Support text for A1.L2.1. ID 7

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The soil-water-plant agrisystem: a little about soil, water, and plants

Soil and water are essential for plants to grow.

We are going to start by looking at Figure 1, an NDVI (Normalized Difference Vegetation Index) map of a corn field after emergence.

We can verify that the plot presents a very large variation of chlorophyll in space, identifying zones with either a high concentration of chlorophyll (blue tones), an intermediate chlorophyll concentration (green tones), or a low concentration of chlorophyll (more yellowish tones).

From an agronomic point of view, the questions that are suddenly obvious are the following: i) If we treat the plot in the same way, why are there so large chlorophyll differences within the plot? ii) Do these differences affect production or its quality? iii) Do we have to treat the plot/crop differently to solve any problems that are occurring?

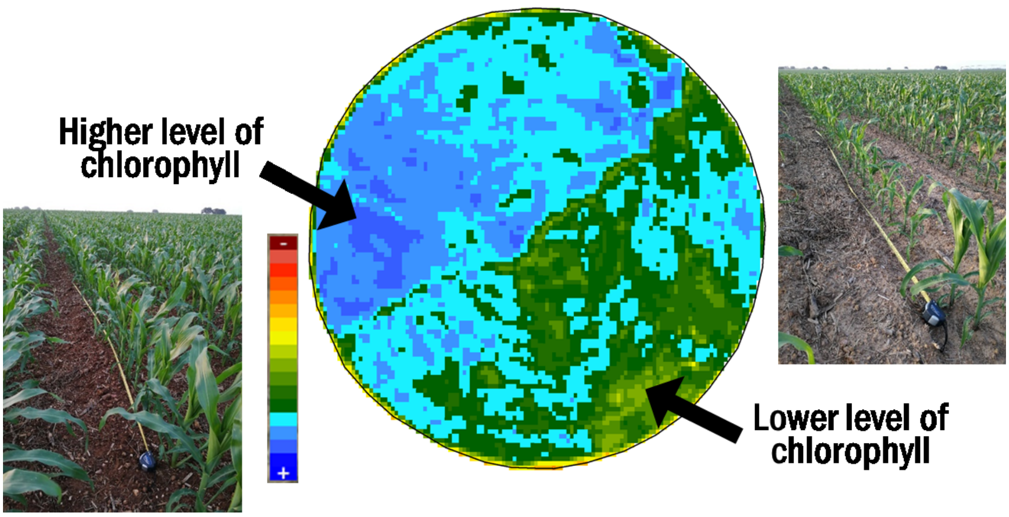


Figure 1 - NDVI map of a corn field after emergence.

The differences in the chlorophyll levels in this map can be related to soil characteristics, irrigation problems, plant germination capacity, nutrition, etc., highlighting the importance of a soil-water-plant agrisystem.

If the crop is in its starting phase, the first questions that we should ask immediately when we get an NDVI map similar to the one presented in Figure 1 are the following: Is the seeder working well? Did we put in the number of seeds per hectare that we intended to sow, considering the crop that we want to install?

Measuring samples of the number of plants per hectare and sowing depth in areas with different NDVI values, allows us to check if the seeder is working correctly because we should have approximately the same number of plants and at equal depth. Sampling plant height can also be important to detect anomalies. Different values of NDVI could be justified because although the seeder may sow the correct number of seeds per hectare, it might be sowing some of them deeper than others.

Most of the seeds nowadays are certified, however, there is nothing wrong in, before sowing, checking how many seeds will germinate (put 100 seeds on a plate with a moistened napkin and count the ones that germinate). Having the right population installed is half of the way towards having a good production.

Besides the germination capacity of the seeds, other aspects are associated with the optimal conditions of germination, that is, colder and wetter soils usually reduce the germination capacity and warmer soils with the correct humidity normally promote good seed germination.

In European and Mediterranean geographies, for example, corn sowing usually occurs in the spring, and during this period we usually have cooler night temperatures. Adding to the fact of still low temperatures the fact that we have clayey and sandy soils within the same plot may cause the germination capacity to be affected by the differences that exist at soil level.

In spring, clay soils are usually cooler, damp, and poorly ventilated, while sandy soils are warmer, less humid, and airier. Considering that, last ones are ideal for germination.

This is shown in Figure 2, showing the same NDVI map of a corn field after plant emergence. The higher values of NDVI (in blue) are observed in zones with less clayey soils (green arrows in the figure).

However, if the soil moisture is already very low and it is not possible to irrigate, then clay soils have the best conditions for germination because they are more humid than the already dry sandy soils (red arrows in the Figure).

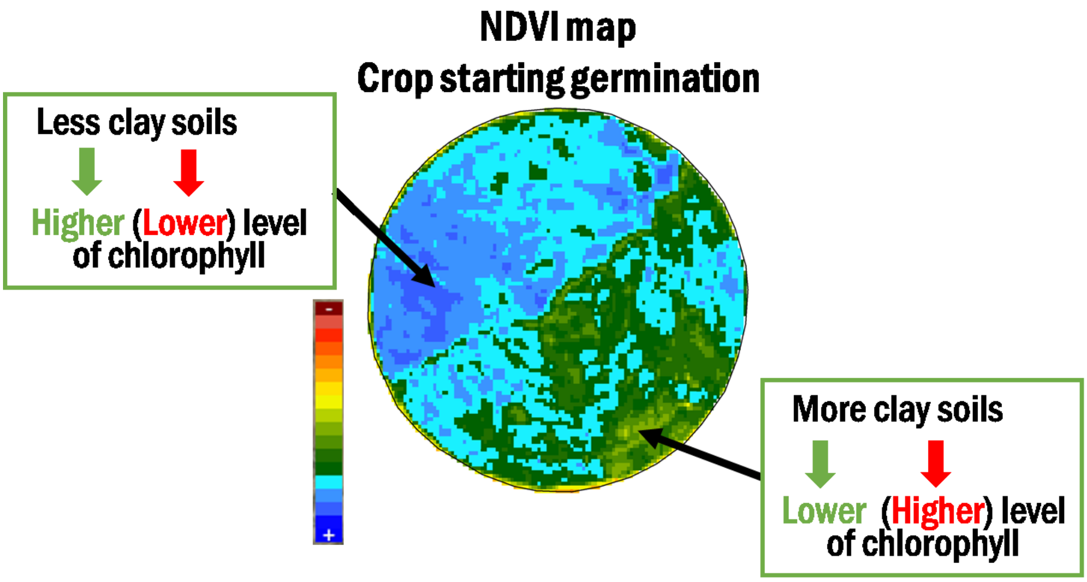


Figure 2 – Differences in plant germination/emergence conditions for different types of soil.

We can try to understand if one of the following processes could have reduced the germination capacity of the seeds (lower NDVI): i) the excess of water and low temperatures of the soil; or ii) the lack of moisture required for germination.

In multi-annual crops such as fruit trees, this effect of soil moisture and temperature differences can also affect the beginning of sprouting, consequently affecting the entire technical itinerary.

In summary, when planning the plant population to be installed it is always necessary to consider both the germination rate of seeds and the differences at soil level, as they both affect the germination capacity of the plants differently. The only way to solve the problem of soil differences is to seed variably (VRT), sowing more seeds in the area with lower NDVI, considering that it would be the zone that would be affected more in terms of germination capacity of the seeds.

We all know that different types of soils often require different types of fertilization strategies. For example, a more clayey soil immobilizes more nutrients than sandy soil, while it also has a higher buffer effect than sandy soil, etc. Given these differences, and to manage fertility, it is necessary to study the existing level of nutrients. This allows you to define the type of nutrition to be performed whilst considering the necessities of the planned crop. To this end, maps of apparent soil electrical conductivity (ECa) are crucial for good soil management (irrigation, plot organization, nutrition, trafficability, etc.), as well as for the sampling strategy.

If the soil ECa varies in space, then it is necessary to make an intelligent sampling, also variable in space, to see whether or not the soil fertility level also varies, and if it is proportional to soil ECa (Figure 3). As can be observed from Figure 3, it is necessary to perform a soil sampling on different soil ECa areas (higher and lower ECa) and, from these, conclude whether or not there are soil fertility differences between areas and whether these differences are related to the soil ECa or not.

SOIL NUTRITION - INTELLIGENT SAMPLING!

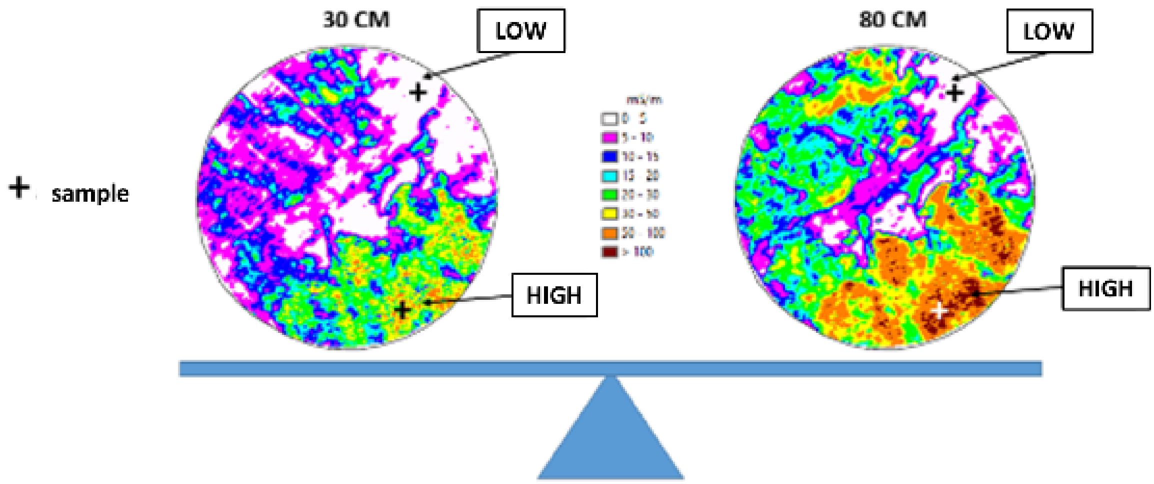


Figure 3 – Soil Apparent Electric Conductivity.

From Figures 4, 5 and 6 we can see that there is a linear relationship between soil ECa and the concentration of certain nutrients, such as P_2O_5, K_2O, Organic Matter (OM), Ca, Mg, Fe, Mn, total sand, silt and clay. However, we also note that in Bo and Cu (Figure 6) there is no actual relationship to soil ECa. If such a relationship exists, it is very easy to develop a variable application rate of any nutrient, but if such a relationship does not exist, however, it becomes difficult to fertilize differentially since there is no spatial pattern associated with soil ECa. From Figure 4 we can see that the P_2O_5 values in the soil range from a minimum of about 300 mg/kg to a maximum of about 500 mg/kg, that is, very high levels of fertility and also a very large range between the minimum and the maximum. If we look at the K_2O we realize that we have minimum concentrations that are around 100 mg/kg of soil and maximum concentrations that are almost four times higher. Without exaggerating too much and without knowing the crop, we could almost say that there are areas on the plot that do not need any P_2O_5 and K_2O. This example reflects the importance of a good agronomic and economic study, because all the nutrients that are introduced into the system and are not used, create an environmental and an economic problem.

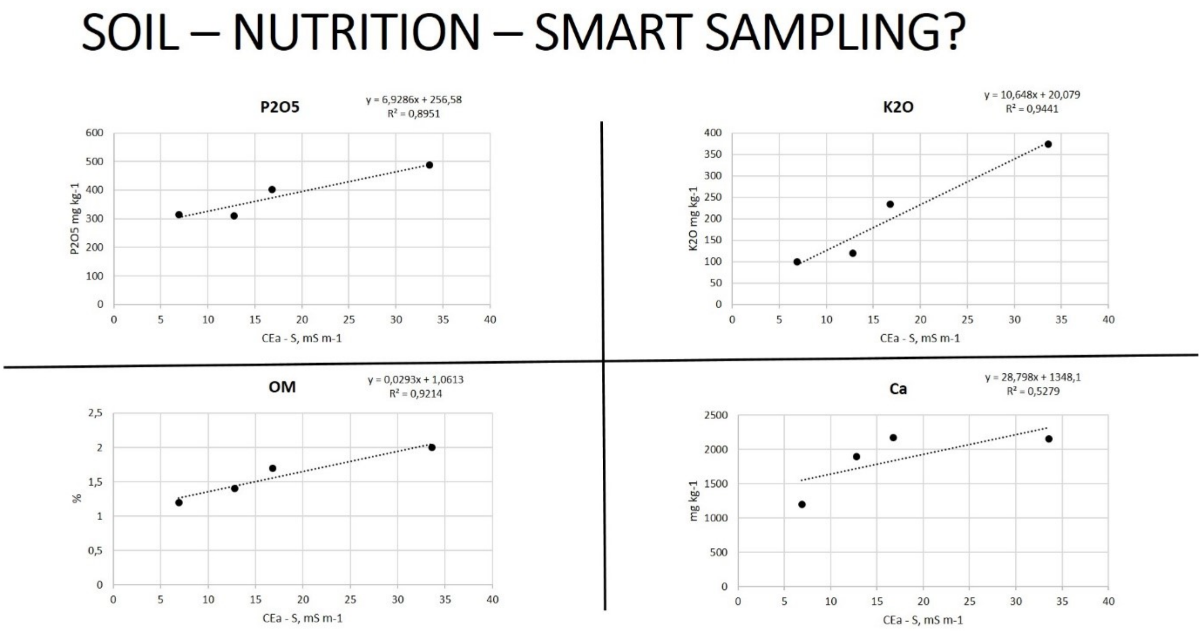


Figure 4 – Soil apparent electric conductivity relationship with soil P_2O_5, K_2O, OM and Ca.

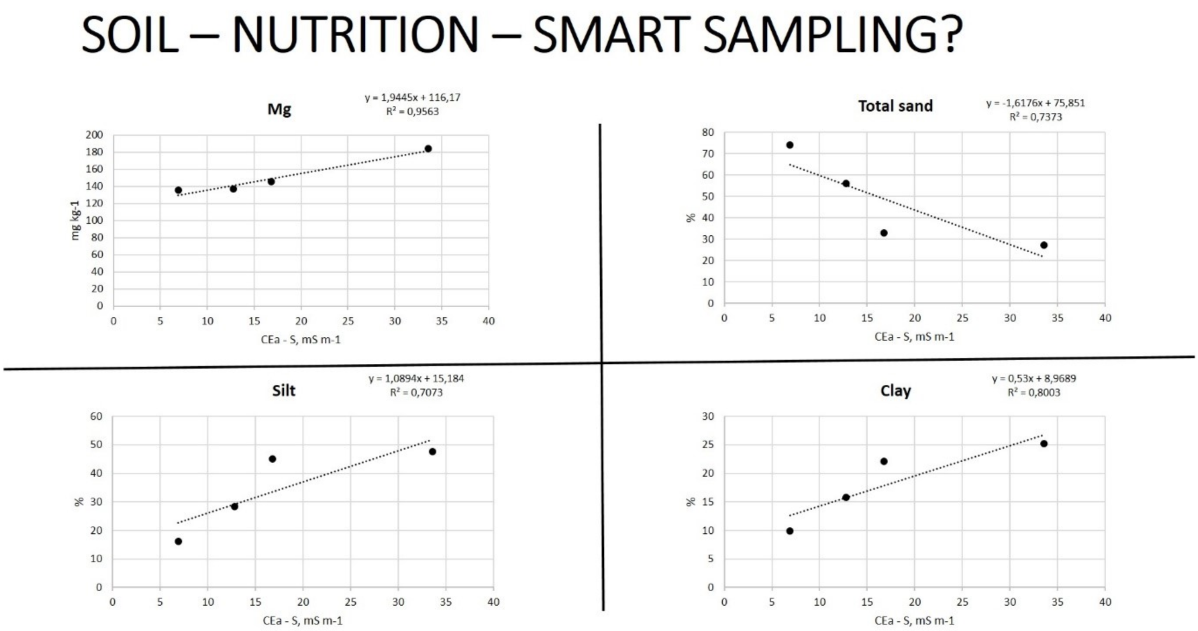


Figure 5 – Soil apparent electric conductivity relationship with soil Mg, Total Sand, Silt and Clay.

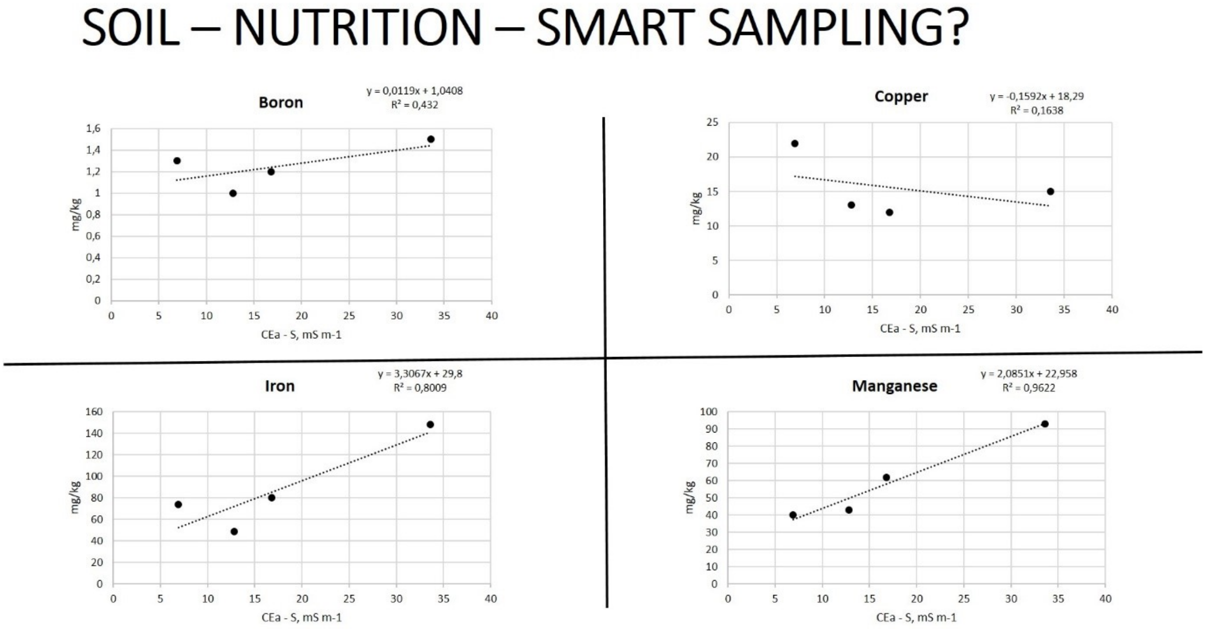


Figure 6 - Soil apparent electric conductivity relationship with soil Bo, Cu, Ir and Mn.

Further discussing the fact that the NDVI map of Figure 1 shows a distinct crop start if despite the plant population and the sowing depth being approximately equal, differences in the development of the plants remain, it is always necessary to be suspicious of phytotoxicity problems caused by pesticides, and in this particular case by the herbicide used in pre-emergence.

We all know that the concentration of herbicide to put in the soil depends on the type of soil, usually, more clayey soils indicate higher application concentration of the active principle when compared to sandier soils. In summary, in the application of pesticides, or this case of herbicides on the soil, we must always consider the type of soil we are applying it to, otherwise, we may have phytotoxicity problems in the plants.

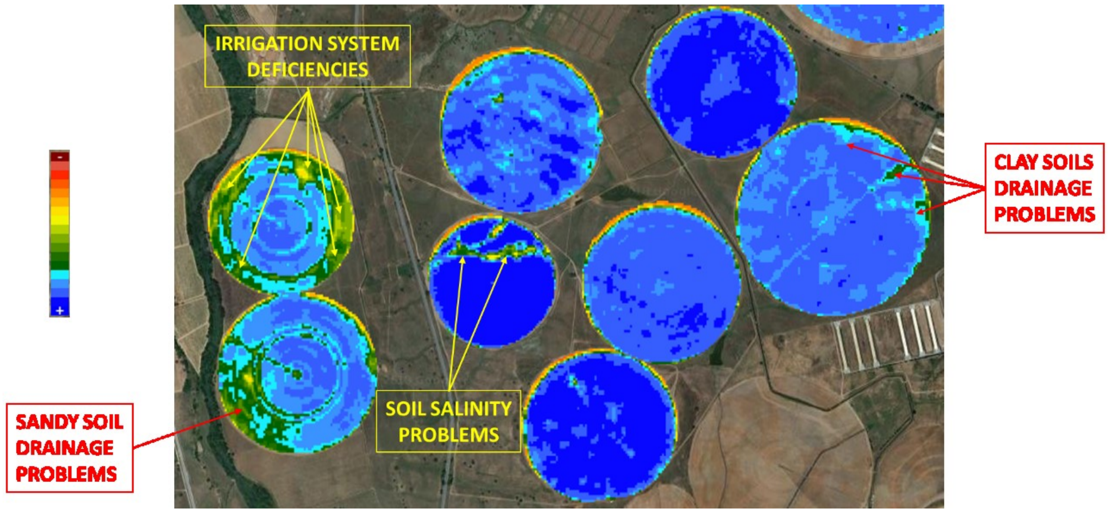
The way to solve this problem would be to construct a herbicide (or any other pesticide) VRT map, to respect the intrinsic soil characteristics and their impact on herbicide/plant relationships. It's the only way to achieve a better production performance, as well as a greater economic and environmental sustainability of the plots where such processes occur.

The concentration of chlorophyll (NDVI) in space and time allows us to study and infer many aspects of the agronomic activity. Fundamentally we can use plants as sensors of the natural/artificial conditions in their direct environment and from their response, we can detect patterns and anomalies relevant to management.

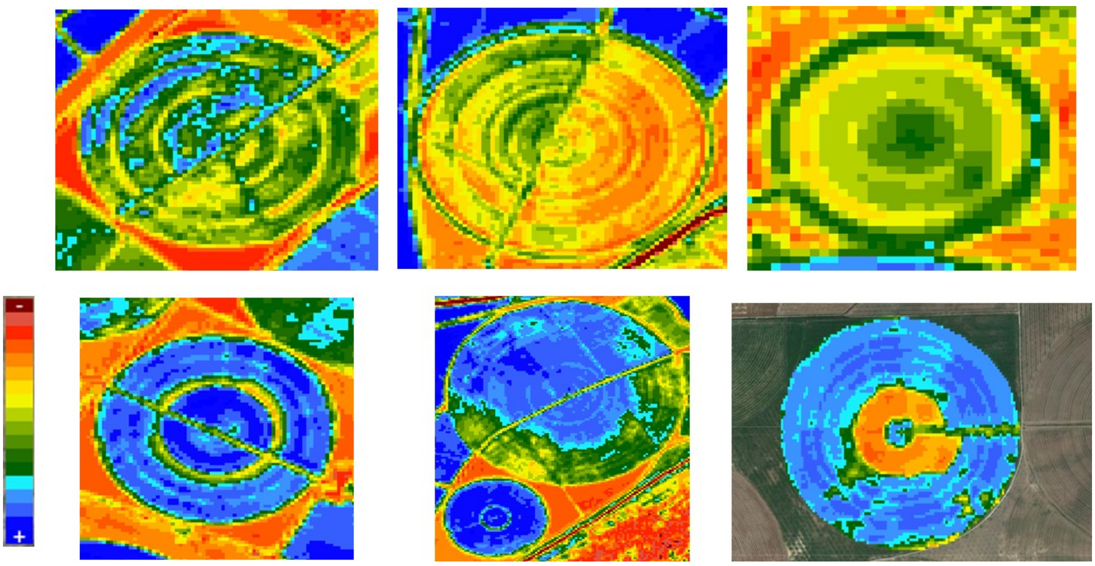
Figure 7 shows a set of anomalies at the chlorophyll level which may be associated with many things. If we know the terrain very well, we quickly assess the cause of this anomaly. If we do not know the terrain, however, we can direct our field inspection to areas that are anomalous and quickly assess the cause of such an anomaly.

As can be seen in Figure 7 (I), in the same zone, and sometimes even within the same plot, situations of anomalies like excess of water (in more clayey soils) and situations of water deficit (in sandier soils) may occur.

We can also detect other anomalies related to irrigation. From Figure 7 (II) we quickly realize that the irrigation system may have serious problems of clogging, pressure, poor design of the system, etc. These types of problems will surely have consequences on the productivity of the plot and thereby certainly affect the economic and environmental sustainability of the activity in face of a deficient water and nutrient management (fertigation).



(I)



(II)

Figure 7 – Examples of NDVI maps to detect anomalies.

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