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Research Paper

PLANTING OF WHEAT WITH HAPPY SEEDER AND ROTAVATOR IN RICE STUBBLES

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On farm research trials were carried out for promoting of happy seeder and rotavator technology for sowing of wheat in the standing stubbles of rice during 2009-10. Data recorded on grain and straw yield of rice from the field of selected farmers to know the average straw yield during kharif of 2009. It was about 10.0, 9.6, 9.4 and 8.1 tha^{-1} in Fatehgarh Sahib, Patiala, Kapurthala and Jalandhar of Punjab, respectively. The paddy straw burning is practiced for early vacant of rice fields for sowing of wheat with conventional tillage and lost with this method average of 33.66 kgha^{-1} available nitrogen, 7.48 kgha^{-1} phosphorous and 65.85 kgha^{-1} potassium. But this quantity returns to the soil with the planting of wheat in the stubbles with happy seeder and rotavator and helps to improve the soil health. The results revealed that the happy seeder (zero tillage) and rotavator (reduced tillage) produced the comparable grain yield to farmer's practice, which are also observed the suitable methods for in-situ management of paddy straw. However, happy seeder is the most efficient method to reduce the expenditure on seed bed preparation with saving the fuel and time and to manage the rice straw and improve the soil productivity. The root mass density was higher in happy seeder and farmer's practice plots at all soil depth than rotavator plots. The maximum root mass was confined to 0-15 cm layer of soil. The bulk density in all the layers under rotavator was generally higher than the conventional tillage and happy seeder sown field at all the locations. The lower bulk density values were recorded in happy seeder than rotavator and conventional tillage sown wheat fields. The porosity was lower in rotavator and farmers' practice as compared to happy seeder at all the soil depths.

Keywords: Happy seeder, Rotavator, Root density, Bulk density, Porosity, Wheat

INTRODUCTION

Rice-wheat is the most important and highly profitable cropping system of Northwestern region of India and is critical for food security and livelihood in India. It is a highly exploitative system and is followed on about 2.7 Mha in Punjab. Soils of Punjab developed under harsh climate are inherently poor in soil organic matter, fertility and water holding capacity. The current rice-wheat production system of intensive tillage and stubble burning/removal

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in the north-western region of India is clearly unsustainable (Yadvinder-Singh, 2012). In India, more than 140 Mt crop residues are disposed of by burning each year. The current system of burning the rice straw, which at present is to the extent of about 80%, causes the pollution of the environment and health hazards (Kalkat, 2012). Crop residue management is receiving a great deal of attention worldwide because of its diverse and positive effects on soil health, crop productivity and environment quality (Yadvinder-Singh, 2012). Punjab Agricultural University developed a machine called happy seeder for sowing of wheat in the combined harvested fields of rice. Another machine called rotavator is also given to the farmers by the Department of Agriculture, Punjab for incorporation of rice straw. Keeping in view the above this study was planned to evaluate the happy seeder and rotavator in comparison to the farmer's practice for popularization of happy seeder in Punjab.

MATERIALS AND METHODS

On farm trials 10 were conducted in each district of Jalandhar, Kapurthala, Patiala and Fatehgarh Sahib to accelerate technology of happy seeder and rotavator for sowing of wheat in the combine harvested fields for in-situ management of paddy straw during 2009-10. All the sites in Kapurthala, Jallandhar, Fatehgarh Sahib had the soil texture loamy sand except one location in Fatehgarh Sahib. However, in Patiala, all the locations showed the soil texture sandy loam. Soil of all the locations of the four districts is low in available nitrogen, medium in available potassium, however, in Kapurthala five sites medium and five high in available phosphorus, in Jallandhar, all were in high available phosphorus except one was medium and in Fatehgarh Sahib and Patiala soil at all the sites was high in available phosphorus. Happy seeder and rotavator machines were used for sowing of wheat in combine harvested paddy fields without any straw burning or removal of paddy straw. Happy seeder and rotavator machines were used for sowing of wheat in combine harvested paddy fields without any straw burning or removal of paddy straw. The loose straw was uniformly distributed in the field before sowing wheat with happy seeder. In case of sowing with rotavator, the one time it was used in the combine harvested paddy fields to incorporate the paddy straw and second time it was used to mix the broadcasted seed of wheat in the soil. The inputs like one quintal Urea and Herbicide (Total 75 WP, 16 g/acre) were supplied as an incentive to the selected farmers. Before sowing the demonstration plots, soil samples were taken from 0-15 cm soil depth to examine the texture of the soil. The performance of wheat sown with happy seeder and rotavator was compared with farmer practice followed for sowing of wheat. The observations such as grain and straw yield were recorded from the demonstration fields to compare the performance of wheat sown with happy seeder, rotavator and farmer's practice. One acre area was sown with each of happy seeder, rotavator and farmer's practice at 10 farmer's field in the each district of Jalandhar, Kapurthala, Fatehgarh Sahib and Patiala. Soil samples for physical and chemical analysis from 0-15 cm were collected from the demonstration sites. The samples were sun dried first then oven dried at 62±5° C for 24 h. Layer wise soil core samples were taken separately with Core Sampler viz., 0-15, 15-30, 30-60, 60-90 and 90-120 cm soil depths with the help of root sampling pipe at maturity stage (145 DAS). The core samples, thus, obtained were washed in thin muslin cloth on a 1 mm sieve in running water. The roots were isolated and kept in the sun for few days. After sun drying, these were oven dried at 60° ±2° C to a constant weight and the dry weight was recorded. The ratio of dry weight to total volume of the soil core was root mass density and expressed as g m^{-3}. It was determined by the following formula:

$$\text{Root mass density } (g\ m^{-3}) = \frac{\text{Total root weight in particular depth increment (g)}}{\text{Total soil volume from which roots were collected } (m^3)}$$

The soil samples were taken for determination of bulk density in four districts of Punjab, viz., Jalandhar, Kapurthala, Fatehgarh Sahib and Patiala to know the formation of compaction in the layers of soil by the Rotavator, Happy seeder and Farmer's practice of planting wheat. The samples were taken from 0-15, 15-30, 30-45 cm soil depth in Jalandhar, Kapurthala, Fatehgarh Sahib and 10-15, 15-20, 20-25 cm soil depth in Patiala for determination of bulk density. The porosity of soil or geologic materials is the ratio of the volume of pore space in a unit of material to the total volume of material. It was determined by the following formula:

$$\text{Porosity} = \left(1 - \frac{\rho_b}{\rho p}\right) \times 100$$

RESULTS AND DISCUSSION

Grain and Straw Yield of Rice

Data recorded on rice grain yield and straw yield are presented in the Table 1. It shows that an average of grain yield of rice was 7.7, 6.5, 6.4 and 5.4 tha^{-1} and rice straw was 10.0, 9.6, 9.4 and 8.1 tha^{-1} in Fatehgarh Sahib, Patiala, Kapurthala and Jalandhar, respectively. Farmers generally follow the practice of burning of paddy straw for sowing of wheat with conventional tillage. They lost with burning of paddy straw an average 33.66, 7.48 and 65.85 $kgha^{-1}$ available nitrogen, phosphorous and potassium, respectively. Farmers can add large quantity of nutrients with the recycling of paddy straw by sowing the wheat with happy seeder and rotavator and this will help to improve the soil productivity. The long term use of this technology reduces the fertilizer requirement and save the environment from pollution by reducing the emission of CO_2 with an average of 13.0 t/ha (Table 1).

Grain and Straw Yield of Wheat

Data on grain yield of wheat sown by happy seeder, rotavator and farmer's practice are presented in Table 2. Grain yield differed significantly by sowing of wheat with happy seeder, rotavator and farmer's practice in Patiala, Fatehgarh Sahib and Kapurthala. In Kapurthala, wheat sown with happy seeder gave

Table 1: Influence of Locations on Straw Yield, Emission of CO_2, Organic Carbon and Nutrient in Rice Straw

Location	Grain Yield (tha^{-1})	Straw Yield (tha^{-1})	Emission of CO_2 (tha^{-1})	Nutrient in Straw		
				Nitrogen ($Kgha^{-1}$)	Phosphorous ($Kgha^{-1}$)	Potassium ($Kgha^{-1}$)
Kapurthala	6.4	9.4	13.2	33.84	7.52	66.74
Jalandhar	5.4	8.1	11.3	29.16	6.48	57.51
Fatehgarh Sahib	7.7	10.0	14.0	35.64	7.92	71.00
Patiala	6.5	9.6	13.4	36.00	8.00	68.16
Mean	6.5	9.3	13.0	33.66	7.48	65.85

Note: Paddy straw contains 0.36 Nitrogen, 0.08 Phosphorous, 0.71Potassium

Source: Handbook of Agriculture ICAR

significantly higher grain yield than rotavator and farmer practice but grain yield was significantly similar under rotavator and farmer practice. In Patiala district, significantly higher grain yield was obtained with happy seeder sown wheat than farmer practice and rotavator. However, it was also significantly higher under farmer practice than rotavator sown crop. In Fatehgarh Sahib, significantly equivalent grain yield of wheat was recorded from the crop sown with happy seeder and farmer's practice. It was significantly more than rotavator sown crop. Whereas, method of planting did not influence significantly on the grain yield of wheat sown in Jalandhar district**.** However, the grain yield was higher of happy seeder sown crop than rotavator and farmer practice. It is interesting to mention here that the average grain yield of four districts of wheat sown with happy seeder was slightly higher than wheat sown with rotavator (1.06 qha^{-1}) and farmer's practice (1.03 qha^{-1}). It might be due to the higher number of tillers per plant and ear length. Secondly, it could be due to the presence of paddy straw on the soil surface resulted in more availability of moisture for longer period during the growing season. Mulching has been proved to be useful in conserving moisture and increasing productivity in wheat (Chakraborty *et al.*, 2008; Huang, 2005; Li, 2005; Rahman, 2005; Verma and Acharya, 2004). The results are also in conformity with the findings of Singh *et al.* (2011); Singh *et al.* (2012); Yadav *et al.*, (2005); Tripathi *et al.* (1999); English and Raja (1996); Martens and Frankenberger (1992); Sardana *et al.* (2002); Singh *et al.*, (1991). They reported significantly higher grain yield under zero tillage compared with the yield obtained conventional tillage. An average 9-15% higher grain yield of wheat was recorded with the happy seeder sowing in rice residues (Sidhu *et al.*, 2007), with fertilizer broadcast at sowing and before the first irrigation compared with farmer's practice (conventional tillage after burning). Average grain yields with no-tillage and conservation tillage were significantly greater than yields using conventional tillage (Ciha, 1982).

Data on straw yield of wheat are given in the Table 2. The different methods of planting were influenced significantly on straw yield of wheat sown in Patiala, Fatehgarh Sahib and Kapurthala except Jalandhar. In Kapurthala and Patiala, the straw yield recorded from the crop sown with rotavator and farmer practice was statistically at par with each other but it was significantly higher recorded under happy seeder than rotavator and farmer practice**.** In Fatehgarh Sahib, straw yield of wheat sown with farmer practice and happy seeder was statistically at par with each other, but was significantly better than rotavator, whereas, in Jalandhar, straw yield of happy seeder sown wheat was higher than farmer practice and rotavator, but was statistically similar among all the treatments. On an average the straw yield recorded from the crop sown with happy seeder was maximum followed by farmer practice and rotavator.

Table 2: Influence of Sowing Methods on Grain and Straw Yield of Wheat

Treatment	Grain Yield (q/ha)				Straw Yield (q/ha)			
	Jalandhar	Kapurthala	Patiala	Fatehgarh Sahib	Jalandhar	Kapurthala	Patiala	Fatehgarh Sahib
Rotavator	41.19	46.79	44.52	47.88	63.02	71.58	68.1	73.26
Happy Seeder	43.63	47.76	49.53	51.13	66.75	73.08	75.8	78.23
Farmer Practice	42.47	46.91	46.02	50.86	64.98	71.78	70.4	77.80
CD (p=0.05)	NS	0.65	1.36	2.06	NS	1.00	2.08	3.14

Bulk Density

The data pertaining to bulk density presented in Tables 3 and 4. It was found that the bulk density at all the layers under rotavator was generally higher than the conventional tillage and Happy Seeder sown field in all the locations of Jalandhar, Kapurthala, Fatehgarh Sahib and Patiala districts. The lower bulk density values were recorded in happy seeder than rotavator and conventional tillage sown wheat fields. The average bulk density of soil increased with the increase in soil depth from 0-15 to 15-30 cm in the field of happy seeder and rotavator sown wheat, but in case of farmer's practice the bulk density was increased up to the 30-45 cm soil depth. It shows farmer's practice cause compaction up to the lower depth. In Patiala district, the samples were taken at 5 cm interval of soil depth, the bulk density increased with increase in soil depth from 0-5 cm to 20-25 cm, but in case of happy seeder it was increased up to 15-20 cm after that it was decreased at the soil depth 20-25 cm. Bulk density and modulus of rupture were significantly smaller in the straw incorporation treatment compared with straw removal and straw burnt treatments (Singh *et al.,* 2005). Merotto Jr and Mundstock (1999) reported that the increase in the bulk density from 1.29 to 1.67 kg/dm^3 resulted in increase in soil resistance from 1.0 to 5.5 MPa.

Table 3: Influence of Sowing Methods on Bulk Density (gcm^{-3}) in Jalandhar and Kapurthala

Sample	Jallandhar and Kapurthala								
	Rotavator			Happy Seeder			Farmer Practice		
	0-15	15-30	30-45	0-15	15-30	30-45	0-15	15-30	30-45
1	1.2	1.2	0.9	1.1	1.1	1.1	1.4	1.2	1.4
2	1.1	1.5	1.3	1.0	1.2	1.0	0.8	1.2	1.0
3	1.2	1.5	1.5	1.1	0.9	1.3	1.1	1.0	1.3
4	1.3	1.5	1.3	0.7	1.4	1.1	1.1	1.3	1.6
5	1.1	1.1	1.6	0.7	1.3	1.1	1.1	1.0	1.1
6	1.7	1.7	1.6	0.8	1.2	1.3	1.1	1.2	1.1
Mean	1.27	1.42	1.37	0.90	1.18	1.15	1.10	1.15	1.25
Fatehgarh Sahib									
1	1.3	1.3	1.2	1.4	1.0	1.2	1.5	1.4	1.3
2	1.2	1.3	1.4	1.2	1.5	1.3	1.6	1.8	1.5
3	1.5	1.2	1.5	1.0	1.3	1.4	1.2	0.9	1.4
4	0.9	1.3	1.4	1.4	1.5	1.2	1.3	1.1	1.3
5	1.3	1.6	1.4	1.2	1.5	1.3	1.2	1.4	1.2
6	1.2	1.1	1.5	1.1	1.2	1.0	1.2	1.4	1.2
7	1.4	1.2	1.0	1.3	1.3	1.4	1.1	1.3	**1.7**
8	1.2	2.0	1.0	1.1	1.0	1.2	1.1	1.5	1.4
Mean	1.25	1.38	1.30	1.21	1.29	1.25	1.28	1.35	1.38

Table 4: Influence of Sowing Methods on Bulk Density (gcm-3) in Patiala District						
Sample	**Rotavator**			**Happy Seeder**		
	0-15	**15-30**	**30-45**	**0-15**	**15-30**	**30-45**
1	1.58	1.53	1.28	1.32	1.27	0.78
2	1.69	1.34	1.85	1.28	1.09	1.14
3	1.55	1.67	1.67	1.23	1.04	1.19
4	1.62	1.51	1.76	1.25	2.36	1.44
5	1.44	1.49	1.83	1.27	1.28	1.62
6	1.44	1.61	1.51	1.33	1.39	1.34
7	2.16	1.65	1.20	1.37	1.29	1.28
8	1.37	0.9	1.59	1.37	1.39	1.14
9	1.50	1.58	1.76	0.83	1.56	1.31
10	1.51	1.62	1.59	1.45	1.29	1.55
11	1.39	1.55	1.71	1.53	1.7	1.55
Mean	1.57	1.50	1.61	1.29	1.42	1.30

Porosity

Porosity or pore space is the amount of air space or void space between soil particles. Infiltration, groundwater movement, and storage occur in these void spaces. The porosity of soil or geologic materials is the ratio of the volume of pore space in a unit of material to the total volume of material. The data pertaining to porosity was presented in the Tables 5 and 6. The whole data from Jalandhar, Kapurthala, Fatehgarh Sahib and Patiala shows that the values of porosity were lower in rotavator and farmers' practice as compared to Happy seeder at all the soil depths, i.e., 0-15,15-30, and 30-45 cm. It shows compaction occurs in rotavator and farmers' practice due to heavy machinery and repeated tillage operations. In rice-wheat system, straw incorporation for 5 years on a sandy loam soil significantly increased mean weight diameter of aggregates, aggregate stability and total soil porosity than straw removal, and the straw burnt treatment was intermediate (Singh *et al.*, 2005).

Root Mass Density

Layer wise soil core samples were taken separately with Core Sampler, viz., 0-15, 15-30, 30-60, 60-90 and 90-120 cm soil depths with the help of root sampling pipe at maturity stage (145 DAS). The core samples, thus, obtained were washed in thin muslin cloth on a 1 mm sieve in running water. The roots were isolated and kept in the sun for few days. After sun drying, these were oven dried at 60° ±2° C to a constant weight and the dry weight was recorded. The ratio of dry weight to total volume of the soil core was root mass density and expressed as g m^{-3}. The results were depicted in Table 7.

The data of root mass density of wheat presented in the Table 7. It shows that the values of root mass density were higher in the fields of wheat where it was sown with happy seeder and farmer's practice at all the soil depth than rotavator sown wheat fields. It might be due to the compaction in the soil layers. The maximum root mass was confined to 0-15 cm layer of soil

Table 5: Influence of Sowing Methods on Porosity (%) in Jalandhar and Kapurthala

Sample	Jallandhar and Kapurthala								
	Rotavator			Happy Seeder			Farmer Practice		
	0-15	15-30	30-45	0-15	15-30	30-45	0-15	15-30	30-45
1	53.8	53.8	65.4	57.7	57.7	57.7	46.2	53.8	46.2
2	57.7	42.3	50.0	61.5	53.8	61.5	69.2	53.8	61.5
3	53.8	42.3	42.3	57.7	65.4	50.0	57.7	61.5	50.0
4	50.0	42.3	50.0	73.1	46.2	57.7	57.7	50.0	38.5
5	57.7	57.7	38.5	73.1	50.0	57.7	57.7	61.5	57.7
6	34.6	34.6	38.5	69.2	53.8	50.0	57.7	53.8	57.7
Mean	51.2	45.4	47.3	65.4	54.6	55.8	57.7	55.8	51.9
Fatehgarh Sahib									
1	50.0	50.0	53.8	46.2	61.5	53.8	42.3	46.2	50.0
2	53.8	50.0	46.2	53.8	42.3	50.0	38.5	30.8	42.3
3	42.3	53.8	42.3	61.5	50.0	46.2	53.8	65.4	46.2
4	65.4	50.0	46.2	46.2	42.3	53.8	50.0	57.7	50.0
5	50.0	38.5	46.2	53.8	42.3	50.0	53.8	46.2	53.8
6	53.8	57.7	42.3	57.7	53.8	61.5	53.8	46.2	53.8
7	46.2	53.8	61.5	50.0	50.0	46.2	57.7	50.0	34.6
8	53.8	23.1	61.5	57.7	61.5	53.8	57.7	42.3	46.2
Mean	51.9	46.9	50.0	53.5	50.4	51.9	50.8	48.1	46.9

Table 6: Influence of Sowing Methods on Porosity (%) in Patiala

Sample	Rotavator			Happy Seeder		
	0-15	15-30	30-45	0-15	15-30	30-45
1	40.38	42.26	51.70	50.19	52.08	70.57
2	36.23	49.43	30.19	51.70	58.87	56.98
3	41.51	36.98	36.98	53.58	60.75	55.09
4	38.87	43.02	33.58	52.83	10.94	45.66
5	45.66	43.77	30.94	52.08	51.70	38.87
6	45.66	39.25	43.02	49.81	47.55	49.43
7	18.49	37.74	54.72	48.30	51.32	51.70
8	48.30	66.04	40.00	48.30	47.55	56.98
9	43.40	40.38	33.58	68.68	41.13	50.57
10	43.02	38.87	40.00	45.28	51.32	41.51
11	47.55	41.51	35.47	42.26	35.85	41.51
Mean	40.75	43.40	39.25	51.32	46.42	50.94

Table 7: Influence of Sowing Methods on Root Mass Density (gm^{-3})						
S.No.	**Treatment**	**Root Mass Density (gm^{-3})**				
		0-15 cm	**15-30 cm**	**30-60 cm**	**60-90 cm**	**90-120 cm**
1	Happy Seeder	2518.5	611.1	296.2	153.4	84.6
	Rotavator	1666.6	370.4	153.4	111.1	58.2
	Farmer's practice	2851.8	481.5	211.6	216.9	148.1
2	Happy Seeder	2462.9	592.5	217.6	169.3	121.3
	Rotavator	1870.3	351.9	135.2	116.4	116.4
	Farmer's practice	2407.4	407.4	222.2	158.7	132.3
3	Happy Seeder	6537.0	907.4	296.2	116.4	58.2
	Rotavator	4648.1	814.8	153.4	111.1	52.9
	Farmer's practice	5370.3	555.5	211.6	158.7	132.3
4	Happy Seeder	2777.7	505.5	158.7	153.4	137.5
	Rotavator	2314.8	462.9	142.9	153.4	111.1
	Farmer's practice	2518.3	611.1	174.6	169.3	132.3
5	Happy Seeder	3481.4	555.5	259.3	158.1	137.5
	Rotavator	3666.6	388.8	155.2	158.7	105.3
	Farmer's practice	2518.5	666.6	232.2	105.8	132.3

Table 8: List of Hiring Cost of Implements in Different Operations												
Items	**Happy Seeder**				**Rotavator**				**Farmer's Practice**			
Tillage operations	**Disc-ing**	**Culti-vating**	**Plank-ing**	**Sow-ing**	**Disc-ing**	**Culti-vating**	**Plank-ing**	**Sow-ing**	**Disc-ing**	**Culti-vating**	**Plank-ing**	**Sow-ing**
No of operations required	-	-	-	1	-	-	-	3	2	2	1	1
Required time (h/ha/ operation)	-	-	-	2.30	-	-	-	2.30	1.10	1.00	0.38	2.30
Hiring Cost (Rs/ha)	-	-	-	2500 +*500	-	-	-	5250 @1750 +*500	2500 @ 1250	1500 @750	750	1500
Fuel (lts/h)	-	-	-	11.5 @51/hr	-	-	-	11.5 @51/h	8.81 @41/h	81/hr @41/hs	1.52 @al/h	9.21 @41/h
Note: *Rate for sowing with Happy Seeder was Rs, 1,000, *Charges for uniform distribution of loose straw - Rs 500.												

Table 9: Comparative Fuel, Time and Monetary Gain of Seed Bed Preparation for Wheat After Rice Harvest			
Particulars	**Fuel (l/ha)**	**Time (h/ha)**	**Monetary Gain (Rs./ha)**
Saving of fuel/time/Monetary gain of Happy Seeder over Rotavator	0.0	4.31	2250
Saving of fuel/time/Monetary gain of Happy Seeder over Farmer's practice	16.03	5.38	3250
Saving of fuel/time/Monetary gain of Rotavator over Farmer's practice	16.03	1.07	1000

irrespective of method of planting and it was decreased in the lower layers up to 120 cm depth (Meenakshi, 2010, Kaushal *et al.*, 2012b).

Economics

Sowing of wheat with happy seeder farmers can save time 4.31 h and Rs. 2250 /ha over the rotavator however, fuel 16.03 L diesel, time 5.38 h and Rs. 3250/ha over the farmer's practice (Tables 8 and 9). Similarly, crop sown with rotavator, farmers can save fuel 16.03 L diesel, time 1.07 h and Rs. 1000/ha over the farmer's practice. It shows that sowing wheat with zero tillage technology (Happy seeder) is economical than the rotavator and farmer's practice (Conventional tillage). The similar results were reported by (Meenakshi, 2010)

CONCLUSION

It can be concluded from the findings of this study that happy seeder sown wheat gave the comparable grain yield as wheat sown with farmer's practice and rotavator. It was also found that happy seeder has many benefits as saving fuel, time, expenditure and can be used for sowing of wheat in the combine harvested rice and ultimately improve the soil health. In case of rotavator sown wheat crop, the bulk density of soil was observed higher, which resulted in lower root mass density due to compaction in soil layers. Therefore, it is advocated that the farmers must adopt the zero tillage technology like happy seeder for planting wheat to increase the return as well as to sustain the productivity of rice-wheat cropping system with the addition of paddy straw in the soil and reducing the environmental pollution by skipping tillage operations. The rotavator technology should be discouraged keeping in view the adverse effects on soil and environment.

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