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Compatibility of Citrus Cultivars on Rough Lemon Rootstock in Botswana

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***Abstract* – Universally, budding is the most common method practiced in propagation of citrus. In Botswana, citrus production is still at an infant stage and propagation materials are outsourced. This study was designed to determine the compatibility and growth performance of seven citrus cultivars budded on rough lemon rootstock. Each cultivar was budded on eighty (80) lemon rootstocks, making a total of 560 budded seedlings using T-budding technique. The experiment was conducted under protected environment (shade net 60%). The experiment was arranged in a Randomized Complete Block Design (RCBD) with four replicates. The budding success rate of cultivars ranged from 70% to 100%. All cultivars studied showed a100% compatibility with rough lemon except Palmer navel which recorded 85%. Cultivars differ in plant height, number of branches and leaves, rootstock diameter, scion diameter and photosynthetic parameters. Budding using rough lemon as a rootstock in cultivars tested can be recommended in Botswana. However, more tests like the time of budding, the optimal age of rootstock as well as more components of photochemical activities ought to be determined before any commercial recommendation is made.**

***Keywords* – Budding, Citrus, Compatibility, Cultivars, Survival Rate.**

I. Introduction

Citrus fruits are produced in many areas around the world. The center of origin of citrus is the southeast foothills of the Himalayas, in a region stretching from eastern Assam, northern Myanmar to western Yunnan (Wu et al., 2018). Currently, about 1.5 million hectares is cultivated for citrus under commercial scale internationally and yielded nearly 40 million metric tons of oranges, lemons, limes (Ataweia et al., 2015). Globally, the most used citrus species are sweet orange (*Citrus sinensis*) and lemon (*citrus limon*) (Luro et al., 2011; Chahal and Gill 2015). In Botswana, majority of citrus produced are sweet orange and production is still from small scale producers. Recently, a large commercial citrus farm (1,200 ha) was established aiming at increasing citrus produce as well as venturing into the export market. As a result, small scale citrus producers are now envisioned to upscale both in quantity and quality production. In addition, the first ever citrus producers' association emerged and is getting attention from the prospective farmers. This motivated the need for quality propagation materials. Currently, both small scale farmers and the emerging commercial farmer depend on imported propa- -gation materials. According to Gagopale et al. (2021), the dependance on imported basic resources for production such as propagation materials can disrupt the flow of local production during the perilous times, particularly when movements restriction remains the option for intervention. Therefore, the need for local production of citrus propagation materials is inevitable. Thus, research is expected to find outstanding and innovative methods to produce citrus propagation materials locally for continuous production even in adverse seasons.

Asexual reproduction is a remarkable feature of perennial fruit crops that facilitates the faithful propagation of commercially valuable individuals by avoiding the uncertainty associated with the sexual reproduction of hybrid plants (Wang et al., 2017). The commonly used asexual method in citrus is budding, the process of connecting rootstock (stem and roots) and scion (top portion of the plant) in a manner that they may unite and grow successfully as one plant. The union of the rootstock and the scion must be strong mechanically. According to Albrecht et al. (2021), when it happens, the rootstock-scion combination is considered compatible. When the rootstock and the scion are not compatible then the movement of water, nutrients and other substances across budding zone will be limited, resulting in low success or death of seedlings. The more distant the genetic relationship between the budding partners, the more likely the chance that the budding combination will be incompatible (Albrecht et al., 2021). Incompatibility is the failure of a combination between rootstock and scion which can be noticed immediately after budding, at a later phase of the growth of seedling or during the first seasons of fruit bearing.

The success of budding first depends on the choice of a suitable rootstock and the selection of satisfactory bud wood (Kamanga et al., 2017). Selection of bud wood requires careful identification of mother trees and appropriate selection of bud sticks on the chosen tree. The growth of different scion cultivars depends on the successful callusing, union of vascular systems of graft components, type of rootstock and scion cultivar. Martínez-Cuenca et al. (2016) highlighted that citrus rootstocks influence the optimal performance of scions regarding photosynthetic capacity. The more the rootstocks vary, the more their photosynthetic rates differ (Liao et al., 2019). Perfect connectivity between rootstock and scion ensures translocation of photosynthates as well as outstanding in photosynthetic capacity.

This study, therefore, is aimed at determining the compatibility and growth performance of seven (7) citrus cultivars budded on rough lemon rootstock in Botswana.

II. Materials and Methods

Experimental Site Description

The study was conducted at the National Fruit Tree Nursery (21°45’ S and 27°49’ E), Ditladi village in the Northeast District of Botswana, during 2023 and 2024 season. The area lies on flat land with an altitude of 1020 m above sea level. The area’s local climatic conditions are characterized by low rainfall and dry periods (between April and October), wet and hot season (between November and March). The average annual rainfall is about 630 mm. The experiment was conducted under protected environment (shade net 60%).

Field Procedure

Mother trees of citrus cultivars (Navelian navel, McLean, Palmer navel, Gilenburg, Salustiana, Tamango Mid-Valencia, Newhall) which were not showing signs of diseases were selected for scion wood (buds wood) at Mmamanaka Research Site Orchard. The scion wood was mature, round and green from the last flush of growth. Bud’s woods were collected from the peripheral of the canopy where the branches were well exposed to sunlight. Each bundle of scion wood was labeled and wrapped in a moist piece of muslin cloth to keep buds wood from drying until arrival at National Fruit Tree Nursery. The buds were budded on a year-old rough lemon rootstock at a budding height of 15-20 cm. Each cultivar was budded on eighty (80) lemon rootstocks, making a total of 560 budded seedlings using T-budding technique described by Bilderback *et al*. (2014). Budded seedlings were irrigated daily using arrow drippers.

After determination of budding success rate, forty (40) healthy successfully budded seedlings from each cultivar were selected for growth performance. The experiment was arranged in a Randomized Complete Block Design (RCBD) with four replicates, making ten (10) seedlings per replication and a total of 280 plants for growth evaluation.

Data Collection

Data was recorded on randomly selected five seedlings per replication at monthly intervals from 90 days after budding (DAB) till 210 DAB except where stated in respective section. Data was measured from parameters as follows;

Budding Success/Bud Break Percentage (%)

A budding success or bud break is a successful union evident from the growth of the budded scion on the rootstock was determined two months after budding operation. The percentage of budding success was calculated with the help of formula 1.

$$\text{Budding success percentage} = \frac{\text{Sprouted buds}}{\text{Total number of budded plants}} \text{ X } 100 \qquad (1)$$

Survival Percentage (%)

The number of surviving budded seedlings were counted from all treatments, survival percentage was calculated using formula 2:

$$\text{Survival percentage} = \frac{\text{Number of survived plants}}{\text{Total number of budded plants}} \text{ x } 100 \qquad (2)$$

Seedlings Height (cm)

The height of seedlings was measured using meter ruler and averages calculated. The height was measured from the top level of the soil in the planting bags to the highest tip of the seedling.

Number of Leaves

The total number of leaves per seedling were counted and then averages calculated.

Number of Branches

The number of branches or shoots were counted from each treatment, thereafter, newly developed branches were then removed to remain with single stem. This was done each time when data was collected.

Rootstock and Scion Thickness (mm)

The thickness of rootstocks and scion of seedlings were measured using digital caliper and then averages were calculated.

Photosynthetic Parameters

Photosynthetic parameters were measured after 210 DAB on the middle fully expanded upper leaf using a portable photosynthetic handheld meter, multispe Q. Parameters measured include linear electrons flow (LEF), Photosystem -II photochemical efficiency (Phi 2), Photo-protective non-photochemical quenching (NPQ), Basal

basal dissipation of non-regulated light energy (PhiNO) and non-photochemical quenching (NPQt).

Pests and Diseases Incidence

Monitoring of pests and diseases was done and recorded on a weekly basis. Dieback was controlled by pruning the affected part of seedlings. Pests were controlled using chlorpyrifos (Organophosphate) at 200g/l and Deltamethrin (Pyrethroid) at 7.5 g/l.

Statistical Analysis

Statistical analysis was performed by using Statistical Analysis System (SAS) software package except on budding success and survival percentage. The significant differences between means were evaluated using Tukey's multiple range test at $P \leq 0.05$.

II. Results and Discussion

Budding Success (%)

In this study, the bud break which refers to the emergence or sprouting of new shoots from the bud will be referred as budding success. The results in table 1 below indicate that the maximum budding success rate of 100% was attained on cultivar McLean, Palmer navel, Salustiana and Newhall. These were followed by cultivar Gilenburg at 95%, then Navelian navel with 80% and lastly Tamango Mid-Valencia at 70%. According to Lewis and Alexander (2008), under optimal conditions the bud break ranges between 90% and 100%. Singh and Chahal (2021), stated that bud break depends on the thickness of stem, flow of sap and the season of budding. Vijayakumari (2019) reported a budding success rate of 90.57% when citrus cultivars were budded on rough lemon rootstock. Singh et al. (2019) reported budding success rate ranging from 46.4% to 81.9% when investigating the performance of exotic citrus rootstocks under protected conditions, they concluded that the success of budding is dependent on the characters of rootstock. Kamanga et al. (2017) studied budding and grafting performance in sweet orange and reported a bud break ranging from 90 to 100% in grafted plants. Mataa et al. (2017), studied four methods of vegetative propagation including budding in citrus, and the results indicated that different budding techniques play a role in the success of budding. Koti et al. (2023) reported a budding success rate of 96.67% and highlighted that the physiological state of rootstock plays a role in the success rate.

Table 1. Budding success of citrus cultivars on rough lemon rootstock

Cultivar	Number of Budded Seedlings	Number of Sprouted Seedlings	Budding Success (%)
Navelian navel	80	64	80
McLean	80	80	100
Palmer navel	80	80	100
Gilenburg	80	76	95
Salustiana	80	80	100
Tamango Mid-Valencia	80	56	70
Newhall	80	80	100

Survival Rate (%)

The survival of budded seedlings indicates the compatibility of rootstock and scion. Failure of compatibility results in lower success rate or absolute death of seedlings. The survival rate from this study was determined at 210 days after budding. The results indicate that the survival rate of citrus cultivars differs (Table 2). A survival rate of 100% was noted in all cultivars except Palmer navel which had 85% survival rate. A survival rate of 100% on citrus cultivars was also reported by Dinesh *et al*. (2021). The budding affinity of seedlings depends on either anticipated or unanticipated factors. These factors are not limited to, time of budding (Seletsu *et al*., 2011), environmental conditions (Karunakaran *et al*., 2014), age of rootstock (Deshmukh *et al*., 2017), type of rootstock (Ataweia *et al*., 2015; Rajamanickam *et al*., 2023), scion variety (Wheaton *et al*., 1991; Samra, 2008), technique of budding (Hussain *et al*., 2018; Le *at al*., 2020), diseases (Graham *et al*., 1999) and nutrients (Dinesh *et al*., 2021). The higher percentages of survival from the current study might be due to the efficient functional integration mechanisms between the rootstock and the scion. The other factor might be due to craftmanship at initial budding and seedling management post budding. Randhawa and Kaur (2021) reported a survival rate of 91.99% when budding at different intervals. Singh and Chahal (2021) reported the high success rate of 81.9% when budding Kinnow mandarin on lemon rootstock in comparison to other rootstocks. Considering this as the first trial in Botswana, further assessment of survival of the cultivars understudy needs to be determined in the field. Since incompatibility may take several years to be noticeable (Albrecht *et al*., 2023). This was previously pointed out by Martínez-Ballesta *et al*. (2010) as they stated that grafting incompatibility usually occurs at early stages, when vascular connections are forming, but it can manifest at the fruiting stage, when the demand for water and nutrients escalates.

Table 2. Survival rate of citrus cultivars budded on rough lemon rootstock

Cultivar	Seedlings at Initial Stage	Seedlings at 210 DAB	Survival Rate (%)
Navelian navel	40	40	100
McLean	40	40	100
Palmer navel	40	34	85
Gilenburg	40	40	100
Salustiana	40	40	100
Tamango Mid-Valencia	40	40	100
Newhall	40	40	100

DAB = Days after budding.

Plant Height

Table 3 shows that all cultivars had a periodic increment in plant height when budded on rough lemon rootstock. The increment in plant height was recorded in all budded cultivars except cultivar Tamango Mid-Valencia which showed a significant decline at 210 DAB. Cultivar Gilenburg and Mclean showed their superiority regarding plant height, recording 65.14 cm and 64.17 cm respectively. The two cultivars also showed vigorous growth throughout as shown by the highest growth across all the period of study. Cultivar Navelian na--vel was the shortest, producing seedlings of mean height of 43.79 cm. The differential growth pattens might be attributed to the inherent genetic characters of cultivar (Kumar *et al*., 2017; Yulianti *et al*., 2020).

Table 3. Plant height of citrus cultivars budded on rough lemon rootstock.

Cultivar	Average Plant Height (cm) (DAB)					Mean
	90	120	150	180	210	
Navelian navel	35.65^{e}	30.00^{d}	47.20^{c}	52.30^{cd}	53.80^{c}	43.79
McLean	51.40^{b}	55.25^{a}	69.90^{ab}	70.47^{a}	73.83^{a}	64.17
Palmer navel	48.55^{bc}	48.05^{bc}	55.85^{b}	60.05^{bc}	63.10^{b}	55.12
Gilenburg	58.16^{a}	56.05^{a}	65.42^{a}	69.74^{a}	76.32^{a}	65.14
Salustiana	43.65^{cd}	47.35^{c}	49.35^{c}	47.26^{d}	51.80^{c}	47.88
Tamango Mid-Valencia	47.12^{bc}	54.00^{ab}	59.25^{ab}	61.05^{b}	48.60^{c}	54.00
Newhall	39.20^{ed}	43.20^{cd}	43.50^{c}	45.45^{d}	64.00^{c}	47.07
Mean	46.25	47.70	55.78	58.05	61.64	

Different letters between cultivars denote significant differences (LSD test, $p \leq 0.05$). DAB = Days after budding.

Number of Branches

The data of branch quantity per cultivar is shown in table 4, indicates the decline in number of branches at 210 DAB. The result also shows that citrus cultivars differ in producing number of branches. The maximum average number of branches (1.70) was produced by Salustiana, followed by the values of 1.64, 1.56 and 1.46 produced by Tamango Mid-Valencia, Palmer navel and Gilenburg respectively. The smaller number of branches (1.10) was recorded on McLean. However, McLean produced statistically the same number of branches with other cultivars that produced high number of branches. In a study by Rehman *et al*. (2017), cultivar Salustiana and Cara Cara were at par, surpassed other cultivars regarding the production of branches. Seletsu *et al*. (2011) reported different numbers of branches on different citrus cultivars and maximum number of branches was 2.22 and the least was 1.04.

Table 4. Average number of branchers of citrus cultivars budded on rough lemon rootstock.

Cultivar	Average Number of Branches (DAB)					Mean
	90	120	150	180	210	
Navelian navel	1.00^{b}	1.00^{b}	1.40^{a}	1.45^{bc}	1.15^{ab}	1.20
McLean	1.00^{b}	1.05^{b}	1.20^{a}	1.26^{c}	1.00^{b}	1.10
Palmer navel	2.00^{a}	1.37^{ab}	2.15^{a}	1.25^{c}	1.05^{ab}	1.56
Gilenburg	1.21^{b}	1.47^{ab}	2.05^{a}	1.56^{abc}	1.00^{b}	1.46
Salustiana	1.75^{a}	1.90^{a}	1.50^{a}	2.10^{ab}	1.25^{ab}	1.70
Tamango Mid-Valencia	1.29^{b}	1.40^{ab}	2.15^{a}	2.35^{a}	1.00^{b}	1.64
Newhall	1.20^{b}	1.00^{b}	1.25^{a}	1.70^{abc}	1.40^{a}	1.31
Mean	1.35	1.31	1.67	1.67	1.12	

Different letters between cultivars denote significant differences (LSD test, $p \leq 0.05$). DAB = Days after budding.

Number of Leaves

The enhancement of vegetative growth in terms of the number of leaves is shown in Table 5. Cultivar Gilenburg had the highest average number of leaves (27.41) followed by Tamango Mid-Valencia (20.71) then

Palmer navel recording 20.47 leaves. Most cultivars had around 20 leaves and were statistically at par with each other. Cultivar Newhall had the lowest number of leaves (14.63). Higher vegetative growth was observed at 180 DAB for all the cultivars. Certain plants genotypes had fewer leaves as a characteristic and exhibit slower growth which can also lead to lower number of leaves. The higher number of leaves on cultivar Gilenburg indicates the ability of the cultivar to grow faster as indicated by the corresponding largest plant height shown in Table 3. This might be due to the accumulated biomass that enable the cultivar to have a higher growth rate. Most cultivars started shedding leaves at 210 DAB. This can be attributed to the winter season and the deciduous nature of citrus. Randhawa and Kaur (2021) reported varying number of leaves on different citrus cultivars when investigating budding time of different cultivars on Carrrizo rootstock. According to Kamanga *et al*. (2017), number of leaves in plant depend on the average number of leaves per branch and the number of branches per plant. However, such relationship is not the case from this study. Rehman *et al*. (2017) highlighted that quantity of leaves might be associated with maximum shoot thickness and compatibility of species.

Table 5. Average number of leaves of citrus cultivars budded on rough lemon rootstock.

Cultivar	Average Number of Leaves (DAB)					Mean
	90	120	150	180	210	
Navelian navel	10.15^{c}	8.65^{e}	19.15^{cd}	22.25^{b}	20.70^{bc}	16.18
McLean	10.55^{c}	11.10^{ed}	17.00^{ed}	21.74^{b}	20.22^{bc}	16.12
Palmer navel	12.25^{bc}	16.90^{bc}	25.40^{b}	23.30^{b}	24.50^{ab}	20.47
Gilenburg	18.95^{a}	24.00^{a}	32.00^{a}	34.56^{a}	27.53^{a}	27.41
Salustiana	9.75^{c}	13.85^{cd}	17.60^{ed}	24.32^{b}	17.40^{c}	16.58
Tamango Mid-Valencia	11.12^{b}	19.15^{b}	24.15^{bc}	32.50^{a}	16.65^{c}	20.71
Newhall	9.80^{c}	9.20^{e}	12.95^{b}	19.20^{b}	22.00^{abc}	14.63
Mean	11.80	14.69	21.18	25.41	21.29	

Different letters between cultivars denote significant differences (LSD test, $p \leq 0.05$). DAB = Days after budding.

Stem and Scion Diameter

The equilibrium diameter of rootstock and scion is critical for compatibility of rootstock and scion. Stem diameter was recorded starting at 108 DAB (Table 6). The mean steam diameter of most cultivars is around 7 mm and scion diameter averages above 5 mm. The diameter enlarged from 7.37 mm at 180 DAB to 8.03 mm at 210 DAB. McLean produced thicker stem (7.97 mm), followed by Salustiana (7.83 mm), then Gilenburg which is at par with Newhall, then Palmer navel (7.40 mm), then Navelian navel (7.36 mm). Tamango Mid-Valencia produced the thinnest steam diameter (7.35 mm).

Table 6. Stem and scion thickness of citrus cultivars budded on rough lemon rootstock.

Cultivar	Stem Diameter (mm) (DAB)				Scion Diameter (mm)
	180	210	210	Mean	210
Navelian navel	7.38^{ab}	6.60^{c}	8.10^{abc}	7.36	5.20^{abc}

Cultivar	Stem Diameter (mm) (DAB)				Scion Diameter (mm)
	180	210	210	Mean	210
McLean	7.75[a]	7.60[ab]	8.57[a]	7.97	5.76[a]
Palmer navel	7.14[ab]	7.64[ab]	7.41[d]	7.40	4.95[bc]
Gilenburg	7.47[ab]	7.58[ab]	7.96[bcd]	7.67	5.84[a]
Salustiana	7.72[a]	7.48[ab]	8.28[ab]	7.83	4.47[c]
Tamango Mid-Valencia	7.29[ab]	7.15[bc]	7.62[cd]	7.35	4.94[bc]
Newhall	6.87[b]	7.86[a]	8.29[ab]	7.67	5.48[ab]
Mean	7.37	7.42	8.03		5.23

Different letters between cultivars denote significant differences (LSD test, $p \leq 0.05$). DAB = Days after budding.

Scion diameter was recorded at 210 DAB (Table 6). Gilenburg and McLean produced significantly thicker scion diameters recording 5.84 mm and 5.76 mm respectively. Though these cultivars produced thickest scion diameters, their scion diameters were not significantly different from scion diameters of Newhall and Navelian navel which had scion diameters of 5.48 mm and 5.20 mm respectively. Newhall and Navelian are statistically the same with Palmer navel (4.95 mm) and Tamango Mid-Valencia (4.94 mm). Thinnest scion diameter was recorded on Salustiana, however, its diameter was not statistically different from scion diameters of Navelian navel, Palmer navel and Tamango Mid-Valencia. The differential growth of the cultivars under study might be attributed to the inherent genetic traits (Randhawa and Kaur, 2021). In a study of the influence of different citrus rootstocks on plant growth and internal quality of cultivar 'Mosambi', a significant difference ratio of rootstock and scion was observed and reported to be influenced by the type of rootstock (Aziz et al., 2020). Raja et al. (2023) also reported different rootstock diameters when investigating pre-bearing performance of various rootstocks in sweet orange cultivar 'Sathgudi'.

Photosynthetic Parameters

The results for evaluated photosynthetic parameters are presented in table 7. The results showed a significant difference in photosynthetic traits measured. However, Gilenburg and Newhall had the highest values of NPQ which indicates the amount of light dissipated as heat to avoid damage to the leaves. This shows that the varieties can withstand high temperatures hence the vigorous growth. In addition, Newhall, Gilenburg and Mclean showed the lowest values of PhiNo which indicates the light received that has not been used by the leaf for photosynthesis. This measure indicated that the cultivars could convert or use most of the light they receive for photosynthesis. This corresponds to the growth traits of the plant height and the number of leaves observed. The ability of genotypes to withstand various environmental stresses is determined by NPQ and the lower the values of NPQ, the more resilience the cultivar is to various environmental stresses. Aiyelaagbe *et al*. (2005) reported a significant increase of NPQ when citrus was subjected to shading. Thus, from current results, Navelian navel might be more adaptive to stress whereas Newhall might be intolerant of stress. Chen *et al*. (2021) also reported insignificant variation of NPQ on the photosynthetic physiology of citrus subjected to different seasons and cultivation practices. Further research on the same cultivars of this present study, under stressful conditions is paramount to validate if Navelian navel is competitively adaptive to stressful conditions compared to other cultivars.

Table 7. Photosynthetic parameters of citrus cultivars budded on rough lemon rootstock.

Cultivar	Photosynthetic Parameters				
	LEF	Phi2	NPQ	NPQt	PhiNO
Navelian navel	45.81[a]	0.30[a]	0.50[b]	2.65[c]	0.21[a]
McLean	21.93[ab]	0.18[ab]	0.71[a]	10.82[ab]	0.08[b]
Palmer navel	30.42[ab]	0.16[ab]	0.73[a]	7.58[b]	0.12[b]
Gilenburg	14.82[b]	0.07[b]	0.84[a]	9.87[ab]	0.09[b]
Salustiana	20.81[ab]	0.08[b]	0.83[a]	9.77[ab]	0.09[b]
Tamango Mid-Valencia	32.08[ab]	0.09[b]	0.85[a]	9.49[ab]	0.09[b]
Newhall	7.78[b]	0.07[b]	0.86[a]	11.83[a]	0.08[b]

Different letters between cultivars denote significant differences (LSD test, $p \leq 0.05$). DAB = Days after budding.

Pests and Diseases Incidence

Severity of diseases and pests can result in declining production and to some extent huge economic losses. Tennant *et al*. (2009) highlighted that citrus is susceptible to several catastrophic pests and diseases which limit production or ultimately decimate citrus industry. During the study, symptoms of foliar damage were associated with Dieback disease, Citrus thrips (*Scirtothrips aurantii*) and Citrus bud mite (*Aceria sheldoni*). These were noted during the seedling's growth period. The effect of dieback was previously reported on citrus by (Ezeibekwe, 2011; Ahmed *et al*., 2020). Thrips and mites might have had access to the shade net each time the entrance was opened. Their prevalence in study, supports the pest risk assessment for lemon, grapefruit, mandarin, and sweet orange in Botswana (United States Department of Agriculture, 2024). Gilbert and Samways (2018) reported citrus thrips in citrus orchard and Gravéa *et al*. (2000) highlighted that thrips are capable of rendering citrus fruits unsuitable for export market. The damage of citrus bud mite on citrus was recorded by Gilbert (1990) and Walker *et al*. (1992).

IV. Conclusions

The budding success rate and survival rate of all studied cultivars confirm their compatibility to rough lemon. Thus, rough lemon can be exploited for production of quality rootstocks in Botswana. However, the optimal age of rootstock, budding time and other photochemical activities of cultivars ought to be determined before releasing cultivars for local production.

V. Authors' Contributions

Conceptualization of research work and design of experiment, writing -original draft, (GB); Execution of field experiment (TR); Data curation, data analysis, Software (MR); Data collection and interpretation (GB and MR); Writing - review and editing (GB and MR). Preparations of manuscript (GB). All authors read and approved the final manuscript.

VI. Conflict of Interests

The authors declare that there are no conflicts of interest related to this article. We compliment Ministry of Agriculture for funding propagation materials and National Agricultural Research and Development Institute (NARDI) for funding transport logistics to the experimental site.

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