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Darpana Patel
Soil and Water Management Research Unit, Navsari Agricultural University, Navsari, Gujarat, India

Mukesh Chaudhari
Agricultural Research Station, Aseda, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat, India

Correspondence
Darpana Patel
Soil and Water Management Research Unit, Navsari Agricultural University, Navsari, Gujarat, India

Production potential and economics of sugarcane based cropping system

Darpana Patel and Mukesh Chaudhari

Abstract
Field studies were taken for three seasons (2016-17 to 2018-19) at the Main Sugarcane Research Station, Navsari Agricultural University, Navsari 396450, Gujarat to studies the production potential and economics of sugarcane based cropping system. Experimental results indicated that sugarcane-Ratoon (trash mulching with *Trichoderma*)-Maize produced significantly higher values of growth attributes (no. of tillers and plant height), yield contributing parameters (no. millable cane, cane and CCS yield) as compared to other cropping system in the study. Cane yield (118.66 t ha^{-1}) obtained under T_5 system (Sugarcane-Ratoon (trash mulching with *Trichoderma*)-Maize) was higher to the tune of 13.19%, 5.64%, 3.46, 8.39%, 19.53%, and 6.42% respectively than that of T_2 (Sugarcane-ratoon-moong bean), T_3 (Sugarcane-ratoon-(trash mulching without *Trichoderma*)-Maize), T_4 (Sugarcane-Ratoon-(trash removal without *Trichoderma*)-Maize), T_6 (Sugarcane-Ratoon-Maize (trash incorporation through rotavator and *Trichoderma* incorporation before sowing of Maize)), T_7 (Sugarcane-Ratoon-Maize (Zero tilled) without *Trichoderma*) and T_8 (Sugarcane-Ratoon-Maize (Zero tilled) with *Trichoderma*). Cane equivalent yield (CEY) and economic analysis revealed that the higher CEY (175.08 t ha^{-1}) was recorded highest with cropping system T_1 while net profit (₹ 436954 ha^{-1}) and benefit cost ratio (4.24) were recorded in T_5 cropping system as against other cropping system. Commercial cane sugar per cent was also recorded significantly highest in T_5 cropping system and exhibited almost similar trend as the yield of cane under different cropping systems while juice quality parameters did not alter significantly. Thus, sugarcane-Ratoon (trash mulching with *Trichoderma*)-Maize can be initiated as cropping system for reaping higher production potential and net return.

Keywords: Sugarcane production, sugarcane based cropping systems, economics

Introduction
Intensification of cropping is the need of the day to increase monetary output from the available land. The per capita availability of land is consequently decreasing while food and fodder demand is increasing. A cropping system signifies the system of crops grown over a specific piece of cultivated land and to increase the benefits from the available physical resources. Therefore, the basic approach in an efficient cropping system is to increase production and economic returns (Yadav *et al*. 1998) [8]. A flexible cropping system helps in capturing economic opportunities and environmental realities (Gangwar *et al*. 2004) [3] and in ensuring balanced farm growth at regional level (Reddy and Suresh 2009) [5]. Hence, selection of component crops needs to be suitably planned for efficient utilization of resource base and to increase overall productivity (Anderson 2005) [1]. Inclusion of crops like oilseeds, pulses, vegetables and fodder crops will improve the economic condition of small and marginal farmers owing to higher price and/or higher volume of their main and by-products (Sharma *et al*. 2007) [6]. Rice is the major and most common *kharif* crop of the high rainfall area and mainly grown rainfed either by transplanting or direct seeding by drilling. Rice transplanting on puddled soil is complicated and highly labour intensive. The timely availability of labour for transplanting is a big problem in most area. Moreover, under puddled condition, though the yield of paddy is high it has its own limitations and ill effects on soil health and subsequent sequential field crops on same field. Puddling results in poor soil physical condition for establishment and raising the succeeding crops (Tripathi *et al.*, 2003) [7]. An effective crop rotation not only helps to increase the crop productivity, economics and soil fertility, but also improve the water use efficiency by reducing weeds, providing conducive microclimate for plant growth and development as well as physical properties of the soil (Faroda *et al.*, 2007) [2]. To find alternative and more remunerative cropping system this experiment was conducted.

Material and Methods
Field experiments were conducted at the Main Sugarcane Research Station, Navsari Agricultural University, Navsari, Gujarat during the years 2016-17 to 2018-19. The soil of

experimental field was deep black clayey with pH 8.19, organic carbon 0.61 %, medium in available nitrogen and phosphorus and high in available potash.

The experiment was conducted in randomized block design with three replications and eight treatments to sugarcane based cropping system. The treatment details for cropping system are given below:

T_1 : Rice-Maize
T_2 : Sugarcane-Ratoon-Moong bean
T_3 : Sugarcane-Ratoon (trash mulching without *Trichoderma*)-Maize
T_4 : Sugarcane-Ratoon (trash removal without *Trichoderma*)-Maize
T_5 : Sugarcane-Ratoon (trash mulching with *Trichoderma*)-Maize
T_6 : Sugarcane-Ratoon-Maize (trash incorporation through rotavator and *Trichoderma* incorporation before sowing of Maize)
T_7 : Sugarcane-Ratoon-Maize (Zero tilled) without *Trichoderma*
T_8 : Sugarcane-Ratoon-Maize (Zero tilled) with *Trichoderma*

Recommended dose of fertilizer for plant crop: 250-125-125 kg NPK ha^{-1}, ratoon crop: 300-62.5-125 kg NPK ha^{-1}), Rice-100-30-0 kg NPK ha^{-1}, Green gram-20-40-0 kg NPK ha^{-1} and Maize-120-60-0 kg NPK ha^{-1}.

Recommended dose of fertilizer N (RDFN) were applied in four splits *viz.*, 15 % as basal, 30 % at 1.5 to 2 month after planting, 20 % at 3 to 3.5 month after planting and 35 % at final earthing up. Full dose of P and K was applied as basal to plant while for ratoon crop it was applied in three splits viz., 25 % as basal, 50 % at 2-3 month after planting and 25 % at 4-5 month after planting. Sugarcane CoN 05071 was planted in autumn season every year at row spacing of 90 cm using 50,000 setts ha^{-1} (2 eye bud setts). The plant crop was harvested in January/February and treatments for ratoon crop were imposed. Maize and green gram crop was planted in *Rabi* and rice in *kharif*. Crops under different cropping system were raised with recommended package of practices under irrigated conditions. Rice was conventionally transplanted in the end of June with 25 days old seedling after normal puddling. Transplanting of rice was done at row to row distance of 20 cm. Maize was grown at row distance of 60 cm and green gram at 30 cm in *rabi* season. The juice quality observations were recorded from the five cane samples taken from each plot and analysed for CCS % cane as per the procedure described by Meade and Chen (1977) [4]. To compare the crop system, the yields of all crops were converted into cane equivalent yield on the basis of prevailing market prices. All the data recorded for three years of experimentation were got pooled and later on analysed statistically to interpret the results.

Results and Discussion

Experimental data presented in Table 1 revealed that number of tillers was significantly affected at various growth stages due to different cropping system. Significantly highest tillers population were recorded with cropping system T_5 and at par with all the treatment except T_1 and T_2 cropping system at almost all the growth stages. Significantly highest plant height was recorded with cropping system T_5 and remained at par with T_4 and T_6. The probable reason for the increase in this growth attributes under T_5 cropping system having sufficient time for vegetative growth and more interception of solar radiation resulted to higher tiller production and plant height. Significantly highest number of millable canes was counted under cropping system T_5 and at par with T_3, T_4, T_6 and T_8. Cane length, cane diameter and single cane weight was not significantly influenced due to various cropping system. A perusal of data summarized in Table 1 also indicated that the cane and CCS yield was recorded highest with cropping system T_5 and remained at par with T_3, T_4, T_6 and T_8. It may be due to higher number of millable canes and cane weight under this cropping system. Rice and green gram grain yield in different cropping system was almost normal while maize grain yield grown after harvest of ratoon crop was recorded highest with cropping system T_5 (Sugarcane-Ratoon (trash mulching with *Trichoderma*)-Maize) followed by rice-maize cropping sequence (T_1). Quality parametres did not alter significantly due to different cropping system (Table 2).

A perusal of three seasons mean data summarised in Table 3 revealed that among different crop systems, the highest cane equivalent yield (175.08 t ha^{-1}) was obtained with crop system T_1 (Rice-maize) while net return (₹ 436954 ha^{-1}) and b: c ratio (4.24) was recorded with cropping system, Sugarcane-Ratoon (trash mulching with *Trichoderma*)-Maize (T_5), followed closely by T_4 (Sugarcane-Ratoon (trash removal without *Trichoderma*)-Maize). The higher net returns and b: c ratio was obtained from the cropping system T_5 was apparently due to higher cane price on account of improved production potentials of the system and thereby fetched to more economic gains.

Conclusion

It can be concluded that farmers of the area can follow cropping system Sugarcane-Ratoon (trash mulching with *Trichoderma*)-Maize have been observed more productive, sustainable and economically viable that fetched more net returns. This can be better system for the farmers growing sugarcane of south Gujarat.

Table 1: Effect of different cropping system on growth and yield parameters (Pooled)

Treatment	Number of tillers (000 ha^{-1}) at			Plant height (cm) at			NMC at harvest (000 ha^{-1})	Cane length (cm) at harvest	Cane diameter (cm) at harvest	Single cane wt. at harvest (kg)	Cane yield (t ha^{-1})	CCS yield (t ha^{-1})	Grain Yield (q/ha) other than sugarcane	
	90 DAP	120 DAP	180 DAP	90 DAP	120 DAP	180 DAP							Kharif	Rabi
T_1	-	-	-	-	-	-	-	-	-	-	-	-	53.46	49.34
T_2	141.75	149.03	115.83	101.37	137.08	193.63	94.12	278.64	2.59	1.63	103.01	14.91		10.51
T_3	159.86	169.46	135.64	113.16	149.36	206.82	99.75	283.60	2.53	1.63	111.97	15.88		46.69
T_4	157.93	164.08	130.29	117.45	150.61	206.79	105.26	264.22	2.49	1.74	114.56	16.18		40.86
T_5	171.20	181.53	146.03	130.31	162.83	221.63	108.93	285.88	2.60	1.76	118.66	17.20		55.31
T_6	160.05	167.77	133.98	118.93	151.62	206.73	102.17	263.39	2.50	1.55	108.71	15.88		48.64
T_7	161.13	167.02	133.60	102.40	138.17	193.34	85.16	266.87	2.47	1.75	95.48	13.51		42.69
T_8	162.73	170.34	136.64	113.68	148.91	202.31	99.68	282.33	2.49	1.50	111.04	15.58		39.86
S.Em. ±	4.90	4.60	4.46	4.46	5.14	6.34	3.36	8.02	0.08	0.09	3.80	0.64		-
C.D.at 5%	14.15	13.28	12.88	12.89	14.84	NS	10.44	NS	NS	NS	10.97	1.85		-

Table 2: Effect of different cropping system on quality parameters (Pooled)

Treatments	Brix %	Pol % juice	Purity %	CCS %	Fibre %	Pol % cane
T_1	-	-	-	-	-	-
T_2	22.02	19.92	90.28	14.11	14.05	15.18
T_3	22.38	20.55	91.81	14.47	14.07	15.59
T_4	22.09	20.30	91.86	14.29	14.05	15.44
T_5	22.40	20.30	90.96	14.14	14.05	15.38
T_6	22.60	20.64	91.25	14.50	14.16	15.69
T_7	23.02	21.13	91.56	14.60	14.18	15.99
T_8	22.09	19.94	90.35	14.07	13.94	15.20
S.Em. ±	0.24	0.32	0.63	0.25	0.12	0.24
C.D.at 5%	NS	NS	NS	NS	NS	NS

Table 3: Effect of different treatments on gross returns, variable cost, net returns and B: C ratio (pooled)

Treatments	Cane equivalent yield (t ha^{-1})	Gross returns (₹ ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net return (₹ ha^{-1})	B : C ratio
T_1	175.08	127719	35362	92357	3.61
T_2	121.59	480881	125739	355142	3.82
T_3	132.61	524462	134475	389987	3.90
T_4	132.62	524521	132491	392030	3.96
T_5	144.61	571943	134990	436954	4.24
T_6	130.21	514971	133488	381483	3.86
T_7	114.35	452253	129524	322729	3.49
T_8	128.66	508851	130027	378824	3.91

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