Interactive effects of drought and N stress on wheat and canola growth

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Abstract

A comparative study of the growth of wheat and canola under varying levels of N and soil moisture was carried out in pots under a rain-shelter, during vegetative and early reproductive stages. The crops had a different response to the combination of water and N levels. In canola, N fertilisation partially relieved the loss of production due to drought. In wheat at high N supply, restoring water availability after drought increased growth beyond the irrigated control. The reasons for these differences are discussed in relation to root:shoot ratio, leaf area, leaf gas exchange and stress timing.

Key Words

Drought, nitrogen, canola, wheat

Introduction

Water and nitrogen (N) deficits cause major yield losses in rainfed wheat and canola crops. However, while there is considerable understanding about their individual effects on crop growth (e.g. 1), there is limited information on how a crop copes with multiple stresses or cycles of stresses. As a consequence, recommendations such as to add more N fertiliser to canola than wheat in order to maximise yields under rainfed conditions (2) are difficult to interpret. The objective of this work was to do a comparative study of the growth of wheat and canola under limiting levels of both N and water, with emphasis on the vegetative and early reproductive phases of the crop.

Methods

Spring wheat (*Triticum aestivum* L., var. Pegaso) and spring canola (*Brassica napus* L., var. Topaz) were grown in 10 L pots under an automatic rain shelter in Buenos Aires, Argentina. Pots were grouped in small plots simulating a canopy. Treatments resulted from the factorial combination of crop species, N addition and irrigation levels. Treatments were arranged in a completely randomised block design with three replications. N was added as NH_4NO_3 at 10.0 (High N) or 0 (Low N) g N m^{-2} to a sandy loam soil containing 3 g mineral N m^{-2}. The pots were irrigated to either 90-100% field capacity (irrigated control, I), with 50% of the water consumed by the irrigated control (drought, D) after 25 days after emergence (DAE) or re-watered to 90-100% field capacity since 53 DAE (R). N was added in the irrigation water, split in three additions during vegetative growth to prevent depletion effects. Macronutrients other than N and micronutrients were supplied in non-limiting amounts and weeds, pests and diseases controlled as required. The pots were covered with a layer of polyethylene granules to reduce soil evaporation. The response was measured in terms of biomass, leaf area, N uptake, water consumption and leaf gas exchange. Crop phenology was described with decimal codes (DC) for wheat (3) and oilseed rape (4). Harvests were carried out at 53, 68 and 82 DAE, corresponding to tillering (DC22-25), two-three nodes elongated (DC32-33) and heading (DC59) in wheat and beginning of stem elongation (DC2.02), first flower fully open (DC41) and lower pods longer than 2 cm (DC51) in canola. Leaf gas exchange was measured prior to harvesting and also at 61 DAE.

Results

Biomass and leaf area were significantly reduced by low N and water supplies. Individually or jointly, drought and N deficiency reduced the growth of canola more than that of wheat, except under limited water but high N supply (Fig. 1, Table 1). High N partially alleviated the loss of production due to drought in both crops, but the effects were only significant in canola (Table 1). Rewatering after 53 DAE had a major impact on wheat regrowth at high N supply relative to the control (Fig. 1), whereas in canola, the effect of re-watering on growth was independent of the N level. Among the reasons for the responsiveness of wheat to rewatering under high N were its plasticity to reduce the root:shoot ratio, 37% for I and 27% for R at 68 DAE, and its capacity to expand leaf area to the level of the controls (data not shown). In canola, rewatering at the beginning of stem elongation had a small effect on leaf area index because of the more advanced phenological stage of the crop and the limited impact on individual leaves expansion rates (data not shown). A fortnight after resuming irrigation (68 DAE) wheat leaf photosynthesis at high N was higher than in the irrigated treatment (Fig. 2). In canola, rewatering increased leaf photosynthesis rates beyond the control only at low N (Fig. 2). Considering all measurements, canola had lower transpirational water use efficiency than wheat (data not shown).

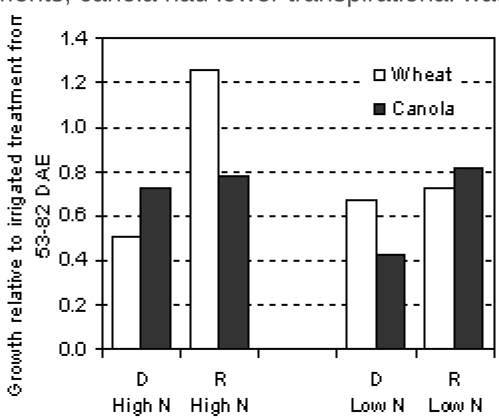
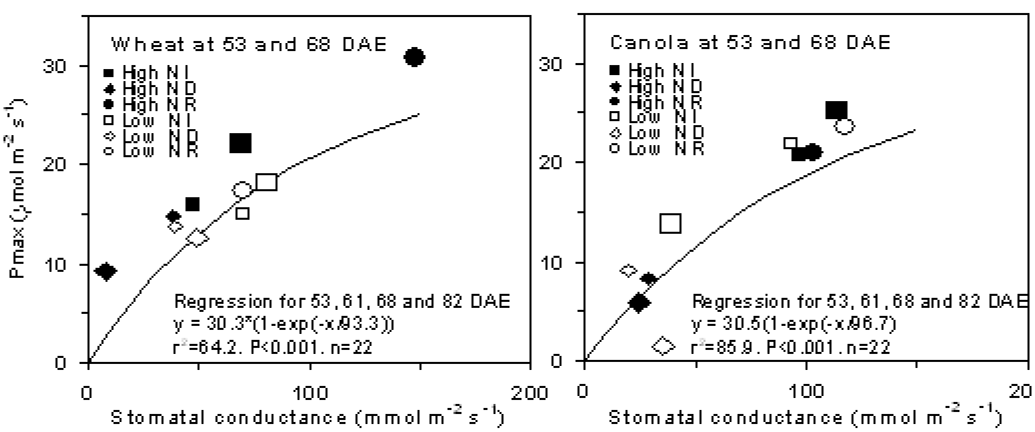


Figure 1 and Table 1. Changes in growth from 53 to 82 days after emergence under drought (D) or rewatered (R) at different N levels relative to the irrigated control (I) (Figure) and absolute values (Table).

	Growth rate ($g\ m^{-2}\ d^{-1}$)					
	Low N			High N		
Wheat	**I**	**D**	**R**	**I**	**D**	**R**
	10.5	6.8	7.4	14.9	7.6	18.7
Canola	6.1	2.6	4.8	13.6	9.7	10.6
LSD(P=0.05) across comparisons		2.4				

Figure 2: Photosynthesis at light saturation (Pmax) vs. stomatal conductance at two measurement dates, i.e. 53 (small symbols) and 68 DAE (big symbols). Regression lines were calculated including all measurement dates, i.e 53, 61,68 and 82 DAE.



Conclusion

High N contributed to increase growth under limited water supply in canola, probably associated with a delay in leaf N mobilisation and senescence, which are usually accelerated in canola crops under drought. In wheat, an improvement in water availability during tillering boosted growth beyond the irrigated control under high N supply. Higher leaf photosynthesis levels and leaf area growth were associated with this phenomenon. These results highlight the need to finetune N fertilisation differently in both crops in order to optimise growth in seasons with contrasting water availability.

References

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