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Effect of cropping system and age of plant at harvest on tuber rot and performance of elite cassava varieties in derived savannah

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ABSTRACT

Devastated tuber rot disease among farmers prompted the evaluation of the elite improved varieties in the intercrop and the practice of delaying harvesting when there is glut in the market necessitated this study. Trial was carried out at the Federal University of Agriculture, Abeokuta between 2011 and 2014 to evaluate yield performance of 21 elite cassava varieties planted as sole crop verse intercropped and harvested at different age. The 2 x 21 x 3 factorial experiment was laid out in randomized complete block design and replicated three times. The tuber yield obtained from sole plot in 2011/2012 cropping season was significantly higher than intercrop whereas those of 2012/2014 cropping season were similar. Land Equivalent Ratio was above one in both cropping seasons indicating that the performance of the improved varieties in intercrop was efficient. The pooled mean tuber yield showed that TMS 30572, 92/0326, 95/0211, 01/1371, 00/0338, 01/0046, 00/0098, 01/1097, 01/0085, 98/0581 and 98/510 were among the top eight varieties. Harvesting could be delayed up to 15 months after planting to reduce tuber rot.

Key words: cassava; intercrop; tuber rot; delay harvest; Nigeria

IZVLEČEK

UČINKI NAČINA GOJENJA IN STAROSTI RASTLIN OB SPRAVILU NA POJAVLJANJE GNILOBE GOMOLJEV PRI ELITNIH SORTAH MANIOKE V ANTROPOGENI SAVANI NIGERIJE

Zaradi prakticiranja odloga spravila pridelka manioke, kadar se pojavlja njen višek na trgu in pojavljanja uničujoče gnilobe gomoljev, se je pojavila potreba po ovrednotenju elitnih sort te tropske gomoljevke, gojene v medsadnji. Poskus je bil izveden na Federal University of Agriculture, Abeokuta med 2011 in 2014 z namenom ovrednotenja pridelka 21 elitnih sort manioke, posajene v monokulturi ali v kombinaciji z drugimi kulturami in pospravljene v različnih časovnih obdobjih. Faktorski 2 × 21 × 3 poskus je bil izveden po sistemu naključnih blokov s tremi ponovitvami. Pridelek gomoljev na površinah z monokulturo je bil v rastni sezoni 2011/2012 značilno večji kot na površinah z medsadnjo, v rastni sezoni 2012/2014 pa sta bila pridelka podobna. Ekvivalent zemljišča je bil nad ena v obeh rastnih sezonah in kaže prednost izboljšanih sort, gojenih v medsadnji. Analiza povprečnih vrednosti pridelka gomoljev je pokazala, da so bile sorte TMS 30572, 92/0326, 95/0211, 01/1371, 00/0338, 01/0046, 00/0098, 01/1097, 01/0085, 98/0581 in 98/510 med osmimi najdonosnejšimi. Za zmanjšanje gnilobe je izkop gomoljev lahko zamaknjen do 15 mesecev po sadnji.

Ključne besede: manioka; medkultura; gniloba gomoljev; poznejši izkop; Nigeria

1 INTRODUCTION

Cassava (*Manihot* spp.) belongs to the family of Euphorbiaceae. Cassava is one of the most important food crops in Africa, South America and Asia. It derives its importance from the fact that its starchy, thickened, tuberous roots are a valuable source of cheap calories, especially in the developing countries where calorie deficiency and malnutrition are widely spread. Its usage as a source of ethanol for fuel, energy in animal feed,

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and starch for industries is increasing. Cassava contributes the largest share of daily per capita food consumption (1.6 kg) in Nigeria (FAOSTAT, 2003) and ranked number one among the top 20 commodities produced in Nigeria (www.fao.org/faostat/en/#rankings/commodities_by_countries) for more than estimated 800 million people around the world (Akparobi et al., 1998; Lebot, 2009).

Nigeria, Thailand, Indonesia and Brazil were ranked as first, second, third and fourth respectively, among the top 20 countries producing cassava in the world. The current estimated cassava production in 2013 for Nigeria, Thailand, Indonesia and Brazil were 47.4, 30.2, 23.0 and 21.5million tonnes, respectively (www.fao.org/faostat/en/#rankings/countries_by_commodities). Total area harvested in 2009 was 3.13 million ha, with an average yield of 11.7 t ha^{-1} (FAO, 2010). It is produced predominantly (99 %) by small farmers with 1-5 ha of land intercropped with yams, maize, or legumes in the rainforest and savannah agro-ecologies of Southern, Central, and lately Northern Nigeria. The world production of cassava root was estimated to be 184 million tonnes in 2002.

IFSERAR, (2009) conducted a diagnostic survey in South West Nigeria and reported that the local varieties grown among the farmers were not only low yielders but their ability to tolerate, or resist new strains of diseases and pests occasioned, perhaps, by climate change. Mwangi et al. (2004) similarly reported that the root rots are an important constraint to cassava production in humid forest and forest transition of Central and West Africa and can impact negatively on food security to several millions people inhabiting the regions. Rotting is known to increase significantly if mature plants are left in the soil for extended period of time (Oyeka, 2004). Yield loss was estimated at 20 to 100 % in Democratic Republic of Congo (Mwangi et al., 2004). These challenges necessitated the evaluation of 21 promising varieties collected from International Institute of Tropical Agriculture (IITA) in maize/cassava intercrop.

IITA have released several high yielding varieties but there performances in the intercrop as well as their tolerant or resistant level to cassava root rot disease have not been documented. There is therefore the need to ascertain the performance of these elite cassava varieties under the predominant intercropping systems among the resource constraint farmers in the region. Besides, the highly perishable nature of cassava tubers has compelled the farmers to harvest only when there is availability of market or family need. This delay harvesting enables farmers to leave the mature plant in the soil as a form of storage. This storage period enable the farmers to keep the fresh tuber in good quality for an extended period. Growth and dry matter accumulated will continue since cassava is believed to mature 7-24 months. Most cassava varieties attain optimum weight at 18 months after planting when starch accumulation is highest (Ekanayake et al., 1997). Hammer et al. (1987), who evaluated sequential harvests to age 24 months, reported that root rot occurred in the second year. Sagrilo et al. (2006) quoted Sagrilo et al. (2002) that cassava harvested at 21 months could improve storage root yield compared to 12 months. Ebah-Djedji et al.(2012) who harvested cassava sequentially at 11, 13, 15 and 17 months after planting in Cote d' Ivoire recommended that tuberous root of improved cassava varieties should be harvested at 13 MAP to obtain optimum dry matter content.

These inconsistencies in the appropriate time of harvesting to obtain optimum dry matter content and quality is further aggravated by the prevailing tuber rot. Consequently, there is the need to ascertain the appropriate time to harvest these elite cassava varieties. This will ensure maximum dry matter accumulation without losing much of the tuber to root rot, particularly when harvesting is delayed because of poor market arrangement. The objectives of this study therefore were to**:** evaluate the performance of the improved varieties, 2) investigate the effect of intercropping on the elite cassava varieties and 3) determine the effect of delay harvest on the cassava tuber rot.

2 MATERIALS AND METHODS

The study was carried out at the Institute of Food Security, Environmental Resource and Agricultural Research (IFSERAR) farm, Federal University of Agriculture, Abeokuta in 2011/2012 and repeated in 2012-2014 cropping seasons. The experiment was laid out in a Randomized Complete Block Design in split plot and replicated three times in the 2011/2012. Cropping systems and variety factors were assigned to the main plot and sub plot, respectively. However, in 2012-2014 cropping season, harvesting date (12, 15 and 18 months) was varied as the third factor i.e. sub sub-plot (split split-plot) to gain additional information. The intercrop proportion mixture and population adopted was additive series. Table 1 shows the twenty one elite cassava varieties collected from International Institute of Tropical Agriculture (IITA), Ibadan. Benlate treated stem cuttings of 25 cm were planted into plot size of 9 m x 7 m (1.2 ha experimental field) at spacing of 1 m x 1 m in July 2011 and harvested in July, 2012. The cuttings obtained from the harvest were replanted in

July 2012 and harvested sequentially in July (12 months after planting MAP), October 2013 (15 MAP) and January 2014 (18 MAP). Three seeds per hole of treated maize 'SUWAN 1' variety was alternately planted in-between cassava stands (in the intercrop plots only) to evaluate the performance of cassava under intercropping (i.e. additive series). Maize was harvested at green stage. Weeding was carried out at 3, 9 12 WAP. Other weedings were done once in a month. Fertilizer 400 kg/ha N: P: K: Mg (12:12:17:2) was applied in the 2011/2012 cropping season whereas 2012/2014 trial did not receive fertilizer because of circumstance beyond our control.

2.1 Data collection on cassava

2.1.1 Plant height (cm):

5 randomly selected cassava plants within the plot were measured with aid of graduated meter rule from the ground level to the highest leaf.

2.1.2 Stem girth (mm):

Vernier caliper was used to determine the stem girth (at 10 cm above the ground) of 5 randomly selected cassava stems within the plot.

2.1.3 Tuber girth (mm):

Vernier caliper was used to determine the tuber girth of 5 randomly selected freshly harvested tubers from ten up rooted cassava stands samples

2.1.4 Number of tubers per plant:

Determined by average number of freshly harvested tuber from the ten samples uprooted.

2.1.5 Rot incidence (%):

This was done by dividing the rotted tubers by total tuber multiplied by 100.

2.1.6 Tuber yield (t/ha):

The mass of uprooted tuber from the ten sampled cassava stand was converted to t/ha. (i.e. mass of sampled/sampled area*10000/1000}

2.2 Data analysis:

Data collected were subjected to analysis of variance using GenStat Edition 12. Significant means were separated by using DMRT at 5 % probability.

Table 1: Selected cassava varieties used for the experiment

Variety	Tuber color
TMS98/0581	White
TMS 01/1797	White
TMS 95/0211	White
TME 1	White
TMEB 693	White
TMS 01/0046	White
TMS 01/0093	White
TMS 00/0338	White
TMS 01/1097	White
TMS 01/1086	White
TME B 419	White
TMS 30572	White
TMS 01/1371	Yellow
TMS 01/0085	White
TMS 98/0510	White
TMS 01/0131	White
TMS 98/0505	White
TMS 92/0326	White
TMS 01/0098	White
TMS 01/1368	Yellow
TMS 97/JW2	Yellow

3 RESULTS AND DISCUSSION

3.1 Influence of intercropping on the plant height of elites cassava varieties at 12 MAP

Plant height and stem girth are essential component to determine plant growth particularly when intercrop is involved. The plant height of the 21 varieties obtained at 12 months after planting varied significantly (P>0.05) from each other in the 2011/2012 cropping season (Table 2). TME B 419 had the tallest plants but comparable to TMEB 693, TMS 01/1097, TMS 01/1797, TME 1, TMS 01/1086, TMS 01/1371,TMS 97/JW2 and TMS 92/0326. Whereas, TMS 98/505 had the shortest plant which was similar to those of TMS 01/0098, TMS 01/0131, TMS 01/0046, TMS 01/0093 and TMS 00/0338. In 2012/2014 cropping season, TMS 97/JW2 and TMS01/0093 had the tallest plants at 12 MAP but were similar to those of TMS 95/0211, TME 1, TMS 00/00338, TME B 419, TMS 30572, TMS 01/1371, TMS 01/0085, TMS 98/0510, TMS 92/0326, TMS 01/0098 and TMS 01/1386 (Table 3). However, TMS 01/1797, TMEB 693, TMS 01/0046, TMS 01/1097, TMS 01/1086, TMS 01/0131 and TMS 98/0505 had the shortest plants in 2012/2014.The plant heights in the two seasons were at variance except those of TMS 97/JW2, TME B 419 and TMS 01/1371 which were consistently top on the list, whereas TMS 01/0131, TMS 01/0046 and TMS 98/0505 constantly had the shortest plants. This consistency in plant height implies that the varieties were stable in the different environment, whereas the others were influenced more by the environment.

3.2 Influence of intercropping on the tuber number of elites cassava varieties at 12 MAP

The number of fresh tubers observed in 2011/2012 on cassava varieties TME 1, TMS 98/0505, TMS 97/JW2, TMS 98/0581, TMS 01/1097, TMS 01/1386, TMS 30572, TMS 01/1086, TMS 01/0085 and TMS 00/0338 were similar but significantly higher than those of TMS 01/1371 and TMS 01/0131 varieties in 2011/2012 cropping season (Table 2). The varieties TMS 30572, TME 1, TMS 01/0093, TMS 00/0338, TMS 1097, TMS 01/0046, TMEB 693, TMS 98/0510 and TMS 92/0326 in 2012/2014 were among the top varieties with high number of fresh tuber while TME B 419 had the least (Table 3). TME 1, TMS 01/1097, TMS 30572 and TMS 00/0338 were constantly ranked amongst the top varieties with high number of tubers in 12 MAP of the two seasons. The variance in tuber number could be genetically inherent and was considered as vital yield attribute that contributes immensely to the increase in tuber yield. It has been documented that the increase in yield were attributed to increase in number of tuber/stand and single root mass (Kogram et al., 2002).

3.3 Influence of intercropping on the tuber girth of elites cassava varieties at 12 MAP

The cropping system and variety did not influence tuber girth in 2011/2012 (Table 2), however, in 2012/2014 the varieties varied significantly among each other in 2012/2014 at 12 MAP (Table 3). 'TMS 98/0510' had the highest tuber girth while 'TMS 97/JW2' had the least. The stem girths of the varieties were influenced by cropping systems in both seasons of the trial at 12 MAP (Tables 2 and 4). However, the varieties TMS 00/0338 and TMS 98/0505 consistently recorded the highest and the lowest, respectively in 12 MAP of both cropping season.

3.4 Influence of intercropping on the root rot of elites cassava varieties at 12 MAP

The cropping systems did not influence tuber rot infection in both seasons but there were significant differences among the varieties in 12 MAP of 2011/2012 (Table 2), they were however similar in 2012/2014 (Table 4). The rot incidence observed in 2011/2012 was high and ranges between 9.8 and 22.5 % while that of 2012/2014 was low and range between 0.00 and 0.94 % at 12 MAP. The lost incurred during 2011/2012 cropping season is in consonant with the finding of Mwangi et al. (2004) who documented 20 to 100 % tuber lost.

3.5 Influence of intercropping on the LER and tuber fresh mass of elites cassava varieties at 12 MAP

The Land Equivalent Ratio (LER) was similar in both cropping season but above one suggesting that intercrop plots was more productive. The fresh tuber mass of the varieties varied in the two cropping seasons at 12 MAP (Tables 2 and 4). Sole cassava plots had significantly higher tuber mass than intercrop in 2011/2012 (Table 2) but similar 2012/2014 cropping seasons (Table 4). In 2011/2012 cropping season, TMS 98/0505, TMS 97/JW2, TME 1, TMS 30572, TMS 95/0211, TMS 92/0326, TMS 01/0085, TMS 01/0098, and TMS 98/0581 varieties were the nine topmost in terms of fresh tuber mass at 12 MAP. Whereas the following varieties: TMS 01/1086, TMS 01/1368, TMS 98/0510, TMS 01/1097, TMS 01/1371, TMS 01/1797 and TMS 01/0046 closely followed. However, 'TMEB 693' had the lowest tuber yield. The fresh tuber yields range between 27.5 and 57.4 t ha^{-1} in 2011/2012 while those of 2012/2014 was 12 to 32.3 t ha^{-1}. The yield range obtained in 2011/2012 was substantially higher than that of 2012/2014 at 12 MAP as expected. However, the results obtained in 2012/2014 was comparable to range of 9.9 to 30.1, 8.49 to 28.38, and 10.0 to 26.9 t ha^{-1} as

reported by IITA (1987), Maroya et al. (2010) and Ssemakula and Dixon (2007), respectively.

The eleven topmost varieties in 2012/2014 cropping season at 12 MAP, were TMS 00/0338, TMS 30572, TMS 92/00326, TMS 01/1097, TMS 98/0581, TMS 01/0046, TME 1, TMS 98/0510, TMS 01/0085, TMS 01/1371,and TMS 95/0211 in that order. These were closely followed by TMS 01/1086, TMS 01/0093, TMS 01/1797, TMS 01/0098, TMS 01/1368, TME B 419 and TMS 01/0131 varieties. While TMS 97/JW2 variety had the lowest tuber yield. The variation in tuber yield of the varieties agreed with the finding of Howeler (2007); Mulualem and Ayenew (2012); Odedina et al. (2012) who reported that yields of cassava roots vary with cultivars, plant growth conditions (soil, climate, rainfall) and agronomic practices. It is pertinent to note that the variation in tuber yield of the 21 varieties was only observed in 12 MAP (Tables 2 and 4) while the harvest made at 15 and 18 MAP had similar tuber yield. This is, perhaps, an indication that maturity had not been attained and thus dry matter accumulation were at variance at 12 MAP. Although, number of tuber, stem girth and tuber girth varies among the varieties at 15 and 18 MAP (Table 3) but all the varieties had similar tuber yield (Table 4). This is an indicative of the fact that all the varieties tested in this trial attained maturity period after 12 MAP. Based on the definition of maturity period of cassava by Benesi et al. (2008) is the point where maximum or near maximum yield is obtained.

The topmost 3 consistent varieties in the two cropping seasons were TMS 30572, TMS 92/0326 and TMS 98/0581. Although 'TMS 01/1371' and 'TMS 01/1386' were not listed among top yielder, but had beta carotene as an advantage and statistically comparative yield with the top varieties in the two cropping seasons.

Table 2: Influence of intercropping on the tuber rot, agronomic parameters and tuber yield performance of elites cassava varieties in 2011/2012 cropping season

Treatment	Plant height (m)	Fresh tuber no.plant^{-1}	Tuber girth (mm)	Stem girth (mm)	Rot incidence (%)	LER	Fresh tuber mass (t ha^{-1})
Cropping System (CS)							
Sole	2.74	7.2	63.66	28.93	14.3	-	44.2a
Intercrop	2.72	6.9	62.22	28.52	14.3	-	39.4b
LSD	NS	NS	NS	NS	NS	-	2.07
Variety (V)							
TMS 98/0581	2.78bcde	7.3a-e	69.13	32.75ab	22.5a	1.96	41.7abc
TMS 01/1797	2.98abc	7.0b-f	59.97	27.94abc	18.3a-d	1.73	38.5bcd
TMS 95/0211	2.61cdef	6.8b-f	67.04	28.75abc	11.7ef	1.40	46.5abc
TME 1	2.93abcd	8.7a	64.40	28.26abc	10.2f	1.96	47.6abc
TMEB 693	3.13ab	7.0b-f	57.22	27.12abc	13.4d-f	1.56	27.5d
TMS 01/0046	2.49efg	6.7c-f	66.14	32.22abc	16.3b-f	1.86	38.1bcd
TMS 01/0093	2.49efg	6.2d-f	60.44	25.76bc	18.2a-d	1.60	35.3cd
TMS 00/0338	2.31fg	7.5a-e	58.90	34.24a	12.0ef	1.56	34.5cd
TMS 01/1097	3.00abc	6.0ef	61.23	29.72abc	11.8ef	1.73	40.1bcd
TMS 01/1086	2.69adef	8.0abc	60.02	26.88abc	13.5c-f	1.96	41.2bc
TME B 419	3.23a	6.7c-f	61.85	27.96abc	12.9d-f	1.73	37.0cd
TMS 30572	2.78bcde	8.0abc	65.23	28.68abc	13.6c-f	1.73	47.2abc
TMS 01/1371	2.90abcd	5.7f	58.45	29.19abc	20.1ab	1.56	39.4bcd
TMS 01/0085	2.75cde	7.3a-e	63.83	27.81abc	16.6a-e	1.50	45.8abc
TMS 98/0510	2.66cdef	6.2d-f	73.30	31.51abc	19.5abc	2.03	40.6bcd
TMS 01/0131	2.54defg	5.7f	60.41	27.23abc	16.6a-e	1.56	36.6cd
TMS 98/0505	2.21g	8.2ab	66.08	24.52c	12.9d-f	1.70	57.4a
TMS 92/0326	2.85abcde	7.0b-f	68.70	28.65abc	13.9c-f	1.50	45.9abc
TMS 01/0098	2.40fg	6.7c-f	61.75	28.95abc	15.0b-f	1.90	45.1abc
TMS 01/1368	2.82bcde	7.7abc	61.01	31.16abc	11.5ef	1.80	40.3bcd
TMS 97/JW2	2.85a-e	8.2ab	56.58	25.97abc	9.8f	1.90	51.3ab
SE (V)	0.201	0.75	12.53	4.147	3.07	NS	6.69
CS X V	NS	NS	NS	NS	NS	NS	NS

NS = not significant

Table 3: Influence of intercropping on agronomic performance of elite cassava varieties at different age of plant in 2012/2014 cropping season

Treatment	Plant height (m)			Fresh tuber No.			Tuber girth (mm)		
	12 MAP	15 MAP	18 MAP	12 MAP	15 MAP	18 MAP	12 MAP	15 MAP	18 MAP
Cropping systems (CS)									
Sole	2.25	2.71	2.87	6.1	6.6	5.71	57.22	67.1	64.1
Intercrop	2.31	2.76	2.94	6.3	6.6	5.67	58.66	66.9	65.0
LSD	NS	NS	NS	NS	NS	NS	NS	NS	NS
Variety (V)									
TMS 98/0581	2.66ab	3.15abc	3.04abc	6.2b-f	6.7a-d	5.6a-e	64.1ab	66.1a-e	69.5abc
TMS 01/1797	1.70d	2.12d	2.21bc	5.5c-f	4.8cd	4.5cde	55.0bc	64.9a-e	57.4cde
TMS 95/0211	2.27a-d	2.41bcd	2.73abc	6.2b-f	6.2a-d	6.0a-d	62.0abc	66.2c-e	68.1a-d
TME 1	2.27a-d	2.93a-d	3.13abc	7.2a-d	7.2abc	7.6ab	59.4abc	67.7a-e	56.9de
TMEB 693	1.97cd	2.35bcd	2.53a	8.0a-c	8.5a	7.7ab	52.2bc	57.4e	57.7b-e
TMS 01/0046	1.94cd	2.22cd	2.20bc	7.0a-e	6.8a-d	6.3abc	61.1abc	66.6a-e	69.3a-d
TMS 01/0093	2.80a	3.78a	3.66a	8.2ab	8.8a	6.7abc	55.4bc	58.5e	66.2a-e
TMS 00/0338	2.49abc	2.74bcd	2.85abc	7.3a-d	6.5a-d	5.7a-e	53.9bc	63.0b-e	62.6a-e
TMS 01/1097	2.09bcd	2.43bcd	2.90abc	6.3a-f	6.3a-d	6.0a-d	56.2abc	74.0ab	63.8a-e
TMS 01/1086	2.11bcd	2.79bcd	2.94abc	5.0def	6.3a-d	4.7cde	55.0bc	61.1c-e	61.3a-e
TME B 419	2.41abc	2.54bcd	2.78abc	4.2f	5.1bcd	3.2e	56.9abc	74.1ab	72.6ab
TMS 30572	2.26a-d	2.62bcd	3.07abc	8.7a	8.3ab	8.3a	60.2abc	71.2a-d	63.7a-e
TMS 01/1371	2.43abc	3.10abc	3.16ab	5.8b-f	7.5abc	6.5abc	53.5bc	68.5a-e	68.4a-d
TMS 01/0085	2.23a-d	2.77bcd	3.00abc	5.8b-f	7.7abc	5.5b-e	58.8abc	72.5abc	63.3a-e
TMS 98/0510	2.25a-d	2.79bcd	2.98abc	7.0a-e	6.7a-d	5.7a-e	68.3a	74.9a	74.3a
TMS 01/0131	1.94cd	2.34bcd	2.23bc	5.2def	5.0b-d	4.3cde	55.4bc	67.6a-e	60.7b-e
TMS 98/0505	2.05bcd	2.32bcd	2.12c	4.7ef	3.7d	3.3de	61.1abc	71.4a-d	65.2a-e
TMS 92/0326	2.41abc	3.02a-d	3.40a	7.3a-d	7.5a-c	6.0a-d	63.7abc	72.1a-d	71.6abc
TMS 01/0098	2.48abc	3.26ab	3.43a	5.8b-f	6.8a-d	5.3b-e	56.8abc	62.0c-e	53.9e
TMS 01/1368	2.35abc	2.53bcd	3.09abc	4.7ef	5.7a-d	5.3b-e	56.0abc	67.7a-e	68.8a-d
TMS 97/JW2	2.77a	3.12ab	3.52a	4.7ef	6.5a-d	5.3b-e	51.6c	60.4de	60.9a-e
SE	0.65	0.96	1.02	2.5	3.4	2.8	12.5	11.9	13.8
CS x V	NS	NS	NS	NS	NS	NS	NS	NS	S

NS = not significant, S = significant

Table 4: Influence of intercropping on root rot and tuber yield of elite cassava varieties at different age of plant in 2012/2014 cropping season

Treatment	Stem girth (mm)			Root rot incidence (%)				Fresh tuber mass (t ha^{-1})		
	12 MAP	15 MAP	18 MAP	12 MAP	15 MAP	18 MAP	LER	12 MAP	15 MAP	18 MAP
Cropping systems (CS)										
Sole	23.9	23.1	23.3	0.29	0.48	11.61	-	23.7	31.0	27.0
Intercrop	23.52	23.7	23.0	0.31	0.73	11.06	-	24.6	31.5	26.6
LSD	NS	NS	NS	NS	NS	NS	-	NS	NS	NS
Variety (V)										
TMS 98/0581	27.8ab	24.7abc	24.4a	0.39	1.60	35.14	1.46	29.3ab	30.0	23.6
TMS 01/1797	22.9c-g	21.2bcd	23.1ab	0.14	0.44	4.93	1.23	22.1a-d	29.2	26.7
TMS 95/0211	23.8b-f	24.9abc	24.1a	0.5	2.39	10.99	1.10	24.5abc	38.9	35.8
TME 1	23.3c-g	25.0abc	23.0ab	0.12	0.94	28.02	1.46	26.7abc	26.5	22.4
TMEB 693	22.1d-g	22.2a-d	20.7ab	0.0	0.50	14.40	1.06	19.7cde	25.4	27.2
TMS 01/0046	25.2a-e	20.7cd	21.0ab	0.94	1.40	11.20	1.36	27.4abc	37.3	25.5
TMS 01/0093	20.8f-g	22.2a-d	22.2ab	0.24	0.56	12.10	1.10	22.6a-d	30.7	26.2
TMS 00/0338	29.2a	22.7a-d	27.1a	0.73	0.73	7.57	1.06	32.3a	29.1	29.5
TMS 01/1097	24.7b-f	25.1abc	23.3ab	0.24	1.43	5.36	1.23	29.6ab	31.7	25.8
TMS 01/1086	21.9efg	21.6a-6	21.6ab	0.00	0.78	17.48	1.46	23.1a-d	29.2	24.4
TME B 419	23.0c-g	24.7abc	24.4a	0.27	0.80	4.74	1.23	21.3a-d	27.0	20.8
TMS 30572	23.7b-f	22.5a-d	25.3a	0.14	2.09	21.97	1.23	32.0a	39.0	35.4
TMS 01/1371	24.2b-f	26.3a	24.4a	0.00	1.78	20.02	1.06	25.0abc	37.5	32.7
TMS 01/0085	22.8c-g	23.1a-d	23.3ab	0.56	0.65	4.61	1.10	25.6abc	33.6	30.5
TMS 98/0510	26.5abc	23.5a-d	26.2a	0.27	1.24	18.34	1.53	26.6abc	30.4	24.7
TMS 01/0131	22.2d-g	23.7a-d	21.8ab	0.27	1.49	4.25	1.06	20.1a-d	24.2	20.2
TMS 98/0505	19.5g	22.0a-d	17.7b	0.14	1.01	11.33	1.20	15.2cd	23.1	17.7
TMS 92/0326	23.7b-f	26.2ab	23.7a	0.00	1.43	16.31	1.10	30.1ab	38.5	31.8
TMS 01/0098	24.0b-f	24.4a-d	23.0ab	0.71	1.01	2.85	1.40	22.0a-d	33.3	32.3
TMS 01/1368	26.2a-d	25.0abc	23.8a	0.27	0.56	2.92	1.30	21.6a-d	39.4	21.2
TMS 97/JW2	21.0fg	19.5d	21.4ab	0.94	0.27	8.80	1.50	12.0d	21.5	28.3
SE	4.2	5.0	5.8	NS	NS	NS	NS	12.3	NS	NS
CS X V	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS = not significant, S = significant

3.6 Influence of age at harvest and intercropping on the plant height, tuber girth and tuber rot of elites cassava varieties at 12, 15 and 18 MAP

The pooled mean plant height, tuber girth and tuber rot obtained from 2012/2014 showed significant difference among the ages of plant at harvest (Table 5). The similarity in height and tuber girth of plants harvested at 15 and 18 MAP buttressed the fact that maturity had been attained compared to 12 MAP. The higher incidence root rot recorded in 18 MAP accounted for the apparent decline in fresh tuber mass. This result contradicts the finding of Mulualem and Ayenew (2012) who recommended 18 months as the appropriate age to harvest cassava to get the desired yield.

The pool mean of varieties TMS 01/0093, 97/JW2 and 01/0098 had similar but the tallest plants. However, varieties 97/JW2 and 01/0098 were not significantly taller than those of TMS 92/0326, TMS 98/0581 and TMS 01/1371. The following varieties TMS 01/0131, TMS 98/0505, TMS 01/1797, TMEB 693 and TMS 01/0046 had the shortest plants. The pooled mean fresh tuber number of varieties TMS 30572, TMEB 693, TMS 01/0093 and TME 1 were similar and highest among the others. But the tuber number of varieties TMS 01/0093 and TME 1 were not significantly higher than at TMS 92/0326. Variety TMS 98/0505 had the minimum number of fresh tubers but not significantly lower than TMS 01/1797, TME B 419 and TMS 01/0131.The tuber girth of varieties TMEB 693, TMS 01/0093, TMS 00/0338, TMS 01/1086, TMS 97/JW2, TMS 01/1797 and TMS 01/0098 were similar but significantly lower than those of TMS 98/0510, TMS 92/0326, TME B 419 and TMS 98/0581. The stem girth of varieties TMS 98/0510, TMS 00/0338 and TMS 98/0581 were significantly higher compared to others whereas TMS 97/JW2 and TMS 98/0505 had the lowest.

3.7 Influence of age at harvest and intercropping on the tuber yield of elites cassava varieties at 12, 15 and 18 MAP

Although the tuber yield recorded for the three ages were similar but dropped at 18 MAP evidently due to rot damage. Ebah-Djedji et al. (2012) reported decline in cassava tuber at 17 months old, however, the decline was not linked to root rot. Hammer et al. (1987) reported that root rot occurred in the second year but was not specific on the number of months.

The tuber fresh mass of varieties were significantly different from one another. The following varieties TMS 30572, TMS 92/0326, TMS 95/0211, TMS 01/1371, TMS 00/0338, TMS 01/0046, TMS 00/0098 and TMS 01/1097 were among the topmost eight varieties whereas TMEB693, TMEB 419, 01/0131, TMS 97/JW2 and TMS 98/0505 were the least.

Generally, the consistence in plant heights values at 12 MAP of varieties TMS 97/JW2, TME B 419 and TMS 01/1371 (which ranked among the top) and those of TMS 01/0131, TMS 01/0046 and TMS 98/0505 (at the bottom of the list) in both cropping seasons are indication of their stability despite differences in crop management. Besides, the ability of TMS 30572, TMS 92/0326 and TMS 98/0581 to constantly rank among the first six varieties at 12 MAP in the two seasons makes them candidates to be recommended to farmers (Table 6). The wide gap in tuber yield between the two cropping seasons could be attributed to the fertilizer application. Although, farmers hardly use fertilizer for cassava production because of the notion that cassava can thrive on marginal soils that cannot sustain other crops. This trial connotes that the addition of fertilizer can substantially enhance tuber yield. Odedina et al. (2012) who worked on integrated nutrient management reported similar gap between control and other sources of nutrient. Ironically, appreciable quantity of root rot was observed in the first cropping season compared to the second, it was not quite clear if the addition of fertilizer was responsible for the tuber rot. Consequently, there is the need to validate whether or not fertilizer application to cassava influences root rot.

4 CONCLUSIONS

The study has shown that the cassava varieties were not affected by intercropping but Land Equivalent Ratio was above one in both cropping seasons indicating that the performance of the improved varieties in intercrop was efficient. Plant height and tuber girth were higher in 15 and 18 MAP than 12. On the bases of their consistent performance at 12 MAP, in the two cropping seasons, TMS 30572, TMS 92/0326 and TMS 98/0581 are candidate varieties to be recommended to farmer with or without resource constraints. The pooled mean tuber yield showed that TMS 30572, TMS 92/0326, TMS 95/0211, TMS 01/1371, TMS 00/0338, TMS 01/0046, TMS 00/0098, TMS 01/1097, TMS 01/0085, TMS 98/0581 and TMS 98/510 are top eight varieties. The incidence of tuber rot was highest at 18 MAP hence; harvesting could be delayed up to 15 MAP to reduce

tuber rot. The three yellow flesh tuber varieties identified had comparable performance with their white counterpart.

Table 5: Performance of elite cassava varieties as influenced by age of plant at harvest and intercropping in 2012/2014 cropping season

Treatment	Plant height (m)	Fresh tuber no.plant^{-1}	Tuber girth (mm)	Stem girth (mm)	Root rot incidence (%)	Fresh tuber mass (t ha^{-1})
Age at harvest (H)						
12 MAP	2.28b	6.2	57.9b	23.73	1.95b	24.12
15 MAP	2.73a	6.6	67.0a	23.39	0.90c	31.23
18 MAP	2.90a	5.7	64.6a	23.17	3.43a	26.78
LSD	0.30	NS	5.23	NS	0.67	NS
Cropping systems (CS)						
Sole	2.61a	6.1a	62.8a	23.44a	2.09a	27.21a
Intercrop	2.67a	6.2a	63.5a	23.42a	2.09a	27.55a
LSD	NS	NS	NS	NS	NS	NS
H x CS	NS	NS	NS	NS	NS	NS
Variety (V)						
TMS 98/0581	2.95bcd	6.1defg	66.6bc	25.6ab	2.89a	27.76bcdefg
TMS 01/1797	2.01j	4.9hijk	59.1fgh	22.4fgh	1.52a	26.01defgh
TMS 95/0211	2.47fghi	6.1defg	65.5bcd	24.2bcdef	2.33a	32.98abc
TME 1	2.78cdef	7.3abc	61.4defg	23.8bcdef	2.49a	25.21defgh
TMEB 693	2.28ghij	8.1a	55.8h	21.7gh	1.76a	24.10efghi
TMS 01/0046	2.12ij	6.7cd	65.7bcd	22.6efg	2.71a	30.09abcde
TMS 01/0093	3.41a	7.9ab	60.0efgh	21.7gh	1.99a	26.53cdefgh
TMS 00/0338	2.69def	6.5cde	59.8efgh	26.4a	2.25a	30.31abcde
TMS 01/1097	2.48fgh	6.2cdefg	64.3bcde	24.4bcde	1.61a	29.04abcdef
TMS 01/1086	2.61defg	5.3fghi	59.2fgh	21.7gh	1.89a	25.57defgh
TME B 419	2.58efg	4.1jk	67.9abc	24.0bcdef	1.77a	23.04fghi
TMS 30572	2.65def	8.4a	65.1bcd	23.8bcdef	2.27a	35.48a
TMS 01/1371	2.90b-e	6.6cde	63.5cdef	25.0abcd	1.98a	31.72abcd
TMS 01/0085	2.67def	6.3cdefg	64.9bcd	23.1defg	2.09a	28.88bcdef
TMS 98/0510	2.67def	6.4cdefg	72.5a	25.4ab	2.37a	27.21bcdefg
TMS 01/0131	2.17hij	4.8ijk	61.2defg	22.6efg	1.64a	21.52ghi
TMS 98/0505	2.16hij	3.9k	65.9bcd	19.7i	1.93a	18.64i
TMS 92/0326	2.94bcd	6.9bcd	69.1ab	24.5abcde	2.02a	33.68ab
TMS 01/0098	3.06abc	6.0defgh	57.5gh	23.8bcdef	2.00a	29.19abcdef
TMS 01/1368	2.65def	5.2ghij	64.2cde	25.0abcd	1.66a	27.40bcdefg
TMS 97/JW2	3.15ab	5.5efghi	57.6gh	20.6hi	2.74a	20.58hi
SE (V)	0.36	1.18	4.9	2.0	NS	6.56
H X V	NS	NS	NS	NS	NS	NS
CS x V	NS	NS	NS	NS	S	NS
H x CS	NS	NS	NS	NS	NS	NS
H X CS x V	NS	NS	NS	NS	NS	NS

NS = not significant, S = significant

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