Wheat quality: how to increase proteins?

CARING FOR BOTH, PROTEINS AND THE ENVIRONMENT

Today, wheat covers more of the earth's surface and produces more food than any other grain crop. Farmers strive to maximize yield, minimize cost, reduce environmental impact and ensure a high baking quality. In recent years, the quality of wheat has been subject to discussion, since higher yields have created a trend towards lower protein content. A satisfactory protein content in wheat translates into better flours and, most importantly for the farmer, higher selling prices.

YARA

Knowledge grows

Farmer's words on **quality**

We have asked farmers in Germany and France about their opinions and experiences regarding quality, yield and fertilization strategies. No wonder, priorities are not exactly the same regarding details, but most farmers agreed that quality is an issue that they need to address.

Here is what they say.

PHILIPPE JUSTINE

Aisne (France)

Philippe Justine is cultivating winter wheat on some 52 ha of his farmland this year. The 190 to 200 kg N/ha are split in 3 applications. "I reserve 40 to 50 kg/ha as AN 33.5 for the last application. The first application is timed at tillering with 40 to 50 kg/ha AN 33.5. The second application takes place at beginning of stem elongation (Z30) with 80 to 100 kg/ha as UAN. For the third application, I have chosen since many years to apply ammonium nitrate 33.5, in contrast to other farmers in the region. The intervention is more reliable using my spreader than with the sprayer. And there is less risk of volatilization losses." Since 4 years, Philippe Justine adjusts N-rates to intra-field variations using the N-Sensor. The first application is triggered by the N-tester. "Avoiding over-fertilization in certain areas has stopped lodging" observes Philippe Justine, "though this was a recurrent problem with a negative impact on yield and quality." Regarding protein, this is not a major concern up to now with 10.8 to 12.4 % of RP content in 2013, also due to regular application of poultry manure.

VÉRONIQUE RICHON

Marne (France)

While nitrogen is principally applied as UAN in the Champagne region, Véronique Richon uses since 2004 ammonium nitrate for the last application on wheat. "Protein content of our milling wheat was not quite high, always between 10 and 11 %. In addition, according to weather conditions (sunshine, dew) during spraying, the UAN solution could cause leaf necrosis. Ammonium nitrate for the third application proved to be more efficient than UAN, producing 0.5 % more protein for the same nitrogen application rate. Our wheat now attains a mean protein content of 11.5 % over the last five years, providing an extra earning of 3.50€/t."

THOMAS SEEGER

Saxony-Anhalt (Germany)

Thomas Seeger never trades quality for quantity on his 2.000 ha farm, but strives for both: "Since A-wheat (> 13% protein) produces the same yield but offers better returns (+5€/t), protein content is important for me. When yield is the same, protein content is financially rewarding". Thomas Seeger achieves an average of 13.3 to 13.5 % about all wheat types. His strategy for high yield and quality: "4 applications, optimum seeding time, matching of wheat type with previous crop... I'm applying ammonium nitrate for the first application, since 2 or 3 years as Sulfan at EC 25-28. I'm also planning to spread Sulfan for the last application this year, at EC 49-57 but have no experience yet". Thomas Seeger uses the N-Tester and the N-Sensor from the second application on, allowing only tight variations from mean application rates of 15 kg maximum.

CORD NISSEN

Schleswig-Holstein (Germany)

Cord Nissen is running a 460 ha farm. When asked whether protein content is an issue for him, he responds: "Yes, but I don't strive for RP values higher than 12% at maximum yield. I therefore privilege winter-resistant, healthy varieties with safe RP. We experienced quality problems in 2011 with severe income losses. B-quality could not be achieved everywhere and prices for low RP wheat dropped significantly. Last year we achieved 12% RP, due to a quality spreading at BBCH 51 with Sulfan." Cord Nissen makes 3-4 applications, the first as Sulfan or Optimag, sometimes also spreading Sulfan for the 3rd application at BBCH 37-59. He uses the "N-Tester to provide an overview about N-supply" and the "N-Sensor to provide fertilizer where it is really needed." About the N-Sensor, Cord Nissen adds: "I'm totally convinced by it. When correctly calibrated, anyone with the technical skills but not necessarily having the agronomic know-how can do the spreading."

What is **wheat quality** and why is it important?

Wheat quality means different things to different people. While farmers generally look at yield and productions costs, millers need to predict the resulting flour type and baking quality. The quality of a wheat class is determined by its suitability for a specific final product.

What makes a good wheat today?

QUALITY ATTRIBUTES

Quality of wheat and flour is primarily determined by wheat type, hardness, protein content, sedimentation value, falling number, alveolarity, water absorption and baking volume. Millers need to regard many other parameters too. In practice, however, the commercial value of wheat is determined by protein content alone.

Protein content

Protein content is a key specification for wheat since it is related to many processing properties, such as water absorption and gluten strength. Protein content also can be related to finished-product attributes, such as texture and appearance. Acceptable levels depend on targeted use, especially flour type. In general, high quality flours require a protein content of at least 12%.

PROTEINS DRIVE QUALITY

Glutens

The gluten forming proteins of wheat, known as gliadins and glutenins, are what make bread possible. When flour and water are mixed, the gluten forming proteins begin to organize and cross-link so that a gluten web is formed. It is this protein web that allows the baker to shape the dough and have it remain in that shape instead of simply flowing across the table. This web also traps the carbon dioxide gas produced by the yeast during fermentation, allowing the loaf to rise. The concentration of gluten forming proteins is an important number that millers need to evaluate in each lot of grain.

Nitrogen

There can be differences in the quality of the protein, such that two flours with similar protein measures can give different baking results. In general, however, the protein concentration gives a good overall indication of the probable success of the flour in bread baking. The assumption is made that as the total amount of protein increases so does the amount of the gluten forming proteins. Rather than measuring actual protein concentration, laboratories determine nitrogen concentration. They then apply a conversion factor to estimate protein content. For wheat the conversion factor is 5.7 (i.e. "crude protein" = nitrogen x 5.7).

PROTEINS ARE MADE OF NITROGEN

Proteins build up in the grain at the end of the vegetation cycle. The protein content in the wheat grain is dependent on genotype but is also clearly influenced by environmental variables such as water access and temperature during growth especially through the grain filling period. The most effective environmental factor on wheat quality, however, is nitrogen supply. Proper management of nitrogen fertilizer ensures high quality wheat.

- Roughly 80 % of the nitrogen (and thus protein content) of the grains originates from stems and leaves and was absorbed earlier in the vegetation period. It is transferred to the grains during the senescence.
- The remaining 20 % of nitrogen is accumulated after flowering by additional supply of nitrogen from the soil.

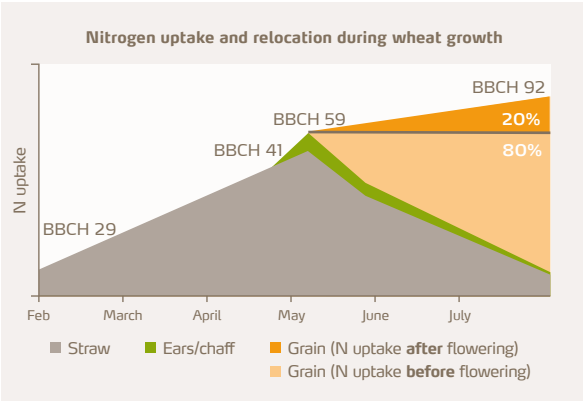

Figure 1: 80% of nitrogen in grains was absorbed before flowering, but 20% is taken up by the plant after flowering (BBCH 59). Late fertilization therefore increases grain nitrogen content [1].

MARKETS REQUEST PROTEIN

Wheat markets are highly segmented: interior markets and export markets have their own requirements, but all are based on key characteristics such as protein content.

- The biggest market for wheat is animal nutrition. While price and specific weight traditionally used to be the main drivers, producers of animal feedstuff are increasingly attentive to protein content for its nutritional qualities.
- Starch production requires a steady supply of homogeneous batches. Overall quality criteria are similar to flour milling.
- Human nutrition is characterized by a very strong segmentation of end products and processes with specific requirements for each of them. There is a general trend towards bread types requiring flour with high protein content. Frosted goods also need higher protein content.
- For export trading, protein content is the primary criteria for wheat quality. In recent years, European production (especially from France) fell short of the requirements in many foreign markets and was replaced by wheat of other origins.

	Morocco	Spain	Italy	Egypt
Protein content	11,5%	10-12%	11,5-12%	11%

Table 1: Example of protein content requirement for wheat importing countries [2].

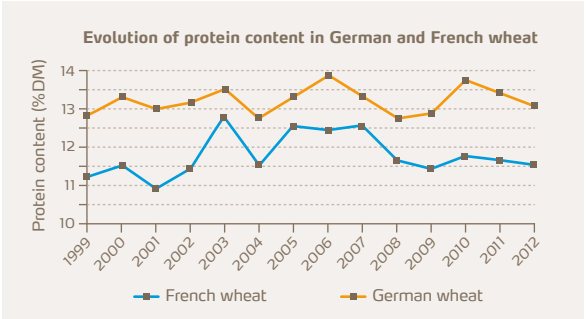

Figure 2: Official data from France and Germany shows a significant difference in protein content for wheat from both countries [3].

Quality in practice

Producing wheat that meets high quality standards requires attention to all aspects of crop production and post-harvest handling. These management strategies are key to ensure high returns by optimizing quality.

What needs to be checked?

OPTIMUM N-EFFICIENCY

Nitrogen uptake

Yield expectations reach a ceiling at the agronomic optimum and increasing nitrogen supply further will not improve yield, as shown by the nitrogen response curves. Nitrogen absorption and protein content, however, continue to increase linearly even beyond the agronomic optimum. This relation is shown in figure 1. Limiting nitrogen supply therefore has a strong effect on protein, but less so on yield. The question therefore arises how to manage quality and thus protein content under the increasing economical and environmental pressure that limits nitrogen use.

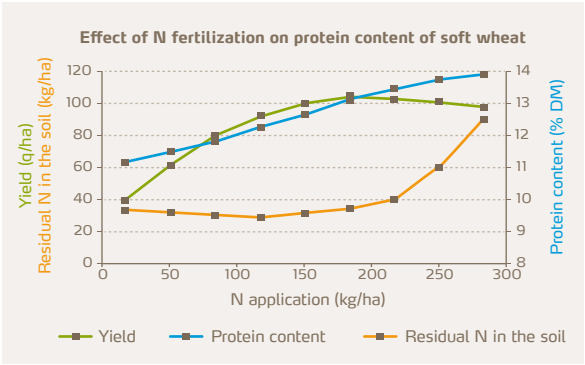

Figure 3: Field trials conducted in France. Proteint content increases linearly even beyond the agronomic optimum but so does the residual nitrogen in the soil [4].

Nitrogen use efficiency

Achieving high protein content needs special care regarding nitrogen application. Increasing dosage is a simple but inefficient means under environmental and economic considerations. When the absolute amount of applied nitrogen is limited, the only way to improve nitrogen availability to the plant is to raise nitrogen use efficiency.

Split application

Split application has been established as best agricultural practice since the early 90s. It enables improved matching of nitrogen supply with actual plant needs and absorption capacities and therefore enhances nitrogen use efficiency. Splitting nitrogen fertilization into 3 or 4 applications increases protein levels and yield as compared to single or dual application. For the same reason it reduces residual nitrogen in the soil after harvest and thus reduces the risk of leaching.

Late application

Special attention needs to be paid to the last (3rd or 4th) application. This shall be timed when absorption is highest. The nitrogen is then stocked in the organs involved in active growth, close to the ear. It therefore contributes to an efficient nitrogen transfer into the grains. Figure 4 compares impact of application timing on yield and protein content.

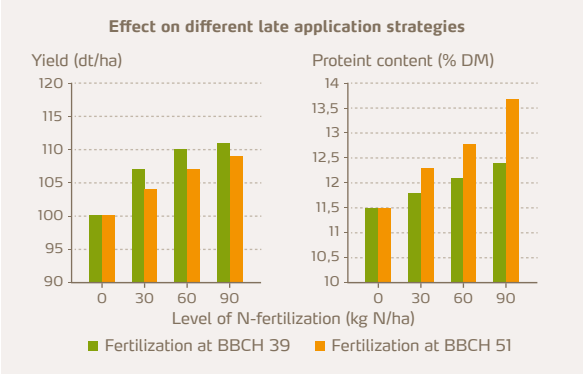

Figure 4: Field trial conducted in Germany with different level of last N-application at different stages of growth. Late application of nitrogen (stage BBCH 51 as compared to BBCH 39) reduces yield but increases protein [5].

SULFUR FERTILIZATION

Sulfur increases quality

Sulfur is key when it comes to fertilization strategies that target highest quality. Without sulfur, crops can't reach their full potential in term of yield, quality or protein content. Figure 5 shows the result of field trials in Germany for different scenarios. Yield and protein content were compared for mean and high nitrogen intensity strategies. The results show the potential of sulfur in high value cropping strategies.

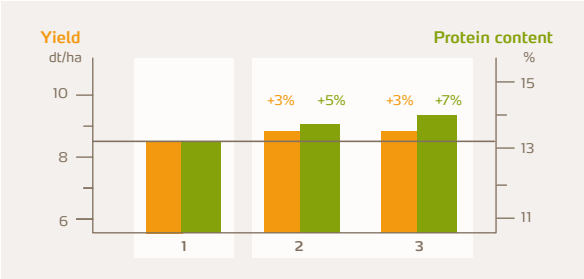

Figure 5: Comparison of yield and protein content for different fertilization strategies: 1) mean nitrogen intensity, no sulfur; 2) high nitrogen intensity (+30 kg N), one application of sulfur at the first dressing (+15 kg S); 3) high nitrogen intensity (+30 kg N), sulfur application at the first (+15 kg S) and third dressing (+15 kg S). Optimum nutrition enables 7% increase in protein content [8].

CHECKLIST FOR PROTEIN CONTENT

- ☐ Select appropriate wheat variety
- ☐ Use high efficiency nitrogen form
- ☐ Measure and address sulfur needs
- ☐ Account for in-field variations
- ☐ Plan for late application

ADEQUATE TIMING

Precision farming

Increasing protein by late application of nitrogen requires a fine adjustment of the last application. Precision farming tools such as the N-Tester or the N-Sensor® reliably detect the nitrogen status of plants. They enable a tailored application and compensation for in-field variations of nitrogen needs. Accounting for such in-field variations significantly increases overall nitrogen use efficiency and thus protein content while maintaining the same nitrogen balance for the entire field.

Proven results

Field trials have demonstrated the capacity of the N-Tester and N-Sensor® to enhance protein content and yield as compared to standard nitrogen balances. Using the N-tester in a field trial conducted by Arvalis in France increased protein content by 0.3 % and yield by 1.2 dt/ha while the overall nitrogen application rate remains the same.

N-Sensor®

N-Tester

ADEQUATE N-SOURCE

Avoiding losses

Urea and UAN are known to produce higher volatilization losses than nitrate fertilizers. To reach the same protein content and yield, significantly higher amounts of nitrogen need to be spread as Urea or UAN than as ammonium nitrate. This, however, is in contradiction with high protein strategies that try to maximize nitrogen use efficiency. In addition, losses with urea and UAN are hard to predict. It is therefore particularly difficult to fine-tune the critical last application with Urea or UAN. Many studies have demonstrated the superior performance of nitrate-based fertilizers as compared to ureic fertilizers with regard to both, yield and quality of produced crops.

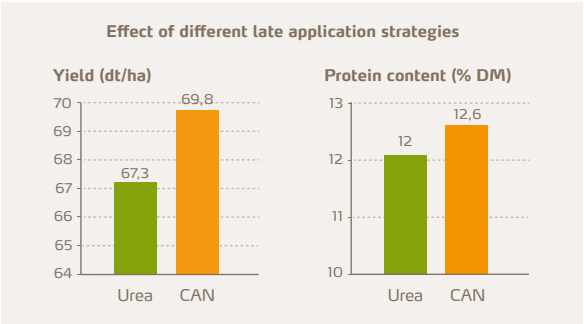

Figure 6: Field trial conducted in Germany. Yield and protein content with 3 N applications. Identical 1st (60 kg N/ha) and 2nd (65 kg N/ha) applications, 3rd application of 85 kg N/ha as Urea or CAN. Nitrogen uptake is higher with CAN [6].

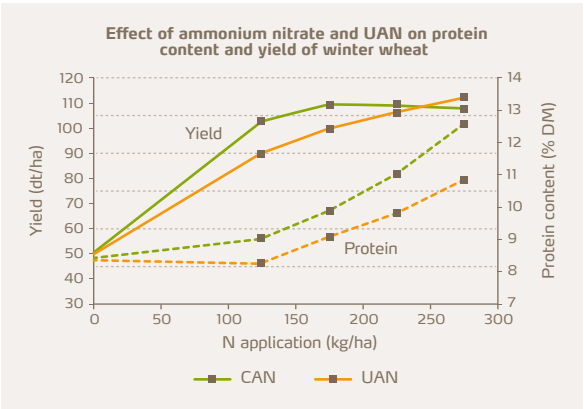

Figure 7: Trial conducted in France by an independant organization. Ammonium nitrate is more efficient than UAN both in terms of protein content and yield [7].

Increasing earnings with **high quality wheat**

Optimizing returns is not necessarily equivalent to working at the economic optimum. Quality can make a huge price difference that farmers need to take into account.

What are the concrete numbers?

NITROGEN DRIVES QUALITY

The following example from Germany shows that working at the economic optimum may create surprising results. In this example, reducing nitrogen application from 200 kg to 170 kg has a very limited effect on yield. The lower yield seems to be more than compensated for by the economies in fertilizer cost. However, the diminished protein content does not allow to maintain the higher wheat quality standard. The resulting loss in revenue therefore largely exceeds the cost of the additional fertilizers. In this case it would have been more interesting to optimize protein content and revenues by tailored nitrogen application.

High efficiency nitrogen fertilizers from Yara with and without sulfur for optimum wheat quality.

	Fertilization		Difference
	At economic optimum	Below economic optimum	
Fertilizer cost*	207 €	176 €	+31 €
Yield	93,5 dt	91,4 dt	+2,1 dt
Protein content	12,3 %	11,8 %	+0,5 %
Wheat price**	21 €/dt (C-WW)	20,2 €/dt (B-WW)	+0,8 €/dt
Revenue	1964 €/ha	1846 €/ha	+118 €/ha
Revenue apart from fertilizer cost	1757 €/ha	1670 €/ha	+87 € /ha

* 1,04 €/kg N
** average price difference between, B and C-wheat 2006-2014

Table 2: Optimizing revenues by reducing fertilizer application shall take into account protein content to avoid unforeseen surprises.

YouTube

For further information about nitrate fertilizers and farming, visit Yara website www.yara.com or our YouTube Channel: www.youtube.com/yarainternationalasa

You can also download the Pure Nutrient app (available for iOS and Android devices).

ABOUT YARA

Yara International ASA is an international company headquartered in Oslo, Norway. As the world's largest supplier of mineral fertilizers for more than a century, we help to provide food and renewable energy for a growing world population.

Yara provides quality products, knowledge and advice to farmers. Please do not hesitate to contact one of our local agronomists for further information.

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