Soil Fertility and Yield Performance of Cassava (*Manihot esculenta* Crantz) Under Different Cut – Back Regimes of Cassava

[1]B. Osundare and [2]M .S. Olaleye

[1]Department of Crop, Soil, and Environmental Sciences, Ekiti State University, Nigeria
[2]Department of Agronomy, University of Ibadan, Nigeria.
[1]Correspondence author

ABSTRACT

A two –year field experiment was carried out during 2009/2010 and 2010/2011 cropping seasons at the Teaching and Research Farm of the University of Ibadan, Nigeria, to assess the effects of different cut - back regimes of cassava on soil chemical properties and performance of cassava (*Manihot esculenta* Crantz). The experiment was laid out in a randomized complete block design with three replicates. The different cut – back regimes were: cut - back at 3, 6, 9 and 12 months after planting (MAP) and no cut – back (NCB), which served as the control treatment. The results of the experiment indicated existence of significant (P = 0.05) differences among the different cut – back regimes with respect to their effects on soil chemical properties, yield and yield components of cassava. At the end of 2009/2010 cropping season, cut – back treatments significantly (P = 0.05) increased soil organic carbon (SOC) from 1.16 g kg^{-1} for NCB to 1.40, 1.34, 1.28 and1.22 g kg^{-1} for cut – back at 3, 6, 9 and 12 MAP, respectively. Similarly, at the end of 2010/2011 cropping season, cut – back treatments significantly increased SOC from 1.10 g kg^{-1} for NCB to 1.34, 1.29, 1.23 and 1.18 g $kg^{-1}$for the respective cut – back at 3, 6, 9 and 12 MAP. At the end of 2009/2010 cropping season, cut – back treatments significantly increased total N from 0.20 g kg^{-1} for NCB to 0.47, 0.40, 0.34 and 0.26 g kg^{-1} for cut – back at 3, 6, 9 and 12 MAP, respectively. Similarly, at the end of 2010/2011 cropping season, cut – back treatments significantly increased total N from 0.16 g kg^{-1} for NCB to 0.44, 0.36, 0.29 and 0.21 g kg^{-1} for cut – back at 3, 6, 9 and 12 MAP, respectively. Averaged over the two years of experimentation, cut – back treatments resulted in significant decreases in cassava root yield from 12.75 t ha^{-1} for NCB to 5.00, 7.12, 8.33, and 10.15 t ha^{-1} for cut – back at 3, 6, 9 and 12 MAP, respectively.

Key words: Cut – back, soil, chemical, cassava, yield.

INTRODUCTION

Stem cut – back of cassava is not a common agricultural practice in Nigeria. However, it is prevalent in some African countries, where cassava leaves are eaten as green vegetables (Asi, 2009; Kinsella, 2012). Cut – back of cassava reduces its growth, which consequently results in a significant reduction in its root yield, based on the premise that the yield of crops is positively correlated with their growth (Lobet, 2009).

Previous studies (Arigbede, 2001; Tobor, 2009; Ega, 2011) had demonstrated significant effects of stem cut – back on the growth and yield attributes of cassava. In all the studies, significant differences among cut – back treatments with respect to their effects on the growth and yield of cassava were reported. Migot (2005) and Nelean (2011) reported significant reduction in the shelf – life or storability and quality of cassava roots due to cut – back treatments.

Although, many aspects of the Agronomy of cassava had been researched with a view to raising its yield on farmers' farms. However, in Nigeria, Literature Review indicates dearth of information and statistical data on the effects of cut - back regimes of cassava on soil chemical properties and performance of cassava. To this end, this paper reports the results of a two – year trial, aimed at determining the effects of different cut – back regimes of cassava on soil chemical properties and yield performance of cassava.

MATERIALS AND METHODS

Study site: A two – year field experiment was carried out at the Teaching and Research Farm of the University of Ibadan, Nigeria, during 2009 – 2011 cropping seasons. Ibadan lies between latitude 7°24'N and longitude 3°54'E. The soil in the study site is oxic Paleustalfl(SSS, 2003). The site had earlier been cultivated to arable crops, among which were cassava, cocoyam, maize, melon, soybean before it was allowed to fallow for five years. During the fallow period, cattle sheep and goat used to graze on the fallow land. At the commencement of this study, the fallow vegetation was manually cleared, after which the land was ploughed and harrowed.

Collection and analysis of soil samples: Prior to 2009/2010 planting, ten core soil samples, randomly collected from 0 – 15 cm soil depth, were bulked inside a plastic bucket to form a composite sample, which was analyzed for chemical properties. At the end of each year cropping season, another set of soil samples was collected in each treatment plot and analyzed. The soil samples were air – dried, ground, and passed through a 2 mm sieve. The processed soil samples were analyzed in accordance with soil analytical procedures outlined by IITA (1989).

Experimental design and treatments: The experiment was laid out in a randomized complete block design with three replicates. The different stem cut – back regimes of cassava included: cut - back at 3, 6, 9 and 12 months after planting (MAP) and no cut – back (NCB), which served as the control treatment. The cut – back treatment involved cutting cassava stem at 1.5 m above ground level. Each plot size was 2 m x 2 m. No fertilizer application was carried out throughout the course of the experiment.

Planting, weeding, collection and analysis of data: Planting was done on March 2 and March 3 in 2009 and 2010, respectively. Stem – cuttings (20 cm long each) of early maturing cassava variety TMS 30572, obtained from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, were planted at 1m x 1m (10,000 plants ha^{-1}). Weeding was done manually at 3, 6, 9, 12 and 15 weeks after planting (WAP), using a hoe. At harvest (15 months after planting, MAP), data were collected on root yield and yield components. All the data collected were subjected to analysis of variance, and treatment means were compared using the Duncan Multiple Range Test (DMRT) at 5% (0.05) level of probability.

RESULTS

The chemical properties of soil in the study site prior to 2009/2010 cropping season are presented in Table 1.

Table 1: The chemical properties of soil in the study site before 2009/2010 cropping season

Soil Parameters	Values
pH	6.2
Organic carbon (g kg^{-1})	1.66
Total nitrogen (g kg^{-1})	0.69
Available phosphorus (mg kg^{-1})	0.61
Exchangeable bases (cmol kg^{-1})	
Potassium	0.78
Calcium	0.59
Magnesium	0.62
Sodium	0.49
Exchangeable acidity	0.36
ECEC	2.84

Changes in soil chemical properties after 2009/2010 and 2010/2011 cropping seasons: Tables 2 and 3 show the effects of different cut – back regimes of cassava on soil chemical properties after 2009/2010 and 2010/2011 cropping seasons. At the end of 2009/2010 cropping season, cut – back treatments significantly increased soil pH from 4.0 for NCB to 6.0, 5.6, 5.2 and 4.6 for cut – back at 3, 6, 9 and 12 MAP, respectively. Similarly, at the end of 2010/2011 cropping season, cut – back treatments significantly increased soil pH from 3.5 for NCB to 5.6, 5.1, 4.5 and 4.0 for the respective cut – back at 3, 6, 9 and 12 MAP, respectively. At the end of 2009/2010 cropping season, cut – back treatments significantly increased soil organic carbon (SOC) from 1.16 g kg^{-1} for NCB to 1.40, 1.34, 1.28 and 1.22 g kg^{-1} for cut – back at 3, 6, 9 and 12 MAP, respectively. Similarly, at the end of 2010/2011 cropping season, cut – back treatments significantly increased SOC from 1.10 g kg^{-1} for NCB to 1.34, 1.29, 1.23 and 1.18 g kg^{-1} for the respective cut – back at 3, 6, 9 and 12 MAP, respectively. At the end of 2009/2010 cropping season, cut – back treatments significantly increased total N from 0.20 g kg^{-1} for NCB to 0.47, 0.40, 0.34 and 0.26 g kg^{-1} for cut – back at 3, 6, 9 and 12 MAP, respectively. Similarly, at the end of 2010/2011 cropping season, cut – back treatments significantly increased total N from 0.16 g kg^{-1} for NCB to 0.44, 0.36, 0.29 and 0.21 g kg^{-1} for cut – back at 3, 6, 9 and 12 MAP, respectively. At the end of 2009/2010 cropping season, cut – back significantly increased available P from 0.24 mg kg^{-1} for NCB to 0.58, 0.50, 0.44 and 0.35 mg kg^{-1} for the respective cut – back at 3, 6, 9 and 12 MAP, respectively. Similarly, at the end of 2010/2011 cropping season, cut – back significantly increased available P from 0.20 mg kg^{-1} for NCB to 0.54, 0.47, 0.40 and 0.31 mg kg^{-1} for the respective cut – back at 3, 6, 9 and 12 MAP, respectively. At the end of 2009/2010 cropping season, cut – back treatments significantly increased exchangeable K from o.34 cmol kg^{-1} for NCB to 0.68, 0.57, 0.50 and0.43 cmol kg^{-1} for cut - back at 3, 6, 9 and 12 MAP, respectively. Similarly, at the end of 2010/2011 cropping season, cut – back significantly increased exchangeable K from 0.30

cmol kg^{-1} for NCB to 0.63, o.51, 0.46 and 0.38 cmol kg^{-1} for the respective cut – back at 3, 6. 9 and 12 MAP, respectively. At the end of 2009/2010 cropping season, cut – back significantly increased exchangeable Ca from 0.20 cmol kg^{-1} for NCB to o.44, 0.38, 0.31 and 0.25 cmol kg^{-1} for the respective cut – back at 3, 6, 9 and 12 MAP. Similarly, at the end of 2010/2011 cropping season, cut – back significantly increased exchangeable Ca from 0.15 cmol kg^{-1} for NCB to 0.40, 0.32, 0.27 and 0.21 cmol kg^{-1} for the respective cut – back at 3, 6, 9 and 12MAP. At the end of 2009/2010 cropping season, cut - back significantly increased exchangeable Mg from 0.24 cmol kg^{-1} for NCB to 0.49, 0.44, 0.38 and 0.32 cmol kg^{-1} for cut – back at 3, 6, 9 and 12 MAP, respectively. Similarly, at the end of 2010/2011 cropping season, cut – back resulted in significant increases in exchangeable Mg from 0.20 cmol kg^{-1} for NCB to 0.43, 0.39, 0.32 and 0.27 cmol kg^{-1} for the respective cut – back at 3, 6, 9 and 12MAP. At the end of 2009/2010 cropping season, cut – back significantly increased exchangeable Na from 0.19 cmol kg^{-1} for NCB to 0.39, 0.34, 0.29 and 0.24 cmol kg^{-1} for the respective cut – back at 3, 6, 9 and 12 MAP. Similarly, at the end of 2010/2011 cropping season, cut – back treatments resulted in significant increases in exchangeable Na from 0.14, cmol kg^{-1} for NCB to 0.34, 0.29, 0.24 and 0.19 cmol kg $^{-1}$ for cut – back at 3, 6, 9 and 12 MAP, respectively.

Table 2: Soil chemical properties as affected by different cut – back regimes of cassava after 2009/2010 cropping season.

Cut – back treatments	pH	Org. C (g kg^{-1})	Total N (g kg^{-1})	Available P (mg kg^{-1})	Exchangeable bases (cmol kg^{-1}) K	Ca	Mg	Na
No cut – back (control)	4.0e	1.16e	0.20e	0.24e	0.34e	0.20e	0.24e	0.19e
Cut - back (3 MAP)	6.0a	1.40a	0.47a	0.58a	0.68a	0.44a	0.49a	0.39a
Cut - back (6 MAP)	5.6b	1.34b	0.40b	0.50b	0.57b	0.38b	0.44b	0.34b
Cut - back (9 MAP)	5.2c	1.28c	0.34c	0.44c	0.50c	0.31c	0.38c	0.29c
Cut - back (12 MAP)	4.6d	1.22d	0.26d	0.35d	0.43d	0.25d	0.32d	0.24d

Mean values in the same column followed by the same letter (s) are not significantly different at P = 0.05 (DMRT). MAP = Months after planting.

Table 3: Soil chemical properties as affected by different cut – back regimes of cassava after 2010/2011 cropping season.

Cut – back treatments	PH	Org. C (g kg^{-1})	Total N (g kg^{-1})	Available P (mg kg^{-1})	Exchangeable bases (cmol kg^{-1}) K	Ca	Mg	Na
No cut – back (control)	3.5e	1.10e	0.16e	0.20e	0.30e	0.15e	0.20e	0.14e
Cut - back (3 MAP)	5.6a	1.34a	0.44a	0.54a	0.63a	0.40a	0.43a	0.34a
Cut - back (6 MAP)	5.1b	1.29b	0.36b	0.47b	0.51b	0.32b	0.39b	0.29b
Cut - back (9 MAP)	4.5c	1.23c	0.29c	0.40c	0.46c	0.27c	0.32c	0.24c
Cut – back (12 MAP)	4.0d	1.18d	0.21d	0.31d	0.38d	0.21d	0.27d	0.19d

Mean values in the same column followed by the same letter (s) are not significantly different at P = 0.05 (DMRT). MAP = Months after planting.

Yield and yield components of cassava roots at harvest: The effects of different cut – back regimes of cassava on the yield and yield components of cassava are presented in Table 4. On the two - year average, cut – back treatments significantly decreased cassava root yield from 12.75 t ha^{-1} for NCB to 5.00, 7.12, 8.33 and 10.15 t ha^{-1} for cut - back at 3, 6, 9 and 12 MAP, respectively. Similarly, cut – back treatments resulted in significant decreases in cassava root length from 20.67 cm for NCB to 12.11, 12.72, 13.68 and 18.21 cm for cut – back at 3, 6, 9 and 12 MAP, respectively. Cut – back treatments significantly decreased cassava root diameter from 18.42 cm for NCB to 7.16, 9.36, 11.47 and 15.66 cm for the respective cut – back at 3, 6, 9 and 12 MAP.

Table 4: Yield and yield components of cassava roots as affected by different cut – back regimes at harvest.

Cut - back treatments	Cassava root yield (t ha^{-1})			Cassava root length (cm)			Cassava root diameter (cm)		
	2010	2011	Mean	2010	2011	Mean	2010	2011	Mean
No cut - back (control)	12.89a	12.60a	12.75	20.61a	20.73a	20.67	18.60a	18.24a	18.42
Cut - back (3 MAP)	5.11e	4.89e	5.00	12.21e	12.00e	12.11	7.21e	7.11e	7.16
Cut - back (6 MAP)	7.23d	7.00d	7.12	12.81d	12.63d	12.72	9.44d	9.28d	9.36
Cut - back (9 MAP)	8.49c	8.17c	8.33	13.77c	13.58c	13.68	11.56c	11.38c	11.47
Cut - back (12 MAP)	10.26b	10.04b	10.15	18.33b	18.09b	18.21	15.77b	15.54b	15.66

Mean values in the same column followed by the same letter(s) are not significantly different at P = 0.05 (DMRT). MAP = Months after planting.

DISCUSSION

The lowest pH value of soil in the no cut – back plots after 2009/2010 and 2010/2011 cropping seasons can be ascribed to the lowest value of the exchangeable bases of soil in the no cut – back plots. The lowest value of the exchangeable bases in the no cut – back plots can be adduced to uptake of the exchangeable bases by cassava, since cassava was not cut – back throughout, and hence, nutrient absorption by cassava from the soil system was not disrupted, compared to what obtained under the cut – back treatments. This observation suggests that, continuous cultivation of cassava, apart from resulting in declined soil fertility, another attendant problem is that of acidity. To avert this problem of acidity, thus, the addition of limes to soil under continuous cassava cultivation is strongly recommended.

The significantly higher pH values of soil in the plots where the cut – back treatments were administered, compared to that of the control treatments can be attributed to low uptake of the exchangeable bases by cassava, following the disruption of certain physiological activities by the cut – back treatments. Similarly, the significantly higher values of organic carbon, total nitrogen and available phosphorus of soil in the cut – back plots than those of the no cut – back treatments can be attributed to low uptake of these nutrient elements by cassava due to the set – back caused by the cut – back treatments.

At the end of 2010/2011 cropping season, values of soil nutrients under all the cut – back treatments were lower than what obtained under all the cut – back treatments after 2009/ 2010 cropping season. This observation can be adduced to nutrient removal by cassava during 2009/2010 cropping season. This suggests that, continuous cassava cultivation will consequently result in declined soil fertility, except addition of organic and / or inorganic fertilizers is carried out.

The significant reduction in the root yield and yield components of cassava, associated with the cut – back treatments agree with the reports of Arigbede (2001); Tobor (2009); Ega (2011). These authors observed that cut – back resulted in a significant reduction in the yield and yield components of cassava roots. The lowest root yield and yield components of cassava that attended cut – back treatment at three months after planting can be attributed to disruption of the process of root initiation. This is because, studies by Tobor (2009) and Ega (2011) have established that root initiation in cassava commences three months after planting, and incidentally, the root initiation phase coincided with this growth stage of cassava when it was cut back. This implies that, the cut – back treatment at three months after planting had the most serious adverse effects on cassava, of all the cut – back treatments, assessed in this study. The significant reduction in the root yield of cassava that was cut back at twelve months after planting cannot be ascribed to upset of root initiation process, as it was the case in cut – back at three months after planting. This is because, at twelve months after planting, cassava plants had already attained full maturity, and root initiation process would have also ended. However, the significant reduction in the root yield of cassava that was cut back at twelve months after planting can be adduced to decay of some of the roots, following the cut – back treatment at twelve months after planting, observed in the course of this experiment. This shows that, root decay is an indirect attendant detrimental effects of cut – back treatments on cassava, apart from upsetting certain physiological activities in cassava plants.

The lower root yield of cassava under all the cut – back treatments for 2010/2011 cropping season, relative to what obtained at the end of 2009/2010 cropping season can be attributed to declined soil fertility due to nutrient removal by cassava during 2009/2010 cropping season. Although, previous studies had reported significant reduction in cassava root yield due to cut – back treatments. However, based on the results of this present research, the severity of root yield reduction, associated with cut – back treatments, depends on the age of growth of cassava when the cut – back treatments are administered.

CONCLUSION

The results of this study have indicated that, cut – back treatments resulted in significant increases in soil nutrients after cropping. The significant decreases in root yield of cassava under the different cut – back treatments can be ranked as: cut – back at 3 < 6 < 9 < 12 MAP < no cut – back .

REFERENCES

Arigbede, O.K. (2001): Growth and yield responses of cassava to cut – back regimes. *Crop ScienceResearch.* 26:311 – 316

Asi, V. N. (2009): Growth and yield responses of cassava to NPK fertilization and defoliation. *Crop Physiology.* 15:17 – 23.

Ega, S.O. (2011): Study on cassava performance in relation to application of different organic fertilizers and frequency of defoliation. *Plant Nutrition*. 42(30): 412 – 417.

International Institute of Tropical Agriculture (IITA) (1989): Automated and semi – automated methods of soil and plant analysis. *Manual Series*, No. 7, IITA, Ibadan, Nigeria.

Kinsella, A.B. (2012): Effects of sodium and potassium on the growth and oxalate content of cassava *Fertilizer Research.* 26(24): 364 – 369.

Lobet, A.I. (2009): Nitrogen and potassium interrelations in growth and mineral content of cassava. *Agricultural Science Journal.* 21:316 – 321.

Migot, O.O. (2005): Effects of nitrogen application and cut – back on size and storability of cassava roots. *Journal of Food and Agricultural Research*. 24:181 – 186.

Nelean, K.S. (2011): Molecular mechanism of N, P and K uptake in cassava. *Journal of Pure and Applied Sciences.* 12:210 – 216.

Soil Survey Staff (SSS) (2003). Keys to soil taxonomy, 9th edition. USDA Natural Resources Conservation Services. U S. Department of Agricultural, Washington D.C. 306 p.

Tobor, S. (2009). Mineral requirements of cassava . *Journal of Sustainable Agriculture.* 16: 6 - 11