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Using Excel Macros and Time Series to Study Electrical Response in Strawberry Plants

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INTRODUCTION & AIM

It is important to improve the analysis of plant electrical signals using macros with simpler tools that require less time and resources and are within the reach of future researchers, who do not have specialized computational tools to obtain equally acceptable results.

The aim of this study is develop an autoregression model in Excel by implementing macros in Visual Basic for Applications (VBA), which allows analyzing time series and characterizing the electrical signal generated by the strawberry plant, in response to different lighting stimuli, using forecasting techniques by moving averages, quantification of error and autoregressive models.

Building well-fitting models is a current challenge. Having a multi-method tool that can visualize the fit and numerically evaluate its performance saves time and allows for decision-making using common codes and shared spaces for different methods.It also allows for plotting at custom intervals.

METHOD

A hydroponic system was built with PVC pipes, equipped with sensors and light-emitting diodes. Twenty plants were selected. Once the readings were obtained, a VBA code was developed for their analysis and characterization.

Excel was configured with the most common variables of time series methods, including up to 4 light stimuli in the plant, and iterative forecasts will be applied according to the method; some macros were reused to evaluate the performance saving space and time.

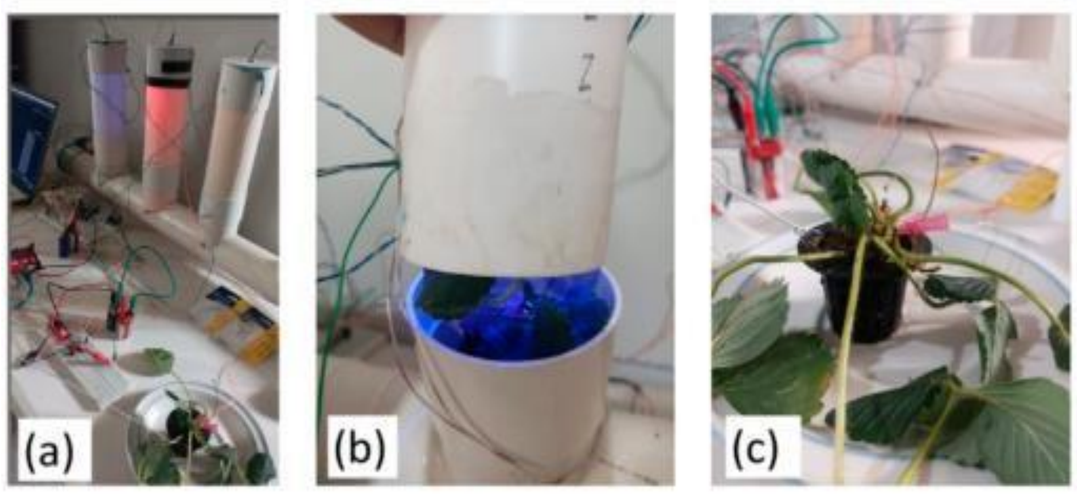

Figure 1. (**a**) Electronic configuration. (**b**) Stimulation of the strawberry plant (**c**). Measurement of the electrical signal [2].

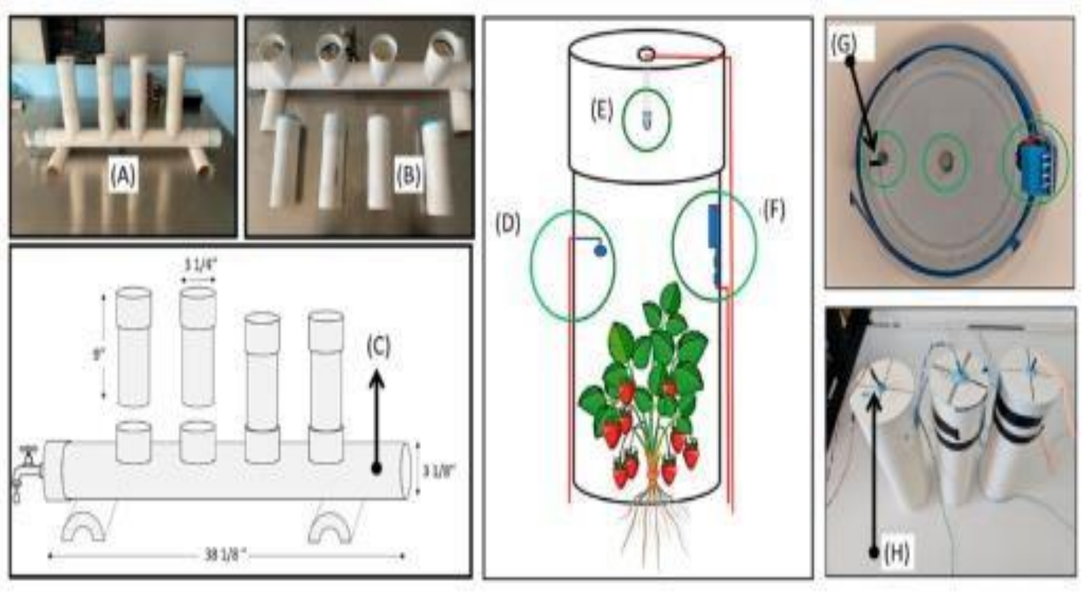

Figure 2 (**A**) hydroponic system. (**B** Light stimulation tubes. (**C)** Hydroponic support system, (**D**) Photodiode sensor. (**E**) LED, (F) Temperature-humidity sensor, (**G**) Internal view of photodiode sensor. (**H**) Securing the LED device.

RESULTS & DISCUSSION

```
Sub movingaverages()
n = Range("E1")
totalraw = Range("E3")
initial_position = 5
final_position = initial_position + n
totalforecast = totalraw - n
For i = 0 To totalforecast - 1
With ActiveSheet.Cells(final_position + i, "C")
.NumberFormat = "General"
.FormulaLocal = "=SUM(B" & (initial_position + i) & ":B" & (final_position + i - 1) & ")/" & n
End With
Next i
End Sub
```

Figure 3. Code to calculate moving averages.

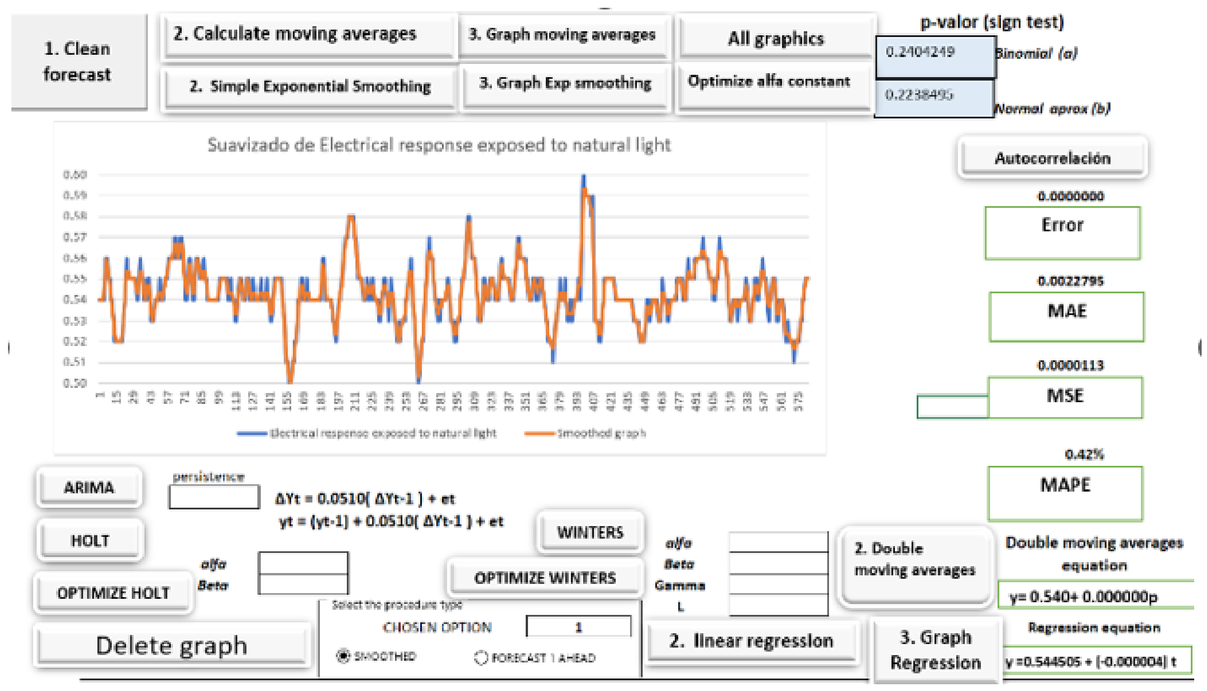

Figure 4. Time series analysis system screen

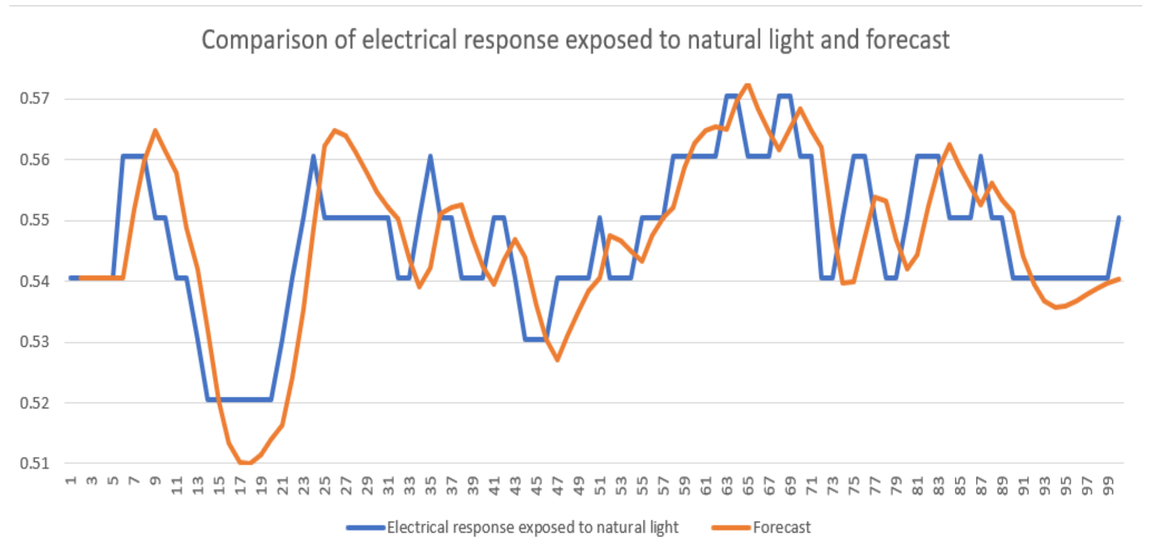

Figure 5. Customizable Interval graphing

CONCLUSION

It was possible to develop an analysis, decomposition of time series and forecast by moving averages, exponential smoothing and autoregressive models using Excel and (VBA).
When comparing the methods used, it was observed that the moving average method gave the lowest percentage of error compared to exponential smoothing, linear regression, Holt and Holt Winters, and even double moving averages. When comparing the 4 electrical signals, a significant difference was observed at 95% between natural light and colored light, with the green light having the highest voltage.

FUTURE WORK / REFERENCES

[1] Villarreal, F. (2016). Introducción a los Modelos de Pronósticos. *Univ. Nac. del Sur*, 1-121.

[2] Garcia-Menchaca L, Guerra-Sánchez C, Tarchoun N, Lebbihi R, Cruz- Dominguez O, Sifuentes-Gallardo C, Peréz-Martínez JG, Cleva M, Ortega-Sigala J, Durán-Muñoz H. Early-Stage Research to Characterize the Electrical Signal of Optically Stimulated Hydroponic Strawberries Using Machine Learning Techniques. Engineering Proceedings. 2025; 87(1):44. https://doi.org/10.3390/engproc2025087044