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SHORT COMMUNICATION

EVALUATION OF ALTERNATIVE NURSERY POTTING MIXTURES FOR BETEL (*Piper betle* L.)

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ABSTRACT

Betel (*Piper betle* L.) is a woody climber with cultural and economic significance. Precise potting mixture is a prerequisite to produce quality nursery plants. Exploring alternative potting mixtures is crucial in addressing limitations associated with traditional potting mixtures. This research aimed to evaluate the different alternative potting mixtures for nursery production of betel. The research was conducted at Betel Research Station, Department of Export Agriculture, at Narammala. Seven potting mixtures were prepared using different ratios of topsoil, coir dust, sand, cattle manure, compost, goat manure, Partially Burnt Paddy Husk (PBPH) and poultry manure. Department of Export Agriculture (DEA) recommended potting mixture (Topsoil: Sand: Coir dust: Cattle manure 1:1:1:1) was used as the control (T1). This experiment was laid out in a Complete Randomized Design and each treatment consisted 15 nursery pots. "Ratadalu" stem cuttings were used as planting materials. Analysis was done on the EC, pH, and N, P, and K content of the nutrients in potting mixes. Growth parameters; number of leaves, shoot length and diameter were recorded weekly. Survival rate, shoot and root weight, root volume measured at 9th week. Except, T8 (Topsoil: PBPH: Poultry manure 1:3:1) potting mixture, other alternative nursery potting mixtures showed similar performances to control (T1) for most of the tested parameters. Out of alternative mixtures, T2 potting mixture exhibited more similar performances to the DEA recommended potting mixture. Therefore, T2 (Topsoil: Sand: Coir dust: Compost 1:1:1:1) can be suggested as the best alternative potting mixture for nursery production of betel.

Keywords: Alternative, Betel, Growth performances, Nursery plants, Potting mixture

INTRODUCTION

Betel is an export agriculture crop grown as an intercrop throughout Sri Lanka. Majority of commercial cultivations can be found in Kurunagala, Gampaha, Kegalle, Kalutara and Colombo districts. In Sri Lanka, betel leaves are in high demand, particularly during religious and cultural celebrations such as Sinhala and Hindu New Year and "Thaipongal". Pakistan is the primary destination for Sri Lankan betel exports, and the country's export industry has continued to grow, bringing in Rs. 3164.08 million in revenue in 2017 (Custom Report 2017). The consumers prefer Sri Lankan betel because of the high quality, with good appearance and taste. Moreover, soil and climatic conditions prevailing in Sri Lanka are more suitable for betel cultivation. But, most of the Sri Lankan betel growers are disorganized and not properly following the standard production practices recommended by the Department of Export Agriculture (Lakshi *et al*. 2021).

The growing media plays a vital role in improving the vegetative growth in betel stem cuttings. (Usendi *et al*. 2022). Generally, about 50% of the cuttings may not succeed after field planting in betel cultivation in Sri Lanka. The main reason behind the poor success rate is the low quality of planting materi-

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als. The use of quality planting materials is a foundational element in ensuring the success and productivity of betel plants after field establishment. It directly influences growth, disease resistance, uniformity, and overall adaptability, ultimately contributing to a more successful and sustainable betel cultivation. There is a limitation of obtaining good quality planting material from nurseries in sufficient quantities for cultivation. However, betel growers have to face many difficulties in production such as lack of quality planting materials, water scarcity, pest and disease attacks and high cost of fertilizer and agro chemicals (Herath 2015).

Production of nursery plants greatly depends on potting mixture. It directly determines the quality and success rates of the betel nursery plants. Some of the important characteristics of an effective potting mixture are low cost, readily available, good drainage properties (air-filled porosity of at least 15%), optimum pH of range (5.6 - 8.2) and free from pests and disease-causing organisms (Shantha *et al*. 2018). This would improve the vegetative growth of cuttings materials in the potting media and reduces the rate of mortality of plants. The growth performances of nursery plants mainly depend on the potting materials included in the nursery potting mixture. Potting materials are influencing the factors such as nutrient availability, pH and EC levels, water retention, drainage and aeration. There are wide range of materials which can be used as potting materials. Top soil, compost, animal manures (cow dung, goat manure, poultry manure), sand, coir dust, paddy husk charcoal are some commonly used potting materials in nursery potting mixtures.

Department of Export Agriculture (DEA) recommended potting medium for betel nursery production is a mixture of topsoil: sand: coir dust: cattle manure (1:1:1:1). The primary issue with betel nurseries is the lack of essential key potting combination elements, particularly top soil and cow dung. Finding alternative potting mixtures for betel nursery production is really important because it provide opportunity to select wide range of ingredients based on availability and cost effectiveness. There is a lack of comprehensive studies addressing the most effective and sustainable potting mixtures for nursery production of betel. Therefore, there is an urgent need to address this gap and conduct a systematic evaluation of alternative nursery potting mixtures for betel to provide valuable insights for farmers and stakeholders in the betel industry. Therefore, under present study, several nursery potting mixtures were evaluated with the objective of finding out the more effective alternative potting mixtures for nursery production of betel stem cuttings. In general, the alternative nursery potting mixtures which are selected for the present study commonly incorporate materials that are biodegradable, accessible locally, and environmentally sustainable thus leading to a reduction in waste and the optimal utilization of available resources.

MATERIALS AND METHODS

This study was conducted at Intercropping and Betel Research Station, Department of Export Agriculture, at Dampallassa, Narammala. The experimental field located in the Low Country Intermediate Zone (IL1) in Sri Lanka. Eight potting mixtures were prepared using different ratios of topsoil, sand, coir dust, cattle manure, compost, partially burnt paddy husk (PBPH), goat manure, and poultry manure. The DEA recommended nursery potting mixture (T1) was used as the control treatment. The T2 potting mixture, recognized as a promising medium for nursery applications through prior research, was employed in the current experiment to facilitate further examination. Partially Burnt Paddy Husk (PBPH) was chosen as a readily available waste material derived from rice processing. The efficient use of waste materials and the availability of nutrients were the main factors in the selection of animal manures. Furthermore, the proportions of specific potting materials were determined in accordance with findings from previous studies and established literature (table 1).

The experiment was conducted as Complete Randomized Design (CRD) and each treatment consisted 15 nursery pots. Betel (*Piper betle* L.) "Ratadalu" variety was used as the planting material for the study. One nodal, healthy and vigorous semi hard wood betel

Table 1: Nursery Potting mixtures and their proportions

Treatment	Treatment Combination	Proportion
T1	Topsoil: Sand: Coir dust: Cattle manure	1:1:1:1
T2	Topsoil: Sand: Coir dust: Compost	1:1:1:1
T3	Topsoil: PBPH: Cattle manure	1:3:1
T4	Topsoil: PBPH: Compost	1:3:1
T5	Topsoil: Sand: Coir dust: Goat manure	1:1:1:1
T6	Topsoil: Sand: Coir dust: Poultry manure	1:1:1:1
T7	Topsoil: PBPH: Goat manure	1:3:1
T8	Topsoil: PBPH: Poultry manure	1:3:1

stem cuttings were collected from the Intercropping and Betel Research Station, Narammala. Cuttings were obtained from mother vines exhibiting high yield, robust health, and leaves characterized by their larger size and rich, dark green coloration.

Selected betel stem cuttings were treated with 1% Captan fungicide solution to control fungal infections. The prepared potting mixtures were filled into 150 gauge and 8" × 5" size black color polybags which had holes at the bottom for drainage. Media filled polybags were labeled according to the treatments. Planted stem cuttings were kept in a propagator (350 gauge) for three weeks and then transferred in to a shade house with 45% of shade condition, a standard practice commonly applied in betel nurseries.

Electrical conductivity, pH level and nutrient composition (N, P, K) of different potting mixtures were analyzed at the beginning of the experiment. Furthermore, the nutrient composition of the raw materials used to prepare potting mixtures were also analyzed. Numbers of leaves per cutting, shoot length (cm) and shoot diameter (cm) were recorded in weekly as growth parameters. Destructive sampling was done at 9^{th} week after planting and survival percentage, shoot fresh weight (g/plant), shoot dry weight (g/plant), root fresh weight (g/plant), root dry weight (g/plant) and root volume (g/cm3) betel plants were measured respective for each treatment. The collected data were statistically analyzed with ANOVA using Minitab 17 software and means were compared using Tukey test.

RESULTS AND DISCUSSION

Physiochemical parameters

The nutrient composition of different raw materials which used to prepare nursery potting mixtures were summarized in table 2.

Poultry manure contained extensively higher N percentage (0.7%) compared to other potting materials. Moreover, highest P and K contents were also recorded in poultry manure 0.03% and 1.22% respectively. Similarly, according to the nutrient analysis of different locally available manures, highest N (1.8-

Table 2: Composition of nutrients in potting materials

	N%	P%	K%
Compost	0.28	0.02	0.61
Cattle manure	0.34	0.01	0.37
Poultry manure	0.70	0.03	1.22
PBPH	0.17	0.02	0.72
Goat manure	0.29	0.02	0.71

2.4%), P (0.6-1.2%) and K (1.6- 2%) contents were reported in poultry manure (Tennakoon 2003). However, the nutrient composition of organic materials can be varied according to the origin and the location.

The summarized results of pH values, Electrical conductivity (EC) and nutrient composition [Nitrogen (N), Phosphorous (P), and Potassium (K)] of different betel nursery potting mixtures used for the present study are presented in table 3.

Variation of pH level of different nursery potting mixtures

The pH value reflects the acidity or basicity (alkalinity) which is one of the important parameters in crop cultivation. The pH of the soil affects the availability of nutrients to the plant, as well as the activity of microorganisms in the soil. The optimum pH range for betel cultivation ranging from 5.6 to 8.2 (Guha and Jain, 1997). The highest pH value (7.4) was observed in T7 potting mixture, and the lowest values (6.45) were recorded in T2 and T8 treatments. As all the resulted pH values mentioned in table 2 above are ranging from 6.45 to 7.4, it can be suggested that all these nursery potting mixtures contain optimum pH values for betel growth.

Variation of Electrical Conductivity (EC) of different nursery potting mixtures

Electrical conductivity (EC) provides information about the concentration of dissolved salts in the soil and irrigation water which can be simply defined as a measure of the ability of the soil to conduct an electrical current. Electrical conductivity correlates with many of the important soil properties such as cation exchange capacity, organic matter level, drainage conditions, salinity and subsoil characteristics. Typically, a soil/ media with EC less than 1.0 dSm^{-1}, indicates that these soils are free from salinity and can be as very much suitable for cultivation of betel vines. (Kalaivanan *et al.* 2019). In this study, the EC of T1 (Department Recommended potting mixture) and T2 (Topsoil: Sand: Coir dust: Compost at 1:1:1:1 ratio) potting mixtures were found to be less than 1.0 dSm^{-1},which can be considered as potting mixtures which possess optimum soil characteristics for betel production.

Nutrient composition of nursery potting mixtures

Nitrogen (N), Phosphorus (P), and Potassium (K) are three essential nutrients that are important for the growth and development of betel plants. These nutrients play vital roles in various plant physiological processes and are necessary for the production of healthy and high-yielding crops (Kalaivanan *et al.* 2019). Therefore, it can be proved that optimum amounts of macro nutrients such as Nitrogen, Phosphorous and Potassium would enhance the yields and improve the economically important parts of the vine. It was also found that 682.5 kg of Nitrogen as groundnut cake, 56.9 kg P_2O_5 as Super Phosphate, and KCl as Muriate of Potash with basal dressing of 50

Table 3: Properties of different potting mixtures

Parameters	pH	EC (ds/m)	N%	P%	K%
T1	6.55	0.73	0.11	0.01	0.16
T2	6.45	0.98	0.17	0.01	0.14
T3	7.12	1.23	0.22	0.01	0.21
T4	7.26	1.36	0.20	0.01	0.31
T5	7.09	2.05	0.14	0.01	0.23
T6	7.33	4.97	0.17	0.02	0.62
T7	7.40	2.09	0.22	0.01	0.38
T8	6.45	6.61	0.21	0.03	0.67

tons of compost per hectare resulted in better yields of betel leaves in Andhra Pradesh (Bharat, *et al.,* 2016). In Maharashtra, it was observed that application of 200 kg Nitrogen, 50 kg P_2O_5 as Super Phosphate and KCl as Muriate of Potash, resulted in maximum yields of kapoori leaves. (Bharat *et al.* 2016).

As the green leaves of these vines are the economic and beneficial parts of this plant, the Nitrogen requirement for this crop is quite high (Basayake *et. al.* 2005). In Maharashtra, it was found that the maximum yield of marketable leaves was obtained when the vine was treated with 200 kg Nitrogen per hectare via neem cake (Bharat *et al.* 2016). Present study, the Nitrogen content of all introduced nursery potting mixtures was higher compared to the department recommended nursery potting mixture (T1).

Application of 125 kg per hectare of P_2O_5 annually resulted in gaining the maximum height of betel vine and maximum leaf yield along with the lowest incidence of bacterial leaf spot anthracnose and vine rot. (Bharat *et al.* 2016). Betel vine response to phosphorous was positive and those high doses of P_2O_5 at 250 kg per hectare reported to increase the yield of leaves and to reduce the mortality of vines which are caused by foot rot. It was also found that in Maharashtra 100 kg P_2O_5 per hectare significantly increased the yield of betel leaves. (Bharat *et al.* 2016). The T8 potting mixture contained the highest P percentage among the different nursery potting mixtures tested during the study. From initial analysis, it was found that P content of poultry manure was higher comparatively, which was 0.03%. It can be further confirmed by (Bolan *et al.* 2004) in their article shows high availability of N and P in poultry manure, this may be the reason for higher P percentage value recorded the T8 potting mixture.

In Uttar Pradesh, application of potassium at 100 kg per hectare was reported to be sufficient to get the maximum yield with acceptable quality in betel production. (Bharat *et al.* 2016). It was observed that application of potassium at 100 kg per hectare to increase the oil contents and also essential to improve the storage quality of betel leaves. (Bharat *et al.* 2016). Present study, the highest potassium percentage also reported in T8 treatment, which was 0.67% and the lowest found in T4 nursery potting mixture, which was 0.14%. When considering the physiochemical parameters, similar nutrient composition, pH and EC values were observed in department recommended potting mixture (T1) and T2 potting mixture which consist of Topsoil: Sand: Coir dust: Compost at a ratio of 1:1:1:1.

Effect of different nursery potting mixtures on growth parameters

Growth performances of betel nursery plants respected for different potting mixtures were summarized in table 4.

As the leaves are the economically beneficial part of these betel vines, the number of leaves per plant is a very important parameter that should be considered when determining an effective potting mixture for betel cultivation. When considering the results obtained from this study, significantly ($P<0.05$) highest number of leaves per plant (4.33) was recorded in T2 potting mixture (Topsoil: Sand: Coir dust: Compost at a ratio of 1:1:1:1) at the end of the 9th week compared other treatments. Moreover, number of leaves resulted in T2 potting mixture closely followed department recommended potting mixture (T1), which was 4.00 leaves per plant. At 9th weeks after planting, the shoot length of T1 mixture was recorded as the highest, which was 26 cm and the second highest was the T2 potting mixture which was 25.00 cm. However, shoot length at 9th week was not significantly ($P>0.05$) different among these treatments. Shoot diameter was observed to be highest at the end of 9th week after planting in T1 mixture which was 1.67 cm, and the 2nd highest was observed in T2 mixture which was 1.53 cm. Here also, it can be said that all the treatments are not statistically significant ($P>0.05$) from each other.

Destructive sampling was done at 9th week after planting and survival rate, shoot and root parameters of nursery plants were measured in betel plants respective for each treatment.

Table 4: Effect of different potting mixtures on growth performances of betel nursery plants at 5th and 9th weeks after planting

Treat-ment	No. of leaves/plant		Shoot length (cm)		Shoot diameter (cm)	
	5th WAP	9th WAP	5th WAP	9th WAP	5th WAP	9th WAP
T1	2.4±0.55[a]	4.00±1.00[ab]	15.22±3.44[a]	26.00±6.56[a]	1.5±0.31[a]	1.67±0.06[a]
T2	2.4±0.55[a]	4.33±1.15[a]	11.16±5.30[ab]	25.00±8.19[a]	1.48±0.19[a]	1.53±0.12[a]
T3	2±0[ab]	2.67±0.58[abc]	9.06±3.92[ab]	12.83±3.75[a]	1.32±0.28[a]	1.40±0.20[a]
T4	2.2±0.45[ab]	3.00±1.00[abc]	8.2±2.49[ab]	17.67±12.50[a]	1.24±0.34[a]	1.50±0.17[a]
T5	2.4±0.55[a]	3.67±1.53[abc]	9.5±3.66[ab]	23.33±11.02[a]	1.32±0.23[a]	1.33±0.32[a]
T6	2.2±0.84[ab]	2.67±0.58[abc]	11.02±3.71[ab]	18.67±7.57[a]	1.46±0.34[a]	1.43±0.25[a]
T7	1.8±0.45[ab]	1.67±0.58[bc]	7.66±3.36[b]	13.33±5.01[a]	1.28±0.59[a]	1.47±0.25[a]
T8	1.2±0.45[b]	1.33±0.58[c]	3.76±2.58[b]	10.67±3.06[a]	1.08±0.56[a]	1.27±0.15[a]

Table 5: Effect of different potting mixtures on survival, shoot and root parameters of betel nursery plants at 9th Weeks after planting

Treat-ment	Survival rate (%)	Shoot FW (g)	Shoot DW (g)	Root FW (g)	Root DW (g)	Root Volume (g/cm^3)
T1	80.00	7.77±4.29[a]	0.27±0.11[a]	1.62±0.41[a]	0.19±0.05[a]	2.51±0.14[a]
T2	80.00	8.27±3.71[a]	0.27±0.10[a]	1.56±0.55[a]	0.15±0.05[ab]	2.10±0.39[ab]
T3	73.33	2.90±1.05[a]	0.16±0.04[a]	0.72±0.4[a]	0.08±0.04[ab]	1.42±0.36[bc]
T4	73.33	4.68±4.43[a]	0.11±0.05[a]	0.94±0.44[a]	0.10±0.07[ab]	1.35±0.14[bc]
T5	80.00	5.91±2.58[a]	0.17±0.03[a]	0.93±0.13[a]	0.09±0.05[ab]	1.59±0.21[bc]
T6	66.66	3.24±1.54[a]	0.12±0.07[a]	0.57±0.46[a]	0.06±0.03[b]	1.25±0.60[bc]
T7	66.66	3.01±2.14[a]	0.17±0.13[a]	0.59±0.33[a]	0.06±0.02[b]	1.35±0.17[bc]
T8	60.00	2.00±0.26[a]	0.07±0.03[a]	0.45±0.41[a]	0.02±0.01[b]	0.95±0.14[c]

Survival rate of plants is one of the most important parameters need to be considered in nursery management. Higher survival rate (80%) was observed in T1 (control), T2 and T3 nursery potting mixtures of 9 weeks after planting. Lowest survival percentage (60%) was recorded in betel nursery plants in T8 potting mixture. A fungal infection was detected in betel nursery plants. Plants in T6, T7, and T8 nursery potting mixtures exhibiting higher susceptibility. The majority of infected plants in these substrates were died during the experiment. Shoot fresh and dry weights of betel nursery plants were not significantly ($P>0.5$) different among the nursery potting mixtures tested during the present study. However, the highest shoot fresh weight (8.27g) was recorded in T2 potting mixture. Similar shoot dry weights (0.27g) were observed in T2 potting mixture and T1 potting mixture, which is the recommended nursery potting mixture for betel by the Department of Export Agriculture.

Fresh weight of shoots was not significantly (P>0.5) different among the treatments. Highest root fresh weight was recorded in T1 mixture, which was 1.62 g, and the second highest potting mixture was found to be T2 mixture, which was 1.56 g, 9 weeks after planting. Highest root dry weight (0.19g) was recoded in T1 nursery potting mixture. T2 showed the second highest results, which was 0.15 g. Moreover, T2, T3, T4 and T5 potting mixtures were found to be statistically not significant from each other.

Different nursery potting mixtures were differently influenced on root volume of betel nursery plants. Root characteristics also have a significant impact on the success rate of betel nursery plants. Especially nursery plants with good root system can tolerate the transplanting shock and adopt to the field condition properly. The highest root volume (2.51g) was observed T1 mixture and the second highest results were obtained from T2 mixture (2.10 g) which was more similar to T1 (DEA recommendation).

The success and quality of nursery plants primarily depend on the composition of the potting materials present in the nursery potting mixture. Potting materials are influencing the factors such as nutrient availability, pH and EC levels, water retention, drainage and aeration. One of the main sources of nutrients and organic materials is compost. Compost enhances the structure and texture of the soil while releasing nutrients gradually, giving plants a steady and balanced supply of nutrients. In addition, compost introduces beneficial microorganisms to the potting mixture, including bacteria, fungi, and other soil organisms. These microbes play major role in nutrient cycling, organic matter decomposition and disease suppression. Incorporation of compost in potting mixtures was proved to increase the growth performances of many crops. Sulok *et al.* 2021 has confirmed that through the interaction of beneficial microorganisms, biochar, and compost, introducing organic amendments in immature pepper cultivation has reported to increase the yields. It was also found that coir pith compost could be effectively used as potting medium for rooting and also for the establishment of laterals for large scale production of bush pepper (Ramya *et al.* 2017). However, the performance highly depends on the source, composition and quality of the compost. Incorporation of animal manures in potting mixtures reported both positive and negative impacts. The effects depend on the type of animal manure, its source, maturity and its nutrient composition. Animal manures are rich in nutrients and ideal source of N. Improve the physical, chemical characteristics and overall sustainability of soil. However, imbalance nutrients, pH fluctuations and pathogenic contaminations may have negative impacts to plants (Ayantha *et al.* 2000). Utilizing manure that has been appropriately aged and composted helps reduce the negative impacts. To improve drainage in the potting mixture, sand is added. It prevents water from becoming stagnant and reduces the risk of root rot by allowing excess water to drain away. Coir dust has excellent water holding capacity, allowing to retain moisture in the medium while providing good aeration and drainage to prevent water logging condition. Shantha *et al.* 2018 reported that coconut husk and coir dust can absorb sufficient amounts of water and release them slowly to the soil, thus maintaining the optimum moisture requirement and resulted higher growth performances in betel. Paddy husk charcoal has a porous structure, which can enhance the aeration of the potting mixture. It allows excess water to drain away more effectively. This helps to prevent waterlogging and root rot, which can be detrimental to betel plants in nursery stage.

Overall, these alterative nursery potting mixtures often utilize materials which are degradable, locally available and environmentally friendly. Many alternative nursery potting mixtures make use of waste products or by-products that help to reduces waste and maximizes the utility of available resources. Moreover, their utilization has contributed to reduced ecological footprints, lowered greenhouse gas emissions and better utilization of local resources. These potting materials can introduce a diverse range of organic matter and microorganisms to the soil, enhancing soil structure, nutrient availability and microbial activity. Exploring alternative nursery potting mixtures provide opportunity for growers to select wide range of potting ingredients based on the availability and cost effectiveness.

Minimizing the potential influence of environmental factors, including temperature, humidity, and light conditions, is crucial for conducting a controlled and reliable experiment. Present experiment the placement of treatments were randomized within the experimental setup to control any potential micro-environmental variations. The experiment was conducted under shade house and 45% shade net was used to control the light level. However, conducting the experiment under protected house with controlled condition will provide the ability to manipulate and maintain specific environmental conditions to minimizing external influences. Moreover, the current study did not include measurements of the water-holding capacity and drainage characteristics of the potting mixture. Evaluating these factors is crucial for developing an effective irrigation plan that mitigates the risks of waterlogging or drought stress, thereby maintaining optimal moisture levels for betel plants. The current study focused on evaluating the short-term performance of nursery plants in different alternative nursery potting mixtures. However, it is imperative to extend the duration of field trials to thoroughly assess and comprehend the long-term field performances after establishment of these nursery plants.

CONCLUSION

In conclusion, except, T8 potting mixture, other nursery potting mixtures used for the study exhibited similar performances as Department of Export Agriculture recommended nursery potting mixture (T1) for most of the tested parameters. These alternative potting mixtures can be potentially used in betel nursery production depending on the availability and cost effectiveness. Especially, betel nursery plants grown in T2 potting mixture showed more similar performances to Department of Export Agriculture recommended potting mixture compared to other alternative potting mixtures. Moreover, T2 potting mixture is already under consideration of Department of Export Agriculture to recommend for betel nursery production. Unavailability of cow dung is a major limitation in current recommendation of Department of Export Agriculture. Therefore, T2 (Topsoil: Sand: Coir dust: Compost 1:1:1:1) can be recommended as the best alternative potting mixture for nursery production of betel.

AUTHOUR CONTRIBUTION

DMPVD and UGATP designed the study. SAND and DMPVD performed the experiments. SAND, UGATP and GPANW analyzed the data. UGATP and GPANW wrote the manuscript with input from all the authors. All the authors discussed the results and commented on the manuscript.

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