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Effect of Planting Land Forms and Orientation of Stem Cuttings on Yield of Cassava

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Abstract

To ascertain whether tillage land forms and orientation of cassava stem cuttings at planting affect yield, a factorial experiment comprising three landforms and three stem orientations were tested in 2010 and 2012 at Wenchi. The land forms were: (i) no till, (ii) mounds and (iii) ridges, while stem orientations comprised: (a) vertical, (b) horizontal and (c) inclined. The nine treatment combinations were replicated four times in a randomized complete block design (RCBD), and the test crop was the variety, *Tekbankye*. No till yielded a mean of 17.96 tonnes/ha in tuberous roots, while mounds gave 21.21 tonnes/ha and ridges yielded 23.35 tonnes/ha. Vertical cuttings averaged 21.06 tonnes/ha, horizontal ones gave 21.22 tonnes/ha and those inclined yielded 20.25 tonnes/ha. These yields were not significantly different at the 5% level. Similarly, landforms did not differ significantly in number of tuberous roots per hectare, averaging 357,000, but orientation was significant, with vertical cuttings giving 388,600, while horizontal and inclined cuttings gave 314,400 and 367,900 / ha, respectively. Vertical cuttings bore their tuberous roots deeper (about 60 cm) into the soil and were more compactly packed at the tips of the cuttings. They caused bruises and breakages at harvest and thereby reduced shelf life. Tuberous roots from the horizontal cuttings were about 25cm deep, and inclined cuttings were intermediate between the other two.

Keywords: Cassava stem, cutting orientation, tillage landforms, yield

INTRODUCTION

Cassava, (*Manihot esculenta* Crantz), is an annual woody shrub cultivated extensively by stem cuttings as a tuberous root crop in the tropics and sub-tropics for its edible and industrial starch (Chavez, 1990; Fianu, 2006). It is the third largest carbohydrate staple food for more than 800 million people in the tropics (FAO, 1995). It is the only crop whose production cuts across all tropical ecologies and poor soils, cultivated by small scale farmers as a subsistence crop in a diverse range of farming systems (Ofori, 1973 & Dapaah, 1991). The tuberous roots can be left in the ground without harvesting for long periods (Sinthuprama, 1980), making the crop very useful for food security. Dapaah (1991) reported that cassava was the largest agricultural commodity in Ghana, generating 22 per cent of agricultural gross domestic product (AGDP), compared to 5 per cent for maize, 2 per cent for rice, sorghum and millet, 14 per cent for cocoa, 11 per cent for forestry and 7 per cent for livestock. In the Democratic Republic of Congo, cassava accounts for 27.8 % of the AGDP followed by peanuts with 9.4% (Vanlauwe *et al.*, 2012).

The choice of orientation of cassava stem cuttings at planting varies according to countries and even regions within countries (Krochemal, 1969; Ezumah and Okigbo, 1981; Sinthuprama, 1980). In the Francophone community, ACCT (1981) favoured horizontal planting because of greater fertilizer use efficiency leading to higher yields, however, in la Cote d'Ivoire, horizontal and inclined positions are more common than vertical placement. In large scale cassava production systems, horizontal and inclined orientations are preferred because of ease of mechanization in harvesting operations. Chavez, (1990) in Colombia, showed that sprouting and emergence under field conditions were always more rapid with vertical planting than with any other. Vertical placement resulted in fast crop establishment and rapid soil cover development, together with good anchorage provided by a deep root system and less risk of lodging (Ujuanbi, 2002 & Odumosor, 2003). In Ghana, cassava is generally propagated by inclined stem cuttings, 20 – 25 cm long with 4-6 nodes. However, sometimes it is planted vertically with a third to half of the stem cutting buried, and at times, horizontally with total burial (Ofori, 1973).

Since 1990, the Ghana Ministry of Food and Agriculture (MOFA), in collaboration of the International Institute of Tropic Agriculture (IITA) and the International Fund for Agricultural Development (IFAD), has been promoting cassava cultivation for rural poverty alleviation in the country (MOFA, 2010). But the farmer's average yield is about 12.7 Mt/ha instead of the achievable yield of 28.0 Mt/ha and contrasts with the yields of 40 to 59 tonnes/ha reported from Thailand (Jongruaysup, Treloges & Chuenrung, 2003). Thus there is a wide deficit of 220 % to 460 % of the potential yield.

Would the choice of planting orientation and tillage landform help explain this yield deficit? To investigate this issue, the yield of cassava planted vertically, horizontally or inclined, in combination with no tillage, mounds and ridges, was tested in this study.

METHODOLOGY

The study was conducted at Wenchi, (latitude 7° 45' N and longitude 2° 6' S) at an average altitude of 338 metres, in 2010 and 2012. The site is located in the forest – savannah woodland transition zone with a sparse population of deciduous fire tolerant trees and shrubs. Rainfall is bimodal with the major season beginning in February/March and lasting for about four months, while the minor season starts in late August and ends in late November to early December. Ten-year (2006 – 2016) annual rainfall average was 1212.9 mm (Anon, 2016). The soil is a sandy-loam savannah ochrosol underlain by an iron pan as is typical of Wenchi series as described by Brammer (1961). The test crop was *Tekbankye* and the experimental design, a 3 x 3 factorial with four blocks in a randomized complete block design (RCBD). The two factors tested were land forms (no till, ridges and mounds), and stem cutting orientation (inclined, vertical and horizontal), to give nine treatment combinations as follows:

- No till with vertical stem cuttings
- No till with horizontal stem cuttings
- No till with inclined stem cuttings
- Mounds with vertical stem cuttings
- Mounds with horizontal stem cuttings
- Mounds with inclined stem cuttings
- Ridges with vertical stem cuttings
- Ridges with horizontal stem cuttings
- Ridges with inclined stem cuttings

The treatments were randomly assigned to the plots within each block. Each plot measured 5 m × 3 m, with 1.5 m intra-block and 2 m inter-block paths. The ridges and mounds were raised manually, using hoes. After the entire experimental area had been slashed with machetes, all trash was removed and about three weeks later, *Glyphosate* herbicide was applied to clear weeds that had emerged before planting. Machetes and secateurs were used to cut the cassava stems into planting materials, 20-25 cm long, each bearing four or five nodes. Planting was done by hoe and machete at a spacing of 1 m × 1 m. Weeds were initially controlled by hoeing but when storage root bulking commenced and the canopy started closing (at about 6-8 weeks), machetes were used to clear weeds as and when it became necessary, up to harvesting time.

Plants in two central rows were harvested 12 months after planting. Data collected included, number of tubers per hectare, yield per ha of fresh tubers and shoot weight per hectare. The data collected were computed by procedures described by Le Clerg, Leonard & Clark (1966) for the analysis of variance and separation of means.

RESULTS

Tables 1a and 1c depict the treatment means of tuberous root yield per hectare and Tables 1b and 1d show the ANOVA on the yields. Apart from significant block effects due to soil variation from slope, none of the nine treatments gave significant tuberous root yield differences. The mean yield for the two trials was 20.84 tonnes per hectare.

Table 1a: Yield of Tuberous Roots (Tonnes/Ha) (Trial 1) (2010)

	Vertical	**Horizontal**	**Inclined**	**Σ**	**μ**
No Till	18.50	21.50	17.40	57.40	19.13
Mound	20.70	14.20	15.30	50.20	16.73
Ridge	18.50	19.30	18.00	55.80	18.60
Σ	57.70	55.00	50.70		
μ	19.23	18.33	16.90		**18.15**

Table 1b: ANOVA on Tuberous Root Yield (Tonnes/Ha) (Trial 1) (2010)

Source	D F	SS	MS	F	$F_{0.05}$	$F_{0.01}$
Blocks	3	290.4792356	96.8264119	3.41*	3.01	4.72
Tillage land forms	2	16.7605869	8.3802934	0.29 **ns**	3.40	5.61
Cutting orientations	2	3.4836278	1.7418139	0.06 **ns**	3.40	5.61
Tillage x Orientation	4	134.8372049	33.7093012	1.19 **ns**	2.78	4.22

Table 1c: Yield of tuberous roots (Tonnes/Ha) (Trial 2: 2012)

	Vertical	Horizontal	Inclined	Σ	μ
No till	14.33	20.18	15.85	50.36	16.79
Mound	24.63	21.90	30.53	77.06	25.69
Ridge	29.68	30.23	24.40	84.31	28.10
Σ	68.64	72.31	70.78		
μ	22.88	24.10	23.59		**23.52**

Table 1d: ANOVA on Tuber Yield (MTs Per Ha) (Trial 2) (2012)

Source	DF	SS	MS	F	$F_{0.05}$	$F_{0.01}$
Blocks	3	52.82	17.6067	0.4206ns	3.01	4.72
Tillage land forms	2	594.74	297.3700	7.1042**	3.40	5.61
Cutting orientation	2	9.11	4.5550	0.1088ns	3.40	5.61
Tillage x Orient.	4	1,265.27	316.3175	7.5569**	2.78	4.22

Tables 2a and 2c, and 2b and 2d show the number of tuberous roots produced per hectare and the ANOVA thereon, respectively. Land forms had no significant effect on the number of tuberous roots, but cutting orientation significantly affected this number ($p<0.05$), with vertical cuttings giving the highest number, 388,600 of root tubers per hectare, while the horizontal and inclined ones gave non-significant numbers of tuberous roots of 314,400 and 367,900 respectively.

Table 2a: No of Tuberous Roots/(x1,000 per Ha) ((2010: Trial 1)

	Vertical	Horizontal	Inclined	Σ	μ
No Till	44.67	37.82	38.62	121.11	40.37
Mound	45.88	39.04	39.84	124.76	41.59
Ridge	50.59	43.74	44.54	138.87	46.29
Σ	141.14	120.60	123.00		
μ	47.05	40.20	41.00		**42.75**

Table 2b: ANOVA on No. of Tuberous Roots/(x1,000 per Ha) (2010: Trial 1)

Source	D F	SS	MS	F	$F_{0.05}$	$F_{0.01}$
Blocks	3	379.116322	126.372107	0.78	3.01	4.72
Tillage land forms	2	962.666990	463.3334495	2.86	3.40	5.61
Cutting orientations	2	1356.278643	678.139322	4.19*	3.40	5.61
Tillage xOrientation	4	1225.889711	306.472428	1.89	2.78	4.22

Table 2c: Number of Tubers (x 1,000 Per Hectare) (2012) (Trial 2)

	Vertical	Horizontal	Inclined	Σ	*μ*
No till	22.25	8.00	23.25	53.5	17.83
Mound	35.50	30.50	36.25	102.25	34.08
Ridge	34.25	29.50	38.25	102.00	34.00
Σ	92.00	68.00	97.75		
μ	30.67	22.67	32.58		28.64

Table 2d: ANOVA on No of Tubers x 1,000 Per Ha (2012: Trial 2)

Source	D F	SS	MS	F	$F_{0.05}$	$F_{0.01}$
Blocks	3	21.76	7.2533	0.1195ns	3.01	4.72
Tillage Land Forms	2	67.32	33.6600	0.5544ns	3.40	5.61
Cutting orientations	2	107.54	53.7700	0.8857ns	3.40	5.61
Tillage x orientations	4	2,133.89	533.4725	8.7874**	2.78	4.22

With regard to shoot weight, Tables 3a & 3b give averages of 21.15 and 24.13 tonnes/ha for 2010 and 2012, respectfully. Combining these shoot weights with the tuberous root yields of 18.15 and 23.52 tonnes per ha (Tables 1a & 1c), a root/shoot ratio of 0.86 - 0.97 is obtained, compared with 1.53 – 1.59 reported by Cadavid *et al.* (1998) in Colombia. The difference between the present study and the Colombian report is reflected in the higher yield of tuberous roots of up to 40 tonnes / ha in Colombia.

Table 3a: Tonnes of shoot weight / ha (Trial 1)

	Vertical	**Horizontal**	**Inclined**	**Σ**	**μ**
No Till	24.80	15.20	23.30	63.30	21.10
Mound	16.90	22.90	18.80	58.60	19.53
Ridge	21.70	26.90	19.90	68.50	22.83
Σ	63.40	65.00	62.00		
μ	21.13	21.66	20.66		**21.15**

Table 3b: Shoot Weight (Mts Per Hectare) (Trial 2)

	Vertical	Horizontal	Inclined	Σ	*μ*
No till	10.83	17.08	16.87	44.78	14.93
Mound	24.49	26.89	27.38	78.76	26.25
Ridge	33.33	25.41	34.89	93.63	31.21
Σ	68.65	69.38	79.14		
μ	22.88	23.13	26.38		**24.13**

DISCUSSIONS

The effect of tillage in this study agrees with the findings of Al-Hassan (1989), Keyamu (1999), Hauser & Hallugale (2000), Oghede (2002) and Agbogidi (2006), who found that method of planting cassava did not seem to affect yield. On the contrary, the outcomes of this experiment are at variance with Woghigen (2004) and Ageh (2005) who observed that cassava yield was better on ridges than on mounds. Similarly, this study failed to uphold the finding by Hong, Danjuma & Musah (2005) and Odjugo (2008), that planting on mounds generated a more congenial micro-environment such as higher soil temperatures and was therefore, better for cassava yield than ridges. However, the study indicated that vertical planting of cuttings had a significant effect on the number of tubers harvested per ha. Indeed, even where the response was not significant ($p > 0.05$), vertical planting was slightly higher than horizontal and inclined cuttings. This would tend to support the findings of Chavez (1990), Ujuambi (2002) and Odumosor (2003) that vertical planting is more favourable as it sprouts more rapidly and provides better anchorage.

Ease of Harvesting

During harvesting, it was observed that the method of planting affected depth of tubers. Vertically planted cuttings produced tubers whose depth reached about 60 cm into the soil and they were more compactly packed at the tips of the cuttings. This made harvesting difficult and resulted in bruising and breaking of the tuberous roots. As a result, the shelf-life of these roots was shortened. Tuberous roots from horizontally planted cuttings were slightly shallower, being about 25cm deep, while those from inclined cuttings were intermediate between the horizontally and vertically planted cuttings. Thus, the advantages of vertical planted stem cuttings, touted by Chavez (1990), Ujuanbi (2002) and Odumosor (2003), were not upheld by this study.

CONCLUSIONS

The study showed that planting land forms (no till, mounds and ridges) and orientation of the planted stem cuttings (vertical, inclined and horizontal) had no effect on the number of plants harvested and tuberous root yield in cassava. However, vertically planted cuttings produced more tubers which reached deeper into the soil causing much difficulty during harvesting and shortening shelf life. Conversely, horizontal cuttings spread their tuberous roots at a shallower soil depth making such tubers easier to harvest with reduced damage.

RECOMMENDATION

It is therefore, recommended that any of the three tillage landforms may be used for cultivating cassava. However, the stem cuttings may be planted horizontally or inclined but not vertically.

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