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Performance of sugarcane cultivars under graded fertility levels

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Abstract
Field study was conducted during 2021-22 to check the performance of sugarcane cultivars under graded fertility levels. The two fertility levels were 100% RDF (250:75:190 kg N: P_2O_5: K_2O ha^{-1}) and 125% RDF (312.5:93.75:237.5 kg N: P_2O_5: K_2O ha^{-1}). The test cultivars were *viz.*, Co 11015, Co 14005, Co 15005, Co 15006, Co 15007, CoSnk 15102, Co 15009, Co 15010, Co 15017, Co 15021, CoN 15071, PI 15131, Co 86032, CoC 671 and Co 09004. The experiment was conducted in factorial RCBD replicated three times. Results indicated that, among the fertility levels, application of 100% or 125% RDF did not differ with respect to yield and quality of sugarcane. Among the cultivars, Co15009 recorded significantly higher cane yield which was on par with the cultivar Co 15006 and checks, Co 86032 and Co 09004. In interactions, application of 125% RDF with cultivar Co 15009 recorded significantly higher yield followed by cultivar Co 15006 and check cultivars Co 86032 and Co 09004 with application of 125% recommended dose of fertilizer.

Keywords: Sugarcane, fertility levels, cultivars, cane yield

Introduction
Sugarcane (*Saccharum* spp. hybrid) is an important industrial crop used for sugar production, bioenergy, and other derivatives. Consequently, it is an economically important crop in tropical and subtropical regions, which is grown in 121 countries on 26.9 million hectares of land with a yield of 70.9 tonnes/hectare. Sugarcane, a renewable and natural agricultural resource, originated in South East Asia and Western India around 327 B.C. It became an important crop in the Indian sub-continent. The distribution of sugarcane worldwide is centered between latitude 36.7° north and 31.0° south of the equator. Sugarcane cultivation has expanded to tropical and sub-tropical regions worldwide. Sugarcane juice is used for making white sugar, brown sugar, jaggery, and ethanol, with the main byproducts being bagasse and molasses. Molasses is the main raw material for alcohol-based industries, while excess bagasse is used in the paper industry and co-generation of power using bagasse as fuel is considered feasible in most sugar mills.

In the world sugarcane cultivation is spread over the 110 countries on an area of 26.2 m ha accounting for production of 1.9 b t with an average 80.0 t ha^{-1} productivity. India stands in second position for area and production of sugarcane next to Brazil. In India, the area is 5.09 m ha with production of 430.5 m t and productivity of 80.5 t ha^{-1}. The sugar recovery (>10%) in Maharashtra, Gujarat and Karnataka ranged from 10.64 to 11.42 per cent with an average recovery of 11.05 per cent. New verities largely contribute in boosting the yield of sugarcane. In spite of notable advancements in sugarcane research and the growth of the sugar industry, the Indian subcontinent continues to record low output (Kulkarni *et al.* 2010) [5] with a high production cost and a low sugar recovery rate. Planting improved cultivars of cane is one of the potential solutions to this problem. (Chattha and Ensunullah, 2003; Chattha *et al.* 2006; Kadam *et al.* 2007) [2, 1, 3] In order to achieve maximum production, a variety's performance rests on how well it adapts to the unique agro-climatic circumstances of the area. According to Kathiresan *et al.* (2001) [4], selecting a variety on its own increases cane output by 28-60%. Varieties assume an essential part in deciding the yield, while, cultural practices and climatic component help to investigate their intrinsic potential. Plsanting of improved sugarcane varieties is the only solution to the problem of low yield and sugar recovery (Chattha *et al*., 2006) [1].

Materials and Methods

Field studies were conducted during 2021-22 at Agriculture Research Station, Sankeshwar, UAS, Dharwad, and Karnataka, India in clay loam soil having pH 7.75 and organic carbon content 0.56%. Objective of the study was to evaluate the performance of sugarcane cultivars under graded fertility levels. The two fertility levels were 100% RDF (250:75:190 kg N: P_2O_5: K_2O ha^{-1}) and 125% RDF (312.5:93.75:237.5 kg N: P_2O_5: K_2O ha^{-1}). The test cultivars were *viz*., Co 11015, Co 14005, Co 15005, Co 15006, Co 15007, CoSnk15102, Co 15009, Co 15010, Co 15017, Co 15021, CoN 15071, PI 15131. Co 86032, CoC 671 and Co 09004. Treatments replicated thrice were tested in factorial RCBD design. Sugarcane was planted having 150 cm row to row spacing. FYM (25 t ha^{-1}), Fertilizer (250 kg N, 75 kg P_2O_5 and 190 kg K_2O kg ha^{-1}), Micronutrients ($ZnSO_4$ and $FeSO_4$ each at 25 kg ha^{-1}) and irrigation were applied according to recommended package of practice for Sugarcane. Phosphorus was applied at sowing time. Nitrogen and Potash were applied in four splits, at Planting (10%), 50 DAP (20%), 90 DAP (30%) and at earthing up *i.e.* 120 DAP (40%). The following observations were recorded.

Number of millable canes: At harvest, all the canes treatment wise were cut, dressed, counted and recorded as number of millable canes per plot. These were expressed as number of millable canes per hectare based on plot size.

Single cane weight

The single cane weight was recorded at harvest. The weight of five millable canes was recorded and the average worked out and expressed as single cane weight in kg.

Cane yield: All the canes in the net plot from each treatment were cut close to the ground level. The green tops and trash were removed and cane yield per plot was recorded at harvest and expressed as tonnes per hectare.

CCS yield

Sugar yield was calculated using the following formula as suggested by Sastry and Venkatachari (1960) [9].

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

Where, CCS = Commercial cane sugar (%)

Juice quality parameters

Brix

The brix readings of the filtered juice samples were recorded with the help of Brix hydrometer standardized for 27.5 ºC. The juice temperatures were also recorded for necessary temperature corrections.

Sucrose or Pol

The juice samples were clarified as per Horne's dry lead acetate clarification method (Meade, 1977) [7] and filtered through Whatman number 1 filter paper. The pol per cent readings of the filtrates were recorded with the help of Polariscope. The pol readings so recorded were corrected 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.

Purity coefficient

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

$$\text{Purity coefficient} = \frac{\text{Pol per cent of juice}}{\text{Brix corrected}} \times 100$$

Commercial cane sugar (CCS) per cent

The values of commercial cane sugar on per cent basis were computed from the following formula.

CCS per cent = {S – (B-S) × 0.4} × 0.73

Where,
S = Sucrose per cent of juice, B = Degrees brix

Resource Use Efficiency parameters

Water Use Efficiency	$\text{WUE (kg ha-mm}^{-1}) = \frac{\text{Cane yield (kg ha}^{-1})}{\text{Total amount of water used (mm)}}$
Agronomic Nitrogen Use Efficiency	It is the yield of cane produced per unit quantity of nitrogen used. Agronomic nitrogen use efficiency (NUE) was calculated by the following formula and expressed as kg kg^{-1}. $= \frac{\text{Economic yield (kg ha}^{-1})}{\text{N dose applied (kg ha}^{-1})}$
Agronomic Phosphorus Use Efficiency	It is the yield of cane produced per unit quantity of phosphorus used. Agronomic phosphorus use efficiency (PUE) was calculated by the following formula and expressed as kg kg^{-1}. $= \frac{\text{Economic yield (kg ha}^{-1})}{P_2O_5 \text{ applied (kg ha}^{-1})}$
Agronomic Potassium Use Efficiency	It is the yield of cane produced per unit quantity of potassium used. Agronomic potassium use efficiency (KUE) was calculated by the following formula and expressed as kg kg^{-1}. $= \frac{\text{Economic yield (kg ha}^{-1})}{K_2O \text{ applied (kg ha}^{-1})}$
Agronomic Nutrient Use Efficiency	It is the yield of cane produced per unit quantity of N, P_2O_5 and K_2O (nutrient) used. Agronomic Nutrient use efficiency (ANUE) was calculated by the following formula and expressed as kg kg^{-1}. $= \frac{\text{Economic yield (kg ha}^{-1})}{\text{N, } P_2O_5 \text{ and } K_2O \text{ dose applied (kg ha}^{-1})}$

Results and Discussion

Yield and yield attributing parameters

Sugarcane yield, number of millable canes (NMC), single cane weight, cane height and girth did not differ significantly due to fertility levels (100 and 125% RDF). Among the cultivars, Co15009 recorded significantly higher cane yield (137.8 t/ha) which was on par with the cultivar Co 15006 (129.0 t/ha) and checks, Co 86032 (144.2 t/ha) and Co 09004 (122.4 t/ha). The significantly lower yield was with cultivar Co 11015 (90.7 t/ha). The NMC and single cane weight followed the same trend.

Among the interactions, application of 125% RDF with cultivar Co 15009 recorded significantly higher yield (149.2 t/ha) followed by cultivar Co 15006 and check cultivars Co 86032 and Co 09004 with application of 125% recommended dose of fertilizer which were on par with each other. Similar trend was recorded with yield attributes *viz*., NMC and single cane weight. The variation is found in sugarcane yield and yield attributing traits due to their different genetic makeup (Varghese *et al*., 1985 and Mali and Singh, 1995) [10, 6].

Quality parameters

Juice quality mainly depends on the genetic nature of the variety. Quality parameters *viz*., per cent brix, pol and purity did not differ significantly among the fertility levels and for interactions. Among the cultivars, significantly higher per cent brix was recorded with Co 11015 (25.57%) followed by cultivars Co 15017 (25.4%) PI 15131 (24.15%) which intern on par with each other. Lowest brix was recorded with Co 15010 (21.06%). Whereas, significantly higher per cent pol was recorded with the same cultivars. Purity followed the same trend as that of brix and pol. Commercial cane sugar per cent (CCS %), the factor of prime importance both for millers and breeders (Nadeem *et al*., 2008) [8], showed significant differences among the varieties. CCS yield did not differ significantly due to fertility levels and for the interactions. Among the cultivars, CSS yield followed the trend of cane yield.

Water use efficiency

Total amount of water used by the sugarcane crop was 1285 mm. Among the cultivars, Co15009 recorded higher water use efficiency (107.2 kg/ha-mm) which was on par with the cultivar Co 15006 (100.4 kg/ha-mm) and checks, Co 86032 (112.2 kg/ha-mm) and Co 09004 (95.3 kg/ha-mm). Among the fertility levels application of fertilizer at 125% RDF recorded higher water use efficiency (96.2 kg/ha-mm).

Nutrient use efficiency

Among the cultivars, Co15009 recorded higher agronomic nitrogen use efficiency (551.2 kg/kg), agronomic phosphorus use efficiency (1837.3 kg/kg), agronomic potassium use efficiency (725.3 kg/kg) and agronomic nutrient use efficiency (267.6 kg/kg). Among the fertility levels application of fertilizer at 125% RDF recorded higher agronomic nitrogen use efficiency (494.2 kg/kg), agronomic phosphorus use efficiency (1647.2 kg/kg), agronomic potassium use efficiency (650.3 kg/kg) and agronomic nutrient use efficiency (239.9 kg/kg).

Table 1: Yield and yield attributes of sugarcane cultivars as influenced by fertility levels

		Yield (t/ha)			No. of millable canes ('000/ha)			Single cane weight (kg)		
		F_1	F_2	Mean	F_1	F_2	Mean	F_1	F_2	Mean
V_1	Co 11015	88.9	92.5	90.7	89.47	96.77	93.1	1.46	1.55	1.51
V_2	Co 14005	106.3	129.5	117.9	87.85	99.84	93.8	1.42	1.49	1.46
V_3	Co 15005	102.5	103.8	103.2	92.16	93.41	92.8	1.33	1.39	1.35
V_4	Co 15006	126.5	131.4	129.0	89.15	95.14	92.1	1.62	1.73	1.68
V_5	Co 15007	104.4	127.3	115.9	80.58	87.74	84.2	1.70	1.81	1.74
V_6	CoSnk15102	111.9	115.3	113.6	87.20	89.44	88.3	1.46	1.67	1.57
V_7	Co 15009	126.3	149.2	137.8	93.82	99.78	96.8	1.83	2.17	2.00
V_8	Co 15010	107.4	133.4	120.4	86.56	90.95	88.8	1.85	1.76	1.81
V_9	Co 15017	116.9	126.5	121.7	93.82	99.61	96.7	1.47	1.53	1.50
V_{10}	Co 15021	95.9	103.2	99.6	84.91	89.93	87.4	1.33	1.55	1.44
V_{11}	CoN 15071	118.3	123.0	120.7	84.53	89.46	87.0	1.81	1.85	1.83
V_{12}	PI 15131	109.3	121.1	115.2	83.61	88.39	86.0	2.43	2.47	2.45
V_{13}	Co 86032	136.0	152.3	144.2	93.45	104.32	98.9	1.89	2.22	2.06
V_{14}	CoC 671	116.3	118.9	117.6	81.91	85.61	83.8	1.99	2.11	2.05
V_{15}	Co 09004	118.9	125.9	122.4	85.27	89.67	87.5	1.79	1.83	1.81
	Mean	112.4	123.6		87.6	93.3		1.69	1.81	
		F	V	FXV	F	V	FXV	F	V	FXV
	S. Em. ±	3.89	7.8	11.4	1.9	6.4	8.9	0.048	0.056	0.082
	C.D.	NS	22.1	35.3	NS	18.3	27.1	NS	0.159	0.268

*F1- 100% RDF and F2- 125% RDF

Table 2: Juice quality parameters of sugarcane cultivars as influenced by fertility levels

		Brix (%)			Pol (%)			Purity (%)		
		F_1	F_2	Mean	F_1	F_2	Mean	F_1	F_2	Mean
V_1	Co 11015	25.61	25.53	25.57	23.17	22.00	22.58	90.45	86.24	88.34
V_2	Co 14005	24.52	24.28	24.40	21.12	20.01	20.56	86.15	82.41	84.28
V_3	Co 15005	24.52	23.78	24.15	21.36	21.60	21.48	87.13	90.88	89.01
V_4	Co 15006	23.42	22.87	23.15	18.43	21.38	19.91	78.96	93.46	86.21
V_5	Co 15007	22.96	22.38	22.67	19.64	18.08	18.86	85.83	80.69	83.26
V_6	CoSnk15102	23.55	23.13	23.34	19.92	20.53	20.23	84.74	88.83	86.79
V_7	Co 15009	22.15	22.07	22.11	19.63	19.82	19.73	88.72	89.86	89.29

V_8	Co 15010	20.44	21.67	21.06	18.07	19.68	18.88	88.60	90.98	89.79
V_9	Co 15017	25.10	25.70	25.40	22.30	22.39	22.34	88.88	87.24	88.06
V_{10}	Co 15021	23.86	23.11	23.48	20.87	21.35	21.11	87.49	92.37	89.93
V_{11}	CoN 15071	23.00	21.56	22.28	19.39	17.97	18.68	84.38	83.38	83.88
V_{12}	PI 15131	24.36	23.94	24.15	21.88	21.90	21.89	89.84	91.45	90.65
V_{13}	Co 86032	22.66	22.95	22.81	19.91	19.60	19.76	87.84	85.44	86.64
V_{14}	CoC 671	24.02	23.44	23.73	20.93	21.15	21.04	87.11	90.22	88.66
V_{15}	Co 09004	24.42	23.85	24.13	21.36	21.60	21.48	87.44	90.56	89.00
	Mean	23.64	23.35		20.53	20.60		86.90	88.27	
		F	V	FXV	F	V	FXV	F	V	FXV
	S. Em. ±	0.24	0.38	0.58	0.16	0.38	0.55	0.19	1.60	2.20
	C.D.	NS	1.09	NS	NS	1.09	NS	NS	4.57	NS

*F_1- 100% RDF and F_2- 125% RDF

Table 3: CCS per cent and CCS yield of sugarcane cultivars as influenced by fertility levels

		CCS (%)			**CCS yield (t/ha)**		
		F_1	**F_2**	**Mean**	**F_1**	**F_2**	**Mean**
V_1	Co 11015	16.20	15.03	15.61	14.4	13.9	14.2
V_2	Co 14005	14.42	13.35	13.89	15.3	17.3	16.3
V_3	Co 15005	14.67	15.14	14.90	15.0	15.7	15.4
V_4	Co 15006	11.99	15.17	13.58	15.2	19.9	17.6
V_5	Co 15007	13.37	11.94	12.66	14.0	15.2	14.6
V_6	CoSnk15102	13.48	14.23	13.86	15.1	16.4	15.7
V_7	Co 15009	13.60	13.81	13.71	17.2	20.6	18.9
V_8	Co 15010	12.50	13.78	13.14	13.4	18.4	15.9
V_9	Co 15017	15.46	15.37	15.42	18.1	19.4	18.8
V_{10}	Co 15021	14.37	15.07	14.72	13.8	15.6	14.7
V_{11}	CoN 15071	13.10	12.07	12.59	15.5	14.8	15.2
V_{12}	PI 15131	15.25	15.39	15.32	16.7	18.6	17.7
V_{13}	Co 86032	13.73	13.32	13.53	18.7	20.3	19.5
V_{14}	CoC 671	14.37	14.77	14.57	16.7	17.6	17.1
V_{15}	Co 09004	14.70	15.12	14.91	17.5	19.0	18.3
	Mean	14.08	14.24		15.8	17.5	
		F	V	FXV	F	V	FXV
	S. Em. ±	0.09	0.35	0.49	0.43	1.21	1.71
	C.D.	NS	1.00	NS	NS	3.45	NS

*F_1- 100% RDF and F_2- 125% RDF

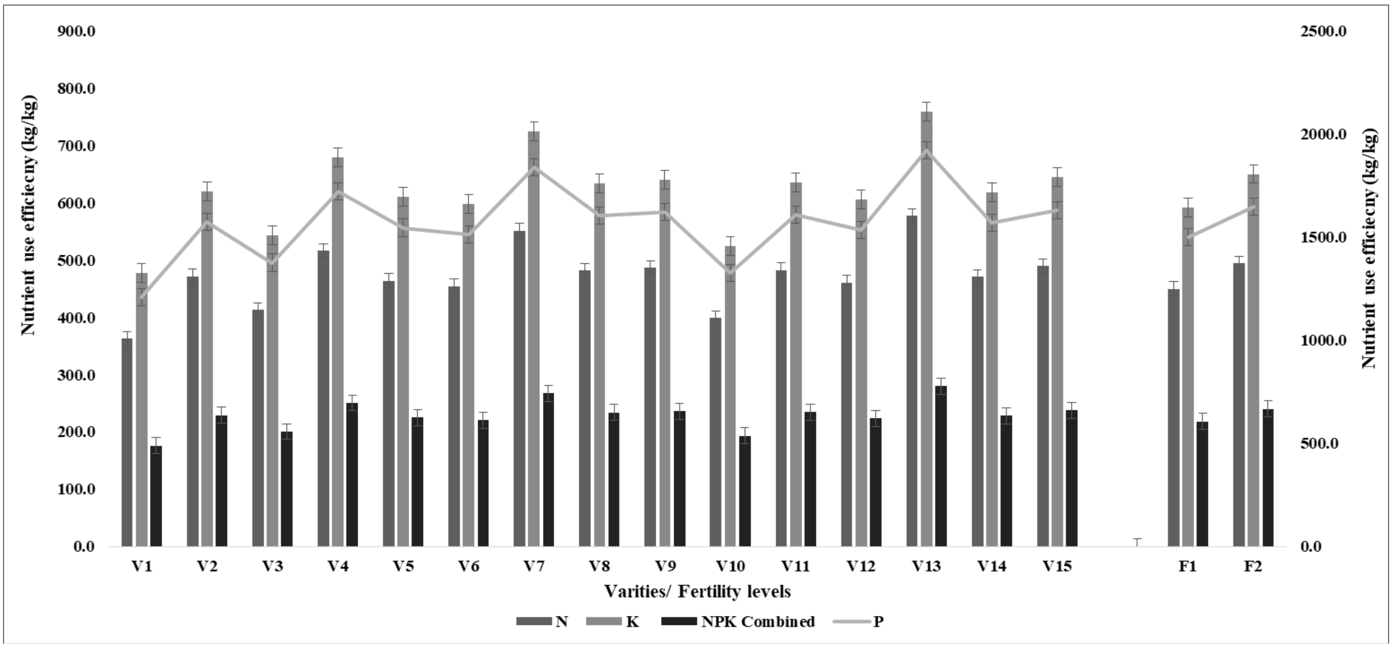

Fig 1: Nutrient use efficiency as influenced by verities and fertility levels

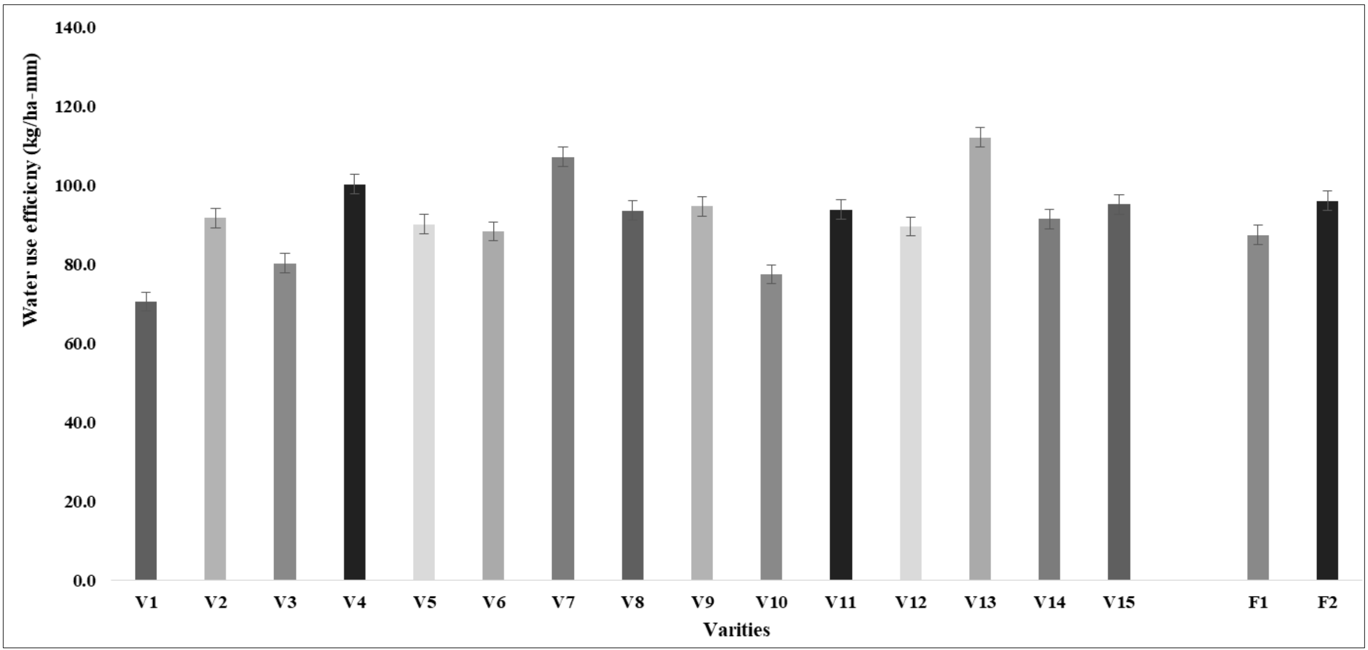

Fig 2: Water use efficiency as influenced by verities and fertility levels

Conclusion

Among the fertility levels, application of 100% or 125% RDF did not differ with respect to yield and quality of sugarcane. Among the cultivars, Co15009 recorded significantly higher cane yield which was on par with the cultivar Co 15006, Co 86032 and Co 09004. In interactions, application of 125% RDF with cultivar Co 15009 recorded significantly higher yield followed by cultivar Co 15006 and check cultivars Co 86032 and Co 09004 with application of 125% recommended dose of fertilizer.

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