Original Research Article

INFLUENCE OF LEVELS OF WATER SOLUBLE FERTILIZER ON YIELD, QUALITY AND ECONOMICS OF SUGARCANE THROUGH FERTIGATION

ABSTRACT

A field experiment was conducted at ZARS, V. C. Farm, Mandya during 2018-19 to study the effect of water-soluble fertilizer levels (urea, MAP, MOP) under drip fertigation on yield, quality and economics of sugarcane. The investigation was carried out in Randomized Complete Block Design with seven treatments and replicated thrice. The treatments comprised of four levels of fertigation viz., 150, 125, 100 and 75 per cent RDF through water soluble fertilizers, 100 per cent RDF through conventional fertilizers without FYM, 100 per cent RDF through conventional fertilizers with FYM and control. The results revealed that application of 125 per cent RDF through water soluble fertilizers recorded significantly higher yield and yield parameters viz., number of millable canes clump^{-1} (14.33), cane length (346.33 cm), number of internodes cane^{-1}(21.00), cane girth (13.80 cm), single cane weight (2.97 Kg) and cane yield (212 t ha^{-1}) and was on par with 150 per cent RDF and 100 per cent RDF through water soluble fertilizer application. Least number of millable canes clump^{-1}(8.67), cane length (220.00 cm), number of internodes cane^{-1} (17.87), cane girth (10.2 cm), single cane weight (1.72 Kg) and cane yield (112.60 t ha^{-1}) was recorded in control. Quality parameters like pol (18.0%), CCS production (12.44%), sugar yield (26.38 t ha^{-1}) and juice extraction per centage (69.65 %) were observed significantly higher with 125 per cent RDF through drip fertigation and was on par with 150 per cent RDFand 100 per cent RDF through water soluble fertilizer application. Economic perspectives such as higher gross returns (Rs. 487600 ha^{-1}), net returns (Rs. 368532 ha^{-1}) and B: C ratio (4.10) was noticed with application of 125 per cent RDF and hence concluded that fertigation at 125 per cent RDF found optimum for higher yield and net returns.

Key words: Yield, Quality, Economics, drip fertigation, Sugarcane, RDF

1. INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is a versatile crop that provides sugar, bio-fuel, fiber and manure besides many by products. The crop is grown mainly to manufacture sugar and for making *gur*and *khandasari*. It is one of the important commercial crops of sugar in the world. Globally it is cultivated over an area of 24.5 m. ha with a production of 1850 m.t and productivity of 75.5 t ha^{-1} [1]. In India, sugarcane is grown under diverse agro-climatic situations covering an areaof 5.35 m. ha producing 366 m. t of sugarcane with the productivity of 69.02 t ha^{-1} with the distinction of being the second largest producer of sugar after Brazil, and the world's biggest consumer of the sweetener (22.5 m. t)[2]. Karnataka ranks third in area (5.0lakh ha), fourth in production (47 m t) and second inproductivity of 94 t ha^{-1} [3].

Sugarcane being a long duration crop, produces huge amount of biomass and requires large quantity of water compared to other crops. Water requirement of sugarcane under conventional method of cultivation variesfrom 2000 to 2500 mm depending upon soil type and climate. Vagaries of monsoon and declining ground-water resource due to over exploitation have resulted in shortage of fresh water supply for agricultural use. Further, India's water demand will nearly double by 2030 from the present 740 billion m^3 to 1.3 trillion m^3, thus necessitating efficient water management for improving agricultural productivity.

In conventional method of irrigation and fertilizer application, there is considerable loss of water and leaching of mobile nutrients, particularly nitrogen which in turn leads to pollution of water bodies and deterioration of soil health. Providing optimum soil condition throughout the growing period of sugarcane is of paramount importance to realize higher yields. Therefore, drip fertigation, one of the promising potential technologies offers the great scope to increase the cane productivity up to 200-220 t ha^{-1} by saving 40-50 per cent irrigation water with increase in nutrient efficiency by 40 per cent [4].

The combined application of water and fertilizers is ideal for proper crop growth, since irrigation water acts as a carrier for the nutrients that the crops require. Through irrigation system, soluble fertilizers are thus transported directly to the feeding zone by frequent application in small quantities. This provides valuable alternative opportunities for growing crops under conditions close to those of nutrient solution, when properly handled. Though fertigation related research in sugarcane is not limited, identification of location specific optimum levels of fertilizers in sugarcane for drip fertigation to enhance productivity and studying the impact of application of MAP (Mono Ammonium Phosphate) which is an acidic fertilizer requires prime attention. Keeping these facts in mind, the present investigation was taken to know the effect of water-soluble fertilizer levels under drip fertigation on yield, quality and economics ofsugarcane.

2. MATERIALS AND METHODS

The experiment was conducted at Zonal Agricultural Research Station, V. C. Farm, Mandya, during 2018-19. The Soil of the experimental site was red sandy loam with medium organic carbon (0.56 per cent), low available N (273 kg ha^{-1}), medium available P_2O_5 (28 kg ha^{-1}) and available K_2O (268 $kgha^{-1}$). The investigation was carried out in Randomized Complete Block Design with seven treatments and replicated thrice. The treatments comprised of four levels of fertigation *viz*., 150, 125, 100 and 75 per cent RDF through water soluble fertilizers (WSF), 100 per cent RDF through conventional fertilizers without FYM, 100 per cent RDF through conventional fertilizers with FYM and control (Table 1). The land was prepared by ploughing with tractor drawn disc plough followed by disc harrowing and passing cultivator twice to bring the soil to fine tilth.

Layout was prepared with gross plot size of 15.0 m × 10.0 m. Drip irrigation system (pump, filter units, main line and sub line) was installed. The laterals were placed at 1.95 m apart. The drip line was passed in between 30 cm apart paired row at 20 cm. Inline emitters were placed 40 cm apart with discharge rate of 4 lph. The recommended FYM (15 t ha^{-1}) was applied uniformly to all the treatments two week before planting of sets except for control plot. The conventional fertilizers were applied as per recommended dose of fertilizer (250: 100: 125 kg of NPK ha^{-1}), 10 percent N, 100 percent of P & K were applied as basal dose and remaining N was applied as top dressing at 45, 75, 105 days after planting with 20, 30 & 40 percent N. While for drip fertigation plots N, P and K were applied as per nutrient scheduling twice in a week.No irrigation and fertilizers were applied to control plot.

The healthy and viable two eye budded sets were collected from a well grown nine-month-old plant crop of sugarcane and planted in a zig-zag manner in paired rows with spacing of 30 cm between rows and 180 cm between pairs of rows (180-30-180 cm)using VCF-0517 variety.Sugarcane variety VCF-0517 was developed at Zonal Agriculture Research Station, V.C Farm, Mandya and unveiled by UAS-B at Krishi Mela in the year 2017. A new high yielding midlate maturing genotype VCF- 0517 was developed from general cross collection of Co-8371.High yielding (80-90 t/acre), high tillering, better quality, suitable for wide row planting, high jaggery yield and quality and good ratooning ability are general characteristics of this variety. It occupied 80 % of the area in Southern Karnataka.

Weed management was done through application of Metribuzin 70 per cent @ 600 g ha^{-1} at two days after planting. Optimum plant population was maintained by filling the gaps at 30 DAP. Hand weeding was done at 45, 90 and 135 days after planting (DAP) to keep plots weed free. Earthing up was carried out by tractor drawn implement at 105 days after planting. Wrapping and propping were done when the crop attained 10 months age to prevent lodging. Healthy crop stand was maintained by adopting need-based plant protection and recommended package of practices. During harvest five canes from each plot were cut randomly and juice was extracted. Juice samples were analysed for brix, pol and purity per cent content as per the standard procedure. The data was statistically analysed by following the method of **[5].**

2.1 Juice quality parameters

The juice samples extracted by means of a power-driven sugarcane crusher from five canes selected at randomly from the net plot area at harvest were analysed for the following quality parameters.

2.1.1Brix (%)

The brix readings of the filtered juice samples were recorded with the help of brix hydrometer standardized for 27.5 ^{0}C. The juice temperatures were recorded for necessary temperature corrections and expressed in per cent Brix values.

2.1.2 Sucrose or Pol (%)

The juice samples were clarified as per Horne's dry lead sub acetate clarification method **[6]** and filtered through Whatman number 1 filter paper. The pol per cent readings of the filtrates were recorded with the help of polarimeter. The pol readings so recorded were correlated with observed degrees brix with the help of Schmitzs table so as to get the values of pol per cent of juice which is synonymously used for sucrose per cent of juice.

2.1.3 Purity (%)

It is the ratio of pol per cent of juice to the corrected degrees of brix expressed in percentage and the values were computed as per the following formula.

$$\text{Purity coefficent (\%)} = \frac{\text{Pol per cent in juice}}{\text{Corrected brix \%}} \times 100$$

2.1.4 Commercial cane sugar (CCS %)

It is the amount of white commercial sugar that can be obtained from total cane juice after removing total soluble solids. The values of commercial cane sugar on per cent cane basis were computed from the following formula.

$$\text{CCS (\%)} = \{S-(B-S) \times 0.4\} \times 0.73$$

Where,

S=Sucrose per cent in juice

B= Brix per cent in juice

2.1.5 Sugar yield (t ha^{-1})

Sugar yield was calculated by using the following formula as suggested by **[7]**.

$$\text{Sugar yield (t ha}^{-1}\text{)} = \frac{\text{CCS (\%)} * \text{cane yield (t ha}^{-1}\text{)}}{100}$$

Where, CCS = Commercial cane sugar (%)

2.1.6 Juice extraction (%)

$$\text{Juice extraction per cent (\%)} = \frac{\text{Juice weight}}{\text{Cane weight}} \times 100$$

Table 1: Treatment details

Treatment	Details
T_1	Control
T_2	RDF through conventional fertilizers +No FYM
T_3	RDF through conventional fertilizers + FYM
T_4	150% RDF through water soluble fertilizers + FYM
T_5	125% RDF through water soluble fertilizers + FYM
T_6	100% RDF through water soluble fertilizers + FYM
T_7	75% RDF through water soluble fertilizers + FYM

Note: RDF: Recommended Dosage of Fertilizer- 250:100:125 kg N: P_2O_5: K_2O ha^{-1}
FYM: Farm Yard Manure
Conventional fertilizers: Urea, SSP and MOP
Water soluble fertilizers: Urea, MAP and MOP

3. RESULTS AND DISCUSSION

3.1Yield and yield attributes of sugarcane

Drip fertigation of 125 per cent RDF through water soluble fertilizers noticed significantly higher single cane weight (2.97 Kg), cane length (346.33 cm), cane girth (13.80 cm), number ofmillable canes clump^{-1} (14.33), number of internodes cane^{-1} (21.00) and cane yield (212 t ha^{-1})andwas observed to be on par with application of 150 per cent RDF and 100 per cent RDF through water soluble fertilizers, respectively.

Cane yield differed significantly with the application of varied fertigation levels of WSF. Cane yield with the application of 125 per cent RDF through WSF was significantly higher (212.0 t ha^{-1}) than recorded in control (112.60 t ha^{-1}), soil application of 100 per cent RDF through conventional fertilizer with FYM (175.00 t ha^{-1}) and without FYM (171.70 t ha^{-1}) and with 75 per cent RDF through WSF (195.00 t ha^{-1}) treatments and was on par with 150 RDF per cent (205.00 t ha^{-1}) and 100 per cent RDF (200.00 t ha^{-1}) through WSF application. The conventional method of cane cultivation recorded the lowest cane yield (171.7 and 175 t ha^{-1}, respectively) when compared to treatments with varied water soluble fertilizer levels under drip fertigation. This might be due to considerable wastage of plant nutrients to alternate drying and wetting with loss of nutrients through deep percolation below root zone and volatilization of nitrogen resulting in imbalance in soil water metabolism and nutrient environment **[8]**.In addition, drip fertigation of WSF at 75 per cent RDF resulted in significantly higher cane yield (195.00 t ha^{-1}) when compared with application RDF through conventional fertilization without FYM (171.70 t ha^{-1}) and RDF through conventional fertilization with FYM (175.00 t ha^{-1}), it clearly indicates that application of fertilizers through drip fertigation system can improve sugarcane growth and yield parameters with 25 per cent lower dose of fertilizers (Table 2, Fig. 1, respectively).

The increased yield and yield parameters in case of drip fertigation treatments is mainly due to better accessibility of essential nutrients and soil moisture at rhizosphere to encounter the crop requirements with optimum sunlight and better aeration leading to improved yield attributes. The dual row planting system recorded higher individual cane weight and cane yield and was observed to be on par with the similar system of planting at 100 per cent RDF and lower cane yield was noticed in conventional irrigation method. Such findings are comparable to those of **[9]** under drip fertigation at 125 per cent RDF through WSF. The increased individual cane length, girth and number of internodes lead to increased single cane weight and this advantageous influence was due to greater uptake of macro nutrients thereby improving the cell activities which eventually resulted in higher cane weight **[10]**. Comparable results were also reported by **[11], [12], [13]** and**[14].**

3.2 Juice quality

Drip fertigation of 125% RDF through water soluble fertilizers noticed significantly higher Juice extraction per cent (69.65%), pol (%) (18.00 per cent), CCS per cent (12.44 %), sugar yield (26.38 t ha^{-1})and was observed to be on par with application of 150% RDF and 100% RDF through water soluble fertilizers, respectively (Table 3, Fig. 2, respectively). The significant difference due to varied

Table 2: Yield and yield parameters of sugarcane as influenced by levels of water-soluble fertilizers through fertigation

Treatments	Single Cane weight (kg)	Cane length (cm)	Cane girth (cm)	No. of millable canes clump^{-1}	No. of internodes Cane^{-1}	Cane yield (t ha^{-1})	Single Cane weight (kg)
T_1	1.72	220.00	10.2	8.67	17.87	112.60	1.72
T_2	2.05	260.00	11.4	9.80	18.21	171.70	2.05
T_3	2.10	265.00	11.8	10.50	18.40	175.00	2.10
T_4	2.63	337.67	13.00	14.00	20.80	205.00	2.63
T_5	2.97	346.33	13.80	14.33	21.00	212.00	2.97
T_6	2.56	336.00	12.30	13.33	20.50	200.00	2.56
T_7	2.44	305.00	12.40	13.00	19.53	195.00	2.44
S.Em ±	0.10	8.41	0.35	0.34	0.39	5.07	0.10
CD (p≤0.05)	0.31	25.90	1.08	1.05	1.19	15.61	0.31

Note:
T_1: Control
T_2: RDF through conventional fertilizer +No FYM
T_3: RDF through conventional fertilizers + FYM
T_4: 150% RDF through water soluble fertilizers + FYM
T_5: 125% RDF through water soluble fertilizers + FYM
T_6: 100% RDF through water soluble fertilizers + FYM
T_7: 75% RDF through water soluble fertilizers + FYM

WSF levels on quality parameters like brix (%) and purity (%) of cane was not noticed. The Juice extraction per cent, brix, pol, purity, CCS per cent and sugar yield were increased with increase in fertilizer levels up to 125 per cent RDF then declined by further increased in fertilizer level; the results are conformity with **[15].**

The results revealed that, juice quality declined beyond the application of fertilizer 125 per cent RDF. The possible reason for this might be, with increased dose of nitrogen and increased activity of enzymes, which is responsible for degradation of sucrose and changing into glucose and fructose. This is in accordance with**[16]** but they reported the poor quality of juice beyond 300 kg N ha^{-1}. The higher brix, sucrose (pol %) and CCS per cent, sugar yield, juice extraction per cent of sugarcane was obtained in the treatment which received fertigation with 125 per cent RDF than the other fertigation levels. Similar findings were reported by **[17]**.

Table 3: Sugarcane juice quality as influenced by levels of water-soluble fertilizers through fertigation

Treatments	Juice extraction (%)	Brix (%)	Pol (%)	Purity (%)	CCS (%)	Sugar yield (t ha^{-1})	Juice extraction (%)
T_1	53.15	19.07	15.28	80.40	10.05	11.33	53.15
T_2	58.03	20.00	16.20	81.13	10.72	18.40	58.03
T_3	59.98	19.87	16.13	81.32	10.69	18.68	59.98

T_4	69.15	19.93	17.50	87.85	12.06	24.74	69.15
T_5	69.65	20.40	18.00	88.25	12.44	26.38	69.65
T_6	67.46	20.20	17.50	86.81	11.99	24.64	67.46
T_7	62.24	19.60	16.87	86.12	11.51	22.44	62.24
S.Em ±	1.20	0.59	0.13	2.24	0.16	0.62	1.20
CD (p≤0.05)	3.71	NS	0.39	NS	0.51	1.92	3.71

Note:
T_1: Control
T_2: RDF through conventional fertilizer +No FYM
T_3: RDF through conventional fertilizers + FYM
T_4: 150% RDF through water soluble fertilizers + FYM
T_5: 125% RDF through water soluble fertilizers + FYM
T_6: 100% RDF through water soluble fertilizers + FYM
T_7: 75% RDF through water soluble fertilizers + FYM

3.3 Economics

Application of WSF at 150 per cent RDF noticed higher cost of cultivation (Rs. 121211 ha^{-1}) when compared with rest of the treatments. However, application of 125 per cent RDF through WSF recorded higher gross returns (Rs. 487600 ha^{-1}), net returns (Rs. 368532 ha^{-1}) and B: C ratio (4.10) as compared to control (Rs. 258980 ha^{-1}, Rs. 173630 ha^{-1}, 3.03, respectively), soil application of 100 per cent RDF through conventional fertilizer with FYM (GR-Rs. 402500, NR-Rs. 292575 ha^{-1}, B:C ratio-3.66, respectively) and without FYM (GR-Rs. 394910, NR- Rs. 296985 ha^{-1}, B:C ratio-4.03) and with 75 per cent RDF through WSF (Rs. 448500 ha^{-1}, Rs. 333719 ha^{-1}, 3.90) and was on par with 150 RDF per cent (Rs. 471500 ha^{-1}, Rs. 350288.6 ha^{-1}, 3.89) and 100 per cent RDF (Rs. 460000 ha^{-1}, Rs. 343075 ha^{-1}, 3.93) through WSF application (Table 4).

The higher gross return, net return and B:C ratio were mainly due to greater cane yield and sugar yield as reported by **[18], [19], [20]**and**[21]**. Soil application of 100 per cent RDF registered lower gross return, net return and B:C ratio and was mainly due lower cane and sugar yield. This result is analogous with the conclusions of **[22]**.

Table 4: Economics of sugarcane as influenced by levels of water-soluble fertilizers through fertigation

Treatments	Cost of cultivation (Rs ha^{-1})	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C ratio
T_1	85350	258980	173630	3.03
T_2	97924	394910	296985	4.03
T_3	109924	402500	292575	3.66
T_4	121211	471500	350288	3.89
T_5	119067	487600	368532	4.10
T_6	116924	460000	343075	3.93
T_7	114780	448500	333719	3.90

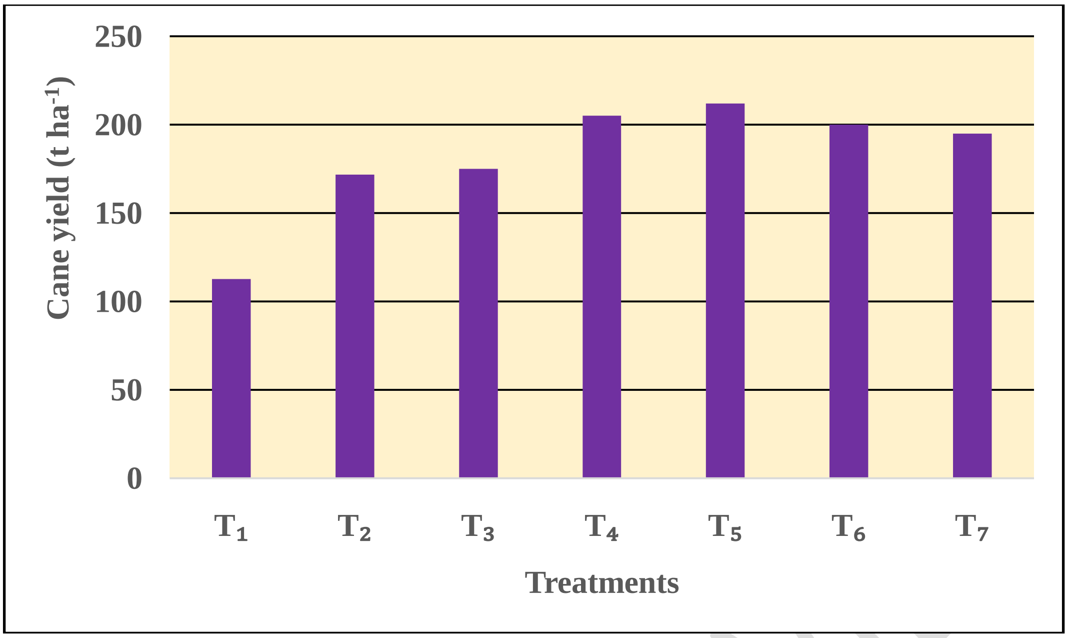

Fig 1: Cane yield (t ha^{-1}) as influenced by levels of water-soluble fertilizers through fertigation

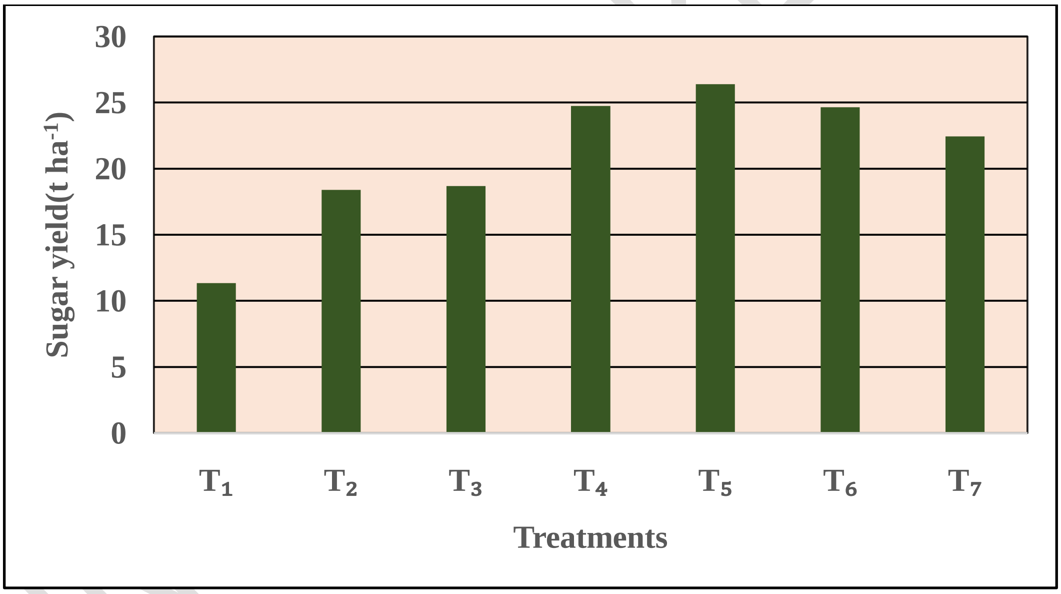

Fig 2: Sugar yield (t ha^{-1}) as influenced by levels of water-soluble fertilizers through fertigation

Note:
T_1: Control
T_2: RDF through conventional fertilizer +No FYM
T_3: RDF through conventional fertilizers + FYM
T_4: 150% RDF through water soluble fertilizers + FYM
T_5: 125% RDF through water soluble fertilizers + FYM
T_6: 100% RDF through water soluble fertilizers + FYM
T_7: 75% RDF through water soluble fertilizers + FYM
RDF-250:100:125 NPK kg ha^{-1}

4. CONCLUSION

The brix values, pol and purity percentage determine the quality of cane. The cane quality is good if it contains 12- 13 per cent of sucrose and purity with minimum amount of reducing sugar. In the present study, the quality parameters were affected due to excess application of fertilizer, *i.e*more than 125 per cent of RDF. Furthermore, higher gross returns (Rs. 487600 ha^{-1}), net returns (Rs. 368532 ha^{-1}) and B: C ratio (4.10) was noticed with application of 125 per cent RDF and hence concluded that drip fertigation is an innovative technology for maximizing the yield. Though the cost of drip fertigation unit was quite high, considering its longer life period, the benefit accrued out of it will be for longer period. Drip fertigation of 125 % RDF through WSF recorded significantly greater cane yield of 212 t ha^{-1} and least cane yield was registered in control and hence concluded that fertigation at 125 per cent RDF found optimum for higher yield and quality of sugarcane.

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