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## Research Article

# Growth Performance of Cocoa (*Theobroma cacao*) Hybrid Seeds in Different Media

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## Abstract

**Background and Objective:** Topsoil scarcity is among the top priority problems faced by cocoa nursery managers in the era free cocoa seedlings distribution to cocoa farmers in Ghana. The study sought to find a substitute media for nursing seedlings of hybrid cocoa seeds since the topsoil in most part of the country has lost its fertility due to erosion while others have become acidic through the excessive application of inorganic fertilizers. **Materials and Methods:** The materials used for the experiment included cocoa hybrid seeds, polybags, ruler and a pair callipers. The experiment was laid out in a randomized complete block design. The study involved the use of 3 media (treatments) with 3 replicates. The treatments were topsoil (TS) (100 v), topsoil+sawdust (TSS) (50:50 v) and topsoil+poultry manure (TSP) (50:50 v). Ten polybags were filled for each treatment, making a total of 90 filled polybags and 2 seeds sown per polybag. Sixty seeds were used for each treatment making a total of 180 seeds for the study. Watering was carried out every morning for a period of two months. The experiment was carried out under a shade net allowing sufficient sunlight through. **Results:** Emergence rate was taken after two weeks of germination while survival rate was also taken at the fourth week. Data on height and diameter of seedlings were analyzed using analysis of variance (ANOVA). In terms of emergence, the soil amended treatments (TSS and TSP) exhibited higher emergence ability than the control (TS), however, they were not significantly different ( $p > 0.05$ ). The TS medium recorded the highest mean height for the four weeks period followed by TSS medium, however there was no significant difference between TS and TSS ( $p > 0.05$ ) but there was a significant differences between TS and TSP media ( $p < 0.05$ ). With regards to diameter, though TS recorded the highest diameter over the soil amended treatments (TSS and TSP) but there were no significant difference among them ( $p > 0.05$ ). Survival rate was highest in the TS medium 91.67% followed by TSS (78.33%) and lastly the TSP medium (53.33%). **Conclusion:** From the results, it is concluded that topsoil amended with sawdust (TSS) can support the growth of the hybrid cocoa (*Theobroma cacao*) seedlings and could be used as substitute to topsoil (TS).

**Key words:** Cocoa seeds, topsoil (TS), topsoil sawdust (TSS), topsoil+poultry manure (TSP)

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**Competing Interest:** The authors have declared that no competing interest exists.

**Data Availability:** All relevant data are within the paper and its supporting information files.

## INTRODUCTION

Family sterculiaceae and genus *Theobroma* is where cocoa tree belongs. The original habitat of it is the lower storey of the evergreen rainforest, native to the deep tropical regions of Central and south America. It contains important nutrient elements and several minerals including phosphorus, potassium, calcium, copper, magnesium, sodium and zinc<sup>1</sup>. Cocoa powder and chocolate are made from its seeds<sup>2</sup>. Cocoa trees grow best in humid areas at temperatures ranging between 18-32°C (65-90°F) and this is due to the fact that they are tropical plants<sup>3,4</sup>. Cocoa trees normally grow in areas where humidity range between 70-80% and the day time humidity extends up to 100%. Cocoa plants require deep, well-drained and fertile soil with a pH of 5.0-7.5 for optimum growth<sup>5</sup>.

Cocoa seeds obtain from ripe, healthy pods stay viable for three weeks and are normally planted directly after harvest to generate new seedlings. Cocoa seeds are planted in plastic bags or fibre baskets filled with fresh soil and situated in a shaded location shielded away from the scorching. Meanwhile, cocoa cultivation can also be propagated vegetative through marcotting, budding and cuttings<sup>6</sup>. After 4-6 months, the seedlings grow quickly and are set to be transplanted. Seedlings are normally planted in the soil when they are 4-6 months old. The young cocoa trees are fragile and they need some protection against direct sun rays and strong winds. Cocoa is Ghana's most important export and remains a critical livelihood activity for many Ghanaians<sup>7</sup>, providing employment for over 30% of the population<sup>8</sup>.

As international demand for cocoa remains high, it is necessary to ensure a sustainable future supply. In Ghana, plantations of cocoa have been established through seedlings raised in the nursery with only topsoil as the growth media and these soils are either suitable or moderately suitable<sup>9</sup>. Meanwhile, the topsoil in most part of the country are scarce and also has lost its fertility through erosion. Consequently, the use of expensive inorganic fertilizers to amend these soils often increases the cost of production of cocoa and unsafe for the environment or health. Again, the current directive from Ghana Cocoa Board to the Seed Production Division (SPU) is to raise 20 million seedlings each year. As a result of the new emphasis on cocoa rehabilitation in the country, there will be the need to increase cocoa seedling production and this will require large quantities of soil for nursery work.

However, excessive scraping of the topsoil to meet this demand will eventually result in serious degradation of productive farmlands since suitable land is limited as a result of climate change and majority of the remaining land is not

suitable for raising cocoa seedlings. Hence, the major problem associated with the use of topsoil as seedling medium is scarcity<sup>10</sup>. This scarcity has led to use of various alternatives and mixtures of other media with topsoil for nursing seedlings of other crops such as coconut<sup>11</sup>. Nevertheless, some studies on the germination and early seedling growth of cocoa have been carried out<sup>12-14</sup>. The main focus of this study is to find out whether the mixture of topsoil and sawdust or poultry manure will support the growth of cocoa hybrid seeds in order to get a substitute media in cocoa nursery management. The objective of this study was to determine the effect of the soil amendments (sawdust and poultry manure) on the germination of the cocoa hybrid seeds and also survival rate of cocoa hybrid seedlings in the different media.

## MATERIALS AND METHODS

**Description of study area:** The experiment was conducted at the experiment was within the nursery premises of the Cocoa Health and Extension Division (CHED) District in Adjoafua at Bia west district of Western Region, Ghana (lat. 6.6547'N, long. 3.0176'W, altitude 206 m above sea level). The study commenced on March, 2018 and ended on June, 2018.

**Experimental materials:** The materials used included a field note book and pencil for taking records of data, Personal protective equipment (PPE's) such as the goggles and nose mask, ruler and a pair callipers for the measurement of seedling height and diameter, respectively. Also, polybags were used for holding the different growth media, shovel and wheel barrow for the collection and carrying of growth media.

**Collection and preparation of material:** Sawdust was collected from sawmills in the Adjoafua district. Sawdust from soft woods was collected and this is due to the fact they decompose better than that of hard woods. Poultry manure was also collected from the poultry house within the district using shovel and wheel barrow while having the appropriate PPE's on (reflectors, hand gloves, goggles and nose mask).

**Seed source:** The cocoa hybrid pods were collected from the seed production division station at Sefwi Boako, Western Region of Ghana and the bad ones were sorted out.

**Experimental design and treatment:** The experiment was laid out in a randomized complete block design. Nursery bags (polybags) were first perforated at the bottom with a

perforator to create a 4 cm<sup>2</sup> hole to facilitate drainage of excess water before filling with the respective media. The study involved the use of 3 media (treatments) with 3 replicates. The treatments were topsoil (TS) (100 v), topsoil+sawdust (TSS) (50:50 v) and topsoil+poultry manure (TSP) (50:50 v). Ten polybags were filled for each treatment, making a total of 90 filled polybags and 2 seeds sown per polybag. The polybags were then arranged on thick polythene sheet to prevent the growth of the roots into the ground and to avoid possible uptake of nutrients. About 60 seeds were used for each treatment making a total of 180 seeds for the study. Watering was carried out every morning for a period of 2 months. The experiment was carried out under a shade net allowing sufficient sunlight through.

**Data collection:** After two weeks of sowing, data was collected on the number of germinated seeds from the different media. After two weeks of germination, simple random was used to select the seedling to be measured. Data on total height and diameter of seedlings was collected at every week for a period of 4 weeks. The height measurement was done by laying the ruler along the stem of the seedling and recordings (centimetres) were made in a field note book. A pair of callipers was used in taking seedling diameter every week. These were also recorded (centimetres) in the field note book.

**Statistical analysis:** Data was analyzed using Microsoft Excel 2016. The mean number as well as the standard error was evaluated. The data was subjected to the analysis of variance (two-way ANOVA) at  $p < 0.05$  to test the significant difference between the media based on the measured parameters.

## RESULTS

**Rate of emergence of the seedlings:** The TSS medium recorded the highest emergence percentage (21.67%) after 2 weeks of planting the seeds. The lowest emergence percentage was recorded in the TS medium (13.33%) and it was significantly different from the other treatments (TSS and TSP) ( $p < 0.05$ ) (Fig. 1).

**Mean height of the seedlings for all the weeks:** In week 1, TS medium recorded the highest mean and it was 17.69 cm and least mean height of 10.92 cm was recorded in the TSP medium. At week 2, TS medium recorded the highest mean height of 23.56 cm and the lowest mean height was recorded in the TSP medium (14.17 cm). At week 3, the TS medium

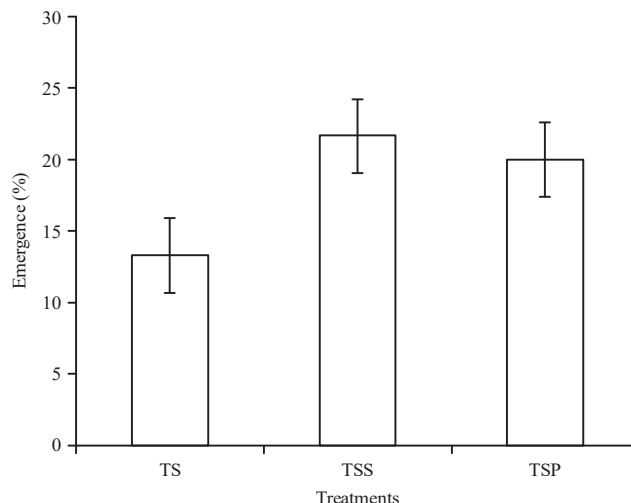


Fig. 1: Emergence of *Theobroma cacao* hybrid seeds (%) in the three media

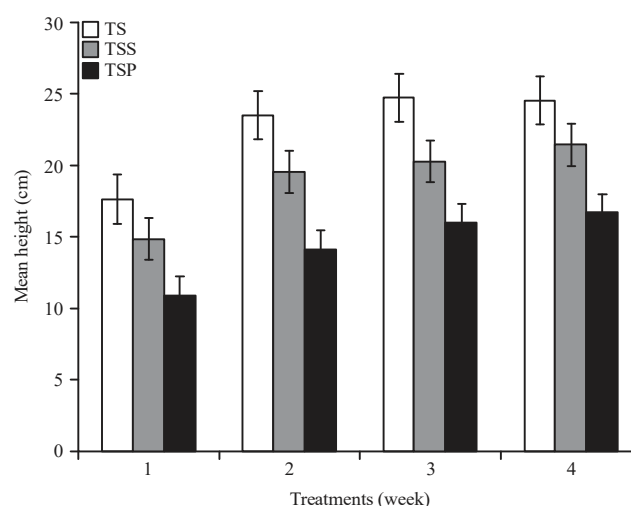


Fig. 2: Mean heights of *Theobroma cacao* hybrid seedlings in the three media through the weeks

recorded the highest height of 24.81 cm and the lowest mean height of 16 cm was recorded in TSP. At week 4, the highest mean height of 24.64 cm was recorded in TS medium and the least mean height of 16.7 cm was recorded in the TSP medium (Fig. 2). At the 4th week, the TS height recorded was significantly different from TSP ( $p < 0.05$ ) but was not significantly different from TSS ( $p > 0.05$ ).

**Mean diameter of the seedlings for all the weeks:** The highest mean diameter of 21.42 cm was recorded in TS medium while the least mean diameter of 18 cm was recorded in the TSP medium at week. At week 2, TSP medium recorded

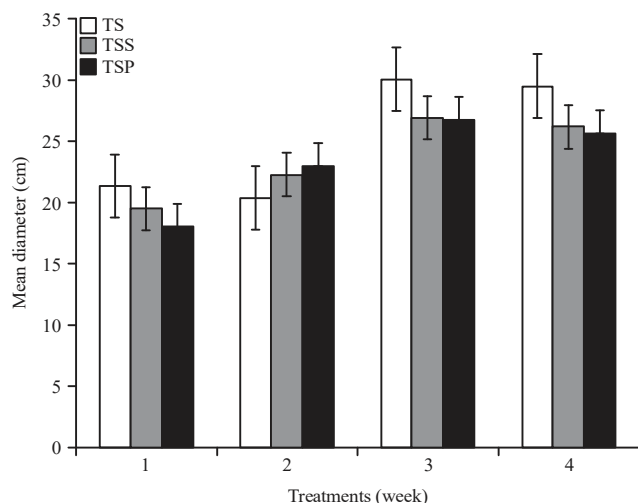


Fig. 3: Mean diameter of *Theobroma cacao* hybrid seedlings in the three media through the weeks

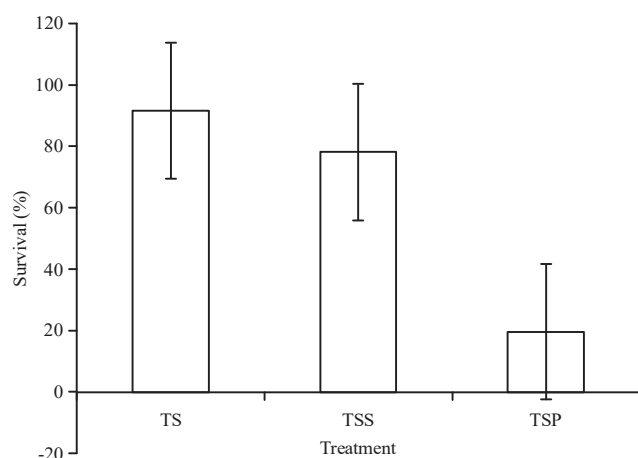


Fig. 4: Survival of *Theobroma cacao* hybrid seedlings (%) in the three media

the highest mean diameter of 22.98 cm and the lowest mean diameter was recorded in the TS medium (20.42 cm). At week 3, the TS medium recorded the highest diameter of 30.10 cm and the lowest mean diameter was also recorded in TSP (26.72 cm). At week 4, the highest mean diameter of 29.56 cm was recorded in TS medium and the least mean diameter of 25.63 cm was recorded in the TSP medium (Fig. 3). Though TS recorded the highest diameter over the soil amended treatments (TSS and TSP) but there were no significant difference among them ( $p > 0.05$ ).

**Survival rate of the seedlings:** As recorded from Fig. 4, the highest survival rate for the hybrid cocoa seedlings was

recorded in the TS (91.67%) and least percentage (53.33%) was recorded of seedlings in TSP. The TSS survival rate was not significantly different from TS ( $p > 0.05$ ) but TSP survival rate was significantly different from TS ( $p < 0.05$ ).

## DISCUSSION

The soil amended media (TSS and TSP) exhibited higher emergence rate as compared to the control (TS). This result is in line with Ndubuaku *et al.*<sup>15</sup>, who reported higher seedlings emergence rate for *Moringa oleifera* on sawdust and poultry manure mix media as compare to the control medium (topsoil). The higher seedlings emergence rate recorded for the TSS and TSP media may be attributed to the available well decomposed organic matter which might have preserve soil humidity, increase nutrient content and improve soil structure which tends to increase water absorption and maintain cell turgidity, cell elongation and increase respiration at optimum level leading to favourable seed sprouting.

The study revealed that the control treatment (TS) recorded the highest mean height followed by TSS and then lastly TSP throughout the weeks of the experiment. It appears that mixing sawdust with the soil reduced nutrient leaching to an extent. It is likely that the sawdust component increased the soil's water holding capacity and interfered with rapid soil water movement thereby preventing rapid leaching of soil nutrients. Previous studies on blueberry bushes indicates that microbe activity increases with increasing proportions of sawdust in a soil-sawdust mixture and it is also on record that high microbe activity leads to increased rate of soil N depletion<sup>16</sup>. That may explained why the TSS medium recorded a higher mean height as compared to the TSP medium. The TSP medium recorded the least mean height throughout the weeks of the experiment.

Diameter was highest in treatment TS during the first week but the TSP treatment recorded the highest diameter during the second week. Similar result was also reported by Supriyanto *et al.*<sup>17</sup> working on orange seedling that media containing manure produced the growth and roots better than those containing sawdust and rice hulk. Purbiati *et al.*<sup>18</sup> also proved that soil+manure (1:1) was the best medium for the growth components of *Salacca* cv. The impact of the TSP treatment increased during the second week because the decomposition process had started and additional nutrient elements from poultry manure was available to be used by the seedling to grow. In all, the TS media perform best in terms of diameter. Some soils have properties that enhance plant growth are bulk density, water holding capacity, cation exchange capacity (CEC), porosity,

organic matter content, pH, total phosphorous, soluble Fe, exchangeable Al and exchangeable K and Ca. Therefore, the cause of the difference in growth of diameter of the seedlings may be due to the differences in the properties of the media.

The most important aspect of seedling production is the quality of the growing media which is determined by the growth rate of the plants grown in them<sup>19,20</sup>. From the study, the hybrid cocoa seeds exhibited considerable amount of success in terms of survival, however TSS performed very well than TSP compared to the TS (control). This assertion supports Anthonio *et al.*<sup>21</sup>, who reported that the higher values recorded for the organically amended soils (sawdust) indicated that the use of the soil amendment is of benefit to cacao production, but may require variation in the amount supplied from the results or mean values obtained. Akanbi<sup>22</sup> reported that higher plant growth as a result of organic amendment application may be associated with the fact that the materials release considerable amount of nutrients for plant use. Generally, loose porous growing media that are rich in organic matter have lower bulk density and when mixed with a growing media that has a higher bulk density such as soil, it decreases the bulk density of the soil<sup>23</sup>. Thus amendment of soil with sufficient amounts of organic matter alleviates compaction and provides a favourable environment for root growth. The loose porous nature of the sawdust might have accounted for the higher survival rate as compare to the poultry manure.

### CONCLUSION AND RECOMMENDATION

At the end of the experiment, it can be concluded that topsoil amended treatments TSS can support the growth of the hybrid cocoa (*Theobroma cacao*) seedlings and could be used as substitutes to topsoil (TS). Considering results from the fortnight readings of height and diameter growth of the hybrid cocoa seedlings on the various growth media (TS, TSS, TSP), it can be concluded that seedlings on TS have the highest growth compared to those on TSS and TSP but was not significantly different TSS. The hybrid cocoa seedlings on the topsoil amended with sawdust (TSS) exhibited a higher growth rate as compared to those on TSP. With regards to emergence of seedlings, the topsoil amended media shown higher emergence rate than the control medium (topsoil).

Topsoil amended with sawdust is recommended for use in the growth of the hybrid cocoa seedlings on a commercial scale since it gives the best results in terms of height and diameter growth. Topsoil amendment should also be done at different ratio with sawdust and poultry

manure to test whether seedling's growth will be affected. Further research work should be carried out to know how the various seedlings raised on the media (TSS and TSP) will perform when transplanted.

### SIGNIFICANCE STATEMENT

This study has proved that topsoil-sawdust amendment can support the growth of *Theobroma cacao* seeds. The study also provide a baseline data to help the researcher effectively experiment on other forms of amendment to ascertain their effect on the growth the hybrid cocoa seedlings.

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