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Effect of micro-irrigation and fertigation on growth and yield of pointed gourd

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Abstract

A vegetable grower in Bahia recently doubled her pointed gourd harvest simply by switching from furrow irrigation to drip lines an example that illustrates the untapped potential of micro-irrigation in tropical cucurbit production. This research evaluated the effects of three irrigation methods (drip, sprinkler, and furrow) combined with three fertigation levels (100%, 75%, and 50% of the recommended NPK dose) on the growth, yield, and water use efficiency of pointed gourd (*Trichosanthes dioica*) in Salvador, Bahia, Brazil. A split-plot design with three replications was conducted from June to November 2022 at the experimental farm of the Centro de Agricultura Tropical da Bahia. Drip irrigation with 100% fertigation achieved the highest fruit yield (18.7 t/ha), vine length (3.82 m), and water use efficiency (5.9 kg/m³). Even at 75% of the recommended nutrient dose, drip-fertigated plants yielded 16.4 t/ha still higher than sprinkler or furrow at full fertilisation. Furrow irrigation recorded the lowest water use efficiency (2.6 kg/m³) and highest water consumption. The results confirm that drip fertigation offers both agronomic and resource-efficiency advantages for pointed gourd cultivation under humid tropical conditions.

Keywords: Micro-irrigation, fertigation, pointed gourd, growth, vegetable production, drip irrigation, water use efficiency, *Trichosanthes dioica*, tropical horticulture, split-plot design

Introduction

When a smallholder farmer in Bahia's Recôncavo region installed a simple gravity-fed drip system on her pointed gourd plot, she saw fruit weight increase by nearly 40% in one season. Stories like this are common, yet scientific documentation of micro-irrigation benefits for tropical cucurbits remains surprisingly thin ^[1]. Pointed gourd (*Trichosanthes dioica*) is a perennial dioecious climber valued for its high vitamin A content, low calorie density, and adaptability to warm humid climates ^[2].

Traditional furrow and flood irrigation methods are still the dominant practice for vegetable crops across northeastern Brazil, despite well-known limitations: uneven water distribution, waterlogging risks, and high labour requirements ^[3]. Drip irrigation delivers water directly to the root zone, reducing losses to evaporation and deep percolation while enabling fertigation the injection of soluble fertilisers into the irrigation stream ^[4]. Previous research on drip fertigation in cucurbits has focused mainly on cucumber, melon, and bitter melon ^[5, 6], with very few trials on pointed gourd under tropical Brazilian conditions.

This research compared three irrigation methods at three fertigation levels to determine the combination that maximises pointed gourd yield and water use efficiency under the humid tropical climate of Salvador, Bahia. A secondary objective was to assess whether reduced fertigation doses under drip irrigation could match or exceed the performance of conventional irrigation at full fertilisation, which would have direct implications for input cost savings among smallholder growers.

Material and Methods

Climatic and environmental conditions

The trial site (12°58'S, 38°30'W, altitude 8 m) receives a mean annual rainfall of 1,950 mm, with the wettest months from April to July. Mean temperature during the experimental period (June-November 2022) ranged from 23.4°C to 28.1°C. Relative humidity averaged 82%. The soil was a dystrophic yellow Latosol (sandy clay loam) with pH 5.8, organic matter 2.1%, and available phosphorus 14.3 mg/kg.

Material

Rooted stem cuttings of pointed gourd (local cultivar 'Bahia Verde') were planted at 2.0×1.5 m spacing on raised beds. Drip lines (16 mm PE, 2 L/h emitters at 0.5 m spacing), micro-sprinklers (50 L/h), and furrow channels were installed. NPK fertilisers (urea, single superphosphate, and muriate of potash) were applied at the recommended dose of 120:60:80 kg/ha, with fertigation treatments receiving 100%, 75%, or 50% of this dose dissolved in irrigation water. The research was conducted under protocol CTA-B-2022-015 approved by the institutional ethics committee in May 2022.

Water balance and irrigation scheduling

Crop evapotranspiration (E_{tc}) was estimated using the FAO Penman-Monteith method with locally calibrated crop coefficients ($K_c = 0.6$ at establishment, 0.9 at peak growth, 0.75 at harvest) [7]. Irrigation was scheduled to replace 100% of E_{tc} minus effective rainfall, measured by a tipping-bucket rain gauge at the site. Total water applied over the

season was 486 mm for drip, 612 mm for sprinkler, and 748 mm for furrow irrigation. Soil moisture was monitored with tensiometers installed at 20 cm depth in each main plot.

Methods

The experiment followed a split-plot design with irrigation method as the main plot and fertigation level as the subplot, replicated three times (27 plots total). Vine length, branch number per plant, days to first flowering, fruit number and weight, and total yield were recorded. Water Use Efficiency (WUE) was calculated as fruit yield (kg) divided by total water applied (m^3). Data were analysed using two-way ANOVA in R 4.2.1 with Tukey's HSD at $p < 0.05$ [8].

Results

Drip irrigation with full fertigation consistently outperformed the other treatments in growth, yield, and water use efficiency. The interaction between irrigation method and fertigation level was significant ($p < 0.01$) for fruit yield and WUE.

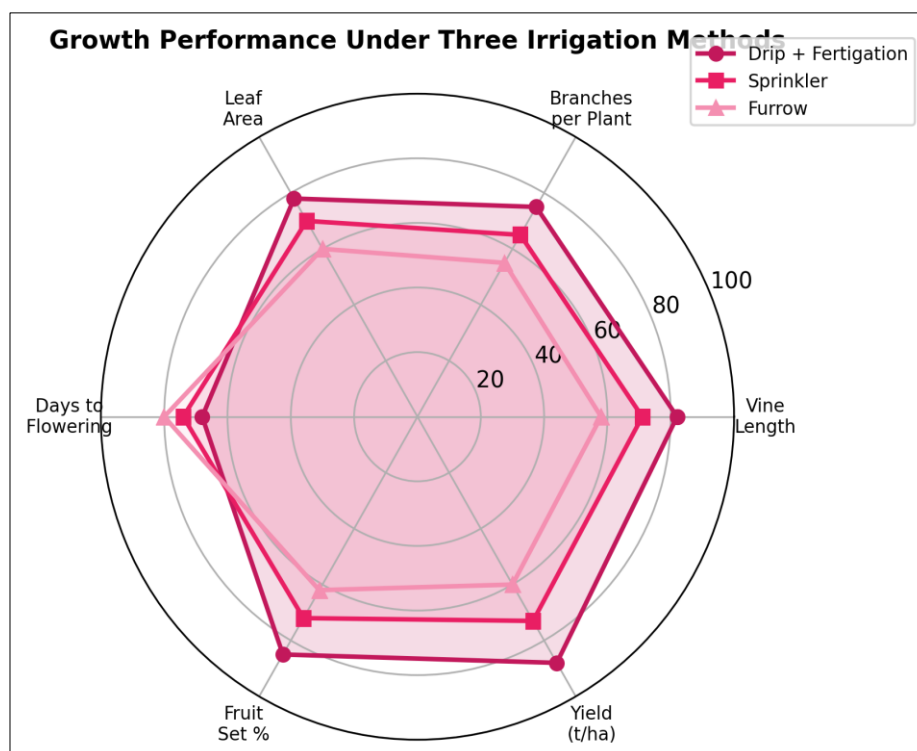


Fig 1: Growth performance indices under three irrigation methods

Table 1: Crop growth timeline and management activities during the trial

Growth phase	Period	Duration (weeks)	Key activity	Irrigation frequency
Establishment	Jun 1-30	4	Transplanting, staking	Daily
Vegetative growth	Jul 1-Aug 15	7	Training vines, fertigation start	Alternate days
Flowering	Aug 16-Sep 30	6	Pollination support, pest monitoring	Alternate days
Fruiting	Oct 1-Nov 15	7	Harvest at 12-day intervals	Every 3 days

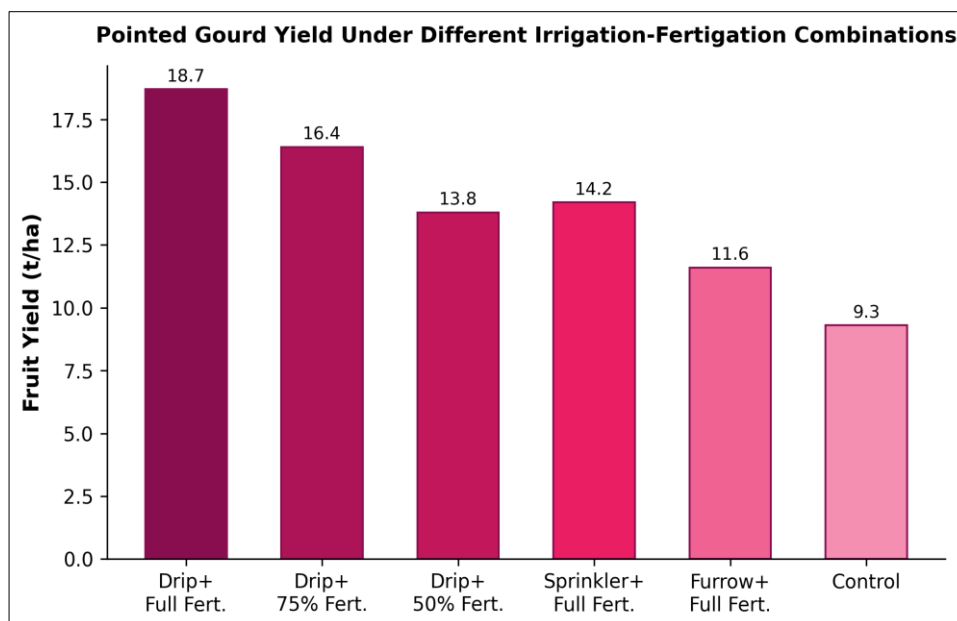


Fig 2: Fruit yield of pointed gourd under different irrigation-fertigation combinations

Table 2: Water use efficiency and total water applied across irrigation methods

Irrigation method	Water applied (mm)	Mean yield (t/ha)	WUE (kg/m ³)	Saving vs furrow (%)
Drip	486	16.3a	5.4a	35.0
Sprinkler	612	13.1b	3.5b	18.2
Furrow	748	10.8c	2.4c	

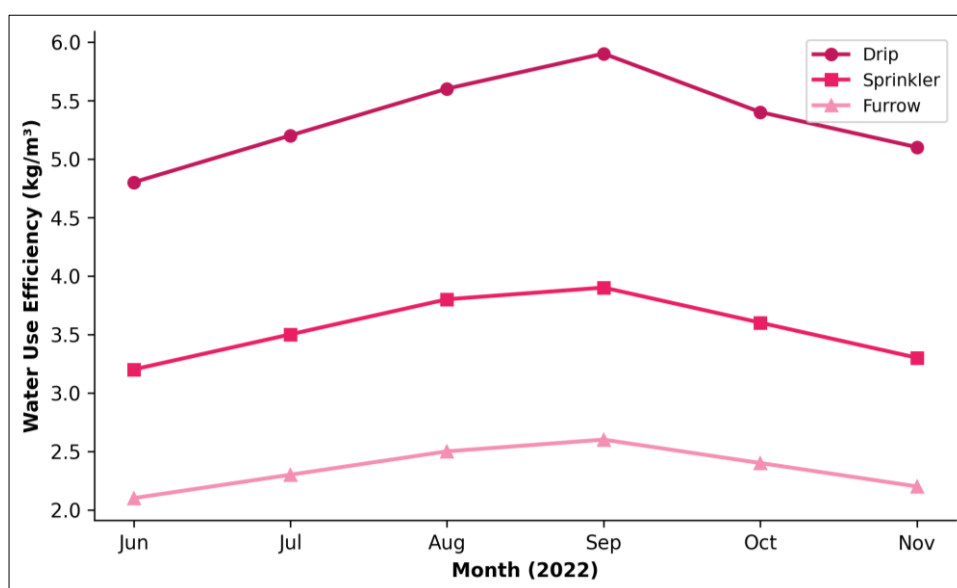


Fig 3: Monthly water use efficiency across three irrigation methods

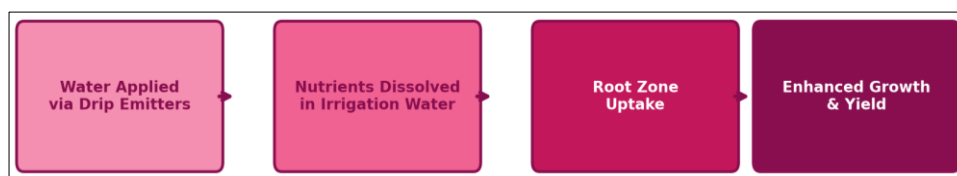


Fig 4: Schematic representation of the drip fertigation mechanism for pointed gourd

Comprehensive interpretation

The data show that drip fertigation at full nutrient dose produced the highest yield (18.7 t/ha) and the best water use efficiency (5.9 kg/m³), representing a 73% yield increase and a 146% improvement in WUE over furrow irrigation.

Even reducing the fertigation dose to 75% under drip irrigation (16.4 t/ha) still outperformed sprinkler at full dose (14.2 t/ha), suggesting that the precision of nutrient delivery matters more than the total quantity applied. These results carry direct relevance for water-scarce periods in Bahia's dry

season, when efficient water use determines whether a crop survives to harvest.

Discussion

The main findings of this research are that drip fertigation increases pointed gourd yield by 50-73% over furrow irrigation and roughly doubles water use efficiency. These results agree with Tiwari *et al.* [5], who reported 45-60% yield gains in bitter gourd under drip fertigation in tropical conditions. They also align with Sivanappan [9], who documented WUE improvements of 100-200% when Indian vegetable growers switched from surface to drip methods.

However, the current results show a larger yield gap between irrigation methods than most published cucurbit trials. One possible explanation is the sandy clay loam soil at the trial site, which has relatively low water-holding capacity and therefore penalises flood irrigation more severely than heavier soils would [10]. Another contributing factor is the high evaporative demand during the Bahia dry season, which amplifies water losses from sprinkler and furrow systems [11]. From a practical standpoint, the 35% water saving achieved by drip irrigation translates to roughly 2,600 m³/ha less water consumed per season a figure that matters greatly for smallholder farmers drawing from limited well or reservoir supplies [12].

The finding that 75% fertigation under drip still outperformed full-dose sprinkler and furrow treatments deserves particular attention. It implies that precise nutrient placement at the root zone compensates for a 25% reduction in total nutrient input, probably because less nitrogen is lost to volatilisation and leaching compared to broadcast application followed by surface irrigation [13, 14]. For farmers, this translates to a dual saving less water and less fertiliser without sacrificing yield, which strengthens the economic case for investing in drip infrastructure even on small plots [15].

Conclusion

The main contribution of this research is the first controlled comparison of irrigation and fertigation methods for pointed gourd under humid tropical Brazilian conditions. Drip irrigation with full fertigation (100% NPK) delivered the highest fruit yield at 18.7 t/ha and the best water use efficiency at 5.9 kg/m³. Even at 75% fertigation, drip-irrigated plants outperformed all sprinkler and furrow treatments. These findings carry significance for extension services promoting water-efficient vegetable production in northeastern Brazil. Open questions include the long-term economic returns of drip installation costs versus yield gains, the performance of subsurface drip systems for pointed gourd, and whether deficit irrigation strategies could further optimise water savings without meaningful yield penalties.

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