Nitrogen fertilization management for seed production of tall fescue

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Abstract:

In France, rules relative to nitrates use (instruction n°91/676/CEE) prescribe 3 different compulsory instructions to farms located in sensitive areas: firstly calculation of N supply by method of nitrogen balance per crop, secondarily edition of a forecasting fertilization scheme, thirdly registration of quantities used and spraying dates in respect to forbidden periods.

For grass seed production, and especially tall fescue, number of analyses of many experiments carried out by FNAMS, in different areas and years have led to define for the first time the exact N needs for the crop (first trials serial between 1986 and 1994). Then, a good ratio was found between N level uptake and seed yield: 160 kg N uptake /ha (at full ear emergence, from aerial part and root system) is necessary to obtain the maximum seed yield. A N balance method ha been described for the N fertilization management of this grass specie.

Following then, different experiments confirmed the validity of this N balance method. In 2007 and 2008, trials have been carried out in different areas of France: south west, centre and north east. In those areas several fields had been selected and three treatments have been compared: T1 without nitrogen (to estimate N soil contribution), T2 calculated with N balance method and T3 based upon the usual farmer practice. For the majority of experiments, the T2 modalities led to reduce the N supply of approximately 10 kg N/ha without any significant difference on seed yield, but varied from 40 kg N/ha to -15 kg N/ha. On the contrary, reduction of N supply (some T3 modalities, compared to T2 - N balance method), decreased significantly seed yield.

These experiments also focussed similar N needs between two different fescue types: turf type (variety TOMAHAWK) and forage type (variety DULCIA), and also between first or second year of production. These results demonstrate that a more extensive use of N balance method could improve N fertilization management in these crops, and reduce luxurious N intake.

Key words: grass seed production, tall fescue (*Festuca arundinacea*), N fertilization

Introduction:

In France, tall fescue is cultivated on small areas, on various latitudes like North-east, West and South-west which are submitted to various conditions of soils and climates.
Before 2003, N fertilization was essentially empiric, based upon visual observations or based on other crops like cereal.

In 2010, France has launched the forth procedure referring the nitrate policies (CEE n°91/676 of the 12 December 1991).The program covering 2009-2012, restrict the use of N in view to respect environment by elimination of the most dangerous practices.

Considering the new context, seed growers located in vulnerable areas are constraint to adjust N fertilization with possibility to refer to three methods. In seed production, only balance method can be used to determine the quantity of N needed for seed crop. FNAMS researches have established the N needs for tall fescue to reach the maximum yield. This quantity can be used in the balance method to calculate the spring N supply.

Material and methods:

Field experiments were carried out on tall fescue from 1986 to 2003 in four locations in France: Angers (north-west), Troyes (north-east), Lavaur and Condom (south-west), Bourges (middle). On these 4 locations and for each year, four rates of spring nitrogen application were compared: 0, 60, 120 and 180 kg N ha^{-1}. Different cultivars were used: Clarine, Barcel, Bariane (forage type) and Apache, Sinfonia,Villageoise (turf type). Each trial is conducted on autumn sowing (august), with 4 replications per object and harvested with an experimental combiner to obtain seed production data after drying and cleaning. In each experiment, a plants sample is clipped at the end of ear emergence, dried (80°C during 24 h), weighted (t $ha^{-1)}$ and analysed for N content (Dumas method by flash combustion with automatic N analyser). At least N uptake is calculated (kg ha^{-1}). A total of 158 dataset has been compiled to define the optimum N uptake to achieve the highest seed yield.

In 2007 and 2008, 17 experiments were carried out on different areas of France. The N fertilization levels varied in each trial. Three treatments are compared (table 1): T1- a control plot without nitrogen (N=0), T2 – N supply calculated with the N balance method and T3 - based upon the usual farmer practice. In all experiments, at ear emergence, plants samples were cut. Methods to carry out trials and to calculate N uptake are the same than described before.

Results and Discussion

- Relationship between N uptake and seed yield

The maximum seed yields obtained on different trials are very variable (from 800 to 2350 kg ha^{-1}), so results are expressed in percentage of the maximum seed yield obtained in each trial. The figure 1 shows the relationship between N uptake at the end of ear emergence and the seed yield for all trials. The response curve can be divided in three parts: (1) until 110 kg ha^{-1} of uptaken nitrogen, yields increase rapidly in all trials, (2) between 110 and 130 kg ha-1, most the maximum seed yields are obtained, (3) above 130 kg ha-1, the increased of uptaken N has no effect on yields.

From the logistic curve $Y = a / [1 + b \times \exp(-c \times X)]$ (with Y = yield in % and X = nitrogen uptake in kg ha^{-1}), we can consider that the optimum amount of N uptake in aerial part at ear

emergence is, on average, 120 kg ha-1 for the tall fescue. The total N uptake by the plant is 30% more, if we take into account uptake by the roots and the lowest parts of the crop which are not cut.

So, we consider the total and optimum nitrogen uptake at ear emergence is 160 kg ha^{-1} (120 kg N ha^{-1} aerial part + 40 kg N ha^{-1} root part).

- Nitrogen balance method

In the second part of study, the N mineral supply is calculated for 17 tall fescue seed crops (table 1) with the next equation:

N supply = (Plant N + N_0) – (RSH + Mr + Mh + Mo)

With: Plant N: plant N uptake at ear emergence, $N_{0:}$ N unavailable by the plant, RSH: soil nitrogen content at the end of winter; Mr: mineralization of vegetal residue; Mh: mineralization of humus; Mo: mineralization of organic matter

For these 17 situations, N supply N uptake, at ear emergence, and seed yield are presented in table 2. The results show that for the majority of trials in first harvest (n° 1 to 9), the modality T2 (N calculated with balance method) led to reduce the N mineral supply of about 10 kg ha^{-1} without any significant different in seed yield. For these situations, the maximum seed yield is generally reached in T2.

For situations in second harvest (n° 10 to 16), the N supply by the N balance method (T2) is generally higher that the usual farmer practice. The modality T2 increases the N supply of about 3 kg ha^{-1} (with an important variation from +40 kg N/ha to -40 kg N/ha), and increase the seed yield with a significant difference, in more than 75% of situations. Use the nitrogen balance method, for tall fescue in secondary harvest, is very pertinent. This method induces most of the time to reach the maximum of yield compared to a empirical method.

In situations 8, 9, 17 and 16, nitrogen balance method is used with the same total nitrogen uptake (160 kg N/ha) for two types of fescue: turf type (variety TOMAHAWK) and forage type (variety DULCIA). The results show a similar nitrogen uptake at ear emergence (140 kg N/ha) but yields mark the difference between variety TOMAHAWK (2137 kg ha^{-1}) and DULCIA (935 kg ha^{-1}). The experiments pointed out similar needs between two different fescue types: turf type and forage type even if the yield level is too different.

In situation 2, farmer practice is more important that nitrogen balance method, the difference between T2 and T3 is equal to - 28 kg N/ha. The nitrogen mineral supply by the farmer induces the beating down of crop by overfeeding. Nitrogen supply, by calculated method, is more right.

In all cases, yield obtained by nitrogen balance method is higher to seed yield T3 (figure 2), and the nitrogen uptake at ear emergence is not too far to 120 kg N/ha (the mean is 145 kg N ha^{-1}).

Conclusion

The results of these experiments show that the maximum seed yield of tall fescue was reached at about 160 kg ha-1 of total nitrogen uptake at the end of ear emergence. The different experiments confirmed the validity of the nitrogen balance method. In few cases, the soil contribution to the total requirement of the crop can be high.

The total N uptake by tall fescue is equal in the different types (turf and forage) as well as in different year of harvest (1^{rst} or 2nd harvest).

Figure 1: Yield response to nitrogen uptake in aerial part, at ear emergence, for tall fescue (total of 158 datasets)

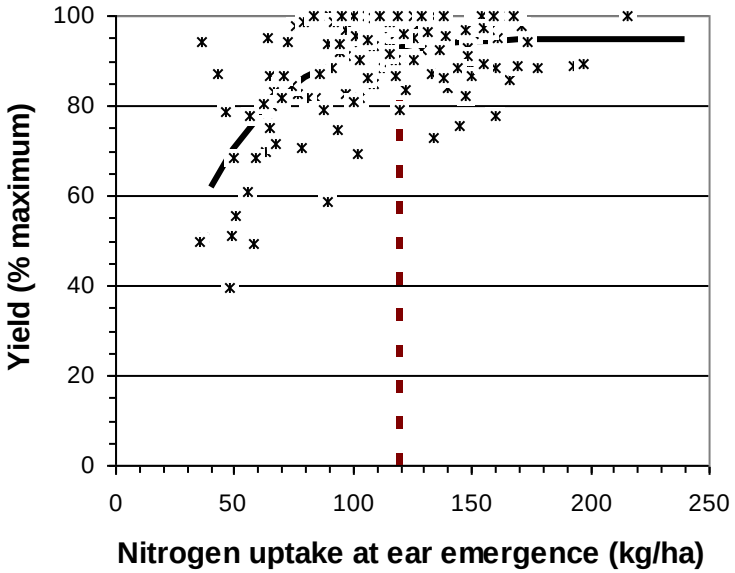

Figure 2: Effect of N fertilization (balance method) on seed yield compared to usual farmer practice (2007 and 2008) – From 1 to 9 (left) crops in first year of production, from 10 to 16 (right) crops in second year of production

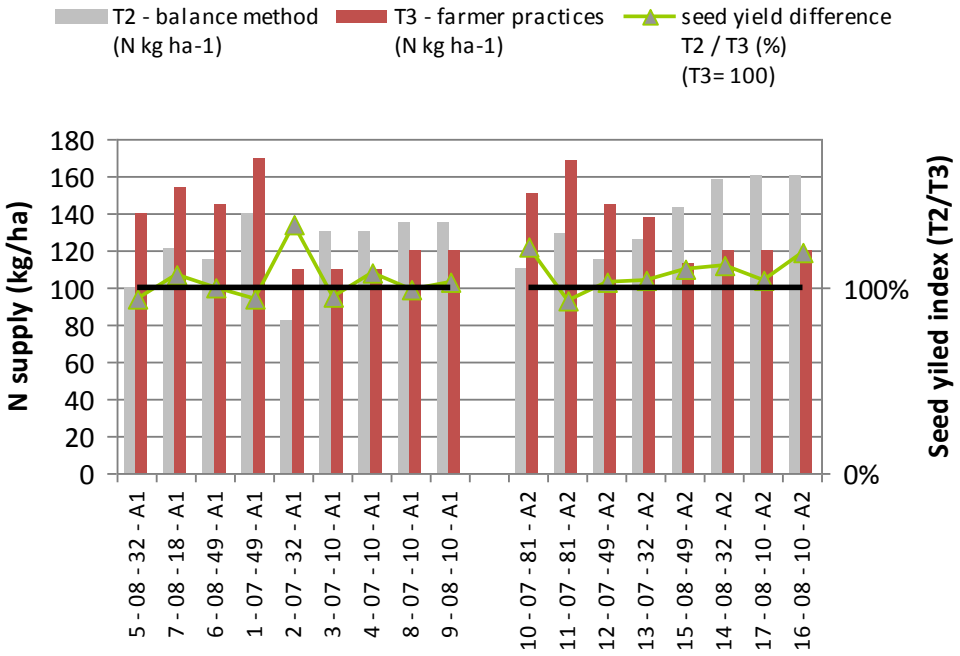

Table 1: Seed crops of tall fescue studied in 2007 and 2008 with N fertilization comparison.

Nitrogen mineral supply (T2) is calculated with N balance method (FNAMS abacus)

N° Trials : (Year, Location and French department) N-W: north-west S-W: south-west M: middle N-E: north-east	**Cultivars (T: turf type F: forage type)**	**N Plant Needs (kg ha-1)**		**N Soil Furniture (kg ha-1)**				**Compared objects**		
		Plant N uptake	**N unavailable**	**Soil nitrogen content at the end of winter**	**Mineralization of vegetal residues**	**Mineralization humus**	**Mineralization organic matter**	**T2 - N calculated by balance method** *(and real N supply)* (kg ha-1)	**T3 - Farmer practice** N mineral supply (kg /ha)	Différence T2 - T3 (kg /ha)
Crops in first year of production (A1)										
1 (07 / N-W / 49)	TOMAHAWK (T)	160	20	11	0	32	0	140 *(140)*	170	- 30
2 (07 / S-W / 32)	VILLAGEOISE (T)		20	82	0	25	0	73 *(81)*	110	- 28
3 (07 / N-E / 10)	TOMAHAWK (T)		20	7	20	22	0	130 *(130)*	110	+ 20
4 (07 / N-E / 49)	DULCIA (F)		20	7	20	22	0	130 *(130)*	110	+ 20
5 (08 / S-W / 32)	VILLAGEOISE (T)		30	88	-20	22	0	100 *(100)*	140	- 40
6 (08 / N-W / 49)	VILLAGEOISE (T)		20	13	20	28	0	119 *(115)*	145	- 30
7 (08 / M / 18)	VILLAGEOISE (T)		15	9	20	33	0	113 *(121)*	154	- 33
8 (08 / N-E / 10)	TOMAHAWK (T)		30	12	20	23	0	135 *(135)*	120	+ 15
9 (08 / N-E / 10)	DULCIA (F)		30	12	20	23	0	135 *(135)*	120	+ 15
Crops in second year of production (A2)										
10 (07 / S-W / 81)	DULCIA (F)	160	30	42	0	27	0	120 *(110)*	151	- 41
11 (07 / S-W / 81)	VILLAGEOISE (T)		20	21	0	20	0	139 *(129)*	169	- 40
12 (07 / N-W / 49)	VILLAGEOISE (T)		20	34	0	32	0	115 *(115)*	145	-30
13 (07 / S-W / 32)	BELFINE (F)		20	28	0	25	0	126 *(130)*	138	- 12
14 (S-W / 32)	VILLAGEOISE (T)		30	10	0	22	0	158 *(158)*	120	+ 38
15 (N-W / 49)	TOMAHAWK (T)		20	13	0	21	0	146 *(143)*	113	+ 30
16 (N-E / 10)	TOMAHAWK (T)		30	10	0	23	0	157 *(160)*	120	+ 40
17 (N-E / 10)	DULCIA (F)		30	8	0	23	0	159 *(160)*	120	+ 40

Table 2: Effect of N fertilization on seed yield, N uptake and dry matter of tall fescue (2008)

		T2 - N Balance Method				**T3** - usual farmer practice			
N° Trials : (Location / French Department) N-W: north-west S-W: south-west M: middle N-E: north-east	**Cultivars (T: turf type F: forage type)**	**N mineral supply** (kg ha^{-1})	**Seed yield** (kg ha^{-1})	**N uptake** (aerial part) (kg ha^{-1})	**Dry matter** (T ha^{-1})	**N mineral supply** (kg ha^{-1})	**Seed yield** (kg ha^{-1})	**N uptake** (aerial part) (kg ha^{-1})	**Dry matter** (T ha^{-1})
Crops in first year of production									
1 (07 / N-W / 49)	TOMAHAWK (T)	140	**784**	193	11.5	145	**837**	210	11.3
2 (07 / S-W / 32)	VILLAGEOISE (T)	82	**1055**	115	5.7	110	**789**	154	6.9
3 (07 / N-E / 10)	TOMAHAWK (T)	130	**1563**	132	10.2	110	**1640**	115	9.7
4 (07 / N-E / 49)	DULCIA (F)	130	**863**	124	10.5	110	**801**	117	11.0
5 (08 / S-W / 32)	VILLAGEOISE (T)	100	**1440**	121	5.0	140	**1540**	118	7.9
6 (08 / N-W / 49)	VILLAGEOISE (T)	115	**2150**	187	12.9	145	**2150**	201	12.0
7 (08 / M / 18)	VILLAGEOISE (T)	121	**1520**	119	11.5	154	**1420**	149	12.3
8 (08 / N-E / 10)	TOMAHAWK (T)	135	**2550**	149	14.2	120	**2570**	172	14.7
9 (08 / N-E / 10)	DULCIA (F)	135	**1090**	148	12.8	120	**1060**	160	14.2
Crops in second year of production									
10 (07 / S-W / 81)	DULCIA (F)	110	**509**	164	10.7	151	**417**	148	10.4
11 (07 / S-W / 81)	VILLAGEOISE (T)	129	**784**	138.5	7.6	169	**841**	172	7.8
12 (07 / N-W / 49)	VILLAGEOISE (T)	115	**999**	131	9.4	145	**973**	141	9.0
13 (07 / S-W / 32)	BELFINE	126	**850**	166	10.5	138	**820**	141	11.7
14 (S-W / 32)	VILLAGEOISE (T)	158	**1550**	176	10.0	120	**1380**	109	8.4
15 (N-W / 49)	TOMAHAWK (T)	143	**1380**	138	9.3	113	**1250**	125	8.6
16 (N-E / 10)	TOMAHAWK (T)	160	**2120**	131	10.83	120	**1780**	124	10.8
17 (N-E / 10)	DULCIA (F)	160	**780**	143	11.6	120	**750**	129	11.9