



RESEARCH ARTICLE

Optimization of irrigation and fertigation schedule for the sugarcane variety cog 7 under sustainable sugarcane initiative technique

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Abstract

Sugarcane requires adequate water and nutrients for growth and development to produce profitable productivity. Providing optimum water during the growth period increases cane yield through the effective utilization of nutrients. Subsurface drip irrigation is designed to supply the required moisture to the root zone. Sustainable sugarcane initiative under subsurface drip irrigation is gaining importance because of the benefits of water and nutrient use efficiencies. However, varietal or location-specific optimization of moisture and nutrient requirements is warranted to enhance productivity in an ecosystem. Therefore, field experiments in split plot design were conducted at Sugarcane Research Station, Melalathur, Vellore district (Northwestern zone of Tamil Nadu) to optimize suitable irrigation regime and fertilizer levels for the sugarcane variety CoG 7 under the sustainable sugarcane initiative approach. Irrigation regimes in the main plot and nutrient levels in subplots were imposed. The main plot comprised of four irrigation regimes I₁: Subsurface drip at 75 % PE - Irrigation once in two days; I₂: Subsurface drip at 100 % PE - Irrigation once in two days; I₃: Farmers practice – surface irrigation and subplot consist of N₁: 100 % of recommended dose of NPK ha⁻¹ through water-soluble, N₂: 125 % of recommended dose of NPK ha⁻¹ through water soluble, N₃: 100 % of recommended dose of NPK ha⁻¹ through urea, super phosphate and MOP and N₄: 125 % of recommended dose of NPKha⁻¹ through urea, super and MOP. These treatments were replicated thrice. The experiments were conducted for 6 years. The combined result revealed that sub-surface drip irrigation at 100 % PE once in two days and application of 125 % of RDF of NPK ha⁻¹ through water soluble fertilizers recorded the highest cane yield.

Keywords: CoG 7; fertilizer levels; SSI; subsurface irrigation; sugarcane

Introduction

Sugarcane is an important C₄ sugar crop that caters to the sugar demand of India in a greater way. It provides various raw materials to sugar, alcohol, electricity, confectionary, biofuel and manure industries. It supports the biofuel industry in a greater way due to its high dry matter-yielding potential. It is the second most important cash crop next to cotton in India. Sugarcane being a C₄ crop is an efficient solar energy harvester. Bright sunlight, adequate water and nutrients determine the sugarcane growth and productivity. Sugarcane is a semi-perennial crop and duration ranges from 10-18 months and it requires high water and nutrients. Traditionally, sugarcane in India is planted with double/three budded setts in ridges and furrows system of planting (ridges are separated by 60 cm) with open channel flooded irrigation. In the conventional ridges and furrows method of planting, easy intercultural operations (after 4/5 months of crop age) and mechanical harvesting are not possible, which warrants wider row planting. In the wider row planting, population maintenance is the crucial factor

influencing the yield. In the normal double/three-budded sett planting, population maintenance at adequate numbers is tedious due to extreme weather conditions and insect attacks. In the open channel flooded irrigation, in most situations, maintaining soil moisture adequacy is difficult due to the loss of groundwater potential. India's groundwater potential is reduced to approximately 23 % due to irrigation (1). Eventually, this depletion alters water supply rates. For example, in peak summer (March to May), sugarcane's water demand is very rarely met with sufficiency.

Sugarcane needs water sufficiency throughout the growth period for a better yield. Further, the growth and quality parameters of sugarcane are very much influenced by water deficit/excess. A few among them are leaf area index (LAI), dry matter production (DMP), number of tillers (NT), number of millable canes (NMC), number of internodes (NI), internode length (IL), cane girth (CG), stalk length (SL), individual cane weight (ICW) and cane yield (CY) (2). The LAI directly influence the DMP and ultimately the yield. It is a

hydrophyte plant but so sensitive to water-logged conditions (3). Excess and deficit irrigation influences the quality parameters like brix percent (BP), pol percent (PP), purity percent and commercial cane sugar percent (CCS).

Further, in the flooding method of irrigation evaporation loss is more. Additionally, the issues of runoff and deep percolation are also more. This method further reduces water and fertilizer use efficiencies (4, 5). These losses can be minimized by employing effective irrigation methods and delivering water to the root zone. This can be achieved by the micro irrigation system. Sprinkler and drip irrigation methods save more water compared to traditional surfaces. Subsurface drip irrigation is one of the technologies that precisely and directly supplies water directly to the root zone minimizing losses due to evaporation, runoff and deep percolation (6). Subsurface irrigation favours sustained soil moisture in the root zone, enhanced root distribution and reduced salt accumulation in the root zone (7). In addition, it reduces nutrient leaching and weed infestation ultimately improving crop yield (8). sustainable sugarcane initiative (SSI) is another popular method in sugar production in which quality seedlings are produced in controlled conditions. Good quality seedlings after obtaining appropriate growth are transplanted to the field. The SSI ensure adequate plant population. The combination of SSI and subsurface drip irrigation methods can improve sugarcane yield but research on these aspects regarding irrigation methods and fertilizer doses for SSI under the subsurface system of drip irrigation is very limited (9). A single sugarcane variety cannot cater to the needs of the whole sugarcane farmers and thereby necessitates location-specific varieties (10). Salinity is one of the major grave abiotic challenges that reduce sugarcane yield (2). Recently, Tamil Nadu Agricultural University, due to its continuous breeding efforts released a saline-tolerant sugarcane variety CoG 7 (2). Strategic experiments on micro-irrigation can further improve the yielding potential of this variety. Hence, current experiments were carried out to optimize the irrigation regime and fertilizer level for the variety under the SSI system and subsurface drip irrigation system.

Materials and Methods

Experimental location and treatment details

The split-plot experiments with the sugarcane variety CoG 7 (culture number: G2005047) were conducted in the research farms lands of Sugarcane Research Station (SRS), Melalathur, Tamil Nadu Agricultural University, Vellore district to optimize irrigation requirements and fertigation schedule for subsurface irrigation system under SSI technique. The soil type was clay loam. The soil and water pH were 7.4 and 7.7 respectively. The experiments were conducted for six cropping years (from 2018 to 2023). The experiments were replicated thrice. Irrigation regimes in the main plot and fertilizer levels in subplots were imposed. The main plot (comprising various irrigation managements i.e. water regimes) treatments were I₁- Subsurface drip at 75 % PE - Irrigation once in two days, I₂- Subsurface drip at 100 %

PE - Irrigation once in two days and I₃- Farmers practice - surface irrigation. The subplot experiments (fertilizer dose) were N₁- 100 % of the Recommended Dose (RD) of NPK ha⁻¹ through Water-Soluble Fertilizers (WSF), N₂- 125 % of the RD of NPKha⁻¹ through WSF, N₃- 100 % of the RD of NPK ha⁻¹ through urea, superphosphate and MOP and N₄ - 125 % of the recommended dose of NPKha⁻¹ through urea, superphosphate and MOP. Before imposing treatments the soil nutrient status of the experimental field was assessed. The available NPK status of the experimented field soils was low, medium and high respectively.

Raising of seedlings for SSI

The disease and pest-attack-free, single-budded setts of the sugarcane variety CoG 7 were planted in the portray 30 days in advance of planting. The portray mixture comprised of red earth, well-decomposed farmyard manure and coir pith (1:1:1 ratio). The seedlings were grown under the shade net condition with need-based watering.

Details of experimentation

Trenches for the installation of sub-surface drip irrigation were laid at 40 cm depth and 20 cm width. The laterals were placed 30 cm below the soil surface on trenches. The distance between the two laterals was adjusted to 150 cm. Healthy portray grown sugarcane seedlings were planted in 60 cm spacing along laterals. The discharge rate of drippers was adjusted to 4 LPH and the irrigations were scheduled according to treatments (11). The blanket recommended dose of fertilizer 300:100:200 NPK kg ha⁻¹ was applied as fertigation through venturi assembly once in 8 days starting from 16 DAT to 210 DAT (25 times). For fertigation treatments, water-soluble fertilizers like ammonium phosphate (12:61:0) and sulphate of potash (0:0:50) besides commercial fertilizers namely urea and muriate of potash were used. Recommended packages of practices were adopted fully to raise the crop except for irrigation and fertilizer applications.

The applied water quantity in a plot was decided by the number of laterals, spacing between the emitter and water discharge rate. Subsequent irrigations were scheduled depending on plot size and PE values (once in three days through the drip system). The following formula was utilized for its purpose,

$$\text{Volume (1 ha}^{-1}\text{)} = E_{\text{pan}} \times K_p \times K_c \times W_p \text{ (Eqn. 1)}$$

V refers to the volume of water (in liters required for a day)

E_p means the pan evaporation which is measured in mm for a day

K_p denotes the pan co-efficient

K_c indicates the crop co-efficient

W_p states to the wetted area fraction (1.0)

To ensure delivery of the required water for a plot the time of drip operation (TDP) was calculated using the following formula

$$\text{TDP} = (\text{Volume of water required} / (\text{emitter discharge} \times \text{number of emitters})).$$

Data documentation and data analyses

The trait NT was documented at the end of the tillering

phase (120 days). All the tillers in a replication were counted and the averages were arrived at. At 8 months of crop age, when the plants were at their peak growth stage, which is characterized, by the stage when maximum leaves are fully expanded (i.e. the canopy was at its densest), the LAI was calculated. The third leaf from the top was utilized to measure the LAI using the formula: leaf length x leaf width x 0.89. The 0.89 is a correction factor for the shape of the sugarcane leaf.

The experimental crops were harvested at 360 days. At harvest, the traits (i) stalk length, number of internodes/canes, internode length and cane diameter were measured using 50 randomly selected canes in a replication; and (ii) the number of millable canes in a replication was counted. The average data of three replications were utilized for statistical analyses.

The SL is measured from the base node to the internode below the meristem tip. The CG of a cane was measured using a vernier caliper at the bottom, middle and top portion of the cane and the average was arrived. The IL between all internodes in a cane was measured and the average was arrived.

After measuring SL, NI, IL and CG the green top, leaf sheath and other trash matters from the selected canes were removed and the ICW was measured. These clean canes were oven-dried at the appropriate temperature for at least 48 hrs and the DMP was estimated by calculating the difference between fresh and dry weight.

The CY was estimated at harvest. Immediately after harvest before microbial degradation, the juice extracted from the clean canes used for estimation of the BP, PP, CCS and PP, which are considered the main quality parameters in sugarcane, were estimated as per ICUMSA methods (12). The BP in the juice was measured using brix spindles. The spindle unit ranges were 11 to 20 and 21 to 30. The PP was measured by saccharimeter. The formula used was pol factor x correction factor (13). The data on PP and BP were used to arrive at the CCS (14). The SY is calculated in terms of a hectare. The SY was calculated using the data of CY and CCS as follows $SP = (CY \times CCS)/100$. The purity percentage is the ratio between pol and brix percent.

Results and Discussion

In India, sugarcane cultivation and its productivity are challenged by input costs, labour shortage and water availability. However, the demand for sugar grows steadily at a rate of 4 % for a year. Sustaining sugarcane productivity requires efficient input usage and mechanization, which means that 'more productivity with less input'.

Sugarcane is a semi-perennial crop which can produce a profitable productivity to the growers for several years under proper maintenance. It is highly responsive to water and fertilizer. Excess and deficit of these key inputs lead to productivity loss. Excess of water leads to lodging and deficit leads to retarded growth. Excess of fertilization leads to less sugar accumulation and invites stresses and deficit of fertigation leads to retarded growth. Traditionally, in

India, sugarcane is grown in ridges and furrows (60 cm apart) with open flooding type of irrigation. The resource use efficiency with less cost of cultivation cannot be achieved in this system of planting and irrigation. Therefore, the need for devising resource uses efficient and mechanized cultivation become essential in this climatic change era.

SSI is an alternate but improved planting technique evolved with the principles of less seed, less water, wider row planting and effective supply of nutrients at the root zone. In a nutshell under the SSI method, (i) single-budded chips are grown in a shaded condition in the portrayal or raised beds and (ii) vigorous seedlings are alone transplanted in the main field under a wider row system with a micro-irrigation system of irrigation. The advantages of SSI include (i) avoidance of carry-over of sett-borne diseases like red rot through mother cane as only bud chips are used, (ii) required population maintenance is feasible since only well-established seedlings are alone transplanted in the main field, (iii) higher productivity is achievable since the wider spacing between seedlings will improve the tillering ability of the seedlings due to abundance of sunlight and appropriate water and nutrient availability and improve tiller counts which will increase the number of millable canes at harvest and hence enhanced cane yield is realized, (iv) the water and nutrients are used at appropriate levels and hence the cost on inputs gets reduced, (v) mechanized inter-cultural operations are possible and hence dependency of labour gets reduced, (vi) maintenance of healthy crop becomes viable since in the wide row planted crops the incidence of pests and disease will be minimal and hence the chance for yield and quality deterioration becomes minimal (vii) in the wider row-spacing of planting mechanical harvesting is easy and hence the cost spent on harvesting labour becomes minimal and (viii) mechanized harvest ensures timely transport of harvest canes to the crushing yard thereby the cane quality deterioration due to bacterial infection minimized.

Though the SSI method under the micro-irrigation system is advantageous in several ways, not all the sugarcane varieties are suitable for this method. In this system, a wider spacing between seedlings and rows is provided to maximize the tillering ability of the seedlings. The shy tillering varieties are not suitable for this method, because shy tillering cannot produce adequate tillers and hence the required millable canes at harvest cannot be realized. Therefore, the suitability of the saline-tolerant sugarcane variety CoG 7 (2) for the SSI system is to be assessed and further optimization of water and fertilizer for this variety will enhance the productivity in the northwestern zone of Tamil Nadu.

Effect of various irrigation and fertilizer levels on growth parameters of CoG 7.

The drip system of irrigation and its modifications like the sub-surface ensures precise water and nutrient delivery to the root zone at all critical growth stages (15). Irrigation regime and fertilizer levels had a significant effect on the growth parameters of sugarcane (Table 1). Subsurface drip irrigation at 100 % PE irrigation once in two days recorded the highest SL followed by subsurface irrigation at 75 % PE irrigation once in two days. Drip

fertigated at 125 % of the RD of NPK through WSF registered higher SL among the subplot treatments. Interaction between the irrigation regimes and fertilizer showed a significant effect. Subsurface drip irrigation at 100 % PE once in two days with fertigation of 125 % recommended dose of NPK through WSF recorded the highest SL. The increased SL is due to the availability of moisture throughout the crop cycle along with split fertigation of nutrients which ensures sufficient cell perpetuation functions (division and elongation) and eventually affirms significant SL (16). Higher LAI and DMP had significant variations due to irrigation regimes (Table 1). LAI is an important factor in deciding sugarcane yield, as it directly influences the amount of photosynthates. Subsurface irrigation at 100 % PE irrigation once in 2 days recorded the highest value LAI of 4.20 and DMP of 67 t ha⁻¹. Regarding the fertilizer levels, subsurface fertigation at 125 % of the recommended dose of NPK through WSF recorded higher values of 3.99 LAI and 62.7tha⁻¹ of DMP. The combination of subsurface irrigation at 100 % PE irrigation once two days and 125 % of the recommended dose of NPK ha⁻¹ through WSF registered higher LAI and DMP. Nutrient adequacy avoids nutrient deficiencies otherwise nutrient deficiency decreases the leaf expansion rate and consequently, reduces the leaf area and photosynthesis. A reduction in photosynthesis affects the biomass production. In this study, the enhanced DMP may be due to the interaction effect between the continuous availability of soil moisture and nutrition helped to maintain required metabolic activities. This sufficient intake ensures the required NPK levels inside the plant which maintain the cell division, expansion and other metabolic processes at their optimum levels. A positive relationship between the availability of optimum levels of nutrients and biomass yield in sugarcane reported in previous works (17). The optimum nutrient application improves its uptake and use efficiency with additional benefits of improvement in cane production (18). This nutrient adequacy maintains the leaf chlorophyll levels which in turn ensures the supply of photosynthates to the growing tissues and maintains metabolic rates. This metabolic rate maintenance produced more DMP and energy for increased nutrient update with thicker canes (19). A strong and positive association between LAI and sugarcane yield was reported in previous works (20).

Subsurface irrigation 100 % PE irrigation once in two days significantly recorded more NT and in fertilizer levels, 125 % of the recommended dose of NPK ha⁻¹ through WSF recorded the highest NT. Regarding the interaction effect,

the irrigation at 100 % PE once in two days and 125 % of the recommended dose of NPK through WSF recorded higher NT. Application of water-soluble fertilizer by fertigation optimizing nutrient availability during critical stages faster the growth at the formative stage bolstering tiller production and canopy expansion (21). The NMC is one of the important parameters which decides the yield of cane. Increased NMC was recorded with 125 % of recommended NPK through WSF under subsurface drip fertigation. Irrigation at 100 % PE once in two days recorded the higher NMC. Interaction between irrigation regimes and fertilizer levels on NMC showed significance with 100 % PE irrigation once in two days and 125 % of recommended NPK through WSF.

Irrigation at 100 % PE once in two days recorded significantly higher NI (18.7), CG (3.3cm) and ICW (1.44 kg) than farmers practice except for internode length (Table 2). In subsurface drip irrigation, 125 % recommended dose of NPK through WSF recorded a greater number of yield attributes. The increase in yield attributes was observed under 100 % PE irrigation once in two days with 125 % recommended dose NPK through WSF. The reason for increasing yield attributes is due to the adequate availability of nutrients for absorption at appropriate soil moisture for plant absorption. The favourable soil moisture availability in the rhizosphere region by a continuous supply of water under subsurface irrigation led to a higher availability of nutrients for plant uptake ensuring higher yield attributes (22).

Cane and sugar yield

Irrigation regime and fertilizer levels made a significant difference in cane yield (Table 3). Among irrigation regimes, 100 % PE irrigation once in two days significantly produced higher CY (150.6 t ha⁻¹) which was higher than other treatments. More vertical distribution of water and high efficiency of reducing evaporation in soil maintained adequate soil moisture in the growing period and provided better root aeration resulting in more yield by subsurface irrigation (23). In fertilizer levels of 125 % RD of NPK through WSF registered the highest CY (140.3 t ha⁻¹). Subsurface irrigation both at 75 % PE and 100 % PE - irrigation once in two-day intervals with 125 % recommended dose of NPK through WSF significantly registered the higher cane yield (139.4 tha⁻¹ - I₁N₂, 165.2tha⁻¹.I₂N₂) and sugar yield (17.5 tha⁻¹ - I₁N₂, 22.3 tha⁻¹.I₂N₂).

A significant interaction effect was noticed in the irrigation regime and fertilizer levels. The 100 % PE irrigation once in two days along with sub-surface 125 %

Table 1. Effect of subsurface drip irrigation on growth parameters of sugarcane variety CoG 7 under SSI at growth phase*

	Leaf area index (LAI)				Number of tillers ('000/ha)			
	I ₁	I ₂	I ₃	Mean	I ₁	I ₂	I ₃	Mean
N ₁	3.74	4.30	3.30	3.78	140.1	147.9	123.5	137.2
N ₂	3.76	4.87	3.35	3.99	144.1	149.3	128.7	140.7
N ₃	3.45	3.77	3.04	3.42	132.0	146.2	113.2	130.5
N ₄	3.53	3.84	3.06	3.48	139.0	147.2	123.5	136.6
Mean	3.62	4.20	3.19		138.8	147.7	122.3	
	SEd	CD (P=0.05)			SEd	CD (P=0.05)		
I	0.14	0.29			4.85	10.34		
N	0.12	0.26			4.29	9.15		
I x N	0.16	0.34			4.91	10.45		

* Arrived after analysis of mean data of 6 years of experiments

Table 2. Effect of subsurface drip irrigation on yield attributes of sugarcane variety CoG 7 under SSI at harvest*

	Number of internodes/cane (No.)			Internodes length (cm)			Cane diameter (cm)			Individual cane weight (kg)			Stalk length (cm)			Dry matter production (t/ha)								
	I ₁	I ₂	I ₃	Mean	SEd	CD (P=0.05)	I ₁	I ₂	I ₃	Mean	SEd	CD (P=0.05)	I ₁	I ₂	I ₃	Mean	SEd	CD (P=0.05)						
N ₁	16.9	18.8	15.4	17.0	11.0	10.3	11.4	10.9	2.86	3.01	2.62	2.8	1.31	1.44	1.26	1.34	185.7	195.7	176.7	186.0	58.39	67.02	50.03	58.5
N ₂	17.4	20.0	15.9	17.8	10.8	10.2	11.4	10.8	2.90	4.31	2.68	3.3	1.33	1.58	1.30	1.40	188.0	203.9	180.7	190.9	60.79	73.79	53.47	62.7
N ₃	16.2	17.8	14.4	16.1	11.2	10.7	11.6	11.2	2.69	2.97	2.52	2.7	1.22	1.36	1.11	1.23	180.9	188.6	164.1	177.9	51.42	62.75	40.82	51.7
N ₄	16.2	18.1	15.3	16.6	11.4	10.8	11.2	11.1	2.73	2.99	2.53	2.7	1.30	1.38	1.22	1.30	184.9	193.3	172.2	183.5	57.50	64.35	48.32	56.7
Mean	16.7	18.7	15.3	11.1	10.5	11.4	11.4	2.8	3.3	2.6	1.29	1.44	1.22	1.84.9	195.4	173.4	57.0	67.0	48.2					
I	0.61	1.31		0.35	NS	0.11	0.23	0.05	0.10	0.10	0.09	0.09	6.42	13.68		6.42	4.85	10.34						
N	0.54	1.16		0.33	NS	0.10	0.21	0.04	0.09	0.09	0.09	0.09	5.82	12.41		5.82	4.29	9.15						
I x N	0.66	1.40		0.34	NS	0.14	0.30	0.05	0.11	0.11	0.11	0.11	6.70	14.27		6.70	4.91	10.45						

* Arrived after analysis of mean data of six years of experiments

Table 3. Effect of subsurface drip irrigation on yield attributes and yield of sugarcane variety CoG 7 under SSI at harvest*

	Number of millable cane ('000/ha)			Cane yield (t/ha)			Sugar yield (t/ha)												
	I ₁	I ₂	I ₃	Mean	SEd	CD (P=0.05)	I ₁	I ₂	I ₃	Mean	SEd	CD (P=0.05)	I ₁	I ₂	I ₃	Mean	SEd	CD (P=0.05)	
N ₁	125.3	131.7	110.0	122.3	136.5	149.7	115.8	149.7	115.8	134.0	16.8	20.1	14.5	14.5	14.5	17.1	17.1	17.1	17.1
N ₂	128.3	132.9	114.5	125.2	139.4	165.2	116.3	165.2	116.3	140.3	17.5	22.3	14.2	14.2	14.2	18.0	18.0	18.0	18.0
N ₃	117.5	130.1	100.8	116.1	124.5	141.6	89.3	141.6	89.3	118.4	15.4	18.3	11.2	11.2	11.2	15.0	15.0	15.0	15.0
N ₄	123.7	131.0	105.0	119.9	128.9	145.8	107.1	145.8	107.1	127.3	16.4	19.4	13.1	13.1	13.1	16.3	16.3	16.3	16.3
Mean	123.7	131.4	107.6	132.3	150.6	107.1	107.1	150.6	107.1	127.3	16.5	20.0	13.2	13.2	13.2	16.3	16.3	16.3	16.3
I	4.32	9.20		4.95	10.54	10.54	10.54	10.54	10.54	0.66	0.66	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
N	3.82	8.14		4.28	9.12	9.12	9.12	9.12	9.12	0.55	0.55	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17
I x N	4.37	9.30		5.43	11.57	11.57	11.57	11.57	11.57	0.73	0.73	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56

* Arrived after analysis of mean data of six years of experiments

recommended NPK through WSF recorded higher cane yield (165.2 t ha⁻¹). This reason for higher yield may be due to minimum water stress and more moisture spreading resulting in prolific root development that favours immediate absorption of WSF resulting in more nutrient uptake by the roots in soil solution (24, 25).

The SY has also shown a similar trend. The subsurface irrigation at 100 % PE irrigation once in two days with 125 % of recommended NPK through WSF registered higher SY (22.3 t ha⁻¹). This significant enhancement is because of better-aerated roots and adequate availability of water and nutrients for uptake. These favorable water and nutrient availabilities made the plants uptake sufficient quantities ultimately this adequacy converts the tillers into crushable canes (millable canes). This early vigour resulted in better yield. The continuous availability of nutrients and water resulted in increased cane and sugar yield (26).

The better performance of the variety CoG 7 is attributed to the following reasons, under SSI sufficient space was provided between seedlings with a controlled irrigation system. Sufficient spacing improves the tillering ability, which in turn increases the leaf number and leaf area. The higher LAI ensures more sunlight interception and enhanced photosynthetic rate (27). Under SSI, the increase in LAI and adequacy of nutrients improves plant metabolic rates. Like, the nitrogen nutrient enhances the synthesis of amino acids and proteins and potassium increases the enzyme activities related to photosynthesis (27, 28). Further, the enhanced LAI improves the crop growth rate (CGR) due to increased assimilate and dry matter productions which finally resulted in enhanced cane length (29). The cane length is considered an important factor influencing the cane yield (30). The space and water adequacy improves the tillering ability (31). The enhanced CGR supports the development of these tillers into millable canes which eventually leads to higher cane yield and sugar yield (29). Similarly, a positive correlation between cane and sugar yield was reported (32, 33).

Quality of juice

The BP, PP, purity percent and CCS were improved due to the irrigation regime and fertilizer levels as compared to farmers' practice, but the difference was not significant (Table 4). The maximum BP of 21.1 % and sucrose (19.2 %) were recorded with 100 % PE irrigation once in two days and subsurface irrigation with 125 % of the recommended NPK through WSF. Uniform development of millable canes with uniform

maturity at harvest under Irrigation regimes and fertigation resulted in higher quality parameters. Sufficient moisture and required nutrient availability produced better quality parameters due to the expansion of vegetative growth, healthy green leaves and adequate elongation of the stem. These reasons ensured the continuous partitioning of photosynthates to vegetative organs instead of investing them in the production and storage of sugar molecules (34, 35).

Conclusion

The results of this research revealed that sub-surface drip irrigation at 100 % PE once in two days with the application of 125 % of RDF of NPK ha⁻¹ through water soluble fertilizers increased the yield and quality of the sugarcane variety CoG 7.

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Authors' contributions

Conceptualization, methodology, experiments conducted, formal analyses were done by NAS. RS prepared the original draft, editing, conducted experiments, formal analyses and reviewed the manuscript. Writing, review and editing were also done by JN. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical issues: None

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Table 4. Effect of subsurface drip irrigation on juice quality parameters of sugarcane variety CoG 7 under SSI at harvest*

	Brix %				Sucrose %				Purity %				CCS%			
	I ₁	I ₂	I ₃	Mean	I ₁	I ₂	I ₃	Mean	I ₁	I ₂	I ₃	Mean	I ₁	I ₂	I ₃	Mean
N ₁	19.5	21.0	19.7	20.1	17.6	19.1	17.8	18.2	90.5	91.2	90.6	90.7	12.3	13.4	12.5	12.8
N ₂	19.8	21.1	19.3	20.1	17.9	19.2	17.4	18.2	90.6	91.2	90.4	90.7	12.6	13.5	12.2	12.8
N ₃	19.6	20.3	19.8	19.9	17.7	18.4	17.9	18.0	90.5	90.9	90.6	90.7	12.4	12.9	12.6	12.6
N ₄	20.0	20.8	19.4	20.1	18.1	18.9	17.5	18.2	90.7	91.1	90.4	90.7	12.7	13.3	12.3	12.8
Mean	19.7	20.8	19.6		17.9	18.9	17.7		90.6	91.1	90.5		12.5	13.3	12.4	
	SEd	CD (P=0.05)			SEd	CD (P=0.05)			SEd	CD (P=0.05)			SEd	CD (P=0.05)		
I	0.68	NS			0.62	NS			3.0	NS			0.44	NS		
N	0.61	NS			0.56	NS			2.8	NS			0.39	NS		
I x N	0.69	NS			0.63	NS			3.0	NS			0.44	NS		

* Arrived after analysis of mean data of six years of experiments

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