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Effect Of Climate Variability On Honey Production In Ondo State, Nigeria

Ijigbade, J.O
Department of Agricultural Technology,
Rufus Giwa Polytechnic, Owo, Nigeria.
ijigbadejustin55@gmail.com

***Abstract*— The study was conducted to assess the effect of climate variability on honeybee's production in Ondo State, Nigeria. Multistage sampling technique was employed to collect the data from 60 beekeepers across six Local Government Areas in Ondo State. Data collected were subjected to descriptive statistics and multiple regression model analyses. The results showed that 93.33% of the respondents were male with over 80% of them above 40 years old. Majority of the respondents (96.67%) had formal education and 90% produced honey for commercial purpose. About 93.33% of the respondents admitted that long period of high rainfall resulted in the reduction in efficiency of foraging of workers bees to source for food for the colony; nearly 73.33% agreed that long period of rainfall also led to high level of diseases and pests activities such as solder ants and bee wax moths which usually destroy the bee colony. A total of 60% and 50% submitted that long hours/period of high temperature resulted in improper composition of the colony (weak colony) and reduction in the growth of the queen and brooding activities respectively. The results of multiple regression indicated that level of education, year of experience, long period of low temperature and long period of humidity were positively and significantly affected honey bee production while long period of high rainfall, increased level of pollutants most especially smoke were negative but significantly affect honey bee output in the study area. The results also revealed that absconds of colony, inadequate finance, infestation of pests and diseases were the main challenges faced by the honeybee keepers in the study area. Therefore, beekeepers should be given more education on climate variability and its adaptive strategies towards ensuring better honey production in the study area.**

Keywords—Climate variability, honeybees, honey production, temperature, rainfall and humidity

I. INTRODUCTION

Climate variability is defined as the variation in the statistical properties of the climate system when considered over long period of time, regardless of cause. Climate variability is a significant and lasting change in statistical distribution of weather patterns over period ranging for decades to millions of years which may be a change in average weather conditions, or in the distribution of weather around average weather conditions [1].

Climate variability is a variation in the long term weather patterns that characterized the regions of the world. Climate variability over any particular place around the world is caused by a host of interacting factors both natural and man-made. [2] also defined climate variability as a deviation from the normal climatic conditions of an area due to land atmosphere and land ocean which cause alterations in balance of gases in the atmosphere. The gases are otherwise called radioactive forcing factors and are responsible for global warming and climate change.

When weather patterns for an area change in one direction over long periods of time, they can result in a net climate change or variation for that area. The key concept in climate variation is time. Natural changes in climate usually occur over time; that is to say they occur over such long periods of time that they are often not noticed within several human lifetimes. This gradual nature of the changes in climate enables the plants, animals and micro-organisms on earth to evolve and adapt to the new temperatures and precipitation patterns.

Climate variability is a global phenomenon, which needs concerted attention. As a result of changes in climate parameter, our ecosystems, forest endowments and biodiversity in general, are prone to insecurity [3]. A change in climatic conditions is bound to have an impact on the survival of these ecotypes most especially honeybees that are closely associated with their environment. Therefore, the migration and changes in their lifecycle and behaviour could help them to survive in new biotopes [4]. In a context of climate change, plant phrenology will be modified especially the flowering period. A new bioclimatic and economic balance will shape the type and distribution of agricultural crops, as well as those of respondent's vegetation [5]. In that case, climate change could destabilize relationships between flowers and honeybees. The honeybees will need to be protected to ensure that they continue their pollination function, which is so important for the economy and ecological balance of the environment [4]. The honeybees and flora and their relationships in the ecosystems show evidence of this phenomenon. As far as honey bees activity is concerned, the effect of climate change becomes apparent in their ethnology and particularly their foraging. At the plants species level, the variation affected the quality and quantity of the nutrients for honeybees, and the plant phrenology is a tool to measure the effects of climate changes [6].

II. PROBLEM STATEMENT

Climate variation affects honeybees through their floral resources and natural enemies. Differential response of insects and plants to changes in temperature could create temporal (phonological) and spatial (distributional) mismatches with severe

demographic consequences for the species involved. Asynchrony may affect plant by reducing insect visitation and pollen deposition, while honeybees experience reduced food availability [7]. Though, climate variation is a threat to agricultural, non-agricultural, social and economic development. Agricultural production activities are generally more vulnerable to climate variation than other sectors. This is considered to have constituted a major threats to pollination services and crop yield [8,9].

III. RESEARCH QUESTIONS

The study proposes to answer the following pertinent research questions:

i. What are the socio-economic characteristics of the respondents?

ii. Do changes in climate affect honeybee activities and performance?

iii. What are the climatic variables that affect honey production in the area?

iv. What are the challenges faced by the beekeepers in the study area as a result of the climate variability?

The answers to these questions by this study will provide useful information that can guide beekeepers on ways to promote adaptation measures in order to achieve sustainable honey production.

1.3 Objectives of the study

The main objective of this study is to investigate the effect of climate variability on honey production in Ondo State, Nigeria.

The specific objectives are to:

i. describe the socio-economic characteristics of honeybee farmers in the study area.
ii. ascertain the farmers' perception on the effect of climate variations on the activities and performance of honeybees in the area;
iii. examine the effect of climatic variables on the production of honey in the area; and
iv. identify the main constraint to honey production in the area.

2.0 Research Methodology

2.1 Study area

This study was carried out in Ondo State, Nigeria. Ondo State is situated within the tropic region of Nigeria and it covers land area of about 14,606km^2 with a fairly large population of 3.4million [10]. The geographical coordinates lies between latitude $5^0$45'N to $8^0$15'N and longitude $4^0$45'E to $6^0$0 0'E. The tropical climate of the State has two distinct seasons: rainy season that starts from April and ends in October, and dry season, that last between November and March. It has a temperature range of 21^0C-29^0C with a relatively high humidity. It has a tropical wet and dry climate with mean annual rainfall of about 1500mm and 2000mm in the derived savannah and humid forest zones respectively. The major occupation of the people in the State is agriculture which promotes apiculture activities. Agriculture offers about 75% of employment to the people of the State. The agricultural landscape is characterized by tree crops such as oil palm, mango, cocoa, cashew rubber and citrus species. Principal crops include cassava, yam, cocoyam, cowpea, maize, plantain, tomato and vegetables; the State is endowed with forest products such as tick, oma, cida, mahogany, obeche, afara, iroko and livestock/animal husbandry such as poultry, piggery, cattle rearing, quail and beekeeping.

2.2 Data and Sampling Technique

Primary data were used for this study. The data were collected through direct personal interview and well structured questionnaire in order to obtain pertinent information on socio-economic characteristics of beekeepers, their perceptions as well as the observed effect of climate variations on their honey production. A multistage sampling technique was used for the random selection of sixty 60 beekeeping farmers in the State. The sampling technique commenced by clustering the State into three (3) senatorial districts following the State administrative divisions and they are Ondo North, Ondo Central and Ondo South senatorial districts. In the second stage, two local government areas were purposively selected from each senatorial district based on the areas where honey productions were prominent. The local governments were Owo, Ose, Akure South, Ondo West, Ile – Oluji/Okeigbo and Odigbo. Stage three involved a random selection of one (1) community from each local government area, making a total of six (6) communities. Lastly, a simple random sampling technique was also used to randomly select ten (10) respondents from each community, thereby, making a total of sixty (60) respondents used for the study.

2.3 Method of Data Analysis

Data collected were analyzed using descriptive statistics and multiple regression analyses.

Descriptive statistics such as frequency, percentage and mean were used to ascertain both the socio-economic characteristics of the respondents and the farmers' perception on the effect of climate variations on the performance of honeybees as well as to identify the main variables observed to be responsible for the changes in honeybee activities in the area. Multiple regressions were used to determine the effect of climatic variables on honey production.

The implicit function is presented as follows;
$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, U_I)$. Where;
Y = Honey yield in litres
X_1 = Level of education either secondary or tertiary
X_2 = Beekeeping experience in years
X_3 = Short hours/period of rainfall (dummy; Yes = 1, No = 0)
X_4 = Long hours/period of high rainfall (dummy; Yes = 1, No = 0)
X_5 = Long hours/period of high temp. (dummy; Yes = 1, No = 0)
X_6 = Long hours/period of low temp. (dummy; Yes = 1, No = 0)
X_7 = Increased level of pollutants from smoke (dummy;Yes=1,N=0)
X_8 = Long period of high humidity (dummy; Yes = 1, No = 0)
X_9 = Long period of low humidity (dummy; Yes = 1, No = 0)
U_I = Error term
The following production functions were fitted to the model.
Linear function, $Y = b_0, + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6 + b_7x_7 + b_8x_8 + b_9x_9 + U_i$
Semi-Log function, $Y = b_0 + b_1\log x_1 + b_2\log x_2 + b_3\log x_3 + b_4\log x_4 + b_5\log x_5 + b_6\log x_6 + b_7\log x_7 + b_8\log x_8 + b_9\log x_9 + U_i$
Double-Log function, $\text{Log } Y = b_0 + b_1\log x_1 + b_2\log x_2 + b_3\log x_3 + b_4\log x_4 + b_5\log x_5 + b_6\log x_6 + b_7\log x_7 + b_8\log x_8 + b_9\log x_9 + U_i$
Exponential function, $\text{Log } Y = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6 + b_7x7 + b_8x_8 + b_9x_9 + U_i$
.
Where ; b_o = Constant
$b_1 - b_9$ = Coefficients or parameters to be estimated
log = Natural logarithm
The following criteria were used in choosing the lead equation of the regression model.

- The coefficient of multiple determinants (R^2) and Adjusted R^2 must be between 0 and 1. The higher the value of R^2 the better the model.
- The significance of the coefficients or estimate with respect to their t - value. Model with highest numbers of coefficient's significance is desirable.
- The *apriori* expectation of the explanatory variable. Variable that follow *apriori* expectation is desirable.
- The measure of overall significance of the regression model using the F test value. It must be significant at least at 5% level in order to be acceptable.
- All these criteria were considered to choose the lead equation in the model.

2.4 Validity of the Instrument

The validity of the content and construction of the instrument (questionnaire) were determined by expert judgment of some selected practicing apiculturists and top management staff of Ondo State Apicultural Unit of her Wealth Creation Agency (WECA).

3.0 Results and Discussion

3.1 Socio-economic characteristics

Results in Table 1 showed that 93.33% of the respondents were male while only 6.67% were female. This implied that beekeeping was predominantly a male gender business in the study area. About 33.33% of the respondents were below 50years of age while about 66.67% of the respondents were above 50years of age. This implied that people within the active labour force age (18 – 50years) were either shy away or not developing interest in beekeeping business in the study area. The result further showed that 76.67% of the respondents were married, which indicated that beekeeping business were being undertaken by responsible and matured people that could take positive decisions jointly with their spouses in the study area. It was revealed that all the respondents were educated with either secondary or tertiary educational qualifications. This implied that beekeeping business was majorly practiced by educated elite who will be ready to adopt innovations that could bring reasonable

improvement to their business in the study area. About 80% of the respondents have between 8 and 18years beekeeping experience. This indicated that majority of the beekeepers in the study area had the prerequisite experience to be successful in the business. The study also showed that 90% of the respondents produced honey for commercial purpose while only 10% produced for their family consumption only. This further implied that majority of the beekeepers took honey production as a means of livelihood in the study area.

Table 1: Distribution by the Socio-economic characteristics of the respondents

Gender	Frequency	Percentage (%)
Male	56	93.33
Female	4	6.67
Total	**60**	**100.0**
Age (year)	**Frequency**	**Percentage (%)**
20 – 30	2	3.33
31 – 40	6	10.00
41 – 50	12	20.00
51 – 60	18	30.00
Above 60	22	36.67
Total	**60**	**100.00**
Marital status	**Frequency**	**Percentage (%)**
Single	14	23.33
Married	46	76.67
Total	**60**	**100.0**
Educational level	**Frequency**	**Percentage (%)**
Secondary education	18	30.0
Tertiary education	42	70.0
Total	**60**	**100.0**
Beekeeping experience (years)	**Frequency**	**Percentage (%)**
2	6	10.0
5	6	10.0
8	18	30.0
12	18	30.0
15	6	10.0
18	6	10.0
Total	**60**	**100.0**

Source: Computed from field survey, 2016.

3.2 Farmers' perception on the influence of climate variations on the activities and performance of honeybees in the area

In the study, about 91.67% of the respondents agreed that climate variations affected the performance of honeybees in the area. Knowledge and perception of the (91.67%) respondents' on climate variation were tested through list of questions on the aspects of their honeybee performance affected by the variations in the study area. It was revealed in Table 2 and Table 3 that 93.33% of the respondents admitted that long hours/period of high rainfall resulted in the reduction in efficiency of foraging of workers bees to source for food for the colony. About 73.33% agreed that long period of rainfall also led to high level of diseases and pests activities such as solder ants and bee wax moths which usually destroy the bee colony. A total of 60% and 50% submitted that long hours/period of high temperature resulted in improper composition of the colony (weak colony) as well as reduction in the growth of the queen and brooding activities respectively. Also, 51.67% submitted that long hours/period of low rainfall led to poor performance of flowering plants and consequently, low level of nectar flow for the bees. About 63.33% of the respondents argued that increased level of pollutants from smoke resulted in high temperature and suffocation from carbon monoxide gas which consequently led to low level of colony reproduction, migration and sometimes death. Long period of low humidity had been attested by 71.67% of the respondents to be responsible for the production of crystalline (not well dissolved/converted) honey. This had also been attributed to the low level of honey deposited in hives. A total of 43.33% of the respondents said long period of low temperature made the bees to be inactive in their colony activities thereby reducing the rate at which they collect food from outside for conversion into honey in the hive.

Table 2: Distribution of respondents according to the aspect of their honeybee's performance and activities influenced by climate variability

Honeybee performance affected by climate change	Frequency	Percentage (%)
Reduction in the growth of the queen and brooding	30	50.00
Production of crystalline honey	44	73.33
Reduction in efficiency of foraging of worker bees	56	93.33
Improper composition of the colony (weak colony)	36	60.0
Low level of nectar flow	42	70.0
High level of pest and disease activity	44	73.33
Low level of colony reproduction, migration and death.	38	63.33

Source: Computed from field survey, 2016.

Table 3: Distribution of respondents according to the observed main climatic variables perceived to be responsible for the changes in honeybee activity

Observed climatic variables	Frequency	Percentage (%)
Long hours/period of high temperature	10	16.67
Long hours/period of low temperature	26	41.33
Long hours/period of high rainfall	56	93.33
Long hours/period of low rainfall	31	51.67
Increased level of pollutants from smoke	38	63.33
Long period of high humidity	10	16.67
Long period of low humidity	43	71.67

Source: computed from field survey, 2016.

3.3 Determining Factors Affecting Honey Production in the Area

Four functional forms (linear, semi-log, double-log and exponential) were run to analyze the effect of climatic variables on the honey production in the study area as presented in Table 4. Based on its economic, statistical and econometric criteria, the semi-log functional form gave the best fit equation. The value of R^2 was 0.715 which implied that 71.5% of the total variation in the honey production was accounted for by all the explanatory variables in the regression model. The significance of the F –Value (29.498; $P < 0.01$) indicated that all the explanatory variables jointly exerted significant influence on the level of honey production in the study area. The results of regression analysis therefore revealed that out of nine variables considered for the model, six variables were statistically significant in addressing honey production, while four variables had negative relationship with the honey output. The results indicated that a unit increase in any of their values will increase (decrease) honey output for the positive (negative) coefficients. This however, agreed with the position of [11] on impact of climate change on honeybee populations and diseases; and [1] affirmed the potential impact of climate change on honeybees and their pollination services. Level of education had a positive and significant coefficient. This implied that a unit increase in the level of education will increase output by 4.34 units.

The coefficient of year of experience was also positive and significant in addressing honey production. This showed that increase in the year of experience in beekeeping will increase the output of honeybee by 41%. The coefficient of long period of high rainfall was negative but statistically significant in affecting honey production. This implied that a unit increase in high rainfall will decrease output by 0.6% in the area. Long period of low temperature was significant and had positive relationship with output. This indicated that a low temperature will increase output by 0.181 units. The coefficient of increased level of pollutants from smoke had negative relationship with output, meaning that the presence of smoke will cause the bees to migrate away thereby reduce production of honey. Again, long period of high humidity had positive and significant relationship with honey production. It indicated that high humidity favours production of honey by 1.46 units in the area.

Table 4: Regression Results on the Effect of Climatic Variables on Honey Production

Explanatory Variables	Linear	Semi-log	Double-log	Exponential
Constant	-121.410 (0.131)	9.608** (0.000)	-4.846 (0.615)	-2.393 (0.075)
Level of education	10.264** (0.003)	4.338** (0.000)	-2.932 (0.520)	-36.60 (0.853)
Beekeeping experience	-721.34 (0.755)	0.407** (0.004)	-1.830 (0.533)	-396.57 (0.757)
Short hours/period of rainfall	30.24 (0.539)	0.029 (0.771)	0.480 (0.768)	-70.72 (0.355)
Gender (1=male; 0=otherwise)	-15.82 (0.650)	0.517 (0.912)	1.090 (0.430)	-1.09 (0.854)
Long hours/period of high rainfall	-114.44 (0.642)	-0.006** (0.000)	1.360 (0.055)	5.22 (0.083)
Long hours/period of high temperature	128.08 (0.480)	-0.019 (0.846)	2.797 (0.251)	2.61* (0.048)
Long hours/period of low temperature	-65.30 (0.064)	0.181* (0.049)	-2.027 (0.154)	-14.98* (0.044)
Increased level of pollutants from smoke	37.45 (0.907)	-0.192* (0.031)	-1.310 (0.239)	-0.120* (0.038)
Long period of high humidity	0.171 (0.731)	1.461* (0.042)	0.432 (0.097)	11.411 (0.691)
Long period of low humidity	321.29 (0.132)	-0.375 (0.712)	0.256 (0.111)	2.314 (0.201)
R^2	0.160	0.740	0.878	0.853
Adjusted R^2	0.080	0.715	0.633	0.560
F–value	1.983	9.498	3.589	2.907

Note: Figures in parentheses are P-value; **,* means significant at least 1% and 5% level respectively.

3.4 Challenges encountered as a result of variation in climate

Table 4 showed that the greatest challenge faced by the beekeepers in the study area was pest and parasite invasion as attested by 86.67% of the respondents. This often resulted into total destruction, death or reduction in the strength and yield of the colonies. The problem was attributed to prolong hours/period of high rainfall or wet season. About 70% of the respondents encountered the challenge of abscond of colonies as a result of long hours or period of high temperature and humidity as well as increased level of pollutants from smoke in the area. The problem of wind displacement/destruction of hives during rain storm and finance accounted for about 16.67% and 60% of the respondents respectively as challenges faced in the study area. These problems caused the respondents to spend more money on replacement and re - baiting of hives as well as on tracing and general maintenance of the apiary.

Table 4: Distribution of respondents according to challenges encountered as a result of variation in climate experienced in the study area.

Challenges encountered	Frequency	Percentage (%)
Absconds of colony	42	70.00
Finance	48	80.00
Low colony population	30	50.00
Low production/yield	36	60.00
Pests and parasites	52	86.67
Diseases	2	3.33
Wind displacement/ destruction of hives during rain storm	10	16.67

Source: computed from field survey, 2016. Note: multiple choice options allowed.

4.0 CONCLUSION AND RECOMMENDATION

4.1 Conclusion

The consequences of climate variability are of recent realized and hence the effect of this global phenomenon on honey bee activity and their interaction with crop plants needs to be understood before formulating specific mitigation strategies. Though concern has been raised about how climatic changes affect honey production. Indeed, effects of annual rainfall, temperature, relative humidity and wind speed have been assessed through honeybee performance and honey production. It can be concluded that long period of high rainfall, increased level of pollutants from smoke and long period of low humidity really affect the productivity and performance of honey bee production as a result of changing in climate. Despite that the enterprise is dominated by young and productive male households, the beekeepers faced the challenges of finances, infestation of pests and diseases, and

absconding of colony as a consequence of variations in climatic variables in the area. However, it implies that moderate temperature level, rainfall and relative humidity at the right season would improve the performance of the honeybees in terms of colony development (reproduction), nectar collection and honey production.

4.2 Recommendations

It is recommended that consideration should be given to the long seasons' resources needed by honeybees, both before and after crop flowering as well as ensuring connectivity of natural habitats in farming areas by the beekeepers. These will enable the bees to disperse easily and make needed range shifts in response to variations in climate. Cultivation of more flowering crops or non-crop flowering resources around the apiary should also be ensured. Proper inspection and maintenance of the apiary must be done regularly by the apiarists in order to mitigate climate variability effects. There is also the need for more educational interventions for beekeepers by relevant government agencies and research institutions on modern global ways of rearing bees under climate variability. Government at different respective levels should also introduce extension workers who are knowledgeable on climate change to educate both practicing and intending beekeepers to develop and adopt climate change adaptation strategies in the study area.

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