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Earthen Storage Influence on Sprouting of *Terminalia ivorensis* (A. CHEV) Stem Cuttings.

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Abstract

The study was conducted to determine the effect of depth and period of burying on the sprouting capacity of *Terminalia ivorensis* stem cuttings. Seedlings were cut 5 cm from the basal portion of the stem with a uniform cutting length of 15 cm. Burying depths of 0 cm, 5 cm, 10 cm and 15 cm and burying periods of 7 days, 14 days, 21 days and 28 days were tested in a factorial experiment at 5% level of significance. Each treatment had ten stem cuttings and three replications as blocks. Results showed that burying of stem cuttings at increasing depths for shorter number of days (interaction), significantly increased the number of stem cuttings sprouted after planting ($p < 0.05$). Stem cuttings buried at a depth of 15 cm for 7 days produced the highest mean number of stem cuttings sprouted (9.00). The burying depths of stem cuttings had significant effect on the sprouting capacity ($p<0.05$). Stem cuttings buried at a depth of 15 cm recorded the highest mean number of sprouted stem cuttings (7.17). The number of days taken to maximum sprouting of the stem cuttings after planting was significantly affected by the burying depths ($p<0.05$). Stem cuttings buried at depths of 15 cm recorded the least number of days (8.58) taken to maximum. The effect on sprouting of *T. ivorensis* was interactive between burying periods/ days and depth.

Keywords: Terminalia ivorensis, Depth, Period, Burying, Stem cuttings

1.0 Introduction

The forestry sector continues to play a significant role in Ghana's socioeconomic development agenda. The sector has accounted for about 5-6% of Ghana's gross domestic product (GDP) and approximately 11% of total commodity export earnings (Owusu, 1998). However, in the past 2 decades, the country has seen almost 34 percent of forest cover loss representing 2.5 million hectares (FRA, 2010) through widespread unsustainable harvesting and encroachment of farmers.

Plantation forestry development in Ghana has been identified as one of the most promising options to reduce deforestation and ensure the availability of forest products to meet social, environmental and economic objectives (Ghana Forestry Commission, 2008b). In the last two decades, the government of Ghana has introduced several plantation development programmes such as the Modified Taungya System (MTS), National Forest Plantation Development Programme (NFPDP) in 2001, Private Plantation Development in 2006 and Green Ghana Project (GGP) in 2009 with the objective of restoring forest cover of degraded forest reserves and ecologically sensitive areas as well as addressing the wood deficit situation especially, timber and fuelwood needs (Benhin and Barbier, 2001) and fostering global carbon arrest initiatives. Restoring these areas is therefore a key component of Ghana's 1994 and 2012 Forest and Wildlife Policies and the 1996-2020 Forestry Development Master Plan as well as other related sector policies including the Ghana Poverty Reduction Strategy (GPRS).

In plantations, various planting designs require at least 10 percent of mixed indigenous tree species such as *Terminalia ivorensis*, *Terminalia superba*, *Triplochyton scleroxylon* etc. in an attempt to increase biological diversity, foster carbon sequestration and improve the soil conditions (Fisher, 1995).

In spite of the enormous contributions of the introduction of plantation development programmes in the country, there has also been a multitude of setbacks in the implementation of these schemes. In large hectares of plantation fields, the planting materials (stem cuttings) are often over-estimated or estimated in proportion to the land size but due to the varying land forms (undulating) and miscalculations, most of the cuttings are left unplanted. The unused stem cuttings are either left to rot on the field or thrown away as waste. In addition, the labour required to convey the cuttings to the field often becomes a problem. Sometimes, the labour force used experiences fatigue leading to the incompletion of the planting of these stem cuttings in large plantation fields. The unused cuttings are left on the field or thrown away as waste. Unfavourable weather conditions at planting sometimes also make it very difficult to plant these stem cuttings on the field. These cuttings are therefore thrown away as waste with the intention of planting fresh stem cuttings during favourable conditions. The Forestry Commission is therefore, confronted with the challenge of throwing large quantities of stem cuttings away as waste as there is no mechanism to preserve these cuttings for future plantation exercise. These entire problems amount to the economic cost incurred during plantation establishments.

To avoid the continual throwing of stem cuttings away as waste during plantation exercises, there is the need to develop preservative mechanisms for the unused stem cuttings for future planting exercises. One of the approaches used by the FC to preserve the unused stem cuttings is the 'heeling-in' that is, the burying of the cuttings at any depth for some time. This has also resulted in occasional destruction of valuable planting materials. No study has been done on the optimum depth and period stem cuttings of *Terminalia ivorensis* may be kept for future planting in the event of unfavourable planting conditions. This study therefore sought to determine the effect of depth and period of burying on the sprouting capacity of stem cuttings of *Terminalia ivorensis* and also to determine the effect of depth and period of burying on the days taken to maximum sprouting of stem cuttings of *Terminalia ivorensis*.

2.0 Materials and Methods

2.1 Area of study

The experiment was carried out in the nursery at the Faculty of Forest Resources Technology (FFRT) of Kwame Nkrumah University of Science and Technology (KNUST) in Sunyani, Brong-Ahafo Region. The campus lies between latitude 7°21'N and 2°03'W. The area falls within the high forest zones of Ghana with dry semi-deciduous vegetation and characterized by bimodal rainfall pattern with maximum rainfall between May-June and September-October. Mean annual rainfall of the area is between 1250mm to 1500mm, mean annual humidity is 70% and atmospheric temperature is about 29^{o} C. The soil type is sandy loam.

2.2 Source of T. ivorensis stem cuttings

Five hundred and ten stem cuttings of a one and half year old *Terminalia ivorensis* plant were obtained at the Faculty of Forest Resources Technology nursery and used for the experiment. The stem cuttings were cut 5cm from the basal portion of the plant and with a uniform cutting length of 15cm. Stem cuttings with at least three nodes were selected for the experiment.

2.3 Treatment selection

Treatment A showed the depths at which the stem cuttings of *Terminalia ivorensis* were buried. Levels of 0 cm ($A_{1)}$, 5 cm ($A_{2)}$, 10 cm (A_3) and 15 cm (A_4), were selected for the experiment.

Treatment B is the period at which the stem cuttings were buried. Levels of 7 days (B_1), 14 days (B_2), 21 days (B_3) and 28 days (B_4), were selected for the experiment.

2.4 Preparation of the Stem Cuttings

A 50-metre linear tape was used to measure the depths at which the cuttings were buried. The stem cuttings were buried at the specific depths for a stipulated number of days (periods). The buried cuttings were flatly covered with soil and watered twice daily with equal volumes of water (1000 ml).

2.5 Factorial Design

The treatments A and B were combined using the 4×4 factorial design method. This resulted in sixteen treatment combinations. Each of the sixteen treatments was made up of ten stem cuttings and was replicated three times (16×10×3). Thus, four-hundred and eighty stem cuttings were used for the experiment (treatment). The stem cuttings were then buried at a specific depth for a specific number of days at the pretreatment site after which they were then removed and planted in the experimental plots.

2.6 Planting of stem cuttings in the experimental plots

The treated stem cuttings (buried at specific depth for a certain number of days) were removed from the pretreatment site and planted on each plot in a block. The stem cuttings were planted in the vertical orientation and in lines at a uniform depth of 8cm. The treated stem cuttings were planted in the east-west direction at a planting distance of 0.5m x 0.5m.

2.7 Control experiment

Thirty stem cuttings of one and half years old *Terminalia ivorensis* plants were used for the control experiment. The cuttings were cut at 5cm from the basal portion of the stem. The stem cuttings with at least three nodes were then cut at a uniform length of 15 cm and planted on a separate plot immediately after cutting. The stem cuttings were planted in the vertical orientation and in lines at a uniform depth of 8cm. The thirty cuttings were planted in three plots with ten cuttings in each plot with a planting distance of 0.5m x 0.5m.

2.8 Cultural Practices
The planted stem cuttings were watered twice daily (morning-6am and evening-5pm) and weeds controlled. Partial shade using palm fronts were made to prevent the sprouted cuttings from being scorched by sun.

2.9 Data Collection
Close monitoring was done on the sprouting of the stem cuttings on each plot in a block. The number of stem cuttings sprouted for each treatment in a block was recorded every day and the days taken to sprout after planting were also recorded. Subsequent data on each treatment were collected for the days taken to maximum sprouting of each cutting and the total number of cuttings sprouted three weeks after planting.
Data was recorded based on:

- The percentage survival of the stem cuttings per treatment.
- The number of stem cuttings sprouted (maximum/peak sprout) per treatment.
- Days taken to maximum sprouting per treatment.

2.9.1 Data Analysis
The data collected were analyzed in two-way analysis of variance using GENSTAT RELEASE 10.3DE at a confidence level of 95% and the results presented in graphs.
The Fisher's multiple comparison test at 0.05 was used to compare the means of the treatments where there were significant differences.

3.0 Results
3.1 Percentage survival of stem cuttings planted
A total of 510 stem cuttings were planted (treatment and control) and out of this, 283 cuttings sprouted within a period of 21 days. For the thirty (30) stem cuttings used as the control, 17 sprouted representing 56.67%. Stem cuttings buried at depths of 5-15 (cm) for periods of 7-28 (days), had more cuttings sprouting than those buried at depth 0 cm for the period of 7-28 days. Stem cuttings buried at a depth of 15 cm for a period of 7 days (T_{13}) had 27 cuttings sprouting out of the total 30 stem cuttings that were planted; thus, representing 90% of the stem cuttings sprouted. Stem cuttings that were buried at a depth of 0 cm for a period of 28 days (T_4) had only three (3) stem cuttings sprouted for the 30 stem cuttings that were planted and thus, had the lowest percentage (10%) of cuttings sprouted. The figure below showed that burying of stem cuttings at increasing depths for shorter number of days increases the number of stem cuttings sprouted **(Figure 1)**.

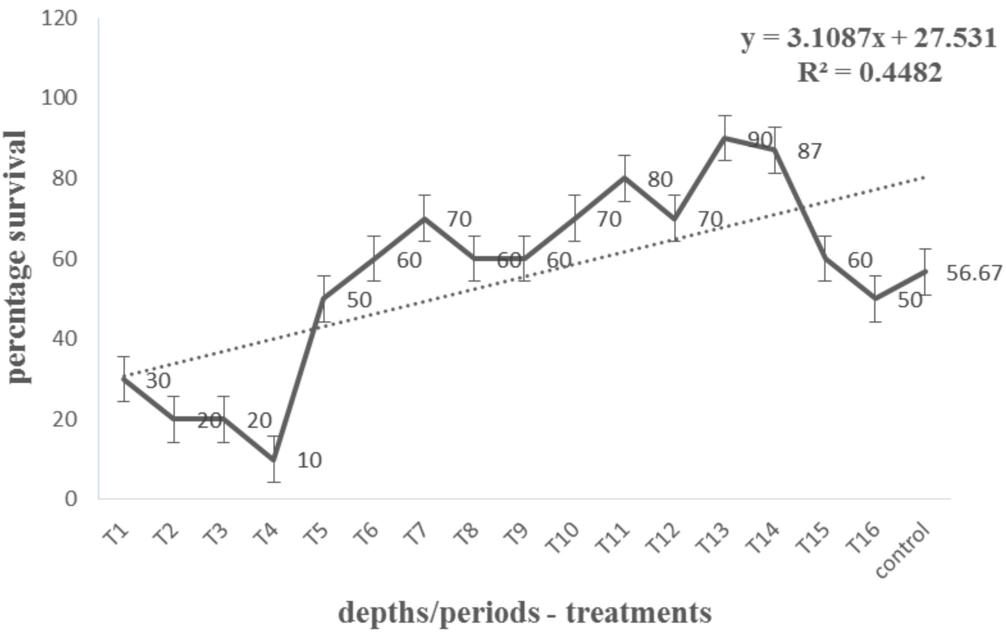

Figure 1: Variation in the percentage survival of *Terminalia ivorensis* stem cuttings.

3.2 Effects of depths of burying on the number of sprouted stem cuttings of T. ivorensis.
The burying depths of stem cuttings of *Terminalia ivorensis* were statistically significant (($p<0.05$) at 5% level of

probability after planting. Stem cuttings buried at a depth of 0 cm recorded the lowest mean number of sprouted cuttings (2.00), stem cuttings buried at a depth of 5 cm had a mean number of sprouted stem cuttings of 6.00 and stem cuttings buried at a depth of 10 cm also recording 7.00 as the mean number of sprouted stem cuttings. However, stem cuttings buried at a depth of 15 cm recorded the highest number of sprouted stem cuttings (7.17). The research indicated that, burying of stem cuttings at increasing depths increases the number of stem cuttings sprouted after planting **(Figure 2)**.

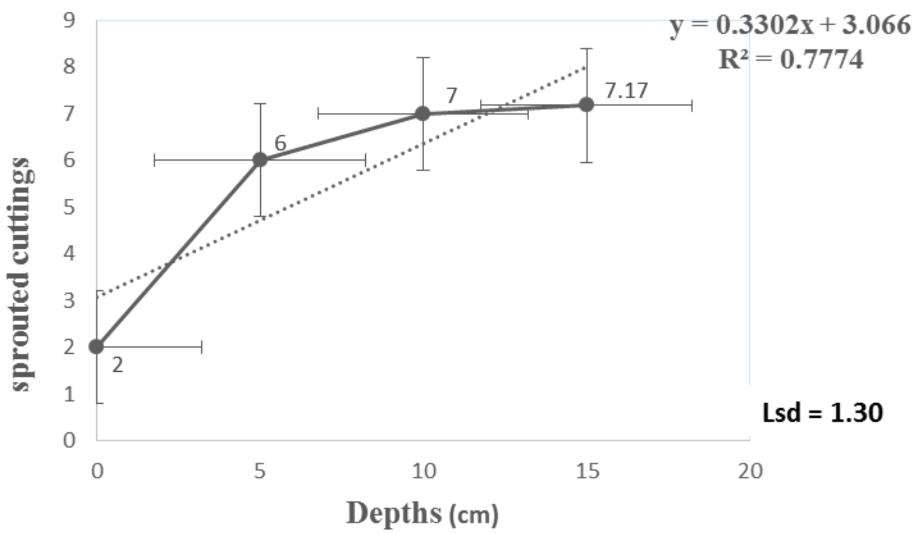

Figure 2. Variations in the mean number of sprouted stem cuttings buried at different depths.

3.3 Effects of periods of burying on the number of stem cuttings sprouted.

The periods at which stem cuttings of *Terminalia ivorensis* are buried for, have no effect (p>0.05) on the number of stem cuttings sprouted after planting at 5% level of probability. Stem cuttings buried for a period of 28 days recorded the lowest mean number of sprouted cuttings (4.75), stem cuttings buried for a period of 7 days had a mean number of sprouted stem cuttings of 5.75 and stem cuttings buried for a period of 21 days also recording 5.75 as the mean number of sprouted stem cuttings. However, stem cuttings buried for a period of 14 days recorded the highest mean number of sprouted stem cuttings (5.92).

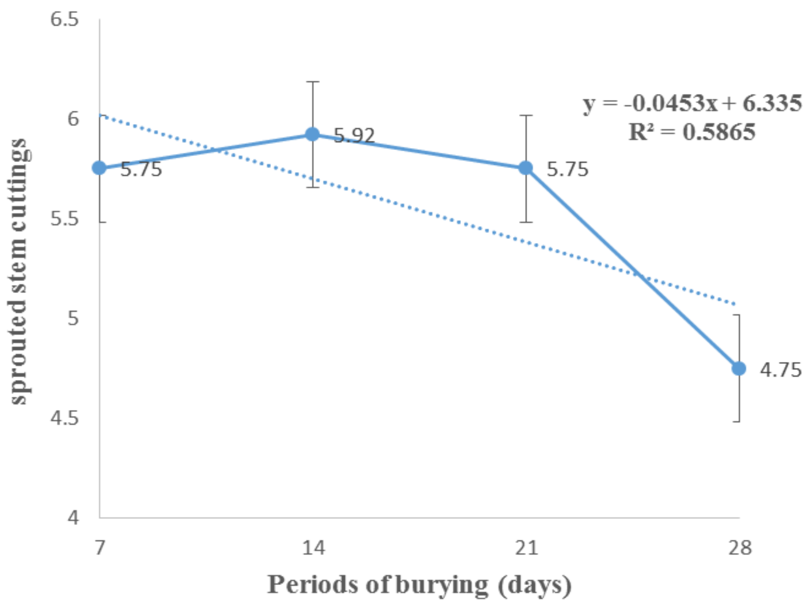

Figure 3. Variations in the mean number of sprouted stem cuttings buried at different periods.

3.4 Effect of depths of burying on the days taken to maximum sprouting of T. ivorensis stem cuttings.
Results **(Figure 4)** showed that the depths at which stem cuttings are buried, have a significant effect ($p<0.05$) on the number of days taken to maximum sprouting of *Terminalia ivorensis* stem cuttings. Stem cuttings buried at a depth of 0 cm recorded the highest mean number of days taken to maximum sprouting (17.83), stem cuttings buried at a depth of 5 cm recorded 12.67 as the mean number of days taken to maximum sprouting. Stem cuttings buried at a depth of 10 cm recorded 10.67 as mean number of days taken to maximum sprouting. However, stem cuttings buried at a depth of 15 cm recorded the lowest number of days taken to maximum sprouting. The research therefore shows that, burying of stem cuttings at increasing soil depths decreases the number of days taken to maximum sprouting.

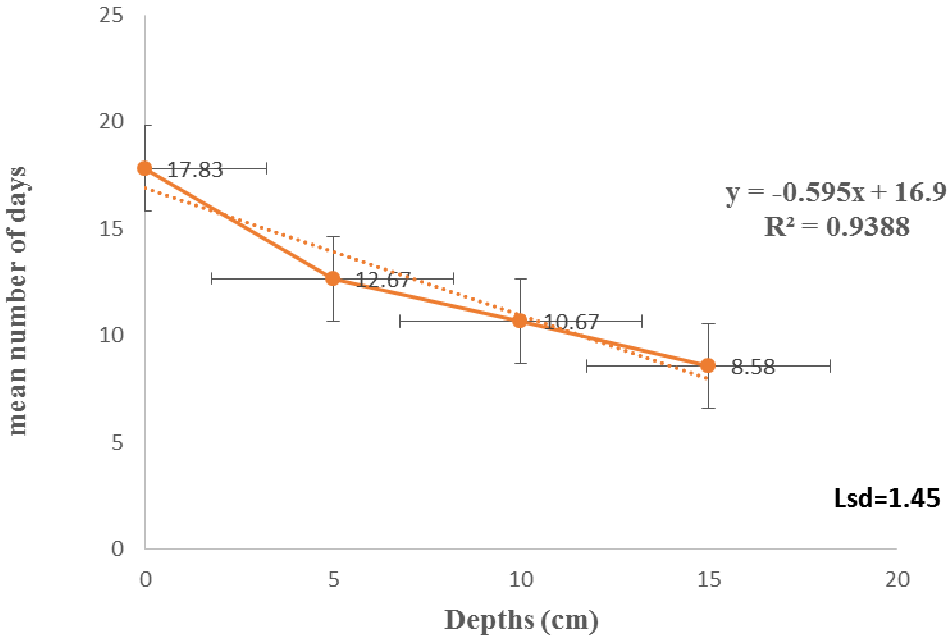

Figure 4. Variations in the mean number of sprouted stem cuttings buried at different depths.

3.5 Effect of periods of burying on the days taken to maximum sprouting of T. ivorensis stem cuttings.
The results in **Figure 5** indicated that burying periods were statistically insignificant ($p>0.05$) on the number of days taken to maximum sprouting of *Terminalia ivorensis* stem cuttings at 5% level of significance. Stem cuttings buried at a period of 21 days recorded the highest mean number of days taken to maximum sprouting (13.00), stem cuttings buried at a period of 14 days recorded 12.42 as the mean number of days taken to maximum sprouting. Stem cuttings buried at a period of 28 days recorded 12.58 as mean number of days taken to maximum sprouting. However, stem cuttings buried at a period of 7 days recorded the lowest number of days taken to maximum sprouting.

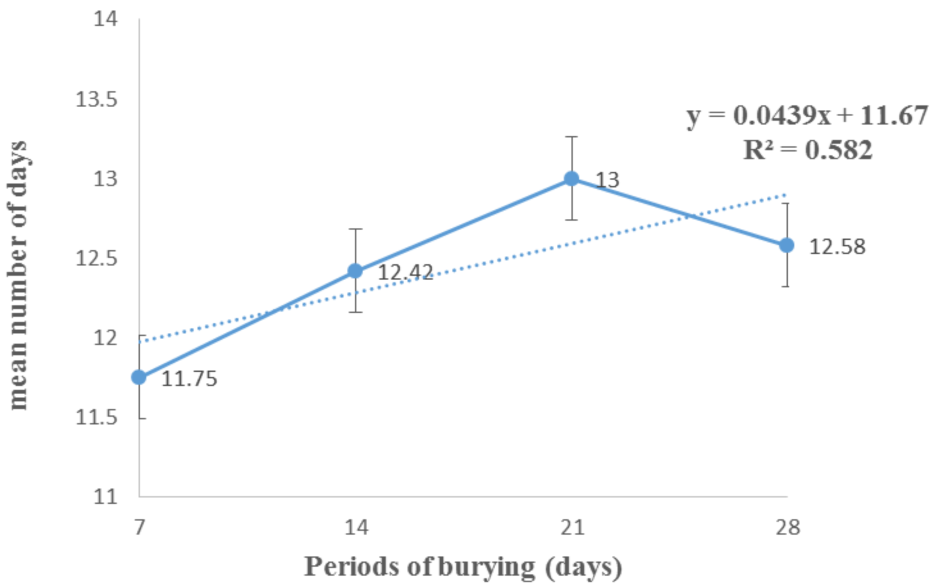

Figure 5. Variations in the mean number of days taken to maximum sprouting of *T. ivorensis* stem cuttings at different number of days of burying.

4.0 Discussion

4.1 Effect of Depths of burying on the sprouting capacity of stem cuttings of T. ivorensis

The study showed that stem cuttings buried at a depth of 0 cm before planting was statistically lower than those buried at 5 cm, 10 cm and 15cm **(Figure 2)**. The results are in assertion with Wright (1975) that, moisture (humidity), warmth (temperature) and light are essential conditions necessary for rooting. Stem cuttings buried at depths of 0 cm recorded high mortalities and this was due to the exposure of the stem cuttings to high light intensity, damaging active buds on the stem cuttings. The results also showed that, the exposure of the stem cuttings to unfavourable temperature and high light intensity caused photo-destruction of the tissues in the stem and subsequent death of the stem cuttings after planting (Hartmann *et al*., 2002a; 2002b). However, stem cuttings buried at depths of 5 cm, 10 cm, and 15 cm recorded maximum number of stem cuttings sprouted as the buds on these stem cuttings were kept alive at favourable conditions without heat injury. This confirmed the work of Kozlowski and Kramer (1979) that, buds on stem cuttings kept at favourable conditions have a strong promoting effect on rooting. The results also supports the assertion by Laubscher and Nadakimemi (2008) that, the propagation environment have an effect on the rooting ability of stem cuttings. Burying of stem cuttings at depths of 5 cm, 10 cm and 15 cm resulted in maximum number of cuttings sprouted after planting and this could be due to the suitability of the propagation environment to precondition root initiation and keep physiological stress at minimum levels (Leaky, 2004b). The results further showed that optimum favourable propagation environment occurred at depths of 15 cm and hence, recorded the highest number of cuttings sprouted and this may be due to stimulation of endogenous substances (auxins) which enhances the movement of boron, nitrogen, zinc, and potassium from the buds to the rooting zone of the stem cuttings (Blazich *et al.,* 1983).

4.2 Effect of Depths and Periods (interaction) of burying on the sprouting capacity of stem cuttings of T. ivorensis

The sprouting capacity of stem cuttings buried at a depth of 0 cm for periods of 7, 14, 21 and 28 days were significantly lower than the stem cuttings buried at depths of 5, 10 and 15 cm for periods of 7, 14, 21 and 28 days as shown in **Figure 1**. The study showed that stem cuttings buried at a depth of 15 cm for 7 days (T_{13}) recorded the maximum number of stem cuttings sprouted. Stem cuttings buried at a depth of 0 cm for a period of 28 days recorded the least number of stem cuttings sprouted after planting. This may be attributed to the fact that keeping the stem cuttings at the soil surface for longer periods exposed the stem cuttings to high light intensity and that caused photo-destruction of internal auxins in the stem cuttings and severe physiological stress (tissue water loss – transpiration, low humidity) and that resulted in the high mortalities of the planted stem cuttings (Hartmann *et al.*, 2002a; 2002b). However, stem cuttings buried at depths of 5 cm, 10 cm, and 15 cm for periods of 7, 14, 21 and 28 days recorded higher number of stem cuttings sprouted. This was due to the presence of favourable environmental conditions necessary for root primordial initiation (Schiembo, Newton and Leakey, 1997) and stimulation of internal auxins that trigger starch hydrolysis and mobilization of sugars and nutrients to the cutting base for root initiation and subsequent rooting (Das, Basak and Das, 1997). Leaky (2004b), asserted that favourable propagation environment minimizes physiological stresses experienced by tissues of the stem cuttings and encourages merismatic activity (mitosis and cell division) in the stem cuttings. The results showed that burying of stem cuttings at increasing depths for shorter number of days, results in maximum number of stem cuttings sprouted. Stem cuttings buried at a depth of 0 cm for a period of 28 days recorded the highest mortality of stem cuttings and this is consistent with Hartmann *et al.* (2002a; 2002b) who reported that, the exposition of stem cuttings on soil surfaces to long periods of intensive light and extreme temperatures result in the death of the stem cuttings when planted. Sufficient light, optimum temperature and sufficient relative humidity occurs at increasing depths of soils and maintains the moisture levels in the stem cuttings that stimulates root primordial initiation (Hartmann *et al.*, 1997). However, stem cuttings kept at higher depths for longer periods result in the turgidity of the stem cuttings leading to an imbalance of tissue water and subsequent death of the stem cuttings when planted (Hartmann *et al.*, 2002a; 2002b).

4.3 Effect of Depths of burying on the number of days taken to maximum sprouting of T. ivorensis stem cuttings

The burying depths (0 cm, 5 cm, 10 cm and 15 cm) had significant effect ($p<0.05$) on the number days taken to maximum sprouting of stem cuttings of *T. ivorensis* after planting as depicted in **Figure 4**. The study showed that the burying depth of 15 cm had the least number of days taken to maximum sprouting of the stem cuttings after planting and was statistically different from the other burying depths of 0 cm (17.83), 5 cm (12.67), and 10 cm (10.67).

According to Hartmann *et al*. (1997), favorable environmental conditions occur at increasing depth and precondition the stem cuttings to respond to root primordial initiation at a faster rate. These may be the underlining factor that enabled stem cuttings burying at depths of 5 cm, 10 cm and 15 cm to take fewer days to maximum sprouting of the stem cuttings. The favourable propagation environment stimulated the formation of callus and the subsequent emergence of the roots within a short period after planting (Hartmann *et al*., 2002a; 2002b). Stem cuttings buried at of 0 cm took longer days to maximum sprouting and this may be caused by the exposure of the cuttings to high light intensity, resulting in the death of the active buds, wilting of the stem cuttings (desiccation) and photo destruction of tissues in the stem cuttings (Hartmann *et al*., 1997).

4.0 Conclusion

The study has provided baseline information on the effects of depth and period of burying on the rate of sprouting *T. ivorensis* stem cuttings.

The depths at which stem cuttings of *T. ivorensis* were buried have significant effect on the number of stem cuttings sprouted. Burying of stem cuttings at increasing depths result in increasing number of sprouted stem cuttings of *T. ivorensis*. Burying of the stem cuttings at a depth of 15 cm recorded the highest mean number of sprouted stem cuttings after planting (7) and this may be due to the favourable propagation environment at this depth. The research also showed that the periods at which the stem cuttings were kept for, had no effect on the number of sprouted stem cuttings. The burying effect of depth and period (interaction) on the number of stem cuttings sprouted was also significant. The stem cuttings buried at a depth of 15 cm for a period of 7 days had the highest mean number of stem cuttings sprouted (9). However, stem cuttings buried at a depth of 0 cm for 28 days recorded the least mean number of sprouted stem cuttings (1). Moreover, the study also indicated that, depths of burying stem cuttings have effect on the days taken to maximum sprouting of the stem cuttings. Stem cuttings buried at a depth of 15 cm recorded the least mean number of days (8) taken to maximum sprouting after the stem cuttings were planted. However, stem cuttings buried at a depth of 0 cm recorded the highest mean number of days (17) taken to maximum sprouting of *T. ivorensis* stem cuttings after planting. The research further indicated that, the periods at which the stem cuttings were kept for had no effect on the days taken to maximum sprouting of *T. ivorensis* stem cuttings. Moreover, burying of the stem cuttings at a specific depth for some time (period), thus, interaction, had no effect on the days taken to maximum sprouting of the stem cuttings. The problem of excessive *T. ivorensis* stem cuttings discarded is dealt with by storing at depth of 15cm for a period of 7 days. This is a major booster for *T. ivorensis* plantation development programmes in Ghana especially in the transition zone.

5.0 Acknowledgements
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