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Late-Season Irrigation Water Input Reduction in Flooded Rice (WIR)

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Case Study: CS3 – Guadalquivir Marshes, Spain
Best Management Practice: WIR – Late-season Irrigation **W**ater **I**nput **R**eduction

Introduction

Rice cultivation in the Guadalquivir Marshes is based on continuous flooding during most of the crop cycle. Water availability for each irrigation season is defined within the allocation framework established for the irrigated area, while water delivery during the season is managed collectively through the irrigation communities. Within this framework, water deliveries, irrigation schedules and inlet flows are adjusted during the crop cycle according to available water resources and water-quality constraints, particularly salinity, and as a general rule, there is a reduction in water delivery towards the end of the cycle. At field level, inlet and outlet flows are managed to maintain the water layer and the water renewal required to control salinity while covering crop needs.

As the crop progresses through the final stages of grain filling and approaches physiological maturity, crop evapotranspiration and irrigation requirements decrease. This creates an opportunity to further reduce irrigation inflow before the final irrigation cut-off, while maintaining appropriate field-water conditions and water renewal. Late-Season Irrigation Water Input Reduction (WIR) is a field-level water-management strategy based on an additional, controlled reduction in irrigation inflow during the final stages of crop development. The intervention is implemented once the crop has reached the dough grain stage, when grain filling is advanced and crop evapotranspiration and irrigation requirements begin to decline compared with earlier reproductive stages. The reduction is managed while maintaining a continuous water layer across the field and avoiding exposed soil, thus, avoiding rapid declines in water depth and increases in salinity associated with insufficient water renewal. In the saline irrigation conditions of the Guadalquivir Marshes, reducing irrigation inflow can also reduce water renewal and increase the risk of salt accumulation within the field. WIR therefore requires monitoring of crop development, field water depth, salinity, weather conditions and crop status, so that the inflow reduction can be maintained, adjusted or reversed according to the observed field response.

Methodology

The demonstration was carried out in a 6.86-ha commercial rice field at Desmaisières farm, Isla Mayor, in the Guadalquivir Marshes (Seville, Spain). The field was sown with the Japonica cultivar 'Hispasen' on June 9th 2025. Flowering was recorded from August 28th to September 4th, the dough grain stage from September 18th to 26th, and physiological maturity from October 3rd to 9th.

Irrigation delivery during the late season was subject to the operating schedule established by the Mínima Water Users Association, to which the farm belongs. On September 27th 2025, a community-wide reduction in irrigation delivery was applied, followed by a scheduled community-wide irrigation cut on September 30th. Irrigation resumed on October 1st, with the additional field-level reduction corresponding to the WIR intervention already in place. The WIR intervention was therefore implemented after the crop had reached the dough grain stage and within the late-season irrigation

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adjustments already being applied at irrigation-community level. The transition date of September 30th corresponded to 113 days after sowing (DAS 113), while the first day of irrigation under the WIR regime was October 1st (DAS 114).

Field, crop and irrigation conditions were monitored throughout the entire growing season through water-level monitoring upstream of a weir of known geometry at the inlet and outlet of the paddy, water-quality sampling, meteorological records and direct crop observations. During the final crop-development stage, particular attention was given to the variables directly relevant to WIR implementation and assessment, especially the maintenance of continuous and spatially uniform flooding across the field, field water depth, irrigation inflow and outflow, and water electrical conductivity. Electrical conductivity (EC) was also monitored at both the field inlet and outlet, with particular attention to outlet EC as an indicator of salinity conditions and water renewal within the field.

Meteorological conditions were characterised throughout the season using local weather data, including precipitation and reference evapotranspiration (ET_o). Crop evapotranspiration (ETc) was estimated from meteorological data and crop coefficients corresponding to the crop developmental stage. Crop phenology was assessed through direct field observations, with particular attention to flowering, milk grain, dough grain and physiological maturity. These data were considered jointly to interpret field conditions before and after the WIR intervention.

To quantify the additional reduction in irrigation inflow associated with WIR, irrigation delivery after implementation was compared with an equivalent pre-WIR reference period. Two 14-day periods were used: September 16th–29th 2025 as the pre-WIR period and October 1st–14th 2025 as the post-WIR period (Fig 1). The scheduled irrigation cut on September 30th was excluded from both periods. The pre-WIR period includes the community-wide irrigation adjustment introduced on September 27th and therefore represents the irrigation regime immediately preceding WIR within the prevailing late-season management conditions.

Irrigation inflow was normalised by the irrigated area and expressed as mean specific inlet flow (L s^{-1} ha^{-1}):

$$q = \frac{Q}{A}$$

where q is the specific inlet flow (L s^{-1} ha^{-1}), Q is the irrigation inlet flow (L s^{-1}), and A is the irrigated field area (6.86 ha).

The relative reduction in mean specific inlet flow associated with WIR was calculated as:

$$\textbf{Reduction}(\%) = \frac{q_{pre} - q_{post}}{q_{pre}} \times 100$$

where q_{pre} and q_{post} represent the mean specific inlet flow during the 14-day periods immediately before and after WIR implementation, respectively.

Results

To assess the WIR intervention, the 14-day period immediately before implementation (16–29 September 2025) was compared with the corresponding 14-day period after implementation (1–14 October 2025) (Fig. 1). The scheduled irrigation cut on 30 September was excluded from both periods.

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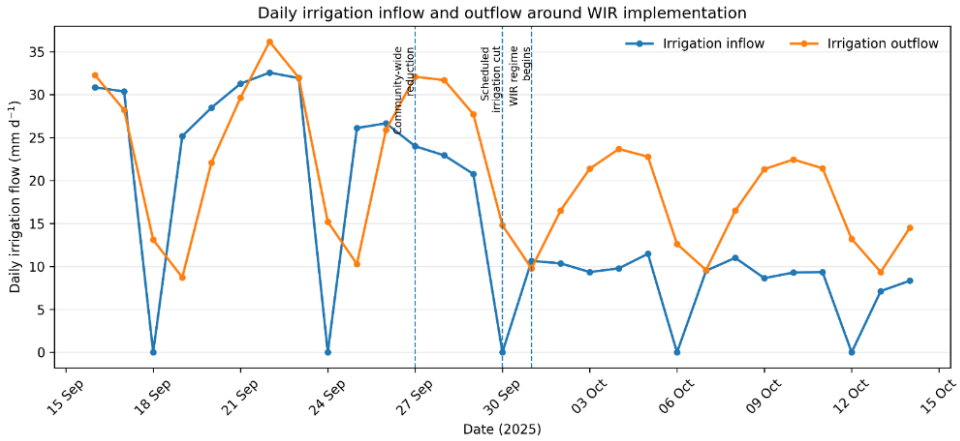


Fig. 1 Daily irrigation inflow and outflow during the periods before and after WIR implementation.

Cumulative irrigation inflow decreased from 331 mm during the pre-WIR period to 115 mm during the post-WIR period, equivalent to 3,311 and 1,148 m³ ha⁻¹, respectively (Fig. 2). This represents an absolute reduction of 216 mm (2,163 m³ ha⁻¹) and a 65% reduction in cumulative irrigation inflow relative to the pre-WIR period. Over the same periods, cumulative irrigation outflow decreased from 345 to 235 mm, equivalent to 3,450 and 2,350 m³ ha⁻¹, respectively.

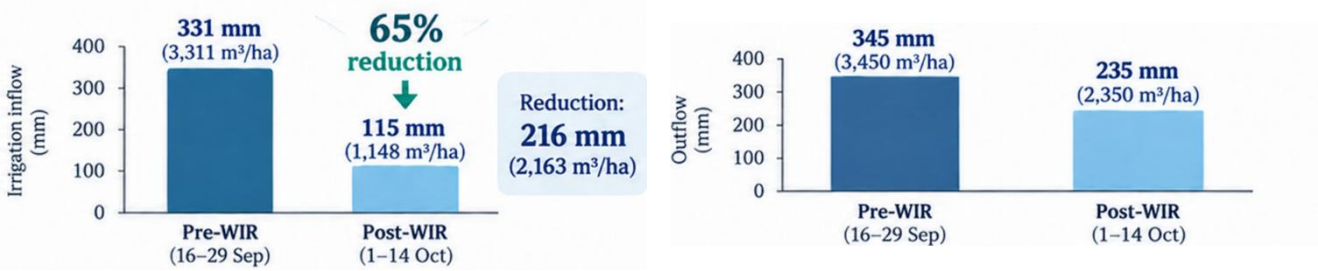


Fig. 2 Cumulative irrigation inflow and outflow

Despite the reduction in irrigation inflow, flooded conditions were maintained in the field. Mean water depth changed from 228mm during the pre-WIR period to 219 mm during the post-WIR period (Fig. 3). The relatively small change in mean water depth, compared with the magnitude of the inflow reduction, indicates that the field remained flooded throughout the monitored post-WIR period.

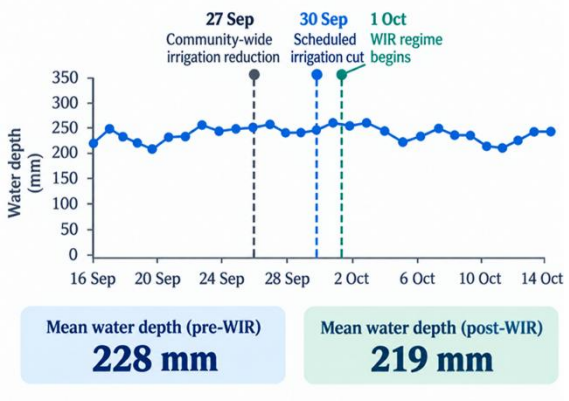


Fig. 3 Flooded conditions – Daily field water depth

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Crop water demand also decreased during the late-season period. Cumulative crop evapotranspiration (ETc) was 66.8 mm during the pre-WIR period and 51.4 mm during the post-WIR period, corresponding to mean daily values of 4.77 and 3.67 mm d^{-1}, respectively (Fig. 4). This reduction was consistent with the progression of the crop towards physiological maturity.

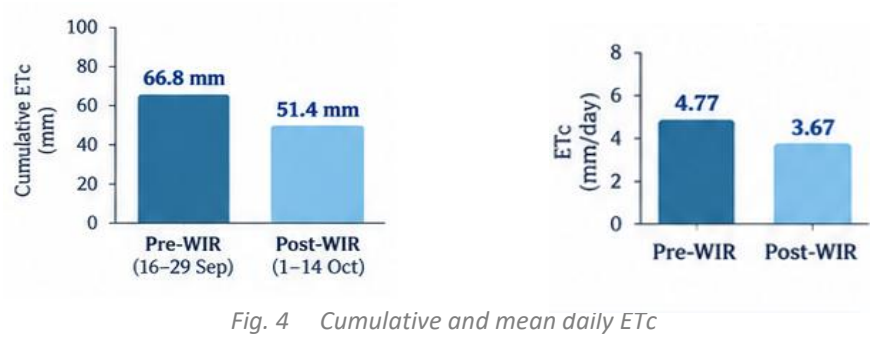


Fig. 4 Cumulative and mean daily ETc

Water-quality monitoring showed changes in salinity at both the field inlet and outlet. Before WIR implementation, on September 17th, EC was 3.19 dS m^{-1} at the inlet and 2.74 dS m^{-1} at the outlet. After implementation, inlet EC was 3.78 dS m^{-1} on October 3rd and 4.91 dS m^{-1} on October 8th, while the corresponding outlet values were 4.81 and 4.58 dS m^{-1}, respectively (Fig. 5). These observations confirm that salinity remained an important management constraint during the late-season period and underline the need to monitor both incoming irrigation-water salinity and outlet-water salinity when inflow is reduced. The available measurements do not allow the observed EC changes to be attributed specifically to WIR, because irrigation-water salinity also varied during the same period.

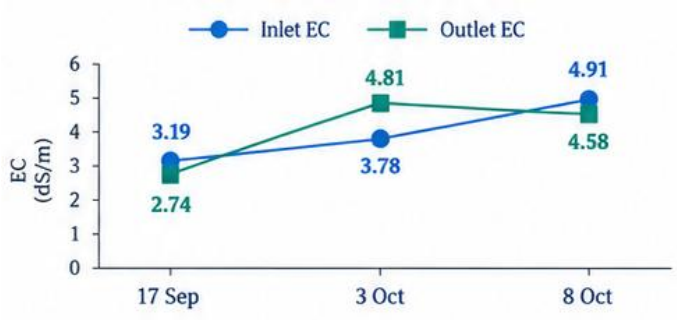


Fig. 5 Electrical Conductivity at inlet and outlet

The field was harvested on November 12th 2025, with a recorded grain yield of 9.52 t ha^{-1} (14% humidity). This value represents the productive outcome of the commercial field in which WIR was implemented and was consistent with the mean yield 9–10 t ha^{-1} range reported for rice crops in Minima Water Users Association (Seville) during the 2025 season.

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Summary table

Indicator	Pre-WIR 16–29 Sep 2025	Post-WIR 1–14 Oct 2025	Change
Cumulative irrigation inflow	331.1 mm	114.8 mm	▽ **65.3%**
	3,311 m^3 ha^{-1}	1,148 m^3 ha^{-1}	▽ **2,163 m^3 ha^{-1}**
Cumulative irrigation outflow	345.0 mm	235.0 mm	▽ **31.9%**
	3,450 m^3 ha^{-1}	2,350 m^3 ha^{-1}	▽ **1,100 m^3 ha^{-1}**
Mean water depth	227.9 mm	219.3 mm	▽ **8.6 mm**
Cumulative ETc	66.8 mm	51.4 mm	▽ **23.1%**
Mean daily ETc	4.77 mm d^{-1}	3.67 mm d^{-1}	

Final remarks

WIR can provide a practical option to reduce irrigation inflow during the final stages of flooded rice cultivation, provided that implementation is based on crop development and supported by field monitoring.

In the 2025 PROMEDRICE demonstration, WIR was implemented after the crop had reached the dough grain stage and within the late-season irrigation adjustments already applied by the irrigation community. Under the conditions tested, cumulative irrigation inflow during the 14-day post-WIR period was 65.3% lower than during the equivalent pre-WIR period, while flooded conditions were maintained throughout the field.

The results also show that implementation cannot be based on inflow reduction alone. Field water depth, crop water demand and salinity must be monitored jointly, particularly in environments such as the Guadalquivir Marshes, where irrigation-water salinity and the need for water renewal can constrain further reductions in water delivery.

The recorded grain yield of 9.52 t ha^{-1} was within the range reported for rice in Seville during the 2025 season. However, the magnitude of the irrigation reduction observed in this demonstration should be interpreted in the context of the specific field, crop-development stage, weather, salinity conditions and irrigation-management framework under which it was obtained.

WIR should therefore be applied as an adaptive late-season management strategy rather than as a fixed irrigation reduction. Its implementation should be adjusted according to field conditions, maintaining continuous flooding and sufficient water renewal to avoid adverse salinity or crop-water effects.

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