacity to enhance aeration and ability to allow for oxygen diffusion to the root zone and gaseous exchange, capacity to retain and hold more moisture, acceptable pH, and improved fertilizing capacity that enhances growth of plants and stem elongation. Chong [17] reported that compost can act as a reservoir for moisture and nutrients suitable for plant growth, making the media suitable for use. However, increasing the percentages of sand in amending compost manure resulted in a reduced stem length of tobacco seedlings. This could have been an indication of compromising the nutritional balance of compost manure, which resulted in reduced fertilizing capacity of the media by nutrient dilution with sand. The medium with 100% cattle manure caused dwarfing of tobacco seedlings. The seedlings were extremely shorter in length (less than the recommended transplanting height of 12 cm to 15 cm for an ideal tobacco seedling) when compared to 100% pine bark (control). This could have been a result of inhibitory effects of cattle manure on seedling growth, attributed to the contaminants generated during decomposition of organic waste such as ethylene oxide [18, 20]. The medium with 75% coal rubble + 25% sand had thin seedlings, although it was not statistically different from 100% coal rubble and 50% pine bark + 50% sand and this is attributed to poor growth due to low water holding porosity and cation exchange capacity, resulting in reduced nutrient availability to seedlings.

2.6.3. The Effect of Soilless Media on Roots, Shoots, Total Dry Mass, and Root: Shoot Ratio of Tobacco Seedlings. Consistently, the medium with 100% compost manure had the highest roots, shoots, and total dry mass of tobacco seedlings when compared to 100% pine bark (control). The superiority of 100% compost manure to 100% pine bark (control) could have been attributed to the improved fertilizing capacity of the medium itself and its capacity to reserve nutrients and moisture suitable for plant growth. In addition, compost manure can enhance aeration, allow oxygen diffusion to the root zone, and can retain and hold more moisture. Therefore, the seedlings had unlimited access to nutrients, moisture, oxygen, and dry matter accumulation, making compost manure a suitable media. The medium with 100% coal rubble had the lowest roots, shoots, and overall dry matter of tobacco seedlings, most presumably because the seedlings were exposed to oxygen deficiency due to reduced air-filled porosity and hydraulic conductivity. In addition, the medium could have been compacted during tray filling. Masaka et al. [21] and Masaka and Ndidzano [7] have reported a significant decrease in plant growth influenced by an increase in the amount of coal rubble in a coal rubble/pine bark mix. More so coal rubble is strongly acidic, having a pH of 4.0. Low pH affects the availability of essential nutrients such as N, P, or S, which can restrict root growth, whilst K, Mg, Mn, and Mo can restrict shoot growth [22], resulting in overall poor plant growth and poor biomass accumulation. Some elements such as aluminum and iron are associated with low pH and they become readily available, causing toxicity to the seedlings.

The highest root: shoot seedling dry matter ratio of tobacco was observed in the medium with 100% coal rubble. This could have been a result of stress in shoot growth which is being countered by root growth. When the soil growing medium have low water content and poor availability of nutrients, the root grows at the expense of shoots in order to compensate for the resources required for plant growth. As expected, the medium with 100% pine bark had the lowest root: shoot seedling dry matter of tobacco; although it was not statistically different to 50% pine bark + 50% sand and 50% compost manure + 50% sand. This could most presumably be attributed to a good balance of availability and absorption of nutrients and moisture, and this will help in increasing shoot biomass and producing healthier plants.

2.6.4. Correlation and Regression Analyses of Measured Variables. The study showed that stem height is an important predictor when selecting tobacco seedlings ideal for transplanting. Most farmers when selecting tobacco seedlings for transplanting, they consider the stem height most than any other factors. However, the stem height of tobacco seedlings is managed by clipping to achieve the ideal plant size [23]. Jones and Terrill [24] revealed that stem length is one of the major factors that influence the early growth and final yield of flue-cured tobacco. The authors also revealed that stem elongation of transplants has an effect on the initiation of flowering of tobacco plants, with shorter plants delaying flowering. The study also revealed that the root, shoot and total dry mass are not important parameters when selecting an ideal tobacco seedling for transplanting [25]. Stress in plant cells quickly affects stem elongation rather than biomass during early growth. When plants are under stress, the immediate response is an active slowing down of growth [26]. Middle-to-long term effects of abiotic stress will reduce the biomass of plants.

3. Conclusions

The growing medium with 100% compost manure is a suitable soilless medium effective for successful seed emergence and growth of superior tobacco seedlings and ideal for planting. The use of cattle manure at all ratios resulted in lower seed emergence, survival, and transplantable percentages of seedlings of tobacco and is not an ideal soilless media to be used in tobacco nurseries. Coal rubble is also not an ideal growing medium as it increases root: shoot growth of tobacco seedlings. Growers are recommended to use compost manure and not cattle manure when raising tobacco seedlings. Stem length and not dry mass, is the strongest predictor when selecting ideal tobacco seedlings for transplanting.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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