Site-specific response to nitrogen fertilization in the Argentinean pampas

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Introduction

Site specific zone management are defined as areas of a field that has a relatively homogeneous combination of yield-limiting factors (Officer et al., 2004)**. Several studies have examined the potential for applying variable rates of fertiliser within fields to improve economic performance and minimise environmental impact** (Mueller et al., 2001; Welsh et al., 2003)**. In addition, a range of approaches for determining management strategies for applying variable fertiliser have been examined including topography, soil electrical conductivity and remote sensing** (Li et al., 2008)**.**

One of the most significant factors that can be varied by a farmer to influence the economics of arable cropping is nitrogen fertiliser application (Ruffo et al., 2006)**. Therefore, the quality of soil property maps is fundamental to site-specific N management. Inaccurate or imprecise soil property maps may explain why some site specific fertility management studies have produced poor results. Consequently, map quality evaluation is critical for assessing or predicting the performance of site-specific N management.**

The objective was to evaluate a set of variable rate nitrogen applications and comparing the crop response in homogeneous zones.

Materials and Methods

The study site was a 65-ha field located on the southeast of Buenos Aires Province in south Pampas of Argentina (Lat:-37.9152, Lon:-59.1321)**. ECa was measured using Veris 3100 Soil Mapping System** (Veris Technologies, Salina, KS)**. A gird of 40x40m was developed to determine spatial variability of effective depth (ED). Elevation data collected by DGPS (Trimble R4) was used in this study.**

MULTISPATI-PCA method proposed by Córdoba et al. 2012 was used for delineating sub-field management zones. This algorithm is used as input of fuzzy cluster analysis k-means and the spatial principal components (PCs) of variables. The PCs with eigenvalues ≥ 1 were selected to be used as input in analysis of cluster fuzzy k-means (CFK). For implementing MULTISPATI-PCA, "ade4" (Chessel et al., 2004) and "spdep" (Bivand et al., 2012) libraries were used of R project (R Development Core Team, 2013).

CFK analysis was performed on the first three PCs (PCs1, CPs2 and CPs3) using software Management Zone Analyst 1.0.1 (MZA) (Fridgen et al., 2004). Two indices were used to determine the optimal number of ZM classes, the normalized classification entropy (NCE) and the fuzziness performance index (FPI) (Odeh et al., 1992).
To evaluate the response of crop yield between ZM and fertilizer rates, a mixed linear model (MLM) was adjusted. This allows us to contemplate the structure of spatial correlation among observations from different plots.

Elevation, ECa30, ECa90, ED, nitrates and clay fraction were analyzed using a MLM with block random effect and isotropic spatial correlation with Gaussian model.

Results and Discussion

Each PC is a linear combination of the original variables. The eigenvalues loading associated with each variable in these linear combinations represents the contribution of the original variable to the PC.

The first PCs was associated with ECa30 and ED having the largest loading on PCs1. PCs2 and PCs3 had the strongest contribution from crop variables.

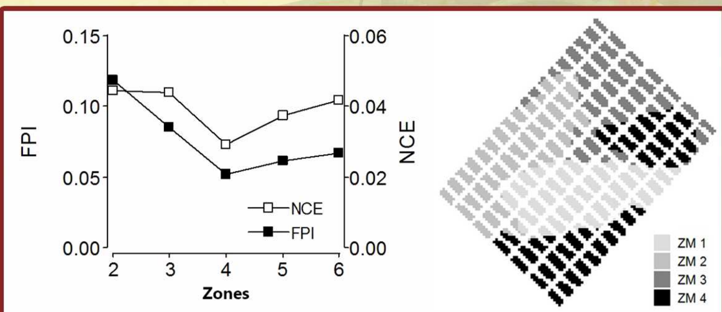

Fig 1. Fuzziness Performance Index (FPI, black) and Normalized Classification Entropy (NCE, white) for different number delimited zones and Map of the four management zones (MZ) bounded

In the PCs2, NDVI from both 2009 and 2007 had the highest positive load. While in the PCs3, was NDVI from both 2010 and 2005 (Table 1). Fig 1 represents the number of ZM according to FPI and NCE indexes. Fig 2 shows the map of four management zones for the study field.

In the model proposed in Eq. 1 the interaction effect between nitrogen application rates and ZM was significant ($p < 0.05$) indicating that the response to fertilization is not the same in all ZM. In ZM 2 and 3, 20 and 138 kg ha-1 nitrogen doses were not statistically different. However, 256 kg ha-1 nitrogen dose was statistically different than other treatments ($p < 0.05$). In ZM 1 and 4 doses of 138 and 256 kgN ha-1 were not statistically different. However, 20 kg ha-1 nitrogen dose was significantly different than other treatments ($p < 0.05$).

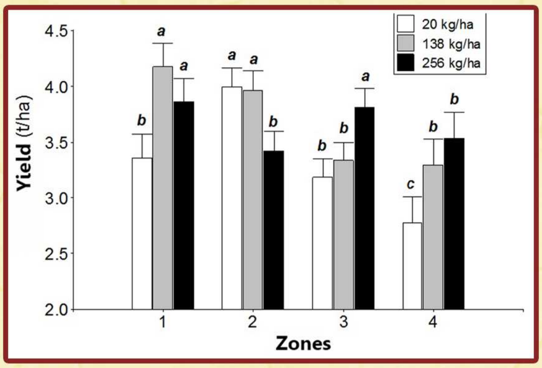

Fig 2. Average yields for management zone and N doses.

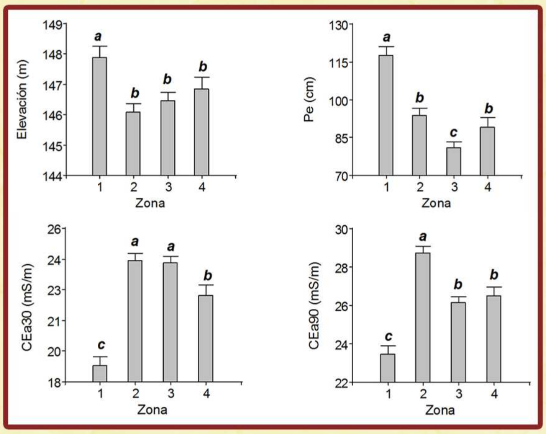

Fig 3. Average levels of soil properties within designated areas

Conclusion

General results between ZM 2 and 3; and ZM 1 and 4 were in a manner consistent with ECa30 readings (Fig 4). ZM 2 and 3 showed higher ECa30 values than in ZM 4 and 1. These results were significantly different in ZM 1 and 4. ZM1 showed lower ECa30 values but higher ones for elevation and ED (Fig. 4). Moreover, the combination of 20 kgN ha-1 and ZM 4 showed significant differences compared to other ones. ZM 3 had ED, OM and nitrates lower and statistically different than other ZM. Except for ZM 4, Clay content was similar between ZMs.

References

Córdoba, M., Bruno, C., Costa, J., Balzarini, M., 2013. Subfield management class delineation using cluster analysis from spatial principal components of soil variables. Computers and Electronics in Agriculture 97(0), 6-14.

Dray, S., Jombart, T., 2011. Revisiting guerry's data: introducing spatial constraints in multivariate analysis. The Annals of Applied Statistics 5(4), 2278-2299.

Fridgen, J.J., Kitchen, N.R., Sudduth, K.A., Drummond, S.T., Wiebold, W.J., Fraisse, C.W., 2004. Management zone analyst (MZA). Agronomy Journal 96(1), 100-108.