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Research Article

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EFFECT OF TIME OF IODINE FERTILIZATION ON EFFECTIVENESS OF AGRONOMIC FORTIFICATION OF CASSAVA IN CALABAR, SOUTH-EASTERN NIGERIA

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ABSTRACT

The experiment was conducted in CalabarSouth-eastern Nigeria to ascertain the appropriate time of iodine application for effective agronomic iodine biofortification of cassava in two varieties of cassava (TME 419 and TMS 30555) fertilized with 2.5kg/ha potassium iodine (KI) at 8, 10 and 12 weeks after planting (WAP). Parameters measured were plant height, number of leaves, number of stem, leaf area (LA), leaf area index (LAI) and iodine content in tuber flesh and processed cassava products. Results showed that time of iodine application did not significantly affect plant height, number of stems, number of leaves LA, and LAI (P>0.05); tuber number weight and plot yield were not significantly influenced by time of iodine application (P>0.05), TME 419 retained higher levels of iodine in tuber flesh when iodine was applied at 8 weeks after planting, at 12WAP TMS 30555 recorded its highest value of retained iodine. Iodine applied at 12WAP translated to higher levels of iodine retained in processed cassava of the two varieties. Application of iodine at 12WAP is recommended for effective agronomic bio fortification.

INTRODUCTION

The importance of micro-nutrients including Iodine in human health has long been identified and has been reported to constitute major deficiency problems especially in the developing world (McWilliams, 2011). Iodine deficiency disorder (IDD) like other micronutrient deficiencies regrettably are preventable health problem of man (Welch and Graham 1999). Iodine an essential trace element in human nutrition occurs in the thyroid gland where it combines with amino acid tyrosin to produce thyroxin a hormone that controls the body idling speed (basal metabolic rate) and support normal growth and development. Its deficiency results in enlargement of the thyroid gland known asgoitre with other associated symptoms as sluggishness (hypothyroidism) and weight gain (Abraham *et al* 2002). World Bank (1994) estimated that about 228 million people were iodine deficient expressed as goiter.

Biofortification , a new horizon aimed at fortifying or incorporating agricultural staples with nutritious elements have been suggested by the global challenging programme as a means of breaking the barrier between agriculture, nutrition and health to alleviate hunger and nutritional challenges particularly in the third world nations (Graham 2003). Cassava is widely cultivated in most parts of the world. FAO (2002), reported that world cassava production in the 2000 reached 172 million tonnes. A subsistence crop of the rural dwellers but increasingly becoming a major cash crop in Africa, cassava is a staple food for both rural and urban households in Africa (Nweke *et al* 2002). Fortification of cassava with vitamin A and other micro-nutrient have been achieved by genetic means but informative literature on agronomic fortification of cassava with iodine especially in tropical Africa is limited. The effectiveness of agronomic Iodine fortification of crops through soil fertilization might be low because of strong iodine sorption in the soil (Smolen and Sady, 2011). Muramatsu *et al* (1990) and Yoshida *et al* (1992) reported that three days after introduction in soil, about ninety per cent of iodine is strongly bound in sesquioxide soils. Any attempt of enriching crops with higher doses of iodine fertilisation may lead to crop damage due to toxic effects of excess iodine levels (Mackowiak *et al* 2005; Hong *et al* 2009). This research thus attempts to determine the appropriate time of a low dose of iodine fertilisation in cassava for effective biofortification.

The research therefore aims to

i) Evaluate the effect of iodine on growth and yield of cassava
ii) Determine the optimum time of iodine fortification of cassava in two varieties of cassava

MATERIALS AND METHODS

Study area and planting dates

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The experiment was conducted at the University of Calabar teaching and research farm, Calabar, South-eastern Nigeria between August 2012 to May 2014. The first planting period was between August 2012 and May 2013 and repeated from August 2013 to May 2014 on the same field.

Soil analysis

Composite soil samples were taken from the site and analysed for Iodine,N, P, K,Ca, Mg, ECEC, organic carbon, pH and total exchangeable acid.

Experimental Design

The experimental factors were

i) Cassava varieties (TME 419 and TMS 30555)
ii) Time of application (8,10 and 12 weeks after planting WAP). The treatments were allotted into a randomised block design, replicated three times to give a 2 x 3 factorial experiment.

Planting and Weed Management

Experimental site was cleared, double ploughed and 4m by 4m plots mapped out. Planting was done on the flat first week of August 2012 and 2013 using matured and healthy 20cm cassava stem cutting planted 1m apart. Plots were kept weed-free by hand weeding as at when due.

Iodine and fertilizer application

Iodine was applied as potassium iodide (KI) at the rate of 2.5kg/ha. Thus 0.25g KI was applied to individual cassava stand buried in banded rings. There was only one seedling per stand. The rate of KI applied was carefully selected in order not to cause physiological damage to the cassava plants (Mackowiak and Gross (1999) Mackowiak *et al* 2005). NPK 15-15-15 at the rate of 200kg/ha was also applied in the plots 12 WAP after planting to enhance cassava growth.

Determination of Iodine

Iodine absorbed in tubers and retained in processed cassava tuber where determined using the x–ray fluorescence spectrometer method according to Allen 1989.

Data Collection

Plant height was measured at 8, 12, 16, 20, 24, 28 and 32 WAP. Mean number of leaves, leaf area (LA), leaf area index (LAI) and number of stems were evaluated at 24WAP. The area of individual compound leaves of cassava was obtained using the formula of Alves andSetter (2000) thus A = 0.9441 X L 1.8985 Where A = cassava leaf area, L = length of central lobe and 0.9441 = constant. Yield parametersaccessed were tuber number per stand, average tuber weiht, and tuber weight per plot.

RESULTS

Table 1 and 2 shows the effect of time of iodine application plant height in 2012 and 2013 respectively. Growth rate in terms of height increment increased with age of the cassava plant for all treatments in both cassava varieties.

Table 1 Effect of time of iodine fertilization on growth rate - plant height(cm)in two cassava varieties (2012)

	Week After Planting					
Variety	**8**	**12**	**16**	**20**	**24**	**28**
TME 419	172[a]	109[a]	147[a]	170.4[a]	192.1[a]	266.0[a]
TMS 30555	604[b]	99.6[a]	141[a]	173.4[a]	197.1[a]	320.0[b]
Time						
Control	66.2[a]	98.8[a]	139.1[b]	168.9[a]	188.8[a]	376.0[a]
8WAP	63.9[a]	97.0[a]	139[b]	168.2[a]	191.6[a]	269[b]
10WAP	70.1[a]	111.0[a]	150[a]	176.8[a]	201.5a	358[a]
12WAP	64.6[a]	106.0[a]	142[ab]	171.8[a]	190.6[a]	251[b]
Interaction						
V & T	NS	NS	NS	NS	NS	NS

Means followed by same letters in each column are not significantly different at p.05 by Duncan multiple range test NS = not significant.

Table 2 Effect of time of iodine fertilization on growth rate - plant height(cm)in two cassava varieties (2013)

	Week After Planting						
Variety	8	12	16	20	24	28	32
TME 419	28.8[a]	42.9	93.1[a]	118.7[a]	142.9[a]	153.0[a]	183.4a
TMS 30555	29.3[a]	98.9	98.3[a]	113.3[a]	145.8[a]	155.2[a]	183.8a
SE	1.601	3.018	2.395	2.935	2.466	1.488	3.473
Time							
Control	28.613a	45.512a	95.129a	117.613a	145.773a	151.5229a	192.37a
8WAP	30.3[a]	42.2	88.5[a]	116.9[a]	143.4[a]	155.3	183.9[a]
10WAP	28.7[a]	45.9	95.9[a]	119.2[a]	145.2a	149.8	188.9[a]
12WAP	28.1[a]	49.7	89.2[a]	111.2[a]	144.4[a]	157.3	178.0[a]
SE	2.015	3.823	2.98	3.7113	3.205	1.826	4.324
Interaction							
V & T	NS	NS	NS	NS	NS	NS	NS

Means followed by same letters in each column are not significantly different at p.05 by Duncan multiple range test NS = not significant.

There was no significant difference in the growth rate with iodine application in both varieties. Interaction of variety and time in relation to time of iodine application was also not significantly different.

Tables 3 and 4 highlight the influence of time of iodine fertilization on vegetative growth in two cassava varieties for both planting years.

Though vegetative characteristics improved in the 2013 planting, similar trends occur in both 2012 and 2013 planting. TMS 30555 had more stems and leaves than TME 419, but the larger leaf sizes of TME 419 resulted in higher LA and LAI than those of TMS 30555. The slight difference in all vegetative parameters measured,which did not significantly vary from each other,was not due to time of iodine application to cassava plants.

Table 3 Influence of time of iodine application on vegetative characteristics in two cassava varieties (2012)

	Number of stems	**Number of leaves**	**Leaf Area (LA)**
Variety			
TME 419	1.64[a]	259.47[a]	223.36[a]
TMS 30555	1.83[a]	317.4[b]	206.30[b]
SE	0.081.	1.76	4.681
Time			
Control	1.89[a]	253.56[a]	206.29
8WAP	1.75[a]	2.81.7[a]	214.9[a]
10WAP	1.79[a]	292.3[a]	216.3[a]
12WAP	1.67[a]	291.3	213.4
SE	.099	2.16	5.733
Interaction			
V & T	NS	*	NS

Means followed by same letters in each column are not significantly different at p.05 by Duncan multiple range test
* - significant, NS = not significant.

Table 4 Influence time of iodine application on vegetative characteristics intwo cassava varieties (2013)

	Number of stems	Number of leaves	Leaf area (LA)	Leaf area Index
Variety				
TME 419	2.25[a]	268.97[a]	220.25[a]	384.78[a]
TMS 30555	2.58[a]	326.67[b]	187.78[a]	694.31[b]
SE	0.08.	1.74	5.38	2.35
Time				
Control	2.17[a]	263.61[a]	202.67[a]	322.50[a]
8WAP	2.42[b]	290.08[b]	210.58[b]	531.75[b]
10WAP	2.46[b]	301.67[b]	255.25[b]	534.46[b]
12WAP	2.40[b]	300.96[b]	196.21[a]	552.38[b]
SE	0.10	2.13	6.59	28.84
Interaction				
V & T	NS	*	NS	NS

Means followed by same letters in each column are not significantly different at p.05 by Duncan multiple range test
* - significant NS = not significant.

Yield

Tables5and 6 displays the varietal yield in two cassava varietiesobtained by applying iodine at different periods after planting. Apart from the average tuber weight per stand and weight per plot that were higher in the 2013 planting, time of iodine nutrition to cassava did not considerably affect tuber number, average tuber weight and tuber weight per plot. However, TMS 30555 produced higher tuber yields than TME 419.

Table 5 Influence of time of iodine application on yield in two cassava varieties (2012)

	Number of tubers	Average tuber weight per stand (kg)	Tuber yield/plot (kg)
Variety			
TME 419	5.83	6.24	35.1
TMS 30555	5.44	6.03	34
SE	0.297	0.34	2.9
Time			
Control	5.17[a]	5.63[a]	32.5[a]
8WAP	5.79[a]	6.07[a]	37.3[b]
10WAP	5.63[a]	5.94[a]	32.8[a]
12WAP	5.50[ab]	5.77[ab]	33.5[a]
SE	0.364	0.417	3.55
Interaction			
V x T	NS	NS	NS

Means followed by same letters in each column are not significantly different at p.05 by Duncan multiple range test NS = not significant.

Table 6 Effect of time of iodine fertilization on yield in two cassava varieties (2013)

	Tuber number	Average tuber weight Per stand (kg)	Tuber yield/plot (kg)	Tuber Yield tons/ha
Variety				
TME 419	5.17	15.82	142.40	89.00
TMS 30555	5.20	16.84	151.60	94.00
SE	0.30	2.10	18.94	11.84
Time				
Control	5.39[a]	20.34[a]	183.10[a]	114.44[a]
8WAP	5.46[a]	18.39[a]	165.46[a]	103.41[a]
10WAP	4.98[b]	14.55[b]	130.97[b]	81.85[b]
12WAP	5.12[a]	16.06[b]	144.57[b]	90.36
SE	0.37	2.58	23.198	14.50
Interaction				
V x T	NS	NS	NS	NS

Means followed by same letters in each column are not significantly different at p.05 by Duncan multiple range test * - significant NS = not significant.

Iodine absorption

The effect of time of iodine application on cassava tuberflesh iodine content is shown in Table 7. Table 8 highlights iodine content in processed cassava, influenced by time of Iodine fertilization in two cassava varieties. Higher levels of iodine were absorbed by both varieties in the 2013 planting. In both years TME 419 absorbed more Iodine in the tubers than TMS 30555, this occurring 8 WAP. TME 419 thus recorded highest levels of Iodine absorption at 8 WAP both 2012 and 2013 though the amount of iodine absorbed was not significantly different from 12 WAP applications. TMS 30555 absorbed its highest amounts of iodine in tubers of plants that received

Table 7 Tuber iodine content (mg/kg) in two cassava varieties influenced by time of iodine application

	2012		2013	
WAP	TME 419	TMS 30555	TME 419	TMS 30555
Control	4.7[c]	4.3[b]	9.0[c]	7.8[c]
8	10.2[a]	10.1[a]	15.8[a]	12.7[ab]
10	8.3[b]	9.9[a]	12.0[b]	15.1[a]
12	10.1[a]	9.1[a]	13.6[ab]	12.9[ab]

Means followed by same letters in each column are not significantly different at p.05 by Duncan multiple range test

iodine 10 WAP in 2013. In 2012, the TMS 30555 cassava plants could not be separated in terms of iodine content of tuber in relation to time of Iodine application (Table 7) When the cassava was processed, TME 419 had more Iodine retained in the processed cassava of plants which were fertilized with KI, 12 WAP in both 2012 and 2013. In both varieties application of Iodine 12 WAP produced cassava which had more Iodineretained in the processed product particularly at the 2013 planting.

Table 8 Effect of time of iodine application on iodine content (mg/kg) in two processed cassava varieties

	2012		2013	
WAP	TME 419	TMS 30555	TME 419	TMS 30555
Control	1.9[c]	1.8[c]	5.4[c]	5.1[c]
8	4.8[ab]	3.69[b]	11.0[a]	9.2[a]
10	4.0[b]	4.8[a]	6.4[b]	7.2[b]
12	5.7[a]	4.3[a]	11.9[a]	9.5[a]

Means followed by same letters in each column are not significantly different at p.05 by Duncan multiple range test

DISCUSSION

Growth and Yield

Irrespective of the time of iodine application, vegetative growth and yield of cassava were not affected by time of iodine application. This might be that the low Iodine dose adopted from this research was within the safe range for physiological development of cassava. This is in line with Mackowiak*et al* (2005) and Strzetelski*et al* (2010) who stressed that excess iodine in plants produce severe physiological symptoms which can result in whole plant death in extreme cases. Zhu et *al* 2003 also reported detrimental effects and yield reduction in spinach when high levels of iodine were applied.

Iodine Absorption

This study obtained appreciable good iodine content in tubers and processed products. According to Alves (2002) and El-Sharkawy (2004), storage root formation in cassava is initiated between 8 to 12 WAP. This informed the choice of the time of iodine application in this study, so that application and absorption will coincide with storage root formation so the crop can utilize the available iodine before it is lost or adsorbed in the soil (Muramatsu*et al* 1990, Yoshida *et al* 1992).

CONCLUSION

Iodine will be effectively incorporated in cassava tissue when applied between 8 to 12 WAP. Applied Iodine will not adversely affect cassava growth or yield. Cassava variety TME 419 retains higher levels of Iodine than TMS 30555, both in tissue and processed product.For variety TMS 419 best time of application for absorption is fresh tubers in 8 WAP though application 12WAP might result in higher iodine levels in processed products.Time of application for high iodine tuber content in TMS 30855 is 10 WAP and at 12 WAP plant so fertilized will expressed higher iodine retention in processed product.

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