



Finding optimum climatic parameters for high tomato yield in Benin (West Africa) using frequent pattern growth algorithm



DEEP LEARNING
INDABA

Ariane Houetohossou¹, Ratheil Houndji^{2,1}, Rachidatou Sikirou³, and Romain Glèlè Kakai¹

¹ Laboratoire de Biomathématiques et d'Estimations Forestières, Faculty of Agronomic Sciences, University of Abomey-Calavi, 04 BP 1525 Cotonou, Republic of Benin

² Institut de Formation et de Recherche en Informatique, University of Abomey-Calavi, 01 BP 526 Cotonou, Republic of Benin

³ Laboratoire de Défense des Cultures, Centre de Recherches Agricoles d'Agonkanmey, Institut National des Recherches Agricoles du Bénin (INRAB), 01 BP 884 Cotonou, Republic of Benin

Abstract

- Agriculture is the backbone of developing countries' economies.
- This paper addresses the challenge of finding fine climatic values for high tomato yield. The Frequent Pattern Growth (FPG) algorithm was used to establish the associations between minimum and maximum temperatures (Tmin and Tmax), maximum humidity (Umax), sunshine (Sun), rainfall (RR), evapotranspiration (ET), and yield.
- High tomato yield was associated with low ET, medium Tmin, Tmax, Umax, and Sun. The best yield patterns were observed in the Guinean Zone. These results are useful in assessing climate variability impact on tomato production.

Introduction

- Agriculture contributes 30% to 60% of the Gross Domestic Product (GDP) in about two-thirds of the developing countries [1]. In Benin, it is the most important sector, providing up to 36% of the GDP [2].
- However, yield prediction is still a challenge for farmers, especially in the context of climate change.
- This paper uses a non-supervised model, the FPG to find the optimum climatic attributes to maximize tomato yield in Benin.

Objective

This study aims to use association rules mining to find associations between weather and high tomato yield in Benin using data collected over 26 years.

Materials and methods

Study area and dataset considered

The study area is the Republic of Benin (Figure 1). Collection of weather data from the synoptic stations of Kandi, Savè, and Cotonou at ASECNA and Annual tomato yields from the DSA.

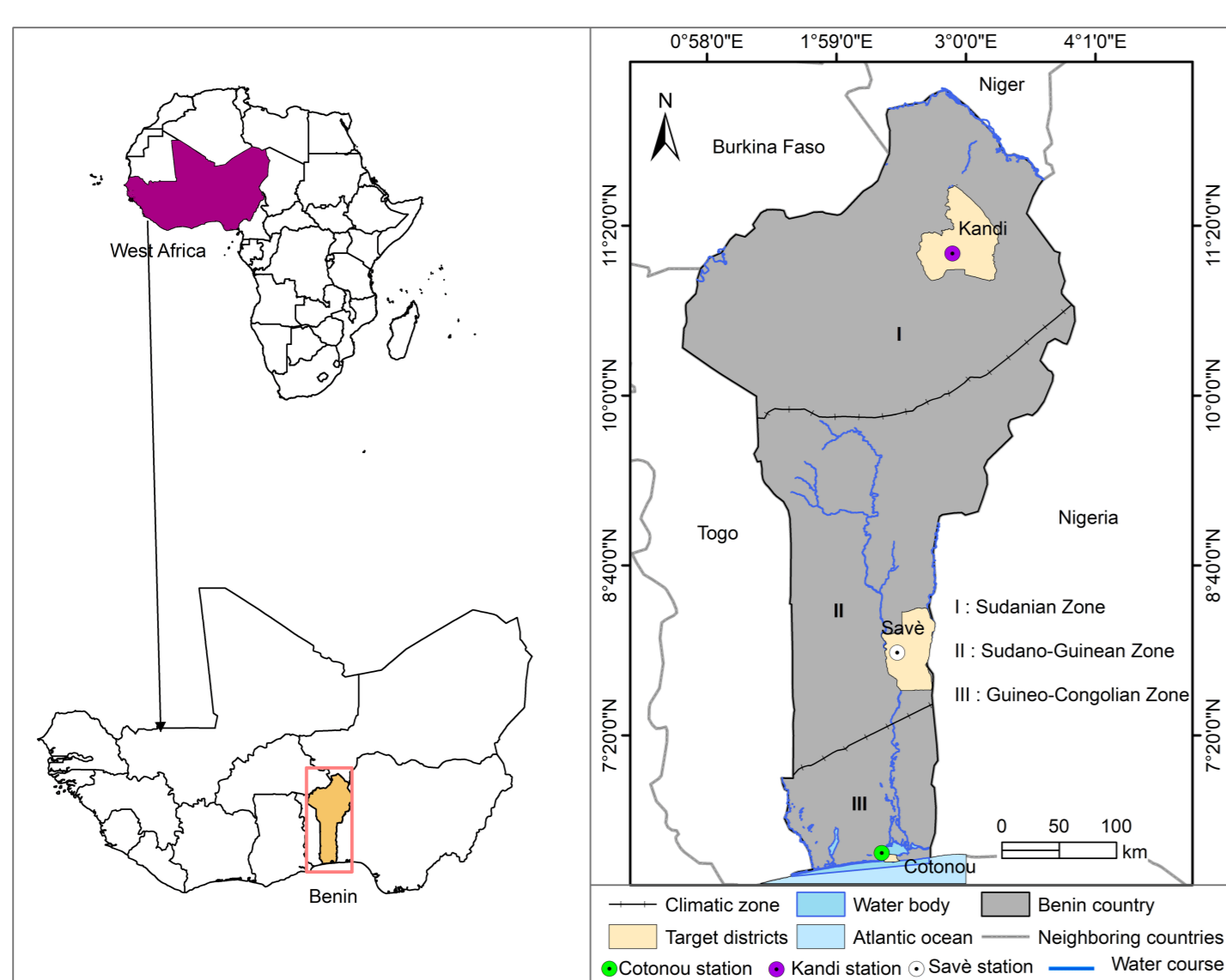


Figure 1: Map of the Republic of Benin

The rainfall boxplots show a similar pattern for the three stations, with outliers at Cotonou (Figure 2). Sun and ET are higher at Kandi. Tmin, Umax, Umin, and yield are more important at Cotonou.

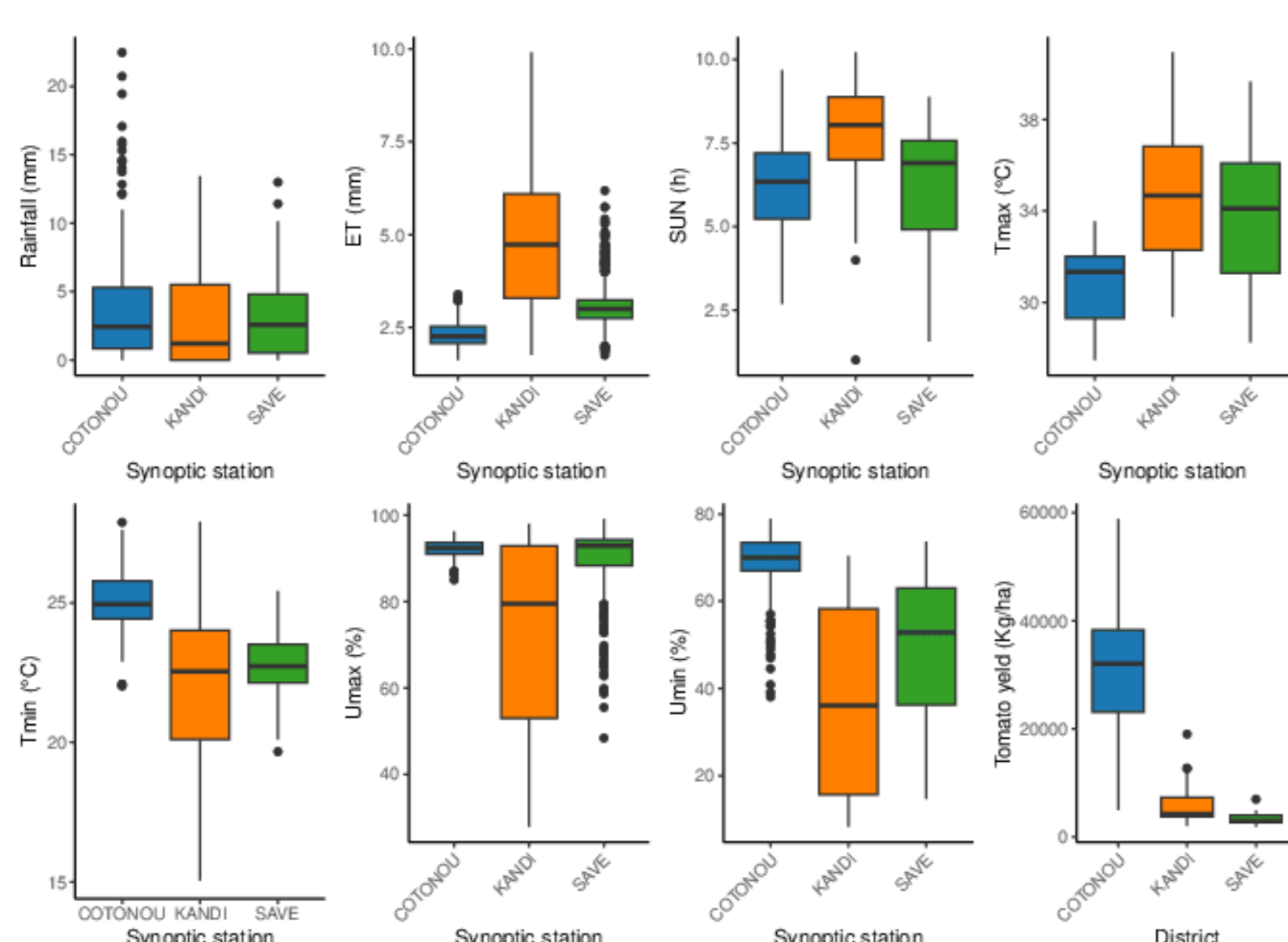


Figure 2: Distribution weather data and tomato yield from 1995 to 2020 in the districts

From Figure 3, Kandi recorded the highest values of ET, Tmax, and Sun. However, Umin was low in Savè and Kandi. The Sun and Umax trends are similar in Cotonou and Savè. Tmin and Umin were high at Cotonou. The yield was higher up to 5000 kg/ha at Cotonou.

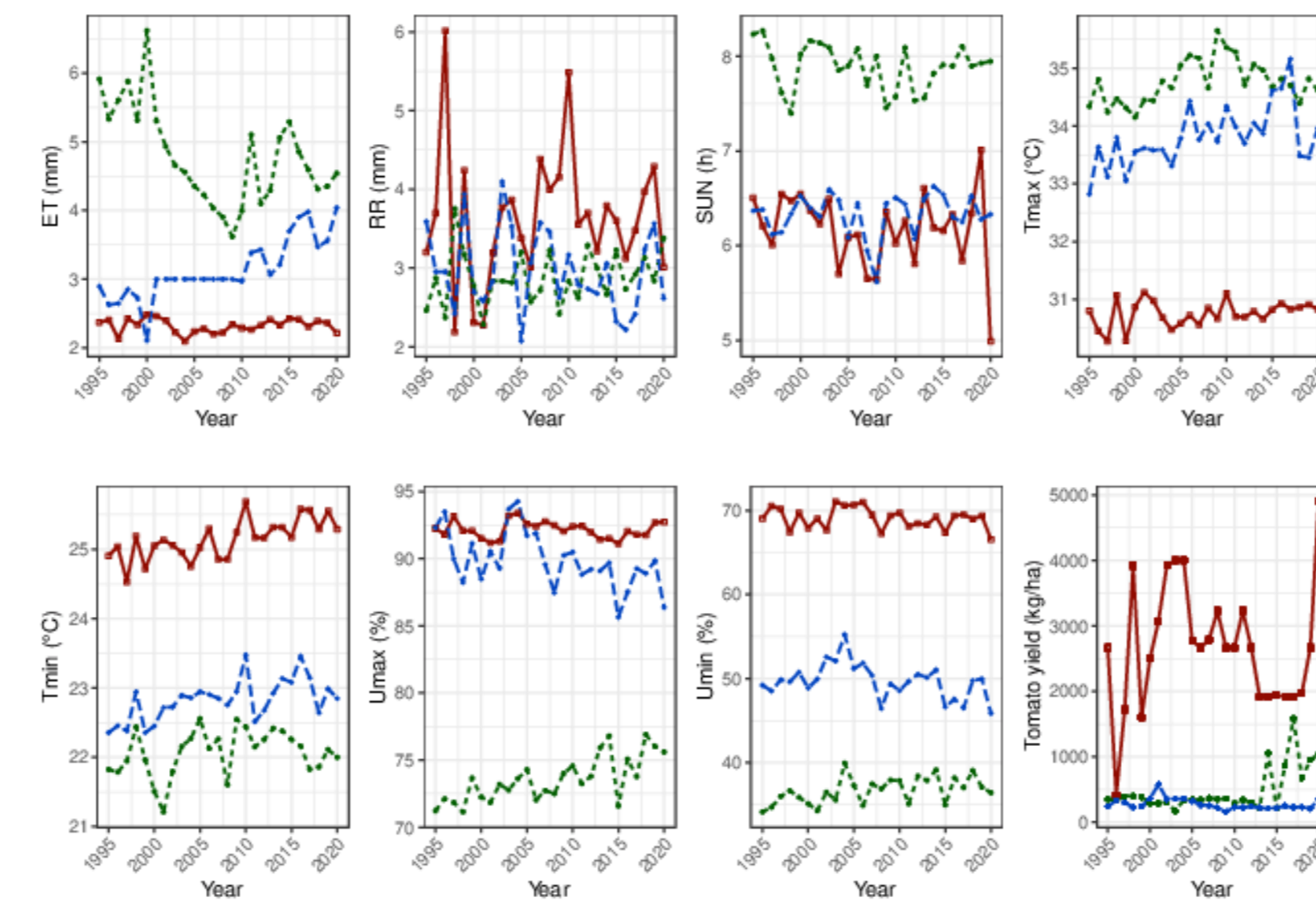


Figure 3: Temporal variation of weather data and tomato yield in the districts

Data pre-processing

- Computation of monthly mean for each variable and monthly average of yield.
- Categorization of attributes as 'low', 'medium' and 'high' using means+or-sd.
- Use of FPG to establish associations between yield and weather parameters.
- Setting the minimum support to 0.2.
- Filtering performed on rules containing at least three antecedents and only high yield as a consequent.
- The rules reported were the most relevant ones whose confidence is at least 0.8, with a lift ≥ 1 . Use of Python for the analysis.

Results and discussion

Results

From Table 1 high yield in the Sudanian Zone was associated to low ET, high RR, and medium values of Tmin, Tmax, and Umax.

Table 1: Rules from Sudanian zone

Antecedents	Consequent	Support	Confidence	Lift
ET Low				
Tmin Medium	Yield High	0.250	1.0	1.0
Umax High				
Tmax Medium				
Umax Medium	Yield High	0.208	1.0	1.0
RR High				
ET Low				
Umax Medium	Yield High	0.250	1.0	1.0
RR Medium				
Tmax Medium				
ET Low	Yield High	0.250	1.0	1.0
RR Medium				

In the Sudano-Guinean zone, a high yield of tomatoes was associated to low ET, with medium values of Tmin, RR, and Umax (Table 2)

Table 2: Rules from Sudano-Guinean zone

Antecedents	Consequent	Support	Confidence	Lift
ET Low				
Tmin Medium	Yield High	0.416	1.0	1.0
RR Medium				
ET Low				
Tmin Medium	Yield High	0.309	1.0	1.0
Umax Medium				
Tmax Medium				
Tmin Medium	Yield High	0.297	1.0	1.0
Umax Medium				
Tmin Medium				
Umax Medium	Yield High	0.261	1.0	1.0
Sun Medium				

In the Guinean zone, the high yield suggested a low ET, and medium values of Tmin, RR, and Umax as presented in Table 3.

Table 3: Rules from Guinean zone

Antecedents	Consequent	Support	Confidence	Lift
ET Low				
Tmin Medium	Yield High	0.457	1.0	1.0
Sun Medium				
Tmax Medium				
Tmin Medium	Yield High	0.237	1.0	1.0
RR Medium				
ET Low				
Umax Medium	Yield High	0.423	1.0	1.0
Sun Medium				
Tmin Medium				
Umax Medium	Yield High	0.288	1.0	1.0
Sun Medium				

Discussion

- Our results align with those of Dwamena [3], who found that high rainfall does not produce higher cassava yields in Ghana.
- Another study reported that high temperatures resulted in lower fruit production and yield reduction in tomatoes [4].
- Similarly, Bhandari [5] observed that tomato production per hectare decreased when Tmax was above 28°C. Tomatoes are sensitive to heat stress, which lead to reduced fruit production.
- In Portugal, it was observed that yield decreased with increasing humidity [6]. Yield increased when relative humidity was between 75% and 95% [7], this is consistent with our findings.
- A high humidity environment is more likely conducive to the appearance of pests and diseases, resulting in low crop yields.
- Our results could be more consistent with the findings of Rao [8], who reported high yield of rice when temperature and rainfall were high.
- Rice and tomato have different requirements. The water requirement for tomatoes is between 1.62 and 4.58 mm per day [9], while rice requires an average of 7.905 mm.

Conclusions

- This paper used the FPG algorithm to link tomato yield and climate parameters in Benin's three agroecological Zones.
- Rainfall was high in the Sudanian Zone but low in the other two areas. On the other hand, the attributes Tmin, Tmax, and Umax were medium regardless of the Zone considered.
- This work can be extended to other vegetables requiring approximately the same climatic conditions as tomatoes.

References

- [1] FAO *The Role of Agriculture in the Development of Least-developed Countries and their Integration into the World Economy*. Fao, 2002.
- [2] MAEP *Stratégie nationale pour l'e-Agriculture au Bénin 2020-2024*. 2019.
- [3] Dwamena H. and Serwaa K.A. Kodua A. *The Effect of Rainfall, Temperature, and Relative Humidity on the Yield of Cassava, Yam, and Maize in the Ashanti Region of Ghana*. IJA, 2022. Hindawi, 10.1155/2022/9077383

This work is submitted to PLOS One as: Houetohossou A., Houndji R., Sikirou R., Glèlè Kakai R. High tomato yield in Benin (West Africa) using frequent pattern growth algorithm. PLOS One.