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Grafting in Screenhouse of Parkland Shea Tree Accessions with the best Agronomic Traits for Quality Seedlings Multiplication for Farmers in Nigeria

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Abstract: The demand for shea has grown up to 600% in the last 20 years while tree populations are declining at an annual rate of 0.05 per hectare. If current trends continue, there will be a supply shortage in Nigeria. On this note, there is an urgent need to supply farmers with grafted seedlings of short gestation period and high yield. We used screenhouse for grafted shea seedlings, grafted shea seedlings planted in open field and shea seeds directly sowed in nursery bags in the field had been studied. The results revealed that scions collected from shea parkland accessions with the best agronomic traits were grafted in screenhouse. Some of the grafted were transferred to open field. The third had the seeds directly sowed in nursery bags in the field. After six months trial, the highest mean survival and mortality rates for grafted shea seedlings in screenhouse were 93.6 and 6.4%. Followed by grafted shea seedlings transferred to open field with 19.1 and 80.9 had the highest mortality rate and seeds directly sowed in the field using nursery bags 94.7 and 5.1% had the highest survival rate respectively. The average mean screenhouse temperature at midday was 38.3^{0}C, open field 32.8^{0}C and screenhouse cooling 27.3^{0}C. The screenhouse temperature were normalized in comparison to the open field by opening the doors, watering and cross ventilation. It controlled unfavorable weather condition that won't stress the plant, protection against flood hazards, insects, and rodents. The differentiated grafted shea seedlings in screenhouse at 3 months old were transplanted to the field. However, direct seeds sowed would have long gestation period. The grafted shea seedlings raised in screenhouse and open field would have short gestation period. The grafted shea seedlings exhibited better agronomic traits for quality seedlings multiplication for farmers in Nigeria.

Keywords: *Accession, Grafting, Shea tree, Multiplication, Seeds, Traits, Screenhouse.*

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INTRODUCTION

Nigeria is blessed with shea tree *Vitelleria paradoxa* and abundant natural resources including a number of cash crops. These include cassava, cashew, cotton, cocoa, oil palm, rubber, etc. (Onwualu, 2012a, 2012b). It has been shown that when the value chains for these crops are developed, it can lead to employment of all these crops, the shea tree although has many industrial applications, its production, processing and handling are still not developed. The shea tree grows naturally in the wild in the dry Savannah belt of West Africa from Senegal in the west to Sudan in the east and onto the foothills of the Ethiopian highlands. It occurs in 19 countries across the African continent, namely Benin, Ghana, Chad, Burkina Faso**,** Cameroon, Central African Republic, Ethiopia, Guinea Bissau, Cote De voire, Mali, Niger, Nigeria, Senegal, Sierra Leone, Sudan, Togo Uganda, Zaire and Guinea. (Warra , 2011}.

Other important uses shea tree butter include its use as an anti-microbial agent for promotion of rapid healing of wounds, as a pan-releasing agent in bread baking and as a lubricant for donkey carts (Bayala et al., 2002). The ecology of the Shea tree including its yield has been well researched (Glele Kakai et al., 2011; Aleza et al., 2018; Bonde et al., 2019). According to these authors, the trees are ravaged by annual bush-fires that usually burn the undergrowth and cause stunted growth of the young trees in the wild. In recent years the shea tree has gained importance as an economic crop because of the heavy demand for its butter, both locally and internationally.

Demand for shea has grown 600% in the last 20 years, and industry forecast a future 50% increase in the next 5 years; while tree populations are declining, with shea tree density declining at an annual rate of 0.05 per hectare. If current trends continue, in 2034, there will be a supply shortage in West Africa. Shea exports provide about $113 million direct income for women shea collectors and about $80 million of additional income for their communities. At the household level, this income represents up to 12% of the total income and up to 32% of the cash. Shea income is received during the lean season, which makes it particularly valuable to bridge the gap between two harvests. (Mohammed, 2021)

In terms of value, the global shea butter market is expected to reach a market value of US$ 3,566.1 Million (or $3.5 billion) by the end of 2028, with an expected Compound Annual Growth Rate (CAGR) of 5.2% over the forecast period. The key factors driving growth of the shea butter market include the growing demand for cocoa butter alternatives in chocolate and confectioneries, increasing consumption of chocolate and bakery products, rise of product premiumization in the food and beverages industry, and soaring shea butter consumption by cosmetics and personal care products manufacturers (Mohammed, 2021)

Grafting is a propagation technique which is used in propagation of many fruit trees to achieve maximum success in the take, dwarfism in trees depending on rootstock types (Simons, 1987), resistance against insects and pests, salinity tolerance (Colla et al., 2010) as well as enhancing the fruit production (Mitani et al., 2008; Mng'omba, 2007). Therefore, many tropical and subtropical as well as temperate fruits such as mango, avocado, citrus, peach, pear, and plums are commonly propagated by grafting as compare to stem cuttings and marcots which may not be successful as a result of difficulties in root development.

There are many factors that influence on grafting, such as skilled grafter, air temperature, relative humidity, moisture and plant water status, growth stage of scion and rootstock, method and time of grafting, compatible size of grafts of both scions and their respective rootstocks (Hartmann et al., 2007; Mng'omba et al., 2010; Pina and Errea, 2005) and age of the mother plants (Salauddin, 2003). Rootstock with 10-mm stem diameter has been considered ideal for grafting of citrus (Hartmann et al., 1997).

Different grafting methods are used to propagate different fruit species, such as tongue, wedge and veneer in walnut (Muzaffar and Kumar, 2011), cleft grafting in citrus (Hartmann et al., 1997; Coronel and Dotto, 2001; Ledesma and Campbell, 2001), soft wood grafting in Khasi mandarin (Patel et al., 2010) and epicotyls grafting in mango (Baghel et al., 2002; Hema et al., 2002).

In the current study, we investigated the effects of different methods of grafting such as side, wedge or cleft and tongue to propagate different species of citrus such as mandarins (*Citrus reticulata* Blanco) cv. Kinnow and sweet orange [*C. sinensis* (L.) Osbeck] cvs. Succri and Jaffa.

Microclimate control in the screen or greenhouse is important to improve yield and obtain low environmental impacts. Ventilation, shading, evaporative cooling and refrigeration are methods of controlling air temperature inside the greenhouse; nevertheless, ventilation and shading are often not sufficient to remove the excess heat, refrigeration is generally expensive and evaporative cooling is based on the use of large quantities of water. In order to enhance the sustainability of the greenhouse sector, renewable energy sources can be exploited with the application of solar absorption systems for screen or greenhouse cooling in areas with high outdoor temperatures and solar insolation. Puglisi, (2018). Consequently, the objective of the study was large scale production of shea grafted seedlings with

high yield and the best agronomic traits to meet the national demand of one million seedlings per annum as planting materials.

METHODOLOGY

The current study was conducted in open field and screenhouse at shea tree research Substation, Bida, Niger State of the Nigerian Institute for Oil Palm Research (NIFOR). Superior mature trees were identified at different parklands in shea growing states in Nigeria with parental accession traits, as sources of scions, according to the plant breeders, agronomists, pathologists, entomologists, biochemists and farmers' criteria. The scions were collected with the best agronomic traits such as canopy size, vigorous growth, high yield, fruits weight per season, fruit size, kernel size and oil content, butter quality, girth size, absence of disease and insect pests and parental accession traits. The one or two years old shea seedlings in nursey were used as the rootstocks for the grafting studies. The rootstocks were selected on the basis of morphological and sanitary characteristics (vigorous growth, stem maturity and absence of diseases/parasites). Their height ranged between 20 and 100 cm and diameter between 1.5 and 3 cm at their base.

Grafting into the rootstocks were carried out on the same day immediately after scions collection (to minimise physiological stress). Each grafted was labelled, with the date of grafting and source of scion. Cleft and tongue method was used. The procedures for grafting was as described by Hartmann et al. (1997). The following were standard procedures: (i) the scion and the rootstock were washed with 10% sodium hypochlorite (the scion by soaking and the root-stock by scrubbing) to remove the latex and sterilise, (ii) the scion and rootstock matched in size, the cambial tissues were juxta-posed, (iii) after inserting the prepared scions into the opening created in the rootstocks, the scion and the rootstock were tied together by wrapping with transparent cellophane and (iv) the grafted were covered with white transparent cellophane to avoid desiccation and also generate heat within.

The region under study represents rainfall 134.52 millimeters (4.9 inches) of precipitation and has 144.7 rainy days (39.65%) of the time annually. Wind speed: The average annual amount of wind speed in Bida, Niger State is approximately 75.5 km/h. Relative humidity: The annual relative humidity of Bida is approximately 63.7%. The highest humidity is recorded during the month of August which is 83% while the lowest is January with 20%.

Data Analysis

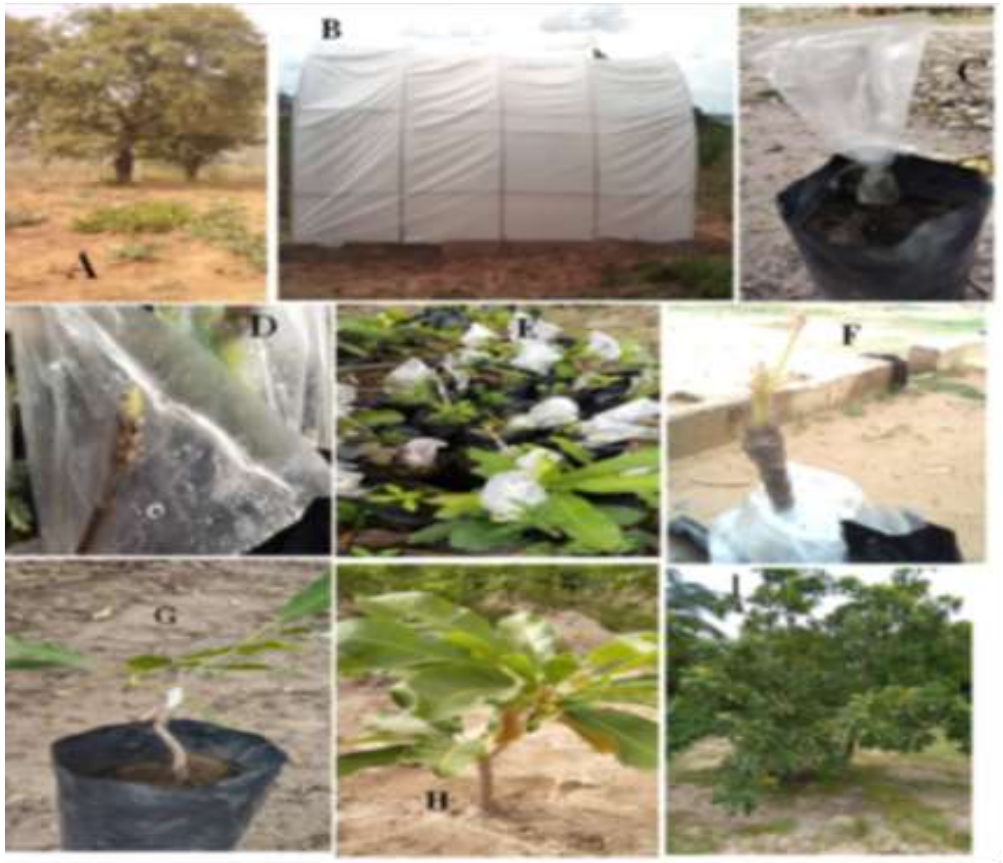
Grafts take percentages were recorded by using the method of Chalise et al. (2013). CM (%) = (T(%) – C(%) / 100 - C(%) x 100 (Abbott, 1925).

RESULTS AND DISCUSSION

The scions for grafting were collected from shea tree parkland accessions with the best agronomic traits such as canopy size, fruits weight per season, fruit size, kernel size and oil content, girth size, butter quality and parental accession traits (plate 1A). The highest mean survival and mortality rates for grafted shea seedlings in screenhouse were 93.6 and 6.4%. Followed by grafted shea seedlings transferred to open field with 19.1 and 80.9 and seeds directly sowed in the field 94.7 and 5.1% respectively (table 1). However, direct seeds sowed with the highest mean survival rate would have long gestation period (plate A). The grafted shea tree seedlings raised in screenhouse would have short gestation period before fruiting (plate I). The screenhouse grafted shea seedlings exhibited better agronomic traits for quality seedlings multiplication for farmers in Nigeria. This agrees with Puglisi et al., (2018) which stated that Microclimate control in the screen or greenhouse is important to improve yield and obtain low environmental impacts.

The average screenhouse temperature at midday were 38.3^{0}C, open field 32.8^{0}C and screenhouse cooling 27.3^{0}C respectively (table 2, plates B-H). The screenhouse cooling was achieved by opening the doors to allow cross ventilation. Photoselective colored nets provide various mixtures of natural, unmodified, and scattered light that is, spectrally modified light (Shahak, 2008, Rajapakse and Shahak, 2007), depending on the pigmentation of the net thread and the design of the fabric with different fibers and densities to create specific tone indices (Castellano et al., 2008). Photoselective nets are also used to protect horticultural plants from sunburn and to prolong the harvest in conditions of excess light (Castellano et al., 2008).

The screenhouse temperature was high and normalized in comparison to the open field. The cooling was achieved by opening the screenhouse doors, watering to allow cooling and cross ventilation. The screenhouse helped to control unfavorable weather condition that won't stress the plant, protection against flood hazards, insects, and rodents. Castellano et al., 2006 stated that the management of the microclimate is the removal of heat and moisture excesses while allowing natural carbon enrichment for photosynthetic purposes. The covering material is a basic factor influencing the energy consumption, the yield and the general economics of the greenhouse. With the new designs of nets for use in greenhouses, and the use of high-quality plastics, environments that favorably influence cultivation of horticultural crops such as peppers can be created (Ayala-Tafoya et al., 2011). The successful differentiated grafted shea seedlings in screenhouse at 3 months old were transplanted to the field (plates B-H).



Plates 1: A-I Shows Screen House Grafting of Parkland Shea Tree Accessions with the best Agronomic Traits for Quality Seed Multiplication

A, Shea tree from Parkland with the best agronomic traits.
B. Screen house with 500 newly grafted Shea seedlings per batch.
C. Newly grafted seedlings
D. Successfully grafted Shea seedlings at 2 weeks old
E. Successfully grafted Shea seedlings at 1 month old
F. Differentiated leaf stage at 3months old
G. Fully differentiated seedlings at one 1 year old
H. 2 years old transplanted grafted seedlings to field
I. Grafted Shea tree fruiting at 7 years old

Table 1: Comparison between Grafted Shea Seedlings in the Screen House, Grafted Shea Seedlings Planted in Open Field and Open Field Direct Shea Seeds Sowing

S/N	Date	No. of graf-ted shea seedlings in screen house	No. of sur-vival rate in screen house	Survival rate (%)	Mortality rate (%)	No.of graf-ted shea seedlings planted in open field	No of sur-vival rate planted in open field	Survival rate (%)	Mortality rate (%)	No. of shea seeds survi-val indirect sowing	No. of survi-val rate of shea seeds direct sowing	Survival rate (%)	Mortality rate (%)
1	5/7/22	500	465	93.0	7.00	500	85	17.00	83.00	500	494	98.8	1.20
2	5/8/22	500	461	92.2	7.8	500	93	18.6	81.4	500	489	89.0	11.0
3	5/9/22	500	470	94.0	6.0	500	103	20.6	79.4	500	496	96.0	4.0
4	5/10/22	500	463	92.6	7.4	500	87	17.4	82.6	500	493	98.6	1.4
5	5/11/22	500	481	96.2	3.8	500	96	19.2	80.8	500	488	97.6	2.4
6	5/12/23	500	467	93.4	6.6	500	109	21.8	78.2	500	489	89.0	11.0
	Mean %			93.6a	6.4			19.1d	80.9			94.7a	5.1

N.B. Means survival rates with different letters are significantly different at 0.1% probability

Table 2: The Monthly Mean of Open Field and Screenhouse Temperatures

Date	Open Field (%)	Screenhouse (%)	Screenhouse Cooling (%)
5/7/22	39^0C	43^0C	29.8^0C
5/8/22	29^0C	33^0C	26.4^0C
5/9/22	29^0C	34^0C	28.4^0C
5/10/22	33^0C	42^0C	26.3^0C
5/11/22	36^0C	41^0C	26.8^0C
6/12/22	31^0C	37^0C	25.9^0C
Mean	32.8^0C	38.3^0C	27.3^0C

For each location the mean percentage was calculated as CM (%) = (T(%) – C(%) / 100 - C(%) x 100 (Abbott, 1925).

CONCLUSION

The screenhouse temperature was high and normalized in comparison to the open field. The cooling was achieved by opening the screenhouse doors, watering to allow cooling and cross ventilation. The temperature allowed grafted shea seedlings production to glue together at the early stage between one to two weeks. The differentiated grafted shea seedlings in screenhouse at 3 months old transplanted to the field would have short gestation period with better agronomic traits of high yield and quality seedlings multiplication for farmers in Nigeria. Grafted shea seedlings in screen house increased survival rate when transplanted to the field while ungrafted without the screenhouse increased mortality rate. The screenhouse helped to control unfavorable

weather condition that won't stress the plant, protection against flood hazards, insects, and rodents

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