Autoregressive model of Sweet orange (*Citru sciensis L. osbeck*) productivity in Ibadan, Nigeria.

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Abstract: Autoregressive model of citrus productivity is important in view of the need to strike a balance between its meeting consumers' demand as well as justifying farmers' input. This study was carried out to evaluate citrus productivity through an autoregressive model using data from the citrus orchard established by the National Horticultural Research Institute, Ibadan in 1977. The citrus orchard covered 20ha of alfisoil, composes of twelve varieties of sweet oranges which represents the blocks while the annuals yield represents the treatments. The results of the analysis of variance showed that the annual yields of citrus regardless of the variety are significantly different from one another because the F- statistics 1578120 returned for the year is greater than $F_{(23,\ 576:\ 0.01)} = 2.26$. Also, there exist significant difference in the mean yield of the variety irrespective of the year because, the 369479 returned for the variety is greater than $F_{(11,\ 576:\ 0.01)} = 3.60$. The interaction of the year by variety of the yield of citrus clearly indicated a significantly different result since the mean (9095.06) returned for the interaction was greater than $F_{(253,\ 576:\ 0.01)} = 1.00$. Yield extension rate (*YER*) of the citrus yield does not follow a regular pattern and it differs across the different period with no two periods (x_{ij}) having the same mean *YER*. The auto regression analysis of the citrus yield gave a linear relationship between the current yield and preceding year's yield of citrus with a very high coefficient of determination (0.993) and a very low residual ($\Sigma Y_r = 0.0022$).. [Report and Opinion. 2010;2(1):38-42]. (ISSN: 1553-9873).

Keywords: Yield extension rate(YER), mean yield, alfisoil

Introduction.

Citrus fruits are produced all round the world and world citrus production in selected major producing countries in 2005/2006 is 72.8 million metric tones (UNCTAD, 2009). Citrus fruit is said to be the first crops in the international trade in term of values (CIAC, 2002.). Two clearly differentiated but mutually in exclusive market have been identified for citrus thus; the fresh citrus fruit market with predominance of oranges and processed citrus products markets mainly orange juice. Its economic importance is not unconnected with its fruit been used for both industrial and domestic purposes (Aubert and Vullin, 1998). It is also reported to be one of the most widely cultivated fruits in South West Nigeria (Adewale *et al.,* 1996). Autoregressive model $AR_{(p)}$ is an extension of random walk model and it is defined as a linear combination of previous values at times/locations $i = 1, 2, . . .p.$ it is a widely used stochastic model that can be extremely useful in the representation of certain practically occurring series. The Autoregressive model $AR_{(p)}$ of order p for the time space/space dependent property A is

$$A_i = \phi_1 A_{i-1} + \phi_2 A_{i-2} + . \ . \ . \ \phi_p A_{i-p} + \omega_i$$

where $\varphi_1, \varphi_2 . \ . \ . \ \varphi_p$ are auto regressive coefficient and A_i are the values at certain times of the order (Nielsen and Wendroth, 2003). Autoregressive model seeks to investigate certain parameter measured at previous location (time/space) in relation to the next or subsequent location. Rich body of work on citrus exist and include, Aiyelaagbe (2001), Aiyelaagbe and Kintomo (1999), Kolade and Olaniyan (1998), Olaniyan and Fagbayide (2005), Aubert and Vullin (1998) and Perez (2000). These works notwithstanding, scanty works on the autoregressive model of citrus particularly in Ibadan is known. Similarly, precision agricultural analysis method is moving agriculture towards “production to specification” which provides impetus to agricultural productivity. In Nigeria, it is difficult for citrus growers to compete in exportation with overseas citrus producers because of their high quality golden yellow colour of the fruit as opposed to greenish coloration typical of Nigeria citrus fruit. Also, citrus production in Nigeria has not recorded any appreciable economic trend and significant breakthrough in high quality fruit of international standard (Afolayan, *et al*, 2004). These might be consequent to improper production planning. This study is thus justified from the need to strike a balance between citrus productivity in meeting consumers’ demand and the need for farmers to break even in their productivity. It consequently enhances adequate planning of citrus productivity. The objective of this work is to evaluate citrus productivity through an autoregressive model.

Study Area.

This study was carried out at citrus orchard of the National Horticultural Research Institute, Ibadan (Latitude 7^o54^1 N and longitude 3^o54^1E, 213 meters above sea level) The Orchard was established in 1977.

Materials and methods.

Data for this study was obtained from the citrus orchard established by the National Horticultural Research Institute, Ibadan (Latitude 7^o54^1 N and longitude 3^o54^1E, 213 meters above sea level) in 1977. The citrus orchard composes of twelve varieties of sweet oranges namely Agege1 Umidike, Bende, Etinan, Meran, Valencia, Parson brown, Pineapple, luegingon, Washington nave, Carter Navel and Hanlin which represents the blocks while the annuals yield represents the treatments. This orchard was established on 20ha of alfisoil and of effective soil depth of over 150cm which makes it suitable for tree crop production. The soils are well drained with low flooding potential.

Data on annual yield of the citrus were collected from 3 randomly selected citrus trees per varieties the data were subjected to descriptive statistics as well as analysis of variance. Means of the significantly different factors were separated using Duncan multiple range test. Yield extension rate of the separated means of years were obtained using.

$$y_r = y_{i+1} - y_i$$

(where y_i is the yield of the initial year and y_{i+1} is the yield of the immediate year). Based on the mean yield extension rate,

annual yield rate was obtained using $\bar{y}_r / \sum \bar{y}_r$. The autoregressive model of the mean annual yield was computed using the relationship between y_i and y_{i+1} as defined earlier. Lastly, the residuals of the model predictions were computed and plotted.

Results.

Mean annual rainfall for the period under study range between 66.19mm/month and 222.58mm/month, (Figure 1). The analysis of variance of the yield of citrus showed that the annual yields of citrus regardless of the variety are significantly different from one another. This is because the Fisher's statistics 1578120 returned for the year is greater than $F_{(23,\ 576:\ 0.01)} = 2.26$. Also, there exist significant difference in the mean yield of the variety irrespective of the year because, the 369479 returned for the variety is greater than $F_{(11,\ 576:\ 0.01)} = 3.60$. The interaction of the year by variety of the yield of citrus clearly indicated a significantly different result. This is because 9095.06 returned for the interaction was greater than $F_{(253,\ 576:\ 0.01)} = 1.00$ (Table 1). This clearly implied that yield differential across year and varieties were not by chance but perhaps by influential yield factor(s). Mean yield of citrus in term of years were partitioned into 24 significantly different classes with no two (2) years falling into the same classes. Mean citrus yield increases continuously as the year increases with the least mean yield (18.229) obtained for 1983 and the highest (259.089) obtained for 2006 (Table 2). Duncan Multiple Range Test partitioned the mean yield by each of the varieties into significantly different varieties. Umudike the significantly highest yielding variety was higher than Agege (1585.539^b). This was followed by the yield obtained for Etinah variety (1564.819^c) which is significantly higher than the one obtained for Bendel (1413.629^d). The least yield variety is the Washington navel (73.6^l) which is significantly lower than the yield (979.789^k) obtained for Cartenaval (Table 2).

The autocorrelation of the citrus yield (Figure 2) clearly followed a negative ridge trends and the 78.3% of the autocorrelation values fall within the range of $\pm 2/\sqrt{n} = \pm 0.417$. The implication of this is that the data used for this study is relatively random and lacks no seasonal fluctuations hence needs no adjustment. Yield extension rate of the citrus yield does not follow a regular pattern and it differs across the different period. No two periods (x_{ij}) have the same mean yield extension rate. However the least yield (MYER = 21.031) was obtained for 23^{rd} (2006 - 2005) rate while the highest was obtained for 8^{th} rate (1991 - 1990) with the mean yield extension rate of 190.80. From the mean yield extension rate, annualized yield rate of 4.35% could be obtained with the residuals of -3.695×10^{-13}. This clearly indicates a plausible level of annualized yield rate.

The auto regression analysis of the citrus yield gave a linear relationship between the current yield and preceding year's yield thus;

$$Y = 124.041 + 0.991x$$

(where x is the citrus yield of the preceding year and Y is as defined in equation).

This model have a very high predictive power (coefficient of determination, $R^2 = 0.993$) and a very low residual $\Sigma Y_r = 0.0022$. The plot of the actual mean annual yield as well as the predicted values produced the almost the same results (Figure 3A). The only exception is the 16^{th} period which can be taken as an outlier. Also, the plot of residuals (Figure 3B) of the

model gave an alternating series indicating a plausible level of randomness of the residuals. It is also noteworthy that the *MYER* and the residual gave almost the same trends though with different ranges (Figure 3B).
The implications of these results are;
i). Differences in annual citrus yield are statistically significant hence must not be associated with mere noise.
ii).Each citrus species investigated have different mean yield that are statistically significant.
iii).The significance of the interaction between the year and the variety clearly indicated an independent in the significance of the sources of variations (years and varieties).

Discussion and Conclusion

The goal of this study is to arrive at a stochastic model that can be used to predict future citrus yield from the available current yield data. The result of the autocorrelation confirms the randomness of the data used for the model despite the constant study area's size and thus justified the safety of the interpolation of the result for a relatively larger area. This is not unconnected with the fact that the experimental site have been carefully chosen and tendered for optimum experimental results. Also, barring all weather condition, mean separations as well as the autoregressive model clearly indicated that citrus productivity in the study area is an increasing trend. This is in line with the citrus productivity trends as reported by CIAC (2002) as well as well as world citrus production trend (UNCTAD, 2009). In addition, the trends of citrus productivity for Nigeria (Yusuf and Sheu, 2007) using $\ln Y_t = b_0 + b_1 T$ gave the same linear trends. The difference in the model type as well as model components in this study and Yusuf and Sheu (2007) are however noteworthy. While the former explore only the yield at different period, the latter explore relationship between yield and cultivated land. These could be hinged on the nature of the type of the model explored by the 2 studies in addition to the objective(s) of the study. Similarly, it need be added that growth rate (sigmoidal shape) is utterly different from the yield rate (which is linear) as revealed in this study. The goodness of the fit of this autoregressive model could be traced to the fact that there exist non significant autocorrelation of the residuals (randomness of the residuals). Also, the trend of the residual is similar with that of mean yield extension rate which could be described as the rate of change. The annual yield rate (*AYR*) obtained from this study is very high when compared to the annualized rate of 0.8% reported for developing countries, (Spreena, 2009). This disparity could be hinged on the area covered by this study Spreena (2009). While this study was carried out within the experimental station of the Institute where external influences are controlled to the minimum, Spreena (2009) covers several developing countries with different peculiarities. One major and important assumption here is that citrus orchards are established in their normal environment with all the growth indices fully provided and with all hindrance reduced to the minimum.
In conclusion, citrus productivity is predictable using the linear autoregressive model arrived at in this study. Also, the model (which presents the simplest model being linear model) can be adopted for areas with similar *MYER*.

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12/25/2009