Research Article

Effect of Subsoiling and Preparatory Tillage on Growth, Yield and Quality of Spring Sugarcane (*Saccharum Officinarum* L.)

P.M. Chaudhari*, K.C. Ombase, S.K. Ghodke, D.S. Potdar, D.S. Bhoite and A.V. Solanke

Central Sugarcane Research Station, Padegaon – 415 521, Tal. Phaltan, Dist.Satara M.S. India

Abstract

Field experiment was conducted at research farm of Central Sugarcane Research Station, Padegaon, Dist. Satara (M.S.) for three years during spring season of 2008-09 to 2010-11 and ratoon in 2009-10 to study the effect of sub soiling on sugarcane growth and yield, physico-chemical properties of soil. The experiment consisting of five subsoiling practices (no subsoiling, subsoiling at 1.0 m distance, subsoiling at 1.5 in distance, cross subsoiling at 1.0 to distance and cross subsoiling at 1.5 m distance) and two preparatory tillage practices (four and two harrowing) was laid out in strip plot design with three replications. Crop grown with cross subsoiling at 1.0 in distance recorded significantly higher cane and CCS yield (118.78 and 17.19 t ha^{-1}, respectively), which was 24.86 and 31.72 % higher than no subsoiling treatment, respectively. Preparatory tillage with four harrowing registered significantly highest cane yield (110.25 t ha^{-1}). The same treatment of cross subsoiling at 1.0 to distance and preparatory tillage with four harrowing registered significantly higher germination, tillering ratio, millable height, girth and weight per cane. The sub soiling and preparatory tillage practices failed to bring significant variations in juice quality. The cross subsoiling at 1.0 in distance recorded lowest bulk density at middle of june and at harvest of sugarcane.

Keywords: Subsoiling, Tillage, Brix, Commercial cane sugar, Juice quality

***Correspondence**
Author: P.M. Chaudhari
Email: omrutusan@gmail.com

Introduction

Sugarcane *(Saccharum* species hybrid) is a major cash crop of India. The productivity of sugarcane in India is quite low owing to several factors viz., poor crop management, poor soil condition, extreme weather situation, abiotic and biotic stress, etc. Hence, there is great need to enhance sugarcane productivity.Ratooning is an integral part of sugarcane based cropping systems and accounts for ever 50 % cane area but contributes only 30-35 % towards total cane production in India. The productivity of ratoon is far less than plant crop. Thus, ratoon holds a great promise for enhancing sugarcane production and sugar output commensurate with the demand of burgeoning population for sweeteners, in the present scenario of globalization. Intense mechanization involving traffic of heavy machinery from planting to harvesting and transporting to the sugar mill or distillery deteriorates for soil physical condition. Soil compaction results in increased bulk density, reduction in porosity, infiltration rates, water storage capacity and impedes of root penetration. Preparatory tillage operations are usually carried out using harrow and rotavator. However, the depth of tillage confined to 10-15 cm of repeated operation by harrows for long time results in hard pan in plough sole. Subsoiling allows for rapid infiltration and breaks up the formation of sheet and rill flow before it reaches scouring velocities. Subsoiler improves soil structure by establishing a system of deep cracks and fissures in the subsoil, facilitating the downward movement of water, air and roots to greater depth of soil profile enabling plants to better withstand short term anaerobic conditions [1, 2]. The function of harrowing or rotavation is to loosen the upper layer of the plough zone and to break it down into relatively small aggregates, while keeping it smooth. Harrowing and rotavator is done to a shallow depth to crush the clods and to uproot the remaining weeds and stubbles. Management of top soil helps in better moisture conservation, which is essential for proper establishment of the crop.

Hence, the present study was conducted to study the effect of subsoiling and preparatory tillage on sugar yield, juice quality and economics in sugarcane plant -ratoon crop sequence.

Materials and Methods

Field experiment was conducted at research farm of Central Sugarcane Research Station, Padegaon, Dist. Satara (M.S.) for three years during spring season of 2008-09 to 2010-11 and ratoon in 2009-10 to study the effect of sub soiling on sugarcane growth and yield, physico-chemical properties of soil. The treatments consisting of five subsoiling treatments viz., no subsoiling (S_1), subsoiling at 1.0 m distance (S_2), subsoiling at 1.5 m distance (S_3), cross

subsoiling at 1.0 m distance (S_4) and cross subsoiling at 1.5 m distance (S_5) and two preparatory tillage practices of four harrowing (H_1) and two harrowing (H_2) were laid out in strip plot design with three replications. The $N:P_20_5:K_20$ doses were applied 250:115:115 kg ha^{-1} in plant crop and ratoon crop. Soil of the experimental plot was clay loam having pH 8.2, organic carbon 0.78 %, available nitrogen 216.2 kg ha^{-1}, phosphorus 20.1 kg ha^{-1} and potassium 342.8 kg ha^{-1}. The initial soil bulk density was 1.228 and 1.239 Mg CM^{-3} in 0-30 and 30-60 cm depth, respectively. Subsoiling was done by subsoiler with depth of 60 cm. Planking was done to break the clods and level the field after final tilling. Sugarcane cv. Co 86032 was planted at 100 cm row spacing. The weight of millable cane from each net plot was recorded with the help of platform balance and yield per hectare was calculated on the basis of net plot. The size of net plot was 8 m x 4 m. Brix, sucrose and CCS % were determined as described by [3]. The juice purity was computed by dividing sucrose by brix content of the juice. The commercial cane sugar (CCS) was computed by multiplication of available sugar (%) by cane yield. The data pertaining to growth, yield and quality parameters were statistically analyzed as per the procedure laid out by [4].

Results and Discussion

The perusal of data presented in **Table 1** revealed that cross sub soiling at 1.0 m distance produced significantly higher cane and CCS yields (118.78 and 17.19 t ha^{-1} respectively) followed by cross sub soiling at 1.5 m distance. The preparatory tillage of four harrowings produced significantly higher cane yields (110.25 t/ha) than two harrowings. The interactions between sub soiling and preparatory tillage in respect of pooled cane yield and CCS yield was found to be non-significant. The increase in cane yield under cross subsoiling at 1.0 m over no subsoiling was 24.86 %. Such increase in yield might he attributed to better crop growth owing to more aeration, root proliferation and more mobilization of nutrients. The low yield under no subsoiling may be imputed to inferior soil environment. [5] and [6] also noted less cane yield under no subsoiling operation. The variations in CCS yield due to preparatory tillage practices were found non significant.

Table 1 Sugarcane and CCS yields (t/ha) as affected by various treatments

Treatments	Cane yield (t/ha)					CCS yield (t/ha)				
	08-09	09-10	10-11	Ratoon	Pooled mean	08-09	09-10	10-11	Ratoon	Pooled mean
A) Sub soiling treatment										
No sub Soiling	95.94	98.78	99.41	**87.22**	**95.13**	12.52	13.45	13.72	11.98	13.05
Sub soiling at 1.0 m	104.38	107.46	113.05	98.63	106.94	14.78	14.99	15.51	13.89	14.80
Sub soiling at 1.5 m	101.41	106.56	117.35	94.40	106.10	13.77	14.66	16.29	13.14	14.70
Cross sub soiling at 1.0 m	117.66	120.09	126.30	109.96	118.78	17.25	17.07	17.72	16.78	17.19
Cross sub soiling at 1.5 m	111.25	115.69	118.89	102.84	112.47	16.06	16.27	16.39	14.64	15.75
SE+	0.25	2.31	5.56	1.50	1.34	0.12	0.33	0.80	0.53	0.27
C.D at 5%	0.83	7.55	NS	4.90	4.36	0.39	1.08	NS	1.71	0.87
B) Preparatory tillage										
4 harrowings	107.38	111.48	118.56	100.03	110.25	15.09	15.57	16.44	14.14	15.38
2 harrowings	104.88	107.75	111.43	97.19	105.53	14.66	15.01	15.41	14.03	14.81
SE+	0.22	1.93	2.52	1.57	0.99	0.06	0.27	0.37	0.44	0.17
C.D at 5%	0.69	NS	NS	NS	3.13	0.18	NS	NS	NS	NS
C) Interaction										
SE+	0.49	4.31	5.63	3.52	2.23	0.13	0.60	0.83	0.98	0.38
C.D at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Growth and quality parameters

The pooled mean data pertaining to growth and quality parameters are presented in **Table 2**. The cross sub soiling at 1.0 m distance recorded significantly higher germination (73.40 %), tillering ratio (1.69), millable height (227 cm), girth (9.8 cm), number of internodes per cane (25) and weight per cane (1.18 kg). However, it was found at par with sub soiling at 1.5 m distance in respect of tillering ratio (1.65) and millable height (222 cm). The results on millable canes at harvest were found not significant. The preparatory tillage with four harrowing registered significantly higher germination (68.62 %), tillering ratio (1.61), millable height (219 cm), girth (9.4 cm) and weight per cane (1.11 kg)

over two harrowings. The results on number of internodes per cane and millable canes were non significant. The interactions between sub-soiling and preparatory tillage were found to be non-significant in all these growth and yield attributes.

The cross sub soiling at 1.0 m distance recorded significantly higher brix (21.84) and sucrose (20.14 %), however sucrose was on par with cross sub- soiling at 1.5 m distance. The preparatory tillage with four harrowing recorded significantly higher brix (21.33) and sucrose (19.77 %). However, purity and CCS % did not differ significantly due to sub soiling and preparatory tillage. The better juice quality obtained under cross sub- soiling at 1.0 m distance was possibly due to overall good plant growth enabling plants to accommodate more photosynthesis for synthesis of juice sucrose. These findings are inclose conformity with those of [6], [7] and [8].

Table 2 Growth and yield attributes as affected by various treatments (Pooled mean)

Treatments	Germ. (%)	Tillering Ratio	Height (cm)	Girth cm)	Internode /cane	Canes (000/ ha)	Wt./ cane (kg)	Brix (c)	Sucrose (%)	Purity (%)	CCS (%)
A) Sub soiling treatment											
No sub Soiling	62.15	1.47	207	8.8	19	95.77	1.00	20.42	19.25	94.29	13.71
Sub soiling at 1.0 m	68.11	1.60	218	9.4	22	97.05	1.10	21.28	19.70	92.59	13.92
Sub soiling at 1.5 m	65.59	1.55	213	9.2	20	100.41	1.06	21.01	19.56	93.10	13.85
Cross sub soiling at 1.0 m	73.40	1.69	227	9.8	25	100.49	1.18	21.84	20.14	92.27	14.20
Cross sub soiling at 1.5 m	70.46	1.65	222	9.5	23	98.65	1.13	21.41	19.84	92.68	14.02
S.E.±	0.32	0.02	1.58	0.05	0.54	2.13	0.01	0.10	0.09	0.31	0.07
C.D. at 5%	1.03	0.05	5.14	0.15	1.75	NS	0.04	0.32	0.30	NS	NS
B) Preparatory tillage											
4 harrowings	68.62	1.61	219	9.4	23	98.89	1.11	21.33	19.77	92.72	13.98
2 harrowings	67.26	1.58	216	9.2	22	98.06	1.08	21.05	19.62	93.25	13.91
S.E.±	0.10	0.005	0.29	0.02	0.25	1.24	0.004	0.05	0.02	0.22	0.02
C.D. at 5%	0.30	0.02	0.90	0.06	NS	NS	0.01	0.14	0.05	NS	NS
C) Interaction											
S.E.±	0.21	0.01	0.64	0.04	0.57	2.77	0.009	0.10	0.04	0.50	0.05
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Bulk density

The bulk density of soil was reduced in all the treatments of sub soiling and preparatory tillage over initials at 0 to 30 cm and 30 to 60 cm depth. However, the cross sub soiling at 1.0 m distance recorded lowest bulk density at both 0 to 30 cm and 30 to 60 cm depth (1.211 and 1.219 Mg cm^3, respectively) at middle of June and (1.214 and 1.222 Mg cm^3, respectively) at harvest of sugarcane. The cross sub soiling at 1.5 m distance was the next best treatment recorded (1.214 and 1.222 Mg cm^3, respectively) at middle of June and (1.218 and 1.225 Mg cm^3, respectively) at harvest of sugarcane (Table 3). These results are in conformity with [9].

Table 3 Pooled mean data on soil properties at harvest as affected by sub soiling and preparatory tillage treatment

Treatments	pH	EC	O.C.	Ava.Nutrient (kg/ha)			Bulk density (Mg CM^{-3}) Mid June		Bulk density (Mg CM^{-3}) After harvest	
				N	P_2O_5	K_2O	0-30	30-60	0-30	30-60
A) Sub soiling treatment										
No sub Soiling	7.73	0.23	0.56	267	17.8	285	1.220	1.229	1.224	1.232
Sub soiling at 1.0 m	7.87	0.22	0.59	264	20.2	281	1.216	1.224	1.218	1.227
Sub soiling at 1.5 m	7.86	0.23	0.57	242	19.8	264	1.215	1.223	1.218	1.226
Cross sub soiling at 1.0 m	7.92	0.20	0.61	258	20.3	275	1.211	1.219	1.214	1.222
Cross sub soiling at 1.5 m	7.80	0.21	0.59	255	19.9	275	1.214	1.222	1.218	1.225
B) Preparatory tillage										
4 harrowings	7.78	0.21	0.58	251	18.7	272	1.215	1.223	1.218	1.226
2 harrowings	7.90	0.23	0.59	264	20.5	280	1.215	1.224	1.219	1.227
Initial	8.20	0.22	0.78	216	20.1	343	1.228	1.239	1.228	1.239

Conclusion

The cross sub soiling at 1.0 m distance and the preparatory tillage with four harrowings found beneficial for higher Cane yield, CCS yield and to reduce bulk density of soil which is essential for better soil aeration, root growth and ultimately for better crop growth.

References

[1] Carter, M.R., D.A. Holmstrom. L.M. Cochrane, P.C. Brenton, J.A. Roestel, D.R. Van Langille, W.G. Thomas, and J.A. Van Roestel. 1996. Persistence of deep loosening of naturally compacted subsoils in Nova Scotia. Canadian Journal of Soil Science 76(4): 541-547.

[2] Raper, R.L., D.W. Reeves, and E.C. Burt. 1998. Using in-row subsoiling to minimize soil compaction caused by traffic. Journal of cotton Science 2: 130-135.

[3] Spencer, G.L. and G.P. Meade. 1955. Cane sugar hand book. A manual for calfe sugar manufacturers and their chemists. London: Willey, Inc. N.Y. Chapman, and Hall Ltd. Springer.

[4] V. G. Panse and P. V. Sukhatme. 1967. "Statistical Methods for Agricultural Workers," 2nd Edition, Indian Council of Agricultural Research, New Delhi,

[5] Jagpat, R.B., S.D. Kamathe, V.R. Athare, B.B. Gumal, R.B. Pawar, and D.B. Hapase. 1991. Effect of sub-soiling in soils with excess water or with a hard pan on soil properties and Sugarcane quality and yield. In: Proceedings of XXII international society of sugarcane technologist, 267-271 Bangkok: Kasetsart University.

[6] Mandal S. 2007. Design and development of subsoiler-cum-differential rate fertilizer applicator and its evaluation on sugarcane crop. M.Tech. Thesis, 178. Pantnagar: G. B. Pant University Agriculture and Technology.

[7] Jagpat, R.B., S.D. Kamathe, and V.R. Athare. 1995. Effect of subsoiling in soils with excess water or with a hard pan on soil properties and sugarcane quality and yield. In: Proceedings of XXI congress of the international society of sugarcane technologists, 657. Bangkok: Kasetsart, University.

[8] Singh, P. 2008. Studies of pre-planting tillage operations and fertilizer placement in sugarcane. M.Sc. Thesis, 110. Pantnagar: G.B.Pant University of Agriculture and Technology.

[9] Bodhinayake W.L, Thenabadu M.W., Somapala H. and N. Dharmawardene 1998.Effects of Sub-Soiling on Soil Physical Properties and Root Distribution in Sugarcane. Tropical Agricultural Research Vol. 10, 48-60.

Publication History
Received 27th Jan 2018
Revised 26th Feb 2018
Accepted 10th Mar 2018
Online 30th Mar 2018