Malaysian Journal of Sustainable Agriculture (MJSA)
*DOI : http://doi.org/10.26480/mjsa.02.2019.46.55*

***ISSN: 2521-2931 (Print)***
***ISSN: 2521-294X (Online)***
***CODEN : MJSAEJ***

***RESEARCH ARTICLE***

# ASSESSING THE GROWTH PERFORMANCE OF TWO DIFFERENT HEVEA BRASILIENSIS CLONES (IRCA 41 AND GT 1) IN THE GUINEA SAVANNA SOIL IN THE NORTHERN REGION OF GHANA

**Damian Felladam Tangonyire**

***Department of Agriculture for Social Change, Regentropfen College of Applied Sciences, Kansoe-Bongo, Upper East Region, Ghana.***
****Corresponding Author Email: damian.tangonyire@recas-ghana.com***



**ARTICLE DETAILS**

***Article History:***

Received 01 June 2019
Accepted 02 July 2019
Available online 31 July 2019

**ABSTRACT**

This study was conducted in the Northern Region of Ghana to assess the growth performance of two different Hevea brasiliensis clones namely IRCA 41 and GT 1 in the Guinea Savanna soil. The fresh rubber stumps which were used for the experiment were collected from Ghana Rubber Estate Limited (GREL) which is located in the Western Region. The research design employed the use of completely randomized design with thirty replicates each of the two Hevea brasiliensis species. Data was collected during the dry and rainy seasons. The results at the end of the project for the two Hevea brasiliensis clones showed an average germination rate of 86.66% and 73.30% during the rainy and dry seasons respectively. A mean height of 25.30cm, mean girth of 6.34mm and mean leaf number of 28 were recorded during the rainy season whiles a mean height of 22.56cm, mean girth of 3.41mm and mean leaf number of 42 were recorded in the dry season for the two Hevea brasiliensis clones. When T-test was performed on the two Hevea brasiliensis clones, it was revealed that, there was no significant difference ($p>0.05$) in height, girth and number of leaves between the two different rubber clones during the rainy season and the dry season. *Hevea brasiliensis* therefore has a greater potential for cultivation in Guinea Savanna soil.

**KEYWORDS**

Hevea brasiliensis, rubber clones, Irca 41, Gt 1, growth rate of rubber, rubber trees, guinea savanna soil, germination rate of rubber

## 1. INTRODUCTION

The common rubber tree (*Hevea brasiliensis)*, also known as the Pará rubber tree is an indigenous tree in Amazon, Brazil. It belongs to the Family *Euphorbiaceae*, Order *Malpighiales*, Genus *Hevea* and Species *brasiliensis* [1]. It is a commercial tree economically grown in plantations and a "hot" commodity with worldwide consumption increasing at an average rate of 5.8% per year since 1900 [1]. One most important use of *Hevea brasiliensis* is the manufacture of jet-aircraft tires and truck tires. It is also used in the manufacture of industrial products which range from balls, containers and shoes to bands and a lot of other items. About 61 different products have been reported to be made from rubber wood [2]. These products are: furniture and furniture parts, parquet, panelling, wood-based panels (particleboard, cement and gypsum-bonded panels, medium-density fibreboard, kitchen and novelty items, sawn timber for general utility and fuel), among others.

*Hevea brasiliensis* is grown mainly for latex production, while its wood is considered as a secondary product. However, its wood can also increase the total productivity hence resulting in maximum productivity of the rubber plant. This is possible because wood selling can shorten the latex tapping period, after which trees can either be felled or used for further tapping depending on the current prices of latex and wood [3,4]. Recent improvements in wood technology have led to *Hevea brasiliensis* becoming increasingly important as a source of wood products [5]. *Hevea brasiliensis* has also enjoyed an environmentally friendly reputation as a raw material, because it is a by-product of latex production, and when grown in renewable plantations, it can substitute timber from natural forests. Its timber is moderately durable and light creamy in colour, which makes it attractive and popular among consumers. *Hevea brasiliensis* can also be a substitute for many species, including teak, oak and pine [6]. The role of *Hevea brasiliensis* as a carbon sink has often been under-estimated. Apparently due to its high leaf area index and the extra energy the tree requires to produce latex, it acts as an effective carbon sink [6]. Due to the numerous benefits that are often obtained from *Hevea brasiliensis*, it has been referred to as a woody agricultural crop together with oil palm and coconut [7].

*Hevea brasiliensis* was first introduced in Asia in 1876, when seeds were first shipped from the Amazon to the United Kingdom and further to Ceylon where they were planted [8]. In the following year, rubber trees were planted in Singapore and Malaya [9]. Although it was first an estate crop, local individual farmers soon adopted the crop and so they were drawn into the world commercial economy [10]. The commercial and large-scale exploitation of the tree did not begin until in the last quarter of the 19th century where the arrival of cars and discovery of pneumatic tyre led to an increase in the prices of rubber which resulted in the increased production of rubber. Production of rubber in the world is mainly found in continents such as Asia, South America and Africa. It was introduced in Africa early in the 20th century: in Uganda and Nigeria (1903), Congo (1904) and Liberia [11]. Countries like Nigeria, Ghana, D.R. Congo, Côte

d'Ivoire, Liberia, Gabon and Cameroon are the major producers of rubber in the African continent [12].

*Hevea brasiliensis* was introduced in Ghana in the botanic garden at Aburi near Accra in 1898 [13]. However, rubber tree is continuously grown in only certain parts of the country. It is widely cultivated in the Western Region, with very few plantations found at Asamankese and Okumaning both in the Eastern Region. It has recently been introduced to the Central and Ashanti regions by a division known as Rubber Out-growers Association [13]. *Hevea brasiliensis* grows best in a climate similar to that in its area of origin in the Amazons. The climate of this region is characterized by heavy rainfall and no distinct dry season. The optimal climatic conditions for the genus *Hevea* are rainfall of 2000mm or more, evenly distributed throughout the year with no severe dry season and with 125-150mm annual rainy days, maximum temperature of about 29-34 °C, minimum temperature of about 20 °C and a monthly mean temperature of 25-28 °C, high atmospheric humidity of about 80% with moderate wind, and bright sunshine for about 2000 hours in a year [14]. *Hevea brasiliensis* is a light demanding tree species and requires moist soil and grows on many soils, with the best options being well drained clayey and deep clay soils. It requires deep soils, relatively stable high temperatures and continuous moisture throughout the year. An optimal soil pH value for hevea brasiliensis tree is at 5-6 [15].

However, the performance of *Hevea brasiliensis* can be restricted where there is rocky surface, heavy drainage or soil pH values above 6.5 or below 4 [16]. It has been revealed by researchers that, unfavorable environmental conditions would more drastically affect the latex yield than the timber production of rubber [17]. In areas where rubber cultivation is less favored by environmental conditions, improved farming systems such as agro forestry could be an option for increasing the economical profitability as well as environmental and social benefits of rubber cultivation.

Studies done by other researchers revealed that, *Hevea brasiliensis* reach maturity at the age of about six and would have achieved a girth of about 1.5m from the ground [18]. *Hevea brasiliensis* plantations are usually established using vegetative propagation and often improved planting material. Rubber clones perform differently in response to stress from external factors such as drought [14]. In hevea brasiliensis plantations, the trees are kept smaller, up to 78 feet (24 m) tall, so as to use most of the available carbon dioxide for latex production. In the wild, the Hevea brasiliensis tree can reach a height of up to 100 feet (30 m). The white or yellow latex occurs in latex vessels in the bark, mostly outside the phloem. These vessels spiral up the tree in a right-handed helix which forms an angle of about 30 degrees with the horizontal, and can grow as high as 45 ft.

Diseases of Hevea brasiliensis are rampant in the nursery than in the field when they are planted. The major diseases at the nursery are mostly fungal diseases and these include; white rot caused by *Fomes lignosus,* brown rot caused by *Fomes noxious* and red rot caused by *Ganoderma pseudoferreum.* Some of the diseases that affect mature rubber trees mostly are known as panel diseases and these include; Mouldy rot, Black thread or black stripe disease, among others. Various pests such as termites, caterpillars, mealy bug, aphids and rodents attack *Hevea brasiliensis* but the most serious plant pest among them is the mistletoe pest [19].

*Hevea brasiliensis* has been targeted by several Western African countries as an opportunity for rural development and poverty alleviation. In line with this, the Government of Ghana (GoG) in particular adopted a Rubber Master Plan in 2001 with a view to expand the areas under rubber tree cultivation from 14,000ha of mainly industrial estates to 50,000ha [19]. Such a significant expansion would only happen if many small private farmers broadly adopt Hevea brasiliensis tree cultivation and grow it on their own as a business. This will then serve as a tool for economic development to the nation especially in the rural communities where these *Hevea brasiliensis* plantations will be established such as infrastructure, roads, schools, clinics, among others.

A study conducted in the plant house on Nyankpala campus to assess the initial growth performance of *Hevea brasiliensis* using different Guinea Savanna soils proved successful [20]. However, the growth performance of *Hevea brasiliensis* in the field has not been studied on Guinea Savanna soils, hence the need for this study. The study aims at determining the germination rate of two different *Hevea brasiliensis* clones, namely GT 1and IRCA 41 as well as investigate the growth rate of these rubber clones in Guinea Savanna soil. The results from this study would be useful in determining which *Hevea brasiliensis* clones would be best suited for planting in Guinea Savanna soils.

## 2. METHODOLOGY

### 2.1 Profile of the study area

The project work was carried out on Nyankpala campus of the University for Development Students (UDS) in the Northern Region of Ghana. Field work was carried out inside the mango plantation of the Faculty of Renewable Natural Resources from July, 2013 to March, 2014. Nyankpala campus is located in the Tolon District in the Northern Region of Ghana. It lies between latitude 09̊ 25″N, longitude 0̊ 58″W in the Guinea Savanna woodland ecological zone of Ghana [21]. The area is 183m above sea level. Nyankpala campus is about 20km to the South-West of Tamale, the capital. The vegetation of the area is Guinea Savanna comprising trees of varying sizes and density, dispersed in a ground cover of perennial bush, grasses and associated herbs [22]. These trees include shea (*Paradoxa vitellaria)*, baobab (*Adansonia digitata)*, dawadawa (*Parkia biglobosa)*, neem (*Azadirachta indica)*, among others. Guinea Savanna woodland has a vegetation zone area of 147.9 square. km representing about 62% [23].

### 2.2 Climatic conditions and soil types

The area has a unimodal rainfall pattern which starts from May and ends in October. The peak rainfall occurs between June and September with the dry season usually running from November to April. Temperatures are relatively constant throughout the year ranging between 25̊C and 32.4̊C with a mean monthly minimum temperature of 23.1̊C and mean monthly maximum temperature of 32.4̊C. Similarly, relative humidity figures for the study area show high humidity from May to October with a mean monthly minimum relative humidity of 53% and mean monthly maximum relative humidity of 80% [24].

The underlying rock is the Voltain sandstone with lower Birrimians chist. The overlying soil is almost entirely Savanna Ochrosols. The soil is mainly loamy which is highly porous and has low moisture holding capacity [24]. The chemical properties of the soil is as follows; pH ranges from 4.5 – 6.7, Phosphorus (Mg/Kg soil) = 2.5 – 10.0, total Nitrogen content = 0.02 – 0.05%, Calcium Chlorine ($Cacl_2$) = 5.6, Organic carbon is 0.43% and Organic matter carbon is 0.74% [22].

### 2.3 Land preparation

Land preparation is very important in the establishment of a good stand. It is the only way to prevent the *Hevea brasiliensis* trees from attack by termites and the deadly disease called fomes. Land preparation was done using hoes and cutlasses. The land was first of all measured and demarcated, an area of $875m^2$ (25m×35m) was used. Stumps within the area were uprooted and all dead wood were also collected. The vegetation was sprayed, weeded, piled together and burnt. The spraying was done on the 19th of July, 2013, after which weeding of the land followed three days later. Weeding is an important weed control method practiced in many crops. The removal of weeds is useful because they compete with the tree crop for space, water and nutrients, increase transpiration and block circulation of air.

### 2.4 Lining and pegging

After the land was cleared and prepared, it was then pegged using garden lines, ranging poles, and pegs. The ranging poles were used to get a straight line. It is very important for the Hevea brasiliensis clones to be planted in

straight lines for easy passage and proper functioning. The planting distance was 3m within rows and 6m between rows.

**2.5 Holing and labeling**

The holes were dug using earth chisels (diggers) and cutlasses. A total of 60 holes were obtained from an area of 875m$^2$. The holes which were dug measured 40 centimeters from one end to the other (diameter) and 60 centimeters deep. These dimensions of the hole were necessary to aid in easy planting and also enhance sprouting of roots into the soil. The topsoil was separated from the sub soil and was later used to refill the hole after planting. The digging of holes was done on the 27$^{th}$ of July 2013. After the digging of holes was done, the total land area was divided into ten equal plots. Each plot contained six holes each measuring 6m×6m. The planting material was then planted according to the plots created.

2.6 **Planting and termiticide application**

Planting of the Hevea brasiliensis clones was done on September 3, 2013 after the digging of holes was completed. It was done very early in the morning. Allocation of the planting materials to the plots created was done through the process of randomization. The planting material (*Hevea brasiliensis* clones) was placed in the hole with the scion (eye of the bud) facing North. This was done to prevent the scion from facing the sun directly which could inhibit survival. The topsoil was used to refill the hole after planting the clones. Firming was done gently with a planting stick and stamping with the feet. This was done in order to make the plant firmer in the ground. After this, a hoe was used to gather more earth soil around the planting material to the level of the root collar. Re-firming was done after planting. Re-firming is the process of making the plant firm in the ground. At the same period of re-firming, a basin was created around each Hevea brasiliensis clone with a hoe with the aim of trapping water for the plant. Immediately after planting the rubber clones, grounded camphor was applied around the base of the rubber clones. This was done in order to prevent the rubber clones from termites attack.

**2.7 Pruning and mulching**

This was done in the course of sprouting. The purpose of pruning was to get rid of undesirable side shoots. The only shoot that was required was that from the bud (eye bud). After planting, all other shoots which appear looking darker than the desirable one was pruned to allow food reserves to be given to the scion alone. This reduced competition between the desirable and undesirable shoots and enhanced the growth of the desirable shoot. Also, all side shoots and branches of the scion were also pruned to encourage terminal growth. All branches of the clone within 2m from the ground were cut. In the case of double sprouting, the weaker one was pruned leaving the healthier one. Pruning is very good because it helps keep the plant shorter and help the plant to branch out making a more esthetic plant.

Mulching was also carried out after pruning. A researcher defined mulching as a crop husbandry practice in which organic material is spread over the topsoil to influence the physical, chemical and biological properties of the soil and its micro-climate with the aim of improving the productivity of a site [25]. It is a form of soil conservation aimed at maintaining, protecting and improving the soil for agricultural purposes. Plant productivity depends on the topsoil, where plant nutrients are concentrated. As this rich layer is at the top of the soil surface, plant nutrients can easily be lost, removed or damaged by various natural processes. Local materials such as dried weeds were used as mulch for the project. The objectives of mulching were to maintain and improve soil structure, maintain organic material content in the soil, utilize available soil water effectively, maintain soil fertility by reducing nutrient loss and to replace those that are lost and reduce erosion. Mulching also induces lower soil temperature and higher soil moisture retention and increases root density [26].

Plate 1: Mulching of IRCA 41

Plate 2: Mulching of GT 1

**2.8 History of the two *Hevea brasiliensis* clones used for the project**

***2.8.1 GT 1 rubber (Hevea brasiliensis) clone***

GT 1 rubber clone originated from Malaysia. It is an approved cultivar which is classified under category II of the rubber board categories. Category II consists of clones with consistent performance over a long term in any one of the evaluation stages. It is recommended that these clones be used to plant up to 50% of the total area of any estate. It has variable branching habit, upright but slightly twisted. The main branches are long and acute angled, secondary branches are light. GT 1 has narrow globular crown and dense dark green glossy foliage. Wintering and refoliation is late and often partial, occurrence of tapping panel dryness and incidence of pink disease are mild, abnormal leaf fall is mild to medium and powdery mildew is medium to severe and requires fairly wind fast. This clone shows rising yield trend with summer yield fairly high. The latex gotten from GT 1 is usually white in colour. Clones RRIM 600, GT l, RRII 5, RRII 203, PB 28/59 PB 217, PB 312, PB 314, PB 255 and PB 280 are other clones in this category II [19].

***2.8.2 IRCA 41 rubber (Hevea brasiliensis) clone***

IRCA 41 originated from Côte d'Ivoire from the experimental plantations of CNRA-Bimbresso research station, situated in Anguédédou, in Southeast of Côte d'Ivoire. It gives high yield in terms of productivity. IRCA 41 is an approved cultivar which is classified under category III of the rubber board categories. This category III consists of clones on which there is only limited data from experimental planting. These clones are recommended for only small-scale experimental planting not to exceed 15% of the total area in aggregate. These clones have exhibited good performance over a long period in small scale trials and/or over a short term in large scale trials in India or abroad. Clones RRII 50, RRII 51, RRII 52, RRII 118, RRII 176, RRII 208, RRII 300, RRII 429, PR 107, PR 255, PR 261, PB 86, PB 5/51, PB 235, PB 311, PB 330, RRIM 605, RRIM 701, RRIM 703, RRIM 712, RRIC 100, RRIC 102, RRIC 130, KRS 163, IRCA 111, IRCA 130, SCATC 88-13, SCATC 93-114, Haiken 1, BPM 24 and Polyclonal seeds are all under this category [19].

### *2.8.3 Study approach and design*

The experimental design was a randomized complete block with thirty replicates, using two different *Hevea brasiliensis* tree species (IRCA 41 and GT 1), six *Hevea brasiliensis* clones were allocated per plot.

### *2.8.4 Field data collection and analysis*

Data was collected everyone week and was based on parameters such as days of shoot emergence, germination percentage, stem diameter, shoot length/height, shoot girth, number of leaves and basal area. The data which was collected was analyzed using Statistical Package for Social Sciences at the end of the project period. The means were computed for the two different clones and the differences between them tested using student's t test. The results were then represented in tables and figures.

## 3. RESULTS

### 3.1 Germination Rate

The first evidence of germination is the emergence of an eye bud from the rubber clones. Data was taken for both the rainy and the dry seasons. The germination rate of both IRCA 41 and GT1 rubber clones after planting during the rainy and dry seasons is shown in figure 1. Week 4, week 8 and week 12 constituted the rainy season while week 16, week 20 and week 24 constituted the dry season. T test performed showed that, there was no significant difference ($p>0.05$) between the survival rate of IRCA 41 and GT 1 at the end of the rainy and dry seasons.

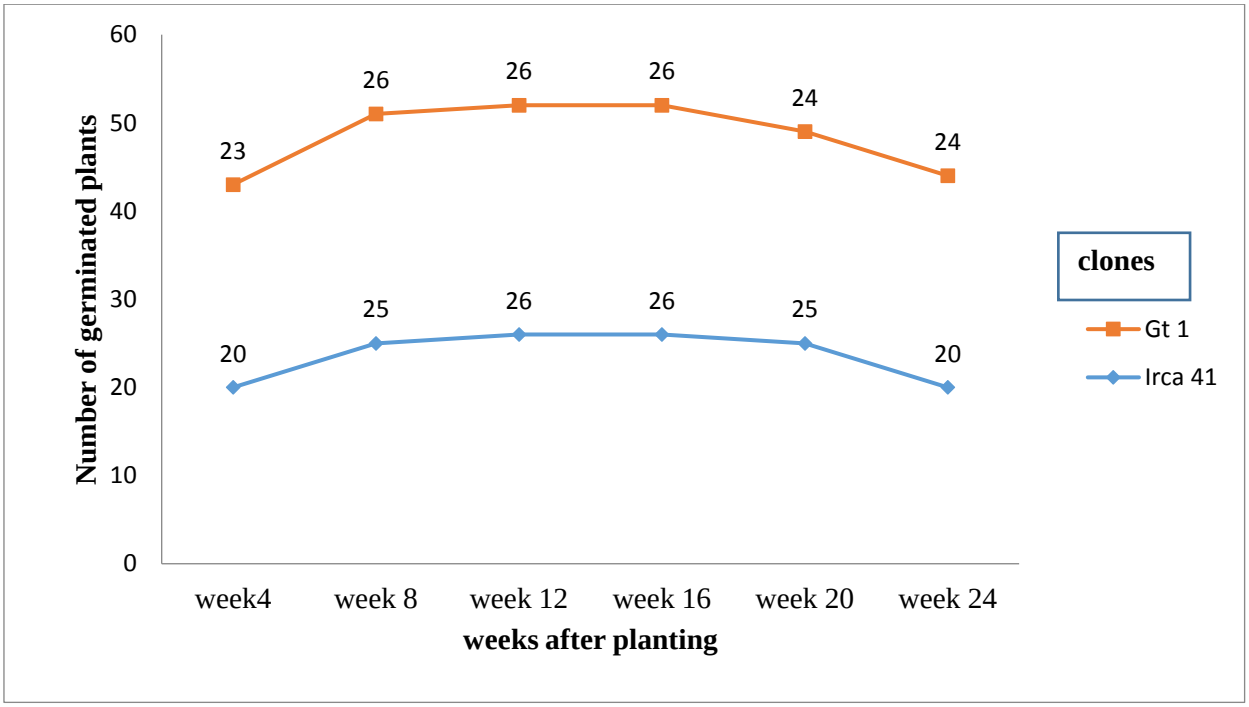


**Figure 1:** Germination rate of IRCA 41 and GT 1 rubber plants

At the end of the rainy season, a total survival rate of 86.66% representing 52 *Hevea brasiliensis* plants and a mortality rate of 13.34% representing 8 *Hevea brasiliensis* plants respectively were recorded. (Table 1)

**Table 1:** Survival rate of IRCA 41 and GT 1 Hevea brasiliensis clones during the rainy season.

| Clone type | Percentage (%) survival | Percentage (%) mortality |
|---|---|---|
| IRCA 41 | 43.33 | 6.67 |
| GT 1 | 43.33 | 6.67 |
| Total | 86.66 | 13.34 |

Also, at the end of the dry season, a total survival rate of 73.30% and a mortality rate of 26.70% representing 44 and 16 *Hevea brasiliensis* plants respectively were recorded. (Table 2)

**Table 2:** Survival rate of IRCA 41 and GT 1Hevea brasiliensis clones at the end of the dry season

| Clone type | Percentage (%) survival | Percentage (%) mortality |
|---|---|---|
| IRCA 41 | 33.30 | 16.70 |
| GT 1 | 40.00 | 10.00 |
| Total | 73.30 | 26.70 |

### 3.2 Growth Performance Of The Rubber (*Hevea Brasiliensis)* Clones

### *3.2.1 Height of plants*

Data was taken on the height of both IRCA 41 and GT 1 during the rainy season. The mean heights of both rubber clones increased gradually after planting from week 4 to week 12. GT 1 had a higher mean height than IRCA 41 only in week 4. IRCA 41 however, had a higher mean height than GT1 in week 8 and week 12 as shown in figure 2. There was no significant difference ($p>0.05$) in height between GT 1 and IRCA 41 at the end of the rainy

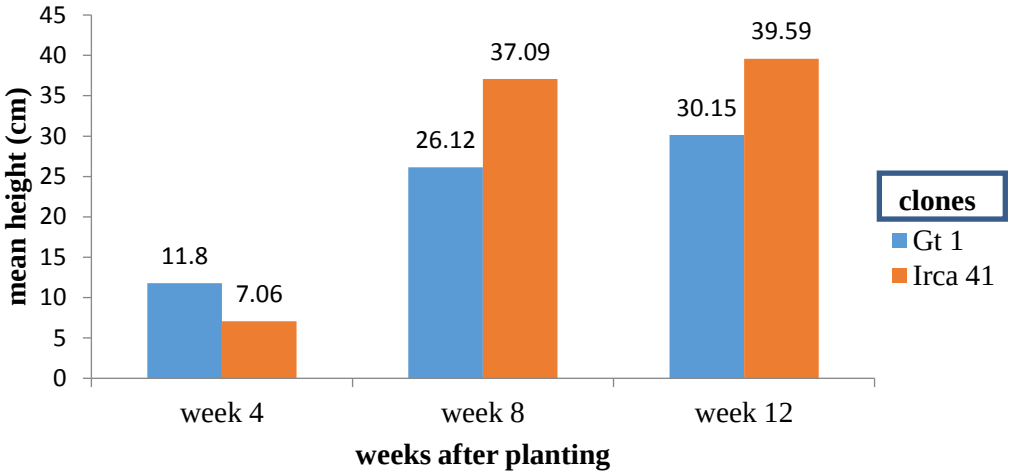


**Figure 2:** Change in growth of height of IRCA 41 and GT 1 during the rainy season.

In the dry season, there was also an increase in the mean height of both species from week 16 to week 24. IRCA 41 however, recorded the higher mean height in all the weeks than GT 1. Figure 3 shows the mean heights of the two rubber clones during the dry season. Also, there was no significant difference ($p>0.05$) in height between GT 1 and IRCA 41 *Hevea brasiliensis* clones at the end of the dry season.

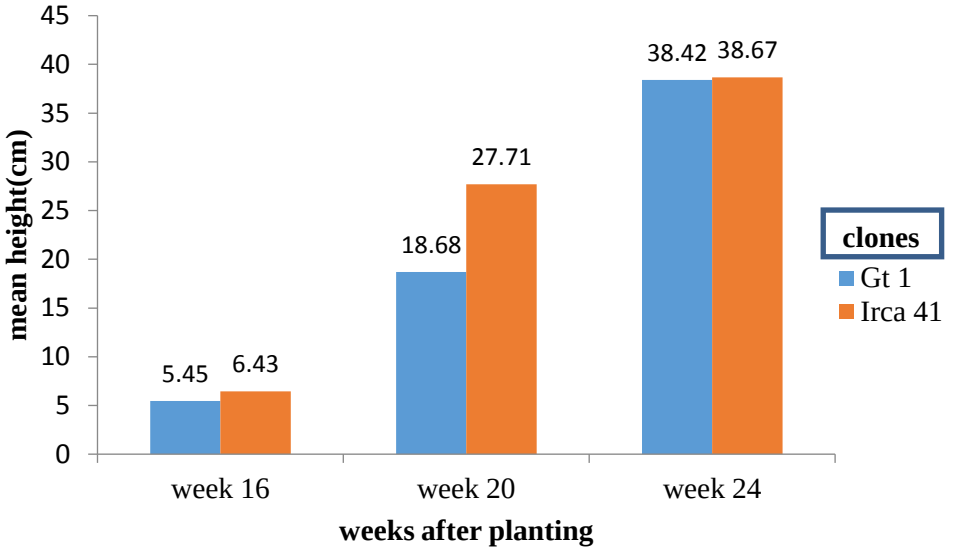


**Figure 3:** Change in the growth of height of GT 1 and IRCA 41 during the dry season.

However, at the end of the project, Irca 41 had a higher mean height both in the rainy and the dry seasons than Gt 1 as illustrated in figure 4.

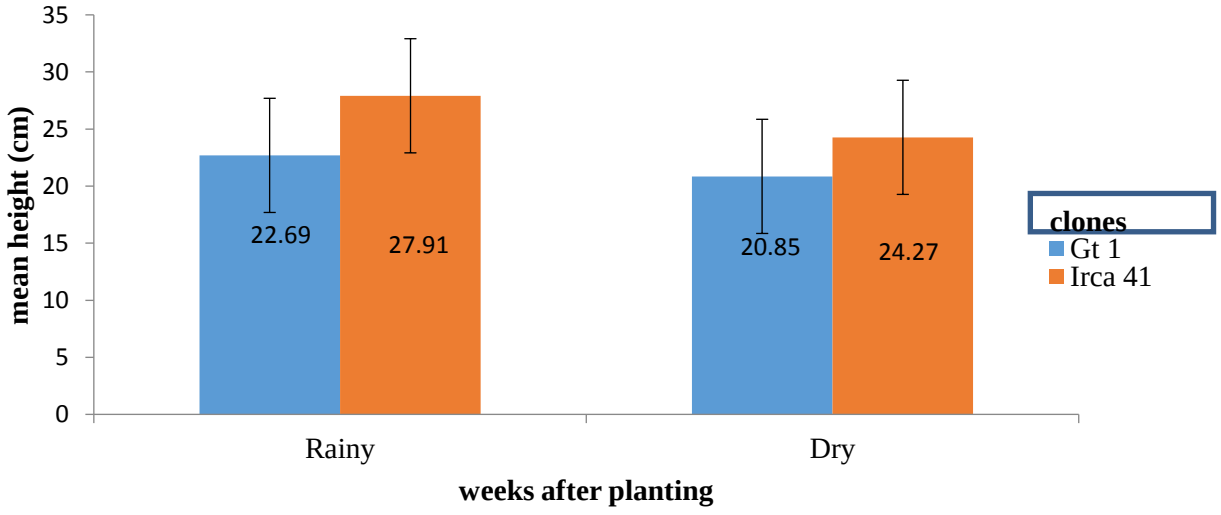


**Figure 4:** Change in the growth of height of IRCA 41 and GT 1 within each season

### *3.2.2 Girth of Hevea brasiliensis plants*

At the end of the rainy season, week 12 recorded the highest mean girth with week 4 having the least mean girth. IRCA 41 had a higher mean girth than GT 1 in week 8 and week 12. GT 1 however, had a higher mean girth than IRCA 41 only in week 4. Figure 5 shows the mean girths of both IRCA 41 and GT 1 during the rainy season.

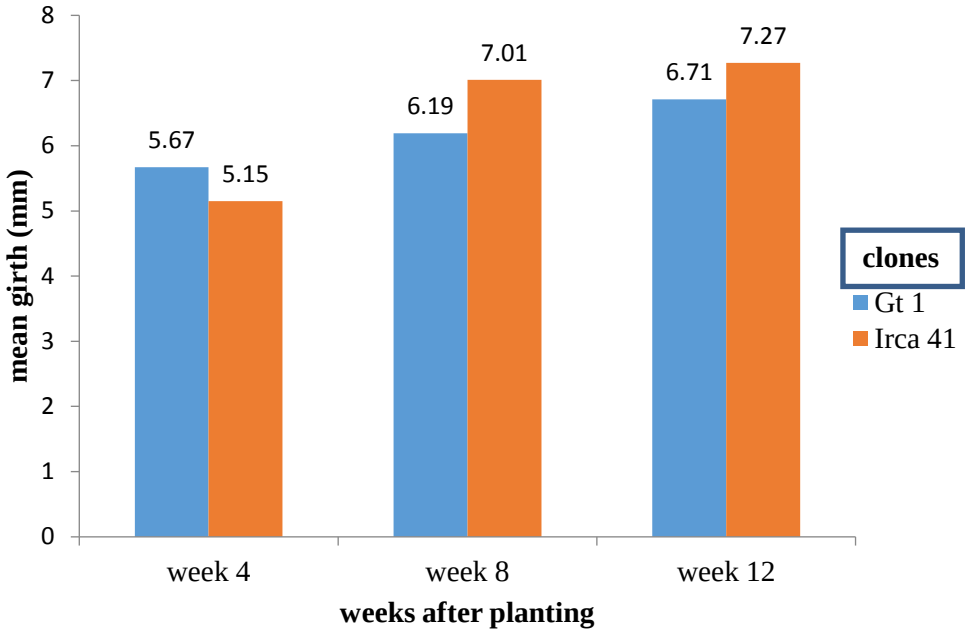


**Figure 5:** Change in the girth growth of GT 1 and IRCA 41 during the rainy season

Both IRCA 41 and GT 1 recorded an increase in mean girth from week 16 to week 24 in the dry season. IRCA 41 had a higher mean girth in all the weeks than GT 1. (Figure 6)

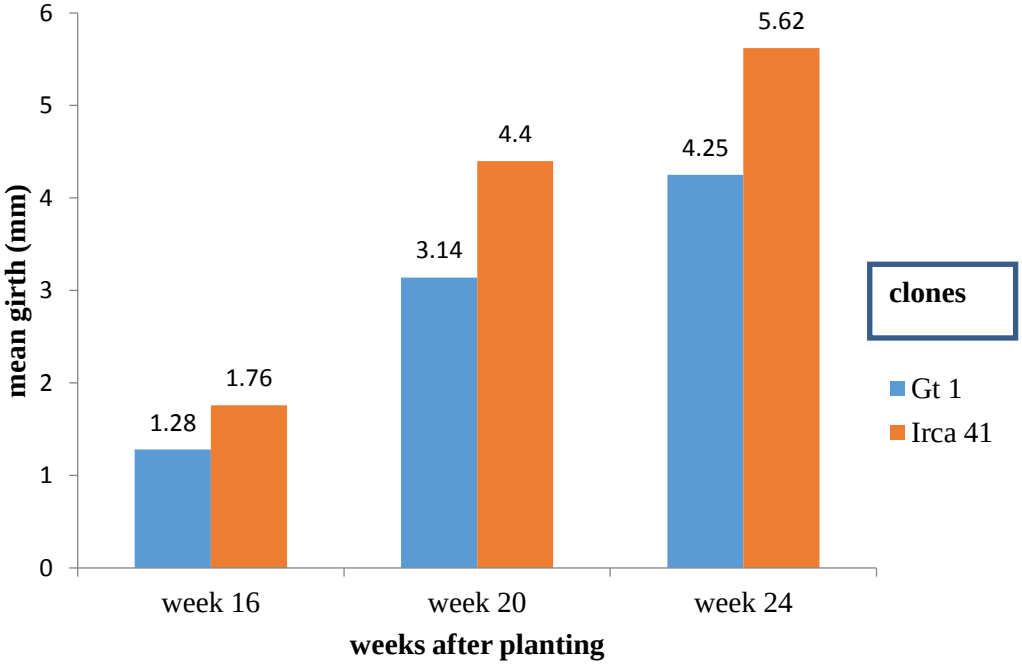


**Figure 6:** Change in the girth growth of GT 1 and IRCA 41 during the dry season

There was no significant difference ($p>0.05$) in girth between GT 1 and IRCA 41 in the rainy and dry seasons. IRCA 41 had a higher mean girth than GT 1 during the rainy and dry seasons. The mean girths of both IRCA 41 and GT 1 for both the rainy and dry seasons are shown in figure 7.

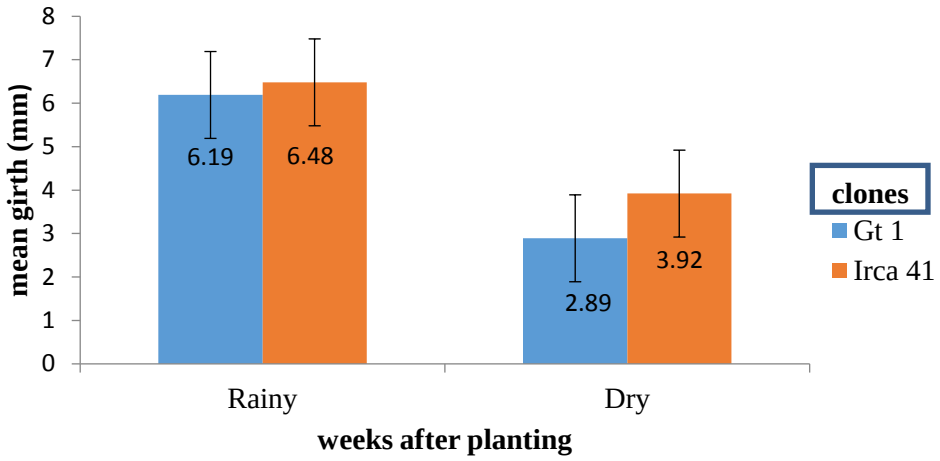


**Figure 7:** Change in girth of IRCA 41 and GT 1 within each season

### *3.2.3 Number of leaves of Hevea brasiliensis plants*

Both IRCA 41 and GT 1 recorded increase in the mean number of leaves during the rainy season. The mean leaves increased gradually from week 4 to week 12 with week 12 having the highest mean number of leaves and week 4 having the least mean number of leaves seen see in figure 8.

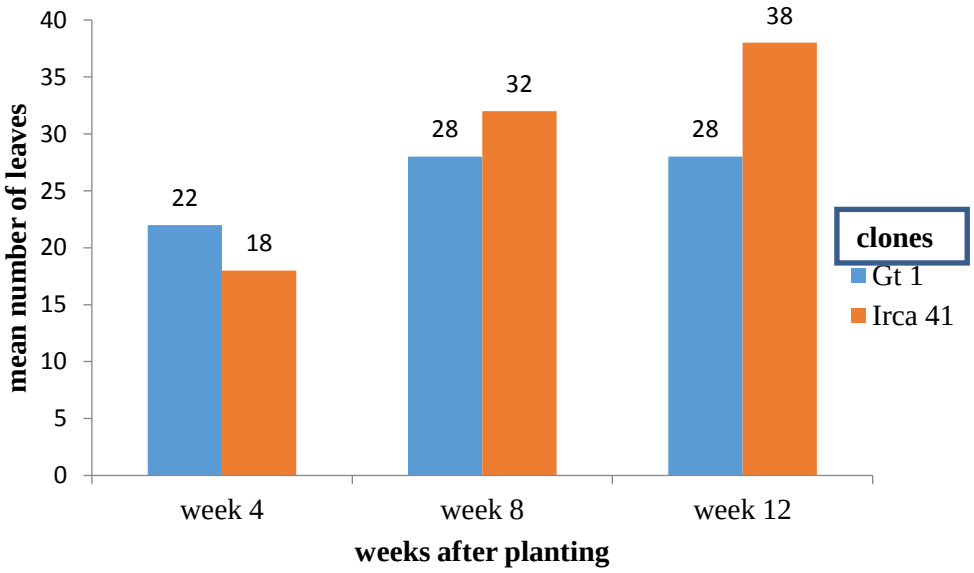


**Figure 8:** Change in the mean number of leaves of GT 1 and IRCA 41 during the rainy season

Similarly, there was an increase in the mean number of leaves during the dry season. The mean number of leaves increased from week 16 to week 24. Week 24 had the highest mean number of leaves while week 16 recorded the least mean number of leaves. IRCA 41 had a higher mean number of leaves throughout the dry season than GT 1 (figure 9). T test showed no significant significance ($p>0.05$) in the mean number of leaves between IRCA 41 and GT 1 in the rainy and dry season respectively.

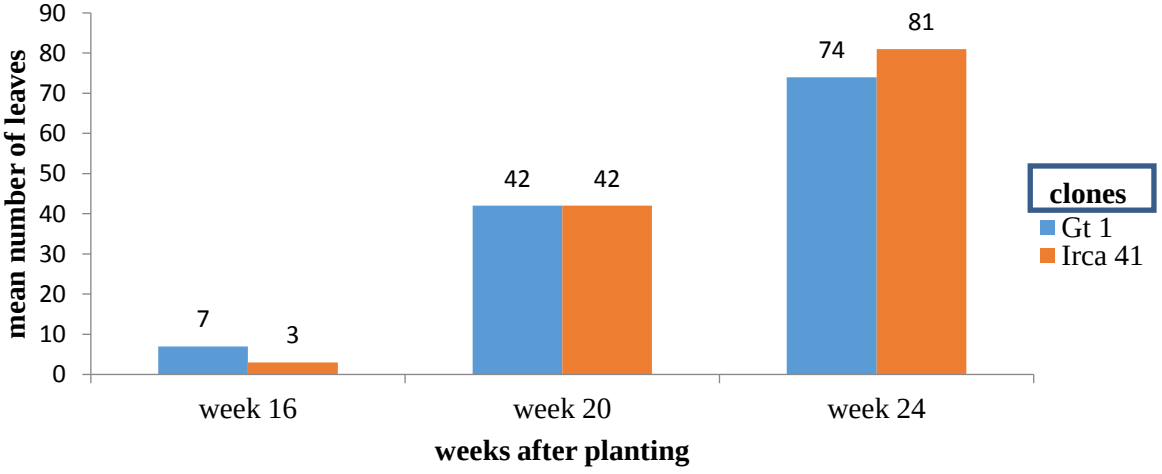


**Figure 9:** Change in the mean number of leaves of GT 1 and IRCA 41 during the dry season

At the end of the project, IRCA 41 recorded a higher mean number of leaves during both the rainy and dry seasons than GT 1. Figure 10 shows the mean number of leaves of both IRCA 41 and GT 1 during the rainy and dry seasons.

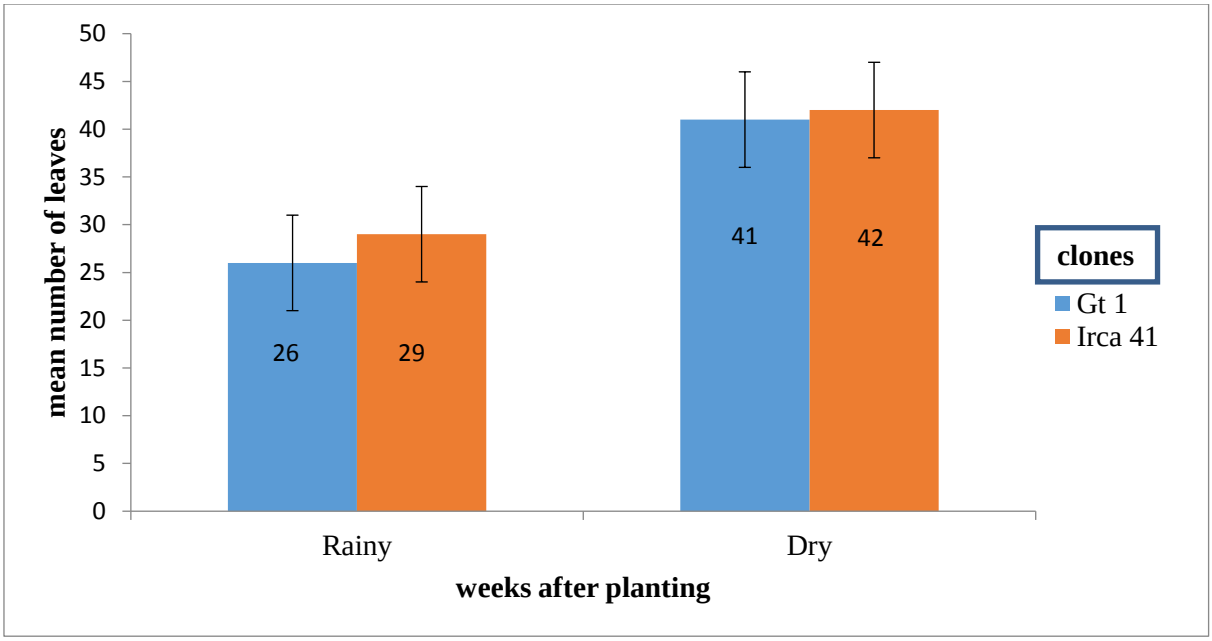


**Figure 10:** Change in the mean number of leaves of IRCA 41 and GT 1 within each season

## 4. DISCUSSION

### 4.1 Germination Rate

The first evidence of germination is the emergence of an eye bud from the Hevea brasiliensis clones. From Figure 1, germination increased from week 4 to week 12 after which mortality set in. At the end of the raining season, the results revealed, a total survival rate of 86.66%. Both IRCA 41 and GT 1 rubber clones had the same survival rate. The highest survival rate in the rainy season was however, recorded in week 12 where both IRCA 41 and GT 1 rubber clones recorded 26 plants each. There was no significant difference ($p>0.05$) between Gt 1 and Irca 41 in their survival rates at the end of the rainy season. Also, at the end of the dry season, a total survival rate of 73.30% was recorded. Between the two Hevea brasiliensis clones, GT 1 had a higher survival rate than IRCA 41. Statistical analysis showed that, there was no significant difference ($p>0.05$) between the survival rates of the two rubber clones at the end of the dry season. This indicates that, both GT 1 and IRCA 41 can be used in Guinea Savanna soil since they both recorded high germination rates. This high survival rate of the two *Hevea brasiliensis* clones agrees with the work of Lemmens [15] that rubber can grow on many soils.

The high survival rate at the end of the project also agrees with the work of one researcher who carried out his work in the plant house on Nyankpala campus and observed a survival percentage of about 75% for the rubber plants [20]. This high survival rate can also be attributed to the fresh state of stumps collected and planted on the same day. The fresh stumps may possess the required amount of moisture needed for germination. A recommendation by one research, was that, for high percentage of germination, Hevea brasiliensis clones should be planted as soon as possible preferably within the first week [27]. Other researchers [28] also reported that, with fresh stumps, the percentage germination can be about 70%.

The high survival rate of the Hevea brasiliensis clones can also be attributed to the type of soil at the site as well as suitable climatic conditions such as adequate light, humidity and temperature. Wide spacing may have reduced competition for nutrients, moisture, and light. Also line clearing around plants may have reduced weed invasion, water transpiration, diseases, among others facilitating proper infiltration and the growth of the plants. In general, suitable conditions for growth were more favourable in the rainy season than in the dry season explaining why there was a higher survival rate in the rainy season than in the dry season. This confirms the studies done by some researchers who suggested that, water assists in the germination and development of plants and also lack of water decreases the intensity of photosynthesis which results in mortality [18].

### 4.2 Mortality Rate

Results of mortality rates for both the rainy season and the dry season were 13.34 % and 26.70% respectively. This shows that mortality rate was higher in the dry season than in the rainy season. Mortality rate was the same for both IRCA 41 and GT 1 during the rainy season. However, IRCA 41 recorded a higher mortality rate in the dry season than GT 1. Low water availability during the dry season can be attributed to the higher death rate of the rubber plants. The humidity at that time was low and the temperature very high leading to high transpiration. This resulted in water deficiency and reduction in the amount of photosynthates produced to support their growth. This confirms the findings of one researcher who revealed that, water assists in the germination and development of plants and also lack of water decreases the intensity of photosynthesis which results in mortality [18].

The high mortality rate can also be attributed to termite infestation as termite moulds were seen on the dead *Hevea brasiliensis* plants. The roots of dead trees also contained termites when they were pulled out. Termites were found to be more devastating in the rainy season since the trees were young and still struggling to establish their roots as compared to the dry season. Browsing by animals was also attributed to the death of the Hevea brasiliensis plants. Animals that escaped into the site fed on the palatable leaves and branches. Some of the plants therefore found it difficult to survive at that time of the dry season where suitable conditions were less favourable. IRCA 41 however, was severely affected by these mortality factors accounting for its low survival rate at the end of the project in the Guinea Savanna soil.

### 4.3 Assessment Of The Growth Performance Of The Rubber (*Hevea Brasiliensis)* Clones

#### *4.3.1 Plant height development*

The results revealed that there was an increase in height of both *Hevea brasiliensis* plants from week 4 to week 24 for both the rainy and dry seasons. IRCA 41 however, had a higher mean height both in the rainy and dry seasons than GT 1. The rainy season had a mean height of 25.30cm

whiles the dry season recorded a mean height of 22.56cm. This shows that, the rainy season performed better in height than the dry season. GT 1 recorded a higher height than IRCA 41 only in week 4. This finding agrees with the work of Addo- Quaye *et al.* [18], that rubber grows 25-30m tall in its natural distribution area. Between IRCA 41 and GT 1, there was no significant difference ($p>0.05$) during the rainy and dry seasons. There was, however, significant difference in height of IRCA 41 between the rainy and dry seasons. GT 1 also had significant difference in height between the rainy and dry seasons. The difference in height between IRCA 41 and GT 1 in the rainy and dry seasons can be attributed to soil conditions such as soil moisture. According to one researcher, the growth and latex yield of rubber trees are affected in different ways by soil moisture [17]. High moisture was prevalent in the rainy season whereas the dry season had lower moisture content. From the findings of Rao and Vijayakumar [14], *Hevea brasiliensis* clones perform differently in response to stress from external factors such as drought. Another researcher also argued that, in favourable soils, rubber trees could tolerate a dry season of four to five months, during which less than 100mm of rain is received and within this period, two to three months with rainfall less than 50mm [29].

Studies carried out by prominent researchers revealed that, 74% of the dry matter of rubber plant is found in their roots indicating that shoot development is suppressed in the early stage of rubber stump growth [28]. The findings from these researchers therefore can be attributed to the difference in mean height between IRCA 41 and GT 1 in the rainy and dry seasons. The difference in the height of the rubber plants between the rainy and dry seasons can also be attributed to the mulch applied. The mulch was fully decomposed in the dry season and supported plants growth by improving soil structure, maintaining organic material content in the soil, utilizing available soil water effectively, maintaining soil fertility by reducing nutrient loss as well as replacing those that are lost and reducing erosion. According to one researcher, mulching also induces lower soil temperature, higher soil moisture retention and increases root density, hence resulting in an increase in the growth of the *Hevea brasiliensis* plants [26].

### *4.3.2 Girth development*

The results revealed that, IRCA 41 had a higher mean girth in the rainy season than GT 1. Mean girth of IRCA 41 increased gradually from week 4 to week 12 in the rainy season. In the dry season, IRCA 41 again had a higher mean girth than GT 1. The rainy season had a mean girth of 6.34mm whereas the dry season recorded a mean girth of 3.41mm. Between IRCA 41 and GT 1, there was no significant difference ($p>0.05$) in girth during the rainy and dry seasons There was however, significant difference in girth for IRCA 41 between the rainy and dry seasons. Significant difference in girth for GT1 between the rainy and dry seasons was also observed. These differences can be attributed to the type of soil at the site as well as suitable climatic conditions such as adequate light, humidity and temperature. Wide spacing may have reduced competition for nutrients, moisture, and light. Also line clearing around plants may have reduced weed invasion, water transpiration, diseases, among others facilitating proper infiltration and the growth of the plants.

In general, suitable conditions for girth growth of IRCA 41 and GT 1 were more favourable in the rainy season than in the dry season and this accounts for a higher girth in the rainy season than in the dry season. This confirms the findings of one researcher who observed that Savanna soil without NPK recorded a girth of 5.94mm when he conducted his studies in the plant house on Nyankpala campus [20].This also confirms the findings by Addo- Quaye *et al.*[would have 18], that rubber plants reach maturity at the age of about six years and achieved a girth of 1.5m from the ground.

### *4.3.3 Leaves development*

The results revealed that, there was an increase in the mean number of leaves from week 4 to week 20 during the rainy and dry seasons. The mean number of leaves for the rainy season was 28 whiles the dry season recorded a mean leaf number of 42 with IRCA 41 recording a higher mean number of leaves in both seasons. Between IRCA 41 and GT 1, there was no significant difference ($p>0.05$) in the mean number of leaves during the rainy and dry seasons. There was however, significant difference ($p<0.05$) in the mean number of leaves for IRCA 41 between the rainy and dry seasons. GT 1 also had significant difference ($p<0.05$) in the mean number of leaves between the rainy and dry seasons. The difference in the number of leaves between the dry and rainy seasons can be attributed to the rapid stem development. The low number of leaves during the rainy season is due to the inability of the plants to develop leaves immediately after germination. The plants have to grow to a certain height before they start producing leaves. As the height increased, the number of leaves increased. One researcher revealed that, when Hevea brasiliensis clone germinates, it sends down a long tap root before producing leaves [30].

Soil moisture absorption by the two rubber clones can be attributed to the difference in the number of leaves between IRCA 41 and GT 1 during the rainy and dry seasons. Soil moisture equally influenced the rate of plant nutrient absorption for leaf development. The higher the soil moisture absorbed by a plant, the higher the number of leaves produced. This confirms the assertion by a researcher who observed that the number of leaves produced by a plant is directly proportional to the photosynthates produced [31]. Also, the high leaf area index of the *Hevea brasiliensis* plants and the extra energy the trees require to produce latex makes them effective carbon sinks [6]. Again, difference in the mean number of leaves of IRCA 41 and GT 1 during the rainy and dry seasons can be attributed to their leaf shedding ability. Several researchers observed that, rubber trees *(Hevea brasiliensis)* shed their leaves annually but the timing and intensity of leaf shedding depends on climatic conditions and varies between different clones [15].

## 5. CONCLUSION AND RECOMMENDATION

The results obtained at the end of the project revealed that, both IRCA 41 and GT 1 rubber clones have a higher survival rate in Guinea Savanna soil. Their ability for latex production could not be assessed since rubber tree takes about six years to reach maturity. *Hevea brasiliensis* therefore has a greater potential for cultivation in Guinea Savanna soil.

The death of the *Hevea brasiliensis* plants during the project can be attributed to termite infestation as termite moulds were seen on the dead rubber plants. Also, browsing by animals and low water availability during the dry season can be attributed to the death of the Hevea clones. The study therefore recommends that, more work should be carried on the rubber plants up to the tapping stage to assess its latex producing ability. Further studies should also be conducted to determine the growth performance of Hevea brasiliensis clones on Guinea Savanna soil using different fertilizer treatments.

## REFERENCES

[1] Rubber Board. 2005. Rubber Growers Companion. Government of India, Kottayam, Kerala, India, 115.

[2] Salleh, M.N. 1984. Heveawood - timber of the future. The Planter, 60(702), 370-381.

[3] Arshad, N.L., Mohamad Hassan, M.J., Ibrahim, A.G., Mahayana Bongkik, D.Y.M., Wahab, M.A. 1997. Viability of *Hevea* plantation for wood production. Pp 41-57. In: Yahya, A.Z., Ghani, A.R.A., Mahat, M.N., Wahab, M.A., Wickneswari, R. and Mahmood, N.Z.N (Editors) Proceedings of the Seminar on Commercial Cultivation of Teak, Sentang, *Acacia* and *Hevea* for Timber. Proceedings of the Seminar 9.1.1997, Kuala Lumpur. Forest Research Institute Malaysia, Kuala Lumpur. 62p ISBN 938-9592-88-2.

[4] Clément-Demange, A. 2004. Rubber: Wood, Cropping and Research-Rubberwood and biomass: adaptation of rubber cropping and rubber research in South-East Asia. Regional workshop for the building of a rubberwood research project, November 12.-14.2003. Scientific and Technical report. 23 p.

[5] Evans, J., Turnbull, J.W. 2004. Plantation Forestry in the Tropics. 3rd Edition. Oxford University Press, Oxford. 467 p. ISBN 0-19-852994-5

[6] Balsiger, J., Bahdon, J., Whiteman, A. 2000. The utilization, processing and demand for rubberwood as a source of wood supply. Asia-Pacific Forestry Sector Outlook Study Working paper series, Working paper No. ABFSOS/WP/50. Forestry Policy and Planning Division, Rome and Regional Office for Asia and the Pacific, Bangkok. FAO, Rome. 56 p.

[7] FAO (Food and Agriculture Organization. 2005. State of the World's Forests, 168 p. ISBN 9251051879

[8] Dijkman, M.J. (1951). Hevea: Thirty years of research in the Far East. University of Miami press, Florida, pp. 5-7.

[9] Hong, L.T. 1999. Introduction. Pp. 1-15. In: Hong, L.T & Sim, H.C. (Editors) 1999. Rubberwood - Processing and Utilisation. Malayan Forest Records 39. Forest Research Institute Malaysia, Kuala Lumpur. 254 p. ISBN 983-9592-27-0

[10] Courtenay, P.P. 1979. Commercial Agriculture. Pp. 108-133. In: Sien, C.L., McGee, T.G., Osborne, M.E., Courtenay, P.P., Neville, W., Swan, B. South-East Asia: A Systematic Geography. Oxford University Press, Kuala Lumpur. 214 p. ISBN 0-19-580393-0

[11] Firestone Tyre & Rubber Company. 1924. http://www.firestonenaturalrubber.com (assessed on 15th June 2014.

[12] Prachaya, J. 2009. Rubber economist quarterly report. London and Bangkok. Provincial Agriculture and Forestry Offices, Laos. Rubber Plantation in Lao PDR

[13] GREL News. 2012. 5 (2). http://www.grel.com. (assessed on 15th June 2014)

[14] Rao, P., Vijayakumar, K.R. 1992. Climatic Requirements. Pp. 200-220. In: Sethuraj, M.R. & Mathew, N.M. 1992. Natural Rubber: Biology, Cultivation and Technology. Developments in Crop Science 23. Elsewier, Netherlands. 610 p. ISBN 0-444-88329-0

[15] Lemmens, R.H.M.J., Soerianegora, I., Wong, W.C. 1995. PROSEA Plant Resources of South-East Asia 5(2), Timber Trees: Minor Commercial Timbers. Backhuys, Leiden. 655 p. ISBN 90-73348-44-7.

[16] Krishnakumar, A.K., Potty, S.N. 1992. Nutrition of *Hevea*. Pp. 239-263. In: Sethuraj, M.R. & Mathew, N.M. (Editors) 1992. Natural Rubber: Biology, Cultivation and Technology. Developments in Crop Science 23. Elsewier, Netherlands. 610 p. ISBN 0-444-88329-0

[17] Grist, P., Menz, K., Thomas. 1998. Modified BEAM Rubber Agroforestry Models: RRYIELD and RRECON. ACIAR Technical Reports Series 42. 43 p. ISBN 1-86320-225-0

[18] Addo-Quaye, A.A., Saah, M.K., C.K.B., Ibrahim A., Tetteh, J.P., Rockson-Akorly, V.K., Kitson, J. E. 1993. Ministry of Education, General Agriculture for Senior Secondary School, H, Grangaram & Sons, Bombay, India 406pp.

[19] Rubber Board. 2013. www.Rubber board.com Classification and diseases of rubber clones

[20] James Orhin (ud). 2013. Assessing the initial growth performance of rubber clone (*Hevea brasiliensis)* on guinea Savanna soil. A case study in the Tolon District in Northern Region of Ghana. Unpublished BSc. Thesis submitted to Department of Forestry and Forest Resources Management, UDS, Tamale.

[21] Meteorological Service. 2005. Tamale, Ghana

[22] Nyankpala Agriculture Station (NAS). 1993. Annual report, edited by Art Hum Rungemetzger and Lothar Diehl Velag Losef. Margrafin Imental station and crop research institute, Ghana. Pp 5, 6 and 41

[23] Ministry of Lands & Forestry. 2001. Statistics, Research and Information Directorate (SRID).

[24] Savanna Accelerated Research Institute (SARI). 2005. Annual report 2005, Tamale, Ghana.

[25] Muller-Samann, K.M., Kotschi, J. 1994. Sustaining growth: Soil fertility management in Tropical small holdings. Magraf Verlag. Weikersheim.

[26] Maurya, P.R., Lal, R. 1981. Effects of different mulch materials on soil properties and root growth and yield of maize (Zea mays) and cowpea (Vigna unguiculata). Field Crops Res., 4(1), 33-45.

[27] Ruyssen, B. 1957. Le Karate au Soudan. Agronomie Tropical, 12, 143-127, 297-306, 415- 440. In Hall *et al.,* 1996. A monograph Pp.13-21

[28] Frimpong, E.B,, Adomako, D. 1986. Tree Germination and Mineral Nutrition Studies. Annual Rep. Cocoa Res. Ins. Ghana 1985/86, Pp. 98-100

[29] Compagnon, P. 1987. Le Caoutchouc Naturel- Biologie, Culture, Production. Techniques Agricoles et Productions Tropicales. G.-P. Maisonneuve & Larose, Paris. 595 p. ISBN 2-7068-0910-8

[30] Yayock, J.Y., Lombin, G., Owonubi, J.J. 1988. Crop Science and production in warm climates- Shea butter, pp. 150.

[31] Ridge, I. 1991. Plant Physiology. Hodder and Stoughon Educational Press. United Kingdom. 233p