



RESEARCH PAPER

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Production of grafted cacao seedlings in dry Season: Its survival and profitability

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Abstract

The study aimed to assess the survivability and profitability of cacao seedlings production using the grafting technique. Specifically, it aims also to produce at least 1,000 grafted cacao seedlings of the five different varieties of cacao (K1, K2, BR25, ICS40, and UF18) during dry cropping seasons while earning at least Php60.00 each seedling. Cacao seedlings and scion rootstock were obtained from several cacao types and used in this investigation. Cleft grafting was performed by connecting the rootstock and scion until they were permanently united and continued to develop as one plant. In this study, it is concluded that the five varieties of cacao (K1, K2, BR25, ICS40 and UF18) are all suitable for the cleft grafting method. However, in terms of the survival rate of different varieties, UF18 has better survival. Also, the study was able to attain its objectives and generated Php42,356.00 net income with an ROI of 240.06% for the dry season. Therefore, the study is considered highly profitable. This type of business is recommended for small businesses and young entrepreneurs because manpower and machinery are optional and are guaranteed a convenient type of business for small-scale farmers. Furthermore, the five varieties of cacao were suitable for the cleft grafting technique. However, in terms of the survival rate, it is recommended that proper selection of scion, the expertise of a person, cleanliness of the tools and most importantly, the compatibility of the stock and scion must be considered. Moreover, another trial must be confirmed and give a more conclusive result.

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Introduction

Cacao, scientifically called *Theobroma cacao* L., was originated from Central America and this has been introduced by the Spanish colony. Cacao is considered the equatorial crop that thrives well in the region occupying the equator means that here in the Philippines has a favorable condition and characteristic soil for cacao production.

Based on World Cacao Production, Asia has only 11% of production compared to Africa, which has 72%. To reach the target of the Philippines in 2020, 100,000 metric tons of dried cacao beans must produce. This can bring opportunity for the nursery operator and the raiser of a grafted cacao. (Cacao Production Guide, 2016).

Asexual propagation is the method of propagation that maintains the desirable quality of the selected variety and the ability to induce fruitfulness without the need to complete the juvenile. Grafting is known as the most ancient of the propagation art. It's about 500 BC since Feng Li Chinese diplomat, was documented as the first man to introduce grafting. Grafting is the art of connecting two living tissue to unite, grow and develop as one plant to improve yielding capacity, resistance and early maturity. (<https://aggie-horticulture.tamu.edu.ph>)

On the other hand, high-yielding cocoa clones known for their genetic stability exist in research stations but have not yet been released to farmers. Clones are easily propagated through grafting (Mng'omba and du Toit, 2006). One advantage of grafting technique is that new plants are identical to the original plant. Furthermore, the technique can be easily executed by farmers. Grafting has successfully been used for vegetative propagation of species such as mango (*Mangifera indica*), bush mango (*Irvingia gabonensis*), Akpi (*Riciodendron heudelotii*) and *Allanblackia* spp. (Mng'omba *et al.*, 2010; Munjuga *et al.*, 2013). Grafting is known to shorten the period between flowering and fruiting. Grafting on mature cocoa trees has been demonstrated to double cocoa yield within two years (ICRAF, 2014). This

propagation method can also be performed on young seedlings. Several grafting methods exist; among them are top grafting, budding, whip, and whip and tongue.

The choice to be used in any particular plant depends on the grafting's success. Budding in cocoa has been used for the multiplication of elite clones and has been shown to be expedient in rehabilitating unproductive cocoa trees (Eskes and Efron,

2006). According to Effendy *et al.* (2013), budding increases production and also stimulates flowering and fruits in cocoa. The most successful method for *Allanblackia parviflora* is top grafting, while budding is the best method for *Allanblackia floribunda* (Munjuga *et al.*, 2011).

Moreover, the study aimed to assess the survivability and profitability of grafted cacao seedling production following the proper management through the grafting technique. The study also aimed to produce at least 1,000 five different varieties of grafted cacao seedlings within the period of six months and generate a net income of ₱60.00 per seedling and evaluate the growth performance of five cacao varieties (K1, K2, BR25, ICS40 and UF18) using cleft grafting technique.

Methodology

Site selection

The site was carefully chosen by considering the following: continuous available source of water, good drainage, accessibility, open from sunlight, and free from pests and other animals that could destroy the seedlings.

Experimental design and treatments

The experimental design used in the study was Completely Randomized Design (CRD) with five treatments (represented by cacao varieties) and replicated three (3) times. A total of 200 seedlings per population per variety were used on the treatments and labeled as follows: T₁- K1, T₂- K2, T₃- BR25, T₄- ICS40 and T₅- UF18.

Repairing the nursery

The nursery was repaired using the available materials in the locality, such as bamboo tie wire and coconut palm leaves which serves as roofing. The nursery was repaired to protect the grafted cacao from calamities as well as too much exposure to sunlight.

Purchasing of rootstock

The rootstock was purchased at Cagayan Valley Research Center in San Felipe, Ilagan City. The rootstock was selected based on the following criteria: it should be healthy with at least 75 cm in height, pencil size diameter of stem and at least 8-10 months old.

Hauling

The cacao seedlings were carefully hauled and arranged to the nursery to avoid damage that would result wilting of seedlings.

Collecting of scion

A healthy scion was collected at CSU Lal-lo from the branched of a fruit-bearing cacao tree. Scion that has pencil-sized in diameter was used.

Grafting of cacao seedlings

Cleft grafting was done in the nursery by uniting scion and the rootstock to live as one plant. A plastic bag was placed in each of the grafted seedlings to cover up the scion below the graft union to protect from air drying and entering of water that can cause the death of grafted cacao.

Removing ice candy bag from the grafted cacao

Removing the ice candy bag was done when shoots were slightly matured.

Removing shoots of grafted cacao on rootstocks

The shoot of the rootstock was removed to direct the nutrient into the shoots developed from the scion.

Slitting of grafted cacao

Grafted cacao was slitted by slicing the plastic strip that bonded in the grafted cacao.

Watering the grafted cacao

The grafted cacao seedlings were watered regularly or as needed.

Weeding

Weeds were uprooted manually to avoid the competition of nutrients as well as sunlight.

Applying fertilizer and pesticide

A urea of ½ kilo was applied by diluting it and was used by watering it to the seedlings. Lanate was applied to control the presence of armyworms, aphids and beetles.

Marketing

Grafted cacao seedlings were sold to the local farmers in Allacapan for at least ₱60.00 per grafted cacao seedling.

Data gathered

The number of developed leaves: This was taken by counting the number of fully developed leaves per plant 90 days after grafting (DAG).

Stem girth of the scion: The girth of the scion was measured one centimeter above the graft joint after using the vernier caliper. This was done by putting the vernier caliper 1 cm above the graft union. (G. Srinivas, 2007).

Leaf area index (LAI): This was taken by computing the product of length and width of two leaves per plant in treatment and multiplied by the leaf area factor of cacao (0.75). This was measured in centimeters (cm) 90 days after grafting.

Survival rate (%): This was taken by calculating the percentage survival of cacao using the formula:

$$\text{Survival rate} = \frac{\text{number of seedlings survive}}{\text{Total number of seedlings}} \times 100$$

Initial height: This was taken by measuring the initial height of rootstock and scion upon the study started and was measured in centimeters (cm) by using a foot rule.

Analysis of data

The data was analyzed using the Analysis of Variance (ANOVA) of the Completely Randomized Design (CRD).

Results and discussion

Survival rate

Table 1 shows the result of the survival rate of grafted cacao varieties. The results revealed that the UF18 grafted cacao seedlings obtained the highest survival rate of 75%, followed by Treatment 5 with 68.33%. Among the least survived grafted cacao seedlings were BR25, ICS40 and K1 with survival rates of 65%, 62.7% and 61%, respectively.

However, the differences in the treatments of this parameter did not show any significant results.

This collaborates with the study of Adjei *et al.*, 2005 that the differences in the number that were successfully grafted among the three methods were not significant. However, the side grafting method recorded the highest percentage compared to the cleft and whip-and-tongue methods. Growth inhibition and high mortality in grafts (i.e. severe graft compatibility) were due to discontinuities in the vascular bundles at the graft union, which prevented the translocation of assimilates, mineral nutrients, and water between scions and rootstocks.

Table 1. Survival Rate (%) of five varieties of cacao using cleft grafting techniques.

Treatment	Mean
T1- K1	61.00
T2- K2	68.33
T3- BR25	65.00
T4- ICS40	62.70
T5- UF18	75.00

ns- not significant at 5% level, LSD.

Growth parameters of five cacao varieties using cleft grafting techniques

Table 2 shows the results of stem girth (cm), number of developed leaves, Leaf Area Index (LAI) and initial height of the grafted five cacao varieties. In terms of stem girth, it showed that K2 got the highest stem girth mean of 3.77 cm, followed by BR25, UF18, K1, and ICS40 with means of 3.67 cm, 3.47 cm, 3.40 cm, and 2.87 cm, respectively. Turkey's Honest Significant Difference (HSD) test revealed that the five varieties were not significantly different from each other in terms of stem girth. In the study of Fakariyya *et al.*, 2015, he explained that the stem girth was not different among the treatments, either clone or number of scion budwoods.

Furthermore, Adjei *et al.*, 2005, stated that the result did not show up in girth in all the methods. However, cleft graft recorded the highest mean stem girth with the lowest from the whip-and-tongue. Producing more leaves could ultimately lead to higher photosynthates and, therefore, more distribution to other parts of the plants. R. Satoo *et al.* 2006 reported that the greater the number of leaves, the greater was wood production in *Populus Daviana* trees. Koslowski, 2001 also reported that the increase of girth of trees occurring primarily from meristematic activity in the cambial growth was greatly influenced by leaf development since photosynthates distribution might not be proportionally sent to other parts of the plants.

Table 2. Selected growth parameters of five cacao varieties using cleft grafting techniques.

Treatment	Stem girth (cm) mean	No. Of developed leaves mean	Leaf area index (LAI) (cm) mean	Initial height (cm) mean
T1- K1	3.40	7.93	57.52	39.18
T2- K2	3.77	9.53	46.01	43.05
T3- BR25	3.57	8.33	61.22	51.34
T4- ICS40	2.87	7.73	57.93	46.62
T5- UF18	3.47	8.87	72.79	45.93

On the other hand, results revealed that the most developed leaves were also obtained by varieties K2, followed by UF18, BR25, K1, and ICS40 with means of 9.53, 8.87, 8.33, 7.93 and 7.73, respectively. However, the differences among treatments on this parameter did not prove any significant result. As Hussian *et al.*, 2007 stated that the cleft grafting method registered more leaves than the other grafting methods (whip-and-tongue and side grafting); however, it does not show up any significant effect.

Much as the operation brought about lower success compared to the side grafts, it could have encouraged earlier scion/stock union. This means growth resumed quicker. In the whip-and-tongue, leaf production was better early weeks compared to the side grafts. Since the seedling rootstock in the whip-and-tongue operation was older, this could mean a more extensive root growth and a stronger rootstock to supply water and nutrients to effect rapid leaf production compared to the side grafting.

Table 3. Monthly Cash Flow of the Five Varieties of Grafted Cacao Seedlings Production. Cagayan State University, Lal-lo, Cagayan.

Particulars	January	February	March	April	Balance (₱)
Inflows:					
Family loan	16,000				16,000
Sales of grafted cacao seedlings				60,000	60,000
Total Inflows	16,000			60,000	76,000
Outflows:					
Record notebook	10				75,990
Ballpen	10				75,980
Ice bag	80				75,900
Ice candy bag	50	30			75,820
Tie wire	80				75,740
Root stocks	11,000				64,740
Polyethylene bag	1,500				63,240
Fertilizer	30		30		63,180
Fuel			50	176	62,954
Transportation	1,600	20			61,334
Pesticide			50		61,284
Paying of family loan				6,000	55,284
Paying of SMLF loan and interest				10,228	45,056
Miscellaneous				200	44,856
Labor cost				2,500	42,356
Total Outflows	14,360	50	130	19,104	
Cash Surplus/Deficit	1,640	(50)	(130)	40,896	
Opening Balance	0	1,640	1,590	1,460	
Closing Balance	1,640	1590	1,460	42,356	

Moreover, in terms of the Leaf Area Index (LAI), the result shows that UF18 got the highest mean of 72.79 cm, followed by BR25, (61.22 cm), ICS40 (57.93 cm), K1 (57.52 cm), and K2 (46.01 cm), respectively.

However, the differences among the treatments did not prove any significant results. In the study conducted by Naik 2008, he stated that there were no

significant differences observed in the leaf size from the fifth month of the graft union among the grafting methods used in the study. Perhaps, the cleft grafting method imparts vigour to the plant, according to Webster and Wilson 2000. moreover, the degree of leaf production and expansion may suggest vigour by the use of the cleft grafting technique. Furthermore, the result of the initial height of the five grafted cacao

varieties showed that BR25 got the highest mean of 51.34 cm, followed by ICS40, UF18, K2 and K1 with the mean of 46.62 cm, 45.93 cm, 43.05 cm, and 39.18 cm, respectively. The analysis of variance (ANOVA)

revealed no significant impacts on the initial height of the five cacao varieties; this means that whichever types were used for the grafting process may have an influence on the cacao plants' initial height.

Table 4. Gross Margin Analysis of Five Varieties of Grafted Cacao Seedlings Production. Cagayan State University, Lal-lo, Cagayan.

Items	Amount (₱)
I. Cash return	
A. Total cash return	60,000.00
II. Cash cost	
Record notebook and ball pen	20.00
Ice bag and ice candy bag	160.00
Tie wire	80.00
Rootstocks	11,000
Polyethylene bag	1,500
Fertilizer and pesticide	110.00
Fuel	226.00
Transportation	1,620.00
Miscellaneous	200.00
Loan interest	228.00
Labor cost	2,500.00
B. Total cash cost	17,644.00
C. Net profit	42,356.00
D. Return on investment (ROI)	240.06%

Monthly cash flow

The monthly cash flow is presented in Table 3. The study started on January 4, 2018, with the inflow of ₱16,000.00 that came from Family Loan. Outflows were recorded when the record notebook, ball pen, ice bag, ice candy bag, and tie wire were purchased. The outflow for this month amounted to ₱14,360.00 which was used to purchase 1,100 pieces of root stocks, polyethylene bags, fertilizer, fuel and transportation. A total cash surplus and closing balance for this month amounted to ₱1,640.00. For the month of February, the opening balance with a total amount of ₱1,640.00 was used to purchase an ice candy bag with a total of ₱30.00 and a transportation expense of ₱50.00. A total cash deficit of ₱50.00 and closing balance for this month amounted to ₱1,590.00 which also serves as the opening balance for the next month.

For the month of March, a kilo of fertilizer (46-0-0) and a sachet of pesticide (Lanate) were purchased with a total amount of ₱130.00 including the fuel, and a cash deficit amounted to ₱130.00 and the closing balance amounted to ₱1,460.00.

In the month of April, the grafted cacao seedlings were sold. Hence an inflow of ₱60,000.00 was recorded. The family loan including its interest, were paid. Miscellaneous expenses, fuel and labor costs were also calculated and paid. The computed outflows has amounted to ₱19,104.00, and the closing balance was ₱42,356.00, which serves as the total net income of the project.

Cost and return analysis

Table 4 shows the cost and return analysis of the study for four (4) months of operation (January, 2018 to April, 2018). It shows a cash return of ₱60,000.00 and a total cash cost of ₱17,644.00. Net income generated was ₱42,356.00 with a return on investment of 240.06%. This denotes that for every peso invested in the study, there was an equivalent return of ₱2.4006 for a period of four (4) months.

Conclusion

Based from the results of the study, it was concluded that the five treatments represented the five varieties of cacao (K1, K2, BR25, ICS40 and UF18) are all suitable for the cleft grafting method. However, in

terms of the survival rate of different varieties, UF18 has better survival. Thus, based on the cost and return analysis of the study, the study was able to attain its objectives and generated ₦42,356.00 net income with an ROI of 240.06%. Therefore, the study was considered highly profitable.

Recommendation

Based on the results of the study, production of grafted cacao seedlings under five varieties of cacao is recommended because it generated a high income out of the small investment, small area and in a short period of time; thus, full-time management is not totally required and manpower and machinery are optional and it's guaranteed a convenient type of enterprise to students and farmers. However, in terms of the survival rate, it is recommended that proper selection of scion, the expertise of a person, cleanliness of the tools and most importantly, the compatibility of the stock and scion must be considered. Moreover, another trial must be confirmed and give a more conclusive result. Another research and observation must be performed using the different grafting methods for more reliable data.

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