

Davis, D., S. Fountas, K. Aggelopoulou, T. A Gemtos, and G. Vellidis. 2007. Management zones for high valued crops in Greece. In: Aggelopoulou, A., S. Blackmore, T. Gemtos, S. Fountas (Eds.), Poster Proceedings of the Sixth European Conference on Precision Agriculture (6ECPA), Skiathos, Greece, 6pp.

## **Management Zones for High Valued Crops in Greece**

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### **Abstract**

The goal of this project was to Determine the potential of using precision agricultural practices in small fields throughout Greece. This project is an extension of a prior study carried out in a 0.8ha apple orchard in Northern Greece. Maps were created to view the variability of four different soil characteristics pH, Nitrogen (N), Phosphorus (P), and Potassium (K). The three nutrients are the major soil amendments that are applied to crops each year. Results have shown that utilizing management zones can benefit farmers by lowering cost, time spent in the field, and by increasing profits. Management zones can also benefit farmers with small fields by utilizing smaller precision farming equipment.

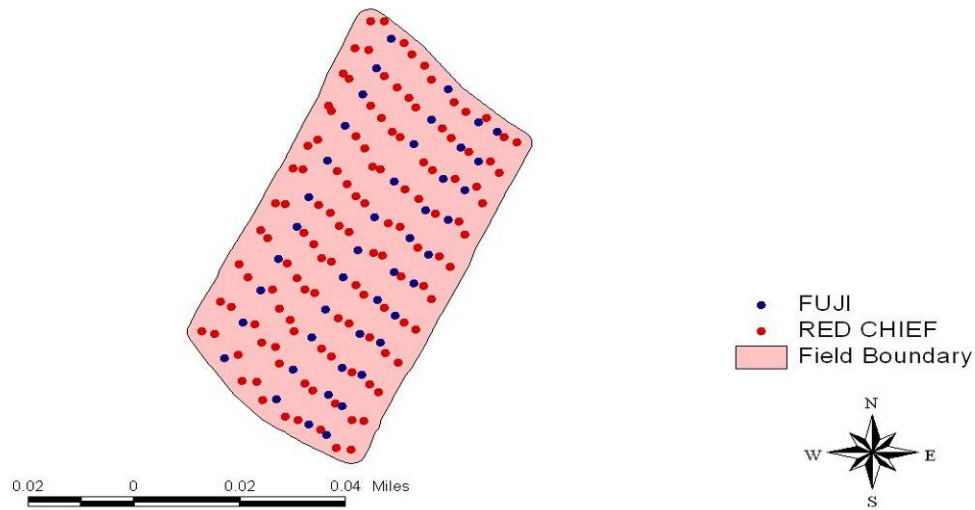
**Keywords:** Precision Agricultural, Management Zones

### **Introduction**

A management zone is a sub-region of a field that expresses a relatively homogenous combination of yield limiting factors for which a single rate of a specific input is appropriate (Doerge, 1999). These management zones are combined to create a field with several different management strategies. It is of special interest to see the results of the application of precision farming techniques in high valued crops such as fruits and vegetables, in order to improve fruit yield, fruit quality, and limit negative impacts on the environment (Aggelopoulou et al, 2006). The small fields (approximately 0.8ha) studied in this research project showed variability in nitrogen (N), phosphorus (P), and potassium (K).

### **Materials and Methods**

The initial study was carried out in a 0.8 ha commercial apple orchard for the years 2004 and 2005. The orchard is located in Ptolemaida area, Northern Greece (21° 50'15'' E, 40° 39'13'' N and 790m elevation) in a clay soil. It was planted in 1998 and consisted of two apple cultivars; Red Chief which is the main cultivar and Fuji which is the pollinator. The field has 15 tree rows, 11rows with Red Chief and 4 with Fuji. The arrangement between the two cultivars is presented in Fig.1. The between-row spacing of the trees is 4m and the intra-row 2.5m. Trees were trained as free palmette.



**Fig.1.** Red Chief (main cultivar) and Fuji (pollinator) rows

For yield mapping, apples were collected manually and placed in plastic bins. Yield per five trees was weighed and the geographical position in the centre of the five trees was recorded using a hand-held computer with GPS (Trimble Pathfinder). Each yield point represented the centre of a 4m by 10m cell. In all, 121 measurements for Red Chief and 44 for Fuji were taken. Yield data were interpolated to 2m grid maps using kriging.

The present study maps were created from the data collected during the initial study to be compared to soil characteristics of the field. Soil samples were taken throughout the field and sent to a lab to determine soil nutrient levels of the field. The comparisons between apple quality and soil characteristics were used to help create management zones. The Management Zones Analysis (MZA) software (Fridgen, 2004) was used to determine how many zones should be applied to the 0.8 ha field. This software calculates an average value of all the values used. The number of management zones is determined by how far the data is above or below the average value.

## Results and discussion

Management Zone Analysis (MZA) uses user determined viabilities to categorize the information and to determine how many management zones would be applicable to a field. Management Zone Analyst's function is the calculation of descriptive statistics, the delineation of management zones using the fuzzy *c*-means unsupervised classification algorithm, and the evaluation of the performance of the clustering by the number of clusters (Fridgen, 2004). Data being used in the MZA software should be comma delimited text files. Any data can be used with this program such as yield, soil characteristic, etc. The flowchart in Fig 2. describes how MZA works.

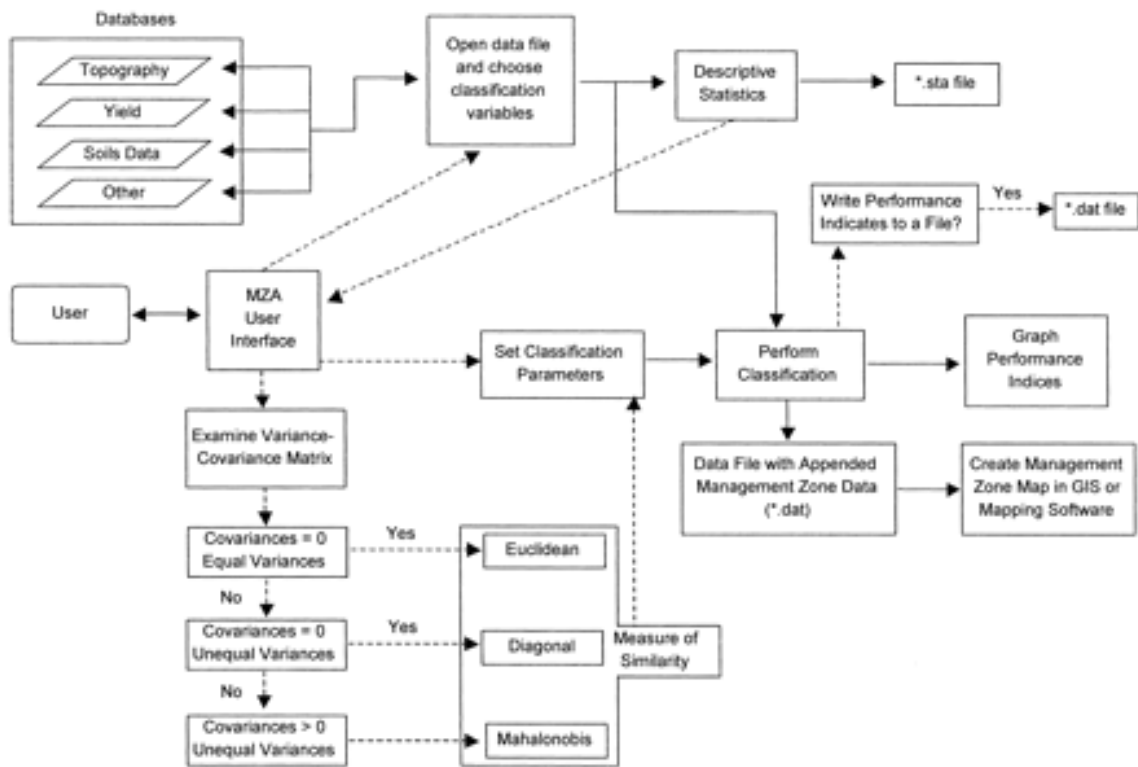


Figure 2. Description of Management Zones Analyst (Fridgen et al., 2004)

The algorithmic structure of the iterative fuzzy  $c$ -means algorithm (Bezdek, 1981) is

1. Choose the number of clusters  $c$ , with  $2 \leq c < n$ .
2. Choose the fuzziness exponent  $m$ , with  $1 \leq m < \infty$ .
3. Choose an appropriate measure of similarity for the distance metric  $d_{ik}^2$ .
4. Choose a value for the stopping criterion  $\epsilon$ .
5. Choose a value for the maximum number of iterations  $l_{\max}$ .
6. Initialize  $U^0$  with random values meeting the specified constraints.
7. At iteration  $l = 1, 2, 3, \dots$ , calculate updated  $V^l$  from  $U^{(l-1)}$ , using:

$$v_i = \sum_{k=1}^n (u_{ik})^m y_k / \sum_{k=1}^n (u_{ik})^m, \quad 1 \leq i \leq c \quad [7, 8.]$$

8. Calculate updated  $U^l$  from updated  $V^l$ , using:

$$u_{ik} = \left[ \sum_{j=1}^c \left( \frac{d_{ik}}{d_{jk}} \right)^{2/(m-1)} \right]^{-1} \quad [8, 9.]$$

9. Stop when  $l_{\max}$  is reached or when  $\|\mathbf{U}^{(l)} - \mathbf{U}^{(l-1)}\| \leq \epsilon$ ; otherwise go to Step 7.
10. Compute the cluster validity functions (FPI and NCE).

Nitrogen, phosphorus, potassium, and pH were the variables used in this project. The four soil characteristics of the field have variability and the MZA software showed that management zones will work for this field. The software does not take into consideration if the data being used is the best variables to use when creating management zones for an apple orchard. It was found that management zone can be utilized by farmers with small fields. In this project all of the variables used may not be the best for determining management zones. pH is a good variable because scientists have shown that 6.0 to 7.0 is a good range for growing quality apples. The other three variables are needed to grow apples, but know one has determined if these soil elements are crucial for apples. Figures 3 – 6 illustrate the yield map and the soil maps for the three of four components (N, P, K), where no correlations between the yield and the soil elements is visibly seen.

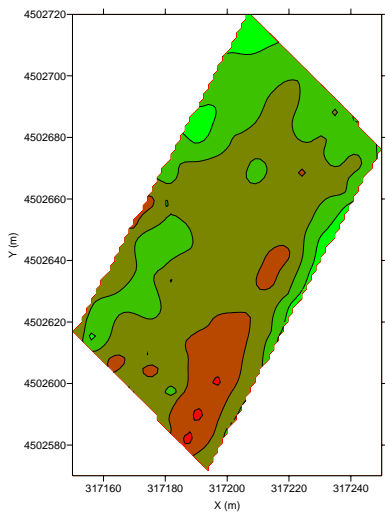


Figure 3. 2004 Yield

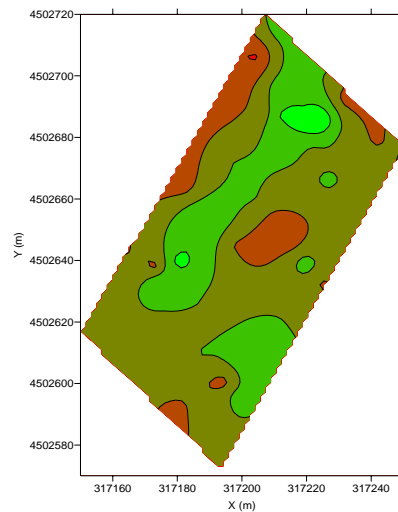


Figure 4. 2004 Phosphorus



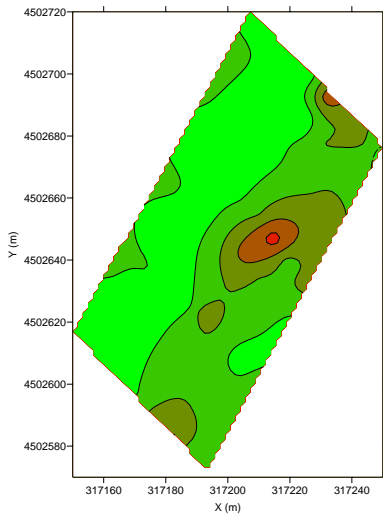


Figure 5. 2004 Potassium

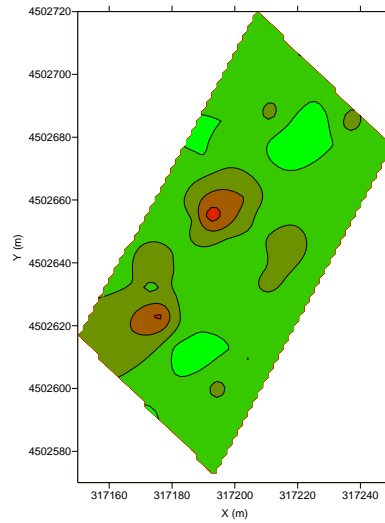


Figure 6. 2004 Nitrogen

Using the values of the four variables (N,P,K and pH) and the coordinates of the locations from which the data were collected, MZA predicts the optimal number of management zones as well as assigns the data points to a management zone. For the data collected from this field, MZA predicted that the optimal number of management zones was 2 for pH (Fig. 7), 3 for K (Fig. 8), 4 for N (Fig. 9), and 3 for P (Fig. 10). Overall the data showed that using three management zones would be ideal for the 0.8ha field.

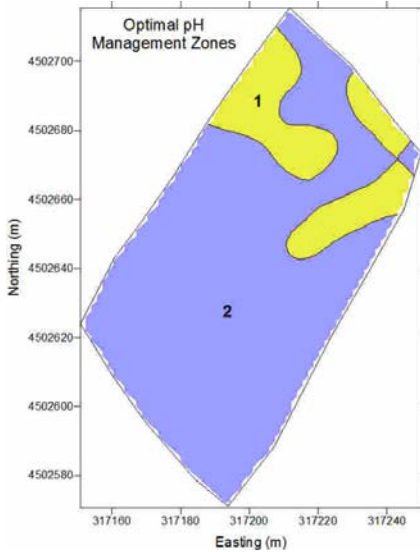


Figure 7. Management zones for pH

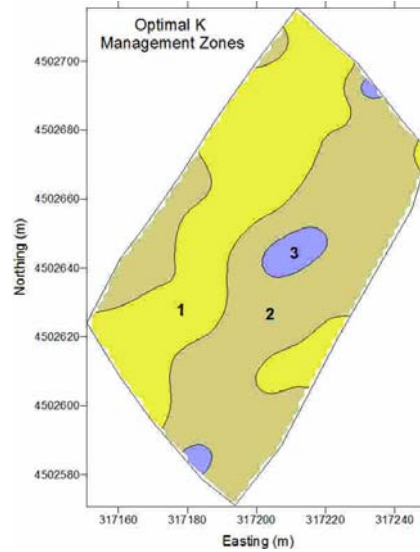


Figure 8. Management zones for K

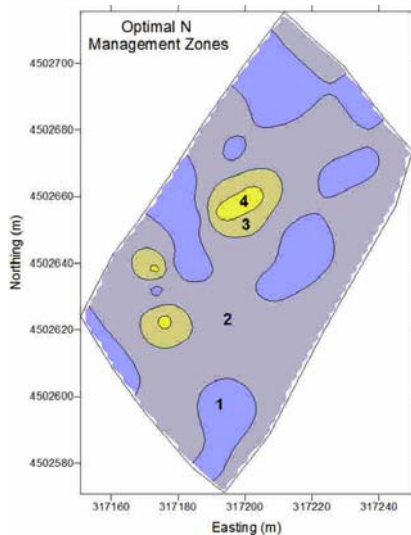


Figure 9. Management zones for N

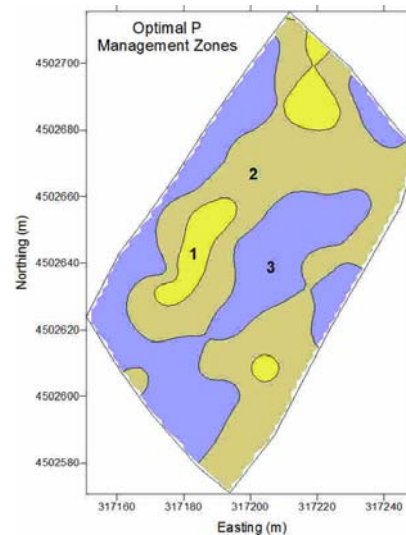


Figure 10. Management zones for P

Further studies should be done on this subject to determine what variables would work best for creating management zones. Strip experiments should be carried out to estimate if variable rate application based on these management zones could have a positive effect on the yield and quality.

## Conclusions

Management zones should be determined by variables that would have an impact on the end result (apple yield and apple quality). In this project three of the four variables were not applicable for creating management zones. Further studies should be done on this subject to determine what variables would work best for creating management zones. These variables should not be taken out of the studies to have consecutive years of data to prove these variables to be good or bad.

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