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Short Communication

Evaluating the Suitability of Tillage Technique in Paddy–Sugarcane Crop Sequence for Higher Yield under South Gujarat Condition

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Paddy–sugarcane cropping sequence is the most common and predominant in area of clayey soils of South Gujarat. The practice of puddling though benefits paddy cultivation, it often adversely affects the succeeding upland crops by altering physical, physico-chemical and microbiological properties of the soil. Puddling operation through tractor affect soil structure very badly, making soil more and more compact. Further, more use of tractors, fertilizers and limited application of organic manures (owing to unavailability) have accentuated further deterioration of soil physical properties causing water-logging and decreased yield of sugarcane under paddy-sugarcane cropping sequence in this region of South Gujarat in the recent past. More mechanization coupled with unavailability of organics has ultimately led farmers to apply less organics in soil to sustain its physical, chemical and microbiological properties. Unpuddled transplanting of rice and chiseling and deep plowing operation in subsequent sugarcane crop may not only improve drainage, but also reduce the compaction, and thereby increase the yield of sugarcane. The single parameter 'soil tillage' may have large bearing on the overall production of paddy-sugarcane sequence in this region. So, keeping all background in mind an experiment was planned to evaluate suitability of tillage technique for higher yield in paddy- sugarcane crop sequence.

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An experiment was conducted on *Typic Chromustert* from 2005 to 2007 on paddy-sugarcane crop sequence at Main Sugarcane Research Station, NAU, Navsari, with an objective to evaluate the suitability of tillage technique in paddy–sugarcane cropping sequence for higher yield. The rainfall received during 2005, 2006 and 2007 were 2435.1, 1855.1 and 1687.5 mm, respectively in 58, 65 and 81 rainy days in chronological order. The maximum temperature recorded during summer season of 2005, 2006 and 2007 were 36.5, 37.0 and 40.5^{0}C respectively, while the minimum temperature registered during the winter season were 9.5, 10.0 and11.5^0 C, respectively in chronological order. The soils of the experimental site was clayey, low in available N, medium in available P and high in available K, having $pH_{2.5}$ 7.62, $EC_{2.5}$ 0.46 dSm^{-1} and organic carbon 5.0 g kg^{-1}. The bulk density (BD), infiltration rate (IR), water stable micro- (0.053-0.25 mm) and macro-aggregates (>0.25mm) in beginning of the experiment were 1.73 Mg m^{-3}, 8.8 mm h^{-1}, 15.2 and 84.8 per cent, respectively. The experiment was conducted in split-plot design with four replications. Before rainy season land was prepared every year by cultivating twice with tractor-drawn-cultivator. Then after the onset of monsoon four types of puddling treatments viz. M_1: Unpuddled (only planking,), M_2: Plogh and planking with bullock, M_3: Power tiller puddling and M_4: Tractor puddling were imposed in four main large plots of rice before transplanting. Each main plot was divided into four sub-plots and four types of

tillage treatments viz. T_1: Cultivator two times, T_2: Five tine cultivator two times, T_3: Chisel plogh (shallow till up to 20-25 cm) + T_1 and T_4: Deep ploghing (deep tillage up to 45-50 cm) + T_1 were imposed to sub- plots for land preparation of sugarcane before planting. Yield of paddy was recorded from each sub- plot and soil samples were collected before applying tillage treatments for planting sugarcane and also after harvest of sugarcane. The soil samples were analyzed for pH, EC and organic carbon following standard procedure (Jackson, 1973). Physical parameters like, bulk density (BD), infiltration rate (IR) and water stable micro (0.053-0.25 mm) and macro-aggregates (micro & macro-WSA) were determined following standard procedure of 'clod method', 'double ring infiltrometer' and 'Yoder's wet sieving methods, respectively.

The results revealed that paddy grain and straw yield in all the treatments were higher during 1st year over 2nd and 3rd year, most possibly due to higher rainfall in 1st year. However, in the 2nd and 3rd year, due to almost same quantum of rainfall, paddy grain and straw yield in all the respective treatments were, more or less, same (Table 1). Results further indicated that yield of paddy grain yield significantly differed due to varying puddling treatments during 3rd year and in pooled analysis while, straw yield significantly varied during 1st, 3rd year and in pooled analysis (Table 1). Significantly the highest grain yield (4333 kg ha^{-1}) was obtained in treatment M_4 i.e. under tractor puddling during the 3rd year as well as in pooled analysis over three years (4580 kg ha^{-1}). However, the pooled yield was at par with treatment M_2 i.e. Plogh and planking with bullock (Table 1). Pooled analysis of straw yield revealed that significantly highest yield was obtained under treatment M_4 (5241 kg ha^{-1}) which was at par with M_2. Among different puddling treatments, tractor puddling (M_4) produced significantly higher grain and straw yield of rice, but it remained at par with M_2 treatment.

The effect of different tillage treatments was not significant on cane yield of sugarcane in all the individual years, but the effect was significant in the pooled analysis. The significant effect in pooled yield might be due to the definite increasing trend of yield under unpuddled (only planking) treatment ($M_{1,}$) over others in all the years (Table 2). Yield of sugarcane in all the treatments decreased gradually from 1st year to 3rd year which might be due to gradual decrease in profile-moisture storage from 1st year to 3rd year as a result of decrease in rainfall from 1st year to 3rd year. The effect of different tillage practices on sub-plot was found significant on cane yield of sugarcane during 1st and 2nd year and the highest cane yield was noted under T_3. In third year, cane yield was not significant as to varying tillage treatments and the highest yield was recorded under T_1 which might due to higher moisture storage under low tillage practices in comparatively low rainfall situation . Thus, in pooled analysis, the cane yield was not significant because of inconsistent trend in yield in different

Table 1. Effect of different puddling treatments on grain and straw yield of paddy (kg ha^{-1})

Treatments	Grain yield			Pooled yield	Straw yield			Pooled yield
	Year				Year			
	2005	2006	2007		2005	2006	2007	
M_1	4824	3944	3926	4232	5222	4278	4333	4611
M_2	4889	4204	4203	4435	5398	4778	4833	5003
M_3	4954	4000	4046	4333	5528	4389	4556	4824
M_4	5269	4139	4333	4580	6287	4667	4769	5241
S.E.m ±	187	129	93	79	231	142	104	102
CD @ 5 %	NS	NS	281	225	696	NS	312	290
Y × T	-	-	-	NS	-	-	-	NS

Note: M_1= Unpuddled (only planking,), M_2 = Plogh and planking with bullock, M_3 =Power tiller puddling and M_4= Tractor puddling

Table 2. Effect of different treatments on millable cane yield (Mg ha^{-1}) of sugarcane

Treatments	Years			Pooled
	2005	2006	2007	
Pudding (main plot)				
M_1	95.44	81.65	72.77	83.28
M_2	90.20	79.70	65.65	78.52
M_3	90.73	80.74	60.85	77.44
M_4	88.99	77.33	65.72	77.35
S.E.m±	1.79	1.79	3.86	1.51
CD @ 5 %	NS	NS	NS	4.40
Cultivation (sub plot)				
T_1	88.01	76.58	67.82	77.47
T_2	91.62	78.79	67.06	79.15
T_3	94.25	83.56	66.24	81.35
T_4	91.49	80.49	63.88	78.62
S.E.m±	1.43	1.46	2.36	1.06
CD @ 5 %	4.16	4.27	NS	NS
M × T	-	-	-	NS

Note: M_1= Unpuddled (only planking,), M_2 = Plogh and planking with bullock, M_3 =Power tiller puddling and M_4= Tractor puddling, while T_1= Cultivator two times, T_2= Five tine cultivator two times, T_3= Chisel plogh (shallow till up to 20-25 cm) + T_1 and T_4= Deep plowing (deep tillage up to 45 -50 cm) + T_1

years. The treatment M_1 i.e. unpuddled registered significantly the highest cane yield (83.28 t ha^{-1}). The effect of various tillage operations on yield of different upland crops after paddy was also reported earlier by Shetty and Moody (1984) on mung bean, Gajera *et al*. (1998) on pigeon pea and Kumar *et. al* (2004 a, b) on wheat. Aggarwal *et. al.* (1997) obtained higher yield of wheat after paddy with chisel plough plot.

Effect of different puddling and tillage treatments on soil pH, EC, organic carbon, BD, IR and water stable aggregates did not show significant variation after harvest of paddy and sugarcane (Table 3 and 4). However, BD and IR were found comparatively superior (i.e. low BD and high IR) under unpuddled (only planking) plot at the end of 3rd year of experiment. The results were in good conformity of Aggarwal *et. al.* (1997).

When yield of paddy and sugarcane in paddy-sugarcane crop sequence were considered separately, it was found that treatment M_4 in case of rice and treatment M_1 in case of sugarcane gave

Table 3. Effect of different treatments on soil chemical properties after harvest of Sugarcane in paddy-sugarcane sequence

Treatments	pH (1:2.5)			EC (1:2.5) (dS m^{-1})			Organic carbon (g kg^{-1})		
	2005	2006	2007	2005	2006	2007	2005	2006	2007
Pudding (main plot)									
M_1	7.69	7.95	7.65	0.46	0.34	0.44	4.50	5.00	4.10
M_2	7.71	7.90	7.68	0.49	0.36	0.47	4.70	4.09	4.10
M_3	7.74	7.89	7.69	0.47	0.35	0.49	5.00	5.10	4.20
M_4	7.76	7.96	7.68	0.45	0.34	0.48	4.80	4.70	4.20
S. Em ±	0.05	0.06	0.04	0.02	0.02	0.02	0.20	0.20	0.20
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
Cultivation (sub plot)									
T_1	7.72	7.88	7.67	0.50	0.37	0.45	4.70	4.90	4.20
T_2	7.76	7.94	7.67	0.47	0.35	0.48	4.60	4.80	4.10
T_3	7.68	7.92	7.68	0.44	0.33	0.47	4.80	5.10	4.20
T_4	7.74	7.96	7.68	0.46	0.34	0.47	4.90	5.00	4.20
S.Em±	0.03	0.03	0.03	0.01	0.01	0.02	0.10	0.10	0.20
CD @ 5 %	NS	NS	NS	NS	NS	NS	NS	NS	NS
M × T	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: M_1= Unpuddled (only planking,), M_2 = Plogh and planking with bullock, M_3 =Power tiller puddling and M_4= Tractor puddling, while T_1= Cultivator two times, T_2= Five tine cultivator two times, T_3= Chisel plogh (shallow till up to 20-25 cm) + T_1 and T_4= Deep plowing (deep tillage up to 45 -50 cm) + T_1

Table 4. Effect of different treatments on soil physical properties after harvest of sugarcane in paddy-sugarcane sequence

Treatments	BD (g cc^{-1})			IR (mm h^{-1})			WSA (%)					
	2005	2006	2007	2005	2006	2007	2005	2006	2007	2005	2006	2007
							Micro (0.053-0.25 mm)			Macro (>0.25mm)		
Pudding (main plot)												
M_1	1.75	1.69	1.72	9.0	10.3	8.1	17,3	18.6	18.9	82.7	81.4	81.1
M_2	1.74	1.72	1.74	8.3	11.2	7.8	18.8	19.0	20.3	81.2	81.0	79.7
M_3	1.72	1.73	1.76	8.7	10.6	7.9	19.0	20.7	21.5	81.0	79.3	78.5
M_4	1.69	1.73	1.79	9.0	10.3	7.3	20.1	20.9	21.1	79.9	79.1	78.9
S.Em±	0.02	0.03	0.03	0.5	0.6	0.22	2.90	3.04	4.20	3.89	3.24	3.70
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Cultivation (sub plot)												
T_1	1.71	1.73	1.71	8.3	9.8	7.5	17.6	17.8	19.6	82.4	82.2	80.4
T_2	1.74	1.72	1.72	8.8	9.8	7.7	19.2	19.3	20.5	80.8	80.7	79.5
T_3	1.72	1.70	1.76	9.0	12.0	7.9	20.1	21.7	21,9	79.9	78.3	78.1
T_4	1.72	1.71	1.77	8.8	10.7	7.9	21.3	22.8	23.7	78.7	77.2	76.3
S.Em±	0.03	0.02	0.02	3.2	0.4	0.41	3.06	2.79	4.04	3.76	4.10	2.95
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
M × T	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: M_1= Unpuddled (only planking,), M_2 = Plow and planking with bullock, M_3 =Power tiller puddling and M_4= Tractor puddling, while T_1= Cultivator two times, T_2= Five tine cultivator two times, T_3= Chisel plow (shallow till up to 20-25 cm) + T_1 and T_4= Deep plowing (deep tillage up to 45 -50 cm) + T_1

the higher yield. As the cost of cultivation under M_4 >> M_1 and difference in selling price of sugarcane yield under M_1 and M_4 > difference in selling price of paddy yield under M_4 and M_1 , the net income (details of economics not shown here) under treatment M_1 i.e. unpuddled (only planking) would be higher for the paddy-sugarcane cropping sequence in this zone .Further M_1 maintained superior soil IR and BD also.

Thus, it can be concluded that transplanting of paddy should be done following planking operation only in the field during monsoon in the south Gujarat condition for higher yield in paddy–sugarcane crop sequence. However, before onset of monsoon, the land should be prepared every year by cultivating land twice with tractor- drawn-cultivator.

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