DOI: https://dx.doi.org/10.4314/gjass.v22i1.7

GLOBAL JOURNAL OF AGRICULTURAL SCIENCES VOL. 22, 2023: 63-70
COPYRIGHT© BACHUDO SCIENCE CO. LTD PRINTED IN NIGERIA ISSN 1596-2903
www.globaljournalseries.com.ng, Email: globaljournalseries@gmail.com

PRODUCTION RETURNS OF CASSAVA-TURMERIC INTER-CROPPING SYSTEM IN CALABAR, SOUTHERN NIGERIA

FRANCIS A. NWAGWU, OKECHUKWU C. UMUNNAKWE, THOMAS O. OJIKPONG, LAWRENCE I. OMADEWUAND EMMANUEL A. AWELEWA

(Received 13July2023; Revision Accepted 28 July 2023)

ABSTRACT

Field experiments were conducted in the 2019 and 2020 early cropping seasons at the University of Calabar Teaching and Research Farm, Calabar, Nigeria, to assess the profitability of inter-cropping cassava with turmeric. There were seven treatments: sole cassava, sole turmeric, cassava intercropped with turmeric at 66,666; 50,000; 40,000; 35,714 and 28,571 turmeric plants/ha, laid out in a randomized complete block design (RCBD) and replicated three times. The cost implication of the technology was analyzed by computing the production cost, gross income, gross margin, benefit/cost ratio and percentage net returns of each treatment. Results showed that maximum cost was incurred by cultivating cassava with the highest turmeric density of 66,666 turmeric plants/ha (30 cm x 50 cm spacing of turmeric). The lowest average percentage net return of 29.34 % was obtained from sole turmeric treatment plot. The inter-crop mixture with the lowest turmeric population density of 28,571 plants/ha produced the highest percentage net return of 62.78 % on the 2 year-average, and could therefore be recommended for optimum cassava/turmeric intercrop productivity.

KEYWORDS: Cassava, Intercrop, Turmeric, Production cost, Percentage net returns

1 INTRODUCTION

Cassava and its by-products are increasingly popular in the world food markets as cassava serves as staple food for over 800 million people all over the world (Uwah*et al*., 2013; Adeniyan*et al*., 2014). Cassava roots are rich in starch and contain significant amounts of calcium, phosphorus and vitamins (Ajah*et al*., 2022; Itam*et al*., 2018). Cassava was described by FAO (2018) as the crop for food security, economic growth, poverty alleviation and rural development.

Weeds have been reported to be a major biotic threat to cassava production and should be controlled at the early stages of the crop growth, if optimum yield is to be desired (Anikwe and Ikenganyia, 2018; Nwagwu *et al*., 2023a; Umunnakwe *et al*., 2023a,b). Weeds normally explore the niches not occupied by crops (Nwagwu *et al*., 2023b) and any farming practice that considers putting the empty pockets between cassava stands to judicious use could enhance productivity of the land (Umunnakwe *et al*., 2023a). Such farming practice includes inter-cropping cassava with a low growing component

Francis A. Nwagwu, Department of Crop Science, Faculty of Agriculture, University of Calabar, Calabar, Nigeria
Okechukwu C. Umunnakwe, Department of Crop Science, Faculty of Agriculture, University of Calabar, Calabar, Nigeria
Thomas O. Ojikpong, Department of Agronomy, Faculty of Agriculture and Forestry, Cross River University of Technology, Obubara Campus, Nigeria
Lawrence I. Omadewu, Department of Soil Science, Faculty of Agriculture, University of Calabar, Calabar, Nigeria
Emmanuel A. Awelewa, Department of Soil Science, Faculty of Agriculture, University of Calabar, Calabar, Nigeria

crop such as turmeric.

Inter-cropping has been heralded as an insurance against total crop failure. It is one of the most efficient ways of buffering the soil surface against agents of denudation, purifying the atmosphere through effective carbondioxide utilization, enhancing land use efficiency and maximizing available growth factors such as moisture, nutrients and light (Abraha, 2013; Adeniyan *et al*., 2014; Amoako *et al*., 2022). Inter-cropping cassava with suitable smother crops enhances weed suppression (Amosun and Aduramigba-Modupe, 2016; Islami *et al*., 2017).

Cassava is commonly inter-cropped with other food crops such as maize, yam, groundnut, *egusi* melon. Low growing tuberous crops such as turmeric can successfully grow under the canopy of taller plants like cassava (Singh *et al.*, 2016), thereby contributing to weed suppression and greater land productivity (Singh and Singh, 2015). When Mohanthy *et al*. (1991), worked on the effects of inter-cropping systems on the performance of turmeric under rain-fed agriculture, they observed that turmeric seedlings emerged earlier and the crop produced more with higher economic returns per investment.

The recent surge in the cost of inputs calls for judicious use of available resources, thus, the cost implications of any given farming technique should be thoroughly analyzed to ascertain its effectiveness and adoptability (Sanchi *et al*., 2022). As Ikuemonisan *et al*. (2020) referenced the theory of production which asserts that a cassava farmer will only make good profit if a high yield could be achieved from a least cost possible, ascertaining the percentage gross returns of each given farming method, will highlight the best combination that will give a greater yield at the least cost. This therefore means that a rational cassava farmer would go for a proven cassava production technology that is cheap and the most efficient combination of production factors that gives maximum output (Ikuemonisan and Akinbola, 2019). Farmers who produce at high cost will not be able to participate in an ever-changing competitive market. This research was therefore conducted to investigate the cost implications of using different population densities of turmeric as associate crop in cassava farm.

2 MATERIALS AND METHODS

Location

The experiment was conducted at the University of Calabar Teaching and Research Farm, Calabar, Nigeria. Calabar is located at the southeastern rainforest agro-ecological zone of Nigeria (4.5^0N - 5.2^0N, 8.0 - 8.3^0E), about 39 m above sea level and has a bimodal annual rainfall distribution that ranges from 3,000 mm to 3,500 mm with mean annual temperature range of 27^0 C to 35^0 C and relative humidity of 75 % to 88 % (CRBDA, 1995). The experimental site was in secondary vegetation following a two-year fallow period having been previously used for cassava cultivation.

Experimental design and layout:

The experiment was laid out in a randomized complete block design (RCBD) and replicated three times. There were seven treatments: cassava intercropped with turmeric at 66,666 turmeric plants/ha (30 cm x 50 cm spacing), 50,000 turmeric plants/ha (40 cm x 50 cm spacing), 40,000 turmeric plants/ha (50cm x 50 cm spacing), 35,714 turmeric plants/ha (40 cm x 70 cm), 28,571 turmeric plants/ha (50 cm x 70 cm), and sole turmeric at 66,666 plants/ha, 30 x 50 cm standard spacing (Amadi *et al*., 2015) and sole cassava as the controls.

Plot size and planting

A gross experimental plot measuring 25 m x 29.5 m was used for the investigation. The plot was demarcated into uniform plot sizes (experimental units) of 4 x 5 m (20 m^2) with 0.5 m and 1 m gaps between experimental units and between blocks respectively. Cassava cuttings were first planted on the 16th of March, while the turmeric rhizomes were introduced two days later on the 18th of March in each of the planting years. Cassava stem cuttings of 20 – 25 cm length with 4 – 7 nodes each were inserted in a slanting position into the soil 1 m x 1 m apart. The cuttings were planted one per stand resulting in a population of 20 plants per 20 m^2 plot and 10,000 plants per hectare. Forty bundles of 50 stems each were used per hectare.

Turmeric rhizomes weighing 18 – 20 g were introduced in-between cassava rows according to treatment specifications (133, 100, 80, 71 and 57 turmeric plants per 20 m^2). Thus, about 1,200 kg / ha, 900 kg / ha, 720 kg / ha, 643 kg / ha and 514 kg / ha of turmeric rhizomes were planted accordingly.

Crop management and field maintenance:

Mixed fertilizer NPK 12:12:17 was ring applied 6 – 10 cm around the cassava base at 5 and 12 weeks after planting at the rate of 0.8 kg / 20 m^2 plot, equivalent to 400 kg / ha (Hauser *et al*., 2014). Earlier, mixed fertilizer NPK 12:12:12 was ring applied 6 – 10 cm around the turmeric base at 4 weeks after emergence at the rate of 0.4 kg / 20 m^2 plot, equivalent to 200 kg / ha (Akpan *et al*., 2013; Nwokocha *et al*., 2017). Manual weeding using hand-held hoe was carried out at 4 and 8 weeks after planting.

Analysis of production cost and returns:

The components of production cost and returns used for benefit / cost analysis are total variable cost (production cost), gross income, gross margin and percentage net returns. The costs and returns were calculated on treatments bases and expressed in Naira per hectare (₦ha^{-1}).

Total variable cost (TVC):

The total expenditure incurred from land preparation through planting to harvesting was worked out on treatment basis and expressed in Naira per hectare (₦ha^{-1}). The cost items included cassava stems, turmeric rhizomes, fertilizer and labour for bush clearing, tillage, planting, fertilizer application, weeding, transportation and harvesting. As noted by Itam *et al*. (2018) total variable cost (TVC) is

mathematically expressed as: TVC = cost of materials + cost of labour.

Gross income (GI):

The monetary values of the stem and tuber yields of Cassava, and rhizome yield of turmeric of each treatment were estimated and worked out in Naira per hectare (₦ha^{-1}) and recorded on treatment basis.

Gross margin (GM):

This is the difference between the gross farm income (total revenue) and the total variable cost (production cost). The net returns were calculated by subtracting the total variable cost from gross returns and expressed in Naira per hectare (₦ha^{-1}). It is mathematically expressed as: GM = GI – TVC. Where;

GM = Gross margin
GI = Gross income
TVC = total variable cost

Benefit cost ratio:

This is the ratio of gross income to the cost of production. The benefit-cost ratio was worked out by dividing the gross income of each treatment by its total variable cost. It is mathematically expressed as: BCR = GI / TVC. Where;

BCR = benefit-cost ratio
GI = Gross income
TVC = total variable cost

Percentage net returns:

This shows the value of the returns relative to the production cost and is determined by dividing the gross margin by the gross income, then multiplying by 100 and the result expressed in percentage, denoted as %. Mathematically, percentage net returns (% NR) = GM / GI x 100.

3 RESULTS AND DISCUSSION

Production cost, gross income, gross margin and benefit/cost ratio as influenced by cassava/turmeric inter-cropping system

Table 1 shows total variable cost, gross income, gross margin and benefit cost ratio as influenced by cassava / turmeric inter-cropping system. The total variable cost incurred was least in sole cassava plot and increased as the turmeric population density in the inter-crop increased. Maximum cost was incurred by cultivating cassava with the highest turmeric density of 66,666 turmeric plants/ha (30 cm x 50 cm spacing of turmeric), followed by sole turmeric (30 cm x 50 cm spacing). Maximum gross income and gross margin were obtained from inter-cropping cassava with 28,571 turmeric plants/ha (50 cm x 70 cm spacing of turmeric), followed by inter-cropping cassava with 35,714 turmeric plants/ha (40 cm x 70 cm spacing), while the least gross revenue and net income were obtained from the sole turmeric treatment. The maximum benefit-cost ratio was obtained when cassava was inter-cropped with the lowest population density of turmeric (28,571 plants/ha), followed by sole cassava, while the minimum benefit-cost ratio was obtained from sole turmeric. The benefit-cost ratio of sole cassava was higher than the mixture of cassava with 35,714 turmeric plants/ha (40 cm x 70 cm spacing of turmeric) and 40,000 turmeric plants/ha (50 cm x 50 cm spacing of turmeric), even though they had higher gross revenue and gross margin than sole cassava. With respect to net returns, growing cassava with turmeric at the lowest population density of 28,571 turmeric plants/ha gave the highest values per hectare (₦682,081.8 and ₦760,581.8 in 2019 and 2020 cropping, respectively). Sole turmeric produced the least net income (₦228,381.8 and ₦223,381.8 in 2019 and 2020, respectively) which was less than 50 % of the net income from each of the inter-cropped plots and sole cassava.

The percentage net returns of cassava production as affected by cassava / turmeric inter-cropping system

The effect of cassava/turmeric inter-cropping system on percentage net income of joint cassava and turmeric production is as presented in Table 2. Results showed that the inter-crop mixture with the lowest turmeric population density of 28,571 stands/ha produced the highest percentage net return of 62.78 % on the 2 years average, followed by the sole cassava treatment with percentage net return of 60.92 % on the 2 years average. The lowest average percentage net return (29.34 %) was obtained from sole turmeric treatment plot. Generally, percentage net returns decreased as the turmeric population in the inter-crop mixture increased.

DISCUSSION

The higher cost incurred in cultivating turmeric in pure stands at 66,666 plants/ha than the mixture with cassava at lower densities of turmeric was due to the high cost of turmeric planting material. Also, the higher cost incurred in the inter-cropped plots than the sole cassava plot was due to the extra input cost of procuring the turmeric planting material and fertilization. The higher gross income, gross margin and benefit cost ratio obtained when cassava was inter-cropped with 28,571 turmeric plants/ha (50 cm x 70 cm spacing) can be attributed to the higher income from the sales of cassava stem and tuber (Appendix A and B) obtained from that treatment added to the income from the sale of rhizomes from the associating turmeric crop resulting in revenue optimization. This finding conforms with Ikuemonisan and Akinbola (2019) and Sanchi *et al*. (2022).

TABLE 1: The economics of cassava / turmeric intercropping system

	Total variable cost (₦ha^{-1})		Gross revenue (₦ha^{-1})		Net returns (₦ha^{-1})		Benefit cost ratio	
	2019	2020	2019	2020	2019	2020	2019	2020
CA	345,618.20	350,618.20	904,500	900,000	558,881.80	549,381.80	2.62	2.57
TM_0	541,618.20	546,618.20	770,000	770,000	228,381.80	223,381.80	1.42	1.41
$CA+TM_1$	561,618.20	566,618.20	1,059,500	1,033,500	497,881.80	466,881.80	1.89	1.82
$CA+TM_2$	501,618.20	506,618.20	1,023,500	1,107,000	521,881.80	600,381.80	2.04	2.18
$CA+TM_3$	465,618.20	470,618.20	1,027,000	1,063,000	561,381.80	592,381.80	2.21	2.25
$CA+TM_4$	450,218.20	455,218.20	1,100,500	1,146,500	650,281.80	691,281.80	2.44	2.52
$CA+TM_5$	424,418.20	429,418.20	1,106,500	1,190,000	682,081.80	760,581.80	2.61	2.77

See appendices for sources of costs and revenue
KEY:
CA = cassava @ 10,000 plants/ha
TM_1 = turmeric @ 66,666 plants/ha (30 cm x 50 cm spacing)
TM_2 = turmeric @ 50,000 plants/ha (40 cm x 50 cm spacing)
TM_3 = turmeric @ 40,000 plants/ha (50 cm x 50 cm spacing)
TM_4 = turmeric @ 35,714 plants/ha (40 cm x 70 cm spacing)
TM_5 = turmeric @ 28,571 plants/ha (50 cm x 70 cm spacing)
CA_0 = sole cassava @ 10,000 plants/ha
TM_0 = sole turmeric @ 66,666 plants/ha (30 cm x 50 cm spacing)

Table 2: Percentage net returns of cassava production as influenced by cassava/turmeric inter-cropping system.

Treatments	**Percentage net returns (%)**		
	2019	2020	Means
CA	61.79	60.04	60.92
TM_0	29.66	29.01	29.34
$CA+TM_1$	46.99	45.17	46.08
$CA+TM_2$	50.99	54.24	52.62
$CA+TM_3$	54.66	55.73	55.20
$CA+TM_4$	59.09	60.29	59.69
$CA+TM_5$	61.64	63.91	62.78

KEY:
CA = cassava @ 10,000 plants/ha
TM_1 = turmeric @ 66,666 plants/ha (30 cm x 50 cm spacing)
TM_2 = turmeric @ 50,000 plants/ha (40 cm x 50 cm spacing)
TM_3 = turmeric @ 40,000 plants/ha (50 cm x 50 cm spacing)
TM_4 = turmeric @ 35,714 plants/ha (40 cm x 70 cm spacing)
TM_5 = turmeric @ 28,571 plants/ha (50 cm x 70 cm spacing)
CA_0 = sole cassava @ 10,000 plants/ha
TM_0 = sole turmeric @ 66,666 plants/ha (30 cm x 50 cm spacing)

The high benefit cost ratio obtained in sole cassava than the mixture of cassava with 35,714 turmeric plants/ha (40 cm x 70 cm spacing) and 40,000 turmeric plants/ha, even though they had higher gross revenue and net income than the sole cassava, was because of their higher total variable cost compared with that of cassava. The higher gross revenue, net income and benefit cost ratio obtained from cassava inter-cropped with the lowest turmeric population density of 28,571 plants/ha may be attributed to the reduction of extra cost needed to purchase more turmeric rhizomes for planting and reduction of inter-specific competition of the intercrops, which was translated into higher yield of the component crops compared with their yields in the other combinations with higher turmeric densities. This affirms the earlier reports of Abraha (2013); Adeniyan *et al*. (2014) and Amoako *et al*. (2022) that at the right plant population, both inter-specific and intra-specific competitions of intercrops are reduced.

The reduction in percentage net returns of this production system as the turmeric population in the inter-crop mixture increased could be attributed to several factors. Firstly, the high cost of turmeric rhizomes impacted immensely on the production cost of the treatment with higher turmeric population through the extra cash spent on procuring more rhizomes needed for higher population density. Secondly, at higher density of the component crop, intense inter-specific competition begins, resulting in impaired production, consequently impacting negatively on the economic returns of the production system and the extra cost incurred in obtaining the extra planting material for the higher plant population remains unjustified. On the other hand, the higher percentage net returns obtained from the treatment

plot with the lowest turmeric population of 28,571 turmeric plants/ha (50 cm x 70 cm spacing) in the inter-crop suggest that at the right population density, inter-cropping system is highly profitable relative to sole cropping. The increased percentage net returns from this treatment suggest that any technology that boosts production will result in higher revenue and greater gains. This observation agrees with Zengin and Ada (2010);Tepper (2017); Egbide*et al*. (2019) and Al-Hattami*et al.* (2020). Also, the lower percentage net returns obtained from the inter-cropped plots with higher turmeric populations relative to sole cassava suggests that cassava/turmeric inter-cropping system could be counterproductive if the populations of the inter-crops are not appropriately combined.

CONCLUSIONS

This study on the economic returns implications of cassava/turmeric inter-cropping has shown that the economic returns of an inter-cropping production system are dependent on the density of the component crop in the mixture. It was observed that at the highest turmeric population density of 66,666/ha, the production return diminished abruptly below the sole cassava production system. The highest percentage net returns was achieved when the lowest population density of 28,571 turmeric plants/ha was combined with cassava at 10,000 stands/ha. Conclusively, inter-cropping of cassava with 28,571 turmeric plants/ha was optimum for maximum production returns of the inter-crops and is therefore recommended for farmers in the Calabar humid tropical area and its environs.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest associated with the study.

REFERENCES

Abraha, L., 2013. The effect of intercropping maize with cowpea and lablab on crop yield.Herald Journal of Agriculture and Food Science Research, 2: 156-170.

Adeniyan, O. N., Aluko, O. A., Olanipekun, S. O. Olasoji, J. O. and Aduramigba- Modupe, V. O., 2014. Growth and yield performance of cassava/ maize intercrop under different plant population density of maize. Journal of Agricultural Science, 6(8): 35 – 40.

Adeniyan, O. N., Aluko, O. A., Olanipekun, S. O., Olasoji, J. O and Aduramigba-Modupe, V.O. 2014. Growth and yield performance of cassava/maize intercrop under different plant population density of maize. Journal of Agricultural Science, 6:35-40. http://dx.doi.org/10.5539/jas.v6n8p35.

Ajah, E.A., Ofem, U.I.,Effa, E.B. and Ubabuko, L.I., 2022. Analysis of risk management practices among cassava farmers in Ideato South Local Government Area, Imo State, Nigeria. African Journal of Food, Agriculture, Nutrition and Development, 22(3):19871-19885.

Akpan, I. I., Muoneke, C. O. and Okpara, D. A., 2013. Effect of egusi planting density on productivity of egusi / turmeric intercrop in southeastern Nigeria. Asian Journal of Crop Science, 5(1): 41 – 47.

Al-Hattami, H.M.,Kabra, J.D. and Lokhande, M.A., 2020. Reducing costs in manufacturingfirms by using target costing technique. International Journal of Business Excellence, 22(1): 69–82.

Amadi, C., Olojede, A. O. and Obasi, M., 2015. Growth and yield of turmeric in a derived savanna agro-ecology of Nigeria. International Journal of Agricultural Policy and Research, 3(11): 388 – 395.

Amoako, O. A., Adjebeng-Danquah, J., Agyare, R. Y., Tengey, T. K., Puozaa, D. K. and Kassim, B. Y., 2022. Growth and yield performance of cassava under different plant population densities of cowpea in cassava/cowpea intercrop. International Journal of Agricultural Technology, 18(5):1917-1936.

Amosun, J. O. and Aduramigba-Modupe, V. O., 2016. Influence of groundnut populations on weed suppression in cassava-groundnut systems. Journal of Agricultural Science, 8(5): 72 – 78.

Anikwe, M.A. and Ikenganyia, E.E., 2018. Ecophysiology and production principles of cassava (Manihot species) in Southeastern Nigeria.Cassava.Intechopen, 105. DOI: 10. 5772/interchopen.70828

CRBDA, 1995. Cross River Basin Development Authority. News Letter, pp. 1-7.

Egbide, B. C. Eshua, R., Otekunrin, A., Rasak, B., Adewara S. and Oladipo, O., 2019. Cost Reduction Strategies and the Growth of Selected Manufacturing Companies in Nigeria. International Journal of Mechanical Engineering and Technology 10(3): 305–312.

FAO, 2018.Food outlook-biannual report on global food markets-November 2018. Rome. 104 pp. License: CC BY-NC-SA 3.0 IGO. http://www.fao.org/3/ca2320en/CA2320EN

Hauser, S., Wairegi, L., Asadu, C. L. A., Asawalam, D. O., Jokthan, G. and Ugbe, U., 2014. Cassava System Cropping Guide 2015

Revised Edition. African Soil Health Consortium.CABI, Nairobi, Kenya.

Ikuemonisan, E. S., Mafimisebi, T. E., Ajibefun, I., Adenegan, K., 2020. Review of Cassava Production in Nigeria: Trends and Decomposition Analysis Approach. Agricultural Economics Research Paper, 6(2): 102-114.

Ikuemonisan, E.S. andAkinbola, A.A., 2019. Welfare effects of transportation cost and food price volatility in the context of globalization in Nigeria. African Journal of Food Science, 13(6), 111-119.

Islami, T., Wisnubroto, E. I.Utomo, W. H., 2017. Effect of Chemical and Mechanical Weed Control on Cassava Yield, Soil Quality and Erosion under Cassava Cropping System. Journal of Advanced Agricultural Technologies, 4, (1), 57 – 61.

Itam, K.O., Ajah, E.A. and Udoeyop, M.J., 2018. Comparative cost and return analysis of cassava production by adopters and non-adopters of improved cassava varieties among farmers in Ibesikpo Asutan LGA, AkwaIbom State, Nigeria. Global Journal of Agricultural Sciences, 17, 33 – 41.

Mohanty, S., Sonkar, R. K. and Marathe, R. A., 2002. Effect of mulching on Nagpur mandarin cultivation in drought prone region of Central India.Indian Journal of Soil Conservation, 30, 286 – 289.

Nwagwu, F. A., Obok, E. E., Umunnakwe, O.C. and Akpan, J.F., 2023b. Influence of polyethylene film colour and soil solarisation duration on weed dynamics and performance of hybrid maize (Zea mays L.). International Journal of Agricultural Technology, 19(2), 555-580.

Nwagwu, F. A., Ojikpong, T.O. and Umunnakwe, O.C., 2023a. Effect of polyethylene sheet colour and in situ solarization durations on the phytosociological structures of the predominant weeds in the humid environment of southern Nigeria.Journal of Bangladesh University of Agriculture, 21(2), 161-167.

Nwokocha, C. C., Ano, A. O., Njoku, N. R., Korieocha, D. S., Achebe, U., Nwangwu, B. C., Daniel-Ogbonna, C.Uchechukwu, U. N., 2017. Economic potentials of oil palm production and weed control on sustainable turmeric production and selected soil properties in southeastern Nigeria. The Nigerian Agriculture Journal, 48, (1), 249 – 254.

Sanchi, I. D., Alhassan, Y. J. and Sabo, A. Y., 2022. Rising Costs of Farm Inputs and its Implication on 2022 Wet Season Farming in Northwest sub region of Nigeria.Direct Research Journal of Agriculture and Food Science, 10: 144-150. https://doi.org/10.26765/DRJAFS013726489

Singh, S. K. and Singh, P. K., 2015. Intercropping elephant foot yam is an economical cultivation practice for Indian goose berry (Phylanthusemblica) orchard management. New Agriculturist, 26, (2), 357 – 363.

Singh, S. K., Sharma, M. and Singh, P. K., 2016. Combined approach of intercropping and INM to improve availability of soil and leaf nutrients in fruit trees. Journal of Chemical and Pharmaceutical Sciences, 9, (2), 823 – 829.

Tepper, D., 2017. What is the reason for price increase of a product? Retrieved June 12, 2023, from Quora: https://www.quora.com/What-is-the-reason-forprice-increase-of-a-product

Umunnakwe, O. C., Nwagwu, F. A., Onen, B. E. Ekeruke, A. N. and Awelewa, E. A., 2023a. Phytosociological characteristics of the predominant weeds in Calabar, as influenced by cassava density and soil solarization duration. Journal of Agriculture and Environmental Science, 19(1):145-164.

Umunnakwe, O.C., Nwagwu, F. A., Ojikpong, T.O., Awelewa, E. A. and Ebri, B.O.,2023b. Influence of cassava and turmeric intercropping system on phytosociology of predominant weeds in Calabar. Nigerian Agricultural Journal, 54(1), 42 - 48.

Uwah, D. F., Effa, E. B., Ekpenyong, L. E. and Akpan, I.E., 2013. Cassava (Manihot esculenta Crantz) performance as influenced by nitrogen and potassium fertilizers in Uyo, Nigeria. The Journal of Animal and Plant Sciences, 23, 550–555.

Zengin, Y. and Ada, E., 2010. Cost management through product design: target costing approach. International Journal of Production Research, 48(19): 5593–5611.

APPENDIX 1: Components of cost and revenue for cassava / turmeric intercropping experiment in 2019

s/n	Input / output	First planting (2019) Unit	Price (₦)	CA_0 (₦/ha)	TM_0 (₦/ha)	CA + TM_1 (₦/ha)	CA + TM_2 (₦/ha)	CA + TM_3 (₦/ha)	CA + TM_4 (₦/ha)	CA + TM_5 (₦/ha)
	Labour									
1	Clearing	M^2	4.46	44,603.03	44,603.03	44,603.03	44,603.03	44,603.03	44,603.03	44,603.03
2	Tillage	M^2	7.22	72,206.07	72,206.07	72,206.07	72,206.07	72,206.07	72,206.07	72,206.07
3	Planting	MD	2000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00
4	Weeding	M^2	4.46	133,809.07	133,809.07	133,809.07	133,809.07	133,809.07	133,809.07	133,809.07
5	Fertilizer app	MD	2,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00
6	Transportation	-	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00	5,000.00
7	Harvesting	MD	2,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00
	Materials									
8	Stems	Bundle	500.00	20,000.00	-	20,000.00	20,000.00	20,000.00	20,000.00	20,000.00
9	Rhizomes	Kg	200.00	-	240.000.00	240.000.00	180,000.00	144,000.00	128,600.00	102,800.00
10	Fertilizer	Kg	12.50	40,000.00	40,000.00	40,000.00	40,000.00	40,000.00	40,000.00	40,000.00
	TVC			345,618.20	541,618.20	561,618.20	501,618.20	465,618.20	450,218.20	424,418.20
	Yield									
11	Tubers	Ton	10,000.00	471,000.00	-	313,000.00	337,000.00	347,000.00	367,000.00	400,000.00
12	Stems	Bundle	500.00	433,500.00	-	266,500.00	266,500.00	300,000.00	333,500.00	366,000.00
13	Rhizomes	Ton	100,000.00	-	770,000.00	480,000.00	420,000.00	380,000.00	400,000.00	340,000.00
	TR			904,500.00	770,000.00	1,059,500.00	1,023,500.00	1,027,000.00	1,100,500.00	1,106,500.00
	Net returns			558,881.80	228,381.80	497,881.80	521,881.80	561,381.80	650,281.80	682,081.80

KEY:

CA = cassava @ 10,000 plants/ha, TM_1 = turmeric @ 66,666 plants/ha (30 cm x 50 cm spacing), TM_2 = turmeric @ 50,000 plants/ha (40 cm x 50 cm spacing), TM_3 = turmeric @ 40,000 plants/ha (50 cm x 50 cm spacing), TM_4 = turmeric @ 35,714 plants/ha (40 cm x 70 cm spacing), TM_5 = turmeric @ 28,571 plants/ha (50 cm x 70 cm spacing), CA_0 = sole cassava @ 10,000 plants/ha, TM_0 = sole turmeric @ 66,666 plants/ha (30 cm x 50 cm spacing), M^2 = meter square, MD = man-day, Kg = kilogramme, TVC = total variable cost, TR = total revenue, Ton = tonnes, ₦/ha = naira per hectare

APPENDIX 2: Components of cost and revenue for cassava / turmeric intercropping experiment in 2020

		Second year planting (2020)								
s/n	Input / output	Unit	Price (₦)	CA_0 (₦/ha)	TM_0 (₦/ha)	CA + TM_1 (₦/ha)	CA + TM_2 (₦/ha)	CA + TM_3 (₦/ha)	CA + TM_4 (₦/ha)	CA + TM_5 (₦/ha)
	Labour									
1	Clearing	M^2	4.46	44,603.03	44,603.03	44,603.03	44,603.03	44,603.03	44,603.03	44,603.03
2	Tillage	M^2	7.22	72,206.07	72,206.07	72,206.07	72,206.07	72,206.07	72,206.07	72,206.07
3	Planting	MD	2000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00
4	Weeding	M^2	4.46	133,809.07	133,809.07	133,809.07	133,809.07	133,809.07	133,809.07	133,809.07
5	Fertilizer app	MD	2,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00
6	Transportation	-	5,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00
7	Harvesting	MD	2,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00
	Materials									
8	Stems	Bundle	500.00	20,000.00	-	20,000.00	20,000.00	20,000.00	20,000.00	20,000.00
9	Rhizomes	Kg	200.00	-	240.000.00	240.000.00	180,000.00	144,000.00	128,600.00	102,800.00
10	Fertilizer	Kg	12.50	40,000.00	40,000.00	40,000.00	40,000.00	40,000.00	40,000.00	40,000.00
	TVC			350,618.20	546,618.20	566,618.20	506,618.20	470,618.20	455,218.20	429,418.20
	Yield									
11	Tubers	Ton	10,000.00	500,000.00	-	320,000.00	337,000.00	353,000.00	390,000.00	430,000.00
12	Stems	Bundle	500.00	400,500.00	-	233,500.00	300,500.00	300,000.00	366,500.00	400,000.00
13	Rhizomes	Ton	100,000.00	-	770,000.00	480,000.00	470,000.00	410,000.00	390,000.00	360,000.00
	TR			900,000.00	770,000.00	1,033,500.00	1,107,000.00	1,063,000.00	1,146,500.00	1,190,000.00
	Net returns			549,381.80	223,381.80	466,881.80	600,381.80	592,381.80	691,281.80	760,581.80

KEY:

CA = cassava @ 10,000 plants/ha, TM_1 = turmeric @ 66,666 plants/ha (30 cm x 50 cm spacing), TM_2 = turmeric @ 50,000 plants/ha (40 cm x 50 cm spacing), TM_3 = turmeric @ 40,000 plants/ha (50 cm x 50 cm spacing), TM_4 = turmeric @ 35,714 plants/ha (40 cm x 70 cm spacing), TM_5 = turmeric @ 28,571 plants/ha (50 cm x 70 cm spacing), CA_0 = sole cassava @ 10,000 plants/ha, TM_0 = sole turmeric @ 66,666 plants/ha (30 cm x 50 cm spacing}, M^2 = meter square, MD = man-day, Kg = kilogramme, TVC = total variable cost, TR = total revenue, Ton = tonnes, ₦/ha = naira per hectare