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Economic Analysis of Bell Pepper Cultivated under Screen House Production System in Ondo State, Nigeria

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Abstract
Production under protected cultivation systems such as greenhouses and screen houses is a technique for regulating the environmental factors for the benefit of the plants (bell pepper) under a controlled atmosphere situation. This study assessed the economic feasibility of bell pepper production under the screen house system, focusing on cost analysis and profitability indicators. Data were obtained from farm records and the operational system of a screen house production system in the Akure North area of Ondo State. Data collated were obtained from four production cycles during two years (2022 and 2023 production seasons). The findings reveal that while the initial investment in infrastructure represents a significant portion of total costs, the overall net benefit and efficiency of the production system are favorable. With an average investment of N3,417,500 per production unit, the annual total cost of production was N1,447,417, resulting in a net benefit of N5,752,583.33 per unit and an impressive profit margin of 80%. The Benefit to Cost Ratio (BCR) exceeding 1 indicates the efficiency of the system, with every N1 invested yielding a N4.97 return. Recommendations include policymakers incentivizing infrastructure investments, reducing variable costs through targeted support programs, and promoting climate-smart agricultural practices. By leveraging the positive economic indicators and profitability of the screen house system, policymakers can implement interventions such as subsidies, credit access, and technical assistance to facilitate the adoption and scaling up of similar high-value crop production systems, ultimately enhancing agricultural productivity, farmer income, and food security.

Keywords: Bell pepper, greenhouse, profitability, protected cultivation, benefit-cost ratio.

Introduction

The agricultural production system in Africa is faced with a myriad of problems, including climate change, edaphic factors and ecological and biotic factors (pests and diseases). The majority of crop production systems depend on natural or rainfed production system, with a consequent effect on yield limitation. To achieve competitive production, farmers must be able to manage their farms to mitigate the effect of those limiting factors that prevent their crops from attaining the potential yield as dictated by the genetic composition. The most limiting factor of production usually determines the crop performance, as expressed by Leibig's law of minimum. Hiddink and Kaiser (2005) stated that the growth of a species is determined by the most limiting resources. In the face of the current challenges with climate change, farmers can shift to more climate-smart production systems under controlled or partially controlled production systems, as in the case of greenhouse or screen house production systems. These systems are often referred to as controlled atmosphere agriculture (CEA). Greenhouse farming is one of the options for combating food insecurity in Nigeria (Abimbola *et al*., 2013). Greenhouse, a protected cultivation system, make use of advanced production systems using scientific methods and technology to provide suitable climatic conditions for growing crops outside their normal times or seasons (Mohammed and Dulamin, 2021). This system of production is gaining popularity and contributes to sustainable vegetable production with improved quality due to the intensification of the production system. There has been a rapid increase in the cultivation of high-value vegetables such as pepper, tomatoes, and other exotic vegetables in the tropics. Greenhouse farming is affirmed as one of the promising production techniques for vegetable (Reddy *et al.,* 2022).

Capsicum (*Capsicum spp*) is grown as a vegetable or spice in tropical and subtropical regions of the world (Reddy *et al*., 2022). Pepper is an annual vegetable crop which ranks next to potatoes and tomatoes in order of production. It belongs to the family *Solanaceae* and genus *Capsicum* which comprises 20-30 species.

Pepper grows in most countries and covers 1.93million ha (FAOSTAT, 2022). Using culinary and organoleptic features, pepper fruits are classified into Bell pepper (sweet pepper) and Chilli pepper (De, 2003). Sweet pepper (*Capsicum annum* L.), commercially known as bell pepper, it is an annual herb or shrub, 0.5-1.5m tall, erect and highly-branched crop with fruits harvested at green mature stage or at red and/or yellow ripened stage. Pepper is cultivated extensively under rain-fed conditions but the soil moisture and thermal stresses in dry season affect for crop performance (Tombesia *et al*., 2018, Agele, 2021). The inability to meet this moisture requirement through rainfall necessitated the use of irrigation to support the production during such period. The use of greenhouse is becoming a popular farming system among pepper farmers. Greenhouses are reported to increase crop yields by as much as two to five times as plants grown under open field conditions; the quality of the product is normally higher than in open fields and the incidence of pests and diseases is reduced (Olatunji and Akeem, 2002).

With challenges experienced in the availability of vegetable crops, especially pepper and tomatoes and the associated high prices in recent years, vegetable production in the Southwestern part of Nigeria has increased. Ondo State has become a growing hub of vegetable production in the Southwest Nigeria, especially tomato and pepper. This is not only supporting the local market, but marketers from Lagos, Edo, and Delta States also source their fresh vegetables from the state. However, the majority of the tomatoes and peppers are produced under an open-field production system with some little supplemental irrigation in the dry season. The unstable pattern of the weather and climate change often results in losses when unexpected rain cessation occurs. The use of protected cultivation or partially protected cultivation in the state is becoming visible in some parts of the state but the adoption of such a farming system is still low due to the initial high cost of investment. The profitability of greenhouse farming depends on some factors, including the types of crop grown, the location of the greenhouse, and the cost of construction and operation, and the market for the produce. Greenhouse production has been reported to be more productive or increase crop yield than open field production by as much as two to five times. Marcelis *et al.* (2018) attribute increased productivity of crops in greenhouses to more precise control of growth conditions. The climate control possible with these structures enables extending the crop cycle and increasing production beyond the normal season (Romeo-Gamez *et al*., 2012). Crop Production in the greenhouse or screen house is a capital-intensive process technology (Kumar *et al*., 2016; Prakash *et al.,* 2020) that requires substantial initial capital outlay/investment. Peet *et al*. (2005) asserted that greenhouse production is more expensive than producing the same crop in an open field. However, investment in the greenhouse could be recovered within a short period of time as asserted by Abimbola *et al*., 2013. The most important factors determining costs are depreciation of the structure and equipment and variable costs such as labour, energy, planting material, substrate, and fertilizer (Olatunji and Akeem, 2022). The study was conducted to examine the cost components and profitability of growing bell peppers under a screen house production system (a naturally ventilated greenhouse equipped with a drip irrigation facility) in Ondo State, Nigeria.

Methodology

The data for the study were obtained from a screen house farm located in the Akure suburb (coordinates: 7.266, 5.317). Akure, Ondo State, is a cosmopolitan city located in the humid rainforest zone of the Southwestern part of Nigeria and surrounded by a number of agrarian communities. The operational system of the farm was monitored for two years when production started. Data were collected regularly from the records of production and sales from the farm. The farm site where data were collected comprises four production units of screen houses, each measuring 10 × 30 m (300m^2). Data were obtained on the cost of investment, cost of production, outputs, and price for the production cycle. One crop cycle of bell pepper production in a screen house takes 5- 6 months and hence, two cropping cycles are obtainable in a year. For this study, records of two years of production (four production cycles covering the 2022 and 2023 production seasons) were obtained and documented, and average values were presented. Data used were actual data extracted on the cost of investment (cost of fabrication and other components), and variable costs (inputs, labour, energy, and other variable costs in the current price obtainable). Average prevailing crop prices for were used. Total revenues (gross income) for the number of production were estimated from output and price. Variable costs were the computed cost of production. Profit margins, a magnitude of excess income over total cost, were estimated. Formulae for estimating economic indices used were:

1. Total Variable Cost (TVC) = Labor cost + Cost of inputs + other operating cost
2. Total Cost (TC) = Total Variable Cost (TVC) + Fixed Cost (FC)
3. Gross return/revenue = Average yield/ha x farm gate price (N/kg)
4. Net Benefit (NB) = Total Revenue (TR) – Total Cost (TC)
5. Benefit to Cost Ratio (BCR) = $\frac{\text{Total revenue TR)}}{\text{Total Cost (TC)}}$
6. Profit Margin (%) = $\frac{\text{Net Benefit (NB)}}{\text{Total Revenue (TR)}}$

Table 1 shows the cost of investment in infrastructure required for production under the screen house system. 79% of the cost is for the fabrication of the main protected structure. An average of N3, 417,500 is invested per production unit set up. The variable cost comprising the cost of inputs, labour cost and other operation costs averaged N1, 082,000 per year (Table 2).

The cost of inputs constituted 53.33% of the variable cost while 30.5% of the cost was spent on labour. The cost of soluble fertilizers deployed in weekly fertigation constituted 30.22% of the variable cost while the cost of plant protection chemicals (pesticides) constituted approximately 10.9%. The yield (which depends on the plants' response as affected by micro-climate fluctuation with season and management such as irrigation, pest and other agronomic management practices) obtained under the production system per unit of production (300 square meters screen house unit) averages 2000 kg of marketable fruits of bell pepper per cycle. The annual total cost of production per production unit was N1, 447,417 while the net benefit per production unit was N5, 752,583.33. A positive net benefit was recorded from the bell pepper production under the screen house. The benefit to cost ratio (BCR) obtained was greater than 1 and indicates an efficient production system. By implication, for every N1 invested into the enterprise, a **N**4.97 return or benefit is obtained. The annual profit margin of the production enterprise expressed in percentage is 80%.

The high upfront cost of investment in infrastructure, specifically in the fabrication of the main protected structure, accounts for a substantial portion of the total investment required per production unit. Policymakers could explore ways to incentivize or subsidize such infrastructure investments to promote the adoption of modern agricultural practices like the screen house system among farmers. This can help improve productivity and overall agricultural output. Understanding the composition of variable costs, including inputs, labour, soluble fertilizers, and plant protection chemicals, can guide policymakers in developing targeted support programs. For instance, providing access to affordable and high-quality inputs, training programs to enhance labor efficiency, and promoting sustainable pest management practices can help reduce variable costs for farmers and improve overall profitability. The dependency of yield on factors such as micro-climate fluctuations, irrigation, and pest management practices underscores the importance of climate-resilient agriculture. Policymakers may consider investing in research and development initiatives to develop climate-smart agricultural practices, resilient crop varieties, and effective irrigation strategies to mitigate risks associated with climate variability and enhance production stability. The positive net benefit, efficient production system indicated by the Benefit to Cost Ratio (BCR) exceeding 1, and high annual profit margin of 80% highlight the economic viability of bell pepper production under the screen house system. Policymakers could leverage this information to promote the adoption of similar high-value, profitable crop production systems to enhance farmer income and economic sustainability in the agricultural sector. Given the favorable economic indicators and profitability of the screen house production system, policymakers could consider implementing targeted policy interventions such as subsidies, access to credit, technical assistance, and market linkages to incentivize and support farmers in transitioning to or scaling up such production systems. These measures can contribute to enhancing agricultural productivity, income generation, and food security at both the individual farm and national levels.

Conclusion

Cultivation of high-value vegetable crops in greenhouses is profitable in spite of the initial higher cost of investment. Bell pepper production in greenhouses is found profitable with a high benefit-cost ratio and profit margin. The study highlights the economic viability and profitability of bell pepper production under the screen house system. Recommendations derived from the study include policymakers exploring ways to incentivize or subsidize high upfront infrastructure investments to promote modern agricultural practices like the screen house system. Policymakers can also develop targeted support programs to reduce variable costs by providing affordable inputs, training programs for labor efficiency, and promoting sustainable pest management practices. Moreover, investing in research and development for climate-smart agricultural practices can help mitigate risks associated with climate variability and enhance production stability. Leveraging the positive net benefit, efficient production system, and high profit margin indicators, policymakers could promote the adoption of similar high-value crop production systems to enhance farmer income and economic sustainability in the agricultural sector. Implementing targeted policy interventions such as subsidies, access to credit, technical assistance, and market linkages can incentivize and support farmers in transitioning to or scaling up production systems like the screen house, ultimately contributing to increased agricultural productivity, income generation, and food security at both the individual farm and national levels.

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Table 1: Cost of fabrication and installation of screen house structure and associated fixed assets (four production units)

S/n	Particulars	Cost (₦)	% of total cost	Estimated useful life (year)	Depreciation (₦)
i	Screen house main structure fabrication and installation	10,800,000	79.01	10	1080000.00
ii	Drip irrigation kit and installation	1,080,000	7.90	5	216000.00
iii	Irrigation water storage reservoir	240,000	1.76	10	24000.00
iv	Tank stand	400,000	2.96	15	26666.67
v	Water sourcing (well and pump)	600,000	4.39	10	60000.00
vi	Water reticulation and materials	200,000	1.46	10	20000.00
Vii	Generator	350,000	2.56	10	35000.00
	Total	**13,670,000**	**100**		**1,461,666.67**
	Average cost of fabrication and installation per unit of screen house (production unit)	**3,417,500**			
	Average Depreciation cost per production unit				**365,416.67**

Table 2: Variable cost of production of bell pepper in four production units screen house

S/n	Particulars	Cost (₦)	Cost (₦)	% contribution	
1	**Variable cost**				
A	Cost of inputs				
I	Seeds	108,000	216,000	4.92	
Ii	Potting mixture	36,000	72,000	1.64	
Iii	Plant protection chemicals (pesticides)	236,000	472,000	10.76	
Iv	Soluble fertilizers	654,000	1,308,000	29.81	
V	N.P.K. 15.15.15 fertilizer	40,000	80,000	1.82	
Vi	Manure	24,000	48,000	1.09	
Vi	Staking rope	56,000	112,000	2.55	
	sub-total (A)	1,154,000	2,308,000		
B	Cost of labour				
I	Operation labour (2 permanent staff @25,000/month)	300,000	720,000		16.64
Ii	Agronomist cum manager (1 @ 50,000/month)	300,000	600,000	13.86	
	sub-total (B)	600,000	1,320,000		
C	Other operating cost				
I	Cost of fuelling +lubricants for generator	220,000	440,000	4.62	
Ii	Marketing cost (packaging bags + local transport)	80,000	200,000	1.39	
Iii	Rent		60,000		
	Sub-total (C)	300,000	700,000		
	Total Variable Cost (A+B+C)	**2,054,000**	**4,328,000**	100.00	
	Average TVC per unit of screen house (production unit)	**513,500**	**1,082,000**		

Table 3: Returns from bell pepper production in four production units of screen house

S/n	Particulars	Annual Returns for four production units
i	Yield (kg) per production (2000kg/unit of production)	16,000.00
ii	Price per kg (₦)	1,800.00
iii	Total Revenue (₦): TR	28,800,000.00
iv	Total Variable cost (₦): TVC	4,328,000.00
v	Fixed Cost (depreciation): FC	1,461,667
vi	Total Cost (₦): TVC +FC	5,789,666.67
vii	Average TC per unit of screen house (production unit)	1,447,417
viii	Net benefit (₦): NB	23,010,333.33
ix	Average net benefit (₦) per production unit of screen house	5,752,583.33
x	Profit margin (%)	0.80
xi	Benefit to cost ratio (BCR)	4.97