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ANALYSIS OF HONEY PRODUCTION: A CASE STUDY OF APIARY UNIT, FEDERAL COLLEGE OF FORESTRY, JOS, PLATEAU STATE, NIGERIA

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ABSTRACT

Beekeeping is a sustainable form of agriculture that can supplement rural income and nutrition requirements, while sustaining the natural habitat or modifying it; this agroforestry practice can be integrated into many farming systems. However, there is gross underutilization and inadequate exploitation of bee keeping potentials in most farming communities in the country. This study therefore analyzes honey production at the apiary unit, Federal College of Forestry, Jos, Plateau State of Nigeria. Secondary data collected for the study covers the period from 2013 to 2017.Measures of central tendency, cointegration test, regression analysis and elasticity of production were the analytical techniques adopted. The results revealed that 72 man-days of labour were employed at the apiary unit; the apiary had15 active hives; the unit cost per langstroth hive was ₦30,000. Also, the estimated cost for apiary kitswas ₦12,000.Furthermore, cointegration exists among the variables, hence the Trace Statistic value of 77.2 > the critical value of 58.31 and 64.49 at 5% and 1% level of significance. The estimated coefficient of multiple determination (R^2) was 0.621. The estimated value of returns to scale was 0.13 ($\sum\rho<1$); indicating a decreasing returns to scale. Moreover, the following constraints affected honey production at the apiary unit; cost of modern hives and technology (0.5); inadequate capital (0.5); inadequate labour supply (0.5); inadequate baiting materials (0.3); environmental factors (0.3) and post-harvest techniques in honey production (0.16); as indicated by their respective mean score index. Consequently, improved budgetary provisions and funding of apicultural activities; adequate supply of labour and baiting materials; adoption of techniques to mitigate environmental effects and appropriate storage and processing facilities to ensure sustainable honey production and quality over long periods are strongly recommended.

Keywords: apiculture, cointegration, constraints, determinants, production elasticity

Introduction

The Science of Bee-keeping is known as Apiculture. Apiculture can be defined as the science and art of bee keeping while bee keeping includes the collection and taking care of bees, pollination of field crops by the bees, the study of bee products and the breeding of bees for honey and wax production either in small or large scale (Vural and Karaman, 2010). Apiculture which is an aspect of agriculture presents an untapped natural resource that will help diversify farm household income in a dwindling economy and alleviate poverty (Ubeh and Nwajiuba, 2005). Beekeeping for honey and wax production is a profitable agricultural enterprise (Vural and Karaman, 2010). It is an important foreign exchange earner for those that export honey and bee wax. This Agro Forestry System can be integrated into many farming systems. It is best practiced in fallow farm systems. Apiculture is one of the most widespread agro forestry activities that are practiced all over the world. It has been reported that over 56 million bee hives exists in the world and 1.2 million tons of honey is produced from these hives (Technical Center for Agriculture (CTA), 2005).Forests provide adequate bee-forage in terms of both quality and quantity of nectar and pollen grains. For this reason, bee-keeping also has the potential to increase opportunities for forest conservation (Sanford, 2009). When promoted among forest adjacent communities, beekeeping provides reliable livelihood options (Timmer and Juma, 2005; Nicolas, 2004).

Overall, the value of natural honey exports fell by an average of -14.4% for all exporting countries since 2015 when natural honey shipments were valued at $ 2.3billion. Year over year, global exports of natural honey decreased in value by - Following the production trends, 12.5% from 2018-2019 (Chain *et al.*, 2018). Among continents, European countries exported 42.1% of overall international honey sales. That percentage compares with 24.4% from Asian exporters, 13.5% from Latin America and 3% from Oceania. Smaller percentages come from North Africa (6%) and Africa (0.5%) (Bhatta, *et al.*, 2020). The three top countries that exported natural honey in 2019 include; china (11.8%), closely followed by New Zealand (11.5%) and Argentina(7.4%)(Bhatta, *et al.*, 2020).Commercial bee keepers in developed countries using modern techniques harvest an average of about 50 liters of honey per hive and the international market price per liter of honey is about U.S $4 (Ayansola, 2012). However, in Nigeria an average of 15 litres is attainable per hive under ideal conditions (Ayansola, 2012). It is a profitable and healthy form of livelihood to a large number of people; it is of considerable importance in the economies of both developed and developing countries (Fadere *et al.*, 2008). The experiences of apiculturist in developed economies show that commercial apiculture is a money spinner. However, beekeeping as a commercial venture is still largely unexplored in Nigeria, and the country meets most of its domestic demand for honey by importation from producer countries and locally from small scale bee keepers (Ayansola, 2012). Bees, the main player in Bee-farming are four winged flower feeding insects. They are important and beneficial economic insects, as they produce honey, wax and pollinate crops. Honey is a natural food produced by bees from nectar or secretion of flowers. Honey has a content of 80-85 % carbohydrates, 15-17 % water, 0.3 % proteins, 0.2 % ashes, and minor quantities of amino-acids and vitamins as well as other components in low levels of concentration (Ajao, 2012). Bee farming is relatively cheap to manage, as the major production is undertaken by the bees, while man does the harvesting.

Beekeeping offers opportunities for empowering and developing the rural populace. Beekeeping is a sustainable form of agriculture that can supplement rural income and nutrition requirements, while sustaining the natural habitat or modifying it (Babatunde *et al*., 2007).Nigeria opinion leaders have long been concerned with diversifying the economy and increasing rural investment. Though the country is urbanizing rapidly, roughly half of the population lives in rural areas, mostly mired in poverty; conventional wisdom holds that rural Nigerians are poorer than those that have gone to the cities, though credible evidence is lacking. United States Agency for International Development (USAID) beekeeping pollination project reported that Nigeria can generate over $100 million from local and international trade in honey and other hive products as domestic consumption currently stands at 380,000 metric tons. Apart from the present high and still growing demand, bee products are highly priced globally, especially in non-producer countries.

Nigeria farmers generally suffer a lot from deficiencies in production, storage, handling and packaging which makes their output unfit for the export market. Nigeria posses' enormous potential to transform bee keeping into a productive industry. As it can play a very vital role in increasing rural income as well as contributing to increased export earning, its role in biodiversity conservation and the usefulness of its hive products as raw materials for local industries. Hive products are highly demanded by households, hospitals, pharmaceuticals and cosmetic industries (FAO, 2007). Honey can be used for the treatment of wounds, burns, cataracts, skin ulcer and scabies. Bee wax is used in the production of candles, polishes and so on. Pollen from the flowers are sold to perfume industries, they are also used as dietary or nutritional supplement in foods due to its high medicinal and nutritional properties (FAO, 2003).

The rate of expansion of apiculture industry is relatively low compared to other fields of agro forestry in Nigeria. This low expansion rate could be related to gross unawareness of the use and value of honey and other hive products, poor and ineffective collection, processing and preservation method as well as poor handling which results to product of inferior quality. This can be attributed to gross underutilization and inadequate exploitation of bee keeping potentials in most farming communities the country. Therefore, the objectives of this study were to; evaluate factors of honey production; ascertain long run parameters with unit roots; estimate the determinants and returns to scale in honey production, as well as evaluate the constraints confronting the apiary unit.

Methodology

Study Area

This study was carried out at the Apiary unit of Federal College of Forestry, Jos (FCFJOS), Plateau State, Nigeria. Jos is the capital of Plateau State. Jos metropolis is located North-West of the middle-belt of Nigeria, with coordinates of latitude 9°56' and 9°53'N and longitude 8°53' and 8°51'E *(http://www.latlong.net/place/jos-nigeria-21506.html)*. Jos is located at geographical centre of Nigeria about 288km from Abuja, the capital of Nigeria *(https://en.m.wikipedia.org/wiki/jos)*.

Data collection

The study employed Secondary data which were derived from the personnel at the apiary unit; using a checklist and from previous records of honey production at the apiary. The data used for the study covers the period from 2013 to 2017. For this study quantitative data were collected, this included data on output levels, labour supply, production costs and number of active hives.

Analytical Techniques

Descriptive and inferential statistics were used to analyze the data collected. Measures of central tendency (means and score index) were used to evaluate the production factors and constraints. To ascertain the parameter with unit roots cointegration test was adapted in this study. Regression analysis was also used to estimate the determinants of honey production at the apiary unit. The return to scale of honey production was estimated using the elasticity of production factors.

Cointegration Test

Cointegration is a statistical property of a collection (X_1... X_n) of time series variables. Cointegration has become an important property in contemporary time series analysis. Time series often have trends; either deterministic or stochastic. Johansen Cointegration test analyze non-stationary time series data that have variances and means that vary over time. In other words, the method allows you to determine parameters or equilibrium in systems with unit root variables (John, 1997). Two sets of variables are cointegrated if a linear combination of those variables has a lower order of integration. For example, cointegration exists if a set of 1(1) variable can be modeled with linear combinations that are 1(0). The integration order here; 1 (1), tells you that a single set of differences can transform the non-stationary variables to stationarity (John, 1997). More formally, cointegration is where two 1(1) time series Xt and Yt can be described by the stationary process;

$Ut = Yt - \alpha X$t--------------- (1)

The Co-integration test estimates the long run relationship between dependent and independent variables, non-stationarity of one or all of the variables are an indication of a stochastic trend (John, 1997). Co-integration tests are conducted by using the reduced procedure; this incorporates a parametric correction for serial correlation (Risikat, 2010). Johansen method detects a number of cointegrating vectors in non-stationary time series. It allows for hypothesis testing regarding the elements of cointegrating vectors and loading matrix (Risikat, 2010).

Regression Analysis

The semi-log function was adopted in this study; to estimate the determinants of honey production at the apiary unit.Thesemi-log function was well fitted to the data collected; based on the basis of the number of significant variables, magnitude of the coefficients, statistical and econometric criteria. The model in its explicit form is as follows:

$LogY = b_0 + b_1 log \times_1 + b_2 log \times_2 + b_3 log \times_3 + b_4 log \times_4 + e_i$ …... (2)

Where;

Y = Output (quantity of honey harvested) (litres)
$\times_1$= Labour (man-days)
$\times_2$ = Hives (number)
$\times_3$= Hives cost (₦)
$\times_4$= Cost of apiary kits (₦)

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b_0 = Constant term

$b_1 - b_4$ = Regression coefficient to be estimated

e_i = Error term

Returns to Scale

It refers to the change in output as a result of a given proportionate change in all the factors of production simultaneously. It is a long run concept as all the variables are varied in quantity. Returns to scale are increasing or constant or decreasing depending on whether proportionate simultaneous increase of input factor's results in an increase in output by a greater or same or small proportion. Elasticity of production is used to estimate returns to scale generally it given as;

Elasticity of production ($\sum\rho$) = %change in output ($\%\Delta$) / %change in input ($\%\Delta\chi$) ..(3)

It can also be estimated in terms of the relationship between Marginal Physical Product (MPP) and Average Physical Product (APP) as given below;

$\sum\rho = \frac{\Delta \square}{} \div \frac{\Delta\chi}{\chi}$...... (4)

Written as;

$\sum\rho = \frac{\Delta \square}{\Delta\chi} \div \frac{\chi}{}$ ...... (5)

Given that;

$\frac{\Delta \square}{\Delta\chi} = MPP$; and $\frac{\chi}{} = 1/APP$ ...... (6)

Therefore;

$\sum\rho = MPP / APP$ ...... (7)

However, in production function the returns to scale is obtained by the summation of elasticity coefficients of the independent variables (Reddy *et al*., 2004)

$\sum\rho^k = RTS^k$....... (8)

Where;

$\sum$ = Summation sign

$\sum\rho^k$ = Elasticity coefficient of k variable

RTS = Returns to scale

If $\sum\rho^k > 1$ it is increasing returns to scale

If $\sum\rho^k = 1$ it is constant returns to scale

If $\sum\rho^k = < 1$ it is decreasing returns to scale.

Mean Score Index (MSI)

Mean Score Index was used to evaluate the constraints of honey production at the apiary unit. To determine the mean score index, each response pattern with its appropriate nominal value was divided by the sum of the nominal values. The mean score index ($\ddot{X}s_i$) of the production constraints were therefore estimated as follows;

$\ddot{X}s_i = x_i / \sum x_i$...... (9)

Where: $\ddot{X}s_i$=mean score index; x_i = Score assigned to 'n' occurrence $\sum$=Summation

Given that; 1= Not Applicable (NAP), 2 = Minor Constraint (MIC) and 3 = Major Constraint (MAC)

Score index (s_i) =$n / \sum x_i$...... (10)

Where: s_i= score index; n = number of occurrence; x_i = Score assigned to 'n' occurrence;$\sum$=Summation

=3 / 6

= 0.5(thus, factors with score index =0.5 are considered as majorproduction constraints).

Results and Discussion

Factors of Production at the Apiary Unit

Table 1 revealed that the quantity of labour supply employed in the management of the hives; it was estimated that an average of 72 man-days of labour was employed at the apiary unit; however, this labour supply was grossly inadequate due to the extent of activities at the apiary unit which required additional labour supply and consequently resulting to inefficiency in honey production at the apiary unit. This therefore suggests a need for more technical man power supply and development to enhance the efficiency in honey production at the apiary unit. The total number of active hives at the apiary unit was 15. The number of hives increases the probability of having more harvest and hence the likelihood of more output may be derivable thereof. The unit cost per langstroth hive was estimated as ₦30,000, this modern hives are well suited for optimal honey production. Also, the estimated average cost of the apiary kits (e.g., scrappers, smokers, protective gears, etc.) was ₦12,000; implying that the purchase of this inputs constituted a significant variable cost component in honey production.

Table 1: Summary Statistics of Production Factors at the Apiary Unit

Factors	Mean
Labour (man-days)	72
Hives (number)	15
Hive cost (₦)	₦30,000
Cost of kits (scrappers, smokers, etc.)(₦)	₦12,000

Source: Apiary unit, FCFJOS (2018)

Cointegration Test

The result presented in Table 2 reveals that there is cointegration among the variables. This is because the Trace Statistic value of 77.2 is greater than the critical value of 58.31and 64.49 at 5% and 1% level of significance (John, 1997).We reject the null hypothesis of none** of the hypothesized number of cointegrating equations. Accordingly, Trace Statistic test indicates none** cointegrating equations at 5% and 1% significance level respectively (Risikat, 2010).For the remaining number of hypothesized cointegrating equations (at most 1 and 2), we do not reject the null hypothesis as their Trace Statistic values are less than the critical values at 5% and 1% level of significance, with the exception of the hypothesized cointegrating equation (at most 3)(Chain *et al.*, 2018).The main conclusion is that there is the existence of long-run relationships amongst the variables (John, 1997). The variables may wander away from themselves, but in the long-run, there is the existence of relationship amongst them. This corroborates with the findings of (Risikat, 2010) who posited similar results in their work on cointegration test for parameters wit unit roots.

Table 2:Cointegration Test to Determine Parameter with Unit Root Variables

Hypothesized No. of C.E (s)	Eigen value	Trace statistic	5% critical	1% critical value

			value	
None**	0.65	77.2	58.31	64.49
At most 1	0.42	39.5	40.57	46.15
At most 2	0.17	16.15	21.43	26.07
At most 3*	0.18	10.74	8.42	9.83

Source: Author computation (2018); Sample (adjusted): 2013-2017

Trend assumption: Linear deterministic trend; Trace test indicates 1 cointegrating equation(s) at both 5% and 1% levels, * or ** denotes rejection of the hypothesis at the 5% or 1% level (Chain *et al.*, 2018).

Regression Analysis

The regression (semi-log function) analysis presented in Table 3 revealed that the determinants of honey production at the apiary unit. The estimate of the coefficient of multiple determinations (R^2) was 0.621 which implies that about 62% of the variation in honey production was accounted for by the variable inputs in the model. The remaining 38% not explained may be due to omitted variables and the stochastic error term. The regression coefficients of capital labour (0.334) was positive and statistically significant at 1% ($p< 0.01$) level, suggesting that labour supply is very germane in honey production; hence most activities at the apiary unit have significant labour requirements relative to the number of hives.

The coefficient of the number of hives (0.417) was positive and statistically significant at 1% ($p< 0.01$) level, suggesting that suggesting that the number of hives increases the likelihood of having more harvest and hence more yield derivable thereof. However the coefficients of hive cost (-0.348) and cost of apiary kits (-0.273) were both negative but statistically significant at 5% ($p< 0.05$) level, this negative coefficients suggests an inverse relationship with honey production. The unit price of modern hives and apiary kits (scrappers, smokers, protective gears, etc.) constitute a major cost component in apiculture, hence these factors constrain net farm income derivable thereof and significantly affects the efficiency in honey production, suggesting that an increase in the adoption of this variables all other factors held constant may affect the gross output of honey produced. These findings corroborates with the works of Babatunde *et al.* (2007) and Mbah (2012) who also reported similar regression results for the determinants of honey production. The F ratio (5.847) was significant at 5% ($P < 0.05$) level, suggesting a significant and linear relationship among the variables. Also, the variation in the gross output of honey produced was significantly explained by the variables in the regression model, suggesting the regression model was well fitted to the data.

Table 3: Determinants of Honey Production at the Apiary Unit

Variable	Coefficient	Standard error	T-ratio
Constant	3.212**	1.369	2.346
Labour (X_1)	0.334***	0.102	3.274
Hives (X_2)	0.417***	0.131	3.183
Hive cost (X_3)	-0.348**	0.130	-2.677
Cost of kits(X_4)	-0.273**	0.11	-2.48
R^2	0.621		
F Ratio	5.847**		

Source: Apiary unit, FCFJOS (2018)**;** **= significant at 5% (p<0.05) and *** = significant at 1% (p<0.01)

Elasticity of Factors of Production and Returns to Scale

Table 4 revealed that the value of elasticity of production($\sum\rho^k$). The estimated value of returns to scale is 0.13, thus,$\sum\rho < 1$ which indicates a decreasing return to scale. Decreasing returns to scale is due to the operation of diseconomies of scale, that is,the technical efficiency of variable and fixed resources declines. Variable resources are abundant relative to fixed resource. The additional productivity of variable resource becomes negative hence increase in the use of variable factors yields less additional output.

Thus, addition of successive units of variable factors to fixed factors in the process of honey production adds less to the gross output of honey produced. This value represents stage III of the production function; which is regarded as an irrational (supra-optimal) stage of production. This stage offers the opportunity of reorganization of fixed and variable resources; it also correlates with the Law of Negative marginal returns. These findings corroborates with the work of Chain *et al.* (2018) who also reported similar results on firm Efficiency and Returns-to-Scale in the Honey Bee Pollination Services Industry. In addition, this results corroborates with the findings of Bhatta, *et al*. (2020): who posited similar results in their work on Economic Analysis of Honey Production in Chitwan District, Nepal.

Table 4: Elasticity of Production

Factors of Production	Elasticity of production ($\sum\rho^k$)
Labour (X_1)	0.334
Hives(X_2)	0.417
Hive cost (X_3)	-0.348
Cost of kits(X_4)	-0.273
Return to scale	0.13

Source: Apiary unit, FCFJOS (2018)

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Constraints Confronting Honey Production at the Apiary Unit

Table 5 revealed major constraints confronting honey production at the apiary unit. This study identified the significant factors affecting honey production at the apiary unit as indicated by the respective mean score index, these constraints included the following; cost of modern hives and technology (0.5); adoption of modern hives and technology can constitute a major cost component in apiculture; hence, this modern hives and technology are well suited for optimal honey production. Inadequate capital (0.5); bee farming is capital intensive and capital is a very significant factor in apiculture, all procurements of apiary equipment's, kits and technology adoption are correlated to the availability and adequacy of farm capital. Inadequate labour supply (0.5); results to inefficiency in production at the apiary unit.

This therefore suggests a need for more technical man power supply and development relative to the availability of active hives so as to enhance the efficiency in honey production. Inadequate baiting materials (0.3); bait materials are required to enhance colonization of honey bees in the hive, hence to attract bees, colonies must be baited with bait materials such as; bee wax, fruit juice, sweet syrup, pineapple, etc. Environmental factors (0.3); these factors particularly the amount of rainfall and temperature can exert a great influence on the life and work output of the honeybee, this can significantly constrain the gross output of honey produced. Post-harvest techniques in honey production (0.16); once honey is produced it should be handled properly to maintain its quality for a long time, environmental factors can deteriorate the quality of honey, hence adequate and appropriate storage and processing facilities should be selected and adopted. Thus, all the constraints identified affected honey production at the apiary unit. These findings corroborates with the work of Shrestha,(2017) who also reported similar results on Production economics and production problems of honey in Bardiya District, Nepal. Furthermore, this result corroborates with the findings of Bhatta, *et al*. (2020): who posited similar results in their work on Economic Analysis of Honey Production in Chitwan District, Nepal.

Table 5: Constraints of Honey Production

Constraints'	Mean Score Index
i. Cost of modern hives and technology	0.5
ii. Inadequate capital	0.5
iii. Inadequate labour supply	0.5
iv. inadequate baiting materials	0.3
v. Environmental factors	0.3
vi. Post-harvest techniques	0.16

Source: Apiary unit, FCFJOS (2018)

Conclusion and Recommendations

This study focused on the returns to scale and determinants of honey production at the apiary unit Federal College of Forestry, Jos, Plateau state, Nigeria. Secondary data was collected; using a checklist and from previous records of honey production at the apiary unit. The data used for the study covers the period from 2013 to 2017. Measures of central tendency (mean and score index), cointegration test, regression analysis and elasticity of production factors were used to analyze data collected. The results revealed that the factors of production affected the efficiency in honey production. The Cointegration test revealed that there is cointegration among the variables. The variables in the regression model significantly explained the variation in the gross output of honey produced. The estimated elasticity of production indicated a decreasing return to scale. All the constraints identified affected honey production at the apiary unit. It is therefore recommended that effort should be channeled towards ameliorating these constraints. All stakeholders are encouraged to play their part in ensuring the sustainability of the apiary unit. Improving honey production at the apiary unit therefore requires that attention be paid to the following:

The college management should make budgetary provisions for the acquisition of modern technology, apiary kits and equipment's, e.g., langstroth hives, baiting materials, bee veil, gloves, smokers, etc. Also, the college management should increase funding of apicultural activities at the unit to ensure increased productivity in honey production.

Furthermore, strategies should be adopted towards improving technical manpower supply and development to ensure increased productivity in honey production at the apiary unit;

In addition, the personnel at the apiary unit should adopt techniques to mitigate the influence of environmental factors on honey production.

Finally, the personnel at the apiary unit should recommend to the college management appropriate storage and processing facilities to be adopted to ensure increased productivity in honey production and to maintain honey quality over long periods, e.g., automated centrifugal press, appropriate storage containers, etc.

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