Managing nitrogen fertilisation exclusively through foliar spraying with urea or UAN in common wheat

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Introduction

Nitrogen application through foliar spraying is widely recognised as an efficient and sustainable agronomic practice to improve the protein content in common wheat (*Triticum aestivum* L.) (Gooding and Davies, 1992). However, up to date, only few studies have investigated the effects of this practice compared to conventional soil fertilisation, although late-season (between booting and anthesis) foliar supply of small doses of nitrogen has become common practice (Redman et al., 2002). In this framework, this study compared crop growth, yield and grain quality of a bread-making wheat variety fertilised by low N rates entirely applied by foliar applications with UAN (urea ammonium nitrate) or urea, compared to conventional soil fertilisation at higher rate.

Materials and Methods

The trial was carried out in open field at the experimental farm of the University of Padova (Legnaro - Padova, NE Italy) during the 2018-19 growing season. The wheat var. "Bologna" (SIS, Bologna, Italy) was sown on 22 October 2018 (density 450 seeds m^{-2}; rows 12.5 cm apart) in 54-m^2 large plots arranged within a completely randomised three-replicated block design. The crop was harvested on 26 June 2019.
The fertilisers used for the trial were: granular ammonium nitrate (27% N) and granular urea (46% N) for controls, whereas liquid UAN (26 % N) and liquid UREA (solid urea dissolved in water at ambient temperature) were used for the foliar treatments.
Fertilisers type, doses and application timings are listed in Table 1.

Table 1. Dates and growth stages of N application (kg ha^{-1}).

Fertiliser	Treatment	N split						
		Pre-sowing	Tillering (ZDS 26)	Stem elongation (ZDS 37)	Booting (ZDS 40)	Heading (ZDS 58)	**N dose**	
		20 Oct 2018	25 Feb 2019	21 Mar 2019	24 Apr 2019	7 May 2019	**Total**	**% vs. S**
	0N	32 (s)	-	-	-	-	**32**	**-80%**
UAN	S	32 (s)	58 (s)	58 (s)	-	12 (f)	**160**	**Ref.**
	F-1	32 (s)	16 (f)	16 (f)	16 (f)	16 (f)	**96**	**-40%**
	F-2	32 (s)	8 (f)	16 (f)	32 (f)	16 (f)	**104**	**-35%**
	F-3	32 (s)	8 (f)	16 (f)	32 (f)	32 (f)	**120**	**-25%**
UREA	S	32 (s)	58 (s)	58 (s)	-	12 (f)	**160**	**Ref.**
	F-1	32 (s)	16 (f)	16 (f)	16 (f)	16 (f)	**96**	**-40%**
	F-2	32 (s)	8 (f)	16 (f)	32 (f)	16 (f)	**104**	**-35%**
	F-3	32 (s)	8 (f)	16 (f)	32 (f)	32 (f)	**120**	**-25%**

ZDS= Zadoks growth stage; S= soil application of N as ammonium nitrate or urea; F= foliar spraying of N as liquid UAN (26% N) and urea (dissolved in water) by 430 L water ha^{-1}.

Shoot parameters (SPAD, NDVI and dry biomass) were periodically revealed during the crop cycle, and yield, thousand seed weight (TSW), Harvest Index (HI), grain protein content and wet gluten (14% humidity) at harvest.

Results

The seasonal averages (7 dates) of shoot parameters were never statistically different among treatments, except for lower SPAD readings at F-1 dose of UREA, with only slight reductions with foliar spraying in comparison with controls due to reduced N supply. Similarly, HI and TSW were not significantly affected by the method of N supply, whereas yield was higher under F-2 with UAN (Table 2). Unexpected high yield of the absolute control (0N) was explained by the high rainfall during April and May, that sustained greenness and plant growth.

Table 2. Vegetational indices (seasonal means) and yield components in wheat treatments. In brackets: % variation vs. each conventional management S. Letters: statistical comparisons among treatments within same fertiliser (Newman-Keuls test, $P \leq 0.05$).

Fertils.	Treatment	Shoot parameters			Grain parameters		
		SPAD	NDVI	D.W. (g plant^{-1})	Yield (t ha^{-1})	TSW (g)	HI
	0N	44.3	0.745	2.94	6.57	28.9	34.3
UAN	S	47.4 a (ref.)	0.770 a (ref.)	2.95 a (ref.)	6.41 b (ref.)	29.0 a (ref.)	35.7 a (ref.)
	F-1	45.7 a (-4)	0.758 a (-2)	2.92 a (-1)	6.64 ab (+4)	28.8 a (-1)	35.9 a (+1)
	F-2	45.3 a (-4)	0.736 a (-4)	3.14 a (+6)	6.79 a (+6)	30.3 a (+4)	36.8 a (+3)
	F-3	46.8 a (-1)	0.760 a (-1)	3.11 a (+5)	6.36 b (-1)	27.8 a (-4)	33.7 a (-6)
UREA	S	47.4 a (ref.)	0.782 a (ref.)	3.16 a (ref.)	6.39 ab (ref.)	27.7 a (ref.)	33.1 a (ref.)
	F-1	45.7 b (-4)	0.753 a (-4)	3.01 a (-5)	6.53 a (+2)	29.4 a (+6)	35.8 a (+8)
	F-2	46.5 ab (-2)	0.771 a (-1)	3.17 a (=)	6.19 b (-3)	29.1 a (+5)	36.0 a (+9)
	F-3	45.9 ab (-3)	0.771 a (-1)	3.07 a (-3)	6.52 a (-1)	28.9 a (+4)	33.9 a (+2)

With both UAN and urea, the grain protein content was slightly reduced with foliar spraying dose F-1 (96 kg N ha^{-1}) (P>0.05), whereas with the other N doses there was a moderate improvement (range 13.4-14.5 %), although not statistically significant (Woofolk et al., 2002). The wet gluten followed the same trend of the protein content, confirming the high efficiency and improvement of the bread-making quality through N foliar spraying (Ransom et al., 2016), although at reduced doses.

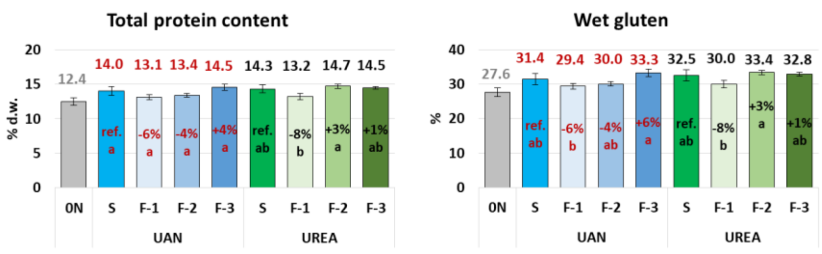

Figure 1. Total grain protein content (left) and wet gluten (right) (± S.E.; n = 3) in N treatments of wheat.
Inside bars: % variation vs. each conventional management S. Letters: statistical comparisons among treatments within same fertiliser (Newman-Keuls test, $P \leq 0.05$).

Conclusions

Compared to conventional soil fertilisation, foliar application of a reduced amount of N by 35% to 25% has improved grain quality without compromising agronomic parameters such as growth and yield. Between the two fertilisers, urea seems to achieve better results and it is recommended as being also cheaper than UAN. Under the high spring rainfall of 2019, foliar spraying improved significantly nitrogen use efficiency, but similar effects would be expected under drought conditions frequently occurring in the Mediterranean area.

References

Gooding M.J., Davies W.P. 1992. Foliar urea fertilization of cereals: a review. Nutr. Cycl. Agroecosyst, 2: 209-222.

Readman R.J. et al. 2002. Effects of spray application of urea fertilizer at stem extension on winter wheat yield. J. Agr. Sci, 139:1-10.

Woolfolk C.W. et al. 2002. Influence of late-season foliar nitrogen applications on yield and grain nitrogen in winter wheat, Agron. J, 94: 429-434.

Ransom J. et al. 2016. Effect of a post-anthesis foliar application of nitrogen on grain protein and milling and baking quality of spring wheat. Am. J. Plant Sci., 7: 2505-2514.