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EPICOTYL GRAFTING IN MANGO (*Mangifera indica* L.) AS INFLUENCED BY LENGTH OF SCION, SCION TYPE AND ROOTSTOCK

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ABSTRACT
The increased demand for high quality mango in Nigeria requires for provision of qualitative fruits with superior characters. This could be achieved by grafting of cultivars with the desired qualities onto and adapted and available rootstocks. In view of addressing the demand deficit, two trials were conducted in 2015 rainy season at the Kano Institute of Horticulture screen house, Bagauda to study the influence of scion length, scion type and root-stock on epicotyl grafting in mango. Treatments consisted of scion lengths (6, 8 and 10 cm), scion types (Alphonso, Julie and Mabrouka) and local rootstocks (Dankamaru and Gwaiwarrago). These were factorially combined and laid in a completely randomized design with three replicates. Results of the study revealed that grafting was most successful in 8 and 10cm scions and these produced more leaves and longest grafted saplings. Alphonso and Gwaiwarrago were most compatible as they recorded the highest graft success. Experiments involving many scions and rootstocks is recommended to determine suitable combination of scion and rootstock for successful epicotyl grafting in mango.
Key words: Cleft, scion, rootstock, veneer

INTRODUCTION

The demand of high quality mango fruit is rapidly increasing globally, as such the long term prospect for the fruit appears to be favorable. This makes mango to be one of the most important and popular fruit to consumers. Unfortunately, in Africa, mango fruit trade is declining yearly as it loses ground to south American mangoes (Adesina and Adekunle, 2007). The export market for mango has become highly profitable, but very selective in terms of cultivar acceptability. Consumer trends are moving slowly towards better and high quality fruits with superior characters. These characters are achieved by grafting cultivars with the desired qualities on to adapted and available rootstocks. The characters needed by consumers are usually the attractive colors, good flavor, good taste and regular bearing among others. Mangoes are usually grafted using veneer, side or cleft grafting.

Hartmann *et al.* (2002) described stone grafting in mango using cleft grafting of mature scions on two to three weeks old mango saplings. This is now prominent and widely used method of mango grafting in some Asian countries. It has many advantages over the old methods as the nursery-life is shortened by a year, so also the grafts are small in size and can therefore easily be transported without much damages (Majumder, 1989). Some of the factors that affect the growth and survival of grafts is the age of rootstock, length of the scion and compatibility of the rootstock with the scion. In mango epicotyl grafting, success of graft also depends largely upon the selection of scion, rootstock seedling, age of scion and rootstock, graft union areas, prevalence of insect pests and diseases on plant materials, hormonal and nutritional imbalance as well as climatic conditions among others (Jadhab *et al.,* 2014).

Efforts are being made to ascertain the length of the scion and scion/ rootstock combination that can be used in epicotyl grafting with high success thereby reducing the cost of production right from the nursery so as to ease establishment in orchards. In Nigeria, information with regards to epicotyl grafting was scanty and non-documented. Hence this experiment was designed to evaluate the effect of scion length and mango cultivar on the success of epicotyl grafting.

MATERIALS AND METHODS

The study was conducted in 2015 rainy season in a screen house of Kano Institute of Horticulture, KIHORT, (Latitude 11^0 48′ N and Longitude 08^0 34′ E) Bagauda. This is located in the Sudan savanna agro-ecology of Nigeria. Treatments consisted of two local mango (*Gwaiwarrago* and *Dankamaru*) rootstocks, three scions of improved cultivars (Alphonso, Julie, and Mabrouka) and three scion lengths (6, 8 and 10 cm). These were factorially combined and laid in a Completely Randomized Design (CRD) with four plants in each treatment combination and replicated three times.

A mixture of well mixed top soil and farmyard manure was used in the ratio of 3:1 to fill medium sized polythene bags (30 x 25 cm) leaving sufficient space for irrigation. Good and disease free *Gwaiwarrago* and *Dankamaru* stones were collected and sown in the poly pots. The endocarp was removed using knife and secateurs. Two hundred stones each of the root rootstocks were planted. Those that emerged at two weeks after planting were selected for grafting. Grafting was performed by the cleft method procedure of grafting as described by Bhan *et al,* (1969).

Healthy and fresh growing branches were selected from improved cultivars and used as scions. These were prepared by defoliation seven days to grafting to mobilize auxins. The grafting trials were performed twice, one in the beginning and one at the end of August, 2015. The rootstock was decapitated 5 cm above the soil level. A vertical cut at the middle of the rootstock was made at about 2-3 cm depth to receive the scion. The wedge of the scion was inserted into the cleft of the rootstock, taking care to ensure that the cambium layers of the rootstock and scion are in perfect contact with each other. The length of the scion was maintained as designed in the experiment.

A slanting 2-3 cm cut of was made on two opposite sides of the scion for easy insertion onto the rootstock. Budding tape of about 1.5 cm was used to tie and cover the site of union to hold them together and prevent entry of foreign materials. The grafted mangoes were then covered with a transparent plastic polythene bag and taken to the screen house to improve micro-climate and reduce the impact of heavy wind and rain. Watering was done carefully when the need arose. Weeds were removed manually by hand picking. Insects were controlled by applying *Chlorpalin* (Chlorpyriphos 20% EC) while emerging disease (fungi) was controlled by application of *Mancozeb* (80% Dithiocarbamate).

Data were collected at 30 days interval on number of leaves per plant and grafted sapling height. Number of days to bud break was evaluated on daily basis. The percentage success of grafts was also evaluated at 30 and 90 days after grafting (DAG) using the following formula (Islam *et al.*, 2004).

$$\text{Percentage success} = \frac{Successful\ seedlings}{Number\ of\ grafted\ seedlings}\ x\ 100$$

This was transformed into arcsine as suggested by Sokal and Rohlf (1995) before analysis. Number of leaves and sapling height were also measured at 30, 60 and 90 DAG. These were analyzed using the Genstat 17^{th} edition statistical software for multifactor analysis of variance to determine the treatment effects. Where the treatment means differed significantly, separation was done using Duncan's Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

Significant (p< 0.05) effects of scion lengths, scion types and rootstock was observed on the number of days to bud break (DTBB) and percent success of mango grafting in this study (Table 1). This showed that the 6 cm scion took more days to bud break than 8 and 10cm only in the first trial.

This corroborates with the findings of Dhakal and Huda (1987) who reported that sprouting of scion usually starts from the second week and completes in the sixth week of grafting.

Similar observation was also recorded for the success of grafts where the 10cm scions surpass during 30 days after grafting (DAG) from both trials as well as in 90 DAG of the second trial. This result is in agreement with the report of Radhamony *et al.* (1989) in which the 8cm and 10cm scions recorded the highest success of grafts.

The results of the investigation further indicated that Mabrouka took more days to bud break, with Alphonso breaking bud much earlier in the first trial. Baita (2009) also reported Alphonso as early bud breaking cultivar. Similarly, plants that were grafted onto *Gwaiwarrago* bud broke much earlier than those grafted onto *Dankamaru*. This confirmed the findings of Reddy and Melanta (1988), who reported that the success of grafts largely defend on the cultivar. The reduction in success of grafts recorded at 90 DAG may be attributed to the prevalence of termites that ate some the grafted saplings at the later period of the study.

The interactions of rootstock with scion type, scion length with scion type as well as root stock with scion length on the success of graft from the first trial were also significant (p< 0.05) at 30 and 90 DAG respectively (Table 2). The highest success of graft was observed from Alphonso that was grafted onto *Gwaiwarrago* at 30 DAG. This was also at par with Julie and Mabrouka that were grafted onto *Dankamaru*.

Table 1: Influence of scion length (cm), type of scion and rootstock on number of days to bud break (DTBB) and success of grafts (30 and 90DAG) in mango.

	First trial			**Second trial**		
Treatment	DTBB	Successful grafts at 30 DAG	Successful grafts at 90 DAG	DTBB	Successful grafts at 30 DAG	Successful grafts at 90 DAG
Scion length (L)						
6	13.20a	1.02b	0.30ab	10.31	0.85b	0.55
8	9.78b	0.99b	0.28b	9.94	1.27a	0.60
10	10.11b	1.31a	0.36a	9.40	1.18a	0.53
SE±	0.480	0.480	0.042	0.551	0.108	0.064
Scion type (S)						
Alphonso	9.44c	1.28	0.30	9.96	0.92	0.68
Julie	11.01b	1.05	0.32	9.62	1.18	0.49
Mabrouka	12.64a	0.99	0.31	10.07	1.20	0.51
SE±	0.480	0.092	0.059	0.551	1.108	0.064
Rootstocks (R)						
Dankamaru	11.57a	1.12	0.28b	9.29	1.17	0.49
Gwaiwarrago	10.50b	1.09	0.34a	10.47	1.03	0.63
SE±	0.392	0.075	0.021	0.450	0.088	0.052
Interactions						
LxS	ns	Ns	*	ns	ns	ns
LxR.	ns	Ns	**	ns	ns	*
SxR.	ns	*	ns	ns	ns	*
LxSxR	ns	ns	ns	ns	ns	ns

Means followed by the same letter(s) within columns are not significantly different at 5% level of probability using DMRT. ns- Not significant, DTBB – Days to bud break, DAG – Days after grafting, * - Significant at 5% probability level, ** - Highly significant at 1% probability level.

Table 2: Interactions of rootstock with scion type, scion length with scion type and rootstock with scion length on success of grafts in mango at 30 and 90 DAG from the first trial

30 DAG				**90 DAG**				**90 DAG**			
Scion type				**Scion length**				**Scion length**			
Rootstock	Alphonso	Julie	Mabrouka	**Scion Type**	6	8	10	**Rootstock**	6	8	10
				Alphonso	0.32ab	0.32ab	0.25b				
Dankamaru	1.06b	1.13ab	1.18ab	Julie	0.31ab	0.25b	0.40a	*Dankamaru*	0.17d	0.30bc	0.38ab
Gwaiwarrago	1.49a	0.97b	0.80b	Mabrouka	0.25b	0.25b	0.43a	*Gwaiwarrago*	0.42a	0.25cd	0.34abc
SE±		0.130		SE±		0.042		SE±		0.059	

Means followed by the same letter(s) within columns are not significantly different using DMRT at 5% level of probability.
DAG - Days after grafting.

The variance in the success of grafts observed in this this study corroborates with the work of Reddy and Melanta (1988) who reported scion cultivar as having significant influence on the success of grafts. The results further revealed highest success of grafts in 10 cm scion from Julie and Mabrouka at 90 DAG. The 6 cm scion from *Gwaiwarrago* also had the highest success of graft in this study. This is an indication that cultivar (*Gwaiwarrago* rootstock) had greater influence on the success of grafts than length of the scion as reported by Reddy and Melanta (1988).

Table 3 presents the interaction of rootstock with scion length and rootstock with scion type on the success of grafts from the second trial at 90 DAG. This showed that successful grafts was recorded from *Gwaiwarrago* irrespective of the scion lengths. Similarly, Alphonso grafted onto *Gwaiwarrago* had the highest successful grafts than all other combinations. The ability of *Gwaiwarrago* to surpass *Dankamaru* in this study could be attributed to its genetic makeup. Similar finding was reported by Minja *et al*. (2017) who observed performance of grafted mango as largely dependent on rootstock and type of scion.

More leaves were produced by the 8cm scion at 90 DAG from the first trial (Table 4). This further showed that Julie has more leaves than Alphonso and Mabrouka at 60 and 90 DAG. The findings also corroborates with the work of Baita *et al.* (2010) who reported Alphonso as bearing less number of leaves than the other cultivars. The study also showed that *Dankamaru* bears the highest number of leaves at 90 DAG in the first trial. Number of leaves was however, not significantly influenced by scion length, scion type and rootstock in the second trial. This may be due to the prevailing climatic condition, which is an important factor that affect the growth and survival of grafts as reported by Jadhab *et al.* (2014). Significant ($p < 0.05$) interactions of scion length with scion type, scion length with rootstock as well as scion type with rootstock on number of leaves of grafted mango at 90 DAG of the first trial were observed in this study (Table 5). This showed that more leaves were recorded from 8 cm scion from Julie. This was also at par with Mabrouka. The results further revealed *Dankamaru* as bearing more leaves from 6 and 8 cm scions. This was also at par with 8 cm scion from *Gwaiwarrago*. Julie that was grafted onto *Dankamaru* bears the highest number of leaves in this study. The differences in the number of leaves across the scions is an indication of the role of genotype in the control of this character as reported by Minja *et al*. (2017). Results of the study also revealed that 10 cm scion had the longest mango saplings from both trials in this study (Table 6). Mabrouka and Julie also had the longest saplings than Alphonso during 60 DAG of the first trial. At 90 DAG however, Mabrouka recorded the longest saplings when compared with Julie and Alphonso. So also *Dankmaru* produced longest saplings at 90 DAG from the first trial, while *Gwaiwarrago* had the longest saplings during 60 and 90 DAG in the second trial. The ability of 10 cm scion to produce the best saplings in this study confirm the findings of Alam *et al.* (2006) and Chakrabarty and Sadhu. (1984) who reported that 10 cm scions performed better than 5 or 15 cm scions.

Table 3: Interactions of rootstock with scion length and rootstock with scion type on success of grafts in mango at 90 DAG of the second trial.

	90 DAG			**90 DAG**		
		Scion				**length**
Scion type						
Rootstock	6	8	10	Alphonso	Julie	Mabrouka
Dankamaru	0.34b	0.61ab	0.57ab	0.47b	0.51b	0.48b
Gwaiwarrago	0.76a	0.59ab	0.54ab	0.88a	0.47b	0.54b
SE±		0.157			0.091	

Means followed by the same letter(s) within columns are not significantly different using DMRT at 5% level of probability.
DAG - Days after grafting.

Table 4: Influence of scion length (cm), scion type and rootstock on number of leaves in grafted mango

	First trial			**Second trial**		
	Days after grafting (DAG)					
Treatment	30	60	90	30	60	90
Scion length (L)						
6	4.52	6.22	8.76b	4.88	6.56	9.40
8	5.24	6.69	10.46a	5.99	6.34	9.54
10	4.54	5.89	8.14b	5.08	6.53	9.09
SE±	0.313	0.430	0.384	0.397	0.304	0.512
Scion type (S)						
Alphonso	4.25	5.38b	8.09b	4.69	5.96	9.68
Julie	5.04	7.01a	10.77a	5.78	6.46	9.40
Mabrouka	5.02	6.19ab	8.64b	5.53	7.01	8.96
SE±	0.313	0.430	0.384	0.397	0.304	0.512
Rootstocks (R)						
Dankamaru	4.46	6.58	10.16a	5.44	6.20	8.88
Gwaiwarrago	5.07	5.94	8.44b	5.20	6.74	9.81
SE±	0.255	0.351	0.314	0.248	0.248	0.418
Interactions						
L x S	ns	ns	**	ns	ns	ns
L x R.	ns	ns	**	ns	ns	ns
S x R	ns	ns	*	ns	ns	ns
L x S x R	ns	ns	ns	ns	ns	ns

Means followed by the same letter within columns are not significantly different at 5% level of probability using DMRT. ns - Not significant, DAG – Days after grafting, * - Significant at 5% probability level, ** - Highly significant at 1% probability level.

The interactions of scion length with scion type, scion length with rootstock as well as scion type with rootstock on saplings height of grafted mango were significant during 90 DAG from both trials (Table 7). Longest saplings were recorded from 10 cm scion irrespective of the scion type and or rootstock from the first trial. This corroborates with the findings of Nalage *et al.* (2010) who reported maximum growth in terms of height and girth in 10 cm scions. The 6 cm scion also gave the shortest saplings irrespective of the scion type and or rootstock in this study.

Similarly, Julie and Mabrouka that were grafted onto *Dankamaru* gave the longest saplings in the first trial. Similarly, the 10 cm scion gave the longest saplings irrespective of the scion type and or rootstock in the second trial. The result further revealed Alphonso grafted onto *Gwaiwarrago* produced longer saplings than all other combinations, while Mabrouka grafted onto *Dankamaru* produces the shortest saplings. These may be explained by factor of the differences in the genetic make-up and their response to the environment as reported by Jadhab *et al.* (2014) and Minja *et al.* (2017).

Table 5: Interactions of scion length with scion type, scion length with rootstock and Scion type with rootstock on number of leaves of grafted mango during 90 DAG of the first trial.

	Scion Type			Rootstock			Rootstock	
Scion Length	Alphonso	Julie	Mabrouka	Dankamaru	Gwaiwarrago	**Scion Type**	Dankamaru	Gwaiwarrago
6	9.63bc	10.48abc	6.17d	10.21a	7.31c	Alphonso	8.76bc	7.42c
8	8.38c	12.00a	11.00ab	11.26a	9.67ab	Julie	11.82a	9.44b
10	6.25d	9.42bc	8.75c	7.94c	8.33bc	Mabrouka	8.83bc	8.44bc
SE±		0.666		0.544			0.544	

Means followed by the same letter(s) with in columns are not significantly different at 5% level of probability using DMRT.
DAG – Days after grafting.

Table 6: Influence of scion length (cm), scion type and rootstock on saplings height of grafted mango

	First trial			Second trial		
	Days after grafting (DAG)					
Treatment	30	60	90	30	60	90
Scion length (L)						
6	9.88c	12.28c	13.75c	9.47c	11.23c	12.06c
8	11.74b	13.57b	15.29b	12.87b	13.42b	14.71b
10	13.99a	15.34a	16.32a	14.16a	15.22a	16.44a
SE±	0.168	0.209	0.247	0.241	0.170	0.205
Scion type (S)						
Alphonso	11.71	13.26b	14.21c	11.94	13.16	15.02a
Julie	11.96	14.00a	15.31b	12.10	13.25	14.10b
Mabrouka	11.95	13.93a	15.85a	12.45	13.23	14.08b
SE±	0.163	0.209	0.247	0.241	0.170	0.205
Rootstocks (R)						
Dan kamaru	11.72	13.93	15.68a	12.32	12.89b	14.10b
Gwaiwar Rago	12.03	13.53	14.57b	12.01	13.54a	14.64a
SE±	0.133	0.202	0.202	0.197	0.139	0.167
Interactions						
L x S	ns	ns	**	ns	ns	**
L x R	ns	ns	**	ns	ns	**
S x R	ns	ns	*	ns	ns	*
L x S x R	ns	ns	Ns	ns	ns	ns

Means followed by the same letter within columns are not significantly different at 5% level of probability using DMRT. ns - Not significant, * - Significant at 5% probability level, ** - Highly significant at 1% probability level.

Table 7: Interactions of scion length with scion type, scion length with rootstock and scion type with rootstock on saplings height of grafted mango during 90 DAG of the first and second trials.

	Scion Type			Rootstock			Rootstock	
Scion Length	Alphonso	Julie	Mabrouka	Dankamaru	Gwaiwarrago	**Scion Type**	Dankamaru	Gwaiwarrago
First Trial								
6	12.58e	15.56cd	13.12e	14.91d	12.60c	Alphonso	13.74c	14.68bc
8	14.53d	14.40d	16.95ab	15.70ab	14.89bc	Julie	16.67a	13.94c
10	15.52cd	15.97bc	17.48a	16.43a	16.21a	Mabrouka	16.62a	15.08b
SE±		0.428		0.349		SE±	0.349	
Second Trial								
6	13.99b	10.68c	13.12e	12.12d	12.00d	Alphonso	14.57b	15.47a
8	14.60b	14.77b	16.95ab	14.91bc	14.50c	Julie	14.28bc	13.92bc
10	16.47a	16.85a	17.48a	15.44b	17.43a	Mabrouka	13.62c	14.54b
SE±		0.354		0.289		SE±	0.289	

Means followed by the same letter(s) within columns are not significantly different at 5% level of probability using DMRT.

CONCLUSION

Epicotyl grafting was found to be feasible using the available local rootstock and desired scion. The 10cm scion was identified to be the most suitable. Alphonso grafted onto *Gwaiwarago* was the best combination as these produce the highest success of grafts and longer grafted saplings. Hence, epicotyl grafting presents quickest means of rapid production of low cost seedlings in mango.

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