International Journal of Bioorganic Chemistry
2021; 6(2): 14-20
http://www.sciencepublishinggroup.com/j/ijbc
doi: 10.11648/j.ijbc.20210602.11
ISSN: 2578-9384 (Print); ISSN: 2578-9392 (Online)

Determination of Appropriate Compost Based Nursery Media Preparation for Pineapple (*Annanas comosus MERR L.*) Seedling Growth at South Ethiopia

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To cite this article:
Leta Ajema Gebisa. Determination of Appropriate Compost Based Nursery Media Preparation for Pineapple (*Annanas comosus MERR L.*) Seedling Growth at South Ethiopia. *International Journal of Bioorganic Chemistry*. Vol. 6, No. 2, 2021, pp. 14-20.
doi: 10.11648/j.ijbc.20210602.11

Received: July 5, 2021; **Accepted**: July 19, 2021; **Published**: July 24, 2021

Abstract: The experiment was conducted at Awada Agricultural Research Center found at south Ethiopia to determine a proper ratio of compost to top soil ratio that enhanced growth of pineapple at seedling stage. The experiment was arranged in randomized complete block design (RCBD) with three replication. Seedlings were raised from ground slip and planted in plastic pots with width to height (16x22cm) containing compost to topsoil in 0:1, 1:1, 1:2, 1:3, 1:4 and 1:0 ratios as treatments. Seedlings were watered as required and grown for 6 months. determination of pineapple seedling height, leaf length, leaf width, leaf area, leaf fresh weight, leaf dry weight, root number, root dry weight and total plant dry biomass. Data were analyzed using SAS software and means were separated using LSD at 5% probability. The results revealed significant variation among the treatments. All the recorded growth parameters showed progressive increase with increase in the proportion of compost. The compost based nursery media preparation from compost (1:0) and or compost to top soil in one to one (1:1) ratio mixture is performed the best growth of pineapple seedling in terms of plant height, leaf length, leaf width, leaf area, leaf fresh weight, leaf dry weight, root number, root dry weight and total plant dry biomass. Therefore, it is recommendable that compost and or compost to top soil in one to one (1:1) ratio mixture media could be used to grow the best performed pineapple seedling in south ecological zone at nursery level via promoting production and utilization of compost from cheaper locally available materials before transplanting to its production field.

Keywords: Compost, Nursery Media, Pineapple, Seedling, Topsoil

1. Introduction

Pineapple (*Ananas comosus L.*) is a perennial herb in the botanical family of Bromeliaceous, native to the American tropics [1]. Pineapple is one of the horticultural crops and the third most important tropical fruit in the world after banana and citrus [2], contributing to the world's production of tropical fruits by over 20% [3]. Costa Rica, Brazil, Philippines, Thailand and Indonesia are the leading producer of pineapple [4].

In 2019, the global production of pineapples amounted to approximately 28.18 million metric tons. Its sweet taste and high content of vitamin B1; B2, B6 and C are the main reason for its popularity with a protein digesting enzyme that helps digestion at the end of a high protein meal is only found in Pineapple [5]. Pineapple has beneficial health effect on dyspepsia and nausea including morning sickness and motion sickness [6].

Pineapple plants require sandy soils and good drainage to prevent water logging. Well drained loamy soil with high organic matter and a pH of 4.5-6.5 is best for pineapple cultivation [7]. Pineapple plants are rather well adapted to water economy due to morphological, anatomical and physiological characteristics [8]. These include the rosette leaf structure that channels light rains and dew along the stem and into the soil; its ability to absorb water and nutrients through their waxy leaves and aerial roots; its ability to store water in specialized aquifer us leaf tissue; multicellular trachoma's that cover the leaves and protect the plant from excessive transpiration by reflecting radiation; a thick cuticle

covering the leaf epidermis that restricts water loss by evaporation, location of the stomata in furrows at the lower leaf surface where they also are covered by trichomes, limiting evapo-transpiration; and its nocturnal carbon dioxide fixation via the crassulacean acid metabolism (CAM) carbon assimilation pathway, which results in stomata opening primarily at night when evaporative demand is lowest [8]. The pineapple can be cultivated in a single cycle or in one or more additional ratoon cycles. The duration of the cycles is variable, depending on environmental conditions, vigor of planting material and the cultural practices applied. In the tropical region of Brazil, which is representative of many pineapple growing areas in the world, the first cycle lasts 14 to 18 months, whereas the ratoon cycles are shorter, taking, in general, about 12 to 14 months [9] As a typical tropical species, pineapple plants show adequate growth and produce fruits of good quality when grown at air temperatures of 22 to 32°C with daily amplitude of 8 to 14°C [10].

In developing countries like Ethiopia, it is produced by small holder farmers on pieces of land mainly in south and south-western parts of the country. According to the key informants the introduction of pineapple in the study area, Aleta Chiko district of Sidama Region (southern Ethiopia), traced back in the 1940's where the plant introduced by a religion church for the first time. Since then, cultivation of the plant intensified and now farmers of three peasant associations in the district (Gambella, Teso and Dibicha) highly depend on cultivation of pineapple in traditional agro forestry system. In these areas farmers usually use soil mixes to raise seedlings which can prompt soil borne pests and diseases [11] and stunted growth that lead less yield. According to [12] in Ethiopia, pineapple was planted by 70,584 farmers on more than 645.2ha. The average yield of the crop is in the country is low (about 45 tons/ha) as compared to global average (67.5 tone ha^{-1}) partly due to low fertility status, lack of improved pineapple technologies for diverse environmental conditions, longer maturity, poor marketing system, presence of diseases and insect pests, and lack of improved post-harvest handling technologies [13]. Besides, lack of sufficient information on the nutritional requirement at seedling stage in nursery before transplanting to the permanent fields, and non-availability of planting material contribute low yield [14]. Different research studies have been conducted in Ethiopia to determine the rate of pineapple required nutrients under field conditions. [15], determined 281.00 $kgNha^{-1}$ and 134.80kg $P_2O_5ha^{-1}$ application rate at Jimma Agricultural Research Center were promising. But, there is still a gap of information on the best soil growth media and appropriate planting material used to raise the pineapple seedling at the nursery stage.

Farmers in the southern Ethiopia use different parts of pineapple like ground sucker, slips, and also crown sucker to transplant to the permanent fields. Some farmers are used to apply organic fertilizers like animal dung at its early growth stage [14] and others use compost to raise the seedling before transplanting to the permanent field. The surrounding farmers traditionally use mixture of compost and soil (1:3 ratios) to raise pineapple seedlings though proportion has not been established via scientific investigation. However, farmers use different proportion of compost and soil which need to be determined scientifically for better productivity. Therefore, this study was proposed at determining the compost to top soil ratio growth media that promote better pineapple seedling growth at nursery stage that can reduce the seedling production constraints in the study area.

Finally, this paper provides essential information that improves the knowledge and understanding on the effects of compost on *A. comosus* var. smooth cayenne seedling production plants and thus allows the usage of nursery produced pineapple plants to be recommended for commercial production.

2. Material and Methods

2.1. Description of Study Area

The study was conducted at Awada Agricultural Research Sub-Center (AARSC). AARSC is situated in the moderate to cool semi-arid mid highland agro-ecology of south Ethiopia [16]. It is located at 6°3'N Latitude and 38°E Longitude at an altitude at an elevation of about 1740 meter above sea level. The area has a semi-bimodal rainfall distribution characterized by double wet and dry seasons with an average precipitation of 1342 mm per annum, while the annual average minimum and maximum air temperatures are 11°C and 28.4°C, respectively. The major soil types of the center are *Nitisol*and chromatic-cambisols that are highly suitable for maize, banana, pineapple and coffee production [16].

2.2. Top Soil and Compost Preparation

Top soil was collected from the surface of cultivable lands at 0-15cm depth, dried crushed by pestle and mortar and sieved by 2mm mesh sieve. Compost was also prepared from locally available materials: maize straw, ash, and farm yard manure following the conventional compost preparation method [17]. A pit with 1mwidth and 1m depth was prepared to prepare the compost. Maize straw was added at the bottom of the prepared pit for keeping good ventilation; immediately on the maize straws, fresh coffee husk and pineapple residue was added to a thickness of about 20cm.

Farmyard manure was added in 5cm thickness to accelerate composting process and make the compost to have better nutritional composition and have abundant microorganism. On top of farmyard manure thin layer of forest soil added up to 3cm thickness to introduce beneficial microorganisms for decomposition [18]. Water was sprinkled after each layer as required to make the layers moist but not wet or soggy. The steps were repeated until the pit filled with the composting materials.

At the end the pit was covered with broad leaves (Banana leaf). Every 21 days, the materials were mixed and turned to next pit. After three times turning, i.e. after 63 days the compost was well decompose and ready as suggested by [17]. After that, the prepared compost was air dried under shade,

crushed, into powder and screened through 2 mm sieve and applied to the experiment. The media was thoroughly mixed with compost following the adjusted ratio for each treatment.

2.3. Preparation of Pineapple Planting Material

For this study, the improved pineapple variety (*Smooth cayenne*) ground slip was used as the seedling source. The selected plants were collected from the seed orchard found at the center and their leaves were cleaned by cutting off the entire length of leaves except for the basal sheath portion, peduncle and roots. The selected slips were sectioned into two and prepared for plantation on the prepared soil-based nursery growth media. Selection of plants supplying stems, harvest and preparation of the stems, sectioning, sanitary treatment of the sections, preparation of the nursery beds and the stem sections were planted in the green house. After planting the nursery beds were kept under humid conditions. In most situations regular irrigation was made at least once a day.

2.4. Soil and Compost Laboratory Analyses

Topsoil and compost samples were subjected to physical and chemical analysis before conducting the experiment. The pH of the soil and soil-compost mixture was determined using 1:2.5 soil or compost ratio of water suspension method by using a pH meter. Organic Matter (OM) determined by wet digestion method [19] and percent of Organic carbon (OC) was obtained by dividing percent soil OM by a factor of 1.724, following the assumption that OM is composed of 58% carbon [20]. Total nitrogen was analyzed using the Kjeldahl method [21]. Potassium (K) was determined by using ammonium acetate extraction method. Available phosphorus was determined by Olsen method [22]. The absorbance of available phosphorus extracted by method was measured using spectrophotometer after color development.

2.5. Experimental Design and Treatments

The study was arranged in a randomized complete block design (RCBD) with three replications and six treatments. Six treatment combinations of compost to topsoil ratio in (Top soil only, One to one, one to two, one to three, one to four and Compost only) ratios by (v/v) (Table 1). Polyethylene bags (16x22 cm) were used for each treatment. The top soil (0:1) were used as a control for the treatments. Top soil was mixed with compost in various ratios according to the desired treatment and filled into the pots. The plots were arranged four rows with five plants per row with three hundred sixty samples. The pots filled with media were arranged on the nursery bed following treatment randomization. All management practices like weeding, watering, were applied throughout the study period until the seedling attains its transplanting stage.

Table 1. *Treatment combinations and experimental design.*

Code	Compost Ratio	Description of treatments
T1	Top soil	Top soil (control)
T2	1C:1TS	One to one ratio of compost to top soil
T3	1C:2TS	One to two ratios of compost to top soil
T4	1C:3TS	One to three ratios of compost to top soil
T5	1C:4TS	One to four ratios of compost to top soil
T6	Compost	Compost only

T=treatments C= compost TS=top soil

2.6. Plant Growth Conditions

After The stem section of pineapple was planted in the nursery bed that was kept under humid conditions. In most situations regular irrigation was made at least once a day and grown for 6months (November 2019-April 2020). There was no any disease symptom encountered throughout the study period. All management practices (weeding and watering) were applied throughout the study period.

Table 2. *Mean monthly maximum and minimum air temperature of the study area.*

Months	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	August	September	October
Minimum	5.00	4.00	6.00	7.00	10.00	10.00	7.00	7.00	9.00	12.00	11.00	7.00
Maximum	14.00	11.00	17.00	16.00	23.00	20.00	20.00	18.00	26.00	29.00	25.00	20.00
Mean	9.50	7.50	11.50	11.50	16.50	15.00	13.50	12.50	17.50	20.5	18.00	13.50

Source: Awada Agro-meteorology station data, (2020)

2.7. Data Collection

2.7.1. Shoot Extension Growth

Pineapple seedling growth parameters were recorded using appropriate measurement materials. Accordingly, plant height was measured for each seedling in a plot using meter tep. Then mean heights were calculated and the results expressed in centimeters per seedling. Shoot and root parts of the seedlings were separated by cutting plant at the collar point using scissors and their fresh weights were measured by sensitive balance and expressed in gram per plant.

2.7.2. Root Extension Growth

The pot containing the roots of pineapple seedlings were immersed in running tap water and roots were carefully separated from the soil still being in the water. Then, the roots were washed with clean water and dried with water adsorbent cloth and fresh weight of roots (g) was measured using sensitive balance. The number of root was counted in number.

2.7.3. Dry Biomass

All plant parts (leaves and roots) were separately placed in labeled paper bag and dried in oven dry at 70°C until the constant weight and dry matter yield was measured for each sample using sensitive balance. The total dry matter yield of the seedlings was also determined.

2.8. Data Analysis

All the measured seedling growth parameters were summarized and subjected to analysis of variance (ANOVA) or one way ANOVA appropriate to RCBD using the General Linear Model (GLM) of Statistical Analysis System (SAS) software version 9.3 [23]. List Significant difference (LSD) at 5% probability level was used for mean separation.

3. Result and Discussion

3.1. Soil Physico-Chemical Properties

The initial soil characterizations result showed that the sand content of the soil was 63%, while clay and silt contents were 26 and 11%, respectively (Table 3). Accordingly, the textural class of the study soil was sandy clay loam. The soil had pH of 4.82, thus, the soil reactions fall under strongly acidic category [24]. Therefore, under very acidic conditions, the soil solution might be occupied mostly by aluminum and hydrogen ions which has a direct effect on crop growth by suppressing the root development and reducing the availability of macronutrients to plants especially phosphorus, which is readily available under medium pH range [25]. The results of present study were almost in line with the findings of [26] who reported a pH of 4.90acidity statuses for Awada research sub-center. Soil Total nitrogen, organic carbon, and available phosphorus contents of the soil were 0.30%, 2.81%, and 19.48 ppm, respectively.

Table 3. *Selected physicochemical properties of growth media (Top soil and Compost).*

S. N	Parameter	Topsoil	Compost
1	Sand (%)	63	-
2	Clay (%)	26	-
3	Silt (%)	11	-
4	Textural class	Sandy clay loam	
5	pH (H_2O)	4.82	6.73
6	Organic carbon (%)	2.81	4.55
7	Organic matter (%)	4.84	7.85
8	Total Nitrogen (%)	0.31	0.36
9	Available phosphorus (ppm)	19.48	71.25
10	C: N ratio	9.10	12.63

3.2. Seedling Growth Indicating Parameters

3.2.1. Plant Height and Leaf Length

Average plant height was very highly significantly (P<0.001) affected by treatments (Table 4). The growth medium prepared from compost alone gave the largest plant height (12.83cm) followed by the one to one ratio of compost to topsoil (11.19cm) used to raise pineapple seedling which were statistically different from each other as well as those grown in lower ratio of compost to top soil with the corresponding values of (9.85cm), (9.83cm), (9.82cm) and (9.77cm), respectively (Table 4). Therefore, this study indicates as the media composition could significantly affected seedling heights of pineapple. [27], also found the significant differences in seedling height between media with organic manure and media without organic manure. The study was also in line with [28] that indicated the seedlings transplanted on growth media with organic manure were generally higher than those transplanted on the media without organic manure.

Table 4. *Plant height and leaf length of pineapple eedling grown in different topsoil: compost ratios.*

Treatments	Plant height (cm)	Leaf length (cm)
Compost	12.83^{a}	31.52^{a}
One to one	11.19^{b}	29.50^{ab}
One to two	9.85^{c}	27.59^{bc}
One to three	9.83^{c}	27.56^{bc}
One to four	9.82^{c}	27.42^{c}
Top soil	9.77^{c}	27.11^{c}
CV (%)	4.69	3.97
LSD (0.05)	0.901	2.05

Means with (In the column raised to) the same letter are not significantly different at P<0.001 and P<0.01

The effect of compost to topsoil was also showed highly significant variation (P<0.01) for average Leaf length of pineapple seedlings. The medium used to raise the seedling from compost alone resulted in larger leaf length of (31.52cm), that were statically different from the medium prepared from one to one, one to two, one to three, one to four ratio of compost to topsoil and topsoil only with the corresponding value of (29.50cm), (27.59cm), (27.56cm), (27.42cm) and (27.11cm), respectively (Table 4). It gave better structure to the soil, provided energy for the microbial activity which is essential for recycling of nutrients affected the nutrient availability like N, P and K. This observation may be attributed to organic matter impact acting as auxin in stimulating growth in plant [29] and was also in line with [30] who established that organic manure application increases leaf numbers and growth capacity of plants. [31], observed increment in pineapple height and leaf length when nourished with organic matter.

3.2.2. Leaf Width, Leaf Number and Leaf Area

Analysis of variance revealed that, the seedling growth media prepared from compost to topsoil ratio showed highly significantly (P<0.01) and very highly significantly (P<0.001) affected leaf width and leaf area of pineapple seedlings respectively. The highest leaf width (4.78cm) and (4.21cm) were recorded for compost alone treatment and compost: soil one to one ratio, respectively though the results were statically similar, while the lowest leaf width (2.76cm) was recorded for seedlings grown in soil alone (Table 5). The leaf number of pineapple seedling was ranged from 20.66 to 20.40 but not statically varied among the treatments. The medium prepared from only compost resulted in maximum leaf area (102.29cm^2) which significantly higher than other treatments (p<0.001). Leaf area for the treatments was varied from 55.88 to 51.41 cm^2; (Table 5). When this happen the plant leaf is more exposed to sunlight which enables it to synthesize more protein through chlorophyll. This observation was in line with [32] who reported increment in width of seedling leaf of pineapple grown in soil with organic

manure medium.

Table 5. *Leaf width, leaf number/plant, and leaf area of pineapple seedlings grown in different medium.*

Treatments	Leaf width (cm)	Leaf Number/plant	Leaf Area (cm^2)
Compost	4.78[a]	20.66[a]	102.29[a]
One to one	4.21[ab]	20.55[a]	55.88[b]
One to two	4.00[b]	20.54[a]	52.35[b]
One to three	2.79[c]	20.50[a]	51.91[b]
One to four	2.78[c]	20.48[a]	51.88[b]
Top soil	2.76[c]	20.40[a]	51.41[b]
CV (%)	13.10	0.73	14.25
LSD (0.05)	0.742	0.27	15.81

Means with (In the column raised to) the same letter are not significantly different at p<0.01 and p<0.001

3.2.3. Average Root Number Per Plant and Root Length

The analysis of variance (ANOVA) indicated that root number of pineapple seedling was significantly (P<0.05) affected due to the application of compost or compost and soil mixture (Table 6). Statically the highest mean root number was recorded from the plot treated compost alone (18.47) compared to the seedling raised on the mixture of one to one (17.89), one to two (17.58), one to three (17.49), one to four (17.43) compost to soil ratios and only topsoil (17.40) (Table 6). This observation agrees with [28] who reported that better relationship between organic manure and rooting rather than conventional soil mix and less pre-dispose the seedlings to soil borne pests and diseases. The root length of pineapple seedling was not statically varied among the treatments.

Table 6. *Root number and root length of pineapple seedling exposed to different treatments.*

Treatments	Root Number	Root Length (cm)
Compost	18.47[a]	11.88[a]
One to one	17.89[ab]	11.85[a]
One to two	17.58[ab]	11.83[a]
One to three	17.49[b]	11.83[a]
One to four	17.43[b]	11.82[a]
Top soil	17.40[b]	11.77[a]
CV (%)	2.88	0.53
LSD (0.05)	0.93	NS

Ns = non-significant difference. Means with (In the column raised to) the same letter are not significantly different at p<0.05

3.2.4. Leaf Fresh and Dry Weight

Leaf fresh and dry weights of pineapple seedling were very highly significantly (P<0.001) higher for those grown in compost alone than the other treatments (Table 7). These weights had progressively decreased as the proportion of compost decreased. The largest leaf fresh weight was collected from the medium prepared from only compost (128.62g) while the medium prepared without compost resulted in the minimum leaf fresh weight (89.36g) (Table 7). Compost releases nutrients which are useful for the normal growth of plants in the meantime it increases the whole plant biomass. The same is true for leaf dry mass as that of leaf fresh mass. It is due to the readily available nutrients for the plant that increases plant biomass in the compost than the control. This observation agrees with [33] who reported that carbonated coffee husk acts as soil conditioner by supplying and retaining nutrients that in turn improves the Physico-chemical properties of the soil would be reasonable for the increased pineapple seedling leaf fresh weight.

Table 7. *Leaf fresh and dry weight of pineapple seedling grown under different treatments.*

Treatments	Leaf fresh weight (g)	Leaf dry weight (g)
Compost	128.62[a]	30.04[a]
One to one	106.66[b]	21.66[b]
One to two	93.23[c]	17.66[c]
One to three	92.19[c]	10.22[c]
One to four	91.06[c]	10.11[c]
Top soil	89.36[c]	9.94[c]
CV (%)	4.36	10.94
LSD (0.05)	7.95	3.30

Means with (In the column raised to) the same letter are not significantly different at p<0.001

3.2.5. Average Root Fresh and Dry Weight

Root fresh weight of pineapple seedling was very highly significantly (P<0.01) affected by the treatments. The largest and significantly different root fresh weight was collected from the medium prepared from only compost (3.55 g) treatment followed by (2.72g) one to one ratio of compost to top soil prepared medium (Table 8). One the other hand, the minimum root fresh weight (1.95g) was recorded for medium prepared without compost. The root dry weight of pineapple seedling was also very highly significantly (P<0.001) affected by the treatments (Table 8). The largest root dry weight was collected from the medium prepared from only compost (0.79g) followed by one to one compost to soil ratio (0.60g). One the other hand, the medium prepared without compost resulted in the minimum root dry weight (0.39g) (Table 8). This might be due to amendment by organic media, which improved soil physical and chemical condition thus favored to increase in the root dry and fresh weights. The differences in root weight might be due to differences in leaf growth and supply of photosynthetic products to the roots [34].

Table 8. *Root fresh and dry weight, and Total dry weight response of pineapple seedlings to ratio of various compost to topsoil application treatment.*

Treatments	Root fresh weight (g)	Root dry weight (g)	Total plant dry biomass (g)
Compost	3.55[a]	0.79[a]	30.85[a]
One to one	2.72[b]	0.60[b]	22.26[b]
One to two	1.99[c]	0.60[b]	18.26[c]
One to three	1.95[c]	0.43[c]	10.65[d]
One to four	1.91[c]	0.40[c]	10.52[d]
Top soil	1.87[c]	0.39[c]	10.34[d]
CV (%)	12.55	4.52	10.62
LSD (0.05)	0.53	0.044	3.31

Means with (In the column raised to) the same letter are not significantly different at p<0.01 and p<0.001

Total plant dry biomass of pineapple seedling was very highly significantly affected by compost and top soil applications ($P<0.001$). Similar to the other growth indicating parameters, the largest (30.85g) total dry biomass was record grown in Compost alone followed by one to one ratio of compost to top soil ratio (22.26g) (Table 8). The minimum value was (10.34g) recorded for seedlings grown in soil alone. The result was in line with [35] that reported the compost application showed higher dry matters of leaf, stem, and total biomass production compared with no compost application. It is due to the readily available nutrients for the plant that increases plant biomass in the compost than the control.

4. Conclusion and Recommendation

4.1. Conclusion

The nursery media composition used for this trail was influenced the growth performance of pineapple seedling at nursery stage before transplanting to the permanent field. The result generated from this work, indicate that, there isa significant differences among the treatments used (compost, a ratio of compost to top soil and topsoil only) growth media used to raise the pineapple seedling in plant height, leaf length, leaf width, leaf area, leaf fresh weight, leaf dry weight, root number, root dry weight and total plant dry biomass. Media composition (compost alone) used for this trail enhanced the growth performance of pineapple seeding at nursery stage better than other treatments and growth indicators of the plant progressive declined with decline in the proportion of the compost indicating the positive impact of compost on soil physical and chemical properties that intern leads to improvement in plant growth. The results revealed significant variation among the treatments that indicated, the soil-based nursery media of compost (1:0) and (1:1) ratio of compost to topsoil responded the best growth of pineapple seedling in terms of plant height, leaf length, leaf width, leaf area, leaf fresh weight, leaf dry weight, root number, root dry weight and total plant dry biomass. The overall results revealed that media supplemented with compost gave higher parameters of growth compared to media without compost.

4.2. Recommendation

1) This result suggested that compost should be mixed in media to attain better growth of pineapple seedling before transplanting to the permanent fields.
2) Farmers should use compost or its mixture with soil for better growth of pineapple seedling at nursery stage. Thus, large scale compost production and utilization should be promoted and encouraged as higher compost to soil ratios promote better plant growth.
3) Therefore, it is recommendable that compost and or compost to top soil in one to one (1:1) ratio mixture media could be used to grow the best performed pineapple seedling in south ecological zone.

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