Original Research Article

Effect of water-soluble fertilizers on growth, yield and quality of drip irrigated ratoon sugarcane

Abstract:

A field experiment was conducted at Zonal Agricultural Research Station, V.C. Farm, Mandya during 2020-21 to study the influence of water-soluble fertilizers on phosphorus dynamics and performance ofdrip irrigated ratoon sugarcane. The experiment site was red sandy loam soil with neutral pH, normal electrical conductivity, medium organic carbon, low available nitrogen, medium phosphorus and potassium content. The experiment was laid out in Randomized Complete Block Design with three replications comprising seven treatments with VCF-0517 sugarcane variety. The results revealed that application of WSF at 125 per cent RDF through drip fertigation showed significantly superior growth and yield attributes such as plant height (357.0 cm), no. of tillers clump^{-1} (15.0), internode length (16.67 cm), cane dry weight (54.8 t ha^{-1}), millable canes (8.17 clump^{-1}), cane length (341.67 cm), cane girth (3.30 cm), single cane weight (2.40 kg), number of internodes cane^{-1} (21.40) and cane yield (182.67 t ha^{-1}), while, application of 125 per cent RDF through WSF recorded significantly superior juice qualities such as juice extraction percentage (70) and sugar yield (20.88 t ha^{-1}).

Keywords: Millable cane, brix (%), pol (%), purity (%), commercial cane sugar (%),

Introduction

Sugarcane (*Saccharumofficinarum* L.) is remunerative commercial cropglobally. It is cultivated for the production of sugar, fibre, bio-fuel and manure besides many by-products. The crop is grown primarily for sugar,gur and khandasari production. Due to growing population, demand for sweeteners is ever increasing, hence further emphasis is required in order to grow and produce higher sugarcane. The horizontal expansion of the area under the sugarcane crop in all probability is not possible due to stiff competition from food, fiber and oil seed crops, besides urbanization or industrialization with growing population. Scarcity of water, land and labour, higher cost of inputslimiting

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sugarcane productionworldwide. However, water for irrigation is limited.Its effective management is most critical, not only reducing wasteful usage, but also reducing production costs and sustaining productivity (Qureshi and Afghan, 2005).Innovative technologies namely dripfertigation with water soluble fertilizers will have to be adopted at farm level for enhancing production and productivity of sugarcane with higher resource use efficiency.

The improved irrigation water management with nutrient application is essential not only for increasing yield, but also lowering the cost of cultivation of sugarcane.Fertigation enhances yield of sugarcane by synchronizing nutrient supply as per crop demand besides saving fertilizer to an extent of 25-30 per cent (Bhoi*et al.*, 1999).Fertigation minimizes leaching of water and nutrients from the rhizosphere, thus minimizes groundwater contamination.Through irrigation system, soluble fertilizers are thus transported directly to the feeding zone by frequent application in smaller quantities. This provides valuable alternative opportunities for growing crops under conditions close to those of nutrient solution, when properly handled.The higher installation cost of the drip irrigation system is a major deterrent in adopting the drip system on field scale. However, the cost could be reduced by altering lateral spacing and shifting to a paired row planting system. Though fertigation related research in sugarcane is not limited, identification of location specific optimum levels of fertilizers in sugarcane under drip fertigation to enhance productivity and studying the impact of application of MAP (Mono Ammonium Phosphate) which is an acidic fertilizer requires prime attention.Such information is meager particularly inthe soils of southern dry zone of Karnatakaand therefore the present study.

MATERIAL AND METHODS:

The field experiment was conducted in D block of Zonal Agricultural Research Station, V.C. Farm, Mandya. The station is situated between 12°18’ and 13°04’ North latitude and 76°19’ and 77°20’ East longitude and at an altitude of 697 meters above mean sea level in southern dry zone (Zone–VI of NARP) of Karnataka which falls in southern dry zone (Region III) of India.Ratoon sugarcane was grown with seven treatments replicated thrice by adopting randomized complete block design. Main crop was sowed during December 2018 and it was harvested during January 2020 from onwards crop kept for ratooning and harvested January 2021. The soil belongs *Alfisols* as

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per USDA classification. Composite soil samples were drawn from the experimental site during the growth stages and samples were air dried, powdered, sieved andanalysedfor various physical and chemical properties. Various phenological, physiological, qualitative, chemical and other analytical procedures on cane, juice, jaggery were recorded. Growth observation recorded are plant height (cm), number of tillers, length of internode and cane dry weight (t ha^{-1}). Adopting standard procedure yield parameters viz., single cane weight (kg), cane length (cm), cane girth (cm), number of millable canes and cane yield (t ha^{-1}) were documented at harvest. Juice quality parameters measured are brix (%), pol (%), purity (%), commercial cane sugar (%), sugar yield (t ha^{-1}) and juice extraction (%).Data recorded on various observations *viz*., growth, yield, quality and soil parameters generated from treatments imposed were subjected to analysis of variance as per the procedures outlined by Rangaswamy (2010). The level of significance used in 'F' and 't' tests were at $p \leq 0.05$ and critical difference values were calculated wherever the 'F' test was found to be significant.

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RESULTS AND DISCUSSION:

Growth parameters:

The observations on various growth parameters of ratoon sugarcane such as plant height (cm), number of tillers ($clump^{-1}$), internodal length (cm) and cane dry weight (t ha^{-1}) at the time of harvesting are furnished in Table 1. Application of 125 per cent RDF through WSF recorded significantly higher plant height (357.0 cm) compared to 75 per cent RDF through WSF (325.0 cm). Soil application of 100 per cent RDF through conventional fertilizer with FYM (314.0 cm) and without FYM (304.7 cm) were significantly lower than WSF applied treatments.The plant height increased with increased levels of drip fertigation might be due to continuous accessibility to nutrients and moisture within the rhizosphere and also due to increased root proliferation with better utilization of nutrients. The better availability of nutrients at critical stages of crop growth resulted in greater plant height which helps for cell division, differentiation and cell metabolism in successive stages. The similar observations were noticed by Sivanappan (1996) and Aujla*et al.* (2005) in sugarcane.

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Cane yield mainly depends on the number of millable canes and hence tillering is the principal component attributed towards achieving higher cane yield. Number of tillers $clump^{-1}$ with the application of 125 per cent RDF through WSF was significantly higher

(15.0 clump^{-1}) compared 75 per cent RDF through WSF (11.0 clump^{-1}).Soil application of 100 per cent RDF through conventional fertilizer with FYM (9.33 clump^{-1}) and without FYM (8.0clump^{-1}) showed significantly lower number of tillers per clump compared to WSF applied treatments.Generally, tillering was higher in all the drip fertigation treatments compared to soil application of conventional fertilizers. The application of water-soluble fertilizers (Urea, MAP and MOP) supplied the nutrients during the critical crop growth stages synchronizing with the demand compared to soil application of urea, SSP and MOP in splits.Early vigorous growth of cane with the availability of required quantity of water and nutrients at the early stages with WSF compared to soil application of fertilizers wherein the fluctuation in nutrient availability is very wide (Gouthaman, 1997). Favourable moisture availability under drip fertigationenhanced nutrient uptake and favoured for good tiller production byChandrashekar (2009) and Nadagouda (2011).

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Drip fertigation with different levels of WSF at harvest recorded significantly higher internodal length in T_5 treatment (16.67cm) compared to T_7 treatment (13.0 cm). Whereas significantly lower internodal length was recorded in soil application of conventional fertilizer with FYM (11.50 cm) and without FYM (10.20 cm) compared to WSF applied treatments.The supply of 125 per cent RDF through WSF resulted in thick and longer internodes which can be attributed to timely supply of adequate nutrients and moisture leading to greater photosynthetic activity and transportation of photosynthates intern resulted in rapid cell division and cell elongation (Veeraputhiran*et al.*,2002).

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Drip fertigation with different levels of WSF at harvest recorded significantly higher cane dry weight at 125 per cent RDF (54.8 t ha^{-1}) compared to 75 per cent RDF (47.3 t ha^{-1}). Whereas significantly lower cane dry weight was recorded in conventional fertilizer soil-based application with FYM (44.2 t ha^{-1}) and without FYM (42.0 t ha^{-1}) compared to WSF applied treatments.Higher cane dry weight noticed in drip fertigated treatments might be due to greater nutrient uptake because of continuous and uninterrupted nutrient and moisture supply, which full filled the crop demand. This must have led to increased plant metabolic activity resulting in higher accumulation of dry matter. These findings are in line with Sudha (1990) and Tiwari *et al.* (2012).

Significant influence of different levels of water-soluble fertilizers through dripfertigation on yield determining components such as single cane weight, cane length, cane girth, number of millable cane, number of internodes per cane and cane yield are presented in Table-2.Significantly lower single cane weight was recorded in basal application of conventional fertilizer with FYM (1.35 kg) and without FYM (1.32 kg) compared to WSF applied treatments like T_4, T_5, T_6, $T_{7.}$

The increased cane weight under drip fertigation could be due to better availability of nutrients and soil moisture at the rhizosphere to meet the crop demand with optimum sunlight and better aeration under paired row system of planting. The increased cane length, girth and number of internodes per cane might led to increased single cane weight and advantageous influence was due to greater uptake of nutrients, thereby improving cell division and cell elongation, which eventually resulted in higher cane weight (Jayaram*et al.*, 2010).

Table 1:Growth observation of sugarcane as influenced by levels of water-soluble fertilizers through fertigation

Treatments	Growth parameters			
	Plant height (cm)	**Number of tillers (per clump)**	**Internodal length (cm)**	**Cane dry weight (t ha^{-1})**
T_1: Control	286.7	6.00	8.70	27.8
T_2: RDF through conventional fertilizers +No FYM	304.7	8.00	10.20	42.0
T_3: RDF through conventional fertilizers + FYM	314.0	9.33	11.50	44.2
T_4: 150% RDF through water soluble fertilizers + FYM	354.0	14.67	16.00	54.0
T_5: 125% RDF through water soluble fertilizers + FYM	357.0	15.00	16.67	54.8
T_6: 100% RDF through water soluble fertilizers + FYM	341.7	13.00	14.50	50.5
T_7: 75% RDF through water soluble fertilizers + FYM	325.0	11.00	13.00	47.3
S.Em ±	3.4	0.45	0.48	1.02
CD (p≤0.05)	10.4	1.39	1.48	3.06

Note: RDF: Recommended Dosage of Fertilizer- 250:100:125 kg NPK ha^{-1},**FYM:** Farm Yard Manure,Urea, SSP and MOP applied to soil in T_2 and T_3; Urea, MAP and MOP applied through drip T_4 to$T_{7.}$

Yield parameters:

Cane length at harvest with the application of 125 per cent RDF through WSF was significantly higher (341.67 cm) compared to 75 per cent RDF through WSF (278.33 cm). Soil application of 100 per cent RDF through conventional fertilizers with FYM (240.67 cm) and without FYM (228.33 cm) recorded significantly lower cane length than WSF applied treatments.Drip fertigation with WSF applied treatments recorded higher cane length, which might be because of greater availability of nutrients and soil moisture in the rhizosphere area, which mightcause higher root proliferation and higher nutrient uptake. The results of this investigation are similar to the findings of Dilip and Mandakini(2015).Cane girth of ratoon sugarcane at harvest found significantly higher in 125 per cent RDF through WSF (3.30 cm) compared to75 per cent RDF through WSF (2.50 cm). Drip fertigation treatments recorded significantly higher cane girth compared to conventional fertilizers based soil application with FYM (2.10 cm) and without FYM (1.98 cm).

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Table 2: Yield and yield parameters of ratoon 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})
T_1: Control	1.00	201.00	1.62	5.83	13.90	92.37
T_2: RDF through conventional fertilizers +No FYM	1.32	228.33	1.98	6.43	15.60	139.33
T_3: RDF through conventional fertilizers + FYM	1.35	240.67	2.10	6.55	15.70	146.75
T_4: 150% RDF through water soluble fertilizers + FYM	2.35	333.00	3.24	8.00	20.97	179.92
T_5: 125% RDF through water soluble fertilizers + FYM	2.40	341.67	3.30	8.17	21.40	182.67
T_6: 100% RDF through water soluble fertilizers + FYM	2.00	310.33	2.90	7.60	19.20	168.25
T_7: 75% RDF through water soluble fertilizers + FYM	1.67	278.33	2.50	7.00	17.43	157.67
S.Em ±	0.10	6.57	0.10	0.11	0.52	3.35

CD ($p \leq 0.05$)	0.31	20.25	0.32	0.34	1.59	10.33

Note: RDF: Recommended Dosage of Fertilizer- 250:100:125 kg NPK ha^{-1}, **FYM:** Farm Yard Manure, Urea, SSP and MOP applied to soil in T_2 and T_3; Urea, MAP and MOP applied through drip in T_4 to T_7.

Higher cane girth in WSF applied treatments compared to conventional soil-based applications was mainly due to better availability of water and nutrients that might helped in achieving higher photosynthetic rate, resulting in higher yield parameters.

Application of WSF at 125 per cent RDF through drip fertigation recorded significantly higher number of millable canes at harvest (8.17 $clump^{-1}$) compared to 75 per cent RDF through WSF (7.0 $clump^{-1}$). Soil application of 100 per cent RDF through conventional fertilizers with FYM (6.55 $clump^{-1}$) and without FYM (6.43 $clump^{-1}$) recorded significantly lower millable cane than WSF applied treatments.This increased number of millable cane was also due to better and early conversion of tillers into millable canes. Otherwise, this would have resulted in the excess production of tillers in the early stages and would have diverted plant nutrients unnecessarily for unproductive purpose. These results are in accordance with the findings of Ghugare and Lokesh (2015).

Drip fertigation with different levels of WSF at harvest recorded significantly higher number of internodes per cane with 125 per cent RDF (21.40) compared to 75 per cent RDF (17.43). Whereas, significantly lower number of internodes per cane was recorded in basal application of conventional fertilizer with FYM (15.70) and without FYM (15.60) compared to WSF applied treatments.Thick and longer internodes were noticed with WSF might be due to continuous supply of water and nutrients resulting in higher photosynthetic mobility leading to greater number of internodes per cane (Dillewijn, 2002). Quicker cell division and elongation results in greater number of internodes per cane (Gurusamy*et al.*, 2013).

Soil application of 100 per cent RDF through conventional fertilizers with FYM (146.75 t ha^{-1}) and without FYM (139.33 t ha^{-1}) recorded significantly lower cane yield compared to WSF applied treatments.A greater yield of cane in drip fertigated treatments might be due to higher plant height, number of tillers, internodal length and cane girth. This couldhave resulted in higher production and accumulation of dry matter, higher photosynthetic activity resulting in improved yield and yield parameters. These observations are in conformity with the findings ofRajanna and Patil (2003) and Prabhakar*et al.*, (2014).

Quality parameters:

Significant influence of different levels of water-soluble fertilizers through drip on juice quality parameters such as juice extraction percentage, brix per cent, pol per cent, purity per cent and commercial cane sugar per cent and sugar yield were presented in Table-3.Soil application of 100 per cent RDF through conventional fertilizers with FYM (51.11 %) and without FYM (48.73 %) were recorded significantly lower juice extraction per cent than WSF applied treatments.

Table 3: Juice quality of ratoon sugarcane as influenced by levels of water-soluble fertilizers through fertigation

Comment [MF15]: sugar ratio

Treatments	**Juice extraction (%)**	**Brix (%)**	**Pol (%)**	**Purity (%)**	**CCS (%)**	**Sugar yield** $(t\ ha^{-1})$
T_1: Control	42.14	19.03	15.97	83.85	10.76	9.89
T_2: RDF through conventional fertilizer +No FYM	48.73	19.73	16.56	83.97	11.16	15.55
T_3: RDF through conventional fertilizers + FYM	51.11	18.57	16.50	89.13	11.44	16.79
T_4: 150% RDF through water soluble fertilizers + FYM	67.55	19.00	16.56	87.18	11.38	20.52
T_5: 125% RDF through water soluble fertilizers + FYM	70.02	19.27	17.03	88.95	11.44	20.88
T_6: 100% RDF through water soluble fertilizers + FYM	62.03	18.60	17.50	90.27	11.73	19.72
T_7: 75% RDF through water soluble fertilizers + FYM	56.65	18.50	16.8	88.09	11.25	17.74
S.Em ±	1.30	0.26	0.13	2.63	0.49	0.50

CD ($p \leq 0.05$)	4.00	NS	NS	NS	NS	1.52

Note: RDF: Recommended Dosage of Fertilizer- 250:100:125 kg NPK ha^{-1}, **FYM:** Farm Yard Manure, **CCS:** Commercial cane sugar, Urea, SSP and MOPapplied to soil in T_2 and T_3; Urea, MAP and MOP applied through drip in T_4 to T_7

Effect of different levels of water-soluble fertilizers through drip fertigation and conventional fertilizer application did not influence significantly on quality parameters like brix, pol, purity and ccs per cent.Sugar yield is the product of commercial cane sugar and cane yield and differed significantly among the treatments.The enhanced sugar yield with WSF might be mainly due to improved juice attributes such as brix, pol percent, purity per cent and CCS per cent as a result of consistent millable cane production under drip fertigation treatments. The increased sugar yield is observed under drip fertigation with the use of WSF by Dhotre et al. (2008).

Application of WSF at 125 per cent RDF through drip fertigation showed significant effect on growth attributes such as plant height (357.0 cm), no. of tillers $clump^{-1}$ (15.0 $clump^{-1}$), internode length (16.67 cm) and cane dry weight (54.8 t ha^{-1}).Yield attributes such as number of millable canes (8.17 $clump^{-1}$), cane length (341.67 cm), cane girth (3.30 cm), individual cane weight (2.40 kg) and number of internodes $cane^{-1}$(21.40) were significantly greater due to application of 125 per cent RDF through WSF. Drip fertigation of 125 per cent RDF through WSF recorded significantly higher cane yield of 182.67 t ha^{-1}.Application of 125 per cent RDF through WSF recorded significantly higher juice quality parameters such as juice extraction percentage (70.02 %) and sugar yield (20.88 t ha^{-1}). Other quality attributes like brix (%), pol (%), purity (%) and CCS (%) of ratoon sugarcane exhibited no significant difference due to application of conventional and water-soluble fertilizers.

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REFERENCES:

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AUJLA, M. S., THIND, H. S. AND BUTTAR, G. S., 2005, Sugarcane yield and water use efficiency at various levels of water and N through drip irrigation under two methods of planting. Agric. Water Manag., 71: 167-179.

BHOI, P. G., M. C. BANKAR, B. S. RASKAR AND S. K. SHINDE, 1999, Effect of fertigation and planting technique on yield and quality of suru sugarcane under drip irrigation. Indian Sugar, pp 487-492.

CHANDRASHEKAR, C. P., 2009, Resources management in sugarcane through drip irrigation, fertigation, planting pattern and LCC based on application and area production estimation through remote sensing. Ph.D. Thesis. Univ. Agric. Sci., Dharwad, Karnataka, India.

DHOTRE, R. S., HADGE S. B. AND RAJPUT, B. K., 2008, Influence of subsurface irrigation through porous pipes on the yield and quality of sugarcane. J. Maharastra Agric. Univ., 29(2): 234-237.

DILIP, H. AND MANDAKINI, 2015, Micro irrigation – An advanced technique in sugarcane. National Workshop on micro irrigation techniques in sugarcane. Vasantdada Sugar Institute. pp. 4-7.

DILLEWIJIN, V. C., 2002, Botany of sugarcane. The ChronicaBotanica. com. Waltham, Mass. U.S.A.

GHUGARE AND LOKESH, 2015, Effect of drip and surface methods of irrigation on yield and quality of suru sugarcane. Indian Sugars, 40: 415-418.

GOUTHAMAN, K. C., 1997, Optimizing irrigation schedule for sugarcane with weed management methods. Ph.D., Thesis. Agricultural College and Research Institute, Tamil Nadu Agric. Univ., Madurai.

GURUSAMY, A., MAHENDRAN, P. P., KRISHNASAMY, S. AND BABU, R., 2013, Multispecialty water-soluble fertilizers and sulphur enhances the yield and quality of sugarcane under subsurface drip fertigation system. Int. J. Chem. Environ. Biol. Sci., 1(2): 387-390.

JAYARAM, S. K., THANUNATHAN, A., JEYABAL AND THIRUPPATHI, M., 2010, Influence of fertigation on sugarcane yield, economics and post-harvest soil status under sandy loam soil condition. Plant Arc., 10(2): 773-775.

NADAGOUDA, B. T., 2011, Precision nutrient management in sugarcane. Ph.D. Thesis. Univ. Agric. Sci, Dharwad.

PRABHAKAR, K., KARUNA SAGAR, G., SREENIVASA CHARI, M., KIRANKUMAR REDDY, C. AND CHANDRA SEKHAR. C., 2014, Effect of planting geometry and nitrogen application through fertigation on production and quality of sugarcane. Agric. Sci. Dig., 34(3): 223–225.

QURESHI, M. A. AND AFGHAN, S., 2005, Sugarcane cultivation in Pakistan. Pak. Soci. Sugar tech., 15(2): 102-105.

RAJANNA M. P. AND V. C. PATIL, 2003, Effect of fertigation of yield and quality of sugarcane. Indian Sugar, 60(5): 1007-1011.

SIVANAPPAN, R. K., 1996. Studies on the use of micro irrigation system in season production. In: Micro Irrigation and Fertigation. Ravi publications, Bengaluru: pp 16-35.

SUDHA, H. S., 1990, Effect of spacing and fertilizer levels on the growth and yield of sugarcane. M.Sc (Agri) Thesis, Univ. Agric. Sci., Bangalore.

TIWARI, S. P., PANIGRAHI, H. K., SHARMA, D., AGRAWAL, N., AGRAWAL, R.AND DUBEY P., 2012, Studies of different fertigation levels on morphological characters and yield of tomato under greenhouse condition. Asian J. Hort., 7(2): 613-614.

VEERAPUTHIRAN, R., O. S. KANDASAMY AND S. D. SUNDARSINGH, 2002, Effect of drip irrigation and fertigation on growth and yield of hybrid cotton. J. Agric. Resource Management, 1(20): 88-97.