Combined effects of irrigation management and nitrogen fertilization on soft wheat productive responses under Mediterranean conditions

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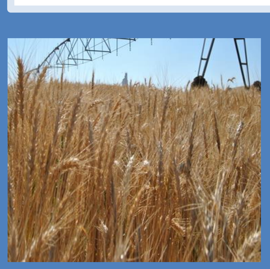
INTRODUCTION

According to EUROSTAT (2018), Portugal contribution for wheat (*Triticum aestivum L.*) production in de EU-28 represents only 0,05% in an area of 0.13%. Thus, Portugal is an importer of common wheat and this situation is difficult to overcome given the less optimal climate conditions and the market fluctuations for farmers to obtain high yields and incomes from this crop. Wheat yield responses to water and nitrogen vary widely among different environments and yield gaps can be shifted due to technological, environmental, or economic factors. Wheat water use depends on cultivar, growth stage, climatic conditions, water availability, soil, and crop management practices (Boteta, 2013). In regions with a Mediterranean-type climate, the balance between the key climate variables and the most critical stages of wheat growth, especially the grain filling stage, implies that the success of the crop depends to a very large degree on the knowledge of proper water management combined with suitable fertilization strategies.

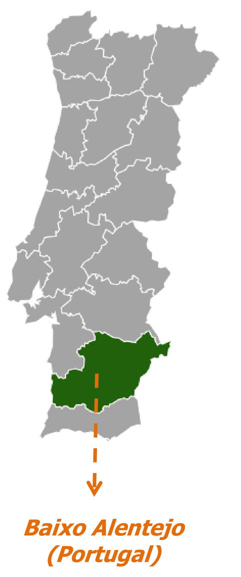
To evaluate water-nitrogen interactions on irrigated wheat production, it is important to know: the dose, the fractioning, and the most recommended period of fertilizers application; the best irrigation volumes and schedules for meeting the crop requirements, ensuring the minimum leaching risks, to obtain the highest yields and quality of the grain, while achieving high water and nitrogen use efficiencies.



AIM

Evaluation of the interactive effect of irrigation and nitrogen (N) fertilization strategies, with conventional and enhanced efficiency N fertilizers, on yield and grain quality parameters of soft wheat (cv. Antequera) irrigated with center-pivot in the Mediterranean region of Baixo Alentejo (South Portugal).

METHODS



Study and site description:

- Trials: two trials were carried out during 2016/2017 in Beja, Baixo Alentejo (Southern Portugal) with the cultivar 'Antequera', a cultivar of improver wheat, used for bread, pastry and flour. Wheat was sown on January 24 and the harvest took place on June 24, 2017.
- Experimental design: two irrigation treatments as main plots and N fertilizer (165 kg N/ ha) splitting and timing of application treatments as subplots, more specifically, six treatments in trial 1, with Enhanced Efficiency fertilizers - stabilized and controlled-release fertilizers - and five treatments in the trial 2, with conventional fertilizers, with three replications. Irrigation treatments were: D1 - 100% of crop evapotranspiration (ETc) throughout the cycle, and D2 - 100% of ETc only at four stages (beginning of stem extension; booting; heading; grain filling).
- Climate: Mediterranean or Temperate with hot and dry summer (Csa, in Köppen classification). The 30-year-long period mean value of annual rainfall and average temperature in the region are 558 mm and 16.9ºC, respectively (IPMA, 2018).
- Soils: predominately Calcic Cambisols.

Meteorological data: recorded in an automatic weather station, belonging to the SAGRA agro-meteorological network support service to farmers in the Alentejo region (COTR, 2016).

Irrigation: performed by center-pivot irrigation: Irrigation dose and opportunity were evaluated using meteorological data and soil water content information registered with capacitance probes. The total irrigation volumes applied during the growth cycle were 2527 m³/ha and 1723 m³/ha, in irrigation treatments D1 and D2, respectively.

Yield, yield components and quality parameters evaluated: number of spikes/m²; 1000-grain weight (g); yield (kg/ha); hectoliter weight (HLW) (kg/hl); grain protein content (GPC) (%).

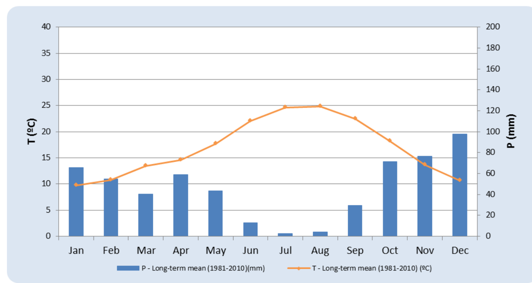
EE N fertilizers

Treatment	% N total				
	Sowing (24-Jan)	Tillering (01-Mar)	Stem extension (25-Mar)	In boot (14-Apr)	Heading (24-Apr)
A1	100				
A2	50			50	
A3	50		25		25
A4	75			25	
A5	75		25		
A6	100				

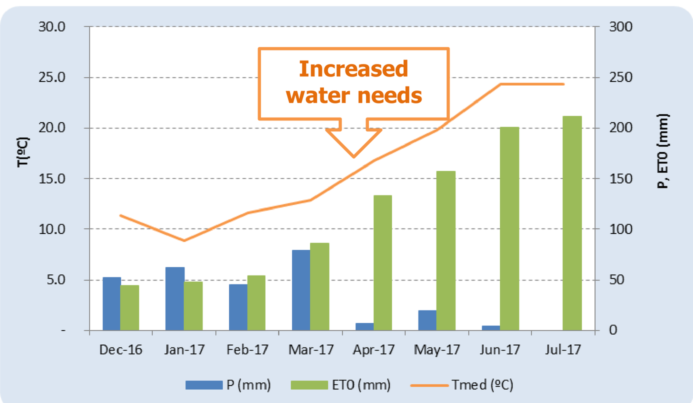
* Controlled release N fertilizer

Conventional N fertilizers

Treatment	% N total				
	Sowing (24-Jan)	Tillering (01-Mar)	Stem extension (25-Mar)	In boot (14-Apr)	Heading (24-Apr)
A1	33	33	33		
A2	25	25	25		25
A3	25	25	25	25	
A4		50		25	25
A5	50		25	25	

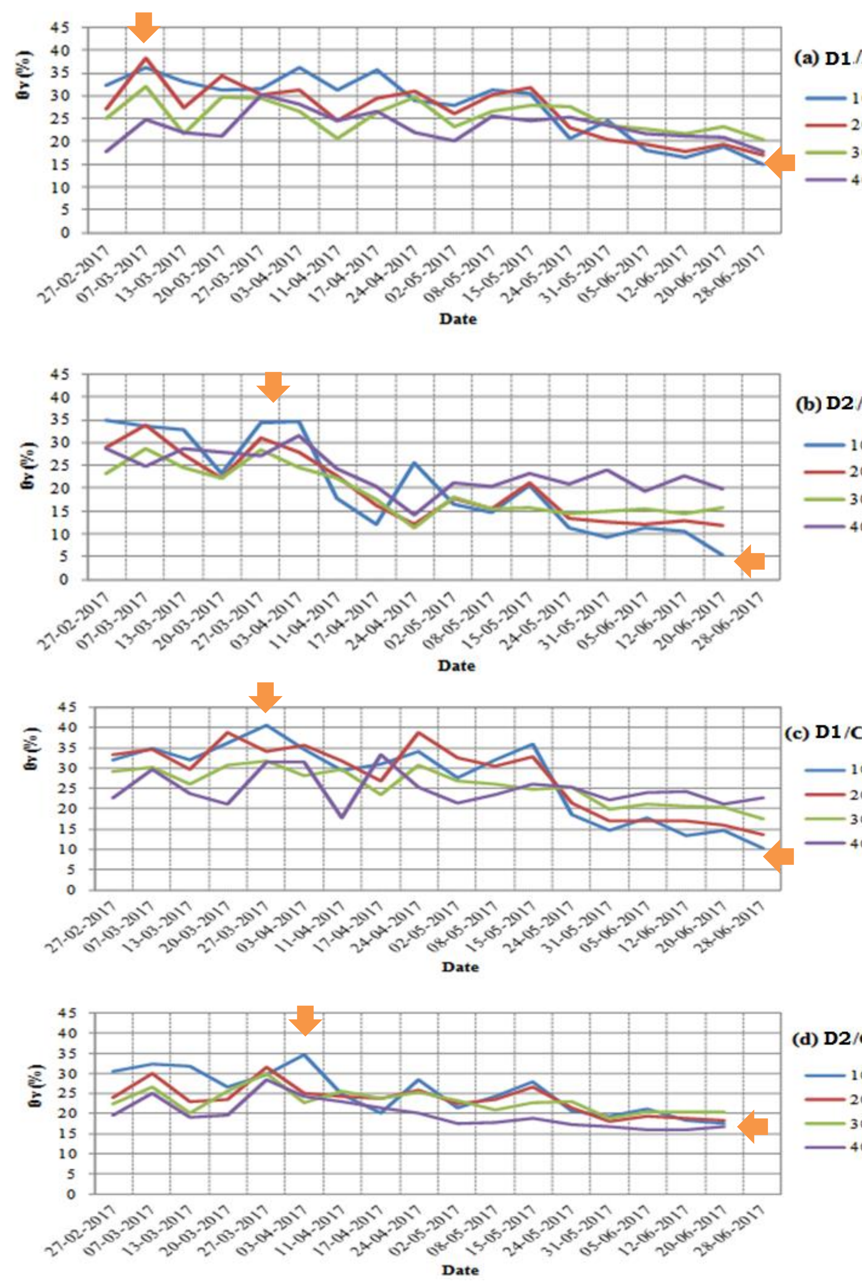


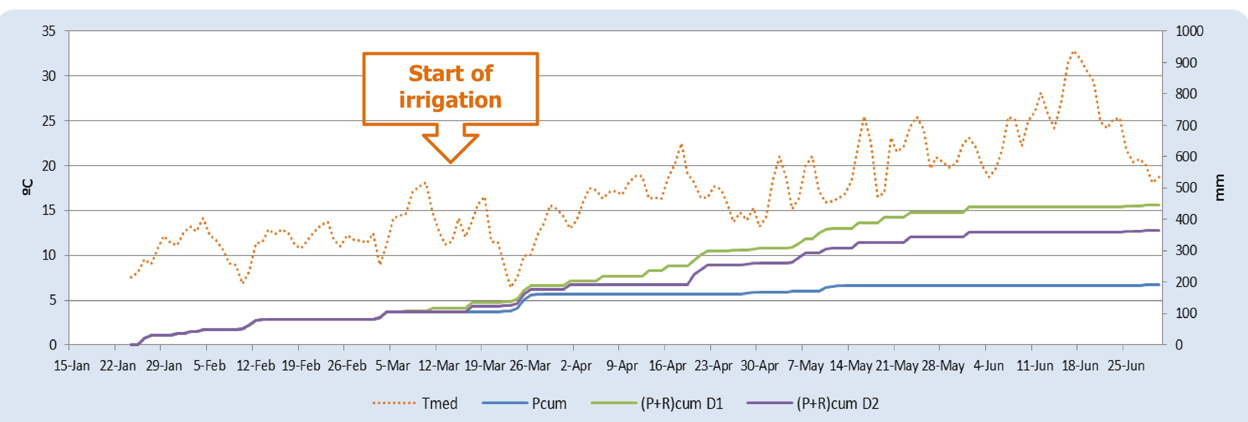
RESULTS



- Given the climatic conditions of 2017, a very dry year, high water requirements were felt from the beginning of March, when the crop was entering the tillering stage.

- D1 treatment: 1st irrigation on March 11.
- D2 treatments: irrigation began on March 17, between the end of the tillering and the start of stem extension.
- Irrigations became more frequent after April, as temperature and evapotranspiration increased. Differences between the two irrigation strategies tested corresponded to the applied volumes and the irrigation schedules: in D1, every time the soil water balance showed an oncoming water deficit, irrigations aimed at the replenishment of the total available soil water, with 2 to 15 days intervals; in D2, following the criterion defined for this strategy, irrigations were carried out every 15-20 days until May. After, given the high water requirements of the crop in the flowering and, mainly, grain filling stages, irrigations were applied weekly. Last irrigation took place on June 1st, in both D1 and D2.





- Maximum soil water content in D2 was lower (35%) then in D1 (38-40%). Maximum values were registered at a 10-20 cm depth in March and beginning of April.
- In general, minimum soil water contents (5-15%) were measured at all depths after the end of irrigation.
- Line patterns show that water extraction occurred at all depths in both irrigation treatments.

Trial 1 (EE N Fertilizers)

Source of variation	No spikes/m²	1000-grains weight (g)	Yield (kg/ha)	HLW(kg/hl)	GPC (%)
Irrigation strategy	*	n.s.	n.s.	n.s.	n.s.
D1	396 a	42.52	4594	80.63	15.61
D2	354 b	40.03	3942	80.52	16.32
Fertilizer sppliting/timing	n.s.	n.s.	*	n.s.	*
A1	335	41.04	4170 ab	80.75	14.71 d
A2	397	42.44	3929 b	79.68	17.38 a
A3	373	40.67	4126 ab	81.05	16.36 b
A4	373	42.14	4458 ab	80.03	16.47 b
A5	400	41.66	4564 a	81.10	15.51 c
A6	371	39.71	4361 ab	80.82	15.36 c
Interaction	n.s.	n.s.	n.s.	n.s.	*

Trial 2 (Conventional N Fertilizers)

Source of variation	No spikes/m²	1000-grains weight (g)	Yield (kg/ha)	HLW(kg/hl)	GPC (%)
Irrigation strategy	n.s.	*	*	n.s.	n.s.
D1	393	41.56 a	5614 a	80.42	16.44
D2	371	39.00 b	3488 b	80.70	16.89
Fertilizer sppliting/timing	n.s.	n.s.	n.s.	n.s.	n.s.
A1	400	40.05	4694	80.55	15.94
A2	390	40.79	4688	80.90	16.94
A3	386	40.99	4686	80.70	17.14
A4	381	38.71	4535	80.47	16.71
A5	354	40.86	4154	80.18	16.57
Interacção	n.s.	n.s.	n.s.	n.s.	n.s.

- Trial 1: only the number of spikes/m² showed significant influence of the irrigation regime, the highest value being registered in the D1 treatment.

  Significant effects of split/time of N fertilizer application occurred. Yield was higher in the A5 treatment, showing that early N applications with this type of fertilizers do not compromise N availability throughout the wheat grow cycle and therefore the grain production; GPC was higher in the A2 treatment, indicating the importance of N availability at the booting stage in order to obtain grains with desirable quality traits.
- Trial 2: significantly higher yields and 1000-grains weights were obtained in the D1 irrigation treatment.

CONCLUSIONS

- **In trial 1, with no significant differences in wheat yield between irrigation treatments, the results may point to a greater efficiency in irrigation water use in the deficit irrigation strategy, D2, suggesting that water applied at the beginning of stem extension, anthesis and grain filling stages is used more efficiently by the crop.**
- **The results indicate that early applications of gradual release fertilizers do not compromise the availability of N throughout the crop cycle and, consequently, the grain yield.**
- **It was also observed that the availability of N in the booting stage is important to obtain higher levels of grain protein.**

ACKNOWLEDGMENTS

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