THE EFFECT OF SHOOT POSITION ALONG THE MOTHER PLANT ON ROOTING OF STEM CUTTINGS OF HYBRID COFFEE VARIETIES

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1.0 INTRODUCTION AND JUSTIFICATION

1.1 Introduction

- Coffee is the second most traded product world wide after oil (DaMatta *et al*., 2007).

- It provides employment to approximately 25 million people world wide.

- In Tanzania, coffee provides direct income to over 450,000 families and benefits indirectly the livelihood of about 2.4 million people (Teri *et al*., 2011).

1.1 Introduction (*Continued*)

- Coffee can be propagated by seeds or vegetatively using cuttings or grafting.

- Propagation by seeds leads to genetic variability due to segregation of genes during fertilization.

- Vegetative propagation through stem cuttings guarantees uniformity as it maintains the genetic make-up (Kumar *et al*., 2006).

- TaCRI multiplies the improved hybrid coffee by vegetative propagation using orthotropic stem cuttings (TaCRI, 2011).

1.1 Introduction (*Continued*)

- However, stem cuttings sometimes have low rooting percentage (Etienne *et al*., 2002) if due instructions are not adhered to.

- The rooting ability of stem cuttings is the function of species, type of cutting, physiological status of the plant and suitability of the rooting medium and environment (Hartman *et al*., 2002).

1.1 Introduction *(Continued)*

- Normally, coffee plants are bent to produce shoots from the base to the apex at each stem internode.

- The shoots from base, middle and apex are collected and mixed together during preparation of stem cuttings.

1.1 Introduction *(Continued)*

- Despite the use of the above practices, the average rooting of stem cuttings has remained low, resulting into slow dissemination of hybrid coffee varieties.

- The low rooting ability of the hybrid coffee varieties is possibly associated with bulking juvenile and aged stem cuttings from different positions along the mother plants.

1.2 Justification

- Many plant species can not produce roots from cuttings taken from the upper parts of the plants since they are physiologically too old (Yeboah *et al*., 2009).

- Cuttings taken from apex of mother plants are chronologically younger but have low ability to root and regenerate into young plants (Chong, 2008).

- Cuttings collected from the base of the mother plants have been reported in other plants to be more juvenile and produce roots easier than those collected from the apex (Yeboah *et al*., 2009).

1.2 Justification (*Continued*)

- However, there are limited reports on the effects of position of stem cuttings along the mother plants on the rooting of hybrid coffee varieties.

Specific objective

- The specific objective of this study was to determine the effect of position of stem cuttings along the mother plants on rooting of hybrid coffee varieties.

2.0 MATERIALS AND METHODS

2.1 Site description and planting materials

- The study was carried out on-station at TaCRI Lyamungu from December 2013 to April 2014
- Latitude 03º14.699’ S and Longitude 037º14.762’E
- Altitude 1268 m.a.s.l
- Average annual temperature is 23°C
- Average annual relative humidity is 65%
- Average annual rainfall is 1250 mm.
- pH range is 4.8-5.7

2.0 MATERIALS AND METHODS *(Continued)*

2.1 Site description and planting materials

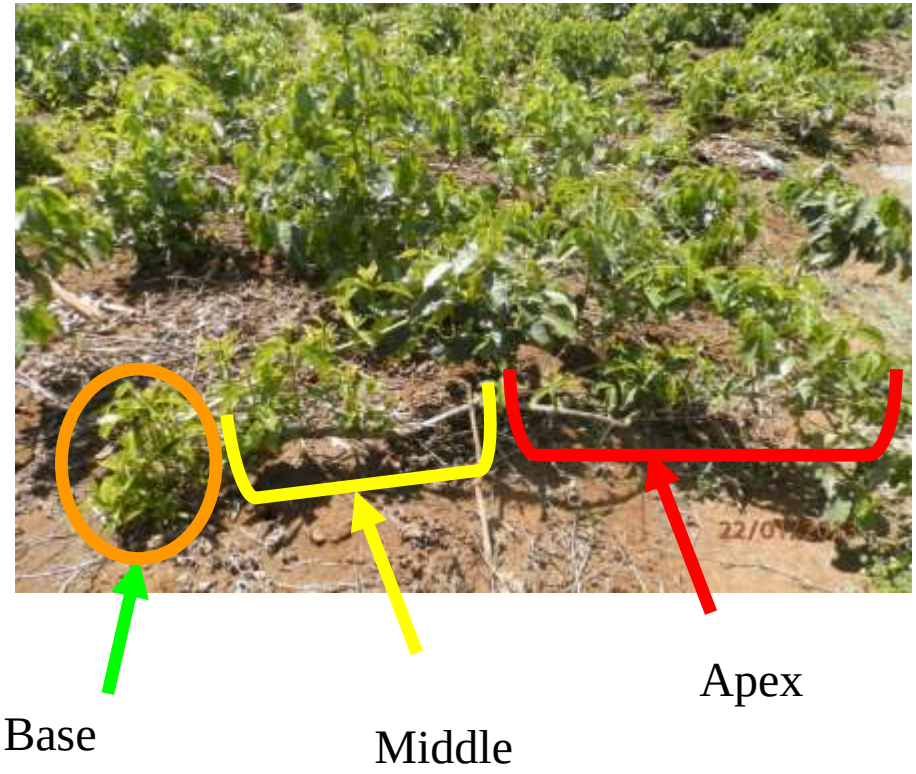
- Five varieties:
  - ✓ N39-1, N39-2, N39-4, KP423-1 and KP423-2

- The orthotropic shoots of the five (5) improved hybrid coffee varieties with at least 4-8 internodes were selected from vigorous mother stocks at TaCRI nursery.

2.0 MATERIALS AND METHODS *(Continued)*

2.3: Site description and planting materials

- The shoots were collected separately at the **base**, **middle, apex** and **mixture of the three as control**.



2.0 MATERIALS AND METHODS *(Continued)*

2.1 Site description and planting materials

- The stem cuttings were processed into cuttings with three nodes with six leaves

- Leaf area for each leaf was reduced by 50% to reduce water loss by transpiration.

2.0 MATERIALS AND METHODS *(Continued)*

2.3 Preparation of rooting medium

- Forest and fine sand soil were sorted to remove debris (gravel, leaves, pieces of wood).

- The rooting medium was mixed in the following ratio:
  (i) Forest soil and fine sand at 2:1

2.0 MATERIALS AND METHODS *(Continued)*

2.3 Preparation of rooting medium

- The medium was moistened to 20-35% then sterilized by heating at 80 ^{o}C for one hour, cooled under the shade for 24 hours and then re-moistened to 20-35% moisture content (TaCRI, 2011).

2.0 MATERIALS AND METHODS *(Continued)*

2.4: Experimental design and treatments applications

- The rooting medium was filled in propagation box measuring 3.65 x 1 x 0.9 m, made up of cement blocks with three layers .

- Gravels (0.15 m thick) which formed the base material, followed by (0.15 m) of rooting medium and 0.60 m which was left empty (TaCRI, 2011).
  - Moisture of the rooting medium was maintained at 20 to 35% by spraying water using a knap sack sprayer before planting (TaCRI, 2011).

2.0 MATERIALS AND METHODS *(Continued)*

2.4: Experimental design and treatments applications

- A split- plot experiment in RCBD with four replications was used.

- Two factors: Main plot: Five Varieties
  N39-1, N39-2, N39-4, KP423-1 and KP423-2
  : Sub-plot: Four positions along the shoots
  Basal, Middle, Apical and Control

- Stem cuttings for the control were collected in equal number from the base, middle and apex parts of the mother plant.

2.0 MATERIALS AND METHODS *(Continued)*

2.4: Experimental design and treatments applications

- The basal ends of 1-3 cm of stem cuttings were sterilized by dipping into 5 g/l of copper oxychloride (50 WP), air-dried for five minutes and immediately planted into the rooting medium as described by Akwaturila *et al.* (2011) and TaCRI (2011).
- Planting was done a 5 x 5 cm spacing and 2.5 cm depth as recommended by Akwaturila *et al*. (2011) and TaCRI (2011).

2.0 MATERIALS AND METHODS *(Continued)*

2.4: Experimental design and

- The box was covered with transparent white polyethylene sheet (5mm thick) to preserve humid condition of about 60-85% as described by Pandey *et al*. (2011).

- Irrigation was performed to take into consideration moisture content of the media (20-35%).

2.5 Data collection (*Continued*)

Data were taken four months after planting as described by Pandey *et al*. (2011)

- Number of dormant, dead cuttings and rooted cuttings
- % of rooted cuttings
- Length (cm) of laterals, number of laterals and fibrous roots

2.6 Data analysis

- Data collected were subjected to analysis of variance (ANOVA) using CoStat software version 6.311 and declared significant at $P \leq 0.05$ using the following sstatistical model for the split-plot design as described by Kuehl (2000): $Y_{ijk} = \mu + \alpha_i + p_k + d_{ik} + \beta_j + (\alpha\beta)_{ij} + e_{ijk}$.

  Where:
  - μ = the general mean;
  - α_i = the effect of the ith level of factor;
  - p_k = the effect of the kth block;
  - d_{ik} = the whole-plot random error;
  - β_j = effect of the jth level of factor B,
  - $(\alpha\beta)_{ij}$ = the interaction effect between factors A and B;
  - e_{ijk} = the sub-plot random error.

- The differences between the treatment means were separated by Tukey's test method at $P \leq 0.05$

3.0 RESULTS

3.1 Effect of coffee hybrid varieties on rooting

- Varieties had a highly significant (P=0.00) effect on rooting with variety KP423-2 having the highest rooting of 58.09% and was significantly different from varieties N39-4 and KP423-1 with rooting of 41.61 and 38.48%, respectively .

- Variety KP423-1 had the lowest rooting of 38.48% but not significantly different ($P \leq 0.05$) from variety N39-4 and N39-2 with rooting of 41.61 and 45.95%, respectively.

- Further, varieties did not significantly ($P \leq 0.05$) affect the number of fibrous roots, lateral root length and number of lateral roots.

3.0 RESULTS *(Continued)*

Table 1.3 Effect of varieties of stem cuttings on rooting of hybrid coffee varieties

Varieties	% rooted cuttings	Number of fibrous roots/cuttings	Lateral root length (cm)	Number of lateral roots/cutting
KP423-1 control	38.48c	71.26	12.16	2.68
KP423-2	58.09a	75.91	12.71	2.62
N39-2	45.95abc	58.25	12.37	2.62
N39-1	56.65ab	60.09	11.38	2.37
N39-4	41.61bc	82.96	12.7	2.75
Mean	**48.16**	**69.69**	**12.26**	**2.61**
CV (%)	**29.83**	**39.28**	**22.59**	**21.45**
P-values	**0.00**	**0.11**	**0.65**	**0.35**

Means followed by the same letter in the same column are not significantly different at ($P \leq 0.05$) according to Tukey's Test

3.0 RESULTS *(Continued)*

3.2 Effect of position of stem cuttings on rooting of hybrid varieties

- The position of stem cuttings along the mother plants significantly (P=0.04) affected the rooting of hybrid coffee varieties.

- Stem cuttings from apex had the lowest rooting of 39.59% and was significantly different from stem cuttings collected from the base and middle of the mother plants with rooting percentage of 45.8, 51.57 and 55.66, respectively.

- No significant difference ($P \leq 0.05$) was found for cutting position for root length, number of lateral roots and number of fibrous roots per cutting.

3.0 RESULTS *(Continued)*

Table 1.4 Effect of position of stem cuttings on rooting of hybrid coffee varieties

Position of cutting	% rooted cuttings	Number of fibrous roots/cutting	Lateral root length (cm)/cutting	Number of lateral roots/cutting
Control (mixed cuttings)	45.81ab	71.71	12.20	2.50
Cuttings from the base	55.66a	72.61	12.79	2.80
Cuttings from the middle	51.57a	74.56	12.81	2.75
Cuttings from the apex	39.59b	59.9	11.27	2.40
Mean	**48.16**	**69.69**	**12.26**	**2.61**
CV (%)	**27.84**	**35.18**	**18.1**	**19.54**
P-values	**0.04**	**0.24**	**0.11**	**0.08**

Means followed by the same letter in the same column are not significantly different at ($P \leq 0.05$) according to Tukey's Test

3.0 RESULTS *(Continued)*

3.3 Interaction effect between hybrid coffee varieties and positions of stem cuttings on mother plants on rooting of stem cuttings

- Interaction effect on the two factors used had a significant effect (P=0.04) on percentage rooted cuttings and significantly (P=0.01) affected the number of lateral root length.

- Variety KP423-2 x cutting from the base had the highest rooting of 73.25% which was significantly different from KP423-1 x cutting from middle.

- Stem cuttings from apex had the lowest rooting of 39.59% and was significantly different from stem cuttings collected from the base and middle with rooting % of 45.8, 51.57 and 55.66, respectively.

Table 1.5 The interaction effect between hybrid coffee varieties and position of stem cuttings on mother plants on rooting of stem cuttings

Varieties x Positions	% rooted cuttings	No of roots/cutting	Average root length (cm)	No of lateral roots/cutting
N39-1 x P4 (control)	70.025ab	70.400	12.775	2.25ab
N39-1 x P1 (cutting from the base)	51.15abc	59.675	10.850	2.25ab
N39-1 x P2 (cutting from the middle)	**62.40abc**	65.875	12.475	2.75ab
N39-1x P3 (cutting from the apex)	43.025abc	44.425	9.4504	2.25ab
N39-2 x P4 (control)	34.925bc	46.775	10.725	2.25ab
N39-2 x P1 (Cutting from the base)	47.500abc	57.600	12.475	2.50ab
N39-2 x P2 (cutting from the middle)	55.025abc	70.425	14.650	3.25a
N39-2 x P3 (cutting from the apex)	46.375abc	58.200	11.650	2.50ab
N39-4 x P4 (control)	33.450c	94.725	13.250	3.00ab
N39-4 x P1 (cutting from the base)	50.350abc	96.875	14.575	3.25a
N39-4 x P2 (cutting from the middle)	44.075abc	63.775	10.400	2.25ab
N39-4 x P3 (cutting from apex)	38.575abc	76.475	12.575	2.50ab
KP423-1 x P4 (control)	31.900c	64.650	11.900	2.25ab
KP423-1 x P1 (cutting from base)	56.075abc	57.600	12.225	2.75ab
KP423-1 x P2 (cutting from middle)	34.275c	93.575	12.650	2.75ab
KP423-1 x P3 (cutting from apex)	31.700c	69.225	11.875	3.00ab
KP423-2 x P4 (control)	58.775abc	82.025	12.350	2.75ab
KP423-2 x P1 (cutting from base)	**73.250a**	91.300	13.850	3.25a
KP423-2 x P2 (cutting from middle)	**62.075abc**	79.150	13.875	2.75ab
KP423-2 x P3 (cutting from apex)	38.275abc	51.1750	10.800	1.75b
Mean	**48.16**	**69.69**	**12.26**	**2.65**
CV%	**29.83**	**35.18**	**18.120**	**21.13**
P-values	**0.04**	**0.24**	**0.12**	**0.01**

4.0 DISCUSSION *(Continued)*

4.1 Effects of hybrid coffee varieties on rooting of stem cuttings

- The observed significant differences in root % recorded in this study were probably due to the differences in the genetic, physiological and morphological characteristics of the varieties used as also reported by Hartmann *et al*. (2002).

- Research by Bartolin *et al*. (1996) concluded that rooting ability was related to water soluble carbohydrate (WSC) contents of stem cuttings which is a physiogenic characteristic.

- During rooting, WSC contents act as source of energy and as a constitutive elements for the newly formed cells (Bartollin *et al*., 1996).

4.0 DISCUSSION *(Continued)*

4.1 Effects of hybrid coffee varieties on rooting of stem cuttings

- Further, root promoting substances such as phenolic compounds and auxins are also produced in leaves and transported to the base of the cuttings where they protect auxins especially indole-3-acetic acid (IAA) from being oxidized and hence more auxins become available to induce roots (Hartmann *et al*., 2002; De Klerk *et al*., 2011).

- The significant differences recorded among position of stem cuttings along the mother plants on rooting of stem cuttings could be related to physiological status of the mother plants from which they were collected (Hartmann *et al*., 2002).

4.0 DISCUSSION *(Continued)*

4.2 Effects of position of stem cuttings along mother plants on rooting

- Stem cuttings collected closest to the base of the mother plants are chronologically the oldest but the most juvenile physiologically and thus having the ability to form roots than those at the apex as reported by Beyl (2008).

- The results from this study are consistent with previous studies which show that plant regeneration potential is high during juvenile phase, and declines as the plant ages.

4.0 DISCUSSION *(Continued)*

4.2 Effects of position of stem cuttings along mother plants on rooting

- Amri *et al.* (2010) also found that stem cuttings collected from juvenile African Blackwood (*Dalbergia melanoxylon* Guill. & Perr.) performed better in all rooting parameters than those collected from mature stock plants.

- The high rooting percentage may be associated with higher levels of root-promoting substances especially auxin and soluble carbohydrates which are higher in juvenile phase (Amissah *et al*., 2008; Islam *et al*., 2010).

4.0 DISCUSSION *(Continued)*

4.2 Effects of position of stem cuttings along mother plants on rooting

- The high rooting ability of cuttings during juvenile phase and middle over those at apex is attributed to the effect of changes in plant developmental process that occur with aging.
  - Such effects are known as maturation or ontogenetic aging, which is commonly found in the upper parts of the tree and least advanced near the base/crown (Browne *et al*., 1997; Beyl, 2008).

- This means stem cuttings from the apex are too mature and highly lignified to develop roots than the cuttings collected at the juvenile phase (Cheng *et al*., 2008).

5.0 CONCLUSION & RECOMMENDATION

5.1 Conclusion

- Clonal multiplication of coffee stem cuttings differed significantly with varieties where varieties KP423-2 and N39-1 had the highest rooting percentage.

- Stem cuttings from middle and basal positions of mother plants had the highest rooting ability than those taken from the apex of the mother plant.

- Moreover, interaction effect between varieties and positions of stem cuttings indicates that varieties N39-1, KP423-1 and KP423-2 had the highest rooting percentage and number of lateral roots when cuttings were collected from base and middle.

5.0 CONCLUSION & RECOMMENDATION

5.2 Recommendation

- Further studies are required to determine yield performance of the stem cuttings in relation to their positions along the mother plants.

12.0 REFERENCES

- Akwatulira, F., Gwali, S., Okulo, J. B. L., Ssegawa, P., Tumwebaze, S. B., Mbwambo, J. R. and Muchugi, A. (2011). Influence of rooting media and indole-3-butyric acid (IBA) concentration on rooting and shoot formation of *Warburgia ugandensis* stem cuttings. *African Journal of Plant Science, Volume* 5 (8): 421-429.

- Amri, E., Lyaruu, H.V.M., Nyomora, A.S. and Kanyeka, Z.L. (2010). Vegetative propagation of African Blackwood (*Dalbergia melanoxylon* Guill. & Perr.): Effects of age of donor plant, IBA treatment and cutting position on rooting ability of stem cuttings. *New Forests, Volume* 39: 183-194.

- Rana, R. S. and Sood, K. K. (2012). Effect of cutting diameter and hormonal application on the propagation of *Ficus roxburghii* Wall. through branch cuttings. *Annals of Forest Research*, 55 (1): 69-84.

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