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Nitrogen fertilization effects on yield and quality of durum wheat in the Ebro Valley (Spain)

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SUMMARY – The study evaluated the effects of nitrogen fertilization (0, 50, 100, 150 and 200 kg N/ha) on durum wheat (*Triticum turgidum* L. var. *durum*) yield and quality (crude protein, carotenoids and vitreousness) during two growing seasons 1994-1995 and 1995-1996 in two locations of the Ebro Valley. Durum wheat yield and quality improved with increasing N fertilization. In Torregrossa (TOR) the average grain yield increased from 2,728 to 3,476 kg/ha, when N fertilization rates increased from 0 to 200 kg N/ha, whereas in Bell-lloc (BELL) with an average yield of 4,257 kg/ha, N fertilization did not increase grain yield. Crude protein (CP) and carotenoids increased with N fertilization rates in both locations, whereas vitreousness only increased in TOR. CP contents increased from 12.5 to 15.2% in TOR and from 15.0 and 15.8% in BELL when N rates increased from 0 to 200 kg/ha. Carotenoids increased from 9.25 to 10.94 ppm in TR and from 10.11 to 10.55 ppm in BELL. Vitreousness increased from 69.7 to 95.6% in TOR. In BELL the average was 85.4%. The levels of response to N fertilization seem to depend mainly on the initial soil nitrate contents, 35 and 348 kg N/ha in TOR and BELL, respectively, suggesting that soil nitrates should be taken into account when recommending N fertilization rates.

Key words: Crude protein, carotenoids, vitreousness, soil nitrate.

RESUME – *"Effets de la fertilisation azotée sur les rendements et la qualité du blé dur dans la Vallée de l'Ebre (Espagne)". Cette étude a évalué l'effet de la fertilisation azotée (0, 50, 100, 150 et 200 kg N/ha) sur le rendement et la qualité (protéines, vitrosité et caroténoïdes du grain) du blé dur (*Triticum turgidum *L. var.* durum*) pendant deux années, 1994-1995 et 1995-1996, dans deux sites de la vallée de l'Ebre. Le rendement et la qualité du blé dur ont augmenté avec la fertilisation. A Torregrossa (TOR) le rendement a augmenté de 2.728 kg/ha à 3.476 kg/ha, avec 200 kg N/ha, alors que à Bell-lloc (BELL) la fertilisation azotée n'a pas eu d'effet (le rendement a été 4.257 kg/ha). La teneur en protéines et en caroténoïdes a augmenté avec la fertilisation dans les deux localités, alors que la vitrosité est seulement diminuée dans TOR. La teneur en protéines a augmenté dans TOR de 12,5 à 15,2% et de 15,0 à 15,8% à BELL avec 200 kg N/ha. Les caroténoïdes ont augmenté de 9,25 à 10,94 ppm à TR et de 10,11 à 10,5 ppm à BELL. La vitrosité a augmenté de 69,7 à 95,6% à TOR. A BELL la moyenne a été 85,4%. L'effet de la fertilisation azotée dépend de la quantité de nitrates dans le sol, 35 et 348 kg N/ha à TOR et BELL respectivement, donc cette quantité doit être tenue en compte pour optimiser la fertilisation.*

Mots-clés : *Protéines, caroténoïdes du grain, vitrosité, nitrates du sol.*

Introduction

It is commonly accepted that the quality of durum wheat is generally dependent on the protein content of the grain and in turn, protein content is largely dependent on genotype but is also clearly influenced by environment, especially N availability (soil N and rate and time of N application) (Gooding and Davies, 1997). Nitrogen fertilization management offers the opportunity for increasing wheat protein content and quality. Application of high N rates may lead, on the other hand, to the increase of nitrate pollution by leaching (Chaney, 1990; Campbell *et al.,* 1995). Thus, the importance of studying the more efficient use of N fertilizer.

In the Mediterranean irrigated areas of the Ebro Valley, wheat forms part of the crop rotations with maize and alfalfa and depending on prices and EU subsidies durum wheat can be seeded instead of bread wheat. At present, growers try to make wheat cultivation profitable and to take advantage of the irrigation by planting priced quality wheats and applying higher N rates, which in turn may increase costs and environmental pollution. There are many reports about the effects of N on wheat quality, yield and nitrate leaching, mainly from central Europe (Chaney, 1990), but there is little information about high quality wheats in the Mediterranean irrigated conditions (Michelena *et al.,* 1995).

Materials and methods

The experiments were conducted in irrigated conditions during two growing seasons, 1994-1995 and 1995-1996, at the IRTA-University of Lleida research fields at Torregrossa (TOR) and Bell-lloc (BELL) (Ebro Valley, Spain) (41^0 39' N, 0^0 51' E), on a Typic Xerofluvent type of soil, with a loam and clay loam textures, respectively, and a soil depth of about 60 cm. Analysis of a composite sample soil (0 to 30 cm depth) were collected from the experimental site in autumn before seeding. At TOR they revealed that pH was 8.4, available P was 41 mg/kg, available K was 305 mg/kg and organic matter was 17 g/kg. At BELL the composite soil sample from 0 to 30 cm of depth revealed that the pH was 8.1, available P was 44 mg/kg available K was 412 mg/kg and organic matter was 21 g/kg. The initial soil nitrate contents from 0 to 30 cm of depth were of 42 and 28 kg N/ha in TOR in 1995 and 1996, respectively. In TOR the initial soil nitrate contents were 117 and 578 kg N/ha in 1995 and 1996, respectively. Wheat received a broadcast preseeding fertilizer application of 43 kg P/ha and 83 kg K/ha. Bolo and Vitrón cultivars of durum wheat were seeded at 450 seeds/m^2 with an interrow spacing of 20 cm and a plot size of 1.2 m by 8 m. The experiments were seeded on 28 December 1994 and 10 February 1996 at TOR, whereas in BELL wheat was seeded on 7 January 1995 and 23 November 1995. Mean temperatures and rainfall for the 1994-1995 wheat growing seasons (December–July) were 12.3ºC and 106 mm, respectively whereas for the 1995-1996 growing season were 12.6ºC and 372 mm, respectively. Crops were irrigated three times in spring, between the 11 March and 17 May, receiving a total of about 130 mm of water. Weeds were controlled by standard herbicide treatments. Five nitrogen fertilizer treatments were compared, 0, 50, 100, 150 and 200 kg N/ha, split between two applications at sowing (50 kg N/ha, except in the rate 0) and at the end of tillering. The grain was harvested by mid July using a 1.5 m wide plot combine. The grain moisture level was measured in a 300 g sample of each plot and grain yield was adjusted to 14% moisture. Grain protein percentage (CP) yellow pigment and vitreousness were determined for each plot. The experimental design was a split-plot, with N rates as main plots, and wheat varieties as a subplot. The results were subjected to analysis of variance with the General Linear Model procedure of Statistic Analysis System. Statistical differences between several treatments and linear and quadratic trends were also used to study the effects of the treatments by orthogonal contrasts.

Results and discussion

The effects of nitrogen fertilization on durum wheat (means of two cultivars) are summarized in Fig. 1. The average yields obtained in BELL (4277 kg/ha) were higher than those obtained in TOR (3252 kg/ha) possibly due to the high initial soil nitrate content of the first location. Probably, for the same reason, no grain yield increase was observed in BELL, suggesting the interest of adjusting the N fertilizer recommendations depending on the soil nitrate contents. Another aspect that can help to explain the low yield response to N fertilization in BELL could be the nitrate contents in the irrigation water evaluated in about 20 kg N/ha/year. No differences between varieties were observed in grain yield in TOR and BELL.

Durum wheat quality measured as grain protein contents, carotenoids and vitreousness increased with N fertilization in all experiments (Fig. 1), although the rates of increase were higher in TOR, probably because of the lower initial soil nitrate. In BELL 1995, however, high vitreousness were obtained at any rates of N, possibly due to the very high soil nitrate content.

Grain protein increase in TOR from 12.5 to 15.2% while N rates increased from 0 to 200 kg N/ha, whereas in BELL, CP increased from 15.0 to 15.8%. Only at the highest rates of N fertilizer, the CP contents obtained in TOR were similar to the values in BELL. No differences were found between cultivars. CP values changed depending on the growing season, but the values obtained in Lleida are in the range of the average grain quality of most cultivated varieties in Spain, reported to be between 14 and 15% of CP (Royo *et al.,* 1998). Other reports from variety trials in different areas of Spain presented CP values of 13.2 and 19.0%, in 1999 (AETC, 1999).

Carotenoids increased with N fertilization (Fig. 1) from 9.25 to 10.94 ppm and from 10.11 to 10.55 ppm in TOR and BELL, respectively when N rates increased from 0 to 200 kg/ha. These values are higher than average yellow pigment content of most cultivated varieties in Spain, reported to be between 7.5 and 8.4 ppm (Royo *et al.,* 1998; AETC, 1999).

Vitreousness (Fig. 1) also increased with N fertilization in TOR, raising from 69.7 to 95.6%, but no increase was observed in BELL, where the average vitreousness percentage was 85.4%. The high soil nitrate content of this location seems to be the main reason of this lack of response to N fertilizer. The average vitreousness of most cultivated varieties in Spain has been reported to be between 78 and 95% (Royo *et al.,* 1998; AETC, 1999). The results indicate that, there were higher response to N fertilization for the grain quality parameters than for the grain yield, and the response to N fertilization depended on the initial soil nitrate contents, a factor that should be taken into account when making N recommendations (Addiscott and Darby, 1991).

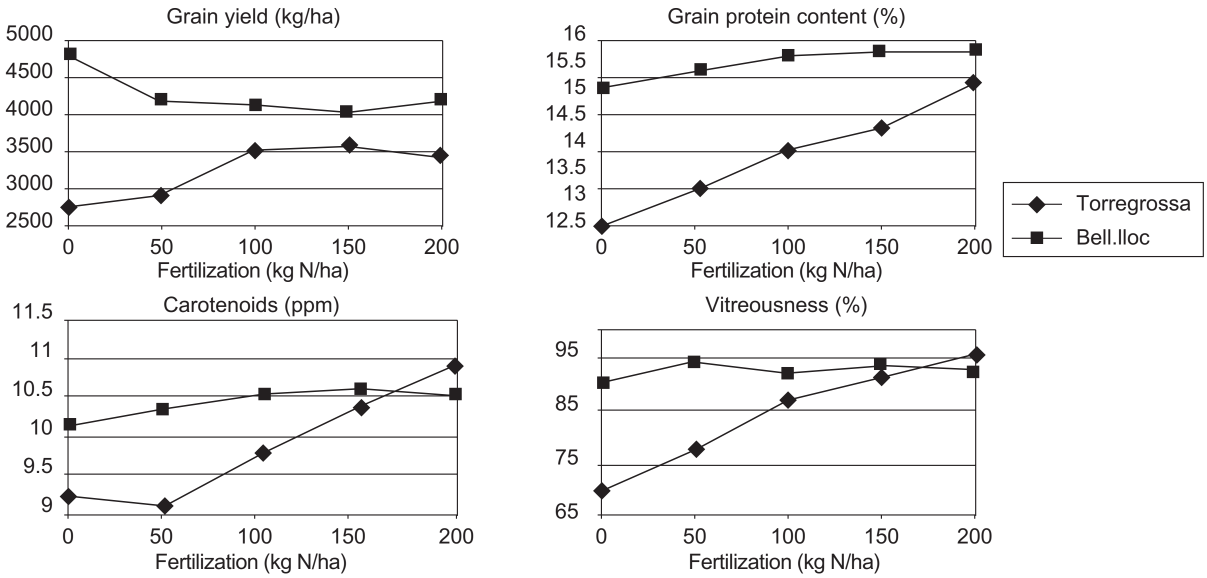

Fig. 1. Effect of nitrogen fertilization on grain yield, protein content, carotenoids and vitreousneuss in durum wheat in two locations (Means of two years 1995 and 1996 and two varieties Bolo and Vitrón).

Conclusions

N fertilization increased yield and quality of durum wheat. Grain yield reached a plateau with lower rates of N than the quality parameters. In the climatic conditions of the Ebro Valley with a low summer and winter rainfall, soils with high NO_3-N can supply nitrogen for the next crop and consequently lower response to N fertilization can be expected.

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