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Effect of tree age, scion source and grafting period on the grafting success of cashew nut (A*nacardium occidentale* L.)

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Cashew (A*nacardium occidentale* L.) can be propagated by seed or vegetative propagation. Grafting is the best method for large-scale asexual propagation of cashew. An assessment of grafting success of cashew nut was conducted at Chikwawa Estate nursery where graft-take was compared for scions obtained from different populations of different ages and then grafted from the month of August to October 2008. Mature and immature scions were collected from forty cashew accessions of age 12 and 20 years in Liwonde, Nkope, Kaputu and Chikwawa populations. Results show that scion source and tree age had no effect on grafting success. However, there were significant differences ($p \leq 0.05$) for scion type. Immature scions performed better in August while mature scions did well in October. The differences are attributed to differences in temperature in the two months that further affect rate of healing of graft unions. There were significant differences ($p \leq 0.05$) for graft take of mature scions as compared to immature scions with 57.5 and 72.5% in August and October respectively. There were no correlations between cashew tree age and scion type on the grafting success suggesting that cashew scions could be collected from trees of different ages to be used for grafting.

Key words: *Anacardium*, grafting, graft-take, season, scion type.

INTRODUCTION

Cashew (A*nacardium occidentale* L.) seedlings present great variation in growth habit, quality and yield of nuts. Traditionally, cashew is propagated using seed resulting in high levels of genotypic and phenotypic variations. Since it is highly cross-pollinated, woody and perennial in nature, progress in the crop's improvement through conventional breeding methods is slow and difficult. Furthermore, over the years trees' nut yield in farmers' fields have been found to be highly varied from nothing to 20kg (Aliyu, 2005). Establishing new orchards of cashew through vegetative propagation is of great importance as it improves maintenance of genetic integrity of the genotypes as well as shortens the juvenile period of the tree. The development of propagation protocols and discovery of root inducing chemicals, in addition to grafting and budding methods, have revolutionized the propagation and nursery procedures. An appropriate propagation technology can be selected for each kind of plant based on its growth, physiology, flowering and phenology. Micro-propagation of cashew has been attempted using explants from both juvenile and mature tree origin with success being registered in explants of juvenile stage (Boggetti et al., 1999). Most farmers in Malawi and a number of southern and eastern African

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Table 1. Location and climatic data for scion source of four *Cashew* populations in Malawi.

Population	Locality		Mean annual rainfall (mm)	Altitude (masl)	Mean temperature °C)	
	Latitude^0 S'	Longitude°E			August	October
Liwonde	15° 02.879'	035° 14.750'	812	478	26	30
Nkope	14° 12.181'	035° 01.933'	743	489	25	30
Chikwawa	13° 31.971'	034° 18.449'	906	525	27	32
Kaputu	13° 45.497'	034° 27.867'	965	508	26	30

countries cannot afford propagation of cashew using modern techniques of tissue culture because of inadequate skills and the high costs associated with chemicals and infrastructure. It has been observed that most orchard owners are establishing their orchards using ordinary grafting techniques such as whip and tongue, splice graft, stub graft, cleft graft and inarching. The cashew estate sector in Malawi has identified some trees with good characteristics where scions are being obtained for grafting and planting in different sites (Chipojola et al., 2009).

To achieve successful tree improvement in cashew through application of vegetative propagation methods such as grafting there is need for knowledge of the phenology of tree and this includes timing of flower emergence, sequence of bloom, fruiting, and leaf drop as all these influence management regimes to be applied. Knowledge of phenology of the plant will determine when scions can be collected to maximum graft-take. Apart from phenology of the plant as determined by the season there are other factors that determine success of grafting and these include age of stock and scion, climatic factors, skill of the grafter and compatibility of the scion and root stock among others (Samson, 1989).In related studies carried out on macadamia, it was found out that explants characteristics such as type, source, genotype and history of plant affect the success and viability of grafting and tissue culture systems (Holy et al., 2003; Gitonga et. al., 2010). The objective of study therefore, was to determine the effect of source and type of scion-wood, tree age and grafting period on the grafting success of cashew.

MATERIALS AND METHODS

Study site and scion collection

Forty cashew accessions were selected according to Muchugi et al. (2008) from 12 and 20 year old cashew from four populations of Liwonde in Machinga district, Nkope in Mangochi district, Chikwawa and Kaputu both in Salima district (Table 1). Scions were collected from non-flowering lateral shoots of current season's growth. Scions measured 10 to 12cm long, uniformly round and 12 to 18 mm diameter, brown or pale brown in color. The mature scions had their top 4 to 5 leaves dark green in color indicating proper maturity with semi hard-wood while the immature scions had their top 4 to 5 leaves pale green with soft wood. The scions were cut early in the morning to avoid desiccation and wrapped in moist cloth, packed in a cooler box and carried in to the nursery for grafting operation. The scions were grafted onto four months old rootstocks raised at Chikwawa Press Agriculture Estate nursery in Salima in August, September and October 2008. The grafted plants were laid out in a randomized complete block design with three replicates.

Grafting technique and management

A transverse cut was made on the main stem 15cm above ground level of the pot. A cleft of 4 to 5 cm deep was made in the middle of the decapitated stem of the rootstock by giving a longitudinal cut and a matching scion was selected with its end cut to a wedge of 4 to 5 cm long by chopping the bark and wood from two opposite sides. The scion wedge was inserted into the cleft of the rootstock to ensure that both scion and stock cambial layers are in perfect contact with each other (Liu et al., 2007). The graft joint was secured firmly by a grafting tape of 1.5cm wide and 30 cm long. The scion was then covered with a transparent polythene bag tied from below the point of union to the tip covering the entire grafted plant. This was done to maintain a high humidity inside and to protect the apical bud from drying. The grafting exercise was conducted by only one grafter and the grafted plants were put under grass shade for 10 to 15 days to enable sprouting of the terminal buds. Scouting for insect pests was conducted on daily basis and Dursban was applied at the rate of 1 ml/L of water to reduce any possible infestation by insect pests.

Data collection and statistical analyses

Data collected included number of days taken for each graft to sprout, number of scions that healed and sprouted, number of leaves per plant and leaf size (cm^2) recorded according to Murthy et al. (2003). The initial height of the grafted scion was recorded on the day of grafting. Heights of the shoot were measured from graft union to the tip of the shoot after 45 days then subtract the initial height. Data on daily temperature and rainfall were recorded in each month. Data was subjected to one way analysis of variance (ANOVA) using Genstat Edition 3 (VSN International, 2008) and means that were significantly different were separated using least significant difference (LSD) and T-test for differences between the two observations.

RESULTS

The effect of scion source

Results in Table 2 show that leaf size of scions grafted in both August and October were significantly different (p ≤

Table 2. Effect of source of scion on shoot height, days to sprout and leaf size of grafted cashew.

Population	Shoot height (cm)		Days to sprout		Leaf size (cm^2)	
	Aug	Oct	Aug	Oct	Aug	Oct
Liwonde	4.7	4.4	15.8	10.7	14.8^a	19.4^a
Nkope	2.8	4.9	12.0	11.2	8.3^b	18.3^a
Kaputu	4.0	4.5	14.3	8.9	13.6^a	12.4^b
Chikwawa	3.4	4.1	14.8	8.9	9.8^{ab}	12.3^b
CV (%)	31.3	5.7	26.0	12.4	35.2	6.4
LSD (0.05)	-	4.4	-	-	4.597	3.115

Means in the same column followed by similar superscripts are not significantly different (p>0.05).

Table 3. Effect of scion age on shoot height, days to sprout, leaf size and leaf number in the grafting of cashew.

Scion age	Shoot height		Days to sprout		Leaf size (cm)		Leaf number	
	Aug	Oct	Aug	Oct	Aug	Oct	Aug	Oct
12-Year old stock	3.1^b	4.1	11.8^b	8.1^b	10.2	14.6	1.9^b	3.2^b
20- Year old stock	4.4^a	4.9	16.7^a	11.7^a	13.1	16.6	2.9^a	4.2^a
(P 0.05)	0.01	0.08	0.01	0.001	0.09	0.28	0.01	0.02
CV (%)	31.3	5.7	26.0	12.4	35.2	6.4	22.1	1.4

Values in same columns followed by same letters are not significantly different (p>0.05).

0.05) amongst all four populations. In the month of August Liwonde and Kaputu populations recorded higher leaf sizes of 14.8 and 13.6cm^2 respectively while Chikwawa and Nkope had lower leaf sizes of 9.8 and 8.3cm^2 respectively. A similar trend was observed for the months of October trial where 19.4 and 18.3 cm^2 were recorded for Liwonde and Nkope, respectively (Table 2). Despite the fact that there was no significant difference in the number of days to sprouting it was observed that all populations took 10 days to sprout in October as compared to 14 days for August. Shoot height measurements were statistically similar for both months in all the populations.

Effect of tree age and scion type

There were significant differences in shoot height, days to sprout and leaf size between scion wood obtained from 12 and 20 years old trees for the different grafting periods in August and October. Scion wood from both 12 and 20 years took fewer days to sprout in the month of October than August while the leaf number was higher in August than October (Table 3). Shoot height, days to sprout and leaf number for August period showed significant differences ($p \leq 0.05$) between immature and mature scion. However for the October period significant differences ($p \leq 0.05$) were registered in days to sprout and number of leaves. Number of leaves in August was less than those recorded in October. There were no variations in performance between the two age groups of the cashew accessions in all the variables tested. Despite this, scions collected from 12 year old trees recorded higher measurements than the 20 years old in August and the opposite was true in September and October.

Effect of grafting period

Successful grafts were observed to show signs of growth in three weeks after grafting. In Table 4 graft take in percent were not significantly different ($p \leq 0.05$) between August and October. Immature scions recorded 60.2% and 60% in August, and October respectively with a mean of 60.4%. The graft take were significantly different ($p \leq 0.05$) in August and October for mature scions.

Correlations

Correlations analyses show that in August scion type significantly correlated positively with number of days to sprout, leaf number and shoot height ($p \leq 0.05$). The number of days to sprout correlated strongly with leaf number, leaf size and shoot height, leaf number and leaf size, and shoot height as well as leaf size and shoot height ($p \leq 0.01$). The tree age had negative correlation with leaf number, leaf size and shoots height but was not significant (Table 5).

DISCUSSION

The results suggest that scions could be sourced from

Table 4. Percent of cashew grafting success rate for months of August and October.

Scion type	Aug	Oct	Mean	CV (%)	LSD
12-Year old stock	60.2[a]	60.0[a]	60.4	8.3	7.15
20- Year old stock	57.5[b]	72.5[a]	65.0	11.1	10.20

Values in same row followed by same letters are not significantly different ($p > 0.05$).

Table 5. Correlations of traits and variables in August (below) and October (upper).

	Tree age	Scion type	Sprout days	Leaf number	Leaf size	Shoot height
Tree age	-	0.000	1.019	0.116	0.034	0.110
Scion type	0.033	-	0.205*	0.157*	0.700	0.112
Sprout days	0.028	0.163*	-	0.713**	0.601*	0.730**
Leaf number	-0.037	0.163*	0.707**	-	0.705*	0.805**
Leaf size	-0.071	0.109	0.589**	0.885**	-	0.771**
Shoot height	-0.045	0.160*	0.757**	0.884**	0.891**	-

* Correlation is significant at the 0.05 level of probability; ** Correlation is significant at the 0.01 level of probability.

different populations despite the variation in leaf size between plants grafted in August and those grafted in October. The variation in leaf sizes could be attributed to differences in temperatures between August and October. Broadleaf tree species in Malawi shed leaves from July to September and this is the time when most species are dormant stage till October and November when the buds break (Chidumayo, 1997). The four populations lie within a similar ecological region with minor differences in elevation with mostly sandy loam to clay loam soils, low acidity and nitrogen levels. Due to exposure to similar climatic and edaphic factors the populations could have developed as ecotypes and adapted to the environmental factors across the range of sites along the Lake Malawi lakeshore region. Such growth pattern in cashew genotypes with respect to tree height, leaf sizes and canopy spread were also reported by Swamy et al. (1998).

Age of the trees

Older tree accumulate high latex and phenolic exudates that may reduce the rate of growth of grafted plants. On the other hand scions from younger trees are said to have higher concentration of meristems that increase the juvenility of plant and enhance faster growth. The findings disagree with those by Liu et al. (2007) who found that sprouting of buds decreased with increasing age of mother plants.

Type of scion wood

The mature scions despite taking more days to sprout recorded higher leaf numbers, leaf sizes and shoot heights in all months indicating superiority over the immature scions. This could be attributed to their well developed and strong tissues that survived scorching sun and high temperatures in the grafting period unlike the tender tissues in the immature scions. Average mean temperatures of 26.8 and 30.9°C were recorded in August and October respectively. In vegetative propagation temperature is a requirement as it induces cell division; shoot elongation, photosynthesis necessary for the growth or shooting of grafted material. The findings are in agreement with Sagar (2007) who reported that air temperature (30.4 to 36.4°C) and relative humidity (80 to 85%) determine the success of grafting propagation on cashew. Temperature also contributes to high respiration which could affect immature scions being tender to quickly lose water and structure then die. Carlos (1995) reported that when temperature increases over the range 19 to 35°C it leads to an increase in shoot elongation this is a reason for manipulating temperatures in cool areas by use of greenhouses to enhance growth of plant materials. The fewer days to sprouting for immature scions in both months could be attributed to the type of rootstocks used in the experiment. These young rootstocks could combine well with the immature scions as they are all tender. This therefore indicates that with good management in place immature scions could equally do well in vegetative propagation as the mature scions. The slow growth of mature scions is typical of mature trees that require manipulation through rejuvenation with plant growth regulators and other substances.

Grafting season

The time period of three weeks when successful grafts were observed agree to what Almeida (1988) reported that it takes between 3 to 4 weeks after grafting for grafts to show signs of growth.Generally average percentages for August (60.2% for immature and 57.5% mature) and October (60 and 72.5%) are lower than the range 85 to 100% reported by Ramadhan et al. (2008) who attributed success to skills of grafters, physiology of the graft components and environmental conditions. The months of September and October is the right time when leaf buds in cashew and other broad leaf tree species in Malawi begin to burst and might be a good time to graft because of high concentration of growth hormones in the buds to induce differentiation of vascular elements in the tissues of the graft (Hartmann et al., 1997). Low percentage in August for mature scions could be attributed to the use of low quality scions as a result of their scarcity because during this month scions require preconditioning prior to grafting. Average mean temperature of 22.8°C could not be ruled out as Kangde et al. (2008) reported that cashew exhibits slow growth at or below 20°C. Broadleaved tree species like cashew in Malawi lose their leaves between July and August as this is the period of dormancy for the tree species. Interlocking of plant tissue to form a union which is dependent on temperature could affect graft take in August hence low percentage. The month of October in Malawi is characteristic of high temperatures that would induce positive development. The differences in weather, management and genotypes may contribute to either success or failures during grafting in the months of August and October. The sunny conditions and high temperatures (26.9°C) in October for example could induce various biochemical activities like photosynthesis, transpiration, cell division and elongation that could positively affect healing of graft union.

Correlations

Low correlations between tree age and all other variables indicates that tree age does not affect grafting success hence scion wood material could be collected from either the 12 or 20 year old cashew trees. The correlation between scion type and days to sprout, number of leaves and leaf size indicate that as scions mature, sprouting may be prolonged.

Conclusion

The four populations of Liwonde, Kaputu, Nkope and Chikwawa did not show any variation in grafting success due to minimal differences in environmental and elevation of the sites. Cashew scions can be collected from 12 and 20 year old trees but period or season of collection and grafting of scions is crucial in the success of the grafting exercise. The success rate for October (58 and 72%) for immature and mature scions suggests that October may be a suitable month for grafting Cashew in Malawi. Higher temperatures at the end of the dry season in October would be suitable for increased growth of leaves to coincide with the onset of rains in November and December. Mature scions demonstrated superiority over the immature scions due to their ability to withstand adverse weather conditions. The findings therefore suggest that type of cashew scions, period of grafting affect graft take while source of the scion and age of tree do not affect grafting. Farmers are advised to match the environmental and edaphic conditions of their source of scions with planting sites before conducting grafting of scions to rootstocks grown in different agro-ecological zones.

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