Influence of drip irrigation on the mobility and accumulation of Arsenic (As), Cadmium (Cd), and Nickel (Ni) in a commercial hybrid rice variety

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Background

Traditional flooded rice cultivation (Continuous Flooding - CF) is linked to high water consumption and specific soil dynamics that increase the mobility of toxic elements like arsenic (As). Transitioning to aerobic systems, such as drip irrigation (DI), significantly reduces water demand and can minimize the translocation of many potentially toxic elements (PTEs) to the kernel [1,2]. This study, part of the Micro4Life project, evaluated the performance and safety of the hybrid RTH74 FullPage® under these systems.

Objectives

- Compare traditional flooding (CF) with aerobic drip irrigation (DI) under Mediterranean field conditions.
- Quantify water savings and grain yield.
- Evaluate grain food safety with a specific focus on the accumulation of arsenic (As), cadmium (Cd), and nickel (Ni).

Methodology

- Location: Santa Lucia experimental farm, Zeddiani (OR), Sardinia; silty-clay soil.
- Cultivar: commercial hybrid rice RTH74 FullPage®.
- Experimental design: continuous Flooding (CF) - total water use ~14,721 m^3/ha vs Drip Irrigation (DI) - two restoration levels (0.8 and 1.2 ET_0), using between 4,850 and 7,738 m^3/ha water.

Yield and yield components of RTH74 in 2024

Irrigation	Plant height		Yield		HI		Grains		Panicles		Kernels/ Panicles	Grain weight		Grain N		Straw N	
	(cm)		(0% t/ha)				(n°/m2)		(n°/m2)		(n°)	(mg)		(%)		(%)	
P	*<.0001*		*<.0001*		*0.0463*		*<.0001*		*0.0006*		*ns*	*<.0001*		*0.0005*		*0.0046*	
CF	102	A	9.6	B	0.48	A	43860	B	380	B	116	21.9	A	1.2	B	0.8	B
DI *0.8*	90	B	11.3	A	0.46	AB	57539	A	499	A	117	19.4	B	1.4	A	1.0	A
DI *1.2*	93	B	11.7	A	0.45	B	59454	A	463	A	130	19.4	B	1.4	A	0.9	A

Results

- Yield and water productivity: both DI achieved significantly higher grain yields (11.3-11.7 t/ha) compared to CF (9.6 t/ha)
- Water productivity: improved drastically in the DI system, with water savings exceeding 50% compared to traditional flooding

Grain Metal Content & Food Safety

The change in water management drastically affected the accumulation of PTEs in the rice kernels.

PTE concentration in rice grains

Element	Continuous flooding	Drip irrigation (DI 0.8-1.2)	Safety limits (mg/kg) **
As*	0.294 mg/kg (A)	<LOQ (B)	0.1-0.15 (iAs)
Cd	0.044 mg/kg (A)	0.066-0.053 mg/kg (A)	0.15
Ni	2.2 mg/kg (B)	5.6-4.5 mg/kg (A)	1.5

*Determined as total As; the EU limit refers to inorganic As (iAs). **Reg. EU 2023/915 and Reg. EU 2024/1987; for each element, different letters denote significant differences between water management (TK test; $P < 0.05$).

Conclusion

Shifting the cultivation of the RTH74 hybrid rice genotype from CF to DI allowed for water savings of over 50% while producing higher grain yields. Although this change caused the minimization of the As bioaccumulation in kernels, and no statistically meaningful variation of the Cd level, it exacerbated the accumulation of Ni, especially compared to previous literature findings [3]. These results underscore the need for integrated management strategies that balance high-yielding hybrid genotypes, water conservation and food safety, considering the varying mobility of PTEs within the soil profile.

References

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