Floret development on spike fertility responses to resource availability in durum wheat cultivars

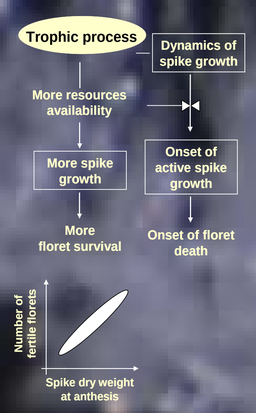
Ariel Ferrante[1], Roxana Savin[1] and Gustavo A. Slafer[1,2]

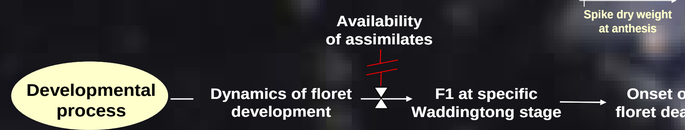
[1]Department of Crop and Forest Sciences, and AGROTECNIO (Centre for Research in Agrotechnology), University of Lleida, Av. Rovira Roure 191, 25198 Lleida, Spain. [2]ICREA (Catalonian Institution for Research and Advanced Studies, Spain). Email: ariel.ferrante@pvcf.udl.cat

optchina
The China - EU Workshop
Barcelona - *September, 2012*

INTRODUCTION

- *Further increasing wheat yield would be more likely if based on an improved understanding of the mechanisms controlling grain number determination. Studying floret generation/degeneration dynamics might be helpful to understand the basis of grain number determination during the active stem elongation phase (critical period in pre-anthesis; Slafer et al., 2005). As during stem elongation florets are developing it would be reasonable to assume that floret development would depend on resource availability (Ferrante et al., 2010) being thus simply a reflection of a trophic process.*
- *In studies by Gonzalez et al. (2003, 2005, 2011) it seemed confirmed that the onset of floret death was coincident with the onset of spike growth. However, there has been debate in the recent literature (Bancal 2008, 2009) on whether the onset of floret death, was triggered by resource allocation or whether it was simple a "pure" developmental process.*





Aim

Determine whether the onset of floret death was related to the developmental stage of the most advance floret (F1) in central spikelets affecting crop growth but not crop development (mainly N fertilisations but also de-tillering and contrasting water regimes).

MATERIALS AND METHODS

Table 1. Experimental details including factorial combination of N x G (Experiment 1); cultivars (Experiments 2 and 3), and G x W x N (Experiment 4) in large containers (experiments 1 and 4) at Lleida or under field conditions (experiments 2 and 3) at Gimenells (NE Spain). Bold type indicates treatments within an experiment.

Growing season	Experiment	Experimental design	Experimental approaches	Sowing date and density	Experimental treatments: Water regime	N availability: Soil N at sowing (kgN ha^{-1})	N availability: Fertilisation[d] (kgN ha^{-1})	Cultivars
2006-07	1	Completed randomised design (3 replicates)	Crops in large containers outdoors	24 Nov. 06 500 plants m^{-2}	Irrigated[a]	**70**	—	Claudio
						70	**50_{DC21} + 50_{DC31}**	
2007-08	2	Completed randomised design (3 replicates)	Crops in large containers outdoors	14 Nov. 07 300 plants m^{-2}	**Irrigated[a]**	**30**	**20_{DC21}**	Claudio
						30	**73.3_{DC21} + 73.3_{DC23} + 73.3_{DC31}**	
					Rainfed[b]	**30**	**20_{DC21}**	Claudio
						30	**73.3_{DC21} + 73.3_{DC23} + 73.3_{DC31}**	
2008-09	3	Completed randomised design (3 replicates)	Crops in large containers outdoors	28 Nov. 08 300 plants m^{-2}	Irrigated[a]	**20**	**30_{DC21}**	**Claudio Donduro Simeto Vitron**
						20	**76.6_{DC21} + 76.6_{DC23} + 76.6_{DC31}**	**Claudio Donduro Simeto Vitron**
	4	Randomised block design (3 replicates)	Field	24 Nov. 08 300 plants m^{-2}	Rainfed	130	—	**Claudio Donduro Simeto Vitron**
	5	Randomised block design (3 replicates)	Field	12 Dec. 08 300 plants m^{-2}	Irrigated[c]	580	—	**Claudio Donduro Simeto Vitron**
2009-010	6	Completed randomised design (3 replicates)	Crops in large containers outdoors	26 Nov. 09 250 plants m^{-2}	**Irrigated[a]**	**20**	**30_{DC21}**	**Claudio Donduro Simeto Vitron**
						20	**76.6_{DC21} + 76.6_{DC23} + 76.6_{DC31}**	**Claudio Donduro Simeto Vitron**
					Rainfed[b]	**30**	**20_{DC21}**	**Claudio Donduro Simeto Vitron**
						20	**76.6_{DC21} + 76.6_{DC23} + 76.6_{DC31}**	**Claudio Donduro Simeto Vitron**

[a]Periodic irrigations throughout the growing season, from once a week in winter to every second day during grain filling. In each opportunity we irrigated each microcrop until individually water freely drained underneath the container. [b]Watered only once at sowing to warrant germination and emergence, and when the minimal N dosis was applied. [c]With sprinklers at mid-tillering (25 mm), jointing (30 mm), anthesis (60 mm) and mid-grainfilling (15 mm). [d]Fertiliser was applied splitting the dose in two or three equal applications at the onset of tillering (DC 2.1; Zadoks et al., (1974)), at mid-tillering (DC 2.3) and the onset of stem elongation (DC 3.1).

Figure 1. Pictures illustrating different aspects of the preparation and installation of the experiments (microcrops and field conditions) carried out at Lleida, Spain. Seeds were manually placed on precise regular intervals, to maximise uniformity of the stand, on masking tape (a), then these 1 m linear strips were covered with tissue paper and placed in the rows of each experimental unit (b). The consequence of the delicate handling for sowing was achieving experimental units with microcrops almost perfectly uniform (c). Panel (d) shows the general appearance of the experiment with all the experimental units covered with an anti-bird mesh. Field experiments under rainfed (e) or irrigated (f) condition.

Measurements

Floret primordia were considered as in Ferrante et al. (2010).

Onset of floret death and onset of spike growth.

RESULTS

Analysing all data together (differences cultivars, different years) for each condition of resources the number of living florets was standardised by estimating this number as a proportion of the maximum number of floret primordia corresponding to each combination of cultivar x year.

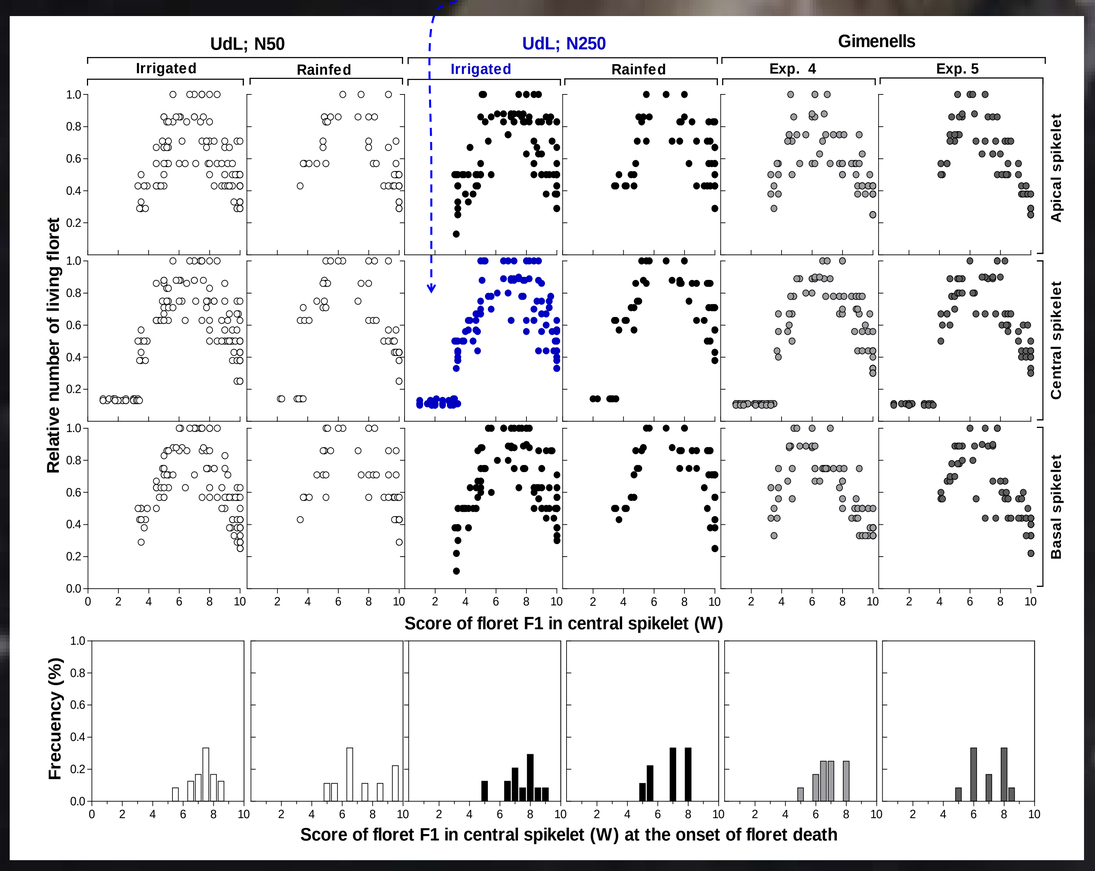


Figure 2. Relationship between the number of living florets for three spikelet position vs the developmental score (Waddington) of the most advance floret (F1) in central spikelet (upper panel). The bottom panels summarises the corresponding panels above them by showing the frequency of F1 developmental stage at which the onset of floret death took place. Symbols and bars represent N50 (open); N250 (closed); Gimenells rainfed (exp. 4, light grey) and Gimenells irrigated (exp. 5, dark grey)

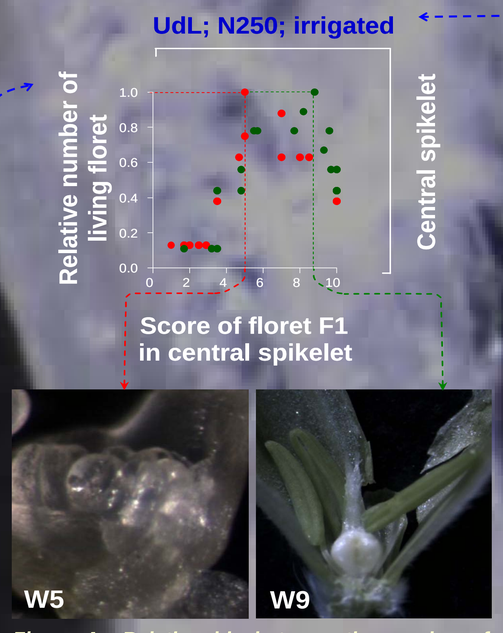


Figure 4. Relationship between the number of living florets for central spikelet position vs the developmental score (Waddington) of the most advance floret (F1) in central spikelet under the most contrasted resources of availabilities, cultivars and growing seasons (upper graph). Pictures illustrating their contrasted developmental scores (W) at the onset of floret death.

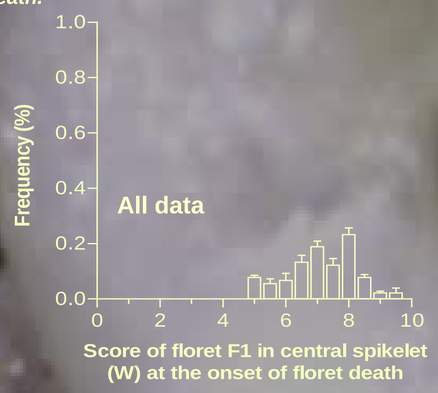


Figure 3. Frequency of developmental scores of the proximal florets (F1) of central spikelets at which floret death started analysing all data. Bars represent standard error.

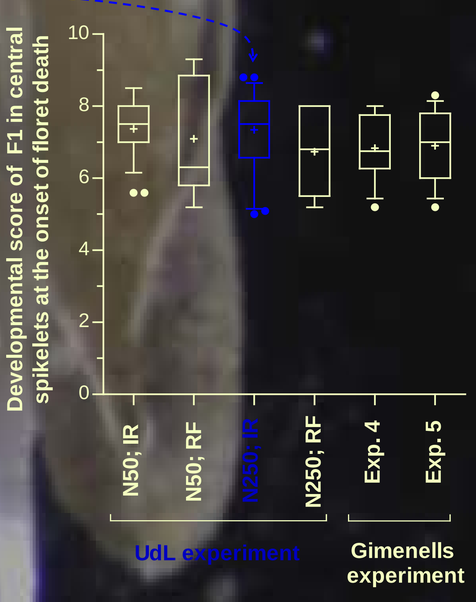


Figure 5. Boxplot of the stages Waddington score of the most advance floret (F1) in central spikelet at the onset of floret death for different treatments throughout years (unfertilised: N50; fertilised: N250; Rainfed: RF and Irrigated: IR). The horizontal line within each box is the median, and the bottom and top of each box represent the 25th and 75th percentiles, respectively. Crosses correspond to the mean. The whiskers represent the 10th and 90th percentiles, respectively and the values outside this range as individual outliers (closed circles).

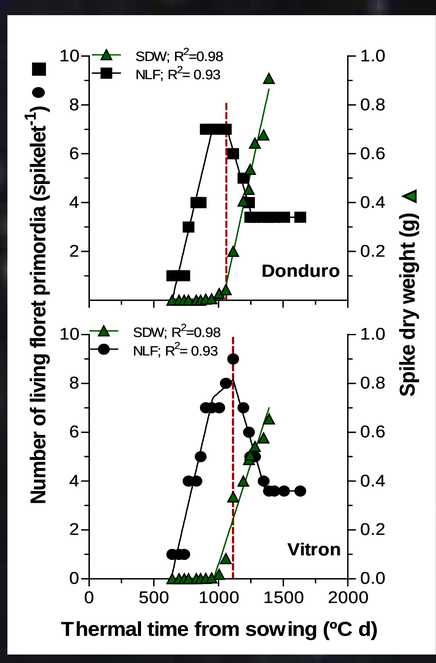


Figure 6. Dynamics of the number of living floret primordia per spiketet and spike dry weight from sowing to anthesis for Donduro and Vitron under the irrigated and N250 treatment in the last growing season (exp. 6). Symbols corresponding to spike dry weight (SDW, green triangles) and number of living floret (NLF, closed circles and squares). Dotted red line showed the onset of floret death.

CONCLUSION

Regardless of the treatments, there was not a clear developmental stage (Waddington score) synchronic with the onset of floret death. The stage of development of the most proximal florets of central spikelets at the timing of the onset of floret death ranged between W6 and W8. In addition, the onset of floret death occurred soon after the onset of rapid dry weight accumulation on the juvenile spike.

References:
- Bancal P. 2008. Positive contribution of stem growth to grain number per spike in wheat. Field Crops Research 105, 27-39.
- Bancal P. 2009. Early development and enlargement of wheat floret primordia suggest a role of partitioning within spike to grain set. Field Crops Research 110, 44-53.
- Ferrante A, Savin R, Slafer GA. 2010. Floret development of durum wheat in response to nitrogen availability. Journal of Experimental Botany 61, 4351-4359.
- González FG, Slafer GA, Miralles DJ. 2003. Floret development and spike growth as affected by photoperiod during stem elongation in wheat. Field Crops Research 81, 29-38.
- González FG, Slafer GA, Miralles DJ. 2005. Floret development and survival in wheat plants exposed to contrasting photoperiod and radiation environments during stem elongation. Functional Plant Biology 32, 189-197.
- González FG, Miralles DJ, Slafer GA. 2011. Wheat floret survival as related to pre-anthesis spike growth. Journal of experimental botany 62, 4889- 4901.
- Slafer GA, Araus JL, Royo C, Garcia del Moral LF: 2005. Promising eco-physiological traits for genetic improvement of cereal yields in Mediterranean environments. Annals of Aplied Biology 146, 61-70.
- Waddington SR, Cartwright PM, Wall PC. 1983. A Quantitative Scale of Spike Initial and Pistil Development in Barley and Wheat. Annual of Botany 51, 119-130.
- Zadoks JC, Chang TT, Konzak CF. 1974. A decimal code for the growth stages of cereals. Weed Research 14: 415-421.

Funding was provided by grant AGL2009 -11964 of the Spanish Ministry of Science and Innovation. A.F. held a FPU scholarship from the Spanish Ministry of Education.