

Original Research Article

Effects of rootstock type and scion cultivar on grafting success and growth of mango (*Mangifera indica* L.) seedlings.

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 altitude of 12 meters above sea level in the coastal belt of Tanzania, from January 2014 to March 2015.

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 ~~number of~~ 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 and~~ highest graft success with all tested scion cultivars ~~was in the order of~~ (Ngwangwa (100%), Zizi (60%), and Sindano (52.5%)). ~~There was significant ($P \leq 0.01$)~~ ~~The~~ interactions between the rootstocks and scion cultivars ~~was significant ($P \leq 0.01$)~~ ~~on~~ 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 ~~to among all the~~ tested cultivars therefore considered a potential rootstock for grafting improved mango seedlings. However, ~~it was also observed that~~ high grafting success at the nursery stage does not always lead high scion growth. ~~Thus~~ ~~Therefore~~, a follow up field study to confirm the success of this rootstock is recommended prior to wider adoption by mango growers.

Keywords: [Mango, grafting, rootstock, scion cultivars]

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1. INTRODUCTION

Mango (*Mangifera indica* L.) belongs to the ~~genus~~ *Mangifera* of the family Anacardiaceae. It is one of the most important fruit in Tanzania. Tanzania is the 16th 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

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traditional mango fruit cultivars are not suitable for processing or export market due to their undesirable features such as high fiber content ~~fibrous strands~~, un-uniform 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 their trees are too big limiting 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 grafting give the scion plant certain characteristics of the rootstock such as hardiness, drought tolerance and disease resistance [3]. In Manilla, Criollo mango rootstock increased the fruit firmness of fruit giving as a result thereby resulting in a greater resistance to infestation by A. oblique [4]. Rootstocks can significantly influence the rate of growth, vigour [5] and productivity of scion cultivars as well as the physical and chemical characteristics of the fruit [6]. Higher yield of When Haden mango variety was obtained when grafted onto Sabre rootstock, produced higher yield 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. MATERIAL 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 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 filled with forest soil. 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 collected 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 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.

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Comment [R4]: Combine this with lines 28-29.

Comment [R5]: Were all the fruits for a variety collected from a single tree or different trees?

Comment [R6]: What was the size of the bags and the quantity of the soil used?

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Fig1: Researchers arranging the grafted seedlings in a split plot design

Plants were then 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
[9]; [10].

Data collected from the experiment was analyzed using the Gen stat 14th edition statistical package [8]. 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. 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
[9]; [10].

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3. RESULTS AND DISCUSSION

3.1 Germination of the rootstocks

The three mango rootstocks had different percentage of seed germination of seeds. 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 in from India [11] where the highest germination (57.18 %) was obtained from the local variety while the Badam variety had the minimum (28.41 %) germination [12].

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 [13].

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 ($P \leq 0.01$) higher more number of leaves (21) followed by Sindano (16) and Zizi (13) had the lowest. In addition, Ngwangwa leaves were significantly ($P \leq 0.01$) longer (20.32 cm) than Sindano and Zizi. Similar results were also reported in from India [12] whereby significant differences in plant height and number of leaves

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112 | between different rootstocks ~~before~~prior to grafting were observed. Seedlings with higher RCD are
113 | considered good for grafting [13]. In this study, though not significantly different, at eight months after
114 | sowing the average diameter for Ngwangwa seedlings was 6.11 mm that was higher than Sindano (5.10
115 | mm) and Zizi (4.55 mm) rootstocks. This means more Ngwangwa seedlings reached grafting stage earlier
116 | than other rootstocks, which is considered a desirable attribute.

117 | Table1: Growth measurements-parameters of different mango rootstocks before grafting

Rootstocks	Plant height (cm)	RCD (mm)	Number of leaves (<u>per plant</u>)	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

118 | * = Means in the same column followed by the same letter are not significantly different at ($P \leq 0.05$) according to DMRT

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3.3 Performance of seedlings after grafting

3.1.1 Graft success

Ngwangwa rootstock had significantly ($P \leq 0.01$) higher number of graft successes compared to other rootstocks (Table 2). The differences between scion cultivar differences 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 [14] and Bangladesh [15] respectively which can be ascribed by 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 will be necessary to provide comprehensive analysis of grafting success of rootstocks in the region.

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 $\pm$	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 $\pm$	0.26
CV (%)	24

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

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The difference in graft success might be attributed to different levels of rootstock-scion compatibility which have implications in wound healing [16]. Unsuccessful graft take can also be caused by failure of translocation of water, starch and sugars and minerals across the graft union [17], [18], [17,18].

3.1.2 Seedling height

A highly significant interaction ($P \leq 0.01$) was observed between rootstocks and scion types on indicates the interactive effect if these variables on seedling height (Fig. 2). Height of the seedlings was influenced by both rootstock and scion cultivar types. On the average scions grafted on Ngwangwa (51.2 cm) had significantly ($P \leq 0.01$) taller seedlings than those grafted on Sindano (44.50 cm) probably due to higher growth rate expressed by Ngwangwa rootstock. Seedlings of Dodo and Keitt had the tallest seedlings 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 as also reported in from India [19] and provide an opportunity for providing mango growers with the best rootstock-scion combinations.

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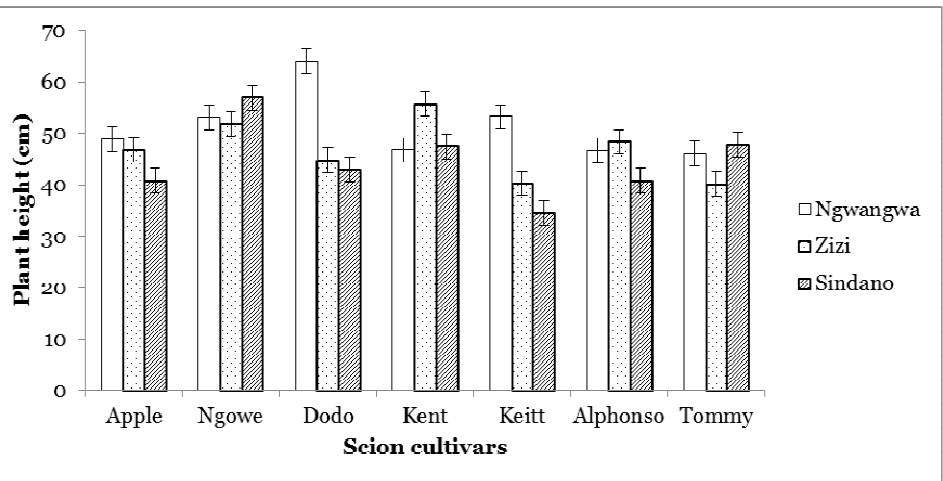


Fig. 2: Effect of rootstock x scion cultivar interaction on mango plant height at four months after grafting. Error bars represent standard errors.

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3.1.3 Root collar diameter

There was significant ($P \leq 0.01$) interaction between rootstock and cultivars on root collar diameter (Fig. 3). Keitt scions grafted on Sindano had the lowest (0.677 cm) RCD while Kent grafted on Sindano had the highest (1.040 cm) RCD. Similarly, on the average Ngowe scions grafted on Zizi had significantly higher RCD (1.0 cm) as compared to when Tommy (0.78 cm) or Dodo (0.78) were grafted on Zizi. However, there was no significant difference on RCD between the scion cultivars when grafted on Ngwangwa.

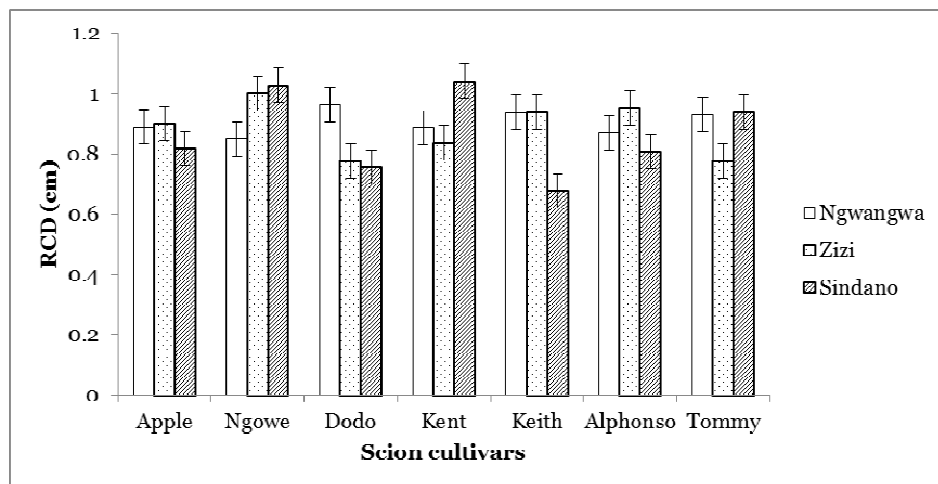


Fig. 3: Effects of rootstock-scion interaction on root collar diameter (Bars represent standard errors)

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3.1.4 Leaf area

Four months after grafting the number of leaves, leaf width and leaf length differed significantly ($P \leq 0.01$) 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 (24.42)-followed by Ngowe, Tommy and Apple when grafted on Sindano (21.33, 20.17, 19.33 respectively) and this was at par with Aphonso grafted on Zizi (20.33) and Apple grafted on Ngwangwa. However when Tommy, Keitt and Dodo were grafted on Zizi they produced the lowest number of leaves 10.28, 9.9, and 9.67 respectively.

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 on leaf width.

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	Leaf width
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
Zizi	Tommy	13.92hi	14.47efg	3.437efg
	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
Sindano	Alphonso	20.33bc	15.7f	3.373efg
	Tommy	10.28j	11.19i	2.85hij
	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 $P \leq 0.05$ ** = Significant at $P \leq 0.01$

There was significant ($P \leq 0.01$) interaction between the rootstock and scion type on leaf area (Fig 4). Dodo (340.28 mm²) and Alphonso (326.09 mm²) had the largest leaves when grafted on Ngwangwa while Tommy (77.6 mm²) and Dodo (116.22 mm²) produced the smallest leaves when grafted on Zizi. Some rootstock stimulate vigorous growth while others cause dwarfing of the scion [14]

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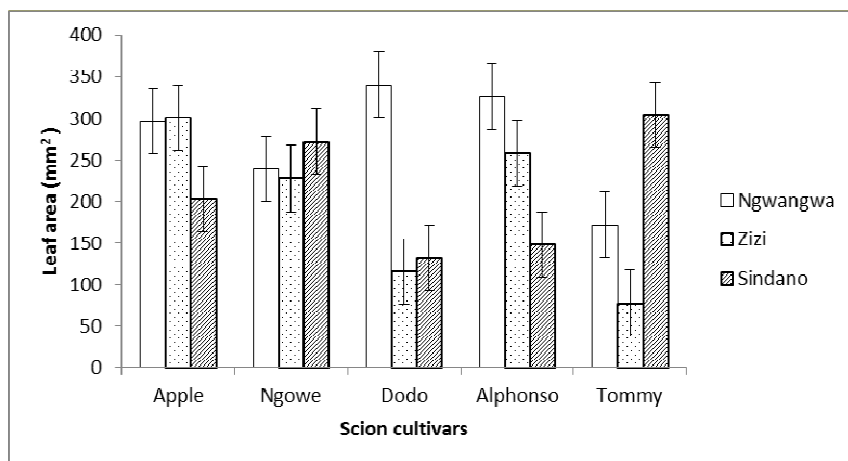


Fig. 4: Effect of rootstock-scion combination on leaf area after grafting (Bars represent standard errors)
(note: Keitt and Kent were omitted in the leaf area analysis due to low number of graft success.)

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Results in Table 4 indicate 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.

Table 4: Simple correlations between grafting success and scion vigour

Variable	Against	Correlation	P value
Grafting success	Plant height	0.928	<0.001
	RCD	0.900	<0.001
	Number of leaves	0.843	<0.001
	Leaf width	0.918	<0.001
	Leaf length	0.923	<0.001

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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 [20] associated 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 in-on to the field to continue with observationsgrowth at least for 10 years to relate the nursery and field performance prior to wider adoption of the 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 lead to 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.

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