Interactive comment on "Scale and space dependencies of soil Nitrogen variability" by Ana M. Tarquis et al.

Anonymous Referee #3

The manuscript deals with the effect of residual soil N content, resulting from a previous experiment with melon, on several parameters in a wheat crop, including grain and plant N content and biomass. The main objective was to identify the structure of the variations in these parameters along a transect at different scales, for which the authors apply multifractal and entropy analyses. The topic of this work is interesting for a wide range of potential readers, and the analyses conducted, although previously used for other parameters, are novel when considering the crop parameters covered.

Thank you for your comments.

However, my recommendation on the manuscript is that it needs a major revision for a series of reasons:

-The introduction section is not well constructed, and contains some paragraphs (more precisely, P. 3, L. 12-20) that are a mere description of the experimental setup. This description should be part of the Material and Methods section and not the Introduction. Moreover, since several other papers with data from this experiment have been published already, their main findings should be included in this section (e.g., Castellanos et al., 2010; Milne et al., 2010).

We have changed the Introduction section leaving a paragraph describing the importance of water and nitrogen in the area.

-The Material and Methods section includes a detailed description of a previous experiment with melon plants that was conducted prior to the establishment of the wheat crop. Although knowing the history of the plots is necessary for the interpretation of the data, many of the details that the authors include are not relevant for the present work, since only parameters of wheat are discussed. For example, melon plant density (P.4, L. 14-15) or the number or rows and plants per row (P.4, L.17), or the details of melon plants (P. 4, L 12-13) are just irrelevant

information. The information on the melon experiment should be revised and only the aspects that are important to understand the wheat data should be kept (fertilization, irrigation, and similar).

We have shorted the section on melon crop and wheat crop focusing only in the points necessary to understand the results.

Also, Figure 1 indicates the plot distribution for the different treatments in the melon experiment, when only the upper line of plots, which are the ones crossed by the transect, are needed in this paper. The figure should be revised to remove unnecessary information.

We have changed Figure 1.

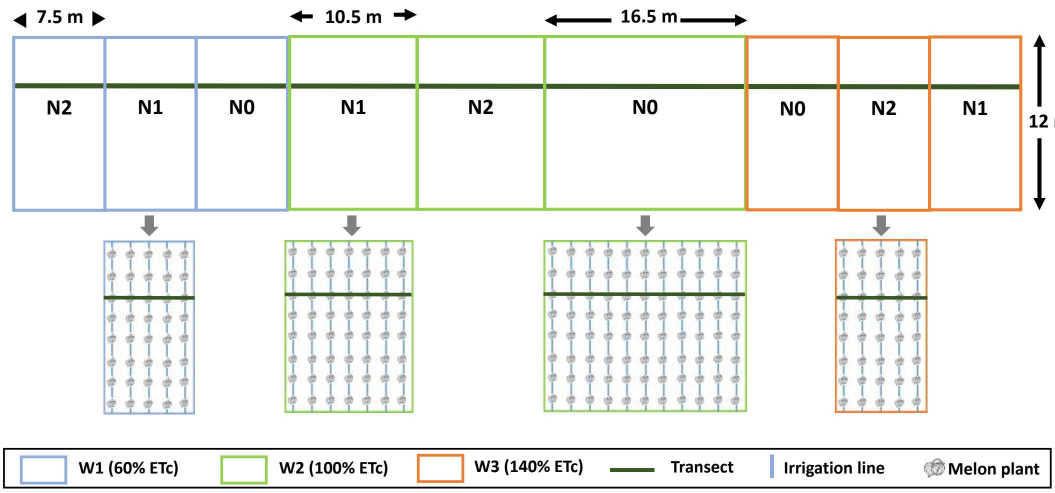


Fig 1. A croquis of the experimental melon crop layout. The nine subplots of the melon crop experiment through which the wheat transect ran are shown. The wheat transect is shown by the dark green line. The fertilizer levels are shown on the figure: N0, N1, N2 and represent 0, 150 and 300 kg N ha^{-1} respectively. The three different irrigation levels are indicated by the colour of the subplot lines: light blue is W1, the light green W2, and the orange W3 corresponding to 60%, 100%, and 140% of the estimated crop evapotranspiration (Ec) respectively. From different sizes subplots an example as how the melon crop are located is showed.

-The results and discussion section is very limited (roughly, one page in length). In my opinion, the authors should do a better job describing and specially discussing the results and the implications of their findings.

We have improve the Discussion section remarking our findings

For example, Milne et al. (2010) used the same data reported here but subjected to a different type of analysis. I might suggest comparing both analyses and discuss differences and similarities.

We have added in section 3.3:

The increments of the $E(\delta)$ ($\Delta E(\delta)$), between two consecutives scales, calculated for Napp and the four variables are shown in Fig. 7B and Fig. 9, respectively. *PN*, *GW* and *PW* present a similar scaling trend, with a maximum structure revealed at scale δ=10, corresponding to a distance of 5 m. This behaviour is the same found in Napp in the melon crop. In the case of *GN*, the maximum structure is found at δ=20 (10 m), indicating that the interaction of other factors influences in this variation, and the Napp is not the main one.

All the values of $\Delta E(\delta)$ at the smallest scales, δ=5, 2 and 1 (2.5, 1 and 0.5 m respectively), show an increase, giving the second maximum value for *GN*, *GW* and *PW*. This result suggests that at those scales, the variation is mainly due to the melon cropping lines, as the uptake of the applied nitrogen by this crop left a lower amount of available nitrogen for the wheat crop. In the case of *PN*, the second maximum was found at δ=20 (10 m) followed by the one at the smallest scales, δ=2 and 1 (1 and 0.5 m), as in the other variables.

Comparing these results with those published by Milne et al. (2010), we found agreement on Napp as the main factor affecting PW change in structure and a noticeable influence at the smallest scales, highlighting the importance of crop melon space arrangement.

Also, the authors could discuss other aspects shown by the data, as why wheat grain weight does not increase substantially with N applications above approximately 150 kg/ha, while N content increases both in the plant and in the grain and plant biomass increases with increasing N.

We have added the following analysis in section 3.1:

Classical statistical analyses were performed on each of the variables to study their first statistical moments (Table 2). We could observe that the average and median present differences for each variable, in contrast to a normal distribution where both coincide. However, kurtosis and asymmetry do not present values higher than the unit in absolute terms. *GW* and *PW* present the highest kurtosis (0.82 and 0.78) and are negative. On the other hand, *GN* and *PN* have the highest asymmetry and are positive. The coefficient of variation is higher in variables related to nitrogen content (*GN* and *PN*) and lower in variables related to weight (*GW* and *PW*).

Table 2. Descriptive Statistics of variables studied: grain N content (*GN*), grain weight (*GW*), wheat N content (*PN*) and wheat weight (*PW*).

Statistics	*GN*	*GW*	*PN*	*PW*
Average	59.01	5531.82	72.58	10365.20

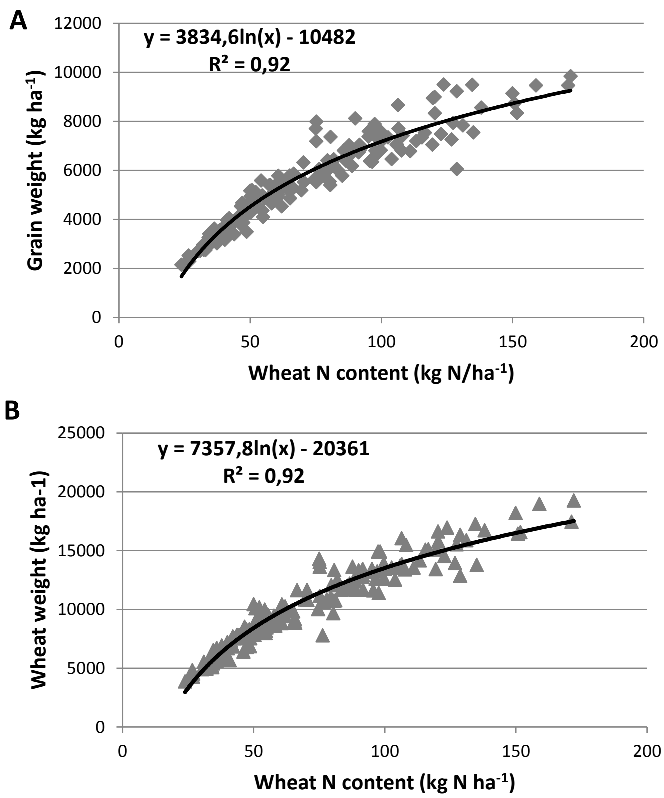
Median	54.84	5404.10	64.82	10016.34
Standard deviation	28.64	1885.18	34.08	3604.59
Variance	820.03	3553897.70	1161.28	12993051.45
Coefficient of variation	0.49	0.34	0.47	0.35
Kurtosis	0.09	-0.82	-0.12	-0.78
Asymmetry	0.80	0.26	0.76	0.30

Also we have included results and discussion of the relation between the variables:

The positive effect of increasing grain weight together with the additional benefit of increasing wheat N content with increasing N application is shown in Fig. 5A. Moreover, the same positive effect of N addition was observed, increasing wheat weight together with increasing wheat N content (Fig. 5B). Closer inspection of Fig. 4 reveals that the variability was much higher when the N application was higher. Barraclough et al. (2010), in an experiment with N fertilization applied homogenously directly to the wheat crop, found that much of the additional N taken up by the plant (PN) is manifested in higher yield (GW), although we remark again that in this work, the N application was performed in the melon crop experiment, through fertigation on crop lines, and the wheat crop did not receive any N fertilization and was not irrigated.

This positive effect of N addition has been observed in numerous studies (Barraclough et al., 2010 and references therein). Several works determine the N optimum in the wheat crop, but in this study, the optimal N dose was not obtained because we sought to study the variability and the effect of the residual N resulting from N application to a previous melon crop months before.

Fig 5. Effect of N applied in previous melon crop on: A) grain weight and wheat N content; B) wheat weight and wheat N content; C) grain weight and grain N content.



-The English of the text should be the subject of a deep revision. There are many mistakes and colloquial expressions that should be removed.

It has been revised and a certificate of the translator is included.

Some specific comments:

The text and expressions should be revised. For example, P.3, L.4 "This can give us an insight into the dominant processes". This sentence seems unfinished (processes governing something?). As another example, in P.3, L. 5-11: the word "scale" is repeated too many times "to study scale effects localized in scale".

We have reviewed the text to improve it.

In P. 3, L 20. What the authors did was to analyze the differences in some plant parameters that may be caused by residual N. However, residual soil N is not evaluated in this work, and the procedures used do not allow to do that. Therefore, this sentence should be deleted. Done.

-Do you, by any chance, have any numbers about N exports from the plots in the melon experiments? This could be very valuable information in order to understand the starting point of the wheat experiment.

We are really sorry but we haven't.

-Revise the Soil Taxonomy classification of this soil (P.4, L.4). Done.

-Check the separators used for decimals and thousands (e.g., P.4, L.6 and 7: "7,9", "2,2"). Done.

-P.4,L.12. "The species: : :" replace with "The variety: : :". Done.

In the same line, "Cucumismelo" should be replaced by "Cucumis melo". Done.

-Table 1 and figure 4. The N-application treatments in the melon experiment are only three, but in figure 4 there are 9 application rates. I guess that this is due to the addition of different irrigation amounts to the plots, which contain some amount of N. These amounts are not indicated in table 1 clearly, probably due to some mistake when preparing the table. I understand from Milne et al. (2010) that it should be the third column from the right in this table.

Table 1 has been changed.

Table 1. The treatments applied to the melon crop, total irrigation (applied irrigation, taking initial establishment irrigation into account, in the different treatments: 60% ETc (W1), 100% ETc (W2) and 140% ETc (W3) (15 to 104 DAT)) and applied nitrogen information. From Milne et al. (2010) with permission.

Treatment		Irrigation (mm)	N applied (kg N ha^{-1})		
Irrigation	Fertilizer		Irrigation water	Fertilizer	Total
W1	N0	342.6	55.58	0	55.58
	N1			150	205.58
	N2			300	355.58
W2	N0	552.9	92.78	0	92.78
	N1			150	242.78
	N2			300	392.78

W3	N0	755.9	129.46	0	129.46
	N1			150	279.46
	N2			300	429.46

In figure 4, and considering the high variability that the treatments present, it might be necessary to calculate the confidence interval for the slope of the regression lines. It seems to me that in the Grain weight vs. N applied the 0 will be included in this interval, and thus no linear relation could be.

We have included the follow paragraph in section 3.1:

To study the relationships of *GW*, *PW*, *GN* and *PN* with the nitrogen applied during the melon crop season (Napp), we have plotted these variables without considering any spatial factors (Fig. 4). All of them show a tendency, as we expected, to increase in value as Napp increases. The correlation coefficient (r) for the four variables range from 0.66 (*GN* case) up to 0.77 (*PN* case) demonstrating that there are statistically significant correlations with the N application in the melon crop experiment (Napp), as the wheat crop did not receive any N directly. For this reason, the relationship that we can observe could be considered linear, as the range we are studying is suboptimal and not as in other studies (e.g., Hawkesford, 2014). However, a quadratic relation can be fitted to all the variables with a similar R^2 (results not shown).

Overall, the manuscript needs a deep revision prior to be accepted for publication in Non-linear Processes in Geophysics.

We have worked hard to achieve the quality required by the journal.