Nitrogen use efficiency:
Setting new standards on wheat in the Western Cape

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Introduction:

The term nitrogen use efficiency or NUE has been used for some time. Since its origin in the early 80s, a wealth of ratios were applied to calculate NUE[3]. However, regardless of the approach or method, it was repeatedly proven that the NUE related to wheat production is seldom higher than 35% if topdressing is not used. When topdressing is applied with careful consideration, measurement and calculation, NUE usually exceeds 50%[4].

In South Africa there is much talk about NUE and a lot has been written about it, but very little measurement is actually done in scientific trials. Also, the uncertainty remains as to which elements to consider when calculating ratios for NUE.

Late in 2015, a comprehensive paper was published by the European Union (EU) Expert Panel, consisting of 12 experts from science, four from policy and three from industry. These experts represented nine EU countries. They reached consensus on how NUE should be calculated and presented[1].

Using the methodology of the expert panel (2015), data from Omnia Nutriology® agronomic research and development (R&D), and trials conducted over the last five years in the Western and Southern Cape, a first estimate can be made of the real NUE achieved in the said regions using classic published guidelines. In these trails the Minolta SPAD 502 chlorophyll meter was also calibrated to define required topdressing levels.

Trial information (summarised)

Trials were conducted under varying environmental conditions on different soil types and in different rotation systems to test the NUE concept under as wide a range of variables as possible. The same treatments and statistical design was used for all the trials over all the years – four repetitions of eight different treatment applications. Some of the treatments were applied to develop production functions for calibration purposes. For the purposes of this report, only results of the following treatments over the five years are shown graphically in **Figure 1**.

- Control (an application of between 24 and 28 kg.ha^{-1} N during planting)
- The regional industry norm[2] which is a total of ± 100 kg ha^{-1} with 25% to 35% of total N applied during planting.
- The SPAD-502 guided N applications according to a locality specific algorithm developed by Omnia.
- N rate as decided by a regional panel of agronomists guided by their expertise and knowledge. This varied according to environmental conditions, rotation system and the crop growth at the measurement stage.

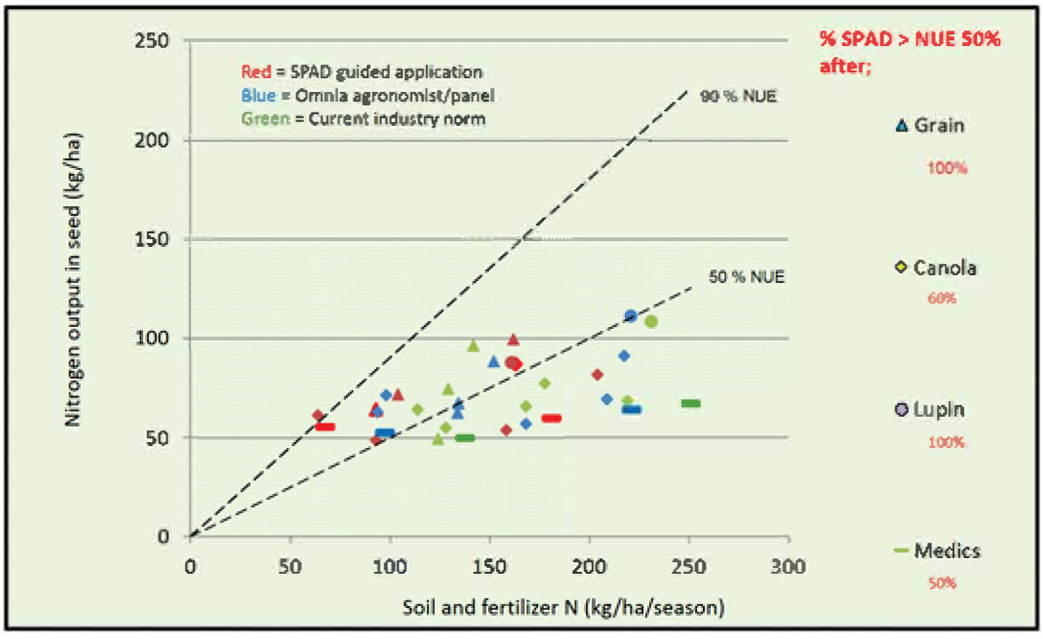

Figure 1: *Combined data for all NUE trials over a period of five years in the Swartland and Southern Cape. Only 3 treatments are represented in the graph in different colours – the industry norm[2], the SPAD algorithm driven recommendation and the agronomist panel decision. The various previous season's crops are represented by different forms of markers. All the trials were conducted in the wheat year of the rotation system.*

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Trial information (continued)

SPAD measurements started five weeks after emergence (WAE) (growth stage BBCH 21 – 23; one to three tillers formed) and were done on a weekly basis up until 10 WAE, then on week 12 and 14 after emergence. The SPAD driven applications were made as soon as the algorithm pointed out a lack of N, while all the other treatments received N at regular times as convention dictates, usually at tillering and stem elongation.

Leaf analyses to monitor N levels were correlated with the protein content of the grain seed. Plant biomass was also monitored to keep track of vegetative growth of the different treatments. Lastly, yield and quality measurements were taken on all the plots.

To derive the points on the graph, the total N input is calculated by calculating the soil available N (from soil analyses using the classic potassium chloride extract) and adding the amount of applied inorganic fertilizer N to that. The N output is calculated by determining the amount of N in the harvested wheat (derived from seed protein content and total yield).

Discussion

If NUE levels of between 50% and 90% is considered near optimal, it could be stated in summary that the current industry norm lead to N application levels that were only "correct" in 27% of all instances measured in the trials. In fact, in 73% of these cases the NUE levels achieved were between 30% and 40%. The Omnia agronomist panel was accurate in 45% of the instances, but in four cases they reached NUE levels of below 35%. The SPAD guided recommendations were accurate in 73% of the instances, but also showed poor results (NUE between 30% and 40%) in three cases when canola and medics had been the previous crop.

It is interesting to note that, when using the SPAD meter, very high N applications of above 150 kg ha^{1} can be made, but with high NUE.

It is thus quite clear that the SPAD algorithm guided recommended applications gave the best results to use N more efficiently and so lessen the risk of over-application, which is not cost effective and definitely not good for the environment. Inefficient N usage impacts negatively on greenhouse gas emissions, soil acidity and unbalanced or deteriorated soil biology among others, thus leading to unsustainable practices.

Lessons learnt are: although the SPAD guided measurements took place at the traditional tillering and stem elongation stages, it would seem that first applications of N should be considered earlier, even at four to five weeks after emergence, while the classic stem elongation N applications need to be done a bit later, probably towards the forming of the third node. When canola and medics preceded wheat, it could presents some challenges, even with the SPAD guided option. With medics only, planting with N is necessary in most of the instances. It is also clear that canola is a high but inefficient N feeder. Further research is needed to refine these results. Generally, the biomass was lower for the SPAD guided treatments and the plants were also less green.

Summary

As suspected, research by Omnia Nutriology® over the last five years has proved that the NUE of wheat is not up to internationally specified standards in the Western and Southern Cape when applying current industry norms and even locality specific experience. Available technology such as the use of the Minolta SPAD-502 provides viable options to improve nitrogen management significantly.

Omnia Nutriology® has developed several algorithms to use with the SPAD meter, not only on wheat, but also on other crops such as maize, potatoes, table grapes and planted pastures to name a few. These algorithms are being updated as research continues and are currently exclusively available to Omnia Nutriology® agronomists by means of cell phone apps.

References

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[2] Fertilizer Handbook. 2007. Published by the Fertilizer Society of South Africa. Pretoria.

[3] Moll, R.H., E.J. Kamprath, and W.A. Jackson. 1982. Analysis and interpretation of factors which contribute to efficiency to nitrogen utilization. Agron. J. 74:562-564.

[4] Vetsch, Jeff, and Gyles Randall. 2004. Corn production as affected by nitrogen application timing and tillage. Agron. J. 96:502-509.

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