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Original Research Article

Effects of rootstock type and scion cultivar on grafting success and growth of mango (*Mangifera indica*) 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 $6^0$30'S and 38^0 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 (92.7%) followed by Zizi (69%) and the lowest Sindano (17.4%), number of leaves (21) followed by Sindano (16) and Zizi (13) and highest graft success with all tested scion cultivars (Ngwangwa (100%), Zizi (60%), and Sindano (52.5%)). There was significant ($P \leq 0.01$) interaction between the rootstocks and scion cultivars on 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, with the largest root collar diameter size at grafting and compatibility with the tested scion cultivars is considered a potential rootstock for grafting improved mango seedlings.

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

1. INTRODUCTION

Mango 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. 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 fibrous strands, un-uniform shape and variable size; so they are sold locally. Improved varieties have potentials for both processing and export.

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Traditional mango varieties are adaptable to local conditions but their trees are too big limiting 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 firmness of fruit giving as a result 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]. When Haden mango variety was grafted on 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 $6^0$30'S and 38^0 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 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. The three rootstocks were main plots while the 7 scion cultivars were subplots.

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.

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 plant height, RCD, number of leaves and leaf area were also determined. Leaf area was computed from a formula:

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LA = 0.2452 [(L *W)*N]
Where LA = Leaf area, W= width, L= Length, N = number of leaves
[9]; [10].

3. RESULTS AND DISCUSSION

3.1 Germination of the rootstocks

The three mango rootstocks had different percent 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 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. On the average Ngwangwa seedlings were the tallest (48.7 cm) followed by Zizi (40.7 cm) while Sindano (35.3 cm) were the shortest (Table 1). Similarly Ngwangwa seedlings had significantly ($P \leq 0.01$) higher number of leaves (21) followed by Sindano (16) and Zizi (13) the lowest. Similar results were reported in India [12] whereby significant differences in plant height and number of leaves between different rootstocks before grafting were observed. Seedlings with higher RCD are considered good for grafting [13]. 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.

Table1: Growth measurements of different rootstocks before grafting

Rootstocks	Plant height (cm)	RCD (mm)	Number of leaves	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 ($P \leq 0.05$) according to DMRT

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3.3 Performance of seedlings after grafting

3.1.1 Graft success

Ngwangwa had significantly ($P \leq 0.01$) higher number of graft successes compared to other rootstocks. Scion cultivar differences were also significant. Dodo and Ngowe had the highest number of graft take while Keitt had the lowest (Table 2). The results indicate that Ngwangwa rootstock was compatible to all tested scion cultivars. Differences in graft success among different rootstocks were also reported in Nigeria [14].

Table 2: Effects of rootstock-scion combination on graft take

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 ($P \leq 0.05$) according to DMRT

The difference in graft success might be attributed to different levels of rootstock-scion compatibility which have implications in wound healing [15]. Unsuccessful graft take can also be caused by failure of translocation of water, starch and sugars and minerals across the graft union [16]; [17].

3.1.2 Seedling height

A highly significant interaction ($P \leq 0.01$) was observed between rootstocks and scion types 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. Dodo and Keitt had the tallest seedlings when grafted on Ngwangwa as opposed to when they were grafted on Sindano rootstock.

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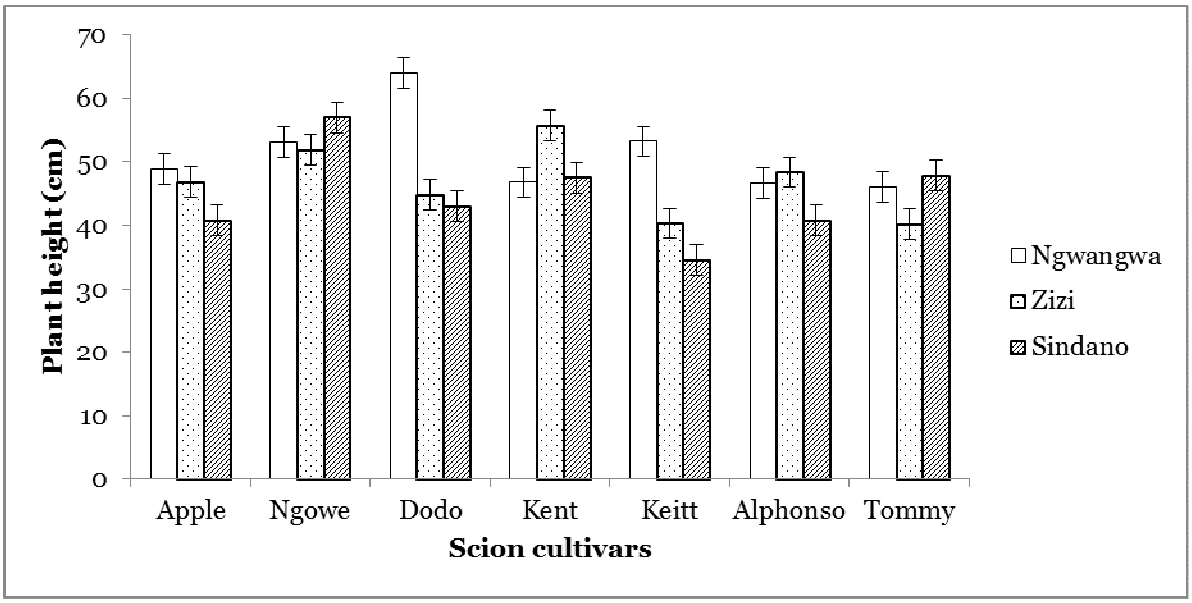

Fig. 2: Effect of rootstock x scion cultivar on plant height at four months after grafting (Bars represent standard errors)

3.1.3 Root collar diameter

There was significant (P ≤ 0.01) interaction between rootstock and cultivars on root collar diameter. 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.

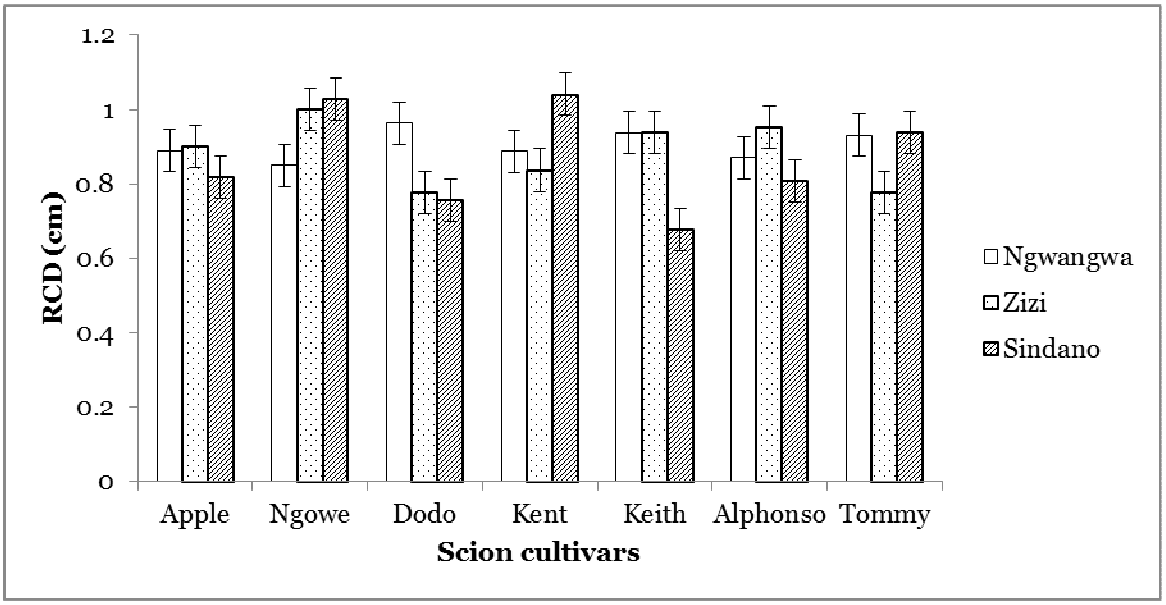

Fig. 3: Effects of rootstock-scion interaction on root collar diameter (Bars represent standard errors)

3.1.4 Leaf area

Three months after grafting number of leaves, leaf width and leaf length differed significantly ($P \leq 0.01$) with different rootstocks and scions. There was significant (P ≤ 0.01) interaction between the rootstock

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and scion type on leaf area. Dodo (340.28 mm^2) and Alphonso (326.09 mm^2) had the largest leaves when grafted on Ngwangwa while Tommy (77.6 mm^2) and Dodo (116.22 mm^2) produced the smallest leaves when grafted on Zizi.

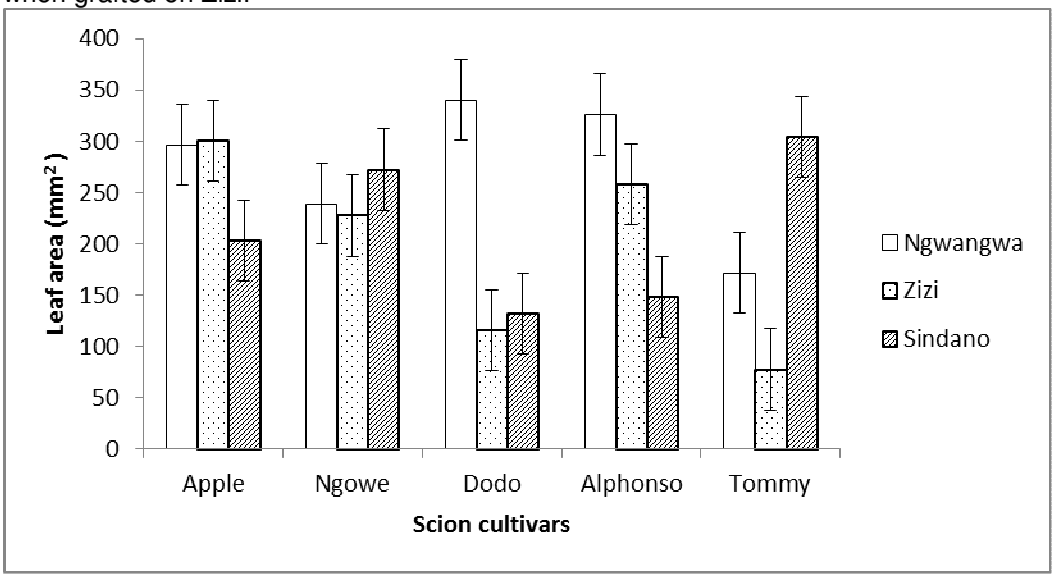

Fig. 4: Effect of rootstock-scion combination on leaf area after grafting (Bars represent standard errors)

(note: Keitt and Kent x Sindano were omitted in the analysis due to low number of graft success.)

Results in Table 3 indicate significant and positive correlation between leaf area and seedling height (*P*=.05, r=.54), root collar diameter (*P*=.05, r=.50), and number of leaves (*P*=.05, r=.64). The results can be attributed to the fact that leaf area growths determines light interception which affects photosynthesis and eventually influence plant growth [18]; [19]. Therefore these results suggest that plant height, root collar diameter and leaf area as indicators for size of the seedlings; are influenced by both cultivar type and rootstock.

Table 3: Simple correlations between plant height, RCD, number of leaves and leaf area during the growth of mango seedlings

Variable	Against	Correlation
Plant height	RCD	0.596**
Plant height	Number of leaves	0.246ns
Plant height	Leaf area	0.541**
RCD	Number of leaves	0.254ns
RCD	Leaf area	0.498**
Leaf area	Number of leaves	0.639**

** = Significant at (*P* = 0.01) n=63 Error df = n-2, ns = non-significant

Similar results were reported in Nigeria [14] where three scion cultivars (Alphonso, Peach and Taymour) grafted on four local rootstocks (Binta Siga, Gwaiwar Rago, Dankamaru and Fafaranda) were evaluated. In addition, rootstocks with high grafting success as the case with Ngwangwa in this study, does not always translate into vigorous scion growth [20]; (Fig. 2, Fig. 3 and Fig. 4).

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4. CONCLUSION

In conclusion Ngwangwa 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. Moreover, both rootstocks and scion cultivars had influence on seedlings growth (leaf area, plant height, and RCD) indicating that growth performance depends on type of rootstock and scion cultivar.

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