Comparative adaptive responses of improved and indigenous lowland rice to water management under Nigeria's derived-savannah

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Scheduled vegetative-stage irrigation reduced water input by 14–15% while increasing grain yield per plant by 9–10% and water productivity by 27–29% — in all four varieties tested.

1 Why & how

Why this study

- Water scarcity threatens lowland rice worldwide (Bouman *et al.*, 2007); AWD can cut irrigation water 15–40% while maintaining yield (Bouman and Tuong, 2001).
- AWD responses vary across environments and genotypes (Carrijo *et al.*, 2017). West African studies provide experimental evidence of AWD-related inland-valley productivity (Blango *et al.,* 2019) and spatial evidence of its agroclimatic suitability (Akpoti *et al.*, 2021), but genotype-specific physiological evidence remains limited for Nigeria's derived-savannah lowlands.

Why varietal information matters

Improved and local varieties occupied 68.7% and 31.3% of rice area, respectively; improved-variety adoption is associated with 452 kg ha^{-1} more grain (Saka and Lawal, 2005; Bello *et al.*, 2021).

Research question

Do improved varieties and the Ofada landrace differ in yield, water productivity and physiological responses to scheduled vegetative-stage intermittent irrigation?

Objectives

- Quantify irrigation water savings under AWD.
- Compare chlorophyll and root-volume responses among the four varieties.
- Evaluate yield and water productivity; characterise developmental variation in growth response.

Experimental design

Pot experiment, hydromorphic inland-valley soil, FUNAAB. 4 varieties × 2 water regimes × 5 seedling ages (at transplanting) × 3 reps × 2 runs = 240 treatment-replicate series; up to 960 physical pots across sequential destructive harvests. Improved: ARICA 3, NERICA® L-19, WITA 4. Landrace: Ofada.

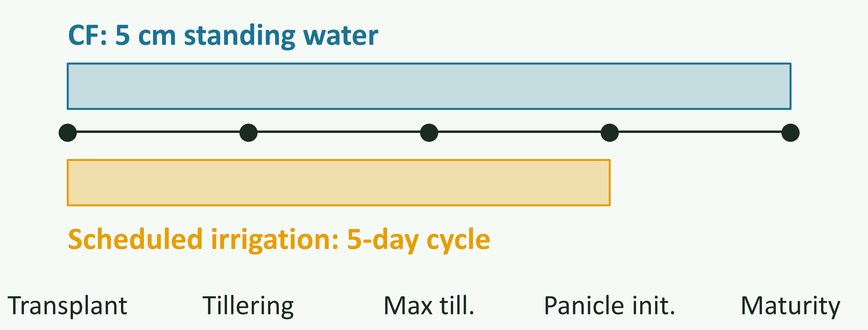

Figure 1: Irrigation schedule across rice growth stages.

How we analysed the data

- REML mixed models included variety, water regime, seedling age and their interactions as fixed effects, run as a blocking term, and replicate series as a random effect.
- Pre-specified AWD–CF contrasts within each variety (Figs 2–4) were multiplicity-adjusted (Holm); results are consistent with the full mixed-model interaction tests reported in each caption.
- Error bars = ±1 SE (95% CI in Figs 2–4) throughout.

***Plate 1:** Inspection of potted upland rice plants at tillering stage in the screenhouse*

Sample structure: n=240 treatment-replicate series (variety×age×water×rep×run). Each series comprised up to 4 stage-specific pots, with one pot destructively harvested at each sampling stage, up to 960 physical pots in total. Grain yield and final-stage traits share the harvest-maturity pot; earlier-stage traits use separate pots carrying the same series label.

Pooling across seedling age: justified for yield, water use, water productivity, root volume and growth rate (three-way interaction ns, P>0.15). NOT justified for chlorophyll (variety×water×age P=0.031), see age-specific breakdown, Figure 5b.

2 Primary evidence

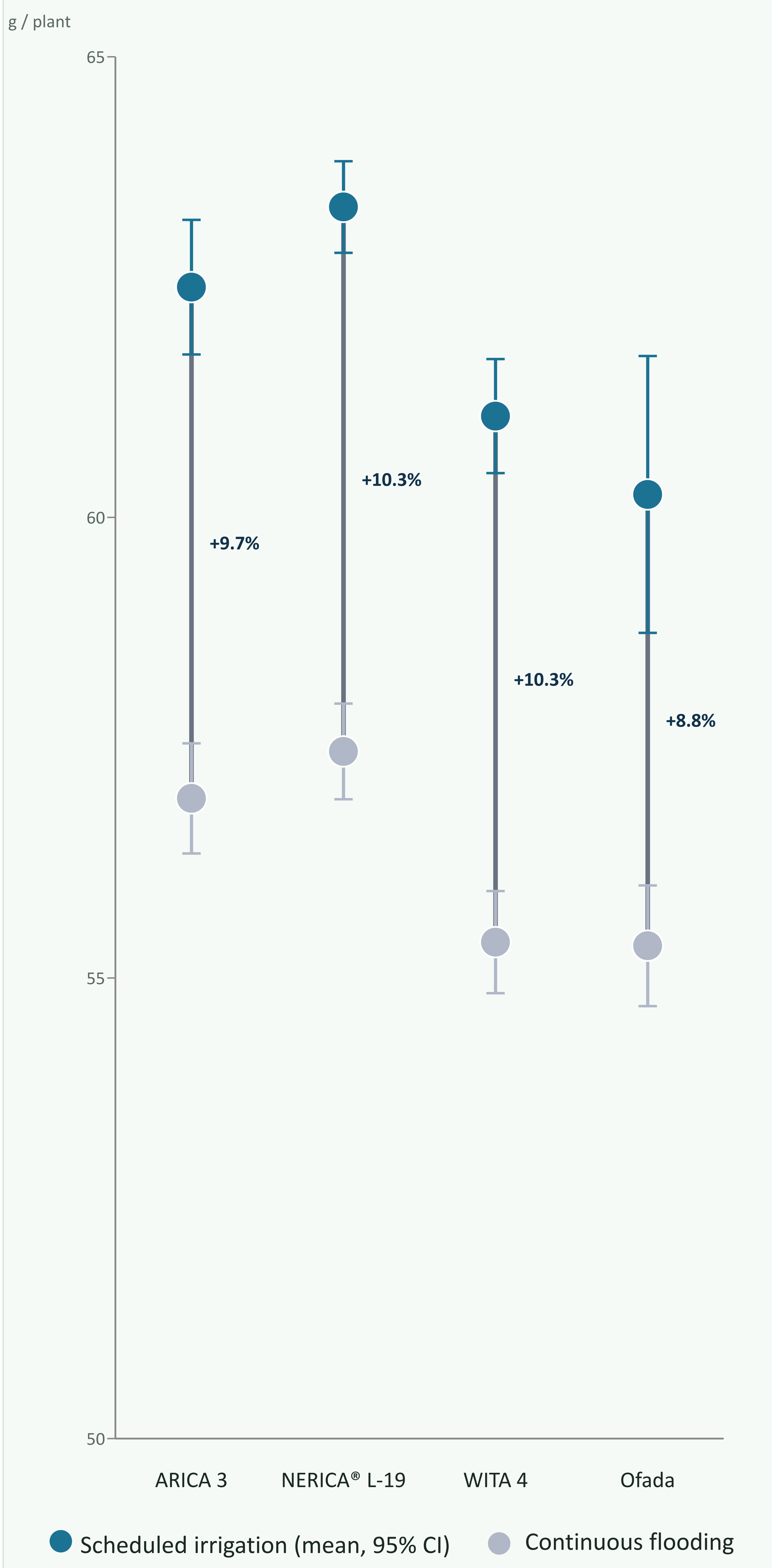

Figure 2: Grain yield of four lowland rice varieties under two water regimes.
Points are mean ± 95% CI (n=30/cell). Axis restricted to show treatment differences.

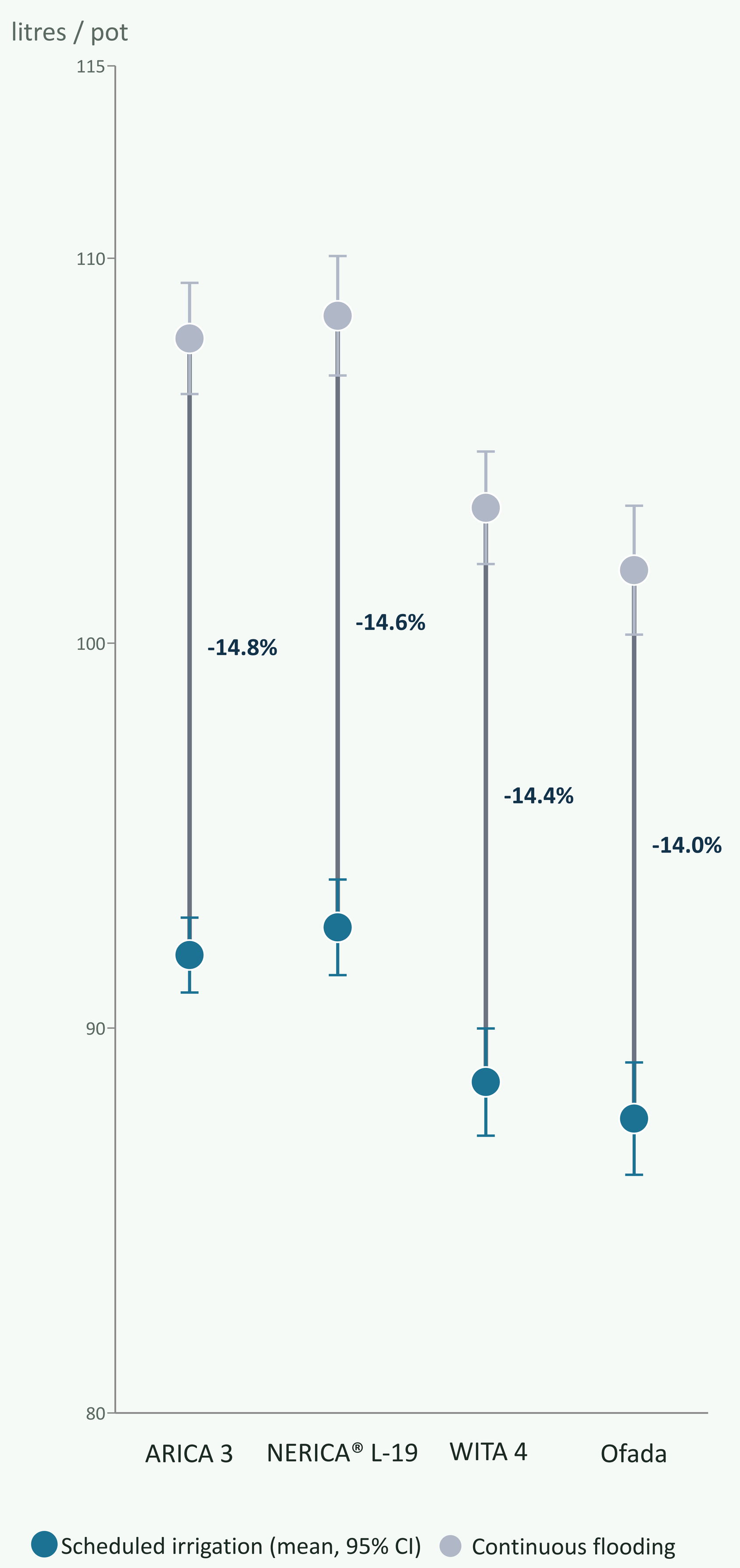

Figure 3: Total irrigation water applied under two water regime.
Points are mean ± 95% CI. Irrigation water applied fell 14–15% under AWD in all four varieties.

3 Efficiency & mechanism

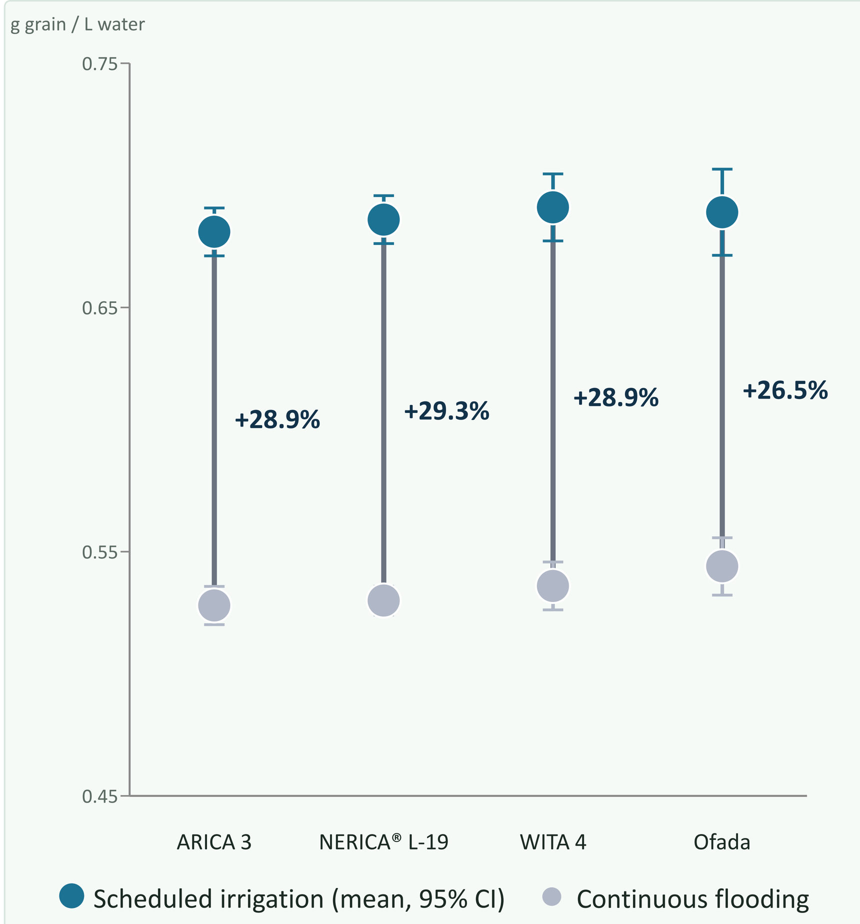

Figure 4: Water productivity of four lowland rice varieties under two water regimes.
Points are mean ± 95% CI. Water productivity (grain yield ÷ water applied) rose 27–29% under AWD in all four varieties.

	Chlorophyll	Root volume	Growth rate*
ARICA 3	-8.0% **	-26.3% ns	+45.2% **
NERICA® L-19	+1.8% ns	-22.3% ns	+37.7% *
WITA 4	+2.9% ns	+9.2% ns	+7.6% ns
Ofada	-3.7% ns	+10.0% ns	+32.2% **

Increase · ns · Decrease

Figure 5a: Physiological responses to intermittent irrigation at flowering.
Colours indicate response direction, not agronomic desirability; ns = nonsignificant.

***Chlorophyll:** V×W P=0.002; V×W×age P=0.031 (Fig. 5b). **Root volume:** P=0.061 (ns). **Growth rate*:** P=0.015. Welch, Holm-adjusted, n=30. *till.→flowering.*

Chlorophyll and growth-rate responses differed significantly among varieties; evidence for root-volume differences was inconclusive.

	9 DAE	12 DAE	15 DAE	18 DAE	21 DAE
ARICA 3	-12.7%	-1.3%	-16.3%	-2.8%	-6.0%
NERICA® L-19	+2.7%	-2.0%	+9.6%	-6.2%	+6.2%
WITA 4	+4.7%	-2.1%	+2.8%	+0.2%	+9.3%
Ofada	-7.5%	-16.1%	+0.4%	+1.4%	+3.2%

Figure 5b: Chlorophyll response to irrigation by variety × seedling age

Descriptive cell responses (n=6/cell, not individually tested) illustrating the significant V×W×age interaction, the pattern is not consistent across ages or varieties.

***Plate 2:** General view of the screenhouse pot experiment showing rice plants at tillering, with field assistant attending to the pots.*

4 Timing & synthesis

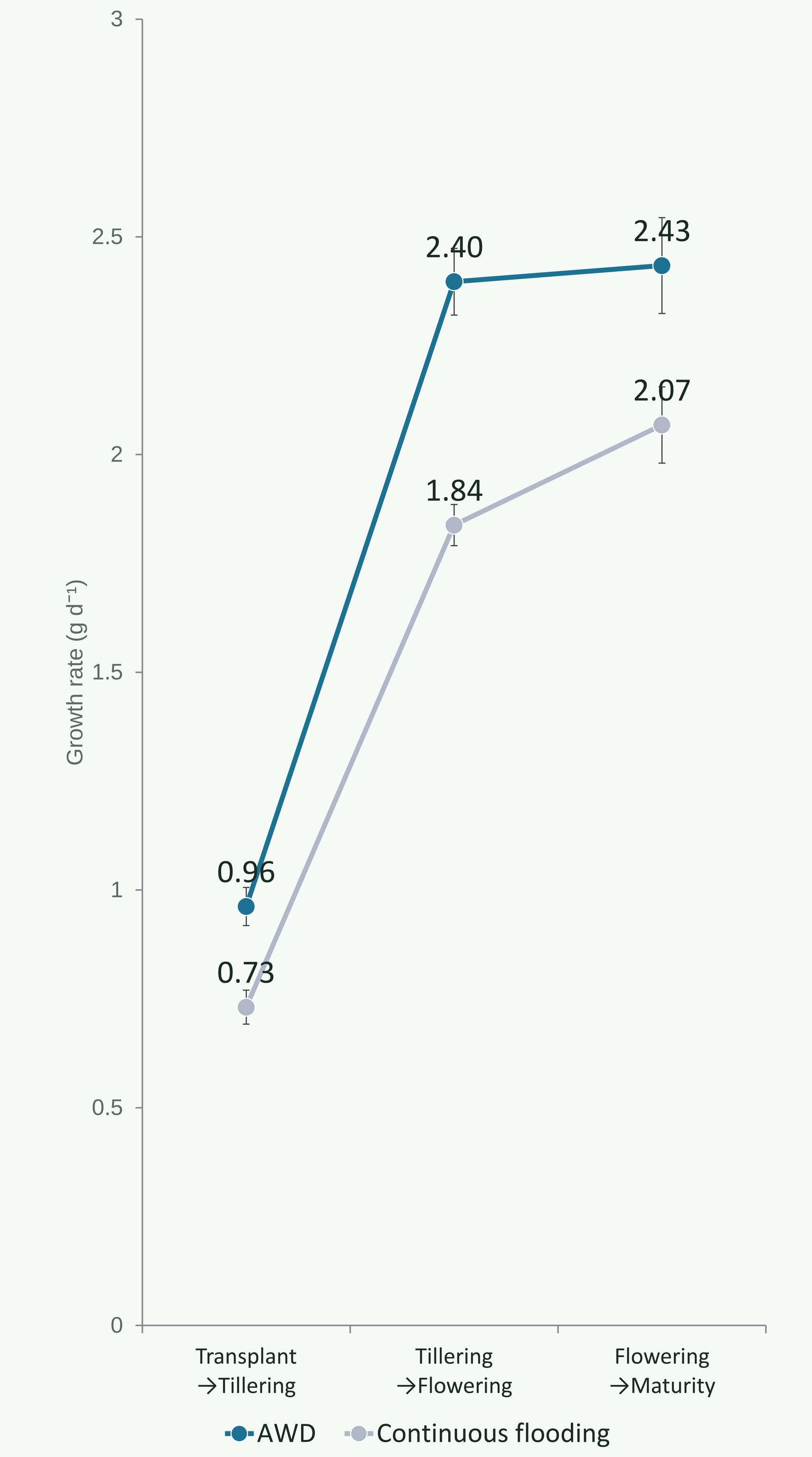

Figure 6: Interval growth rates under intermittent irrigation and continuous flooding.
AWD produced its largest numerical growth-rate gain between tillering and flowering.

Evidence → action

Evidence	Implication
14–15% less water	Field-test scheduled intermittent irrigation, monitored soil-water status
9–10% higher grain yield per plant	Validate across seasons, soils and field environments
27–29% higher water productivity	Include grain-per-water indicators in field/extension trials

Conclusion

Under controlled pot conditions, scheduled vegetative-stage intermittent irrigation reduced irrigation input and increased yield and water productivity across all four varieties tested, including Ofada, with no variety-specific penalty. **Field validation across seasons and soils is the next step.**

Limitations

- Controlled pot conditions; scheduled (not threshold-triggered) irrigation.
- Findings for Ofada should not be generalised to indigenous rice broadly.

References

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