Plant Archives Vol. 26, Supplement 1, 2026 pp. 900-908 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2026.v26.supplement-1.121

OPTIMIZING DRIP IRRIGATION AND FERTIGATION REGIMES FOR IMPROVING GROWTH ATTRIBUTES OF PRE-SEASONAL SUGARCANE

Darshan H.P.*, S.S. Nooli, B.T. Nadagouda, B.N. Aravindakumar, C.R. Patil and Rajakumar G.R.
Department of Agronomy, University of Agricultural Sciences, Dharwad-580005, Karnataka, India.
*Corresponding author E-mail: darshanagri10@gmail.com
(Date of Receiving : 18-10-2025; Date of Acceptance : 20-12-2025)

ABSTRACT

A field experiment was conducted during the pre-season at the Agricultural Research Station, Sankeshwar, Karnataka, India, to evaluate the effect of drip fertigation at different irrigation and nutrient levels on growth parameters of sugarcane. The experiment was laid out in a strip block design comprising three drip irrigation schedules based on reference evapotranspiration (ET_o) applied at critical growth stages *viz.*, germination, tillering, canopy establishment, grand growth and maturity, and three fertigation levels of 75, 100, and 125 per cent of the recommended dose of fertilizers (RDF), along with surface irrigation and drip fertigation controls. Fertigation was applied at 15-day intervals up to 240 days after planting (DAP), while irrigation was scheduled at three-day intervals until harvest. Results indicated that drip irrigation at higher ET_o levels significantly enhanced growth parameters compared to lower irrigation regimes and surface irrigation. Among irrigation treatments, application of drip irrigation at 1.0, 1.2, 1.4, 1.6, and 1.0 ET_o at successive growth stages (I_3) recorded superior plant height, number of tillers, leaf area index, internodal length, and cane diameter across observation stages. Similarly, fertigation with 125 per cent RDF (F_3) consistently resulted in significantly higher growth attributes compared to 75 per cent RDF, and was largely on par with 100 per cent RDF. The interaction effect revealed that the combination of I_3 irrigation schedule with 125 per cent RDF through fertigation (I_3F_3) produced the highest values for all measured growth parameters, including maximum plant height, tiller population, leaf area index, internodal length, and cane diameter at harvest. Lower growth performance was observed under reduced irrigation coupled with 75 per cent RDF and under conventional surface irrigation. The improved growth under optimal drip fertigation was attributed to continuous availability of soil moisture and nutrients in synchrony with crop demand, leading to enhanced cell division, elongation, nutrient uptake and efficient partitioning of assimilates. Overall, the study demonstrates that stage-wise drip irrigation combined with split application of nutrients through fertigation is an effective strategy to improve sugarcane growth, resource-use efficiency, and sustainability compared to conventional irrigation practices.

***Keywords*:** Drip irrigation, ferrtigation, pre-seasonal sugarcane, reference evapotranspiration.

Introduction

Sugarcane is globally a significant crop, valued not only for its role in sugar production but also as bioenergy owing to its exceptional dry matter productivity. It is a C_4 plant, predominantly cultivated in tropical and subtropical regions**.** Sugarcane accounts for approximately 29 per cent of the total global crop production (Gerbens-Leenes and Hoekstra, 2012). Globally, sugarcane is cultivated in 110 countries, on an area of 27.8 million hectares with a production of 1,949 million tonnes, with an average productivity of 72.7 tonnes per hectare. Among sugarcane-producing nations, India ranks second in both area and production (5.1 m ha & 439.42 m t, respectively)**,** following Brazil (9.8 m ha & 724.42 m t, respectively)**,** which holds the leading position.

Globally, it consumes approximately 234 billion cubic meters (m³) of water each year, accounting for about 3.4 – 3.5 per cent of total global water use for crop production (FAO, 2023). Sugarcane requires substantial water throughout its entire crop cycle, which lasts between 12 and 18 months, in different agro-climatic regions. The water footprint of cane sugar varies among major producing countries, estimated at 1,285 m³ t^{-1} for Brazil and 1,570 m³ t^{-1} for India. In India, Uttar Pradesh, Punjab, Haryana, and Bihar the annual water requirement for sugarcane ranges from 1,400 mm to 1,600 mm. Considerable regional variations exists in irrigation efficiency: producing 1 kg of sugarcane requires approximately 75–100 litres of irrigation water in Bihar, compared to 500–800 litres in Maharashtra, Karnataka, and Tamil Nadu. Most sugarcane farmers in India continue to use unscientific irrigation practices, with an average irrigation efficiency of only 35–45 per cent, resulting in significant losses of irrigation water (Shukla *et al.*, 2020).

Application of high doses of nitrogen (N) coupled with low levels of phosphorus (P) and potassium (K) fertilization in many sugarcane growing regions has led to poor cane yield**,** deterioration in juice quality and soil degradation. This imbalance is one of the main causes of declining sugarcane productivity and low sugar recovery in India (Sonawane and Sabale, 2000). Excessive nitrogen also increases the crop's susceptibility to lodging, pests and diseases, which leads to yield reduction and higher production costs. When nitrogen application is not synchronized with crop demand, substantial losses occur through leaching, volatilization and denitrification, resulting in low nitrogen use efficiency (NUE). Therefore, effective nutrient management, particularly of nitrogen, remains a major challenge for researchers and farmers aiming to enhance yield, profitability and sustainability in sugarcane production. Keeping this view the present study was conducted.

Materials and Methods

The experiment was conducted at ARS, Sankeshwar, Karnataka, India. The experimental site was located at 16° 24' North latitude and 74° 50' East longitude with an altitude of 638 m above mean sea level in Northern transition zone of Karnataka (Zone-8). The soil of experimental site was classified as medium black clay loam belonging to the order Vertisol as per USDA soil classification.

The experiment was laid out in strip block design with three drip irrigation levels as vertical strip *viz.*, drip irrigation at 0.6, 0.8, 1.0, 1.2 and 0.8 ET_o at germination, tillering, canopy establishment, grand growth and maturity stages, respectively (I_1), drip irrigation at 0.8, 1.0, 1.2, 1.4 and 0.8 ET_o at germination, tillering, canopy establishment, grand growth and maturity stages, respectively (I_2) and drip irrigation at 1.0, 1.2, 1.4, 1.6 and 1.0 ET_o at germination, tillering, canopy establishment, grand growth and maturity stages, respectively (I_3) and three fertigation levels as horizontal strip *viz.*, 75 % RDF (188:56:143 N:P:K kg ha^{-1}) through fertigation (F_1), 100 % RDF (250:75:190 N:P:K kg ha^{-1}) through fertigation (F_2) and 125 % RDF (313:94:238 N:P:K kg ha^{-1}) through fertigation (F_3) along with two control treatments i.e., drip fertigation and surface irrigation with fertilizer application as per recommended package of practice (UAS, Dharwad POP, 2021).

The recommended FYM (25 t ha^{-1}), $FeSO_4$ & $ZnSO_4$ (each 25 kg ha^{-1}) and biofertilizers like Azospirillum and PSB (each 10 kg ha^{-1}) was applied uniformly for all treatments. Fertigation was given upto 240 DAP at 15 days interval and irrigation was given till to harvest at 3 days interval. 100 per cent of P and 10 per cent of N and K of respective treatment was applied as a basel dose though MAP, urea and MOP, respectively and remaining 90 per cent of N and K was applied in 8 equal splits for all drip fertigation plots. While, for surface irrigation treatment (C_2) 10 per cent and 100 per cent P and K was applied as base dose and 90 per cent of N applied at tillering stage (Appendix I). Observations on all growth parameters were recorded by following standard procedures and were statistically analyzed according to the methodology described by Gomez and Gomez (1984).

Results and Discussion

Plant height

Among the irrigation levels, significantly higher plant height was recorded in the treatment with application of drip irrigation at 1.0 ET_o at germination + 1.2 ET_o at tillering + 1.4 ET_o at canopy establishment + 1.6 ET_o at grand growth + 1.0 ET_o at maturity stage (I_3) at 120, 180, 240, 300 DAP and at harvest (116.89, 184.94, 247.3, 296.95 and 431.93 cm, respectively) over drip irrigation (I_1) at 0.6 ET_o at germination + 0.8 ET_o at tillering + 1.0 ET_o at canopy establishment + 1.2 ET_o at grand growth + 0.8 ET_o at maturity stage (93.97, 149.54, 215.05, 265.51 and 392.62 cm, respectively). However, I_3 was on par with drip irrigation (I_2) at 0.8 ET_o at germination + 1.0 ET_o at tillering + 1.2 ET_o at canopy establishment + 1.4 ET_o at grand growth + 0.8 ET_o at maturity stage (108.93, 172.39, 233.62, 281.65 and 411.28 cm, respectively). Water plays a vital role in the carbohydrate metabolism, protein synthesis, cell wall synthesis, cell enlargement and better partitioning of photosynthates to sink for improved development of growth traits (Gardener *et al.*,1985).

Among fertigation levels, application of fertilizers at 125 per cent RDF through fertigation (F_3) recorded significantly higher plant height at 120, 180, 240, 300

DAP and at harvest (115.85, 180.74, 245.69, 294.97 and 427.70 cm, respectively) over 75 per cent RDF (F_1) through fertigation (96.31, 156.31, 217.80, 237.44 and 394.69 cm respectively). F_3 was found on par with 100 per cent RDF through fertigation (F_2), which recorded (107.64, 169.82, 232.43, 287.69 and 413.44 cm, respectively).

The treatment interaction of drip irrigation at 1.0 ET_o at germination +1.2 ET_o at tillering +1.4 ET_o at canopy establishment +1.6 ET_o at grand growth +1.0 ET_o at maturity stage along with 125 per cent RDF through fertigation (I_3F_3) recorded significantly taller plants at 120, 180, 240 300 DAP and at harvest (128.36, 198.25, 266.05, 313.80 and 456.67 cm, respectively) and was found on par with drip irrigation at 1.0 ET_o at germination + 1.2 ET_o at tillering + 1.4 ET_o at canopy establishment + 1.6 ET_o at grand growth + 1.0 ET_o at maturity stage along with 100 per cent RDF (I_3F_2) through fertigation (117.07, 185.03, 250.00, 298.12 and 436.12 cm, respectively) and the treatment with drip irrigation at 0.8 ET_o at germination + 1.0 ET_o at tillering + 1.2 ET_o at canopy establishment + 1.4 ET_o at grand growth + 0.8 ET_o at maturity stage along with 125 per cent RDF (I_2F_3) through fertigation (118.36, 181.25, 247.21, 295.11and 423.44 cm, respectively). Significantly lower values at 120, 180, 240 300 DAP and at harvest was observed in the treatment with drip irrigation at 0.6 ET_o at germination + 0.8 ET_o at tillering + 1.0 ET_o at canopy establishment +1.2 ET_o at grand growth + 0.8 ET_o at maturity stage along with 75 per cent RDF (I_1F_1) through fertigation (87.24, 135.59, 205.20, 248.93 and 384.33 cm, respectively) and RPP surface irrigation (C_2) (95.84, 143.6, 207.55, 251.27 and 385.67 cm respectively) (Table 1). These findings align with those of Khandagave *et al*. (2005), who reported that the highest yields under drip fertigation resulted from the continuous supply of adequate nutrients and water during all the growth stages.

Number of tillers

Among the irrigation levels, significantly higher number of tillers was recorded due to application of drip irrigation at 1.0 ET_o at germination + 1.2 ET_o at tillering + 1.4 ET_o at canopy establishment + 1.6 ET_o at grand growth + 1.0 ET_o at maturity stage (I_3) at 120, 180, 240 and 300 DAP (59279, 126853, 152152 and 127354 ha^{-1}, respectively) over drip irrigation (I_1) at 0.6 ET_o at germination + 0.8 ET_o at tillering + 1.0 ET_o at canopy establishment +1.2 ET_o at grand growth + 0.8 ET_o at maturity stage (50809, 107876, 134152 and 110927 respectively). However, I_3 was on par with drip irrigation (I_2) at 0.8 ET_o at germination +1.0 ET_o at tillering +1.2 ET_o at canopy establishment + 1.4 ET_o at grand growth + 0.8 ET_o at maturity stage (56558, 119437, 146357 and 121994 ha^{-1} , respectively). Generally, tillering was higher with I_3 treatment compared to other irrigation levels. This was mainly due to the early vigorous growth of cane with the availability of the required quantity of water at the early stages.

Among fertigation levels, application of fertilizers at 125 per cent RDF through fertigation (F_3) recorded significantly higher number of tillers at 120, 180, 240 and 300 DAP (58718, 125378, 151324 and 126529 respectively) over 75 per cent RDF (F_1) through fertigation (52595, 109385, 136784 and 113260 ha^{-1} respectively). F_3 was found on par with 100 per cent RDF through fertigation (F_2), which recorded (55333, 119402, 144553 and 120486, respectively). Consistent nutrient availability, supplied in frequent doses to match crop demand, along with good soil aeration throughout the growth period, likely supported rapid cell division and elongation, ultimately resulting in increased tiller production (Fanish *et al*., 2011).

The interaction of drip irrigation at 1.0 ET_o at germination + 1.2 ET_o at tillering + 1.4 ET_o at canopy establishment + 1.6 ET_o at grand growth + 1.0 ET_o at maturity stage along with 125 per cent RDF through fertigation (I_3F_3) recorded significantly higher number of tillers at 120, 180, 240 and 300 DAP (62448, 133545, 160588 and 133745 ha^{-1} , respectively) and was found on par with drip irrigation at 1.0 ET_o at germination + 1.2 ET_o at tillering + 1.4 ET_o at canopy establishment + 1.6 ET_o at grand growth + 1.0 ET_o at maturity stage along with 100 per cent RDF (I_3F_2) through fertigation (59623, 129756, 154244 and 130775 ha^{-1} , respectively) and drip irrigation at 0.8 ET_o at germination + 1.0 ET_o at tillering + 1.2 ET_o at canopy establishment + 1.4 ET_o at grand growth + 0.8 ET_o at maturity stage along with 125 per cent RDF (I_2F_3) through fertigation (59522, 127556, 152980 and 128788 ha^{-1} respectively). Significantly lower values at 120, 180, 240 and 300 DAP were observed in the treatment of drip irrigation at 0.6 ET_o at germination + 0.8 ET_o at tillering + 1.0 ET_o at canopy establishment + 1.2 ET_o at grand growth + 0.8 ET_o at maturity stage along with 75 per cent RDF (I_1F_1) through fertigation (47952, 100241, 130286 and 107387 ha^{-1}, respectively) and RPP surface irrigation (C_2) (48122, 107620, 131247 and 107428 ha^{-1}, respectively) (Table 2). Adequate soil moisture supplied through frequent irrigation, along with nutrients applied in splits aligned with crop growth stages, likely stimulated rapid cell division and elongation, contributing to increased tiller production.

Leaf area index

In irrigation regimes, drip irrigation at 1.0 ET_o at germination + 1.2 ET_o at tillering + 1.4 ET_o at canopy establishment + 1.6 ET_o at grand growth + 1.0 ET_o at maturity stage (I_3) recorded significantly higher leaf area index (1.91, 5.11, 7.93, 6.52 and 5.53 at 120, 180, 240, 300 DAP and at harvest, respectively) compared to drip irrigation (I_1) at 0.6 ET_o at germination + 0.8 ET_o at tillering + 1.0 ET_o at canopy establishment + 1.2 ET_o at grand growth + 0.8 ET_o at maturity stage (1.57, 4.09, 6.01, 4.54 and 3.86, respectively). Meanwhile, drip irrigation (I_2) at 0.8 ET_o at germination + 1.0 ET_o at tillering + 1.2 ET_o at canopy establishment + 1.4 ET_o at grand growth + 0.8 ET_o at maturity stage (1.80, 4.74, 7.40, 6.11 and 5.16, respectively) was on par with I_3. The leaf area expansion is dependent on leaf turgor potential (Boyer, 1970) and further, it is well known fact that cell enlargement is very sensitive to water deficit and water plays an important role in maintaining the leaf turgor potential. The higher leaf area and LAI recorded at higher irrigation levels could be related to favourable soil water balance due to high frequency irrigations under the drip system.

Among the fertigation levels, application of fertilizers at 125 per cent RDF (F_3) through fertigation (1.88, 5.04, 7.78, 6.31 and 5.29, respectively) recorded significantly higher leaf area index and was on par with 100 per cent RDF (F_2) through fertigation (1.80, 4.72, 7.14, 5.89 and 4.92, respectively). 75 per cent RDF (F_1) through fertigation (1.61, 4.18, 6.41, 4.98 and 4.35, respectively) recorded significantly lower leaf area index values. Split application of nitrogen is known to elevate cytokinin levels, which influence cell wall extensibility (Arnold *et al.*, 2006). Therefore, it is reasonable to infer that nitrogen contributed, directly or indirectly, to enhance cell enlargement, cell division, and tissue formation, thereby improving leaf area and leaf area index.

The interaction effect of drip irrigation at 1.0 ET_o at germination + 1.2 ET_o at tillering + 1.4 ET_o at canopy establishment + 1.6 ET_o at grand growth + 1.0 ET_o at maturity stage along with 125 per cent RDF through fertigation (I_3F_3) recorded significantly higher leaf area index (2.04, 5.47, 8.56, 7.11 and 5.97 at 120, 180, 240, 300 DAP and at harvest, respectively) and was on par with drip irrigation at 1.0 ET_o at germination + 1.2 ET_o at tillering + 1.4 ET_o at canopy establishment + 1.6 ET_o at grand growth + 1.0 ET_o at maturity stage along with 100 per cent RDF (I_3F_2) through fertigation (1.98, 5.30, 8.12, 6.89 and 5.69, respectively) and drip irrigation at 0.8 ET_o at germination + 1.0 ET_o at tillering + 1.2 ET_o at canopy establishment + 1.4 ET_o at grand growth + 0.8 ET_o at maturity stage along with 125 per cent RDF (I_2F_3) through fertigation (1.90, 5.10, 7.98, 6.66 and 5.51, respectively). Significantly lower values at 120, 180, 240 and 300 DAP were observed in the treatment of drip irrigation at 0.6 ET_o at germination + 0.8 ET_o at tillering + 1.0 ET_o at canopy establishment + 1.2 ET_o at grand growth + 0.8 ET_o at maturity stage along with 75 per cent RDF (I_1F_1) through fertigation (1.48, 3.53, 5.34, 4.12 and 3.37, respectively) and RPP surface irrigation (C_2) (1.54, 3.90, 5.61, 4.17 and 3.42, respectively) (Table 3). An increased leaf area index facilitated improved light interception and overall crop growth.

Internodal length

At 300 DAP and at harvest, drip irrigation at 1.0 ET_o at germination + 1.2 ET_o at tillering + 1.4 ET_o at canopy establishment + 1.6 ET_o at grand growth + 1.0 ET_o at maturity stage (I_3) recorded significantly higher internodal length (9.21 and 10.56 cm, respectively) over drip irrigation (I_1) at 0.6 ET_o at germination + 0.8 ET_o at tillering + 1.0 ET_o at canopy establishment + 1.2 ET_o at grand growth + 0.8 ET_o at maturity stage (8.07 and 9.19 cm, respectively). However, I_3 was on par with drip irrigation (I_2) at 0.8 ET_o at germination + 1.0 ET_o at tillering + 1.2 ET_o at canopy establishment + 1.4 ET_o at grand growth + 0.8 ET_o at maturity stage (8.71 and 10.04 cm, respectively).

Significantly higher internodal length was noticed with application of fertilizers at 125 per cent RDF (F_3) through fertigation (9.06 and 10.50 cm, respectively) recorded significantly higher number of internodes compared to 75 per cent RDF (F_1) through fertigation (8.16 and 9.32 cm, respectively). Meanwhile, application of fertilizer at 100 per cent RDF (F_2) through fertigation (8.77 and 9.96 cm, respectively) was found on par with F_3.

The interaction effect of drip irrigation at 1.0 ET_o at germination + 1.2 ET_o at tillering + 1.4 ET_o at canopy establishment + 1.6 ET_o at grand growth + 1.0 ET_o at maturity stage along with 125 per cent RDF through fertigation (I_3F_3) recorded significantly higher internodal length (9.72 and 11.12 cm at 300 DAP and harvest, respectively) and was on par with drip irrigation at 1.0 ET_o at germination + 1.2 ET_o at tillering + 1.4 ET_o at canopy establishment + 1.6 ET_o at grand growth + 1.0 ET_o at maturity stage along with 100 per cent RDF (I_3F_2) through fertigation (9.42 and 10.90 cm, respectively) and drip irrigation at 0.8 ET_o at germination + 1.0 ET_o at tillering + 1.2 ET_o at canopy establishment + 1.4 ET_o at grand growth + 0.8 ET_o at maturity stage along with 125 per cent RDF (I_2F_3) through fertigation (9.11 and 10.79 cm, respectively).

Significantly lower values at 300 DAP and harvest were observed in the treatment of drip irrigation at 0.6 ET_o at germination + 0.8 ET_o at tillering + 1.0 ET_o at canopy establishment + 1.2 ET_o at grand growth + 0.8 ET_o at maturity stage along with 75 per cent RDF (I_1F_1) through fertigation (7.75 and 8.75 cm, respectively) and RPP surface irrigation (C_2) (8.00 and 9.12 cm, respectively) (Table 4).

Cane diameter

Among the irrigation levels, significantly higher cane diameter was recorded due to application of drip irrigation at 1.0 ET_o at germination + 1.2 ET_o at tillering + 1.4 ET_o at canopy establishment + 1.6 ET_o at grand growth + 1.0 ET_o at maturity stage (I_3) at 300 DAP and at harvest (3.04 and 3.38 cm, respectively) and was on par with drip irrigation (I_2) at 0.8 ET_o at germination + 1.0 ET_o at tillering + 1.2 ET_o at canopy establishment + 1.4 ET_o at grand growth + 0.8 ET_o at maturity stage (2.90 and 3.14 cm, respectively). Drip irrigation (I_1) at 0.6 ET_o at germination + 0.8 ET_o at tillering + 1.0 ET_o at canopy establishment + 1.2 ET_o at grand growth + 0.8 ET_o at maturity stage (2.74 and 2.92 cm, respectively) recorded significantly lower cane diameter. This favourable influence was due to more uptake of primary nutrients, thereby increase the cell activities which ultimately contributed to the higher cane diameter (Jayaram *et al.,* 2010).

Among fertigation levels, application of fertilizers at 125 per cent RDF (F_3) through fertigation (3.02 and 3.37 cm, respectively) recorded significantly higher cane diameter compared to 75 per cent RDF (F_1) through fertigation (2.76 and 2.94 cm, respectively). However, F_3 was on par with 100 per cent RDF (F_2) through fertigation (2.89 and 3.13 cm, respectively). The increase in cane diameter can be attributed to the greater availability of essential nutrients that were effectively translocated to the sink. These findings align with the observations of Mahendran *et al.* (2005).

The interaction effect of drip irrigation at 1.0 ET_o at germination + 1.2 ET_o at tillering + 1.4 ET_o at canopy establishment + 1.6 ET_o at grand growth + 1.0 ET_o at maturity stage along with 125 per cent RDF through fertigation (I_3F_3) recorded significantly higher cane diameter (3.21 and 3.62 cm at 300 DAP and at harvest, respectively) and was on par with drip irrigation at 1.0 ET_o at germination + 1.2 ET_o at tillering + 1.4 ET_o at canopy establishment + 1.6 ET_o at grand growth + 1.0 ET_o at maturity stage along with 100 per cent RDF (I_3F_2) through fertigation (3.10 and 3.40 cm, respectively) and drip irrigation at 0.8 ET_o at germination +1.0 ET_o at tillering + 1.2 ET_o at canopy establishment + 1.4 ET_o at grand growth + 0.8 ET_o at maturity stage along with 125 per cent RDF (I_2F_3) through fertigation (3.00 and 3.31 cm, respectively). Significantly lower values at 300 DAP and at harvest were observed in the treatment of drip irrigation at 0.6 ET_o at germination + 0.8 ET_o at tillering + 1.0 ET_o at canopy establishment + 1.2 ET_o at grand growth + 0.8 ET_o at maturity stage along with 75 per cent RDF (I_1F_1) through fertigation (2.66 and 2.70 cm, respectively) and RPP surface irrigation (C_2) (2.70 and 2.89 cm, respectively) (Table 5). Consistent soil moisture supplied by frequent irrigation, along with nutrients applied in split doses matched to crop growth stages, promoted rapid cell division and elongation, resulting in greater cane diameter.

Conclusion

Drip irrigation at 1.0 ET_o at germination + 1.2 ET_o at tillering + 1.4 ET_o at canopy establishment + 1.6 ET_o at grand growth + 1.0 ET_o at maturity stage along with 125 per cent RDF through fertigation (I_3F_3) recorded significantly higher parameters *viz.,* plant height, number of tillers, leaf area index, cane diameter, internodal length and number of internodes up to harvest. Performance of control treatments *viz.,* I_1F_1 and RPP surface irrigation (C_2) was significantly lower with respect to growth and yield contributing parameters compared to I_3F_3.

Table 1: Plant height of pre-seasonal sugarcane as influenced by drip irrigation and fertigation

Plant height (cm)						
Treatment		Days After Planting (DAP)				At harvest
		120	180	240	300	
Drip irrigation levels (I)						
I_1	DI at 0.6, 0.8, 1.0, 1.2 and 0.8 ET_o at G, T, CE, GG & M stages, respectively.	93.97^c	149.54^b	215.05^b	265.51^b	392.62^b
I_2	DI at 0.8, 1.0, 1.2, 1.4 and 0.8 ET_o at G, T, CE, GG & M stages, respectively.	108.93^b	172.39^a	233.62^a	281.65^{ab}	411.28^{ab}
I_3	DI at 1.0, 1.2, 1.4, 1.6 and 1.0 ET_o at G, T, CE, GG & M stages, respectively.	116.89^a	184.94^a	247.3^a	296.95^a	431.93^a
	S.Em.±	1.01	1.85	2.61	2.79	4.13
Fertigation levels (F)						
F_1	75 % RDF (through fertigation)	96.31^b	156.31^b	217.80^b	237.44^b	394.69^b
F_2	100 % RDF (through fertigation)	107.64^{ab}	169.82^{ab}	232.43^{ab}	287.69^{ab}	413.44^{ab}
F_3	125 % RDF (through fertigation)	115.85^a	180.74^a	245.69^a	294.97^a	427.70^a
	S.Em.±	2.77	3.77	5.15	2.79	6.53

Interaction (I×F)						
I_1F_1	DI at 0.6, 0.8, 1.0, 1.2 and 0.8 ET_o at G, T, CE, GG & M with 75% RDF	87.24^{e}	135.59^{f}	205.20^{c}	248.93^{e}	384.33^{d}
I_1F_2	DI at 0.6, 0.8, 1.0, 1.2 and 0.8 ET_o at G, T, CE, GG & M with 100% RDF	96.85^{de}	150.31^{d-f}	216.15^{c}	271.60^{c-e}	390.53^{cd}
I_1F_3	DI at 0.6, 0.8, 1.0, 1.2 and 0.8 ET_o at G, T, CE, GG & M with 125% RDF	99.83^{de}	162.73^{c-e}	223.80^{bc}	275.99^{b-d}	403.00^{b-d}
I_2F_1	DI at 0.8, 1.0, 1.2, 1.4 and 0.8 ET_o at G, T, CE, GG & M with 75% RDF	99.45^{de}	161.80^{c-e}	222.50^{bc}	274.47^{b-e}	396.73^{cd}
I_2F_2	DI at 0.8, 1.0, 1.2, 1.4 and 0.8 ET_o at G, T, CE, GG & M with 100% RDF	108.99^{b-d}	174.13^{bc}	231.15^{bc}	275.36^{b-e}	413.67^{b-d}
I_2F_3	DI at 0.8, 1.0, 1.2, 1.4 and 0.8 ET_o at G, T, CE, GG & M with 125% RDF	118.36^{ab}	181.25^{a-c}	247.21^{ab}	295.11^{a-c}	423.44^{a-c}
I_3F_1	DI at 1.0, 1.2, 1.4, 1.6 and 1.0 ET_o at G, T, CE, GG & M with 75% RDF.	104.25^{cd}	171.53^{bc}	225.85^{bc}	278.93^{bc}	403.00^{b-d}
I_3F2	DI at 1.0, 1.2, 1.4, 1.6 and 1.0 ET_o at G, T, CE, GG & M with 100% RDF	117.07^{a-c}	185.03^{ab}	250.00^{ab}	298.12^{ab}	436.12^{ab}
I_3F_3	DI at 1.0, 1.2, 1.4, 1.6 and 1.0 ET_o at G, T, CE, GG & M with 125% RDF	128.36^{a}	198.25^{a}	266.05^{a}	313.80^{a}	456.67^{a}
C_1	Recommended package of practice - DI	108.65^{b-d}	163.95^{cd}	226.10^{bc}	272.10^{c-e}	406.67^{b-d}
C_2	Recommended package of practice - SI	95.84^{de}	143.6^{ef}	207.55^{c}	251.27^{de}	385.67^{d}
	S.Em.±	2.90	4.20	5.74	5.19	7.00

C- Control, DI-Drip irrigation, ETo-Actual evapotranspiration (mm), G-Germination, T-Tillering, CE-Canopy establishment, GG-Grand growth, M-Maturity, RDF-Recommended dose of fertilizer (250:75:190 kg N, P_2O_5 and K_2O per ha) and SI-Surface irrigation.
Means followed by the same letter (s) within a column do not differ significantly by DMRT (P=0.05)

Table 2: Number of tillers per ha of pre-seasonal sugarcane as influenced by drip irrigation and fertigation

Number of tillers per ha					
Treatment		**Days After Planting (DAP)**			
		120	**180**	**240**	**300**
Drip irrigation levels (I)					
I_1	DI at 0.6, 0.8, 1.0, 1.2 and 0.8 ET_o at G, T, CE, GG & M stages, respectively.	50809^{b}	107876^{b}	134152^{b}	110927^{b}
I_2	DI at 0.8, 1.0, 1.2, 1.4 and 0.8 ET_o at G, T, CE, GG & M stages, respectively.	56558^{a}	119437^{a}	146357^{a}	121994^{a}
I_3	DI at 1.0, 1.2, 1.4, 1.6 and 1.0 ET_o at G, T, CE, GG & M stages, respectively.	59279^{a}	126853^{a}	152152^{a}	127354^{a}
	S.Em.±	551.37	1170.78	1441.75	1206.40
Fertigation levels (F)					
F_1	75 % RDF (through fertigation)	52595^{b}	109385^{b}	136784^{b}	113260^{b}
F_2	100 % RDF (through fertigation)	55333^{a}	119402^{ab}	144553^{ab}	120486^{ab}
F_3	125 % RDF (through fertigation)	58718^{a}	125378^{a}	151324^{a}	126529^{a}
	S.Em.±	883.04	1877.36	2288.74	1911.49
Interaction (I×F)					
I_1F_1	DI at 0.6, 0.8, 1.0, 1.2 and 0.8 ET_o at G, T, CE, GG & M with 75% RDF	47952^{e}	100241^{e}	130286^{e}	107387^{d}
I_1F_2	DI at 0.6, 0.8, 1.0, 1.2 and 0.8 ET_o at G, T, CE, GG & M with 100% RDF	50290^{de}	108352^{de}	131766^{e}	108340^{d}
I_1F_3	DI at 0.6, 0.8, 1.0, 1.2 and 0.8 ET_o at G, T, CE, GG & M with 125% RDF	54186^{cd}	115035^{cd}	140404^{de}	117055^{cd}
I_2F_1	DI at 0.8, 1.0, 1.2, 1.4 and 0.8 ET_o at G, T, CE, GG & M with 75% RDF	54066^{cd}	110656^{c-e}	138442^{de}	114850^{cd}
I_2F_2	DI at 0.8, 1.0, 1.2, 1.4 and 0.8 ET_o at G, T, CE, GG & M with 100% RDF	56088^{bc}	120100^{bc}	147650^{b-d}	122345^{bc}
I_2F_3	DI at 0.8, 1.0, 1.2, 1.4 and 0.8 ET_o at G, T, CE, GG & M with 125% RDF	59522^{ab}	127556^{ab}	152980^{a-c}	128788^{ab}
I_3F_1	DI at 1.0, 1.2, 1.4, 1.6 and 1.0 ET_o at G, T, CE, GG & M with 75% RDF	55767^{bc}	117258^{cd}	141626^{c-e}	117544^{cd}
I_3F2	DI at 1.0, 1.2, 1.4, 1.6 and 1.0 ET_o at G, T, CE, GG & M with 100% RDF	59623^{ab}	129756^{a}	154244^{ab}	130775^{ab}
I_3F_3	DI at 1.0, 1.2, 1.4, 1.6 and 1.0 ET_o at G, T, CE, GG & M with 125% RDF	62448^{a}	133545^{a}	160588^{a}	133745^{a}
C_1	Recommended package of practice - DI	53259^{cd}	110212^{c-e}	137411^{de}	112280^{cd}
C_2	Recommended package of practice - SI	48122^{e}	107620^{de}	131247^{e}	107428^{d}
	S.Em.±	944.98	2009.96	2443.21	2035.67

C- Control, DI-Drip irrigation, ETo-Actual evapotranspiration (mm), G-Germination, T-Tillering, CE-Canopy establishment, GG-Grand growth, M-Maturity, RDF-Recommended dose of fertilizer (250:75:190 kg N, P_2O_5 and K_2O per ha) and SI-Surface irrigation.
Means followed by the same letter (s) within a column do not differ significantly by DMRT (P=0.05)

Table 3: Leaf area index of pre-seasonal sugarcane as influenced by drip irrigation and fertigation

Leaf area index						
Treatment		**Days After Planting (DAP)**				**At harvest**
		120	**180**	**240**	**300**	
Drip irrigation levels (I)						
I_1	DI at 0.6, 0.8, 1.0, 1.2 and 0.8 ET_o at G, T, CE, GG & M stages, respectively.	1.57^{b}	4.09^{b}	6.01^{b}	4.54^{b}	3.86^{b}
I_2	DI at 0.8, 1.0, 1.2, 1.4 and 0.8 ET_o at G, T, CE, GG & M stages, respectively.	1.80^{a}	4.74^{a}	7.40^{ab}	6.11^{a-c}	5.16^{a-c}
I_3	DI at 1.0, 1.2, 1.4, 1.6 and 1.0 ET_o at G, T, CE, GG & M stages, respectively.	1.91^{a}	5.11^{a}	7.93^{a}	6.52^{a}	5.53^{a}
	S.Em.±	0.02	0.06	0.36	0.07	0.06
Fertigation levels (F)						
F_1	75 % RDF (through fertigation)	1.61^{b}	4.18^{b}	6.41^{b}	4.98^{b}	4.35^{b}
F_2	100 % RDF (through fertigation)	1.80^{a}	4.72^{ab}	7.14^{ab}	5.89^{ab}	4.92^{ab}

F_3	125 % RDF (through fertigation)	1.88^{a}	5.04^{a}	7.78^{a}	6.31^{a}	5.29^{a}
	S.Em.±	0.04	0.11	0.19	0.15	0.13
Interaction (I×F)						
I_1F_1	DI at 0.6, 0.8, 1.0, 1.2 and 0.8 ET_o at G, T, CE, GG & M with 75% RDF	1.48^{e}	3.53^{e}	5.34^{d}	4.12^{d}	3.37^{e}
I_1F_2	DI at 0.6, 0.8, 1.0, 1.2 and 0.8 ET_o at G, T, CE, GG & M with 100% RDF	1.56^{de}	4.21^{cd}	5.88^{d}	4.35^{d}	3.74^{e}
I_1F_3	DI at 0.6, 0.8, 1.0, 1.2 and 0.8 ET_o at G, T, CE, GG & M with 125% RDF	1.66^{c-e}	4.54^{c}	6.81^{c}	5.17^{c}	4.48^{d}
I_2F_1	DI at 0.8, 1.0, 1.2, 1.4 and 0.8 ET_o at G, T, CE, GG & M with 75% RDF	1.62^{c-e}	4.45^{cd}	6.80^{c}	5.25^{c}	4.44^{d}
I_2F_2	DI at 0.8, 1.0, 1.2, 1.4 and 0.8 ET_o at G, T, CE, GG & M with 100% RDF	1.80^{bc}	4.66^{bc}	7.41^{bc}	6.42^{b}	5.23^{bc}
I_2F_3	DI at 0.8, 1.0, 1.2, 1.4 and 0.8 ET_o at G, T, CE, GG & M with 125% RDF	1.90^{ab}	5.10^{ab}	7.98^{ab}	6.66^{ab}	5.51^{a-c}
I_3F_1	DI at 1.0, 1.2, 1.4, 1.6 and 1.0 ET_o at G, T, CE, GG & M with 75% RDF	1.72^{cd}	4.57^{bc}	7.10^{c}	5.57^{c}	5.03^{c}
I_3F_2	DI at 1.0, 1.2, 1.4, 1.6 and 1.0 ET_o at G, T, CE, GG & M with 100% RDF	1.98^{a}	5.30^{a}	8.12^{ab}	6.89^{ab}	5.69^{ab}
I_3F_3	DI at 1.0, 1.2, 1.4, 1.6 and 1.0 ET_o at G, T, CE, GG & M with 125% RDF	2.04^{a}	5.47^{a}	8.56^{a}	7.11^{a}	5.97^{a}
C_1	Recommended package of practice - DI	1.67^{c-e}	4.43^{cd}	6.89^{c}	5.11^{c}	4.32^{d}
C_2	Recommended package of practice - SI	1.54^{de}	3.90^{de}	5.61^{d}	4.17^{d}	3.42^{e}
	S.Em.±	0.05	0.12	0.19	0.15	0.13

C- Control, DI-Drip irrigation, ETo-Actual evapotranspiration (mm), G-Germination, T-Tillering, CE-Canopy establishment, GG-Grand growth, M-Maturity, RDF-Recommended dose of fertilizer (250:75:190 kg N, P_2O_5 and K_2O per ha) and SI-Surface irrigation.
Means followed by the same letter (s) within a column do not differ significantly by DMRT (P=0.05)

Table 4: Internodal length of pre-seasonal sugarcane as influenced by drip irrigation and fertigation

Internodal length (cm)				
Treatment		Days After Planting (DAP)		At harvest
		240	300	
Drip irrigation levels (I)				
I_1	DI at 0.6, 0.8, 1.0, 1.2 and 0.8 ET_o at G, T, CE, GG & M stages, respectively.	5.46^{a}	8.07^{b}	9.19^{b}
I_2	DI at 0.8, 1.0, 1.2, 1.4 and 0.8 ET_o at G, T, CE, GG & M stages, respectively.	5.70^{a}	8.71^{ab}	10.04^{a}
I_3	DI at 1.0, 1.2, 1.4, 1.6 and 1.0 ET_o at G, T, CE, GG & M stages, respectively.	5.87^{a}	9.21^{a}	10.56^{a}
	S.Em.±	0.07	0.10	0.11
Fertigation levels (F)				
F_1	75 % RDF (through fertigation)	5.47^{a}	8.16^{b}	9.32^{b}
F_2	100 % RDF (through fertigation)	5.72^{a}	8.77^{ab}	9.96^{ab}
F_3	125 % RDF (through fertigation)	5.86^{a}	9.06^{a}	10.50^{a}
	S.Em.±	0.12	0.19	0.21
Interaction (I×F)				
I_1F_1	DI at 0.6, 0.8, 1.0, 1.2 and 0.8 ET_o at G, T, CE, GG & M with 75% RDF	5.28^{b}	7.75^{d}	8.75^{c}
I_1F_2	DI at 0.6, 0.8, 1.0, 1.2 and 0.8 ET_o at G, T, CE, GG & M with 100% RDF	5.50^{ab}	8.10^{cd}	9.22^{c}
I_1F_3	DI at 0.6, 0.8, 1.0, 1.2 and 0.8 ET_o at G, T, CE, GG & M with 125% RDF	5.60^{ab}	8.35^{cd}	9.60^{c}
I_2F_1	DI at 0.8, 1.0, 1.2, 1.4 and 0.8 ET_o at G, T, CE, GG & M with 75% RDF	5.52^{ab}	8.24^{cd}	9.56^{c}
I_2F_2	DI at 0.8, 1.0, 1.2, 1.4 and 0.8 ET_o at G, T, CE, GG & M with 100% RDF	5.71^{ab}	8.70^{b-d}	9.77^{bc}
I_2F_3	DI at 0.8, 1.0, 1.2, 1.4 and 0.8 ET_o at G, T, CE, GG & M with 125% RDF	5.88^{ab}	9.11^{a-c}	10.79^{ab}
I_3F_1	DI at 1.0, 1.2, 1.4, 1.6 and 1.0 ET_o at G, T, CE, GG & M with 75% RDF	5.62^{ab}	8.50^{b-d}	9.65^{c}
I_3F_2	DI at 1.0, 1.2, 1.4, 1.6 and 1.0 ET_o at G, T, CE, GG & M with 100% RDF	5.90^{ab}	9.42^{ab}	10.90^{a}
I_3F_3	DI at 1.0, 1.2, 1.4, 1.6 and 1.0 ET_o at G, T, CE, GG & M with 125% RDF	6.10^{a}	9.72^{a}	11.12^{a}
C_1	Recommended package of practice - DI	5.57^{ab}	8.40^{b-d}	9.50^{c}
C_2	Recommended package of practice - SI	5.30^{b}	8.00^{d}	9.12^{c}
	S.Em.±	0.14	0.10	0.11

C- Control, DI-Drip irrigation, ETo-Actual evapotranspiration (mm), G-Germination, T-Tillering, CE-Canopy establishment, GG-Grand growth, M-Maturity, RDF-Recommended dose of fertilizer (250:75:190 kg N, P_2O_5 and K_2O per ha) and SI-Surface irrigation.
Means followed by the same letter (s) within a column do not differ significantly by DMRT (P=0.05)

Table 5: Cane diameter of pre-seasonal sugarcane as influenced by drip irrigation and fertigation

Cane diameter (cm)				
Treatment		Days After Planting (DAP)		At harvest
		240	300	
Drip irrigation levels (I)				
I_1	DI at 0.6, 0.8, 1.0, 1.2 and 0.8 ET_o at G, T, CE, GG & M stages, respectively.	2.50^{a}	2.74^{b}	2.92^{b}
I_2	DI at 0.8, 1.0, 1.2, 1.4 and 0.8 ET_o at G, T, CE, GG & M stages, respectively.	2.54^{a}	2.90^{ab}	3.14^{ab}
I_3	DI at 1.0, 1.2, 1.4, 1.6 and 1.0 ET_o at G, T, CE, GG & M stages, respectively.	2.62^{a}	3.04^{a}	3.38^{a}
	S.Em.±	0.03	0.03	0.05

Fertigation levels (F)				
F_1	75 % RDF (through fertigation)	2.50^{a}	2.76^{b}	2.94^{b}
F_2	100 % RDF (through fertigation)	2.56^{a}	2.89^{a}	3.13^{a-c}
F_3	125 % RDF (through fertigation)	2.60^{a}	3.02^{a}	3.37^{a}
	S.Em.±	0.06	0.06	0.07
Interaction (I×F)				
I_1F_1	DI at 0.6, 0.8, 1.0, 1.2 and 0.8 ET_o at G, T, CE, GG & M with 75% RDF	2.37^{a}	2.66^{c}	2.70^{e}
I_1F_2	DI at 0.6, 0.8, 1.0, 1.2 and 0.8 ET_o at G, T, CE, GG & M with 100% RDF	2.50^{a}	2.71^{c}	2.90^{de}
I_1F_3	DI at 0.6, 0.8, 1.0, 1.2 and 0.8 ET_o at G, T, CE, GG & M with 125% RDF	2.54^{a}	2.85^{bc}	3.17^{b-d}
I_2F_1	DI at 0.8, 1.0, 1.2, 1.4 and 0.8 ET_o at G, T, CE, GG & M with 75% RDF	2.48^{a}	2.83^{bc}	3.00^{c-e}
I_2F_2	DI at 0.8, 1.0, 1.2, 1.4 and 0.8 ET_o at G, T, CE, GG & M with 100% RDF	2.56^{a}	2.86^{bc}	3.10^{b-d}
I_2F_3	DI at 0.8, 1.0, 1.2, 1.4 and 0.8 ET_o at G, T, CE, GG & M with 125% RDF	2.57^{a}	3.00^{a-c}	3.31^{a-c}
I_3F_1	DI at 1.0, 1.2, 1.4, 1.6 and 1.0 ET_o at G, T, CE, GG & M with 75% RDF	2.56^{a}	2.80^{bc}	3.11^{b-d}
I_3F_2	DI at 1.0, 1.2, 1.4, 1.6 and 1.0 ET_o at G, T, CE, GG & M with 100% RDF	2.61^{a}	3.10^{ab}	3.40^{ab}
I_3F_3	DI at 1.0, 1.2, 1.4, 1.6 and 1.0 ET_o at G, T, CE, GG & M with 125% RDF	2.68^{a}	3.21^{a}	3.62^{a}
C_1	Recommended package of practice - DI	2.53^{a}	2.80^{bc}	3.09^{b-e}
C_2	Recommended package of practice - SI	2.45^{a}	2.70^{c}	2.89^{de}
	S.Em.±	0.07	0.03	0.08

C- Control, DI-Drip irrigation, ETo-Actual evapotranspiration (mm), G-Germination, T-Tillering, CE-Canopy establishment, GG-Grand growth, M-Maturity, RDF-Recommended dose of fertilizer (250:75:190 kg N, P_2O_5 and K_2O per ha) and SI-Surface irrigation.
Means followed by the same letter (s) within a column do not differ significantly by DMRT (P=0.05)

Appendix I
Nutrient management details (kg ha^{-1})

Monthly interval	F_1			F_2			F_3			C_1			C_2		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Germination October	11.75	56.00	8.93	15.62	75.00	11.81	19.56	94.00	14.87	25.00	75.00	19.00	25.00	75.00	190.00
November	23.50	-	17.87	31.25	-	23.75	39.12	-	29.75						
Tillering December	23.50	-	17.87	31.25	-	23.75	39.12	-	29.75	84.73	0	64.12	225.00	0	0
January	23.50	-	17.87	31.25	-	23.75	39.12	-	29.75						
February	11.75	-	8.93	15.62	-	11.81	19.56	-	14.87						
Canopy establishment February	11.75	-	8.93	15.62	-	11.81	19.56	-	14.87	84.73	0	64.12	0	0	0
March	23.50	-	17.87	31.25	-	23.75	39.12	-	29.75						
April	23.50	-	17.87	31.25	-	23.75	39.12	-	29.75						
May	11.75	-	8.93	15.62		11.81	19.56		14.87						
Grand growth May	11.75	-	8.93	15.62	-	11.81	19.56	-	14.87	28.12	0	21.37	0	0	0
June	11.75	-	8.93	15.62		11.81	19.56		14.87	28.12	0	21.37	0	0	0
Maturity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	188	56	143	250	75	190	313	94	238	250	75	190	250	75	190

References

Arnold, J.B., Frensch, J. and Taylor, A.R. (2006). Influence of inorganic nitrogen and pH on the elongation of maize seminal roots. *Ann. Bot.* **97**, 867–873.

Boyer, J.S. (1970). Leaf enlargement and metabolic rates in corn, soybean and sunflower at various leaf water potentials. *Plant Physiol.* 46, 233–235.

Fanish, S.A., Muthukrishnan, P. and Manoharan, S. (2011) Effect of drip fertigation in maize (*Zea mays* L.) based intercropping system. *Indian J. Agric. Res.* **45**(3), 233–238.

FAO (2023) FAOSTAT Crop Production and Water Use Database. Food and Agriculture Organization of the United Nations, Rome.

Gardener, F.P., Pearce, R.B. and Mitchell, R.L. (1985). *Physiology of Crop Plants*. Iowa State University Press, Iowa, p. 327.

Gerbens-Leenes, W. and Hoekstra, A.Y. (2012). The water footprint of sweeteners and bio-ethanol. *Environ. Int.* 40, 202–211.

Gomez, K.A. and Gomez, A.A. (1984). *Statistical Procedures for Agricultural Research*, 2nd Ed. John Wiley and Sons, New York, pp. 108–116.

Jayaram, S.K., Thanunathan, A., Jeyabal, J. and Thiruppathi, M. (2010). Influence of fertigation on sugarcane yield, economics and post-harvest soil status under sandy loam soil condition. *Plant Arch.* **10**(2), 773–775.

Khandagave, R.B., Hapase, D.G. and Somaiya, S.S. (2005). Maximization of sugarcane yields and reduction of production costs – a participatory rural appraisal. In, *Silver Jubilee Cong.*, Guatemala, 30 January–4 February 2005.

Mahendran, S., Arul, J.S., Prabagar, A.C., Rajarathinam, P. and Yeyasrinivas, R. (2005). Effect of paired row planting on growth, yield and economics of sugarcane under drip fertigation system. *S. Indian Sugarcane Sugar Technol. Assoc. J.* **14**, 44–52.

Shukla, S.K., Nagargade, M., Pathak, A.D. and Blessey, M. (2020). Water footprint in sugarcane. Technical Bulletin, ICAR–Indian Institute of Sugarcane Research, P.O. Dilkusha, Lucknow, pp. 1–36.

Sonawane, D.A. and Sabale, R.N. (2000). Effect of different sources of organic nitrogen on growth, yield and quality of Suru sugarcane. *J. Maharashtra Agric. Univ.* **25**(1), 15–17.