AJMAS
https://journal.utripoli.edu.ly/index.php/Alqalam/index eISSN 2707-7179

Original article

The Effect of Rainfall and Temperature on Honey Production Evidence from Libya

Intisar Mohamed [1], Fouzi Faraj [2]

[1]*Faculty of Natural Resources, Omar Al-Mukhtar University, EL-Beida, Libya*
[2]*Faculty of Agriculture, University of Benghazi, Benghazi, Libya*

ARTICLE INFO

Corresponding Email. *salehfarag1981@yahoo.com*
Received. *20-08-2022* ***Accepted.*** *03-09-2022* ***Published.*** *04-09-2022*
Keywords. *Cointegration, Honey Production, ARDL, Bounds Test, Libya.*

ABSTRACT

***Aims**. The paper aimed to investigates the effect of rainfall and temperature on honey production. **Methods**. An Autoregressive Distributed Lag (ARDL) modeling is employed by using annual data over the period of 1990-2013. **Results**. Bounds test results reveal that there is co-integration between study variables under investigation. Also, the study results indicate a positive effect and significantly of temperature and a negative and non-significant of rainfall effect on honey production in long-run. **Conclusion**. While in short-run, the temperature in lagged one and lagged two has a negative and significant effect on honey production.*

Cite this article. *Mohamed I, Faraj F. The Effect of Rainfall and Temperature on Honey Production Evidence from Libya. Alq J Med App Sci. 2022;5(2):438-446 https://doi.org/10.5281/zenodo.7048735*

INTRODUCTION

The agricultural sector plays a vital role in achieving economic development and it is one of the consolidations of economic databases within the system of vertical and horizontal agricultural development programs. Also, it supplies other sectors with raw materials necessary to create Industrial Development [1]. Moreover, also plays an important role in creating suitable job opportunities and securing food production [2].

Honey production is one of the most lucrative enterprises in many parts of the world [3]. It is one of the activities of forest and is source of employment, provides income to the people, a source of recreation, ecotourism and foreign exchanges earnings [4]. Additionally, it does not require much capital and agricultural labor, and most of its inputs are available locally [5]. Furthermore, it has importance in various agricultural fields, Beekeeping is not limited to the production of honey and wax but it uses in cross-pollination to bloom a large group of crops that contributes to reducing the wastage of plant production and raising the rate of productivity per acre of agricultural crops [6].

Climatic conditions are one of the most important factors affecting honey bees, and this impact may be negative or positive, and it may be direct or indirect, and this is reflected on their activity inside and outside the hive and affects their behavior in the entirety of their activity [7]. It also leads to the death of many bee colonies as result to extreme heat and extreme cold, which leads to a lack or complete cessation its activity [8].

Despite the efforts made by the recovering governments in the Libyan state since the discovery of oil from extensive agricultural development to reduce dependence on oil as the only source of income by creating a strong economic base that relies on multiple agricultural activities that achieve from achieving self-sufficiency in agricultural products and exporting the surplus to foreign countries to obtain foreign revenues to enhance the trade balance in favor of agricultural exports through the implementation of various agricultural development plans which large sums of money have been spent to invest them in various fields to advance this sector to the required level.

Considering honey bee farming is one of the important agricultural economic activities and is sense or affected by climate factors that affect their surrounding them and is affected their behavior and overall activities, whether inside or outside the hive and their overall activities, which leads to fluctuating production from year to year and contribute to the weak contribution of agricultural production to the gross domestic product on it. Therefore, this study attempting to studying the trend of honey production and the climatic variables under the study investigation and examine the effect of the rainfall and temperature on honey production in short and long-run during the period 1990-2013 by using the ARDL approach to provide empirical information to make the result more useful to improve the honey production and regain Beekeeping for its activity and to achieve a surplus in production for export.

METHODS

Model specification

The research uses descriptive and quantitative analysis during the period (1990 - 2013). The ARDL model used by adopting three-time series to examine the relationship between honey production, the annual average of rainfall, and the annual average of temperatures as follows:

$$HP = f\ (RA, TE)$$

$$Y = \alpha + \beta_1 RA_t + \beta_2 TE_t + \varepsilon t$$

Where:

HP= honey production; RA = the annual average of rain; TE = the annual average of temperature; εt = random error

The previous equation indicates to that the production of honey is the dependent variable affected by the annual average of rainfall, and the average of temperatures, which are independent variables. The ARDL model is written in the following form:

$$\Delta HP = \alpha_0 + \alpha_1\ HP_{t-1} + \alpha_2\ RA_{t-1} + \alpha_3\ TE_{t-1} \sum_{i=1}^{n} \beta_1\, \Delta HP_{t-1} + \sum_{i=0}^{n} \beta_2\, \Delta RA_{t-1} + \sum_{i=0}^{n} \beta_3\, \Delta TE_{t-1} + \varepsilon_t$$

where:

AHP	=	Honey Production;
Δ	=	First Difference of Variable;
ln	=	Natural Logarithmic Transformation;
β_0	=	Constant; and
ε_t	=	White Noise error term.

Since the variables in logarithmic form, the parameters of the variables express about elasticity for explanatory variables and a dynamic error correction model can be obtained from the ARDL model through a simple linear transformation; thus, the error correction version of the ARDL model can be expressed as:

$$\Delta HP_t = \alpha + \sum_{i=1}^{P} \beta_{1i} \Delta \ln HP_{t-i} + \sum_{i=1}^{P} \beta_{2i} \Delta lnRA_{t-1} + \sum_{i=1}^{P} \beta_{3i} \Delta lnTE_{t-1} + +\lambda ECT_{t-1} + e_t$$

where:

ECT = Error Correction Term which shows speed of adjustment from short-run to long-run equilibrium and it should be statistically significant with a negative sign.

e_t = Disturbance Term

Data collection procedure

The study relied on secondary data that obtained from statistical bulletins issued by the official authorities in Libya and the Food and Agriculture Organization (FAO), in addition to some published research and dissertations, as well as books related to the field of study.

RESULTS

Descriptive analysis of the study variables

To describe and analysis of the study variables during the period (1990-2013) used the descriptive statistical analysis. In this respect it relied on the Table 1 which clarified that the honey production was 1200 tons in 1990, decreased to 780 tons in 2000 after that increased to 810 tons in 2010, and then decreased to 800 tons in 2013. Also, table 2 indicates to that the mean of honey production was 829.1250 tons; the maximum was 1250 tons, while the minimum was 624tons. As for the standard deviation was 148.6889. This shows that the standard deviation was lower than the mean. That is means that, the data are more reliable or clustered closely around the mean. With regard to the trend of the average annual rainfall, it decreased from 288.4 mm in 1990 to 121.91 mm in 2000 and to 94.99 mm in 2010, and then increased to 150.361mm in 2013. Table 2 highlighted the mean of the trend of the annual rainfall average was 198.9198 with maximum 399.3 and minimum 94.99, while the standard deviation was 80.6575. For the trend of the annual temperature average which was 20.3 °C in1990, increased to 20.4 °C in 2000, also increased to 21.4 °C in 2010, and then decreased to 21.076 °C in 2013. As for, the mean of the annual temperature average was 20.45 °C, the maximum estimated by 21.4 °C, and the minimum was19.20 °C, while the standard deviation was 0.5453.

Table1: The values of the study variables during the period (1990-2013).

Year	Honey Production (HP) Tonnes	Average Annual of rainfall (RA) Mm	Average Annual of Temperature (TE) °C
1990	1200	288.4	20.3
1991	1250	275	19.2
1992	1100	123	19.4
1993	900	159.4	19.9
1994	700	225.1	20.4
1995	624	357.6	19.9
1996	750	237.5	20.3
1997	710	221.5	20.2
1998	715	200.4	20.3
1999	720	168.1	21.3
2000	780	121.91	20.4
2001	800	121.91	21
2002	800	399.3	20.6
2003	805	104.91	19.9
2004	800	136.28	20.5
2005	800	180.6	20.6
2006	800	252.3	20.8
2007	800	234.83	20.5

2008	800	286.28	20.6
2009	800	120.9	20.3
2010	810	94.99	21.4
2011	820	158.88*	20.969*
2012	815	154.625*	21.022*
2013	800	150.361*	21.076*

*Resources: Libyan National Meteorological Center. Food and Agriculture Organization of the United Nations, Faostat, https://www.fao.org/home/en. * Estimated values.*

Table 2. Descriptive statistical analysis of the study variables

Variable	Mean	Maximum	Minimum	Std. Dev.
Honey Production	829.1250	1250.0	624.00	148.6889
The annual average of Rainfall	198.9198	399.3	94.99	80.6572
The annual average of Temperature	20.45279	21.4	19.20	0.5453

Unit Root Tests Results

The stationarity properties of the data need to be tested before determining the suitable approach in analyzing the data to spurious problem in regression when using non-stationary time series; it can be said that the time series data is stationary if the mean and variance are constant in respect of time [9]. The results of the unit root tests can determine whether the data are stationary or non-stationary. PP was adapted to serve as a robustness test on the result obtained from ADF unit root test [10]. The outcomes of PP are presented in table3. The results showed that the honey variable was in first difference (-3.082) at 5 %, the rain in level (-4.072) at 1%, while the temperature was in first difference (-14.76) at 5 % level of significance.

Table 3. Results of Unit Root Test for PP Tests

Variables	Level		First Difference		Decision
HP	-2.713228		-3.0829**		1(1)
RA	-4.0728***		---------		1(0)
TE	-2.4673		-14.7620***		1(1)
1%	-3.7529		-3.7695		
5%	-2.9980		-3.0048		
10%	**-2.6387**		**-2.6422**		

**** Indicates the rejection of null hypothesis at 1% level of significance. ** Indicates the rejection of null hypothesis at 5% level of significance.*

Lag order selection

First, we select the higher lag length to avoid the over parameter problem because lags occupy a central role in economics and this reflected in the short and long-run methodology of economic. Thus, the elasticities in short-run are generally smaller in absolute value than their long-run counterparts because take time to make the necessary adjustment following a change in the values of explanatory variables [9]. The AIC and SIC are often used in model selection for non-nested alternatives- lowest values of the AIC and SIC are preferred. The lag length is decided with the help of the Aikaike information criterion (AIC). As illustrated to Table 4, the optimal lag appeared to be in lag three which its value was -3.0387* and the optimal model is selected on the basis of AIC in which it can be performed in small sample. Following the AIC, the optimal model is (1, 0, 3) as shown in figure 1.

Table 4: VAR Lag Order Selection Criteria

Lag	AIC	SIC
1	-2.6324	-2.2853
2	-2.5919	-2.0945
3	-3.0387*	-2.3915*
4	-2.8909	-2.0956

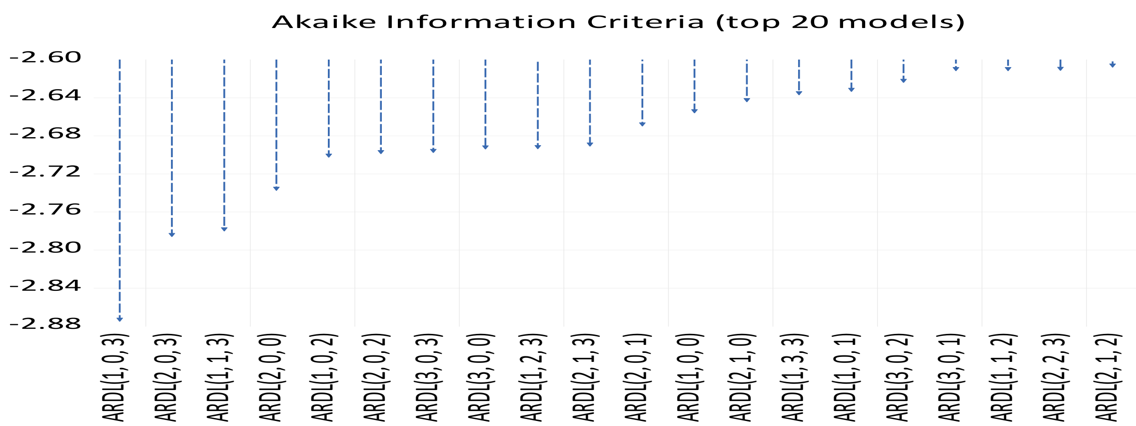

Figure 1. Optimal model selection

Bound Test Approach

The bound testing procedure is based on the F-statistic (Wald) to be considered whether there is long run relationship through co-integration approach [11]. If the F-statistic is larger than the upper-bound critical value, then there is a long-run association among the variables. On the contrary, there is no long-run relationship if the F-statistic lies below the lower bound critical value and the test statistic lies between the lower and the upper limits, the result is inconclusive. As stated in Table 5, the F- statistic large than the upper bound critical values at the 5 % level significance which the generated f-statistic under the bounds test is 9.318.

Table 5: Significance of F-test for Cointegration

Model HP= f (RA, TE)	F- statistic = 9.318248	
Critical Value	Lower bound	Upper bound
10%	2.63	3.35
5%	3.10	3.87
2.5%	3.55	4.38
1%	4.13	5.00

Results of the ARDL Approach

The generated ARDL long-run estimates of the model presented in Table 6, the test statistics results showed that the coefficient of rainfall was (-0.062) with negative sign association with honey production and statistically non-significant. As for the temperature variable the result that illustrated in Table 6 the coefficient has positive (2.8389) related with honey production and statistically significant at 10 %. Level.

Table 6. Coefficients of Long-run estimation from ARDL results (1, 0, 3)

Variable	Coefficient	T-ratio value	P- value
RA	-0.0626	{-1.1873}	[0.255]
TE	2.8389	{2.0983}	[0.055]
C	-1.5871	{-0.3817}	[0.708]

Based on the short-run results in Table7, the coefficients showed the coefficient of rainfall is negative and not-significant relationship with honey production. Furthermore, the coefficient of temperature (TE), it is negative in relationship with honey production .and statistically significant at a 5% and 10% level in lagged one and lagged two respectably. The ECM coefficient result in the dynamic model represents the speed of adjustment to equilibrium following shocks which is found (-0.600) and highly statistically significant at 1 % with correct sign (negative).

Table 7: Short-run estimation results and the Error Correction Model (1, 0, 3)

Variable	Coefficient	T-ratio value	P- value
D(RA)	-0.0376	-1.1500	0.2680
D(TE)	-0.0126	-0.0204	0.9840
D(TE(-1))	-1.7456	-2.6360	0.0190
D(TE(-2))	-1.0817	-2.0724	0.0560
CointEq(-1)	-0.6004	-4.9148	0.0000

Note: The figures in {…} and […] refer to the t-statistics and probabilities, respectively. (*), (**) and (***) means statistically significant at 10%, 5%, and 1% level, respectively.

Diagnostic tests

To ascertain the appropriateness of the ARDL model and to serve as robustness check purposes, the diagnostic checking consists of tests on serial correlation which its probability was about (0.065), meanwhile, the probability of normality test was (0.89) as well as the probability of heteroscedasticity test was (0.16). Besides that, stability tests are performed by utilizing the CUSUM and CUSUM of squares which their parameters are stable over time during the sample period of the study as shown in figure 2.a and 2.b.

Table 8. Diagnostic test results

R^2	**0.77**
F	9.4809
Serial correlation	[0.0653]
Normality	[0.8976]
Heteroscedasticity	[0.1677]

Note: The figures in […] refer to the probabilities.

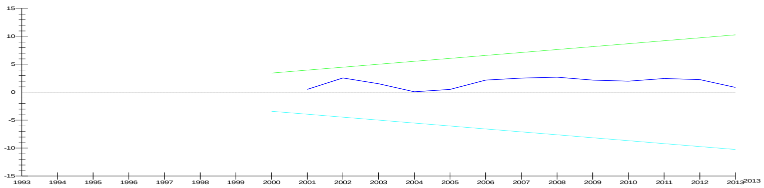

Figure 2.a: CUSUM Stability test

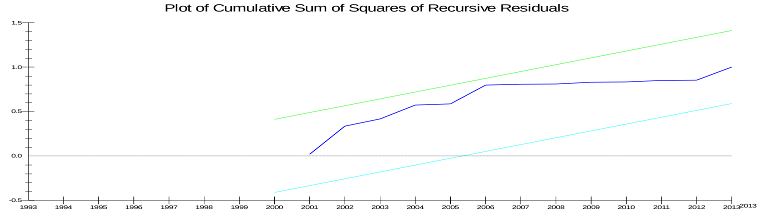

Figure 2.b. CUSUM of squares Stability test

DISCUSSION

In this study, it presents the discussions on the analysis between the variables under the study investigation and centered on the Phillips-Peron (PP) to observe the stationary properties of the time series data. The bounds testing approach to cointegration has been utilized to gain the long-run equilibrium relationship and accordingly, the Autoregressive-Distributed lag (ARDL) tests were performed to attain the long and short-run estimates of the model. Then error correction model (ECM) was generated from the ARDL model. Finally, diagnostic check was carried out to scrutinize the goodness-of-fit of the model.

Regarding to the PP test for stationary found to have a different integrated order in Model. Series that at the level, Rainfall variable is found to be stationary at 1 percent significant level, while Honey production and temperature variables are stationary in first difference form. In view of this, the specific variables are integrated either in 1(0) or 1(1) processes and no variables is integrated of order2. The time series variables are found stationary at the different order, at level and at first difference and this provide justifications for the implementation of the ARDL bounds test for cointegration.

As for determining the lag-order selection statistics lag from Akaike's information criterion by an asterisk"*", this is lag with the smallest value of the criterion and this optimal lag is represented in lag three and the optimal model is (1, 0, 3). Besides, the Bounds test showed the (Wald) F-statistic value was (9.31) is greater than the lower bound critical value (3.87) at 5%. This illustrates further that a long-run relationship is existing and the Bounds test confirms there is cointegration between the variables or there is a long-run association among the variables in the Model.

With regards to the long-run estimate indicated the negative sign implies to effect of the rainfall on a lack of collect nectar. In addition to, the rainfall affects the body of the bees in breaking of their wings or falling to the ground [12]. Moreover, the temperature variable has the expected sign with the honey production and significant at 10 %. Thus, an increase in the temperature by 1% leads to an increase in honey production by 2.83 %. This shows that the decrease the temperature leads to un-able for flying to collect the nectar; also it wasting the energy of the bees to heat the hive [13]. The findings are in line with past studies such as [14], [15], [16]. As for the short-run estimate an increase in temperature (TE) by 1% leads to a decrease in honey production by 1.74% and 1.08% in lagged one and lagged two respectively. Regards to the ECM coefficient shows that the speed back to equilibrium is 60 %

and implies a little high speed of adjustment to equilibrium after a shock happens in the previous period it decreases by 60 % in the current period.

In respect to diagnostic tests that reported that the R^2 explained that about 77 % of total change in honey production is explained by the selected independent variables. Also, the value of F was 4.59 and it imply to good fit of model. Furthermore, the model does not suffer from any problem and residuals are normally distributed. Whereas, CUSUM and CUSUM of squares stability test was performed and emphasized that the parameters are stable over time, whereby it plotted with the 5% critical line and it revealing that the estimated parameters are stable over the period of study at the 5% significance level.

CONCLUSION

The study aimed to examine the effect of the rainfall and temperature on honey production and used time series econometric method from the period from 1990 to 2013 in this study. In terms of methodology, PP test was performed to examine the stationary properties of the time series data. The obtained PP unit root test results indicated that the selected variables in this study are in a mixture of l(0) and l(1) processes. Bounds testing to cointegration based on the joint F-statistic showed that there is cointegration between the variables. The results of the study in long-run indicate that the temperature variable has significant and positive effect in honey production, but the rainfall did not effect on honey production. On the other hand, there is a negative effect and statistically significant for the temperature on honey production in one and two lagged case in the short run. The climate elements must be taken into account for its impact on the Beekeeping decisions.

Disclaimer

The article has not been previously presented or published, and is not part of a thesis project.

Conflict of Interest

There are no financial, personal, or professional conflicts of interest to declare.

REFERENCES:

1. Shehata E. The Role of Technological Change on the Demand of Agricultural Labor in Egypt. Egyptian Journal of Agricultural Economics. 2006; 16 (4):1155-1170.
2. Apergis N, Eleftheriou S. The role of honey production in economic growth: Evidence from a Panel of Major Global Producers. International Journal of Agricultural Economics. 2017; *2(5)*: 154-159.
3. Mazorodze B. The contribution of apiculture towards rural income in Honde valley Zimbabwe. In: Mazorodze B, editor. The National Capacity Building Strategy for Sustainable Development and Poverty Alleviation; *2015 May 26-28*; American University in the Emirates, Dubai. United Arab Emirates.
4. Minja G, Nkumilwa T. The role of beekeeping on forest conservation and poverty alleviation in Moshi Rural District. Tanzania. *European Scientific Journal*. 2016; *12*(23): 366-377.
5. Berem R. Economic analysis of honey production and marketing in Baringo County, Kenya: An application of the institutional analysis and development framework. *Natural Sciences Research*.2015; *5*(10): 34-41.
6. Muhammad O. The reality of beekeeping in Iraq and ways of developing them. *Journal of Economics and Administrative Sciences*.*2011*; *17*(61):183-198.
7. Mehdi H, Jabbar A, AL-Edany T. The Effect of Applying the Cooling System on the Temperature and Humidity of the Apiary and Cells. Syrian Journal of Agricultural Research – SJAR. 2020 ;7(5): 275-387.
8. Fars A, Al-Azaoy A. Material losses caused by some climatic factors for beekeeping and honey production in the Jabal Al- Akhdar region, Libya. Agricultural research Journal of Kafrelsheikh Univ. 2009; 35 (4): 270-284.

9. Gujarati D, Porter D. *Essentials Econometrics.* 4th ed. New York, USA: McGraw-Hill companies; c2010. Chapter12, P. 373-381.
10. Phillips P, Perron P. Testing for a unit root in time series regression. *Biometrika*. 1988; *75*(2):335-346.
11. Pesaran M, Shin Y, Smith R. Bounds testing approaches to the analysis of level relationships. Journal of Applied Econometrics. 2001; 16(3): 289-326.
12. Al-Nafi W, Al-Barqawi H. The role of geographical factors on typical honey apiaries (Al-Hindiya space model). Journal of the College of Education. 2019; (1)1:177-200.
13. Al-Banbi M. Honey bees and their products. 6th ed. Cairo, Egypt: House of Knowledge; c1993.p. 339.
14. Heinrich B. Thermoregulation of African and European honeybees during foraging, attack, and hive exits and returns. Journal of Experimental Biology. 1979; 80(1): 217-229.
15. Petz M, Stabentheiner A, Crailsheim K. Respiration of individual honeybee larvae in relation to age and ambient temperature. *Journal of Comparative Physiology B. 2004*; *174*(7): 511-518.
16. Joshi N, Joshi P. Foraging behaviour of Apis spp on apple flowers in a subtropical environment. *New York Science Journal*. 2010; *3*(3): 71-76.