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Wheat quality

Timing of nitrogen application to improve quality, reduce lodging and minimise disease risks for hybrid and inbred wheat

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Summary

In Belgium results of many trials carried out during the last seven years show the possibility of changing timing of nitrogen application with dose reduction during tillering and transfering this amount to flag leaf application; with this nitrogen dressing, grain proteins are higher and lodging and diseases risks are lower.

Key words: Wheat, nitrogen dressing, nitrogen split application, yield, grain quality, lodging, *Septoria tritici*

Introduction

The evolution of the wheat crop is continuous. Yield potential increased rapidly during the last twenty years due mainly to the evolution of varieties and more efficient crop protection. Higher ear fertility, hybrid varieties and strobilurin fungicides have changed considerably the grain filling period of wheat. In non limited water conditions, two thirds of the dry matter is produced after flag leaf emergence for a wheat crop yielding 10 t/ha (Bodson *et al.,* 2000). For this type of crop, the nitrogen needed and the modalities of fertilizer application are also quite different, particularly when it is necessary to fulfil both yield and quality objectives.

Materials and Methods

The experiments were carried out during the seven growing seasons between 1993 and 2000, in Lonzée (Gembloux) as part of a series of the "Cereal Trials" made by the Faculté Universitaire des Sciences Agronomiques de Gembloux and the Federal Ministry of Agriculture. Several trials were also installed in other farms in the main cereal-growing region of Belgium. All crops were grown in loamy soils after different previous crops (Table 1). Agronomic inputs (seed density, P and K Fertiliser, crop protection) corresponded to good agricultural practice.

Classical (inbred) and hybrid varieties were chosen from amongst the highest yielding varieties present on the Belgian market. The nitrogen fertilizers where applied in the form of NH_4NO_3 (27 % N) usually in three split applications: during tillering (GS 20-25), at beginning of stem elongation (GS 30) and after flag leaf emergence(GS 37-39). The plots (14 m² at Lonzée and 152 m² at the other sites) were arranged in randomised blocks or in split plots with 3 to 5 replicates.

Usually, the protocol contained 20 dressing treatments as described in Bodson *et al.* (1997*a*). This protocol allows, on the basis of data from these 20 nitrogen dressings, the calculation by interpolation the response surfaces for yields, yield components and also quality parameters. In

these response surfaces , the dependant variables (ex. Yield) are given as a function of nitrogen dressings at split applications (X_1, X_2, X_3). Protein contents (in %) and Zeleny index (in ml) are determined by classical methods or by N.I.R. (with variety-specific calibration). Intensity of lodging was evaluated by the method of Rixhon (1968).

Results

Influence on yield

In the 46 trials, the dressings giving greatest profitability ("Optimum"), taking into account 1 kg N = 4 kg wheat, were calculated on the basis of the ADAS equation (Oger, 1994). The second nitrogen dressing ("Gembloux") is defined for each crop situation according to the method recommended by the Cereals team of Gembloux and most frequently used by the Belgian farmers. This method is described in "Fumure et protection phytosanitaire des céréales," edition 2000 (Falisse & Meeus, 2000). The third nitrogen dressing ("0 N at tillering") has a quite similar dose as the second but in this case no nitrogen is given during tillering. The two split applications are applied: the first at beginning of stem elongation (GS 30) and the second after flag leaf emergence (GS 37-39). The amount of the first is nearly the same as the second in the Gembloux method and the amount of the last application is the sum of the first and the third in the Gembloux method: often corresponding to one third at GS 30 and two thirds at GS 37-39.

The yields (in kg/ha) obtained with the three nitrogen dressings are given in Table 1 with protein contents and Zeleny index where these were assessed. In Tables 1a and 1b, the comparison between the different nitrogen dressing: "Optimum", "Gembloux" and "0 N at tillering" show:

- very often the difference in yield and dose of fertilizer between the "Optimum" calculated after harvest and the Gembloux recommended nitrogen dressing is not large;
- but in some cases (2, 5, 14, 40), the advise is not correct and causes an important loss;
- in most of the crop situations, the gap between the yields given by the nitrogen dressing recommended and by the same nitrogen dressing without application during tillering and with a large amount at flag leaf is slight. Often, these very few differences are compensated for by saving the passing cost in the crop to apply the fertilizer.
- Bypassing the tillering application is unfavourable after wheat and in certain soil structure conditions, often associated with minimum tillage. In these conditions, the root growth is often delayed and the crop has difficulties in finding in soil the minimum amount of nitrogen needed. In this case, an early nitrogen dressing is essential to promote crop growth. On the other hand, as in late drilling (Table 2), "0 N at tillering" can be an interesting option.

Figure 1 shows the results observed during four seasons (1996-97 to 99-2000) in nitrogen dressing trials carried out in Lonzée on different classical and hybrid varieties. The classical varieties were high yielding Tremie (97 to 00), Vivant (97 to 00), Rialto (97 and 98) or Tilburi (99 and 00) and the hybrids were Cockpit (97, 98, 99), Hybnos (97, 98, 00), Hynoesta (97 to 00), Mercury (98, 99, 00), HA92 (00) and Fronty (00). Many of these hybrids are still commercialised in Belgium. The yields are means of three or four varieties.

Table 1*a*. *Yields (in kg/ha), protein contents (in %) and Zeleny index (in ml) observed for different nitrogen dressings in 26 nitrogen trials* carried out in *Belgium during seasons 93-94, 94-95, 95-96 and 96-97*

	Place	Previous Crop	Sowing date	Optimum	Yield kg/ha	Prot %	Zel ml	Gembloux	Yield kg/ha	Prot %	Zel ml	0 N at tillering	Yield kg/ha	Prot %	Zel ml
1	Lonzée	Sugar beet	03-11	0-100-100=200	10302			50-70-85=205	10103			0-80-120=200	10194		
2	Lonzée	Seed potato	27-10	100-20-60=180	10791			50-70-75=195	10097			0-70-120=190	9902		
3	Lonzée	Wheat	18-10	100-100-40=240	11693			60-70-75=205	11132			0-80-120=200	10103		
4	Momalle	Sugar beet	09-11	0-100-40=140	10295			40-70-65=175	10093			0-70-105=175	9950		
5*	Fumal	Sugar beet	23-11	0-100-80=180	9003			60-70-85=215	7901			0-85-120=205	8951		
6	Waremme	Sugar beet	26-10	80-0-80=160	9921			50-70-75=195	9875			0-70-120=190	9684		
Means for season 93-94				183	10334			198	9867			193	9797		
7	Lonzée	Sugar beet	04-11	100-0-100=200	9998	11,6	61	50-70-80=200	9775	11,7	63	0-80-120=200	9772	12,1	65
8	Lonzée	Seed potato	03-11	100-0-80=180	10174	11,9		20-70-100=190	9854	12,3		0-70-120=190	9800	12,9	
9	Lonzée	Wheat	18-10	100-60-60=220	8868	12,1		55-80-80=205	8741	12,2		0-80-120=200	8388	12,6	
10	Momalle	Chicory	27-10	100-0-80=180	10308			40-60-60=160	10177			0-60-100=160	10006		
11*	Fumal	Peas	10-10	40-60-80=180	10101			30-50-80=160	9974			0-60-100=160	9791		
Means for season 94-95				192	9890			183	9704			182	9551		
12	Lonzée	Sugar beet	26-10	0-100-80=180	11276	12	51	50-70-80=200	11218	12	52	0-80-120=200	11267	12,3	54
13	Lonzée	Seed potato	19-10	0-60-100=160	12080			40-60-75=175	11861			0-60-115=175	12200		
14	Lonzée	Wheat	13-10	100-60-100=260	10455			40-75-75=190	9527			0-80-120=200	9756		
15	Momalle	Sugar beet	14-11	0-100-20=120	9989			30-40-95=165	9427			0-40-120=160	9175		
16*	Branchon	Chicory	20-12	40-100-40=180	8128			70-60-75=205	8047			0-80-120=200	7773		
17	Waremme	Carrot	25-10	0-0-100=100	10812			40-50-75=165	10620			0-50-115=165	10568		
Means for season 95-96				166	10457			183	10117			183	10123		
18	Lonzée	Sugar beet	24-10	100-0-80=180	10728	11,5		50-60-75=175	10658	11,5		0-60-120=180	10258	12,6	
19	Lonzée	Sugar beet	24-10	0-100-100=200	11555	12,1		30-60-95=175	11204	11,6		0-60-120=180	11167	12	
20	Lonzée	Sugar beet	15-10	0-100-80=180	10452			40-60-75=175	10341			0-60-120=180	10314		
21	Lonzée	Sugar beet	15-10	20-100-80=200	11323			40-60-75=175	11070			0-60-120=180	10824		
22	Lonzée	Wheat	11-10	100-40-80=220	11507			40-75-75=190	11005			0-80-110=190	10975		
23	Lonzée	Chicory	10-12	100-0-100=200	9731	12,8		60-60-75=195	9543	12,7		0-80-120=200	9320	13,2	
24	Remicourt	Chicory	11-12	60-40-60=160	10674			50-40-65=155	10640			0-60-100=160	10539		
25*	Fumal	Sugar beet	16-10	0-80-60=140	8779			40-70-85=195	8642			0-70-120=190	8760		
26	Waremme	Potato	15-11	80-0-60=140	9575			60-40-55=155	9047			0-60-100=160	8352		
Means for season 96-97				180	10480			177	10239			180	10057		

Table 1b. *Yield (in kg/ha), protein contents (in %) and Zeleny index (in ml) for different nitrogen dressings in 20 nitrogen trials carried out in Belgium during seasons 97-98, 98-99 and 99-00*

	Place	Previous crop	Sowing date	Optimum	Yield kg/ha	Prot %	Zel ml	Gembloux	Yield kg/ha	Prot %	Zel ml	0 N at tillering	Yield kg/ha	Prot %	Zel ml
27	Lonzée	Sugar beet	21-10	0-100-100=200	9651	13,3	46	40-60-75=175	9244	12,4	40	0-60-120=180	9118	13,5	48
28	Lonzée	Sugar beet	21-10	0-80-80=160	10409	12,5	28	20-60-95=175	10190	12,9	29	0-60-120=180	10300	13,5	31
29	Lonzée	Sugar beet	20-10	0-60-80=140	10451			30-60-85=175	10205			0-60-120=180	10422		
30	Lonzée	Sugar beet	20-10	0-100-100=200	11139			40-60-75=175	10963			0-60-120=180	11015		
31	Lonzée	Sugar beet	06-12	0-100-60=160	10437	11,4	27	50-60-75=185	10283	11,4	26	0-60-120=180	10140	12,2	27
32	Lonzée	Wheat	06-10	100-40-60=200	9575	12,2	38	55-50-75=180	9059	12,3	40	0-60-120=180	8173	13,4	51
33	Momalle	Sugar beet	18-11	0-0-100=100	11182			30-60-75=165	10790			0-60-100=160	10992		
34*	Héron	Sugar beet	30-10	0-100-100=200	9741			15-65-85=165	9359			0-65-100=165	8677		
35	Waremme	Spinach +bean	30-10	0-100-40=140	11081			40-45-70=155	10733			0-50-100=150	10828		
Means for season 97-98				167	10407			172	10092			173	9963		
36	Lonzée	Sugar beet	23-01	100-40-100=240	10471	12,3	26	80-70-70=220	9970	1,5	24	0-80-140=220	9635	13	36
37	Lonzée	Sugar beet	23-01	100-60-100=260	11200	11,1	37	60-70-90=220	10610	11,2	37	0-80-140=220	10250	12,7	46
38	Lonzée	Sugar beet	07-11	0-100-140=240	11810	11,4	16	85-65-75=225	11530	10,8	13	0-80-140=220	11523	11,2	15
39	Lonzée	Sugar beet	17-03	100-60-80=240	9766			60-70-70=200	9290			0-80-120=200	8145		
40*	Branchon	Potato	27-11	100-80-60=240	9913			60-35-75=170	8755			0-60-110=170	8159		
41	Fallais	Sugar beet	04-12	100-60-100=260	11334	12,7	41	60-60-75=195	10830	12,2	38	0-80-120=200	10746	12,5	40
Means for season 98-99				247	10749			205	10164			205	9743		
42	Lonzée	Sugar beet	18-10	0-75-50=125	9357	11,6	30	40-60-75=175	9337	12,1	32	0-60-115=175	9320	12,4	33
43	Lonzée	Sugar beet	18-10	100-0-100=200	10640	11,6	42	20-60-95=175	10287	11,4	41	0-60-115=175	10400	11,5	42
44	Lonzée	Sugar beet	19-10	0-75-100=175	10727	12,2	39	40-60-75=175	10580	12	38	0-60-115=175	10642	12,3	40
45*	Fumal	Oil seed rape	18-10	0-100-80=180	8387			30-60-75=165	8130			0-60-105=165	7870		
46	Momalle	Sugar beat	10-11	0-60-40=100	9370			20-30-50=100	9287			0-30-70=100	9359		
Means for season 99-00				156	9696			158	9524			158	9518		
Means for 7 years				184				182				182			

* simplified soil tillage with a « Dutzi »

For hybrid varieties, the dressing without nitrogen at tillering is more profitable than for inbred varieties.

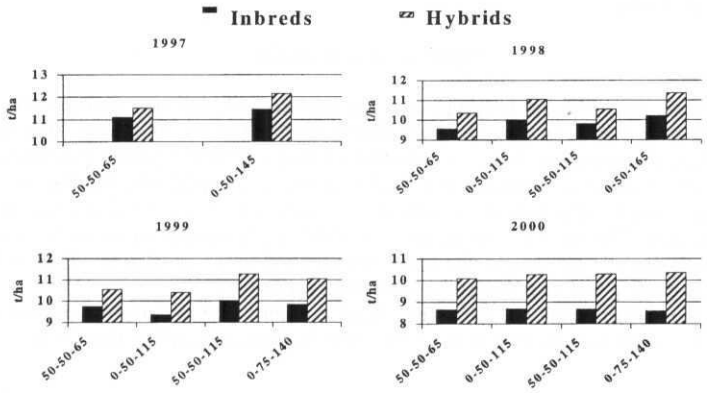

Fig. 1. Yield observed with different nitrogen dressings for inbred and hybrid varieties.

Influence on grain quality

On the basis of 18 trials (Tables 1a and 1b) where quality parameters were measured, the nitrogen dressing with 0 N at tillering gives, versus recommended nitrogen dressing, a mean increase of 0,7 % for protein content (12,6 % vs 11,9 %) and of 4,5 ml for the Zeleny test.

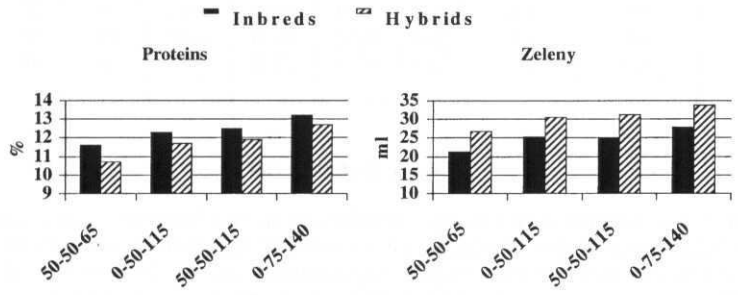

Fig. 2. Protein contents and Zeleny index observed with different nitrogen dressings for inbred and hybrid varieties.

Figure 2 shows protein contents and Zeleny sedimentation volumes observed in the 1999 trial on classical and hybrid varieties with four nitrogen dressings. The same trend is observed on

inbred and hybrid varieties when flag leaf dose is increased with 50 kg N/ha and if the amount from the first application is transfered to a flag leaf application. This quality benefit can be related to a better nitrogen recovery by the crop from fertiliser applied at the flag leaf stage (Destain *et al.*, 1997).

Influence on lodging risk

Table 2 gives the yield and lodging index as observed with different nitrogen dressings in similar trials drilled at three different dates during the 2000 season at Lonzée. The yield and lodging indices are means for five varieties (Ordeal, Folio, Hussar, Sponsor and Mercury) and two levels of intensity of fungicide use. Reduced nitrogen availability for the crop during tillering and at the beginning of stem elongation reduced the number of tillers and number of ears per unit area. This poorer ear population is widely compensated for by an increase in ear fertility and thousand grain weight due to less competition in the vegetation. A large nitrogen application at the flag leaf stage is also favourable for ear fertility.

A lower population density of ears has a beneficial influence on lodging resistance as the results of the intensity of lodging in these "nitrogen dressing and drilling date" trials at Lonzée show.

Table 2. *Influence on yield (in kg/ha) and on lodging index (0-100) for different nitrogen dressings in similar trials drilled at three dates (means for 5 varieties and 2 modalities of fungicide protection) – Lonzée, 2000*

Nitrogen dressings (kg N/ha)				Yield			Lodging index		
G.S.25	G.S.30	G.S.39	Total	Drill 13-10	Drill 15-10	Drill 11-01	Drill 13-10	Drill 15-11	Drill 11-01
0	50	50	100	9029	9223	9406	13	8	18
50	50	50	150	9237	9007	8999	26	39	46
0	50	100	150	9301	9572	9555	22	24	43
50	50	100	200	9168	9020	8904	42	47	57
0	100	100	200	9275	9396	9094	37	39	56
0	50	150	200	9283	9718	9449	28	27	50
50	50	150	250	9262	8999	8897	45	50	57
0	100	150	250	9228	9356	8973	40	40	58

Influence on disease risk

Figure 3, with data also from a nitrogen dressing trial without fungicide protection at Lonzée during the 2000 season, shows the areas with symptoms of *Septoria tritici* observed on different leaves at three dates for different timings for application of the same 200 kg N/ha total fertiliser dose. The management of crop nitrogen alimentation can clearly influence the rhythm of development of *Erisiphe graminis* (Olesen *et al.*, 2000) and also of *Septoria tritici* as the observations made in a trial at Gembloux last year during a season with a high pressure for this disease show.

If during the stem elongation phase, there is never nitrogen overfeeding, *Septoria* development seems slower (Fig. 3). Large amounts of nitrogen at flag leaf emergence may make the crop more sensitive to fungal infections, but it is later when the plant is well protected by fungicide treatment (Bodson *et al.*, 1997*b*).

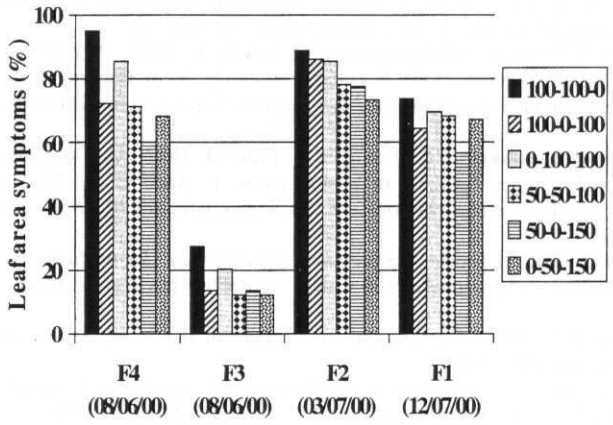

Fig. 3. Leaf area with symptoms of Septoria tritici (in %) observed with different timings of application of 200kgN/ha nitrogen dressings on four leaves at three dates.

Discussion

Increasing the part of nitrogen dressing applied near flag leaf is a necessity if grain protein contents must be increased without taking environmental risks with an excessive total dose (Massé & Hebrard, 2000). Hybrid wheat prefers clearly this timing of nitrogen dressing application because hybrids need more and have better nitrogen-use during the grain filling period (Oury *et al.*, 1995). These results show that in some wheat crop situations, it is possible to maximise nitrogen fertilizer efficiency without yield loss but with an improvement in grain quality and a reduction in lodging and disease risks. In Belgium, these situations are found when the crop has good root development in spring and can take up a minimum amount of nitrogen from the soil. There is an approximate need at the end of winter for 50 kg N/ha to a depth of 150 cm.

This modality for nitrogen dressing must confirm its advantages in many situations and a method must be defined to precisely calculate the right dose for each fertilizer application.

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