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Wheat and Barley Floret Development in Response to Nitrogen and Water Availability

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Introduction

Wheat and barley yields are quite variable under Mediterranean environments mainly due to the erratic rainfall regime. Part of the interannual variation could be managed with nitrogen (N)[1]. In addition, water use efficiency is largely affected by N management. That is why water and N are the two dominant factors controlling cereal yield in Mediterranean conditions. Most of the yield responses to water x N is related to differences in the number of grains m^{-2}. Understanding the physiological bases of grain number responses to these two factors would allow a better understanding of yield determination in Mediterranean agrosystems. Analyses of crop developmental features[3] and responsiveness to radiation and photoperiod[2] affecting grains m^{-2} showed that the outcome is a consequence of the process of floret primordia initiation followed by a strong mortality phase in which a small proportion of the maximum number of primordia initiated survive to produce fertile florets (which then become grains).To the best of our knowledge, no evidences have been provided on whether yield responsiveness to N and water is linked to the fate of floret primordia to produce fertile florets. This study aimed to clarify the main yield responsiveness to N under different water regimes is linked to the fate of floret primordia to produce fertile florets.

Methodology

Cereals were grown in micro-crops in large containers (1 m height x 1 m^2 surface) filled with a sand:soil mixture at the University of Lleida (41º35´S, 58º29´W) during two growing seasons. Treatments consisted in the factorial combination of (i) two species (durum wheat, cv. Claudio, and barley, cv. Sunrise), (ii) two levels of N, an unfertilized control (N-) and a treatment fertilized (N+) [$100_{(2006\text{-}07)}$ or $250_{(2007\text{-}08)}$ kgN ha^{-1}] and (iii) two levels of water availability (irrigated and rainfed).
Aboveground and soil samples were taken in jointing (DC 31); anthesis (DC 65) and maturity (DC 95). Floral development was measured in all florets of two basal, two central and two apical spikelets corresponding to a main-shoot spike throughout the stem elongation phase following a quantitative scale of spike development[4]. Data of floret development stage were regressed against thermal time and rates of floret development (Waddington units per degree day) were estimated for each treatment and experimental condition. For simplicity, in this presentation a linear relationship between developmental scores of floret primordial and thermal time was assumed (and thus in this presentation rates of floret development integrates environmental effects on both actual rates and effective duration of development progress). Due to higher-than-expected rainfall in the pre-anthesis phase of the first experimental year, for this experiment treatments were reduced to the combination of genotypes and N levels.

Results

Nitrogen increased the number of fertile florets, although the pattern of spikelets in which the increased number of fertile florets took place varied with the experimental condition. While in the first experiment the improvement was evident in the extreme spikelets and not in the central ones, in the following year the number of fertile florets increased mainly in the central spikelets (see Fig. 1). Whether this is a consequence of the particular conditions of the years or a consequence of structural differences between the spikes of both years remains to be determined. The greater number of fertile florets in spikelets analyzed was also variable with the environment where the effect of the N was evaluated: in 2006-07, higher N availability accelerated the initiation of floral primordia and reached a greater maximum number of primordia spikelet^{-1} that determined a higher number of fertile florets *a posteriori*, whereas in 2007-08, irrigated and rainfed treatments respectively, the maximum number was independent of N that affected the survival of floret primordia to produce fertile florets (Fig. 1).

The rate of floral development in wheat was greater in all environments for central than for any of the extreme spikelets. The increased number of fertile florets at anthesis produced by N in all the three conditions (Fig. 1) was related to an effect of this factor on the rate of floret development, particularly for the floret positions in which the final number of fertile florets was defined in each of the spikelets considered (Table 1). The effect was not clear in the unique floret of barley spikelets.

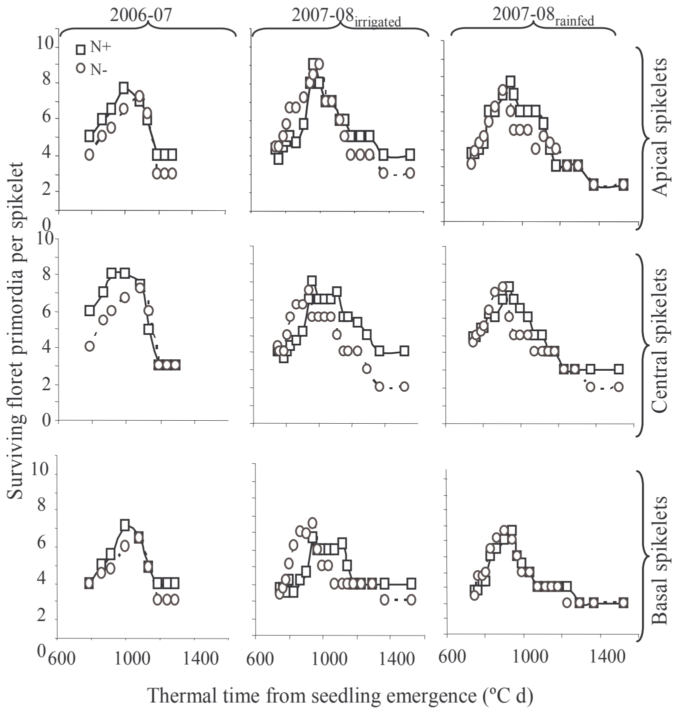

Fig. 1. N effect on the developmental dynamics of floret primordia (those that continue developing from their initiation to athesis) in each of the three experimental conditions and for each of the three spikelet categories considered

Table 1. N effect on the developmental rate of selected florets of wheat and barley in each of the three conditions and for each of the three spikelet categories considered

		Wheat				Barley
Basal		**Floret 1**	**Floret 2**	**Floret 3**	**Floret 4**	
2006-07	*N-*	1.46 ± 0.09	1.65 ± 0.09	1.58 ± 0.12		1.91 ± 0.03
	N+	1.45 ± 0.12	1.56 ± 0.10	1.76 ± 0.08		2.36 ± 0.13
2007-08 Irrigated	*N-*	1.56 ± 0.06	1.54 ± 0.06	0.99 ± 0.09		1.35 ± 0.10
	N+	1.33 ± 0.07	1.29 ± 0.09	1.29 ± 0.07		1.32± 0.07
2007-08 Rainfed	*N-*	1.74 ± 0.11	1.23 ± 0.12			1.31 ± 0.11
	N+	1.68 ± 0.08	1.72 ± 0.07			1.32 ± 0.09
Central						
2006-07	*N-*	1.41 ± 0.11	1.42 ± 0.07	1.52 ± 0.03		2.03 ± 0.09
	N+	1.45 ± 0.13	1.45 ± 0.09	1.50 ± 0.08		1.91 ± 0.20
2007-08 Irrigated	*N-*	1.41 ± 0.08	1.53 ± 0.07	1.24 ± 0.08	0.87 ± 0.07	1.33 ± 0.10
	N+	1.43 ± 0.08	1.59 ± 0.07	1.49 ± 0.06	1.22 ± 0.06	1.29 ± 0.07
2007-08 Rainfed	*N-*	1.55 ± 0.09	1.66 ± 0.09	1.12 ± 0.12		1.25± 0.11
	N+	1.57 ± 0.06	1.71 ± 0.07	1.61 ± 0.08		1.29 ± 0.10
Apical						
2006-07	*N-*	1.57 ± 0.12	1.62 ± 0.06	1.37 ± 0.09		2.10 ± 0.11
	N+	1.62 ± 0.10	1.68 ± 0.08	1.79 ± 0.13		2.06 ± 0.11
2007-08 Irrigated	*N-*	1.62 ± 0.06	1.40 ± 0.06	0.88 ± 0.08		1.52± 0.13
	N+	1.54 ± 0.06	1.45 ± 0.06	1.08 ± 0.07		1.46 ± 0.09
2007-08 Rainfed	*N-*	1.69 ± 0.11	1.25 ± 0.11			1.50 ± 0.12
	N+	1.61 ± 0.06	1.66 ± 0.09			1.49 ± 0.10

Conclusions

N availability in wheat increased the rate of development of the florets mainly at the distal positions, and thus increased the establishment of additional fertile florets in those spikelets. In Barley the dynamics of tillering might be more relevant than in wheat as determinant of the responses to N.

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