

Cassava Varietal Trials for Iodine Absorption in Southeastern Rainforest, Nigeria

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Abstract – The experiment was conducted to assess the ability of selected cassava varieties (TME 419, TMS 30555, TMS 1850, TMS 942 & TMS 30572) to absorb iodine when agronomically fortified by fertilizing with different rates of potassium iodide (KI) of (0, 0.25, 0.5 and 1g) at 8, 10, and 12 weeks after planting (WAP). The pot experiment was arranged in a split-split design replicated 3 times. Parameters measured were plant height, number of tubers, tuber weight and iodine content of tuber. Results showed that rate and time of iodine application did not significantly affect cassava growth rate (plant height) and tuber yield. Iodine content in all five varieties increased with increasing rates of applied iodine respective of time of application. TME 419 and TMS 30555 had strongest association between rate and time of iodine application and iodine content in tubers at 12 WAP ($r=0.86$ and 0.81 respectively). Application of 0.25g per cassava stand, which translates to 2.5kg KI/ha, at 12WAP is recommended for agronomic biofortification of cassava. Further field studies should be carried out to determine the effectiveness of agronomic fortification of cassava using TMS 419 and TMS 30555.

Keywords – Agronomic biofortification, Cassava, Human Nutrition, Iodine.

I. INTRODUCTION

Food supply to the ever increasing population of the human race is not the only nutritional concern of various stakeholders in the human health and nutrition sector. Hidden hunger or mineral deficiency is a major concern especially in the developing world whose staple diet is devoid of the super food (berries, kale, lentils, avocados, etc.), rich in minerals and vitamins [1]. Though, the dependence of single staple by people of the developing world might meet baseline calories needs, it cannot satisfy nutritional needs [2]. Forty nine per cent of Africans and 69 per cent of South East Asians lack vitamin A, 43 per cent of African and 54 per cent of Eastern Mediterranean people lack the recommended level of iodine [2].

Iodine deficiency disorder (IDD) is a preventable and treatable human health problem [3]. Absence of Iodine in the diet affects the production of hormone, thyroxin that supports normal growth and development in humans and deficiency is expressed as enlarged thyroid gland (goiter) [4].

Strategies to remedy micronutrient deficiencies including IDD such as provision of dietary supplementation comprising fruits, vegetable, animal products and processed fortified food have not achieved much success because these approaches are out of the reach of the target population due to their high costs [5].

The above suggest that biofortification of popular staples with higher nutritious content will have greater impact.

Biofortification involves increasing the concentration of minerals and vitamins in edible plant parts to improve consumer health [6],[7],[8], either by genetic or agronomic means of fertilization [9]. The Global Challenge program has listed iodine among the main micro nutrients that require attention in the biofortification program. In addition cassava is among the staples earmarked for biofortification [10].

The success of biofortification of crops with essential micro-nutrients by fertilization is a function of the mineral mobility in the soil, the plant and exchange site together with the composition of the soil [11]. The fact that iodine is mobile in the soil may likely mean that it might be successful in cassava biofortification [12]. The inclusion of cassava among the targeted staples for biofortification is a step in the right direction because cassava is consumed by about 800 million people in sub-Saharan Africa [13]. Its acceptability for cultivation stems from the fact that it is agronomically easy to cultivate, exhibits superior storage potential of its products, possesses the ability to thrive on marginal land and erratic rainfall condition, certainty of obtaining some yield even under the most adverse correlations and flexibility in terms of planting and harvest [14].

Several improve varieties of cassava have been developed and introduced to farmers in the rainforest region of Nigeria and it is necessary to investigate which of those varieties will successfully retain iodine in its tubers for human consumption.

The experiment was therefore conducted to:

Evaluate effect of agronomic fortification on growth and yield of cassava.

Determine the optimum rate and time of iodine fortification of cassava.

II. MATERIALS AND METHODS

Study Area

The pot experiment was conducted in the teaching and research farm University of Calabar, Southeastern Nigeria, between November 2011 – July 2012. Calabar lies between latitude $4^{\circ} 15'$ and $5^{\circ} N$ and longitude $8^{\circ} 25'$. It falls within the tropical rainforest climatic zone with typical primary vegetation and mostly secondary forest regrowth vegetation [15]. It exhibits distinct dry and wet season with annual rainfall ranging from 1900mm – 2000mm, Relative Humidity between 80 – 91% [16],

average of 4.6hrs of sunshine [17] average annual temperature between 25° – 32.5 °C [16].

Five cassava varieties TME 419, TMS 30555, TMS 1850, TMS 942 and TMS 30572 were selected for the trials. Iodine was supplied as potassium iodide(KI) at rate of 0, 0.25, 0.50 and 1.0g applied to individual potted plants at 8, 10 and 12 weeks after planting (WAP). The experiment was a 3 x 4 x 5 factorial laid out in a split-split plot design replicated three times.

Planting Procedures

Plastic basins with bottom diameter of 35cm and height 50cm were perforated at the bottom and filled with top soil up to 5cm from the brim. Two 20 cm by stem cutting of matured healthy cassava of the cassava varieties were planted in each container but later thinned to one when seedlings hand established. Each pot was watered with four litre of tap water after planting. Planting was done in November 2012 and harvested in July 2013. The seedlings were mainly rain fed except in the dry months of December and January where pots were irrigated manually with four litres of water when necessary. Experimental pots were kept weed-free by hand pulling throughout the duration of the experiment.

Application of Iodine

The required rates of iodine (0, 0.25, 0.50 and 1.0 g KI) were weighed using sensitive balance (model: Scout Pro). Iodine (I) as potassium iodide (KI) was applied to individual plants by banding at 8, 10 and 12 WAP.

Data Collection and Laboratory Analysis

Growth rate as increment in plant height was taken at 8, 10, 16, 20 24, 28 and 32 WAP. At harvest number of tubers and tuber weight per pot were determined. After weighing, tubersamples for each treatment were taken to the laboratory to determine the content of iodine in the tuber. Tuber Iodine content was determined in the laboratory using the X-ray fluorescence method of iodine determination [18]. Representative samples of cassava leaves were also collected, oven-dried and analysed for iodine content, as was done with the tubers.

Data Analysis

Growth and yield data were analysed statistically by the analysis of variance (ANOVA) technique of the split-split plot design and means were separated using the Duncan multiple Range test at 5% level of probability, using the Gen Stat for Windows, 8th edition. The association between rate of iodine application and tuber iodine content was determined using correlation coefficient.

III. RESULTS

Growth and Yield

Cassava variety TMS 942, produced the tallest plants in response to iodine application thereby having the highest growth rate. However rate and time of iodine application had no effect on plant height (Table I). Significant difference in plant height only occurred at the early stages of the plant life and interaction effect was also significant within the first 8 WAP.

Table 1. Monthly plant height of five cassava varieties influenced by rate and time of iodine application

Variety	Weeks after planting (WAP)					
	8	12	16	20	24	28
TME 419	32.33 ^b	53.29 ^{ab}	55.20 ^b	67.2 ^b	77.9 ^b	110.0 ^a
TMS 30555	32.00 ^{bc}	60.75 ^a	75.20 ^a	91.9 ^a	115.4 ^a	147.0 ^a
TMS 1850	25.88 ^{cd}	43.04 ^b	49.80 ^b	64.7 ^b	79.1 ^b	132.0 ^a
TMS 942	39.75 ^a	47.71 ^b	55.00 ^{ab}	68.8 ^b	91.4 ^b	188.0 ^a
TMS 30572	23.33 ^d	46.75 ^b	54.00 ^{ab}	65.7 ^b	92.4 ^b	131.0 ^a
Rate						
0g KI	28.93 ^a	50.20 ^a	59.10 ^a	72.5 ^a	94.3 ^a	130.0 ^a
0.25 g KI	33.37 ^a	48.60 ^a	54.90 ^a	73.4 ^a	89.5 ^a	133.0 ^a
0.5gKI	30.83 ^a	52.20 ^a	61.10 ^a	70.5 ^a	90.7 ^a	136.0 ^a
1.0 g KI	29.50 ^a	49.53 ^a	56.20 ^a	70.2 ^a	9.6 ^a	175.0 ^a
Time						
8WAP	29.15 ^b	51.62 ^a	59.00 ^a	71.5 ^a	94.2 ^a	132.0 ^a
10WAP	33.30 ^a	52.12 ^a	60.40 ^a	75.2 ^a	92.8 ^a	167.0 ^a
12WAP	29.53 ^b	47.17 ^a	54.10 ^a	68.3 ^a	87.0 ^a	132.0 ^a
Interaction						
VxR	*	NS	NS	NS	NS	NS
VxT	NS	NS	NS	NS	NS	NS
RxT	*	NS	NS	NS	NS	NS
VxRxT	**	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

* - significant NS = not significant.

Though cassava variety TMS 942 recorded the highest mean tuber yield (weight) when 1.0 g of KI was applied at 10WAP, the difference in weight was not due to iodine application because the observed weights were not

significantly different. Tuber number per plant was markedly varied by iodine application, varieties TMS 942 and 30572 significantly expressing higher number of tuber per plant than the other varieties (Table II).

Table 2. Effects of rates and time of iodine application on tuber yield (kg) in five varieties of cassava

Variety	Number of Tubers	Tuber weight kg/ha
TME 419	3.46 ^b	1.45 ^a
TMS 30555	2.75 ^b	1.24 ^a
TME 1890	3.21 ^b	1.28 ^a
TME 942	4.33 ^a	1.67 ^a
TME 30572	4.54 ^a	1.76
Rate		
0gKI	3.73 ^a	1.52 ^a
0.25gKI	3.40 ^a	1.25 ^a
0.50gKI	4.00 ^a	1.50 ^a
1.0gKI	3.50 ^a	1.66 ^a
Time		
8WAP	3.70 ^a	1.35 ^a
10WAP	4.00 ^a	1.65 ^a
12WAP	3.27 ^a	1.44 ^a
Interaction		
V x R	NS	NS
V x T	NS	NS
R x T	NS	NS
V x R x T	*	*

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

* = significant NS = not significant.

Interaction effects of rate, time and variety to iodine application was significant, but was not significant when any of two factors were combined (Table II).

Iodine Absorption

The correlation coefficient of rate and time of iodine fertilization to tuber iodine content for the five cassava varieties are highlighted in Table III.

All the cassava varieties studied absorbed iodine irrespective of the rate and time of application of iodine content. Iodine content in the tuber increased with increasing application rate, hence the positive correlation value. Positive correlation values were significant at 0.05

probability level at all rates and time of Iodine application except for varieties TMS 1850 and TMS 30572 when iodine was applied of 8 WAP. At 10 and 12 WAP Iodine application, all varieties strongly retained iodine in tuber with increasing KI rates. Cassava variety TME 419, TMS 30555 and TMS 1850 showed very high correlation of absorbed iodine to increasing rates of iodine at 12 WAP. The association between increasing iodine supply with absorptions in the tuber increased strongly with time of application, thus at 12 WAP all varieties expressed significant iodine retention in the tuber flesh with increasing rates of iodine supply.

Table 3. Correlation coefficient (r) of rates and time of Iodine application and Iodine content in tubers of five cassava varieties

WAP	TME 419	TMS 30555	TMS 1850	TMS 942	TMS 30572
8	0.71**	0.59*	0.57	0.67*	0.30
10	0.63*	0.75**	0.77**	0.68*	0.69*
12	0.86**	0.81**	0.79**	0.68*	0.68*

* = significant at 0.05 probability level ** = significant at 0.05 and 0.01

IV. DISCUSSION

Iodine application was not responsible for the slight variation in growth and yield of cassava observed in this study. Growth and yield did not vary considerably among varieties with rate and time of iodine inclusion. This suggests that iodine inclusion might not affect the normal physiological process that determines yield in cassava. This assumption is supported by [19], [20] who reported that iodine does not affect plant physiology (growth and yield) but that its inclusion in small doses is in fact beneficial.

Adequate soil depth, volume and improved physical condition are imperative for nutrient utilization, growth and tuber expansion [21],[22],[23]. The limited soil volume with its associated effects affected growth of the potted cassava and resulted in the low yield observed in this study.

Iodine content in all cassava varieties increased with rates and time of iodine inclusion. The same was observed by [24] and [25] reported that increasing rates of Iodine fertilization resulted in increased absorption of Iodine in tissue contents of spinach, radish and carrots.

V. CONCLUSION

Iodine fertilization did not negatively affect growth and yield of cassava. It also did not suppress yield in the cassava plant that received iodine. The relationship between rates and time of iodine inclusion with iodine retention in cassava tuber is strong and direct. This shows that agronomic fortification of cassava is possible in cassava. Among the varieties studied, TMS 419 and TMS 30555 showed strongest affinity from iodine. Application of 0.25g per cassava at 12WAP is recommended for agronomic biofortification. Further field studies should be carried out to determine the effective of agronomic fortification of cassava using TMS 419 and TMS 30555.

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AUTHOR'S PROFILE



Dr. Joseph E.O. Ansa is a Senior Lecturer in the Department of Agricultural Science (Crop and Soil Science Unit), Ignatius Ajuru University of Education (formerly Rivers State University of Education), Port Harcourt, Rivers State, Nigeria. Though born in Lagos, Nigeria on 15th May, 1965, Dr. Ansa hails from Creek Town, Odukpani Local Government Area, Cross River State, Nigeria. J.E.O. Ansa was admitted to the Bachelor of Science in Agriculture (Crop Science) and Master of Science in Agronomy (Crop Science) from the University of Ibadan, Nigeria in 1988 and 1991 respectively. In July, 2015, Dr. Ansa obtained a doctorate degree in Crop Production from the University of Calabar, Nigeria. Dr. Ansa's major field of study and research interest is in crop eco-physiology and farming systems. He has been teaching higher education courses such as crop physiology, pasture and forage crops production, arable crop production, agro-climatology, cropping systems and agro-statistics and has supervised several students' research project for over twenty years. He has written and coauthored journal articles, edited books and presented papers at conferences. His current research interest is in iodine biofortification of crops and the effects of planting density and fertilizers on sunflower production in tropical rainforest.