International Journal of Agriculture Innovations and Research
Volume 6, Issue 6, ISSN (Online) 2319-1473
Manuscript Processing Details (dd/mm/yyyy):
Received: 30/05/2018 | Accepted on: 08/06/2018 | Published: 15/06/2018

# Identifying the cycles in area, production, productivity and FHP of long staple cotton in Gujarat: A Fourier Analysis

**Daud Mohammad.[1*] Shiyani R.L.[2] and B. Swaminathan[3]**
[1] Ph.D. scholar, Department of Agricultural Economics, Junagadh Agriculture University, Junagadh.
[2] Professor, Department of Agricultural Economics, Junagadh Agriculture University, Mota Bhandariya-Amreli, Gujarat.
[3] Assistant Professor, Department of Agricultural Economics, Junagadh Agriculture University, Junagadh, Gujarat.
(This paper has been developed from submitted PhD thesis of the first author to the Junagadh Agriculture University, Junagadh, Gujarat.).
*Corresponding author email id: dahmadzai@yahoo.com

*Abstract* – **This study was undertaken to study the growth dimensions of long staple cotton in Gujarat. The necessary time series data on area, production productivity and FHP were compiled from various official published sources for the period from 1980-81 to 2015-16. The results of Fourier analysis carried out to find out the cyclical variations in area, production, productivity and farm harvest prices of long staple cotton showed that among the 8 years cycles, the K value of the 5 year cycles of long staple cotton productivity as well as 7 and 8 years cycles of farm harvest prices were found to be significant at 5 per cent level of significance which indicates that the 5, 7 and 8 years time series data should be used for obtaining reliable and accurate farm plans under different types of risk. As the results for area and production of long staple cotton were found to be non-significant, the cycles were rejected implying that they were not identified hence, it cannot form bases for any farm plan.**

*Keywords* – **Long Staple Cotton, Area, Production, Yield, FHP, Fourier Analysis.**

## I. Introduction

Cotton often refers to as ‘White Gold’ or ‘King’ of fibre is an important commercial crop cultivated in India. Cotton, is one of the principal cash crops of India, contributes significantly to its economy and foreign exchange earnings. Approximately, 60 million people depend upon cotton production and related industries for their livelihoods. In fact, India has the largest area, which is approximately 34 per cent of the global area under cotton cultivation. Cotton is important not only for commercial benefits, but also for human consumption and as animal feeds. This holds true for all cotton producing countries including India. Due to its multiple uses, cotton has become a very important agricultural crop both for India as well as for the world. Cotton, though in essence, is produced for its fiber, which is a raw material for producing cotton yarn in textile industry, but at the same time, it has various other usages. It is used for both human in the form of cooking oil and animals as cattle feeds [1].

The ten major cotton producers are India, China, USA, former USSR, Brazil, Pakistan, Turkey, Mexico, Egypt and Sudan accounting for 85 per cent of the total production. The United States, India and China together provide two-thirds of the world’s cotton. It is an important cash crop to many developing countries supporting the livelihoods of millions of poor households [2]. Cotton is a major source of livelihood and also a major source of foreign exchange earnings for the domestic economy. India is one of the four major cotton producing countries, along with China, USA and Pakistan that together contribute about 70 per cent of the world cotton production. World cotton production was estimated at 105.4 million bales in 2016-17. Cotton was planted in an area of 29.28 million hectares in the world during 2016- 17. India continued to maintain its position of the largest producer of cotton with the total production of 27 million bales [3].

## II. Materials and Methods

### 1- *Cyclical variations*

Apart from the secular trend, which is determined using linear growth rate, it is also possible for a trend to have seasonal, irregular and cyclical components. Among which, seasonal variation can be defined as respective and predictable movement around the trend line in one year or less. In order to detect seasonal variation, time intervals must be measured in small units, such as days, weeks, months or quarters [4]. Coming to irregular variations, they are accidental in nature (like floods, fires, earthquakes, revolutions, epidemics, strikes and many other natural and man-made calamities) which may cause changes in growth dimensions and are unlikely to be repeated. Thereby, it is also not in the purview of the study to measure such irregular variations in the particulars of growth dimensions. The only possible thing left to estimate is cyclical variation and it is measured using Fourier analysis.

Cyclical variation is one of the components of a time series that tends to oscillate above and below the secular trend line for periods longer than one year. In this study, Fourier analysis is used to capture this cyclical factor [5] by using Harmonic model. The Harmonic model is applied to the actual data in order to detect the presence of any long term cycles [5]. In order to test the length of the cycle, Fourier coefficients need to be computed. Given a time series $X_1$, $X_2$, $X_3$,… $X_n$ with a period of length T, the deviations of the actual value from the trend value is represented as,

$$Y_t = 1/2\, A_0 \sum_{j=1}^{n}\left( A_j \text{ Cos } \frac{360\, j}{T} + B_j \text{ Sin } \frac{360\, j}{T} \right)$$

Where,

Yt = Dependent variable (Area/ Production/ Productivity/ FHP);

T = Time variable in years, 1, 2, 3 . . . n;

$A_0$, $A_j$, and $B_j$ are constants and are given by,

$$A_0 = \sum_{t=1}^{n} \frac{X_t}{N}$$

$$A_j = \frac{2\left[\sum_{t=1}^{n} X_t \text{ Cos}\left(\frac{360j}{T}\right)\right]}{N}$$

$$B_j = \frac{2\left[\sum_{t=1}^{n} X_t \text{ Sin}\left(\frac{360j}{T}\right)\right]}{N}$$

It is more convenient to group the data as shown below for investigating a given period P, where mP was equal to N or the nearest integer below N.

| | | | | |
|---|---|---|---|---|
| | $X_1$ | $X_2$ | ... | $X_P$ |
| | $X_{p+1}$ | $X_{p+2}$ | ... | $X_{2P}$ |
| | $X_{(m-1)(p+1)}$ | $X_{(m-1)(p+2)}$ | ... | $X_{mP}$ |
| Sums | $U_1$ | $U_2$ | ... | $U_P$ |

If a term of period 'P' is present in the series, the *column total* ($U_{j,\, j = 1, 2 \ldots p}$) indicated the periodic effects, but if the remaining element is random, the effect of summing 'm' rows will reduce the relative contribution of that element to the column totals. Similarly, if there are other elements with different periods, they will be out of phase in successive rows and tend to cancel out in the totals. Hence, if there are enough rows, the total ($U_j$) reveals the periodic effects and reduce marking effects, if any, resulting from random components or oscillatory components of different periods, which will prevent discernment of the periodic effect in the primary series.

The Fourier coefficients $A_P$ and $B_P$ are computed from the following formulae,

$$A_P = \frac{2\left[\sum_{j=1}^{P} U_j \text{ Cos}\left(\frac{360j}{P}\right)\right]}{mP}$$

$$B_P = \frac{2\left[\sum_{j=1}^{P} (U_j \text{ Sin}\left(\frac{360j}{P}\right)\right]}{mP}$$

The squares of the amplitude $R_P^2$ are obtained by adding Fourier coefficients $A_P^2$ and $B_P^2$. Hidden periodicities are found out by periodogram analysis. The procedure for testing the periodogram involves in computing the square of this amplitude ($R_P^2$). If no periodic fluctuations are observed, then mean square amplitude for a random series without periodic fluctuations is arrived at by,

$$R_m{}^2 = \frac{4\sigma^2}{N}$$

Where,

$\sigma^2$ = Variance of the series. $X_t$

Then the indicator of the cycle, K will be calculated as follows,

$$K = \frac{R_P^2}{R_m}$$

## III. Results and Discussion

### 1. *Cyclical Trend: Fourier analysis*

Cyclical variation is one of the crucial components of a time series that tends to oscillate above and below the secular trend line for periods longer than one year. In this study, Fourier analysis is used to capture this cyclical factor by using Harmonic model. Fourier analysis was done only for Overall Period as the cycles were found to be significant over long period of time. So far as the Pre- Liberalization, Liberalization and Post-Liberalization Periods are concerned, the time period was short and cycles were found to be non-significant. Hence 8 years cycle model for area, production, productivity and farm harvest prices of long staple cotton during Overall Period was classified. Fourier analysis for the acreage under long staple cotton for Overall Period was carried out for cycle ranging in the length of time period from 3 to 10 years and Fourier coefficients were also worked out for each cycle. The significance of these cycles are judged based on the calculated *K* value ($\widehat{K}$). If $\widehat{K}$ value is greater than table *K* value, the cycle is said to be significant. The Fourier coefficients, amplitude square, mean square amplitude and the ratio of *K* for long staple cotton area are given in Table 1.

The results revealed that the average absolute value of Fourier coefficients using sines were greater than using cosines for long staple cotton area in 8 years cycle length. Thus, cyclical length was greater than cyclical height for long staple cotton area. In the 8 years cycle length, Fourier coefficients of cyclical peakness ($A_p$) were negative for 6, 7, 9 and 10 years cyclical length and it was positive for 3, 4, 5 and 8 year cyclical length. Negative coefficients imply that they fall in the lower part of the cycle. The Fourier coefficients of cyclical length ($B_p$) were negative for 4, 5, 7, and 8 year and it was found to be positive for 3, 6, 9 and 10 year cyclical length. Squared amplitude was smaller than mean square amplitude for all the cycles. The calculated $\widehat{K}$ value was found smaller than the table value for all the 8 cycles. Thus, F-value seems to be non-significant. Therefore, all the 8 years cycles of long staple cotton area was rejected i.e. the Schuster's '*K*' values of harmonic analysis indicated the absence of cyclical fluctuations in long staple cotton area during the study period. These findings are in line with those of [4] who found that the *K* values were found to be non-significant for maize area in all 8 years cycles of maize crop in India. Similar to area, 8 cycles model for production of long staple cotton was tested and calculated. Fourier coefficients, amplitude square, mean square amplitude and the ratio *K* of long staple cotton production are presented in Table 2.

The results showed that average absolute value of Fourier coefficients using cosines were smaller than using sines for long staple cotton production in the 8 years cycle length.

Thus, cyclical length was greater than cyclical height for long staple cotton production. In the 8 years cycle length, Fourier coefficients of cyclical peakness (*Ap*) was negative for 8 and 9 year cyclical length and it was positive for 3, 4, 5, 6, 7 and 10 year cyclical length. It implies that they fall in upper part of the cycle. The Fourier coefficients of cyclical length ($B_p$) were negative for 3, 4, 5, 7 and 9 year and it was found to be positive for 6, 8 and 10 year cyclical length. It implies that they fall in lower part of the cycle. Squared amplitude was smaller than mean square amplitude, except in case of 8 year cyclical length. The calculated $\hat{K}$ value was found smaller than the table value for all the 8 cycles. Thus, F-value seems to be non-significant. Therefore, all the 8 cycles of different years for area of long staple cotton was rejected implying the absence of cyclical fluctuations in long staple cotton production during the study period. This finding is similar with that of [4] who found that the *K* values were found to be non-significant for maize production in India. Therefore, the 8 cycles of maize production was not identified.

The Fourier coefficients, amplitude square, mean square amplitude and the ratio *K* of long staple cotton productivity are presented in Table 3. The results exhibited that average absolute value of Fourier coefficients using cosines were greater than using sines for long staple cotton productivity in the 8 years cycle length. The Fourier coefficients of cyclical length ($B_p$) were negative for 3, 4, 5 and 7 years and it was found to be positive for 6, 8, 9 and 10 years cyclical length. It implies that they fall in upper part of the cycle. Fourier coefficients of cyclical peakness ($A_p$) was negative for 4, 5, 6, 8, 9 and 10 years cyclical length and it was positive only for 3 and 7 years cyclical length. It implies that they fall in lower part of the cycle. Squared amplitude was smaller than mean square amplitude for all the cycles, except in case of 5, 7 and 8 years cyclical length. The calculated $\hat{K}$ value was found greater than the table value for productivity cycles of 5 year. It was found to be 11.06 which was significant at 5 per cent level for long staple cotton crop using F-test. Hence, the observed ratio for a period of remaining cycles could have occurred by chance.

Thus, the results indicated that 5 years time period of the cycles should be considered in forming relevant farm plans as they were found to be significant. This finding corroborates with that of [6] who found that the *K* values were found to be significant for 6 cycles for productivity of agricultural commodities like rice, ginger, arecanut and coconut, respectively which were significant at 5 per cent level. The Fourier coefficients, amplitude square, mean square amplitude and the ratio *K* of farm harvest prices for long staple cotton are presented in Table 4. The results revealed that absolute average value of Fourier coefficients using cosines were greater than using sines for the farm harvest price of long staple cotton in 8 years cycle length. Thus, cyclical height was greater than cyclical length for long staple cotton farm harvest price. Fourier coefficients of cyclical peakness ($A_p$) were negative for 3, 4, 5 and 7 year cyclical length while it was positive for 6, 8, 9 and 10 year cyclical length. This implies that they fall in upper part of the cycle. The Fourier coefficients of cyclical length ($B_p$) were negative for 5, 6, 7 and 10 year and it was found to be positive for 3, 4, 5 and 9 year cyclical length. This implies that they fall in lower part of the cycle. Squared amplitude was greater than mean square amplitude for 7, 8 and 10 years cyclical length. Thus, in 7, 8 and 10 years actual amplitude was greater than their mean square amplitude. The calculated $\hat{K}$ value was found greater than the table value for farm harvest price cycles of 7 and 8 years. They were found to be 2.98 and 4.69, respectively and were significant at 5 per cent level for long staple cotton crop using F-test. Hence, it can be inferred that the observed ratio for a period of remaining cycles could have occurred by chance.

These findings are in conformity with the findings of [7] who studied the price behaviour of major vegetables in hill region of Nepal and found that Periodogram analysis for onion-dry prices indicated that, the two-year prices cycle were found to be significant at 5 percent level in Kalimati market.

## IV. Conclusion

From the above results we can draw conclusion that the 5 year cycles of long staple cotton productivity as well as 7 and 8 years cycles of farm harvest prices were found to be significant at 5 per cent level of significance which indicates that the 5, 7 and 8 years time series data should be used for obtaining reliable and accurate farm plans under different types of risk. As the results for long staple cotton area and production were found to be non-significant, the cycles were rejected implying that they were not identified; hence it cannot form bases for any farm plan.

## References

[1] Singh, S. P.; Jena, P.S. and Singh, N. K. 2013. Cotton production and environmental sustainability in India. Pp 1-200. Cuts International. Jaipur Printers Private Limited, Jaipur.

[2] Samuel, J.; Basavaraja, H.; Pushpanjali. and Rejani, R. 2015. Production, growth and export competitiveness of raw cotton in India – An Economic Analysis. *Agricultural Research & Technology*. **1(1)**: 1-5.

[3] USDA Foreign Agricultural Service. 2017. World Agricultural Production. WAP 02-17 Available at https:// apps.fas.usda.gov/psdonline/ circulars/production.pdf accessed on 9 February, 2017.

[4] Pangayar Selvi, R.; Muraligopal, S. and Swaminathan, B. 2015. Statistical analysis of trends in the maize area, production and productivity in India. *Annuals of Plant and Soil Research*. 17(22): 233-237.

[5] Fox, K. A. 1958. Econometric analysis for public policy. Iowa, Iowa State University Press.p.288.

[6] Savithri, T. M. 1999. Production, productivity and prices - A study on agricultural commodities in Kerala. Ph.D. Thesis (Unpublished). Dr. John Matthai Centre, University of Calicut. Aranattukara, Thrissur, Kerala.

[7] Mishra, R. and Kumar, D. A. 2012. Price behaviour of major vegetables in hill region of Nepal: An econometric analysis. *SAARC Journal of Agriculture*. 10(2): 107-120.

*Tables:*

Table 1 Fourier coefficients, amplitude square, mean square amplitude and the ratio of K for long staple cotton area (8 cycles)

| Cycle length (Years) | Fourier coefficients | | Amplitude square $Rp^2$ | Mean square amplitude $Rm^2$ | K value |
|---|---|---|---|---|---|
| | $A_p$ | $B_p$ | | | |
| 3 | 0.4056 | 0.4924 | 0.4071 | 0.4719 | 0.8625 |
| 4 | 0.0856 | -0.1057 | 0.0185 | 0.4719 | 0.0392 |
| 5 | 0.4224 | -0.1273 | 0.1946 | 0.4705 | 0.4136 |
| 6 | -0.4084 | 0.0555 | 0.1698 | 0.4719 | 0.3599 |
| 7 | -0.2918 | -0.0169 | 0.0854 | 0.4705 | 0.1815 |
| 8 | 0.0466 | -0.0597 | 0.0057 | 0.5227 | 0.0110 |
| 9 | -0.4626 | 0.3195 | 0.3161 | 0.4719 | 0.6698 |
| 10 | -0.2352 | 0.5750 | 0.3859 | 0.4935 | 0.7820 |

Table 2. Fourier coefficients, amplitude square, mean square amplitude and the ratio of K for long staple cotton production (8 cycles)

| Cycle length (Years) | Fourier coefficients | | Amplitude square $Rp^2$ | Mean square amplitude $Rm^2$ | K value |
|---|---|---|---|---|---|
| | $A_p$ | $B_p$ | | | |
| 3 | 2.5528 | -0.9060 | 7.3376 | 26.7504 | 0.2743 |
| 4 | 0.4561 | -3.1642 | 10.2202 | 26.7504 | 0.3821 |
| 5 | 1.3662 | -1.4103 | 3.8556 | 23.4549 | 0.1644 |
| 6 | 0.3932 | 1.0441 | 1.2447 | 26.7504 | 0.0465 |
| 7 | 1.4429 | -4.1269 | 19.1129 | 23.4549 | 0.8149 |
| 8 | -4.9910 | 2.7850 | 32.6659 | 25.6047 | 1.2758 |
| 9 | -2.8805 | -0.2316 | 8.3509 | 26.7504 | 0.3122 |
| 10 | 0.6263 | 3.2195 | 10.7575 | 27.0705 | 0.3974 |

Table 3. Fourier coefficients, amplitude square, mean square amplitude and the ratio of K for long staple cotton productivity (8 cycles)

| Cycle length (Years) | Fourier coefficients | | Amplitude square $Rp^2$ | Mean square amplitude $Rm^2$ | K value |
|---|---|---|---|---|---|
| | $A_p$ | $B_p$ | | | |
| 3 | 16.2072 | -5.9367 | 297.9167 | 1576.0949 | 0.1890 |
| 4 | -2.4724 | -29.7558 | 891.5213 | 1576.0949 | 0.5657 |
| 5 | -128.5908 | -6.6453 | 16579.7623 | 1498.3274 | 11.0655* |
| 6 | -3.4814 | 2.6055 | 18.9087 | 1576.0949 | 0.0120 |
| 7 | 17.2640 | -43.7638 | 2213.3174 | 1498.3274 | 1.4772 |
| 8 | -38.9767 | 31.4326 | 2507.1924 | 1678.2458 | 1.4939 |
| 9 | -23.8039 | 3.1418 | 576.4967 | 1576.0949 | 0.3658 |
| 10 | -2.9115 | 6.7950 | 54.6489 | 1909.2040 | 0.0286 |

Note: * indicates significance at 5 % level.

Table 4. Fourier coefficients, amplitude square, mean square amplitude and the ratio of K for farm harvest price of long staple cotton (8 cycles)

| *Cycle length (Years)* | *Fourier coefficients* | | *Amplitude square $Rp^2$* | *Mean square amplitude $Rm^2$* | *K value* |
|---|---|---|---|---|---|
| | $A_p$ | $B_p$ | | | |
| 3 | -10.9511 | 15.57691 | 362.5676 | 26445.26 | 0.0137 |
| 4 | -23.5025 | 15.87366 | 804.3392 | 26445.26 | 0.0304 |
| 5 | -85.7463 | -47.4649 | 9605.347 | 27793.05 | 0.3456 |
| 6 | 100.0796 | -11.1856 | 10141.04 | 26445.26 | 0.3835 |
| 7 | -282.969 | -52.5005 | 82827.71 | 27793.05 | 2.9801* |
| 8 | 11.6529 | 391.6364 | 153514.9 | 32689.97 | 4.6960* |
| 9 | 41.23616 | 36.56935 | 3037.738 | 26445.26 | 0.1149 |
| 10 | 133.5596 | -154.795 | 41799.62 | 34981.32 | 1.1949 |

Note: * indicates significance at 5 % level.

## AUTHORS' PROFILES

1. **Mr. Mohammad Daud** was born in Logar province of Afghanistan on 02-10-1985. Completed B.Sc. (Agri.) in the major field of agricultural economics from Faculty of Agriculture, Kabul University in 2007. After that in the same field of agricultural economics completed M.Sc.(Agri.) from Acharya N.G. Ranga Agricultural University (ANGRAU), Hyderabad in 2011. Recently co--mpleted Ph.D. (Agri.) in the major field of agricultural economics from Junagadh agricultural university, Junagadh, Gujarat. He has been working as Assistant Professor at department of agricultural economics at Paktia University, Paktia, Afghanistan, since 2008. He published research article titled '' Growth dimensions of long staple cotton area, production and yield in Gujarat'' in International Journal of Current Microbiology and Applied Sciences in 2018. Mr. M. Daud ICCR Ph.D. Scholar at department of agricultural economics, college of agriculture, Junagadh agricultural university, Junagadh, Gujarat. E-mail Id: dahmadzai@yahoo.com

2. **Dr. R.L. Shiyani**, is currently Professor at department of agricultural economics, college of agriculture, Junagadh agricultural university, Amreli, Gujarat. Dr. Shiyani worked as Professor and Head from 01-08-2004 to 29/05/2017, besides he also worked as University Registrar for four years. He has published thirty international articles, 130 national articles and presented 86 papers at various national and international conferences. In addition, Dr. Shiyani has successfully completed 23 departmental and 12 other agencies research projects including collaborative projects with ICLARM, ICRISAT, NIAP, TNAU, *etc*. He received D.K. Desai National Award for adjudging the best research paper published in Indian Journal of Agril. Economics, Mumbai during Jan-March-2007. He was invited **three** times as a **Visiting Scholar and once as a Visiting Scientist** at **ICRISAT,** Patancheru (A.P.) during 1996- 2000. Dr. Shiyani has guided **13** M. Sc. (Agril. Economics) and **7** Ph. D. students so far. E-mail Id: rlshiyani@yahoo.com

3. **Dr. B. Swaminathan** is presently working as Assistant Professor at department of agricultural economics, college of agriculture, Junagadh Agricultural University, Junagadh, Gujarat. His areas of interest include impact assessment and valuation studies along with research related to trade and marketing aspects. Dr. Swaminathan has received Young Scientist Award besides Research Award for the best doctoral research work. He has attended various national and international conferences and has been a lead speaker in many of these too. To his credit, he has seven international journal articles, forty two national journals articles, six book chapters and two books. E-mail Id: bswaminathan@jau.in