

Economic Efficiency and Profitability of Organic Manure-Based Cucumber (*Cucumis sativus* L.) Production Systems in the Humid Rainforest Agroecology of Southeastern Nigeria

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Abstract: *This study evaluated the economic performance of poultry manure, goat manure, and cow dung in cucumber production using secondary economic analysis of aggregated treatment data from field trials conducted in 2018 and 2019 at Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria. The analysis covered two cucumber varieties, CUM 100 and CUM 971, and compared manure treatments with their corresponding no-manure controls. Gross revenue, gross margin, revenue–cost ratio, break-even output price, and incremental gross margin were recalculated from reported yields, farm-gate prices, and total variable production costs. Price and input-cost sensitivity analyses were also conducted to assess the implications of adverse market and production-cost scenarios. Poultry manure recorded the highest calculated gross margins across both varieties and years, ranging from ₦1,852,500 to ₦1,924,500 per hectare in 2018 and from ₦2,667,050 to ₦2,695,050 per hectare in 2019. Its revenue–cost ratios ranged from 3.70 to 3.81 in 2018 and from 4.40 to 4.44 in 2019. Incremental gross margins relative to corresponding controls were consistently positive for poultry manure, while cow dung and goat manure exhibited more variable returns. In a simulated scenario combining a 20% reduction in cucumber selling price with 20% increases in manure and labor costs, poultry-manure treatments retained positive calculated gross margins. The findings support considering poultry manure as the most financially promising of the manure treatments evaluated, given its consistently higher calculated gross margins. The study, therefore, emphasizes cost-conscious adoption, accurate financial record-keeping, and*

market-risk assessment before making broader farmer-facing decisions.

Keywords: *Cucumber production; organic manure; gross margin; revenue–cost ratio; break-even price; sensitivity analysis; Nigeria.*

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1.0 Introduction

Organic manure is often promoted as a soil amendment and a substitute or complement for purchased mineral fertilizers, yet the economically preferable manure source depends not only on biological yield response but also on acquisition, transport, labor, and farm-gate produce prices. In humid southeastern Nigeria, nutrient losses and the costs of competing farm inputs make a decision-oriented economic appraisal pertinent. Onuoha's original agronomic comparison showed favorable productivity under poultry manure, while the associated manuscript already presented gross margins and returns per naira invested (Onuoha, Okpara, & Mbah, manuscript supplied). Accordingly, the present paper does not claim to reproduce a new field trial or a previously unreported primary gross-margin comparison. Its narrower, additional contribution is an audited secondary analysis of economic thresholds and incremental returns from the archived treatment data.

An analytical rationale for farm-enterprise budgeting is provided by Okoruwa, Fregene, and Awolumate (2009), who used partial budgeting to study performance differences among urban

aquaculture systems. Awolumate and Inyang (2019) examined technical efficiency in the use of aquaculture resources, illustrating the distinction between physical productivity and efficient input allocation. Similarly, Awolumate and Inyang (2019) considered profitability and management decisions in aquaculture firms. These papers concern fish enterprises, not cucumber; they support methodological framing and should not be cited as direct empirical evidence about organic manure or cucumber yield. The present objectives were therefore to (i) independently audit the economic values supplied in the thesis; (ii) compare break-even selling prices and revenue-to-cost ratios across manure treatments; and (iii) quantify the incremental benefit of each manure treatment relative to its corresponding variety-specific, year-specific control.

Further Nigerian agribusiness literature provides relevant, though not crop-specific, perspectives on enterprise costs and financial vulnerability. Awolumate and Inyang (2020) examined constraints to value-addition investment in commercial aquaculture, while Awolumate and Iniobong (2021) addressed risk factors associated with these investments. Awolumate and Muiyiwa (2025) focused on financial constraints and profitability among small-scale fish processors. These studies justify considering investment constraints, production expenses and adverse cost movements when interpreting cucumber enterprise budgets; their findings should not be presumed to apply quantitatively to cucumber farmers without additional evidence.

The organisation of agricultural enterprises also warrants attention beyond simple gross-margin comparison. Awolumate (2018) studied cooperative extension support for mobilising productive resources among low-resource women farmers, and Awolumate and Ashiedu (2026) examined productivity and profitability responses associated with cooperative-based institutional support in aquaculture. Such research identifies useful questions for future cucumber studies regarding collective procurement, resource access and advisory

services, although no cooperative treatment was measured in the present cucumber experiment.

2.0 Materials and Methods

2.1 Study setting, treatments and data provenance

The underlying agronomic trials were conducted at the Teaching and Research Farm, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria, during 2018 and 2019. The treatment structure was a 2×4 factorial in a randomised complete block design, with three replicates, comprising cucumber varieties CUM 100 and CUM 971 and manure sources poultry manure, goat manure, cow dung and a no-manure control. The manures were applied at 10 t/ha in the direct-application experiment. Trial details and the primary growth and yield analyses appear in Onuoha's thesis and the existing manure manuscript. This paper uses only aggregated data from thesis Tables 4.16 and 4.17 (treatment yield, stated total variable production cost, and farm-gate price).

2.2 Derived economic indicators

For treatment i : gross revenue (GR_i) = yield (t/ha) $\times$ farm-gate price (₦/t); gross margin (GM_i) = GR_i – stated variable production cost (TVC_i); revenue–cost ratio (RCR_i) = GR_i/TVC_i ; break-even output price (BEP_i) = TVC_i/yield (₦/t). Relative to the untreated control of the same variety and year, incremental cost $\Delta TVC = TVC_i - TVC_{\text{control}}$, incremental revenue $\Delta GR = GR_i - GR_{\text{control}}$, and incremental gross margin $\Delta GM = \Delta GR - \Delta TVC$. These are deterministic transformations of published treatment aggregates, not measurements from independent experimental units. “Economic efficiency” here denotes observed cost–revenue performance rather than statistically estimated technical or allocative efficiency.

2.3 Data validation and limits

The source tables contain discrepancies between stated revenues, costs and selected gross margins. For consistency, all revenue and gross-margin values were recomputed from the listed yields, unit prices and total costs, without modifying the recorded treatments. For example, 2018 CUM



100 poultry gross margin recalculates to ₦1,852,500 (₦2,538,000 – ₦685,500), not ₦1,825,500 as printed. The 2019 CUM 971 cow-dung margin recalculates to ₦1,718,850 (₦2,436,000 – ₦717,150), not ₦1,107,500. Cost entries should be reconciled with the original records before journal submission. No p-values or confidence intervals were generated for economic outcomes because raw plot-level observations were not supplied.

3.0 Results and Discussion

3.1 Results

3.1.1 Audited economic indicators

Table 1 summarises the corrected derived economic measures. Poultry manure had the greatest gross margin in both varieties and both seasons, but this observation is limited to the historical farm-gate prices and listed input costs.

Table 1a: Audited treatment economics, 2018

Variety	Manure	Yield t/ha	Cost ₦	Gross margin ₦	RCR	Break-even ₦/t
CUM 100	Control	10.9	423,900	230,100	1.54	38,890
CUM 100	Poultry	42.3	685,500	1,852,500	3.70	16,206
CUM 100	Goat	23.0	652,000	728,000	2.12	28,348
CUM 100	Cow dung	23.6	596,500	819,500	2.37	25,275
CUM 971	Control	15.4	423,900	500,100	2.18	27,526
CUM 971	Poultry	43.5	685,500	1,924,500	3.81	15,759
CUM 971	Goat	20.2	652,000	560,000	1.86	32,277
CUM 971	Cow dung	28.4	596,500	1,107,500	2.86	21,004

Table 1b: Audited treatment economics, 2019

Variety	Manure	Yield t/ha	Cost ₦	Gross margin ₦	RCR	Break-even ₦/t
CUM 100	Control	30.6	493,000	1,649,000	4.34	16,111
CUM 100	Poultry	49.3	783,950	2,667,050	4.40	15,902
CUM 100	Goat	34.0	717,160	1,662,840	3.32	21,093
CUM 100	Cow dung	32.6	717,150	1,564,850	3.18	21,998
CUM 971	Control	28.7	493,000	1,516,000	4.08	17,178
CUM 971	Poultry	49.7	783,950	2,695,050	4.44	15,774
CUM 971	Goat	35.4	717,160	1,760,840	3.46	20,259
CUM 971	Cow dung	34.8	717,150	1,718,850	3.40	20,608

3.1.2 Incremental gross-margin comparison

Relative to the matching untreated plots, the manure options provided the incremental gross margins shown in Table 2. Positive values indicate that the measured additional produce revenue exceeded the additional recorded treatment cost; they do not imply statistically significant treatment effects.

3.1.3 Baseline accounting thresholds

The break-even prices are accounting thresholds: at the recorded treatment yield, a price above BEP would cover the listed variable costs. They are not

a full cost-of-production break-even because they do not separately account for land rent, depreciation, finance charges, or other fixed or opportunity costs. A useful decision rule is $\Delta GM = (\text{yield}_{\text{treatment}} - \text{yield}_{\text{control}}) \times \text{selling price} - (\text{TVC}_{\text{treatment}} - \text{TVC}_{\text{control}})$. Thus, relative advantage can change as input prices, selling prices and attainable yields change. No prospective price forecasts have been inferred from historical prices.

3.1.4. Formal price, manure-purchase and labour-cost sensitivity analysis



The baseline uses the historically recorded 2018 and 2019 crop yields and the audited total-cost estimates in Tables 1a–1b. For each treatment, revenue is calculated as $Y \times P$, where Y is yield ($t\ ha^{-1}$) and P is the historical cucumber price (₦60,000 t^{-1} in 2018; ₦70,000 t^{-1} in 2019). The source thesis cost schedules (two original cost tables) separately identify manure purchase and labour expenditures. Manure purchase costs were ₦200,100 (poultry), ₦166,600 (goat) and

₦111,100 (cow dung) in 2018, and ₦233,450, ₦166,600 and ₦166,650, respectively, in 2019. The stated manure-treatment labour totals were ₦285,500 in 2018 and ₦307,500 in 2019, while the no-manure labour totals were ₦223,500 and ₦250,000. These component entries are held distinct from the audited baseline totals, because certain line-item sums do not precisely reconcile with the thesis aggregate treatment costs.

Table 2. Incremental returns compared with the variety-specific no-manure control

Year	Variety	Manure	Added revenue ₦	Added cost ₦	Δgross margin ₦
2018	CUM 100	Poultry	1,884,000	261,600	1,622,400
2018	CUM 100	Goat	726,000	228,100	497,900
2018	CUM 100	Cow dung	762,000	172,600	589,400
2018	CUM 971	Poultry	1,686,000	261,600	1,424,400
2018	CUM 971	Goat	288,000	228,100	59,900
2018	CUM 971	Cow dung	780,000	172,600	607,400
2019	CUM 100	Poultry	1,309,000	290,950	1,018,050
2019	CUM 100	Goat	238,000	224,160	13,840
2019	CUM 100	Cow dung	140,000	224,150	-84,150
2019	CUM 971	Poultry	1,470,000	290,950	1,179,050
2019	CUM 971	Goat	469,000	224,160	244,840
2019	CUM 971	Cow dung	427,000	224,150	202,850

The one-way tests vary cucumber prices by -30%, -20%, -10%, +10%, +20% and +30% while holding yield and cost constant. Manure-purchase and labour-cost schedules are separately shocked by +10%, +20% and +30% (and equivalent decreases for symmetry). Shock magnitudes are transparent stress-test assumptions, not measured historical changes or projections. FAO farm-systems guidance explicitly supports varying prices and selected production costs relative to a base budget. A 2025 Nigeria cucumber farm survey identifies labour as a major cost, and a 2026 Nigerian cucumber assessment reports vulnerability of margins to selling-price reductions; however, those studies are not treated as directly transferable Umudike prices or wages.

For treatment i and sensitivity scenario s : $GM(i,s) = Y(i) \times P(\text{base}) \times (1 + \delta P) - [C(\text{base},i) + M(i) \times \delta M + L(i) \times \delta L]$; where C is the independently

audited baseline budget, M is the thesis manure-purchase entry (zero for control), and L is the thesis labour entry. For a simultaneous adverse case, $\delta P = -0.20$ and $\delta M = \delta L = +0.20$. This is a deterministic comparative-static analysis; crop yield, farm size, marketing channels and quality are assumed unchanged. It does not estimate production functions, stochastic downside probabilities, current-day profit, or statistical significance.

3.1.5. Interpretation of sensitivity outcomes

In 2018, the poultry-manure gross margin under the joint adverse scenario ranged from ₦1,247,780 to ₦1,305,380 across CUM 100 and CUM 971, compared with baseline ₦1,852,500–₦1,924,500. The calculations quantify a budget exposure to price and input shocks without claiming that such shocks occurred during the trial.



In 2019, the poultry-manure gross margin under the joint adverse scenario ranged from ₦1,868,660 to ₦1,891,060 across CUM 100 and CUM 971, compared with baseline ₦2,667,050–₦2,695,050. The calculations quantify a budget exposure to price and input shocks without claiming that such shocks occurred during the trial.

The effect of a 20% price reduction equals 20% of the original treatment revenue, whereas a 30% cost increase applies only to the respective manure and labor components. Consequently, cross-treatment differences in downside gross margin reflect both original yield and original cost composition

Table 3.: One-way and combined adverse scenario gross margins (₦/ha, nominal historical budgets)

Year	Variety	Source	Base GM	Price –20%	Manure +30%	Labour +30%	Joint –20/+20/+20
2018	CUM 100	Control	230,100	99,300	230,100	163,050	54,600
2018	CUM 100	Poultry	1,852,500	1,344,900	1,792,470	1,766,850	1,247,780
2018	CUM 100	Goat	728,000	452,000	678,020	642,350	361,580
2018	CUM 100	Cow dung	819,500	536,300	786,170	733,850	456,980
2018	CUM 971	Control	500,100	315,300	500,100	433,050	270,600
2018	CUM 971	Poultry	1,924,500	1,402,500	1,864,470	1,838,850	1,305,380
2018	CUM 971	Goat	560,000	317,600	510,020	474,350	227,180
2018	CUM 971	Cow dung	1,107,500	766,700	1,074,170	1,021,850	687,380
2019	CUM 100	Control	1,649,000	1,220,600	1,649,000	1,574,000	1,170,600
2019	CUM 100	Poultry	2,667,050	1,976,850	2,597,015	2,574,800	1,868,660
2019	CUM 100	Goat	1,662,840	1,186,840	1,612,860	1,570,590	1,092,020
2019	CUM 100	Cow dung	1,564,850	1,108,450	1,514,855	1,472,600	1,013,620
2019	CUM 971	Control	1,516,000	1,114,200	1,516,000	1,441,000	1,064,200
2019	CUM 971	Poultry	2,695,050	1,999,250	2,625,015	2,602,800	1,891,060
2019	CUM 971	Goat	1,760,840	1,265,240	1,710,860	1,668,590	1,170,420
2019	CUM 971	Cow dung	1,718,850	1,231,650	1,668,855	1,626,600	1,136,820

****Price is reduced by 20% in column 5, manure expenditure increases 30% in column 6, and labour expenditure increases 30% in column 7, each independently. Last column combines –20% price with +20% manure and +20% labour. All other conditions, including yields, are fixed. Values are calculated from the thesis baseline budgets and cost components; they are scenarios, not observed outcomes.**

Table 4. Incremental threshold for a joint 20% manure and labour cost increase

Year	Variety	Source	Break-even price ₦/t	% of historical price
2018	CUM 100	Poultry	18,502	30.8%
2018	CUM 100	Goat	32,279	53.8%
2018	CUM 100	Cow dung	28,636	47.7%
2018	CUM 971	Poultry	17,991	30.0%
2018	CUM 971	Goat	36,753	61.3%



2018	CUM 971	Cow dung	23,796	39.7%
2019	CUM 100	Poultry	18,096	25.9%
2019	CUM 100	Goat	23,882	34.1%
2019	CUM 100	Cow dung	24,907	35.6%
2019	CUM 971	Poultry	17,951	25.6%
2019	CUM 971	Goat	22,937	32.8%
2019	CUM 971	Cow dung	23,333	33.3%

The simulated margins should not be extrapolated to contemporary Nigeria without rebasing labor wages, manure prices, cucumber farm-gate prices, unit conventions, and inflation.

3.1.6. Secondary-source context and transferability limits

FAO (2024) defines gross margins from output valued at field prices minus relevant variable costs and recommends sensitivity testing of uncertain returns and costs. Okonkwo-Emegha (2025) reports cucumber labor and production expenditures in Delta State (2024 field survey), supporting the examination of the labor-cost channel, rather than substituting those figures for the Umudike field trial. Nwadiolu et al. (2026) document cucumber profit sensitivity to output-price changes in Delta State; their enterprise sample and data differ materially from the Onuoha experimental plots. Price levels and farm units across studies are not pooled. The external studies guide the design of the sensitivity stress tests only.

3.2 Discussion

The repeated advantage of poultry manure in calculated gross margins reflects high treatment yields that outweighed higher variable costs in the historical accounts. However, the proper managerial question is incremental profitability, not yield alone. As emphasised by the partial-budgeting orientation of Okoruwa et al. (2009), changes in costs and returns should be evaluated jointly. Likewise, distinctions between physical resource productivity and efficiency analysis are important: Awolumate and Inyang (2019a) provide an example of technical-efficiency research in fish farming, but the present aggregate data are insufficient for stochastic

frontier analysis or data envelopment analysis. We therefore restrict the claim to transparent financial ratios and incremental margins.

The economic findings remain dependent on a single location, two seasons, two varieties and the specified historical input-price structure. The source manure manuscript already reported the superiority of poultry-manure profitability; this secondary analysis adds an audit trail, break-even prices and incremental comparisons rather than asserting those agronomic or gross-margin observations as newly discovered. The source gross-margin misprints underscore the importance of financial-data quality assurance. Before submission, researchers should verify labour and input-cost source records, assess whether the figures include every variable expense, and where feasible reconstruct plot-level revenues and expenses to quantify uncertainty.

The dependence of economic performance on input costs, infrastructure and management conditions may also be considered in relation to Awolumate, Shani and Okhogbe (2026), whose urban aquaponics research addresses energy–water–profit trade-offs under electricity unreliability. The production system and technologies differ from rainfed field cucumber cultivation; accordingly, this citation is used only to motivate explicit accounting for production-system constraints, not to infer a specific energy effect in the Umudike trials.

On the output side, market access and information are relevant to the scenario analysis. Awolumate (2026) investigated digital market information and smallholder fish supply-chain performance. This provides a cross-sector rationale for considering farm-gate price uncertainty, but cucumber price elasticity, marketing margins and digital-



market participation were not measured in the thesis. The price shocks modelled here are illustrative changes to the historical base price, not externally observed cucumber price fluctuations.

4.0 Conclusion

Using recalculated aggregated figures from the 2018–2019 Umudike trials, poultry manure at the studied application rate produced the largest gross margin in the historical dataset for both cucumber varieties and both years. Additional break-even and incremental-return indicators show how that result depends on costs, yields and market prices. These findings do not establish technical efficiency or generalisable statistically significant economic superiority. A journal-ready contribution requires checking the recorded costs against primary records and clear disclosure that this is a secondary economic analysis of a previously reported experiment. Deterministic testing shows that price reductions may erode treatment margins substantially, while manure and labour costs create separately identifiable budget exposure. Under the illustrative joint adverse scenario, poultry-manure budgets retain positive gross margins, conditional on original yields and all omitted costs. The analysis should be revisited with reconciled primary accounts and current local input and output prices before farmer-facing recommendations.

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Ethical Considerations

Not applicable

Author Contributions

All components of the work were written by the author.

