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The Effect of Media Combinations on Nutrient Load in Float Trays and Tobacco (*Nicotina tabacum L.*) Seedling Survival Counts

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Abstract: The main objective of the study was to determine nutrient depletion dynamics in various media combinations and their effect on tobacco seed germination and seedling survival count. Study results showed that the presence of pine bark in the media mix strongly monitored soluble cation nutrient and phosphate holding capability of the container media. When the content of pine bark in the media combination increased from 25% (T_2) through 50% (T_3), 75% (T_4) to 100% (T_5) in the pine bark-coal rubble mix there was a corresponding elevation of cation concentrations in the media from an average of 10.73 to 15.76, 33.04 and 45.72 meq/100 g, respectively. The enhanced nutrient holding ability of pine bark-based media mixtures conferred such combinations the highest tobacco seedling germination and survival. The lowest seedling emergence and survival counts were observed in float trays filled with media combinations dominated by coal rubble. Germination and survival counts improved with reduction in coal rubble component in the media. Research studies elsewhere have recommended replacing coal rubble with sand because of similarities in their physical properties. In this study, results show that replacing coal rubble with sand in the media dwarfs combined nutrient loads by 15.6, 19.1 and 0.9% at 7, 35 and 42 DAS, respectively while it amplifies nutrient content by 4.8% at 21 DAS. Replacing coal rubble with sand in a 50/50 combination with pine bark significantly enhances the phosphate carrying capacity of the media.

Key words: Media mix, nutrients load, tobacco seedling emergence and survival

INTRODUCTION

Sir Walter Raleigh, the great Elizabethan adventurer, is well known to most people in the English-speaking world as the first recorded heavy pipe-smoker who helped to popularize smoking among the high society of England from 1585 (Ramsay, 1974). Today tobacco (*Nicotina tabacum* L.) has become a highly merchantable crop of value competing well on the world commodity trade and has thus shaped land uses, economies and societies in southern African countries. Coupled with this development, is the need for shrewd nutrient management in tobacco production systems in order to ensure maximum productivity (TIMB, 2004).

For the majority of smallholder and commercial farmers in central and southern Africa, tobacco seedlings are produced in conventional seedbeds in which methyl bromide is used to fumigate the soil as a pesticide. The deleterious effects of methyl bromide on the atmospheric ozone layer, which controls passage of harmful ultra-violet EMR from the sun, has raised environmental concerns on the

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continued use of this chemical as a pesticide. The most promising substitute to the conventional methyl bromide-based tobacco seedling production method is the floating tray system (Mazarura, 2004). It is a hydroponics or flooded bench fertigation system in which trays are filled with artificial media and floated in a pond where nutrients are periodically added. Capillary action carries water to the seed, which resides on the surface of the media filling the tray cells (Bilderback *et al*., 1999).

Pine bark is debarked from pine logs (*Pinus radiate* L.) prior to processing into millable timber and it is usually free from woody stuff and cambium. It has been used in tobacco seedling production in floating trays and as potting media since 1981 (Nelson, 1985). Before composting pine bark is reddish brown in colour. It turns brown when fully composted. Among a host of desired characteristics, pine bark provides good drainage and aeration within the media mix as a result of its granular particles. Some bark fragments contain up to 45% porosity (Barnard *et al*., 1996). The size of the particles and their distribution determine the texture of the media, which subsequently affects water retention and air porosity (Pasian, 2003). In pine bark medium small particles of less than 0.01 mm result in smaller pore diameter compared to that with large particles. These small pores increase the water holding capacity of the media and reduce air filled porosity (Van Schoor *et al*., 1990). Pine bark has a low pH range of 3.5 to 4.0 and a balanced carbon to nitrogen ratio. Although the pH range is slightly acidic adding lime can raise it (Hoitinx and Poole, 1976; Stewart, 1986).

Where nutrients are not readily available, plants are bound to exhaust a fair amount of energy that might otherwise have been used for growth, scrounging for mineral nutrients. Soluble mineral salts like potassium sulphate applied in large amounts to media with low nutrient holding capacity cannot be held efficiently because the cation warehouse or reservoir is too small (Street and Kidder, 1997). A high soluble cation value provides a buffer from abrupt fluctuations in media salinity and pH (Miller and Donahue, 1995).

Deficiencies of calcium and magnesium are often possible where their exchangeable base values are less than 0.2 meq/100 g while an excessive content of either of them inhibits uptake of the other (Fonteno *et al*., 2001). The ratio of exchangeable calcium to exchangeable magnesium is of importance in avoiding deficiencies. Bennett (1993) indicated that ratios between 5:1 and 1:1 are desirable while ratios greater than 8:1 indicate possible magnesium deficiencies.

Magnesium constitutes the central atom of the chlorophyll molecule. It plays a role in phosphate metabolism, plant respiration and many enzyme systems. Mg is found in relatively small quantities in course textured growing media due to its high solubility where it is subject to higher leaching losses as compared to other basic cations (Bandel *et al*., 2000).

Potassium is required in high and fairly sufficient amounts for maintenance of osmotic gradients (Street and Kidder, 1997). Potassium deficiency in tobacco will result in slight mottling and brownish yellow spots on leaf tips, which will become necrotic with time. Dead leaf areas fall off giving a rugged appearance. Leaf margins tend to curl downwards. Symptoms of potassium deficiency are mainly observed on upper leaves and lower leaves for older and younger leaves respectively (Mullins *et al*., 1994; Tucker, 2005).

Calcium is an essential part of plant cell wall structure and functions in the normal transport and retention of strength within the plant. Symptoms of calcium deficiency in tobacco include rolling and downward curling of new leaves. Dead necrotic areas are observed on tips and along leaf edges. Lower and middle leaves develop a darker than normal green colour (Tucker, 2005). Calcium exists in a delicate balance with Mg and K in the plant. Too much of any one of the three will result in insufficiencies of the other two (Street and Kidder, 1997; Anonymous, 2005).

An aluminium concentration range of 10-15% is favourable for normal plant growth. Beyond 15%, dangers of Al toxicity appear. There is a direct relationship between Al toxicity risk and the media pH. As pH approaches 1, Al^{3+} toxicity increases. Al dominated media have impaired root systems and inhibited shoot growth resulting in reduced growth vigour (Dobermann and Fairhurst, 2000).

Phosphorus is an important component in the energy metabolism of the plant cell. It constitutes nucleic acids, phospholipids, coenzymes, DNA, NADP and most importantly, ATP and ADP (Bandel *et al*., 2000; Tucker, 2005). Phosphorous availability can be limited by the reaction between applied phosphate and available calcium. The reaction might give out monocalcium phosphate, which is easily available, dicalcium phosphate with moderate availability or tricalcium phosphate, which is not available to plants at all (Penas and Sanders, 1993; Velarde *et al*., 2005).

Generally, there has been a common international consensus on the need to find suitable substitutes for the deleterious ozone-depleting methyl bromide used as a pesticide in the conventional tobacco seedling production. The most promising substitute for this hazardous substance is the use of hydroponics system in which trays are filled with artificial media and floated in a pond where nutrients are periodically added for the growing tobacco seedlings. Exposure of tobacco seedlings to pest and diseases is very low in flooded bench fertigation systems. Unlike the natural soil systems, the artificial media, however, has very low nutrient buffer mechanisms. This implies that seedling nutrient mining in the flooded bench solution (I) easily outweighs ambient nutrient supplying power of artificial media (Q). Under such conditions, the quantity (Q)-intensity (I) gradients in artificial growing media are high and can only be maintained at favourable levels by external additions of nutrients carried in water to the seedlings by capillary action. Although the body of knowledge on the effects of different media mix and plant presence on the dynamics of nutrients in media in flooded bench fertigation systems is appreciable, research studies on the issue have accomplished variable results. Accordingly, we report in this paper on a greenhouse experiment led for 32 weeks whose main objective was to determine nutrient depletion dynamics in various media combinations and their attendant effect on tobacco seed germination and seedling survival count. In this study, we reasoned that various media combinations generated a mosaic of ambient media physical properties, nutrient holding and supplying conditions, which affected tobacco seedling growth that, in turn, conferred different nutrient depleting abilities to tobacco seedlings.

MATERIALS AND METHODS

The Field Study Site

The study was conducted (August-November 2005) at Kutsaga Research Station (17°52′ S; 31°02′ E, elev. >1500 m above sea level) near Harare International Airport, Zimbabwe. The soils at the research station are deeply weathered sandy loams derived from granite and classified as Udic Kandiustalf under the USDA system of soil classification (Nyamapfene, 1991). The area lies in Natural Region II receiving rainfall ranging from 800 to 1000 mm annum^{-1} (average 900 mm per annum) with a coefficient of variation of 19%. The mean annual temperature is 21°C with insignificant frost occurrence in the months of June and July. The rainfall occurs during a single rainy season extending from November to April (Vincent and Thomas, 1960).

Preparation of Growing Media for the Trial

The major constituents of the growing media were composted pine bark, coal rubble and sand. Coal rubble was washed thoroughly before crushing to remove excess ash, which results in high alkalinity. Sand was sieved to collect particle sizes between 0.5 and 2 mm. Pine bark and coal rubble matter were separately crushed using the builder's rammer to pass a series of 0.5, 4 and 6 mm sieves after some extensive shaking. Consequently, three media particle size distributions were generated separately for pine bark and coal rubble: small particles <0.5 mm, medium particles 0.5-4 mm and large particles 4-6 mm. The three media particle size distributions were proportionally mixed separately to generate a media component as follows: <0.05 mm = 10% (small particles), 0.05-4 mm

= 70% (medium particles) and 4-6 mm = 20% (large particles). Samples of pine bark and coal rubble were collected for pH and EC determination (Gabriels and Verdonck, 1992), which was found to be 4.10 and 9.58, respectively. The pH value had to be in the range of 5.5 to 6.9. Coal rubble pH was corrected using soluble citric acid at 1.25 g kg^{-1} of media while that of pine bark was corrected using dolomitic lime at 33 g kg^{-1} media. The amount of either lime or acid to add was determined from titration. Growing media reaction amendments were done two weeks prior to sowing as recommended (Mazarura, 2004).

Treatments, Experimental Design and Management

The prepared pine bark, coal rubble and sand media components were meticulously mixed to generate six treatment combinations as shown in Table 1.

The media was mixed with water in the ratio of 1:4 in order to improve workability. Some 200-cell polystyrene float trays measuring 670×345×60 mm were used in the experiment. The float trays were filled soon after media mixing to avoid loss of moisture. Each tray was hand filled with the prepared media combinations by applying the standard methods. The trays were lifted to a height of about 20 cm above a flat surface and dropped gently. This slightly compacted the media in the trays. This was repeated 2-3 times with the trays being refilled after each drop. Under packing result in media falling out through the holes at the bottom of the cells whilst over packing introduces problems with dibbling and spiral roots. The trays were then dibbled using a dibble board and sown with pelleted KRK26 tobacco seed cultivar. Each cell was then pressed at the centre to create depressions (dibbles) 1 cm deep. Tray filling was done uniformly and consistently to attain uniform and favourable physical properties as inconsistency in the filling process may affect the physical properties of the media.

The experiment was set out in a 6×2 Factorial Design in 3 Completely Randomized Blocks in which Factor 1 was media combinations while Factor 2 was influence of plants as either plants present or absent. The recommended basal fertilizer hydrofert with NPK 20:10:20 was used at rates of 150 mg $L^{-1}$of water split into three application rates of 25, 50, 75 mg L^{-1} at 7, 21 and 35 Days After Sowing (DAS). Top dressing by ammonium nitrate to pond water was done at 42 DAS using a rate of 100 mg N L^{-1} of water.

Media Combination Sample Analysis and Germination Counts

Established standard laboratory procedures were used to determine the combined-cation concentrations (meq/100 g media) of calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^{+}), sodium (Na^{2+}) and aluminium (Al^{3+}) as well as available phosphate (P_2O_5) (μg g^{-1}). Nutrient concentration fluxes in the media samples collected systematically from twelve (12) cells of each tray were determined. Sampling was done 2 days after each fertilizer application, which commenced 7 DAS assuming considerable absorption will have occurred from the applied fertilizer. Separate sample analysis for Al concentration in the growing media was carried out specifically to determine levels of ambience Al toxicity at 7, 21, 35 and 42 DAS. Germination counts were done weekly starting from 14 DAS up to 42 DAS. The counts were undertaken as repeated measurements, which allowed an assessment of the media properties and nutrition factors that may affect germination and seedling survival.

Table 1: Media combinations used in treatments

Treatments	Media combinations
Treatment 1 (T_1) (Control)	100% Coal rubble
Treatment 2 (T_2)	75% Coal rubble + 25% pine bark
Treatment 3 (T_3)	50% Coal rubble + 50% pine bark
Treatment 4 (T_4)	25% Coal rubble + 75% pine bark
Treatment 5 (T_5)	100% pine bark
Treatment 6 (T_6)	50% pine bark + 50% sand

A repeated-measures one-way nested analysis of variance (ANOVA) was used to validate temporal patterns in nutrient concentrations, seedling germination and survival.

RESULTS AND DISCUSSION

Study results shown in Table 2-5 show that there was a relatively discernible treatment separation on the basis of nutrient load dynamics in the growing media and their effect on tobacco seedling survival counts ($F<0.001$). However, distinction within treatments on the basis of soluble cation concentration dynamics in media combinations over time from tobacco seedling germination to pulling stage was less convincing ($F>0.001$).

Media sample analysis results clearly indicate that combined nutrient cation load fluxes in the media effectively separated the six different treatments (Table 2). However, there was neither significant plant influence nor significant interaction between media combination and plant presence

Table 2: Effect of media combinations on soluble cations load (meq/100 g)

Treatments	Media combinations	7 DAS	21 DAS	35 DAS	42 DAS
T_1	100%CR(Control)	4.810^{a}	4.750^{a}	4.640^{a}	4.900^{a}
T_2	75%CR+25%PB	10.980^{b}	9.880^{b}	10.390^{b}	11.660^{b}
T_3	50%CR+50%PB	16.200^{cd}	13.080^{c}	16.420^{bc}	17.320^{cd}
T_4	25%CR+75%PB	28.820^{e}	32.330^{e}	34.120^{d}	36.890^{e}
T_5	100% PB	37.550^{f}	46.240^{f}	48.850^{e}	50.220^{f}
T_6	50%PB+50%Sand	13.680^{c}	13.740^{cd}	13.280^{bc}	17.170^{c}
Mean	………………	18.670	18.340	21.280	19.860
F-test prob	………………	<0.001	<0.001	<0.001	<0.001
SED	………………	20.600	1.398	2.058	1.736
CV (%)	………………	20.600	22.900	16.700	15.100
LSD	………………	2.654	2.900	4.260	3.600
t 0.05,22 df	2.074				

Treatments with the same letter(s) are not significantly different, CR = Coal Rubble and PB = Pine Bark

Table 3: Effect of media combination on soluble phosphate content ($\mu g\ g^{-1}$)

Treatments	Media combinations	7 DAS	21 DAS	35 DAS	42 DAS
T_1	100%CR(Control)	55.0^{a}	39.3^{a}	41.7^{a}	76.3^{a}
T_2	75%CR+25%PB	82.5^{b}	83.7^{b}	99.3^{b}	191.2^{b}
T_3	50%CR+50%PB	102.5^{c}	101.8^{c}	130.2^{c}	236.5^{c}
T_4	25%CR+75%PB	111.2^{c}	126.3^{d}	165.5^{d}	278.7^{d}
T_5	100% PB	130.2^{d}	139.3^{e}	189.3^{e}	323.3^{e}
T_6	50%PB+50%Sand	85.8^{b}	120.2^{d}	167.5^{d}	319.3^{e}
Mean	………………	94.5	101.8	132.2	237.6
F-test prob	………………	<0.001	<0.001	<0.001	<0.001
SED	………………	6.82	4.69	9.99	12.56
CV (%)	………………	12.50	8.00	13.10	9.20
LSD	………………	14.14	9.72	20.72	26.05
t 0.05,22 df		2.074			

Table 4: Effect of media combinations on soluble aluminium content (meq/100 g)

Treatments	Media combinations	7 DAS	21 DAS	35 DAS	42 DAS
T_1	100%CR(Control)	11.660^{a}	7.470^{a}	6.640^{a}	1.140^{a}
T_2	75%CR+25%PB	18.210^{b}	12.600^{a}	11.280^{b}	4.990^{b}
T_3	50%CR+50%PB	19.270^{b}	15.950^{c}	13.460^{b}	9.460^{c}
T_4	25%CR+75%PB	21.140^{b}	12.250^{b}	18.830^{cd}	12.540^{cd}
T_5	100% PB	17.640^{b}	8.670^{a}	14.630^{bc}	10.900^{c}
T_6	50%PB+50%Sand	18.590^{b}	15.030^{bc}	17.130^{c}	10.800^{c}
Mean	………………	17.750	12.000	14.500	8.310
F-test prob	………………	<0.001	<0.001	<0.001	<0.001
SED	………………	1.780	1.267	1.375	0.968
CV (%)	………………	17.400	18.300	16.400	20.200
LSD	………………	3.690	2.630	2.850	2.000
t 0.05,22 df		2.074			

Treatments with the same letter(s) are not significantly different, CR = Coal Rubble and PB = Pine Bark

Table 5: Mean seedling germination and survival percentages in the media combinations

Treatments	Media combinations	14 DAS	21 DAS	28 DAS	35 DAS	42 DAS
T_1	100%CR(Control)	0.000^{a}	3.200^{a}	14.200^{a}	16.200^{a}	15.200^{a}
T_2	75%CR+25%PB	5.000^{a}	10.300^{a}	32.200^{b}	41.500^{b}	41.000^{b}
T_3	50%CR+50%PB	0.700^{a}	14.000^{a}	47.000^{b}	49.300^{b}	49.000^{b}
T_4	25%CR+75%PB	17.700^{a}	28.500^{ab}	55.300^{bc}	59.500^{bc}	59.500^{b}
T_5	100% PB	17.300^{a}	40.800^{b}	59.200^{c}	59.000^{c}	58.700^{bc}
T_6	50%PB+50%Sand	68.800^{b}	75.700^{c}	82.700^{d}	82.500^{d}	81.300^{d}
Mean	………………...	18.200	28.800	48.400	51.300	50.800
F-test prob	………………...	0.001	<0.001	<0.001	<0.001	<0.001
SED	………………...	11.830	10.300	7.220	5.640	5.880
CV (%)	………………...	79.400	43.900	18.300	13.500	14.200
LSD	………………...	26.360	22.950	16.090	12.570	13.100
t (0.05,22d.f)		2.074				

Treatments with the same letter(s) are not significantly different, CR = Coal Rubble and PB = Pine Bark

on the soluble cations concentrations (F>0.001). We attributed this indifference in the nutrient content within a treatment across the tobacco seedling nursery vegetative period to synchronized split applications of compound fertilizer at 7, 21 and 35 DAS, which ensured nutrient replenishments up to pulling stage despite nutrient extraction by the seedlings.

The relationship between the percentage contribution of pine bark in the media combination and cation nutrient concentration levels constituted a relatively distinguishable pattern. The increases in content of pine bark in the media combination from 25% (T_2) through 50% (T_3), 75% (T_4) to 100% (T_5) in pine bark-coal rubble mix were matched by corresponding elevation of cation concentrations in the media from an average of 10.73 to 15.7; 33.04 and 45.72 meq/100 g, respectively. The highest soluble cation concentration was recorded in T_5 float trays where pine bark constituted 100% of the growing media. In this treatment seedling survival rate clocked a modest 58.7% (Table 5). The 100% coal rubble treatment (T_1, control) carried the least amounts of soluble cations in all four sampling events. The all-pine bark float trays (T_5) had 31.74, 41.49, 44.21 and 45.32 meq/100 g in excess of the control treatments at 7, 21, 35 and 42 DAS, respectively.

Although the mechanisms for these nutrient concentration patterns in the media mosaics dominated by pine bark are poorly studied, the general idea on how this was achieved is relatively clear. The effect of different media combinations on water holding porosity, where the nutrients are resident, is a case in point. In comparatively similar studies on properties of pine bark as a container media, Van Schoor ***et al.*** (1990), Barnard ***et al.*** (1996) and Pasian (2003) reported improved water holding capacity in pine bark-based media compared with other soilless media combinations. A bulge in the water holding porosity of the media combinations in which pine bark is present triggered corresponding increases in the total porosity where the soluble cation nutrients were located. Accordingly, the elevated concentrations of nutrient cations in T_2-T_6 media variants in this study were attributable to corresponding increases in contribution of water porosity-enhancing pine bark to the media combinations. The nutrient load is embedded in the aqueous component of the growing media and is directly proportional to magnitude of the water porosity.

Generally, the substitution of coal rubble by sand in the treatments (T_3 and T_6) had a mixed influence on nutrient fluxes in the media. In this study, it does appear however that replacing coal rubble with sand in the media dwarfs combined nutrient loads by 15.6, 19.1 and 0.9% at 7, 35 and 42 DAS, respectively while it amplifies nutrient content by 4.8% at 21 DAS. This is, partially, in direct contradiction with Pasian (2003) who, in a comparative study on the soil and container media physical properties concluded that sand could replace coal rubble as container media because of their similar physical properties. This was, however, was not the case in this study. Replacing coal rubble with sand whittled down cation nutrient carrying potential of the container media.

Phosphate content in the media significantly distinguished variants (F<0.001) while its magnitudes failed to separate the effect of tobacco seedlings presence from germination to pulling stage

(F>0.001) (Table 3). There were, however, statistically significant seedling presence effects on phosphate content trends in T_4, T_5 and T_6 variants. Media phosphate fluxes were largely determined by the content of pine bark in the media combinations. The 100% pine bark media cocktail (T_5) carried the greatest phosphate load while the 100% coal rubble variants (T_1) had the lowest content.

Turning to pine bark content in the media as a determinant of phosphate concentration, results (Table 3) show that the reduction of pine bark component in the media combination from 100% (T_5) to 25% (T_2) whittled down the phosphate concentrations by 36.6, 39.9, 47.5 and 40.9% at 7, 21, 35 and 35 DAS, respectively. The presence of pine bark confers a higher total porosity to the media capable of carrying a greater nutrient load. In the complete pine bark variants at 7 DAS there was a cumulative amplification of the media phosphate load in gradations of 7.0, 45.4 and 148.3% at 21, 35 and 42 DAS despite the vigorous phosphate uptake by growing tobacco seedlings. This trend in the phosphate ion accumulation was not particularly surprising as it was a positive response the incremental triple split applications of compound fertilizer in the float beds in rates of 25, 50 and 75 mg L^{-1} at 7, 21 and 35 days after sowing, which constantly replenished ambience phosphate content.

While the replacement of coal rubble with sand proved inferior in the ambience concentrations of major soluble cation nutrients in the media combination, substitution of coal rubble by sand conferred superior capacity of the media mix to hold more soluble phosphate. A brief reference to results displayed in Table 3 clearly indicate that the substitution of coal rubble in T_3 variants by sand in T_6 float trays blended with 50% pine bark amplified phosphate concentrations in the media by 18.1, 28.6 and 25.9% at 21, 35 and 42 DAS, respectively. This trend in the phosphate content in media was largely attributed to gradual native salinisation of the media ambient environments by the generally alkaline coal rubble component in T_3 float trays, which effectively reduced the solubility (and therefore availability) of phosphatic materials in the media that led to the low content of soluble phosphate ions in T_3. Sand, being generally inert and pH-neutral, did not impart any neutralising effect on the composted acidic pine bark, which, by this property, enhanced the activity of the phosphate radicals in the media. Phosphatic materials in relatively acidic environments are generally unstable and soluble. This led to the elevated concentrations of phosphate ions in the T_6 float trays observed in this study. In this respect, the results disputed the findings by Pasian (2003) who, in a comparative study on the soil and container media physical properties concluded that sand could replace coal rubble as container media because of their similar properties.

Al ion concentrations in media combinations (Table 4) comparably differentiated the six treatments (F<0.001). In concurrence with cation content within variants (Table 2), indistinct Al concentration patterns during the tobacco seedling nursery vegetative period within each treatment were largely perpetuated. However, there were elements of seedling extraction effects on Al loads in the media within T_2-T_6. It is interesting to note that the presence of pine bark in the media combination had a not-so-surprising tendency of accentuating the possibilities of Al poisoning. The lowest content of Al was recorded in the control trays where there was no pine bark. When compared with the control variants, pine bark-based media accentuated Al concentrations by 5.98-9.48, 1.2-8.48, 4.64-12.19 and 3.85-11.40 meq/100 g at 7, 21, 35 and 42, DAS, respectively. There has been considerable argument on the reasons why this trend takes root in pine bark-based container media, but the main idea is reasonably clear. Indeed there is little doubt that composted pine bark is generally acidic (Bilderback *et al*., 1999). Despite initial efforts to reduce acidifying effect of composted pine bark at media preparation stage by adding lime, native media acidity gradually increases, which encourages Al cation activity in the media solution observed in this study.

Treatment separation in T_1-T_5 variants (Table 5) on the basis of seedling emergence and survival percentages at 14 and 21 DAS were less distinct (F>0.001). Correspondingly, there was a discernible pattern in the effect of treatments on seedling emergence and survival at 28, 35 and 42 DAS (Table 5).

There were comparatively clear patterns in the tobacco seedling survival counts within treatments from germination to 6 weeks after sowing in treatments 2-6. The lowest seedling emergence and survival counts were observed in float trays filled with media combinations dominated by coal rubble. In this respect, low counts were recorded in T_1, T_2 and T_3 float trays, which fell below 50% after 42 days in the nursery.

Germination and survival counts improved with reduction in coal rubble component in the media. The highest tobacco seedling emergence and survival at 14 DAS reached 68.8% and levelled out at peaks of 81.3-82.7% between 21 and 42 DAS in T_6 trays. The lowest seedling emergence counts in 100% coal rubble variants which, incidentally, recorded the lowest soluble cation and phosphate concentrations, were largely attributed to poor aeration porosity commonly associated with complete coal rubble or sand container media (Bilderback *et al*., 1999). The growing mix must be able to supply oxygen for proper root function, water and nutrients for shoot growth. The nearly anoxic coal rubble-based media environments did not have adequate oxygen necessary for seedling cell energy metabolism. This condition in the control float trays coupled with inferior nutrient holding and supplying capacities (Table 3, 4) had depressive effects on the survival of seedlings to pulling stage.

In this study, the fact that the highest seedling emergence and survival counts were recorded in the 50% pine bark and 50% sand was indeed for a good reason. In a florists Blom (1993) reported that blending different seedling growing media components generates physical and chemical characteristics that are intermediate between properties of the components. The pine bark component provided the total porosity that carries the aeration and water voids in the media necessary for gaseous exchange and nutrient holding while the sand component's adverse effects on media aeration were effectively cancelled out by the elevated aeration in the pine bark. The sand provided ballast and enhanced the water holding capacity in the media, which magnified the nutrient-laden water wicking ability of the media. This had the effect of enhancing the seedling propagation ability of the T_6 trays observed in this study.

Present study results have conclusively shown that the content of pine bark in the media combination for tobacco seedling production under float tray system is a major determinant of soluble cation nutrient and phosphate holding capability of the media mix. When the content of pine bark in the media combination rises from 25% (T_2) through 50% (T_3), 75% (T_4) to 100% (T_5) in pine bark-coal rubble mix there is a corresponding elevation of cation concentrations in the media from an average of 10.73-15.76, 33.04 and 45.72 meq/100 g, respectively.

While research results reported elsewhere indicate that sand can replace coal rubble in the pine bark-based container media mix because of their reported similar physical properties our results clearly show otherwise. In this study, replacing coal rubble with sand in the T_3 and T_6 media combinations dwarfed combined nutrient loads by 15.6, 19.1 and 0.9% at 7, 35 and 42 DAS while it amplified nutrient content by 4.8% at 21 DAS. In the case of phosphate ion concentration in the media mix, replacing coal rubble with sand in a 50/50 combination with pine bark significantly enhances the phosphate carrying capacity of the media. The substitution of coal rubble in T_3 variants by sand in T_6 float trays blended with 50% pine bark amplified phosphate concentrations in the media by 18.1, 28.6 and 25.9% at 21, 35 and 42 DAS. Accordingly, we concluded that in replacing coal rubble with sand in the pine bark dominated mix the effect of the mix on the desired ambience chemistry of the media must indeed be taken into consideration in addition to the resultant physical properties of the media mix.

Increasing the pine bark component in the media mix for purposes of enhancing nutrient holding capacity introduces its share of problems. Elevating the contribution of pine bark in the media increases possibilities of Al poisoning for the delicate tobacco seedlings. The lowest content of Al was recorded in the control trays where there was no pine bark. When compared with the control variants, pine bark-based media accentuated Al concentrations by 5.98-9.48, 1.2-8.48, 4.64-12.19 and 3.85-11.40 meq/100 g at 7, 21, 35 and 42 DAS, respectively thereby exposing the delicate tobacco seedlings to Al toxicities.

The lowest seedling emergence and survival counts were observed in float trays filled with media combinations dominated by coal rubble. In this respect, low counts were recorded in T_1, T_2 and T_3 float trays, which fell below 50% after 42 days in the nursery. Germination and survival counts improved with reduction in coal rubble component in the media.

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REFERENCES

Anonymous, 2005. Explanation of exchangeable cation analysis and interpretation. NSW Department of Natural Resources, Extension Services

Bandel, V.A., B. James and J.L. Meisinger, 2000. Fact sheet: Basic principles of soil fertility 1: Plant nutrients. University of Maryland Extension Department, College Park.

Barnard, E.L., M.E. Kannwischer-Mitchell and S.W. Fraedrich, 1996. Development and performance of slash and loblolly pine seedlings produced in fumigated nursery seedbeds and seedbeds amended with organic residues. Institute of Food and Agricultural Sciences, University of Florida.

Bennett, W.F., 1993. Plant Nutrient Utilization and Diagnostic Plant Symptoms. In: Nutrient Deficiencies and Toxicities in Crop Plants. Bennett, W.F (Ed.), The American Pathological Society, USA., pp: 1-7.

Bilderback, T.E., W.C. Fonteno and D.R. Johnson, 1999. Physical properties of media composed of peanut hulls, pine bark and peat moss and their effect on azalea growth. Am. Soc. Soil Sci. J./HortSci. J., 107: 522-525.

Blom, T.J., 1993. Working with soil-less mixes. Florists Review. 173: 29-34.

Dobermann, A. and T. Fairhurst. 2000. Nutrient Disorders and Management. Handbook Series.

Fonteno, W.C., D.K. Cassel and R.A. Larson, 2001. Physical properties of three container media and their effect on poinsettia growth. J. Am. Soc. Soil Sci./Hortsci. J., 106: 736-741.

Hoitinx, H.A. and H.A. Poole, 1976. Composted Bark Media for Control of Soil-Borne Plant Pathogens. Prentice Hall, New Jersey, USA.

Mazarura, U., 2004. An eco-friendly replacement for methyl bromide in tobacco seedling production in Zimbabwe. 7th Science Symposium, Zimbabwe 2004.

Miller, R.V. and R.L. Donahue, 1995. Soils in our Environment. 7th Edn., Prentice Hall, New Jersey, USA.

Mullins, G.L., D.W. Reeves, C.H. Burnmester and H.H. Bryant, 1994. In-row sub-soiling and potassium placement effects on root growth and potassium content of cotton. J. Agron., 86: 136-139.

Nelson, P.V., 1985. Greenhouse Operations and Management. 4th Edn., Prentice Hall, New Jersey, USA.

Nyamapfene, K.W., 1991. Soils of Zimbabwe. Nehanda Publishers (Pvt.) Ltd., Harare, Zimbabwe, pp: 75-79.

Pasian, C.C., 2003. Soil Physical Properties and Container Media. Washington State. Olympia, USA., Dep. Agric. J., 360: 407-472.

Penas, E.J. and D. Sanders, 1993. Using Phosphorous Fertilizers Effectively. Published by Cooperative Extension Institute of Agriculture and Natural Resources, University of Nebrasaka Lincoln.

Ramsay, M., 1974. Rhodesian Tobacco. Department of Conservation and Extension, CONEX, Salisbury, Rhodesia.

Stewart, N., 1986. Production of Pine Bark for Composts. McGraw-Hill Book Company, New York, USA.

Street, J.J. and G. Kidder, 1997. Fact sheet: Soils and plant nutrition. Soil and Water Department of Extension Services, Institute of Food and Agricultural Sciences, University of Florida.

TIMB (Tobacco Industrial and Marketing Board), 2004. Flue-Cured (Virginia). Annual Statistical Report. Harare, Zimbabwe.

Tucker, M.R., 2005. Essential Plant Nutrients, Their Presence in North Carolina Soils and role in plant nutrition. NCDA and CS Agronomic Division.

Van Schoor, M.J., I.E. Smith and C.L. Davis, 1990. Preparation and utilization of pine bark as a growing medium of plaints. Pietermaritzburg, South Africa.

Velarde, M., P. Felker and D. Gardiner, 2005. Influence of elemental sulphur, micronutrients, phosphorus, calcium, magnesium and potassium on growth of *Prosopis alba* L. on high pH soils in Argentina. J. Arid Environ., 62: 525-539.

Vincent, V. and R.G. Thomas, 1960. An agricultural survey of southern rhodesia. Part I Agro-Ecological Survey, Government Printers, Salisbury.