Ability of new durum wheat pure lines to meet yield stability and quality requirements in low input and organic systems.

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Introduction

Low-input production schemes adopted in organic or conventional farms require crop varieties that combine good product quality and high yield stability under non optimal environmental conditions (Gooding et al., 1999). These traits are not yet found among the durum wheat genotypes available in France. Consequently the cultivation of this crop is hardly successful in stockless organic farms in southern France, which are characterised by very low nitrogen resources. Some hopes emerged with the identification of new durum wheat pure lines with a high grain protein content in breeding experiments conducted near Montpellier in 2001 and 2002. The aim of the present work was to confirm and elucidate the origin of the enhanced protein performance of these new lines through a field experiment with nitrogen resources ranging from very low to sub-optimal levels.

Methods

The study was carried out in 2002-2003 near Toulouse (43.5° N, 1.43°E) on a deep silty-clay loam soil with a high water holding capacity and a low total organic nitrogen content (1.28 g/kg). Four Triticum durum new pure lines (hereafter referred to as A, B, C and D) were selected according to their grain protein content (GPC) found at the F7 generation (Desclaux et al., unpublished). A highly productive cultivar (referred to as H), widely grown in southern France, was taken as a reference to allow a comparison of the new lines with the current elite genotypes. All five cultivars were grown both organically and in a conventional way with or without fertilizer input (Table 1). The first N input was made at Zadoks stage 25, the second input (B210 treatment only) at Zadoks stage 31/32. N use efficiency for grain biomass accumulation (NUE_{Gw}) was calculated as Gw/Ns, in which Gw is grain yield and Ns is N supply (Soil mineral N in February + N fertilizer applications). This ratio was split into two components according to Moll et al. (1982): (1) the efficiency of uptake (Nt/Ns) where Nt is aerial N in the plant at maturity and (2) the efficiency with which the absorbed N is used to produce grain biomass (Gw/Nt), so that : NUE_{Gw} = (Nt/Ns) x (Gw/Nt). N use efficiency for nitrogen accumulation in the grain (NUE_{Ng}) was similarly analysed with NUE_{Ng} = (Nt/Ns) x (Ng/Nt) = (Nt/Ns) x NHI, where Ng is total N in grain at maturity and NHI is the nitrogen harvest index.

Table 1 : Production scheme and Nitrogen input levels.

Production scheme :		Organic			Conventional	
		B0	**B120**	**B210**	**C0**	**C180**
		kg N / ha				
Soil mineral N*	14/01/03	45	45	37	50	45
1st N application	13/03/03	0	120 a	90 a	0	180 b
2d N application	9/04/03	0	0	120 a	0	0

* Measured in the 120 cm top soil layer.
Fertilizer : a/ hydrolysed feather meal ; b/ ammonitrate

Results

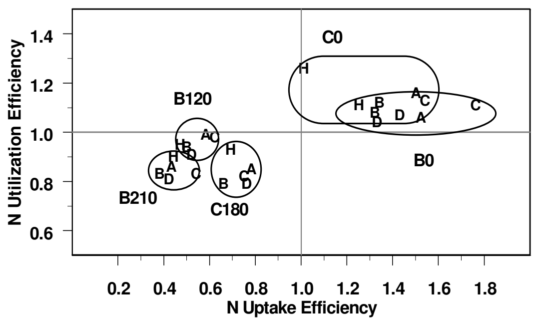
Weeds were well controlled in both organic and conventional plots. Development of foliar diseases was limited except for the D line which was affected by an early attack of S. nodorum. There was no limitation to root expansion from the soil surface down to 120 cm depth. Severe pre-anthesis and post-anthesis drought stress led to a low N uptake during the vegetative period and a limited carbohydrate incorporation during the grain filling period.

In this context, when cultivated without any N fertilizer input either in the conventional or the organic scheme, three of the new lines showed a higher GPC with equal or higher yields than the reference variety in organic treatments. Nevertheless, in both situations GPC remained under 13%, a level below which grain quality is not suitable for the pasta or milling industry. The early single N organic input (B120) was enough to allow all lines except the reference one to meet this commercial protein threshold. Treatment B210 led to a further increase of GPC, with a mean value for the new lines (14.5%) greater than for the reference line (13.7 %). In all treatments except the C180 treatment, line C gave a higher yield than the reference cultivar H. Yield and GPC values for both B0 and C0 treatments were similar. There were no differences in terms of yield among the lines with the treatment C180. In this N sub-optimal condition, three lines (A, C and D) showed a GPC greater than 15%, significantly higher than the GPC of the reference line. Centred values for both components of NUE_{Gw} for the 25 treatments are shown in Figure 1. The N uptake efficiency for grain biomass accumulation was very sensitive to the nature (organic versus mineral) and the level of N resources. Differences among wheat lines only occurred in the absence of nitrogen input (C0 and B0 treatments). The N-use efficiency was less affected than the N-uptake efficiency by variations in the N resources. The reference cultivar displayed a slight tendency for better use efficiency in the conventional treatments C180 and C0. Increases in N uptake after anthesis accounted for the better N uptake efficiency observed for line A and D. Increases in both pre- and post-anthesis N uptake explained the better yield and GPC performances of the C line. NHI was the same in all treatments, so the better N use efficiency for protein accumulation in grain is entirely due to a better N uptake efficiency.

Table 2 : Grain yield and Protein Content

		Mean by N level	Mean by wheat line A	B	C	D	H
Grain yield q / ha (15 % humidity)	B0	31,0	32,4	28,2	**38,6**	27,8	27,5
	B120	36,6	38,0	36,0	**43,0**	35,1	31,3
	B210	38,1	38,8	33,6	**44,6**	35,4	37,0
	C0	33,7	**37,0**	32,9	**37,5**	**34,0**	27,6
	C180	57,9	61,6	52,0	58,5	56,2	60,6
Protein content %	B0	10,4	**11,1**	10,1	**10,6**	**11,0**	9,5
	B120	13,0	12,9	13,0	13,2	**13,6**	12,2
	B210	14,3	14,4	13,9	14,7	14,8	13,7
	C0	10,6	**10,6**	10,5	**10,9**	**11,7**	9,3
	C180	14,9	**15,2**	14,6	**15,3**	**15,6**	13,7

Bold figures significantly differ from the mean of the reference wheat line (H).



Conclusion

This experiment confirmed the enhanced GPC of the new lines compared to the reference line H which is representative of the highly productive cultivars nowadays grown in France. The improved protein performance for three of the new lines and the better yield for the C line were mainly explained by a better N uptake efficiency. Recent pure lines of durum wheat may display the features required for use in low organic or conventional production schemes.

References

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