September 2010

EXPERIMENTAL METHODS FOR THE MEASUREMENT OF NITROGEN STATUS IN WHEAT CROPS
Nitrogen Management and Grain Protein Forecast

Introduction about sensors:

Dualex and Multiplex are optical sensors that measures epidermis absorbance of leaves in UV and visible lights, thanks to the fluorescence's properties of chlorophyll and the use of screening effects. These sensors assess in the same time leaf chlorophyll content thanks to absorbance and fluoescence properties of chlorophyll in visible lights.
Polyphenolics such as flavonoids are UV-absorbers, and are mainly located in the leaves epidermises. So, total Polyphenolic content of a leaf is proportional to the sum of the absorbance of the two epidermises (two different sides) of the leaf. On the other way, chlorophyll absorbance properties in the visible are used to assess crops chlorophyll content.

Associated to other agronomical data, Chlorophyll and Polyphenolic contents are associated in a ratio, called NBI (Nitrogen Balance Index) linked to crops nitrogen status. Polyphenolics content can also be used to estimate the impact of diseases on the crop, and also the quality of crops.
Force-A introduced the Chlorophyll/Polyphenolic ratio (NBI) as an indicator of nitrogen deficiency. It's a more precise indicator of nitrogen deficiency since it is an indicator of the primary and secondary metabolism compounds of the crop, the nitrogen and the carbon metabolism.

Dualex measurements in wheat leaves

Dualex experiments on wheat plants have been conducted since 2004. They allowed us to set a methodology to measure the nitrogen status of a wheat plant.

We studied the variability of a wheat plant in order to define the best site where to make the Dualex measurement. This variability study is important (along the leaves and the plant) in order to define a robust methodology.

On wheat plant, we recommend to make the measurements **at a constant distance from the apex of the first young leaf entirely grown at the top of the wheat plant: the flag-leaf. We recommend avoiding as much as possible the central rib of the leaf.**
- this leaf is sufficiently exposed to sun light to have enough polyphenolics to allow the Dualex measurement.
- this leaf is less heterogeneous than the other leaves between different plants of wheat. Indeed, this leaf seems to have been as much exposed to sun as the others leaves of the same age on the other plants. Moreover leaves lower in the plant are under the shades of the upper leaves and this shade is not the same between plants.
- this young leaf is well adapted for Dualex measurements. A too old leaf may have too much polyphenolics which could saturate the Dualex.

Our other recommendations are the following:

- 30 plants or more have to be measured in order to have enough measurements per field for results with enough statistical power.
- 2 measurements by leaf have to be done to have the polyphenolic content of the epidermis of each side of the leaf and so the total polyphenolic content of the leaf.

Multiplex measurements on wheat canopy

Multiplex measurements can be performed according to two methods:
-punctual mode: at least 30 measures may be achieved per field or treatment. The canopy must be in contact with the Multiplex black plate.
-continuous mode: at least 15 seconds of measure while walking in the field may be achieved par treatment or field.

Refer to the power point linked.

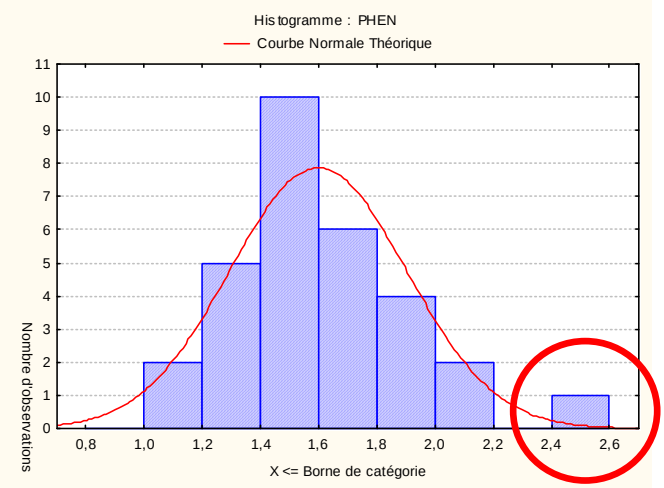
Measurements processing

In order to have the total polyphenolic content of leaves, the measurements of each side of the leaf have to be added for the Dualex.
In the same way, an average of the two chlorophyll measurements achieved with Dualex has to be calculated.

Be careful: Some false measurements may have been saved in the data files.
You can identify these measurements easily:

- plot the diagram of frequency (number of datas VS interval of measurements)

For example:



Correlations and applications

Optical measurements can be plotted as a function of your usual parameters:

- Growth stage
- Nitrogen dressing
- Quality indicators: nitrogen in tuber, tuber dry mass or yield
- Sanitary status of crops

- Differences between varieties (precocity…)

Development of decision rules on wheat:

Fertilisation management:

Decision rules have already been successfully achieved in France through experiments conducted with Dualex since 2004. Today, the management is realised for farmers by comparing measurements realised on a reference area in the field and a measure achieved in the field.

In order to develop a management application, for the third nitrogen treatment, experiments have to be achieved on nitrogen experimental plant. For example, the plant has to gather different treatments (N amounts):

	in uN (kg/ha)	first N treatment	second N treatment	third N treatment	**Total N**
1	Control 0 UN	0	0	0	**0**
2	X-80	30	30	10	**70**
4	X-60	30	30	30	**90**
6	X-40	40	40	30	**110**
8	X-20	40	50	40	**130**
10	X	40	70	40	**150**
12	X+20	40	90	40	**170**
14	X+40	40	110	40	**190**

This plant has to be achieved on many fields and varieties in order to ensure that results are robust.

These results could also be compared to results obtained in France.

Protein Forecast:

Decision rules have already been successfully achieved in France through experiments conducted with Dualex since 2004. Today, protein content at harvest can be directly correlated to NBI assessment at heading and flowering.

Nitrogen experimental plants such as described previously can also be used to measure crops NBI at different stage and these measures have to be correlated to yield and grain protein content.

Or a lot of farmers fields can also be assessed: sensors measurements, yield and grain protein content, varieties stage…

References:

1- Cartelat, A., Cerovic, ZG., and al. (2005) Optically assessed contents of leaf polyphenolics and chlorophyll as indicators of nitrogen deficiency in wheat (Triticum aestivum L.), Field Crops Res, 91, 35-49.

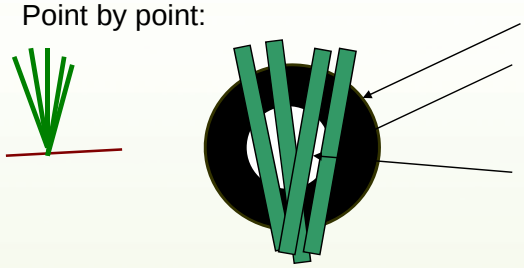
2- Meyer, S., ZG., Cerovic et al. (2006) Relationships between optically assessed polyphenols and chlorophyll content and the dry mass per leaf area ratio of woody plants: a signature of the carbon and nitrogen balance within leaf? Plant Cell Environ 29: 1338–1348

3- Cerovic, ZG., A., Cartelat et al. (2005) In-the-field assessment of wheat-leaf polyphenolics using the new optical leaf-clip Dualex. Stafford JV (Ed.) Precision Agriculture '05, pp 243-250, Wageningen Academic Publishers, Wageningen.

4- Martinon, V., Fadailli, E.M., Evain, S., Becu, M., Duval, C., Fumery, J., 2010. Innovative optical sensors for diagnosis, mapping and real-time management of row crops: the use of polyphenolics and fluorescence. International Conference for Precision Agriculture, Denver, 2010.

Weat Method

- Always use the same method at all measurement date
- Black plate
- Point by point:



- Continous measurement: