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# Effects of Rootstock Type and Scion Cultivar on Grafting Success and Growth of Mango (*Mangifera indica L.*) Seedlings

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***Authors' contributions***

*This work was carried out in collaboration between all authors. Authors RRM, AAK, MM, VM and SM designed the study, supervised the experiment, performed the statistical analysis, wrote the protocol, managed the literature searches and wrote the first draft of the manuscript. Author A. Ngereza performed statistical analysis while authors JA, A. Ndee, BK and GN supervised management of the experiment, collected and compiled the data. All authors read and approved the final manuscript.*

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## ABSTRACT

**Aim:** To evaluate the effects of three types of rootstocks: (i) Ngwangwa (ii) Sindano and (iii) Zinzi commonly used in the coastal belt of Tanzania on grafting success and seedling growth of six improved mango cultivars: (i) Apple (ii) Ngowe (iii) Kent (iv) Keitt (v) Alphonso and (vi) Tommy Atkins.
**Study Design:** Plants were arranged in a split plot design with three replications. The rootstocks were main plots while the scion cultivars were subplots.
**Place and Duration of Study:** At Chambezi research farm of Mikocheni Agricultural research institute (MARI) located at 6°30'S and 38°55'E at al titude of 12 meters above sea level in the coastal belt of Tanzania, from January 2014 to March 2015.

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**Methodology:** Seedlings were raised in polyethylene bags. Data on germination, plant height, root collar diameter (RCD), number of leaves, leaf length, leaf width before and after grafting were recorded at one month interval.
**Results:** Ngwangwa rootstock had the highest seed germination percentage (92.7%) followed by Zizi (69%) and the lowest Sindano (17.4%). The number of leaves was also maximum for Ngwangwa (21) followed by Sindano (16) and Zizi (13). The highest graft success with all tested scion cultivars was in the order of Ngwangwa (100%), Zizi (60%), and Sindano (52.5%). The interactions between the rootstocks and scion cultivars was significant ($P \leq 0.01$) for leaf area, plant height, and RCD indicating that seedlings growth after grafting is influenced by type of rootstock and scion cultivar used.
**Conclusion:** Ngwangwa rootstock had the highest number of leaves, leaf size, graft take and compatibility among all the tested cultivars therefore considered a potential rootstock for grafting improved mango seedlings. However, high grafting success at the nursery stage does not always lead high scion growth. Therefore, a follow up field study to confirm the success of this rootstock is recommended prior to wider adoption by mango growers.

*Keywords: Propagation; compatibility; varieties; nursery.*

## 1. INTRODUCTION

Mango (*Mangifera indica* L.) belongs to the family Anacardiaceae. It is one of the most important fruit in Tanzania. Tanzania is the 16$^{th}$ largest producer in the world with over 410,000 tons in 2012 year [1]. India ranks first in the world followed by China, while Nigeria and Egypt are the leading African countries in mango production. Production of mango is on the increase worldwide. The most common varieties grown in Tanzania include traditional types (95%) and improved varieties (5%) such as Apple, Palma, Bolibo, Haden, Keitt, Kent, Van Dyke, Tommy Atkins, and various others. Most of the traditional mango fruit cultivars are not suitable for processing or export market due to their undesirable features such as high fiber content, irregular shape and variable size; so they are sold locally. Improved varieties have potentials for both processing and export.

Traditional mango varieties are adaptable to local conditions but the trees are too big for proper management [2]. On the other hand, most of improved cultivars are mono-embryonic thus require grafting to produce true to type trees while some of them perform poorly due to unsuitability to tropical conditions. This has necessitated the need to combine improved mango cultivars with traditional types through grafting.

Studies have demonstrated that rootstocks can significantly influence the rate of growth, vigour [3], and productivity of scion cultivars as well as the physical and chemical characteristics of the fruit [4], drought tolerance and disease resistance [5]. In Manilla, Criollo mango rootstock increased the fruit firmness thereby resulting in a greater resistance to infestation by *Anastrepha obliqua* [6]. Higher yield of Haden mango variety was obtained when grafted onto Sabre rootstock, compared to other rootstocks [7]. Apart from duplicating parent plant characteristics, grafting induces earlier bearing and dwarf trees which facilitate management and harvesting.

In Tanzania there are many poly-embryonic mango varieties such as Mviringe, Embe Tanga, Sindano nyeupe, Sindano nyeusi, Bongwa etc. used as rootstocks but there is no conclusive research on elite types and their effects on yield and quality of improved mango cultivars. Farmers are uncertain on the correct type of rootstocks to use. In order to identify the most suitable rootstocks this study was conducted to evaluate the effects of three types of rootstocks commonly used in the coastal belt of Tanzania on graft success and seedling growth of six improved mango cultivars.

## 2. MATERIALS AND METHODS

A nursery experiment was conducted at Chambezi research farm of Mikocheni Agricultural research institute (MARI) located at 6°30'S and 38°55'E at altitude of 12 meters above sea level in the coastal belt of Tanzania from January 2014 to March 2015.

### 2.1 Raising Rootstock Seedlings before Grafting

Three types of local rootstocks (Ngwangwa, Zizi and Sindano) were tested. Ripe Ngwangwa and

Sindano fruits were picked from different mother trees in Chambezi farm in Bagamoyo district while Zizi fruits were picked from Mkuranga farm another research farm under MARI in Mkuranga district. Both districts are located in the coastal belt of Tanzania.

Fruits were cut to remove seeds that were directly sown in polyethylene bags measuring 20 x 10 cm each filled with 1.7 kg top forest soil. Selected chemical properties of the coastal forest soils include: pH (5.0–6.5), total nitrogen (0.03-0.045%), extractable phosphorus (13-23 mg P $kg^{-1}$), organic carbon (0.6–1.2%), and exchangeable cations (4.1–10.4 $cmol_c$ $kg^{-1}$) [8,9,10]. The bags were then arranged in a Randomized complete block design (RCBD) with three replications. Number of plants per plot was 28. Plants were kept under shade, irrigated as required. Data on germination, embryo types (judged based on number of seedlings that sprouted from a single seed) were recorded after germination. Seedling height, root collar diameter (RCD), number of leaves, leaf width and length before grafting were also recorded. Plant height, leaf length and width were measured using a ruler. One topmost matured leaf per plant was measured. The root collar diameter was measured using a slide caliper. The data were recorded at one month interval until the plants reached the grafting stage (8 months).

## 2.2 Raising Seedlings after Grafting

After eight months seven types of scion cultivars (i) Apple (ii) Ngowe (iii) Dodo (iv) Kent (v) Keitt (vi) Alphonso and (vii) Tommy were grafted on the three types of root stocks in different combinations. The top cleft grafting method was adopted for all scions. The seedlings selected for grafting were those above 0.5 cm RCD and taller than 30 cm. The grafted plants were then arranged in a split plot design with three replications (Fig. 1). The three rootstocks were main plots while the 7 scion cultivars were subplots. Each main plot consisted of 28 net plants while a subplot had four net plants.

Plants were then irrigated as frequent as required to maintain soil moisture at field capacity, hand weeded and closely monitored to record graft success. After sprouting plant height, number of leaves, leaf width, leaf length and RCD were recorded at one month intervals for four months. Leaf area was computed from a formula:

$$LA = 0.2452\ [(L * W) * N]$$

Where LA = Leaf area, W= width, L= Length, N = number of leaves [11,12].

Data collected from the experiment was analyzed using the Gen stat 14th edition statistical package [13]. Two way analysis of variance (ANOVA) procedures were used. Duncan's Multiple Range Test (DMRT) at $P < 0.05$ was used for mean separation procedures. Simple correlations between grafting success, seedling height, RCD, number of leaves, leaf width and leaf length were also determined.

**Fig. 1. Researchers arranging the grafted seedlings in a split plot design**

## 3. RESULTS AND DISCUSSION

### 3.1 Germination of the Rootstocks

The three mango rootstocks had different percentage of seed germination. Germination percentage was highest in Ngwangwa (92.7%) followed by Zizi (69%) and lowest in Sindano (17.4%). Significant differences in percent germination between different mango rootstocks were also reported from India [14] where the highest germination (57.18%) was obtained from the local variety while the Badam variety had the minimum (28.41%) germination [15].

The three types of rootstocks had different types of embryo. The occurrence of two or more seedlings was highest in Ngwangwa (average 3 sprouts) followed by Sindano (average 2 sprouts) hence considered poly-embryotic. Zizi produced only one sprout per seed and it was thus considered to be mono-embryotic. Poly-embryonic seeds can produce between 3 and 10 seedlings from one seed. Two to ten seedlings were observed in a single polyethylene bag in a trial conducted in Malawi [16].

### 3.2 Seedlings Growth before Grafting

Before grafting, Ngwangwa rootstock seedlings were most vigorous due to the highest leaf area based on measurement of number and length of leaves (Table 1). Ngwangwa seedlings had significantly ($P \leq 0.01$) more number of leaves followed by Sindano and Zizi had the lowest. In addition, Ngwangwa leaves were significantly ($P \leq 0.01$) longer than Sindano and Zizi. Similar results were also reported from India [15] whereby significant differences in plant height and number of leaves between different rootstocks prior to grafting were observed. Seedlings with higher RCD are considered good for grafting [16]. In this study, though not significantly different, at eight months after sowing the average diameter for Ngwangwa seedlings was 6.11 mm that was higher than Sindano (5.10 mm) and Zizi (4.55 mm) rootstocks. This means more Ngwangwa seedlings reached grafting stage earlier than other rootstocks, which is considered a desirable attribute.

### 3.3 Performance of Seedlings after Grafting

#### 3.3.1 Graft success

Ngwangwa rootstock had significantly ($P \leq 0.01$) higher graft successes compared to other rootstocks (Table 2). The differences between scion cultivar were also significant. Dodo and Ngowe had the highest number of graft take while Kent had the lowest. The results indicate that Ngwangwa rootstock was compatible to all tested scion cultivars implying that this rootstock can be used for a wide range of scions. Differences in graft success among different rootstocks and scion cultivars have also been reported in Nigeria [17] and Bangladesh [18] respectively which was attributed to genotypic differences. Thus, higher performance of Ngowe and Dodo might be attributed to the adaptability of these varieties to the coastal environment. To the best of our knowledge there is limited information on genetic characterization of root stock used in Tanzania. A follow up study in this area is necessary to provide comprehensive analysis of grafting success of rootstocks in the region.

The difference in graft success might be attributed to different levels of rootstock-scion compatibility which have implications in wound healing [19]. Unsuccessful graft take can also be caused by failure of translocation of water, starch and sugars and minerals across the graft union [20,21].

**Table 1. Growth parameters of different mango rootstocks before grafting**

| Rootstocks | Plant height (cm) | RCD (mm) | Number of leaves (per plant) | Leaf length (cm) | Leaf width (cm) | Petiole length (cm) |
|---|---|---|---|---|---|---|
| Sindano | 35.3a | 5.1a | 16.00b* | 16.63b | 4.42a | 1.84a |
| Ngwangwa | 48.7a | 6.11a | 21.00a | 20.32a | 4.92a | 2.23a |
| Zizi | 40.7a | 4.55a | 13.00c | 17.09b | 4.73a | 2.45a |
| Mean | 41.57 | 5.25 | 16.36 | 18.01 | 4.69 | 2.17 |
| F (probability) | 0.133 | 0.163 | 0.002 | 0.002 | 0.120 | 0.087 |
| S.E. | 0.051 | 0.653 | 0.908 | 0.449 | 0.183 | 0.201 |

** = Means in the same column followed by the same letter are not significantly different at (P ≥0.05) according to DMRT*

**Table 2. Effects of rootstock-scion combination on graft take in mango**

| Treatments | Graft take |
|---|---|
| **Rootstocks** | |
| Ngwangwa | 4.00a* |
| Zizi | 2.43b |
| Sindano | 2.19b |
| SE± | 0.40 |
| **Scion cultivar** | |
| Apple | 3.00ab |
| Ngowe | 3.22a |
| Dodo | 3.22a |
| Kent | 2.33b |
| Keitt | 2.44ab |
| Alphonso | 3.00ab |
| Tommy | 2.89ab |
| Mean | 2.87 |
| SE± | 0.26 |
| CV (%) | 24 |

** = Means in the same column followed by the same letter are not significantly different at (P ≥0.05) according to DMRT*

### 3.3.2 Seedling height

The highly significant interaction (*P* ≤ 0.01) between rootstocks and scion types indicates the interactive effect of these variables on seedling height (Fig. 2). On the average scions grafted on Ngwangwa were significantly (*P* ≤ 0.01) taller than those grafted on Sindano probably due to higher growth rate expressed by Ngwangwa rootstock. Seedlings of Dodo and Keitt were the tallest when grafted on Ngwangwa as opposed to when they were grafted on Sindano rootstock. Significant differences in height among different scion genotypes were also reported from India [22] and provide an opportunity for providing mango growers with the best rootstock-scion combinations.

### 3.3.3 Root collar diameter

There was significant (P ≤ 0.01) interaction between rootstock and cultivars on root collar diameter (Fig. 3). Keitt scions grafted on Sindano had the lowest RCD while Kent grafted on Sindano had the highest RCD. Similarly, on the average Ngowe scions grafted on Zizi had significantly higher RCD as compared to when Tommy or Dodo were grafted on Zizi. However, there was no significant difference on RCD between the scion cultivars when grafted on Ngwangwa.

### 3.3.4 Leaf area

Four months after grafting the number of leaves, leaf width and leaf length differed significantly (*P* ≤ 0.01) among different rootstocks and scions Table 3. There was significant interaction between the rootstocks and scion cultivars on number of leaves, leaf width and length. Alphonso grafted on Ngwangwa produced the highest number of leaves followed by Ngowe, Tommy and Apple when grafted on Sindano and this was at par with Aphonso grafted on Zizi and Apple grafted on Ngwangwa. However when Tommy, Keitt and Dodo were grafted on Zizi they produced the lowest number of leaves.

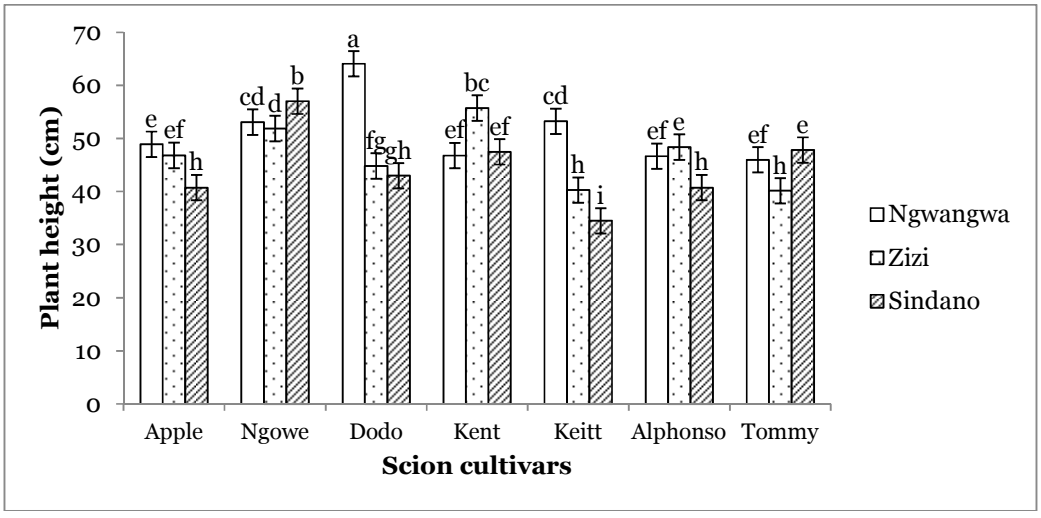


**Fig. 2. Effect of rootstock x scion interaction on mango plant height at four months after grafting. Error bars represent standard errors**

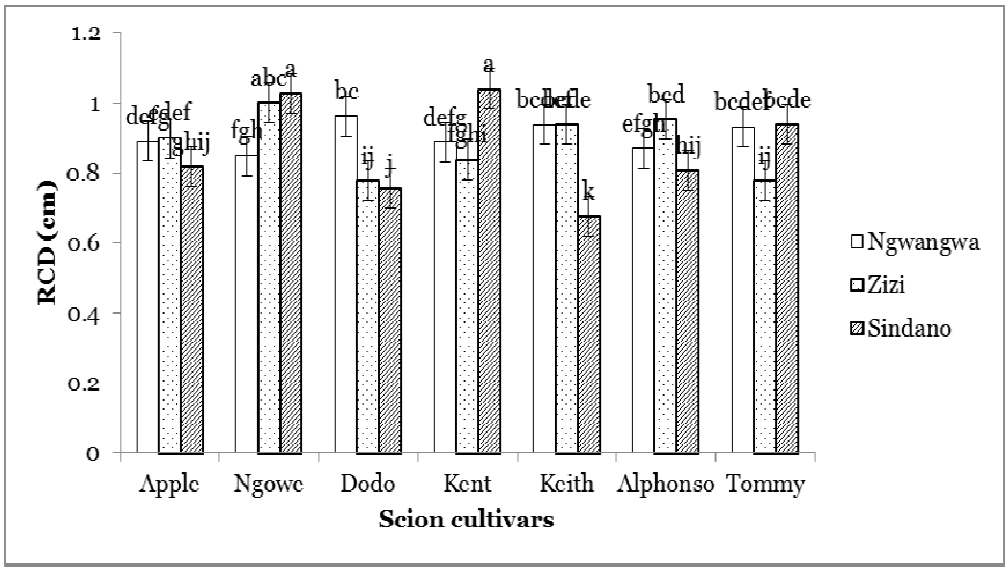


**Fig. 3. Effects of rootstock-scion interaction on root collar diameter (Bars represent standard errors)**

Dodo and Keitt produced the longest leaves when they were grafted on Ngwangwa but had significantly shorter leaves when grafted on Zizi and Sindano. In contrast Kent and Tommy produced the longest leaves when they were grafted on Sindano. A similar trend was observed for leaf width.

There was significant ($P \leq 0.01$) interaction between the rootstock and scion type on leaf area (Fig. 4). Dodo and Alphonso had the largest leaves when grafted on Ngwangwa while Tommy and Dodo produced the smallest leaves when grafted on Zizi. Some rootstock stimulate vigorous growth while others cause dwarfing of the scion [17].

There was significant ($P<0.001$) and positive correlations between grafting success, seedling height (r=0.928), RCD (r=0.900), number of leaves (r=0.843), leaf width (r=0.918) and leaf length (r=0.923), suggesting that grafting success have influence on subsequent scion cultivars vigour.

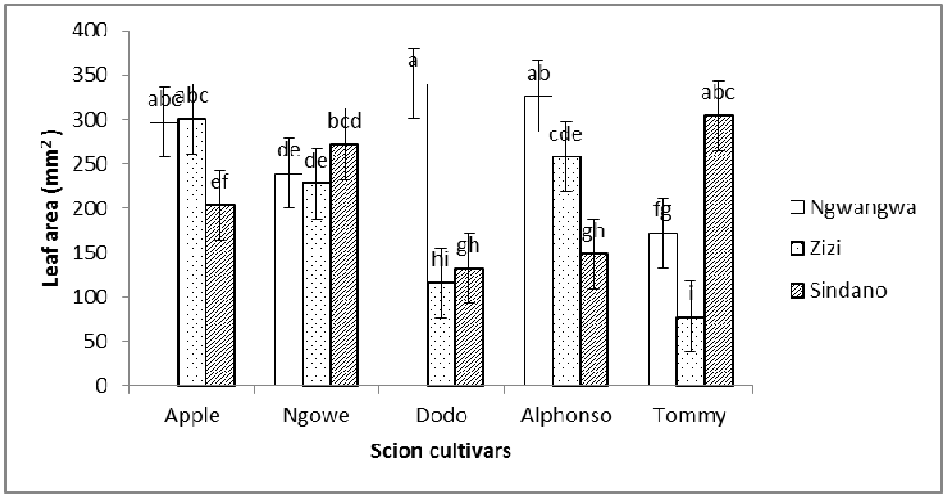


**Fig. 4. Effect of rootstock-scion combination on leaf area after grafting (Bars represent standard errors)**

*(Note: Keitt and Kent were omitted in the leaf area analysis due to low number of graft success)*

**Table 3. Effect of rootstock-scion interaction in mango on the number of leaves, leaf length and width at four months after grafting**

| Rootstocks | Scion cultivars | Number of leaves | Leaf length (cm) | Leaf width (cm) |
|---|---|---|---|---|
| Ngwangwa | Apple | 20.17bc✓ | 14.72ef | 3.997d |
| | Ngowe | 17.08def | 14.66ef | 3.967d |
| | Dodo | 15.08fghi | 21.17a | 4.923b |
| | Kent | 14.08ghi | 15.89de | 4.387c |
| | Keitt | 16.5efg | 17.11cd | 4.297cd |
| | Alphonso | 24.42a | 16.83cd | 3.17fgh |
| | Tommy | 13.92hi | 14.47efg | 3.437efg |
| Zizi | Apple | 14.92fghi | 17.55c | 4.733ef |
| | Ngowe | 18cde | 15.61def | 3.177ghi |
| | Dodo | 9.67j | 14.41efg | 3.38efg |
| | Kent | 13.75hi | 15.8de | 3.427hij |
| | Keitt | 9.92j | 10.54i | 3.067ghi |
| | Alphonso | 20.33bc | 15.7f | 3.373efg |
| | Tommy | 10.28j | 11.19i | 2.85hij |
| Sindano | Apple | 19.33bcd | 14.03fgh | 3.61e |
| | Ngowe | 21.33b | 15.62def | 3.43ef |
| | Dodo | 14.17ghi | 12.95gh | 2.803ij |
| | Kent | 17.5de | 19.7b | 5.6a |
| | Keitt | 13i | 10.1i | 2.65j |
| | Alphonso | 16.11efg | 12.69h | 2.96hij |
| | Tommy | 20.17bc | 17.59c | 4.223cd |
| Rootstock (R) | | ** | * | ** |
| Scion cultivar (S) | | ** | ** | ** |
| R x S | | * | ** | ** |
| SE± | | 0.716 | 0.512 | 0.107 |

** = Significant at P ≤ 0.05 ** = Significant at P ≤ 0.01*

*✓= Means in the same column followed by the same letter are not significantly different at (P ≥0.05) according to DMRT*

However, it is possible that rootstocks with high grafting success as the case with Ngwangwa in this study, does not always exhibit vigorous scion growth (Fig. 2, Fig. 3 and Fig. 4). Working with Kola (*Cola nitida*) Dadzie et al. [23] indicated that the subsequent growth of scion after grafting to be possibly controlled by hormones.

Therefore, preliminary results obtained from this study suggest a need for further observations and genetic characterization to be able to explain the interactions between the rootstock and the scion genotypes. The seedlings were therefore transplanted on to the field to continue growth at least for 10 years to relate the nursery and field performance prior to wider adoption of the recommendation of this study.

## 4. CONCLUSION

This study has demonstrated significant effects of rootstock-scion interactions on grafting success and growth of seedlings of mango varieties cultivated in the Coastal Tanzania. Ngwangwa rootstock seedlings were most vigorous as reflected by the highest leaf area. This rootstock had the highest germination of seeds, root collar diameter size at grafting, graft take and compatibility to all tested cultivars. For this purpose, Ngwangwa is considered as one of potential rootstocks for mango seedlings production under the coastal belt conditions. However, it was also observed that high grafting success does not always result in high scion growth. Both rootstocks and scion cultivars had influence on seedlings growth (leaf area, plant height, and RCD) affirming that growth performance depends on the type of rootstock and scion cultivar. Our results are preliminary evaluation of grafting success and scion growth at nursery stage but they set a stage for a follow up long-term field evaluation of the rootstock effects on yield and fruit quality.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES


1. Food and Agriculture Organization Corporate Statistical Database (FAOSTAT). Tanzania: Mangoes, mangosteens and guavas, production quantity (tons); 2013.
   Available:http://www.factfish.com/statistic-country/tanzania/mangoes,+mangosteens++and+guavas,+production+quantity
   (Accessed 5th March 2016)
2. Small and Medium Enterprise Competitiveness Facility (SCF). Mangoes for Middle East market sub sector quick scan Tanzania. Study commissioned by SCF and conducted by match maker associates limited; 2008.
   Available:http://www.tzdpg.or.tz/fileadmin/_migrated/content_uploads/Vegetables_-Executive_Summary_FFV_Studies_pdf_1_.pdf
   (Accessed 15th May 2016)
3. Reddy YTN, Reju MK, Ramachander PR, Gorakh S, Kohli RR. Long-term effects of rootstocks on growth and fruit yielding patterns of Alphonso mango (*Mangifera indica* L.). Scientia Horticulturae. 2003;97: 95 -108.
4. Vargas Ramos VH, Pinto ACQ, Jungueira NTV, Gomes AC, Andrade SMR, Cordeiro MCR. Effect on growth, yield and fruit quality of four cultivars grafted on mono and polyembronic rootstocks in the Central Region of Brazil. Proc. VIIth IS on Mango. Editors: Pinto ACQ et al. Acta Hort 645, ISHS; Embrapa Cerrados; 2004.
   Available:https://www.researchgate.net/publication/263580311_Effect_of_Mono_and_Polyembrionic_Rootstocks_on_Growth_Yield
   (Accessed 23rd September 2015)
5. Mahunu GK, Adjei PY, Asante AK. Anatomical studies on graft formation in cashew (*Anacardium occidentale* L.). Agriculture and Biology Journal of North America. ISSN Print: 2012;2151-7517.
   ISSN Online: 2151-7525.
   DOI: 10.5251/abjna.2012.3.4.150.153
6. Vazquez-Luna A, Rivera-Cabrera F, Perez-Flores LJ, Diaz-Sobac R. Effect of rootstock on mango fruit susceptibility to infestation by *Anastrepha obliqua*. J Econ Entomol. 2011;104(6):1991-8.
7. Smith MW, Hoult MD, Lyon A, Bright JD. Mango varietal rootstock evaluation. Australia Project Report. 1996;21-23.
8. Kindo AI, Mndolwa MA, Edward E, Chamshama SAO. Southern Forests. 2010;72:13-22.
9. Dondeyne S, Wijffels A, Emmanuel LB, Deckers J, Hermy M. Soils and vegetation of Angai forest: Ecological insights from a participatory survey in South Eastern Tanzania. Afr J Ecol. 2004;42:198–207.
10. Kimaro AA, Novak KD, Shemdoe RS, Chamshama SAO. Carbon stock in planted woodlots at Kongowe, Kibaha, Tanzania. In: Maren O, Editor. Sustainable Agroecosystems in Climate Change Mitigation. Wageningen Academic Publishers. 2014;69-85.
11. Williams III L, Martinson TE. Nondestructive leaf area estimation of Niagara and Dechaunac grapevines. Scient Horticult. 2003;98:493–498.
12. Ghoreish M, Yaghoob H, Manochehr M. Simple models for predicting leaf area of mango (*Mangifera indica* L.). J Biol Earth Sci. 2012;2(2):B45-B53.
13. GenStat PC/Windows, Fourteenth Edition, VSN international Ltd. 2 Amberside House Wood Lane Hemel Hempstead, HP2 4TP UK; 2011.
14. Muralidhara BM, Reddy YTN, Srilatha V, Akshitha HJ. Effect of seed coat removal treatments on seed germination and seedling attributes in mango varieties. International Journal of Fruit Science. 2016;16(1):1-9.
   Available:http://dx.doi.org/10.1080/15538362.2015.1021885
   (Accessed 5th January 2017)
15. Prajapati GK, Patel MM, Bhadauria HS, Garasiya VR, Modi DJ. Studies of different mango varieties stone on germination traits. Asian J. Hort. 2012;7(2):555-557.
16. Mng'omba SA, Festus KA, Gudeta S, Oluyede CA. Rootstock growth and development for increased graft success of mango (*Mangifera indica*) in the nursery. African Journal of Biotechnology. 2010;9(9):1317-1324. Academic Journals
   Available:http://www.academicjournals.org/AJB ISSN 1684–5315
   (Accessed 5th August 2016)
17. Baita HU, Manga AA, Mustapha Y. Evaluation of different morphotypes of mango (*Mangifera indica* L.) for use as rootstock in seedlings production. Bayero Journal of Pure and Applied Sciences. 2010;3(1):79–82.
18. Islam R. Effect of scion diameter on the grafting success, survivability and growth

of different mango varieties. MSc Thesis, Registration No: 39651 Session: 2012-2013. Department of Horticulture Bangladesh Agricultural University Mymensingh; 2013.
Available:http://dspace.bau.edu.bd/bitstream/123456789/1445/1/HORT-1023%20DEC-2013.pdf
(Accessed 10th January 2017)

19. Ajal J, Kizito EB. Performance of local variety mango graft unions under nursery conditions. Bachelors Thesis, Agricultural Science and Entrepreneurship, Uganda Christian University; 2012.
Available:https://www.academia.edu/8488998/Performance_of_local_variety_mango_graft_unions_under_nursery_conditions
(Accessed 10th January 2017)
20. Hariyadi MC, Djumali SS, Purwoko BS. Effects of grafting time and grafting methods used on scion and rootstock compatibility of physic nut (*Jatropha curcas* L.). Asian Journal of Agricultural Research. 2014;8:150-163.
Available:http://scialert.net/abstract/?doi=ajar.2014.150.163
(Accessed 17th March 2017)
21. Kostoff D. Studies on callus tissues. Am. J. Bot. 1928;15:509-563.
22. Patel BB, Tank RV, Bhandari AJ. Response of rootstocks and varieties on growth and survival percentage in epicotyl grafting of mango (*Mangifera indica* L.). The Bioscan, (Supplement on Agronomy). 2016;11(1):479-483.
23. Dadzie AM, Akpertey A, Yeboah J, Opoku SY, Ofori A, Lowor S, Ackyeampong R, Adu-Yeboah P, Asamoah M, Amoah FM. Genotypic effect of rootstock and scion on grafting success and growth of kola (*Cola nitida*) seedlings. American Journal of Plant Sciences. 2014;5:3873-3879.

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