AGRONOMIC PERFORMANCE, MORPHOLOGICAL PLASTICITY AND YIELD DYNAMICS OF CUCUMBER (*CUCUMIS SATIVUS* L.) CULTIVARS UNDER DEFICIT DRIP IRRIGATION IN A SAVANNA AGRO-ECOSYSTEM

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ABSTRACT

Efficient water management is essential for sustaining cucumber production where dry-season moisture scarcity and rainfall variability constrain vegetable productivity. This study evaluated the effects of deficit drip irrigation (DI) on vegetative growth, root length and fruit yield of three cucumber (Cucumis sativus L.) cultivars grown in sacks at Makurdi, Nigeria, during the 2024 dry season. A 5 × 3 factorial experiment was laid out as a split-plot in a randomized complete block design with three replications (45 experimental units). Main plots comprised five irrigation regimes, defined as reductions in irrigation volume relative to full irrigation and scheduled from Class A pan evaporation with plant–pan coefficients of 1.0 (0% DI, control), 0.8 (20% DI, T1), 0.6 (40% DI, T2), 0.4 (60% DI, T3) and 0.2 (80% DI, T4). Sub-plots comprised the cultivars Greengo (R1), Wonalisa (R2) and Marketmore (R3). Data were analysed by analysis of variance appropriate to the split-plot design, and means were separated using Duncan's Multiple Range Test at $P \leq 0.05$. Deficit irrigation significantly ($P < 0.05$) reduced leaf number, plant height and root length, whereas leaf area declined significantly only under 80% DI; the responses were non-linear, with the lowest plant height and leaf number at 40% DI. Cultivar significantly affected fruit yield ($P < 0.01$), but the irrigation × cultivar interaction was not significant. Among the deficit treatments, 20% DI combined with Marketmore gave the highest yield (5.46 kg/m²; 21 fruits/sack), equivalent to 96.5% of fully irrigated Marketmore (5.66 kg/m²), whereas 60% DI combined with Greengo gave the lowest yield (1.70 kg/m²). The 20% DI regime received 1,600 mm of water against 1,800 mm for the control (11% less) and averaged 5.09 kg/m² against 4.85 kg/m². Marketmore gave the highest yield at every irrigation level; however, because the interaction was not significant, its greater tolerance of deficit irrigation is indicative rather than confirmed.

Keywords: *Cucumis sativus*; deficit irrigation; crop morphology; water stress; smallholder drip system; Guinea Savanna; sack gardening

1.0 INTRODUCTION

Cucumber (*Cucumis sativus* L.) is an important vegetable crop cultivated widely for its nutritional, economic and commercial value, and continued genetic improvement of hybrid cultivars has expanded its adaptability across diverse production environments (Pradeepkumara *et al.*, 2025). Its relatively short production cycle of 55–70 days makes it suitable for intensive and peri-urban vegetable production, including irrigated cultivation during periods of inadequate rainfall. However, cucumber is highly sensitive to soil-water deficit because rapid canopy development, leaf expansion and fruit production require adequate and continuous water

availability throughout the growing cycle. Water scarcity can therefore constrain cucumber productivity substantially, particularly in savanna environments where dry-season cultivation depends largely on irrigation. Increasing pressure on water resources has created a need for irrigation practices that improve water productivity without causing unacceptable reductions in crop yield (Rosa, 2022). This pressure is especially acute in West Africa, where erratic rainfall, rising temperatures and expanding urban demand for water are intensifying competition for irrigation water in peri-urban production systems (Frimpong *et al.*, 2023). Deficit irrigation (DI), which involves deliberately supplying less water than the crop requires under full evapotranspiration, is increasingly considered a viable water-saving strategy for vegetable production (Champaneri *et al.*, 2024; Suna *et al.*, 2023). Champaneri *et al.* (2024) emphasized that the effectiveness of the technique depends heavily on the severity and timing of water restriction relative to crop growth stage, as well as on crop and cultivar characteristics, soil texture and climate.

In cucumber, severe water deficits have been reported to reduce leaf area, photosynthetic activity, biomass accumulation and fruit yield, whereas a moderate deficit of about 80% of crop evapotranspiration (ETc) maintained growth and yield comparable with full irrigation (Parkash *et al.*, 2021a). Water stress also alters the coupling between stomatal conductance and photosynthesis (Asargew *et al.*, 2024). In West Texas, a moderate deficit requiring roughly 20–25% less water than full irrigation produced only a modest yield penalty while substantially improving water productivity, whereas severe deficits caused disproportionate declines in leaf area index, dry biomass, chlorophyll content and stomatal conductance (Kafle *et al.*, 2025). Complementary results from the same West Texas trials showed that deficit irrigation reshaped root distribution and reduced soil-water depletion in a way that improved water productivity without a proportional yield penalty (Kafle *et al.*, 2026). Together, these findings indicate that the response of cucumber to water restriction is not simply linear.

The response of cucumber to water deficit is also cultivar-dependent. Differences among cultivars in canopy development, root growth, photosynthetic efficiency and reproductive performance can influence their ability to maintain yield under restricted water supply. Parkash *et al.* (2021a) found that fruit yield and dry biomass declined significantly at 60% and 40% ETc but not at 80% ETc, and that the cultivar Marketmore 76 had higher stomatal conductance, transpiration and leaf area, and lower relative leaf temperature, than Poinsett 76. Root development is particularly important in this context because modification of root growth and soil-water extraction can contribute to plant adaptation under water-limited conditions (Parkash *et al.*, 2021b). Low-tech lined planting beds, which restrict deep percolation and encourage denser root proliferation in the wetted zone, have been shown to sustain shoot and root biomass, leaf area and yield under 50% ETc irrigation at levels comparable to full irrigation, nearly doubling water-use efficiency relative to unlined beds (Abouelsaad, 2026). The severity of yield loss under deficit irrigation is therefore not fixed but can be modulated by root-zone management, container or bed design, and cultivar choice.

Drip irrigation is an effective means of implementing deficit irrigation because water can be delivered directly to the root zone with relatively precise control of application depth and frequency. Evidence from Nigeria indicates that irrigation depth and frequency significantly influence cucumber yield and water productivity. In Kaduna, full irrigation produced the highest yield of cv. Marketmore, whereas deficit treatments generally gave greater water productivity, illustrating the trade-off between maximizing yield and maximizing productivity per unit of water applied (Zakka *et al.*, 2020). In Ikole-Ekiti, drip irrigation frequency interacted significantly with nitrogen fertilization and mulching to affect cucumber yield and water-use efficiency, and water-use efficiency was strongly and positively correlated with fruit yield (Fasina *et al.*, 2021). Such trade-offs are particularly relevant to smallholder and peri-urban farmers in the Guinea Savanna, where dry-season water availability may limit the cultivable area and where low-cost container systems such as sack or bag

gardening are increasingly used to intensify vegetable production on constrained land (Kalanda Joshua *et al.*, 2020; Kiribou *et al.*, 2024).

Global and regional syntheses reinforce this pattern. A meta-analysis of 425 yield and 388 water-productivity comparisons across eight vegetable crops found that the largest water-productivity gains occurred at irrigation levels of 35–50% of full irrigation, but that irrigation below 35% of full irrigation caused yield declines of up to 51% (Singh *et al.*, 2021). A more recent meta-analysis from Ethiopia concluded that irrigating vegetables at approximately 80% of crop water requirement balances yield stability with meaningful water savings, and linked this response to drought-adaptation mechanisms including osmotic adjustment, stomatal regulation and root-system modification (Yimam *et al.*, 2026).

Despite these findings, information remains limited on the combined effects of deficit drip irrigation and cultivar on the morphology, root development and yield of cucumber under the Guinea Savanna conditions of Nigeria, particularly in low-cost sack-based systems that are increasingly relevant to peri-urban food security (Kiribou *et al.*, 2024). Understanding these responses is essential for identifying irrigation regimes that conserve water while maintaining commercially acceptable productivity. This study therefore quantified the effects of five deficit drip irrigation levels on the biophysical, morphological and yield parameters of three cucumber cultivars grown in sacks at Makurdi, in the Southern Guinea Savanna of Nigeria.

2.0 MATERIALS AND METHODS

2.1 Study site and climate

The field experiment was conducted at Industrial Layout, Makurdi, Benue State, Nigeria (7°44′ N, 8°31′ E; altitude 95 m above sea level), on the floodplain of the lower Benue River valley. The site lies in the Southern Guinea Savanna agro-ecological zone, which has a tropical savanna climate with distinct wet and dry seasons. The rainy season runs from March/April to October, annual rainfall is about 1,089 mm, and mean annual maximum and minimum temperatures are 33.0–33.96 °C and 21.15–21.58 °C, respectively. Dry-season vegetable production therefore depends almost entirely on irrigation. The soil is a sandy clay loam. The trial was conducted in the 2024 dry season, with planting in February 2024 and harvest more than 60 days after sowing (DAS). During the trial, mean daily maximum and minimum air temperatures ranged from 36.0 to 37.6 °C and from 21.7 to 22.6 °C, mean daily maximum and minimum relative humidity from 42.7 to 48.1% and from 21.4 to 27.4%, wind speed from 7.2 to 8.1 m/s, sunshine from 10.1 to 11.5 h/day, and crop evapotranspiration (ETc) from 3.9 to 4.6 mm/day. No rainfall was recorded up to 35 DAS, and mean daily rainfall was 1.7–2.6 mm/day thereafter.

2.2 Planting material and crop establishment

Certified seeds of three cucumber cultivars, Greengo (R1), Wonalisa (R2) and Marketmore (R3), were used. The growing medium was contained in jute sacks 40 cm in diameter and 60 cm in height (volume ≈ 75.4 L; top surface area 0.1257 m²), which were irrigated to field capacity three days before sowing. Seeds were sown directly (five seeds per hole), and seedlings were thinned to five plants per sack when about 7.5 cm tall. Sacks were arranged at 90 cm × 90 cm spacing to simulate localized peri-urban container farming, a low-cost production system increasingly documented as a food-security strategy in land-constrained African cities (Kiribou *et al.*, 2024). With five plants per sack and one sack per 0.81 m², the plant population was 6.2 plants/m² (about 61,700 plants/ha).

2.3 Experimental design and treatments

The experiment was a 5 × 3 factorial arrangement, laid out as a split-plot in a randomized complete block design (RCBD) with three blocks (replications). Each block contained five main plots, to which the five irrigation regimes were randomly assigned (5 regimes × 3 blocks = 15 main plots). Each main plot was divided into three sub-plots, to which the three cultivars were randomly assigned (15 main plots × 3 cultivars = 45 sub-plots). Irrigation regime was assigned to the main plot and cultivar to the sub-plot because varying irrigation depth at a fine spatial scale is practically more difficult than varying planting material. One experimental unit was one sub-plot (a single cultivar under a single irrigation regime within one block), consisting of 12 sacks with five plants per sack, giving 45 experimental units in total.

The main-plot irrigation regimes were expressed as deficit irrigation (DI), that is, the percentage reduction in irrigation water relative to full irrigation: control, 0% DI (full irrigation; plant–pan coefficient 1.0); T1, 20% DI (0.8); T2, 40% DI (0.6); T3, 60% DI (0.4); and T4, 80% DI (0.2). The sub-plot factor was cultivar: R1, Greengo; R2, Wonalisa; and R3, Marketmore.

The percentages (0, 20, 40, 60 and 80%) are deficit irrigation levels, not management-allowed depletion thresholds, and they were applied irrespective of crop growth stage. The term “soil water depletion” is used only for the measured loss of soil water from the root zone (Section 2.4), which is a response to the treatments and not a treatment definition.

2.4 Irrigation system and scheduling

Water was supplied through a small-farm, gravity-fed drip irrigation system that delivered water directly to the root zone of each sack. Irrigation quantities were adjusted according to cumulative evaporation from a Class A pan, using plant–pan coefficients of 0.8, 0.6, 0.4 and 0.2 for T1–T4, against 1.0 for the control. A predefined application depth based on a 60 cm root zone was assigned to each treatment, on the assumption that there were no roots below 0.60 m. The irrigation interval was set from the calculated evapotranspiration, the net water requirement of the crop, the water-holding capacity of the soil and the crop root depth; it was 2–3 days in the vegetative stage and 1–2 days in the fruiting stage. Volumetric soil moisture over 0–60 cm was measured before and after irrigation at 15-day intervals in every sack.

Soil water depletion (SWD, mm) in the root zone was calculated as $SWD = I - ASW_r$, where I is the irrigation depth applied (mm) and ASW_r is the available soil water retained in the root zone (mm). The total irrigation depths applied were 1,800 mm (control), 1,600 mm (T1), 1,200 mm (T2), 800 mm (T3) and 400 mm (T4), equal to 89, 67, 44 and 22% of the control volume. Depths are expressed on the surface area of the sack (0.1257 m²), so the seasonal volumes delivered were about 226, 201, 151, 100 and 50 L per sack, equivalent to 279, 248, 186, 124 and 62 mm on the 0.81 m² ground area occupied by one sack. The actual reductions (11, 33, 56 and 78%) were therefore close to, but not identical with, the nominal 20–80% levels. Mean SWD was 659, 538, 325, 313 and 240 mm for the control and T1–T4, respectively.

2.5 Fertilizer application and crop management

NPK fertilizer was applied pre-plant at 60 kg/ha and then supplied through the drip system at 0.6–1.1 kg/ha daily or 3.5–7 kg/ha weekly. Vines were staked or trellised. Weeds were controlled by hand weeding at three-week intervals after planting, and pests were controlled with the broad-spectrum pesticide Sarosate in the third and fourth weeks.

2.6 Data collection

Biophysical measurements were made at 10-day intervals on one plant sampled in each replication. Morphological variables were plant height (cm), measured from the soil surface to the tip of the last leaf; root length (cm), measured with a scale rule on samples taken with a root auger at the growing, flowering and harvesting stages to depths of 20, 40 and 60 cm; total number of leaves per plant, by direct count at all growth stages; and leaf area, measured with an automatic leaf-area meter and also estimated for each leaf of the tagged plants as length × maximum width × a shape factor of 0.75. Leaf area was recorded per plant.

At harvest (more than 60 DAS), fruits from each sack were counted, weighed on a scale balance, measured for length (cm) and diameter (cm), and classed as small, medium or large. Total fruit yield (kg/m²) was obtained by expressing fruit weight per sack relative to the ground area of one sack (0.81 m², from the 90 cm × 90 cm spacing).

2.7 Statistical analysis

Data were subjected to analysis of variance (ANOVA) appropriate to a split-plot design in randomized complete blocks, using GenStat (18th edition). The linear model was $Y_{ijk} = \mu + \rho_k + \alpha_i + \varepsilon(a)_{ik} + \beta_j + (\alpha\beta)_{ij} + \varepsilon(b)_{ijk}$, where μ is the overall mean, ρ_k the effect of block k (k = 1–3), α_i the main-plot effect of irrigation regime i (i = 1–5), $\varepsilon(a)_{ik}$ the main-plot error (block × irrigation), β_j the sub-plot effect of cultivar j (j = 1–3), $(\alpha\beta)_{ij}$ the irrigation × cultivar interaction and $\varepsilon(b)_{ijk}$ the sub-plot error. Irrigation regime was tested against the main-plot error (4 and 8 degrees of freedom), whereas cultivar (2 and 20 degrees of freedom) and the irrigation × cultivar interaction (8 and 20 degrees of freedom) were tested against the sub-plot error; total degrees of freedom were 44. Means were separated using Duncan's Multiple Range Test (DMRT) at $P \leq 0.05$. The data set contained no missing treatment-combination values.

3.0 RESULTS AND DISCUSSION

3.1 Morphological and biophysical growth parameters

Increasing deficit irrigation caused significant changes in vegetative morphology (Table 1), but the decline was clearly non-linear rather than proportional to the severity of the deficit. The 20% DI treatment (T1) retained high vegetative vigour, with a plant height of 85.33 cm and a root length of 42.33 cm. These were reductions of 8.5% in height and 20.6% in root length relative to the fully irrigated control (93.30 cm and 53.30 cm, respectively). T1 did not differ significantly from the control in leaf number, leaf area or plant height, although its root length was significantly shorter. This is consistent with literature indicating that mild-to-moderate deficit irrigation, at about 75–80% of full crop water requirement, allows cucumber to sustain near-optimal vegetative growth while reducing water input (Kafle *et al.*, 2025; Parkash *et al.*, 2021a).

Table 1: Morphological responses of cucumber under varying deficit irrigation (DI) levels.

Treatment	Leaf count per plant	Leaf area (cm²)	Plant height (cm)	Root length (cm)
Control (0% DI)	60.23a	16.25a	93.30a	53.30a
T1 (20% DI)	57.60a	16.57a	85.33ab	42.33b
T2 (40% DI)	33.00c	15.11ab	66.73c	33.33c
T3 (60% DI)	42.00b	16.71a	70.16bc	37.00bc
T4 (80% DI)	40.00bc	11.76b	70.00bc	40.60b

DI = deficit irrigation (percentage reduction in irrigation water relative to full irrigation). Means within a column followed by the same letter are not significantly different at $P \leq 0.05$ (Duncan's Multiple Range Test). Higher deficit levels (T2, T3 and T4) significantly inhibited stem elongation and leaf production, but not in a simple dose-dependent order. Plant height declined by 28.5% under 40% DI (T2, 66.73 cm), 24.8% under 60% DI (T3, 70.16 cm) and 25.0% under 80% DI (T4, 70.00 cm) relative to the control. The intermediate 40% DI treatment therefore produced the lowest plant height and leaf count of any treatment, lower even than the two more severe deficit levels. Leaf count showed the same pattern, falling by 45.2% under T2 but by only 30.3% and 33.6% under T3 and T4, respectively. This non-monotonic response suggests that the adjustment of the crop to water stress is not proportional to the imposed deficit and may involve compensatory or acclimation responses, although the present data cannot identify the mechanism. Non-linear responses have been reported elsewhere: Kafle *et al.* (2025) observed a disproportionately large biomass penalty in cucumber only at the most severe deficit tested, with moderate deficits statistically similar to full irrigation, and Asargew *et al.* (2024) showed that the relationship between stomatal conductance and photosynthesis itself becomes non-linear as water stress intensifies, which could contribute to threshold-type morphological responses of the kind seen here.

Leaf area departed even more clearly from a simple dose–response pattern. Values for the control (16.25), T1 (16.57) and T3 (16.71) were statistically similar, T2 (15.11) was intermediate, and only the most severe deficit, T4, caused a significant reduction (11.76, a 27.6% decline). Leaf-area expansion was therefore comparatively buffered against deficits of up to 60% DI and declined markedly only under the most extreme restriction tested. This is broadly consistent with reports that leaf area index in cucumber declines sharply only under severe, sustained water stress (Kafle *et al.*, 2025, 2026).

3.2 Root development under deficit irrigation

Root length also followed a non-linear trajectory across the deficit gradient. It declined from 53.30 cm (control) to a minimum of 33.33 cm under 40% DI (T2) and then partially recovered to 37.00 cm under 60% DI (T3) and 40.60 cm under 80% DI (T4); root length under T4 was significantly greater than under T2 and did not differ from that under T1. One possible explanation is a drought-avoidance response in which plants under prolonged, severe restriction allocate more assimilate to root elongation in search of moisture, a compensatory response that has been described in cucumber and other vegetable crops under deficit irrigation (Kafle *et al.*, 2026; Parkash *et al.*, 2021b). This was not tested in the present study. Lined planting beds that encourage denser root proliferation have been shown to preserve root and shoot biomass under 50% ETc at levels comparable to full irrigation (Abouelsaad, 2026), suggesting that root responses in sack-based systems might be improved through better root-zone water retention in future trials.

3.3 Fruit yield and cultivar plasticity

Cultivar significantly influenced yield ($P < 0.01$), whereas the irrigation × cultivar interaction was not significant ($P > 0.05$). Among the deficit treatments, the highest yield, 5.46 kg/m² with 21 fruits/sack (matched in fruit number by T2R3), was obtained under T1R3 (20% DI + Marketmore), whereas the lowest yield, 1.70 kg/m² with 6 fruits/sack, occurred under T3R1 (60% DI + Greengo). The best combination thus yielded 221% more than the poorest, a more than three-fold difference that highlights the practical importance of matching cultivar to irrigation regime (Table 2). The fully irrigated Marketmore control yielded 5.66 kg/m² (19 fruits/sack), so T1R3 reached 96.5% of the full-irrigation yield with 11% less water. Means for all cultivar × irrigation combinations are given in Tables 3 and 4.

Table 2: Highest and lowest fruit yield among cucumber cultivar × deficit irrigation combinations.

Treatment combination	Fruit yield (kg/m²)	Fruit count (fruits/sack)
T1R3: 20% DI × Marketmore (highest)	5.46	21
T3R1: 60% DI × Greengo (lowest)	1.70	6

Marketmore gave the highest yield under every irrigation level, and its yield fell by only 12% from the control to T4 (5.66 to 4.97 kg/m²), compared with 42% for Greengo (4.68 to 2.70 kg/m²); Wonalisa did not decline (4.22 to 4.48 kg/m²). This pattern points to a greater tolerance of water deficit in Marketmore, but because the interaction was not significant, the differences among cultivars in their response to deficit irrigation were not statistically confirmed and should be regarded as indicative. In Kaduna, Zakka *et al.* (2020) grew Marketmore under drip irrigation and obtained its highest yield under full irrigation, while Fasina *et al.* (2021) reported that irrigation frequency strongly determined cucumber yield and water-use efficiency at Ikole-Ekiti.

Table 3: Fruit yield (kg/m²) of three cucumber cultivars under five deficit irrigation levels.

Irrigation regime	Greengo (R1)	Wonalisa (R2)	Marketmore (R3)	Irrigation mean
Control (0% DI)	4.68	4.22	5.66	4.85
T1 (20% DI)	4.88	4.92	5.46	5.09
T2 (40% DI)	1.88	3.07	5.04	3.33
T3 (60% DI)	1.70	3.80	4.87	3.46
T4 (80% DI)	2.70	4.48	4.97	4.05
Cultivar mean	**3.17**	**4.10**	**5.20**	**4.16**

The irrigation × cultivar interaction was not significant ($P > 0.05$).

Table 4: Number of fruits per sack of three cucumber cultivars under five deficit irrigation levels.

Irrigation regime	Greengo (R1)	Wonalisa (R2)	Marketmore (R3)	Irrigation mean
Control (0% DI)	16	19	19	18.0
T1 (20% DI)	18	19	21	19.3
T2 (40% DI)	8	17	21	15.3
T3 (60% DI)	6	17	19	14.0
T4 (80% DI)	16	19	18	17.7
Cultivar mean	**12.8**	**18.2**	**19.6**	**16.9**

Fruit number under T4 (17.7 fruits/sack) was close to that of the control (18.0), yet mean yield was 16% lower (4.05 against 4.85 kg/m²). This implies a smaller average fruit mass under T4, about 186 g against 218 g per

fruit (15% lower), calculated from yield, the 0.81 m² ground area per sack and fruit number. Fruit length, diameter and size class were recorded but are not reported here. The result suggests that under severe deficit, fruit size may be reduced even where fruit number is maintained, which would matter for marketable yield.

3.4 Water use and implications for smallholder sack farming

Taken together, the results indicate that a mild deficit (20% DI, T1) combined with Marketmore gave the highest yield among the deficit treatments (96.5% of the fully irrigated Marketmore yield) in this sack-based Guinea Savanna system. This agrees with syntheses showing that mild-to-moderate deficits can conserve water with limited yield loss: Singh *et al.* (2021) reported that yield reductions under low to moderate deficits (above 65% of full irrigation) were accompanied by water-productivity gains, and Yimam *et al.* (2026) concluded that about 80% of crop water requirement balances yield stability with water savings. Irrigation volumes were recorded in this trial: T1 received 1,600 mm against 1,800 mm for the control (11% less) and averaged 5.09 against 4.85 kg/m², whereas T4 received 22% of the control volume and averaged 4.05 kg/m² (16% lower), with T2 and T3 the lowest at 3.33 and 3.46 kg/m². On a volume basis, a mild deficit therefore saved water without a yield penalty. Total crop evapotranspiration and a formal water-productivity analysis are not reported here, and the nominal 20–80% levels correspond to actual volume reductions of 11, 33, 56 and 78%.

These findings are relevant to the growing number of peri-urban and smallholder farmers who use low-cost sack or container systems to intensify vegetable production on constrained urban land in Sub-Saharan Africa (Kiribou *et al.*, 2024). Because sack media generally hold a smaller and more rapidly depleting water reservoir than open-field soil, deficit thresholds developed under field conditions may not transfer directly to container systems.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Deficit drip irrigation, imposed as a reduction in the volume of irrigation water, significantly influenced the growth, root development and yield of cucumber grown in sacks under Guinea Savanna conditions. A 20% DI level (1,600 mm against 1,800 mm for full irrigation) maintained satisfactory vegetative development and gave a mean yield of 5.09 kg/m², comparable with the 4.85 kg/m² of the control, whereas 40–80% DI reduced plant height, leaf number and root length. Yield responses were non-linear, with the lowest means at 40% and 60% DI. Marketmore gave the highest yield at every irrigation level and lost the least yield under deficit irrigation, although the irrigation × cultivar interaction was not significant, so this advantage is indicative. A 20% DI regime combined with Marketmore is suggested for cucumber production in sack-based systems where water is limited. Further studies should evaluate this treatment across multiple growing seasons and should quantify crop evapotranspiration and water productivity before the recommendation is extended to wider production environments.

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