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Rice Residue Management: Farmer's Perspective*

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Abstract

Rice is the important Kharif crop of Punjab covering 60% of the cultivated area in the State. The production of paddy has reached to 15 million tons (MT) in 2004-2005, which results in the production of 18.75 MT of rice residue. The residue can be used as animal fodder, fuel and in paper and cardboard industries. The combined use of all these options does not exceed 10%. The farmers are in a hurry to sow the next crop (wheat) and therefore dispose off the straw immediately by burning. Constant research efforts are being made to return this residue to the soil by direct incorporation or through composting. The machinery for direct incorporation and collection has been developed but still is in its infancy and thus is not available to the farmers. Even with the use of the latest machinery like chopper and rotavator, direct incorporation involves higher cost than normal operations would cost after burning the residues. Moreover, these additional operations increase the drudgery of the farmers. The farmers are very busy in this period (October-November) of the year, where they have to harvest rice, market it and prepare the seedbed for the next wheat crop. Sowing of wheat by no-till drill is the cheapest option but cannot be practiced without burning/ removing the rice residue. Although, the incorporation of the residue results in better physical, chemical and biological properties, but in the long term experiments it has been seen that the increase in wheat yield ranges from 0.0 to 0.5 T/Ha over the burning treatment. Further, the rice straw can be composted into value added Phospho-Compost with a cost of Rs. 1.47 per kg, but the value on the basis of the fertilizer elements (N, P and K) is approximately Rs. 1 per kg.

Introduction

Rice is the most important *Kharif* crop of Punjab. It was grown on about 0.25 m ha in 1966-67, which increased by ten fold (2.53 Mha) by the year 2002-03. The production of rice in the State has also proportionately increased to 9.9 MT (provisional) in 2004-05. With the increase in production of rice there is concomitant increase in the production of residue (rice straw), which is approximately 18.75 MT. About 80 percent of the rice residue produced is burnt in the fields, particularly after harvesting rice by combine harvesters. It is estimated that about 15 MT of rice straw was burnt last year in Punjab. The burning of the residue results in substantial loss of plant nutrients contained therein as also it adversely affects the nutrient budget in the soil. Straw Carbon, Nitrogen and Sulphur are completely burnt and lost to the atmosphere in the process of burning the residue. The other nutrients are partially lost in the particulate matter that mixes with the atmospheric air and blows with the wind. The residue of the last year, that contained about 6.0 MT of Carbon, on burning produced about 22.0 MT of Carbon Dioxide in a short span of 15-20 days. The open burning of residue in the fields results in the burning of trees in addition to adjoining standing crops. The ash left after burning is a very good adsorbent. This ash lying on the surface of the soil, if not mixed properly, adsorbs the applied weedicides, which results in decreased efficacy of herbicides. Therefore, burning of rice residue is not advisable.

The rice straw can be put to many uses. It can be used as dry fodder for animals, but due to the availability of better quality fodder (wheat straw) in the State, it is not preferred. Presently about 5 % of the straw produced is used for this purpose particularly by *Gujjars*. The *Gaushalas* in Punjab can use this cheap fodder for Gaushala animals. Attempts have been made by PSEB to use the rice straw as fuel for generating electricity by installing a 10 MW plant at Jalkheri in Fatehgarh Sahib District. However, it has its own problems like collection and storage of huge biomass. It has been estimated that the combined use of rice straw at present for these purposes is less than 2%.

Suggested Alternates

Presently there is not much alternative use of paddy straw obtained from rice harvesting. The suggested viable uses can be *in situ* management in the field, composting and mulching.

Management in the Field: The combine harvester spreads the residue in the field, which is difficult to collect. It is recommended that the rice residue should be incorporated in the soil before sowing wheat, and allowed to decompose for 2-3 weeks before sowing of wheat There-after, normal fertilizer management

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practices for wheat may be followed. It has been seen through a six year study period (Table 1) that grain yields of wheat and the following rice have not been adversely affected by *in situ* incorporation of rice straw in the soil, 10, 20, or 40 days before sowing wheat. Rice straw incorporated in wheat did not even show a residual effect on the succeeding rice crop. Several reports show similar rice and wheat yields under different residual management practices such as burning, removal, or incorporation (Walia et al., 1995, Singh et al., 1996, Bijay Singh et al., 2001). Singh et al. (1996) reported that the incorporation of rice straw 3 weeks before sowing wheat, significantly increased wheat yield on clay loam soil but not on sandy loam soil.

Detailed studies conducted by Sharma et al (1985, 1987) also showed no adverse effect of straw incorporation on the grain yield of wheat and the following rice (Table 2). On the other hand, it can be noticed in the same Table 2 that the incorporation of rice straw (5 T Ha^{-1} dry weight) over longer periods say 30 days before the sowing of wheat, produced significantly lower wheat yields than the removal or burning of straw in the first two years (Verma and Bhagat, 1992). In another long-term experiment on sandy loam soil (Table 3), however, it was seen that the yield of wheat was at par or it was an increase of 0.0-0.5 T/Ha.

Table 1: Yield (T Ha^{-1}) as Affected by Rice Straw Management in Wheat and its Residual Effect on Rice in the Rice-Wheat Cropping System

Treatment	Experiment 1**		Experiment 2***	
	Wheat	Rice (Paddy)	Wheat (1993-2000)	Rice (Paddy) (1994-99)
Straw Removed	5.06a	4.90a	4.94a	6.19a
Straw Burnt	5.11a	5.13a	5.10a	6.25a
Straw Incorporated (40 DBS)*	4.89a	4.87a	5.17a	6.34a
Straw Incorporated (20 DBS)	5.00a	4.97a	5.22a	6.29a
Straw Incorporated (20 DBS) and 25% N Applied at Incorporation	4.79a	5.02a	4.95a	6.33a
Straw Incorporated (10 DBS)	-	-	4.97a	6.29a

*DBS = days before sowing of wheat; **Bijay Singh et al. (2001); ***Yadvinider-Singh et al. (2004)

Table 2: Effect of Rice Straw Management on Wheat and its Residual Effect in the Next Rice Crop in Rice-Wheat Cropping System

Experimental Details	Crop	Grain Yield of Rice and Wheat (T Ha^{-1}) with Rice Straw Management as			Reference
		Removed	Burned	Incorporated	
Himachal Pradesh Data averaged for 4 yr, Acidic Clay Loam Soil, Rice Straw Chopped and Incorporated 4 Weeks Before Sowing Wheat	*Wheat* *Rice*	2.8 2.4	- -	2.8 (0.0) 2.5 (+4.2)	*Sharma et al. (1985, 1987)*
Himachal Pradesh, 5- yr Study, Acidic Clay Loam Soil, Rice Straw Chopped and Incorporated 4 Weeks Before Wheat Sowing	*Wheat (1984-87)* *Rice* *Wheat (1987-89)* *Rice*	2.6 3.7 2.4 3.8	2.6 3.6 2.4 3.7	2.2 (-15.5) 3.7 (0.0) 2.4 (0.0) 4.0 (+5.3)	*Verma and Bhagat (1992)*

Table 3: Wheat Yield (T/Ha) as Affected by Rice Residue Management (Sidhu and Beri Unpublished Data)

Year	Burnt	Incorporated*	CD(5%)	Increase in Yield by Incorporation over over Burning
1993-94	4.27	4.36	0.27	0.09
1994-95	4.38	4.50	0.28	0.12
1995-96	4.09	4.29	NS	0.20
1996-97	4.85	4.78	NS	-
1997-98	4.85	5.21	NS	0.36
1998-99	4.25	4.37	NS	0.12
1999-2000	5.55	5.71	NS	0.16
2000-2001	4.73	4.87	0.12	0.14
2001-2002	6.01	5.97	NS	-
2002-2003	4.70	5.20	0.12	0.50
2003-2004**	4.10	3.90	0.3	-
* Rice residue was incorporated 2-3 weeks before sowing wheat ** was sown on 28.11.2003 (late)				

Eleven percent of rice area has already been brought under partial incorporation of rice residue. Farmers burn loose straw left by the combine harvester but incorporate half burnt stubbles. The complete incorporation is a laborious exercise, which farmers generally shirk. Punjab Agricultural University has developed some machines / implements especially for this purpose. Various options are available for the farmer for incorporation of the straw in the soil depending upon the resources and availability of the implements and the quantity of the straw to be managed before sowing wheat. The operations involved and the cost of each option are given in Table 4.

Table 4: Options for Managing Rice Residue in the Soil *in situ* and Approximate Cost (Rs/Ha) of each Option

Straw Incorporation Options								Straw Burning Options			
I		II		III		IV		V(Farmer Practice, General)		VI	
Operation	**Cost***	**Operation**	**Cost***	**Operation**	**Cost***	**Operation**	**Cost***	**Operation**	**Cost***	**Operation**	**Cost***
Stubble Shaver (1)	375	*Chopper(1)*	1500	*Chopper(1)*	1500	*Stubble Shaver (1)*	375	*Stubble Shaver (1)*	375	*Stubble Shaver (1)*	375
MB/ Disc Plough(1)	1125	*Disc Harrow(2)*	1125	*Rotavator (1)*	1125	*Bund Maker with Two Disc Plough(1)*	1125	*Complete Burning*	-	*Complete Burning*	
Irrigation (1)		*Irrigation(1)*		*Irrigation (1)*		*Irrigation (1)*		*Discs Harrow(1)*	562.5	*Irrigation(1)*	
Disc Harrow(2)	1125	*Cultivators(2)*	875	*Seeding by No-till Drill*	750	*Discs Harrow(2)*	1125	*Irrigation (1)*		*Seeding by No-till Drill*	750
Planking (1)	250	*Planking(1)*	250	*Bunds by Disc Type Riger*	125	*Planking(1)*	250	*Cultivators (2)*	875	*Bunds by Disc Type Riger*	125
Seeding Normal Drill (1)	500	*Seeding Normal Drill (1)*	500			*Seeding Normal Drill (1) (ND)*	500	*Planking(1)*	250		
Bunds by Riger	125	*Bunds by Riger*	125			*Bunds by Riger*	125	*Seeding Normal Drill (1) (ND)*	500		
Total	**3500**		**4375**		**3500**			*Bunds by Riger*	125		
						Total	3500		2687.5		1250

Note: Costs are as the operation was conducted on hire basis. It may vary according to area and availability of machinery. Irrigation cost is not included as it is common to all the options

All the other implements are common with the farmer except the chopper, which has been recently developed by PAU. The tillage operation after rice harvesting and before sowing wheat has been mechanized

in the state. The option number VI is the cheapest, where rice residue is burnt and the seeding of wheat is done by not-till drill. The option V that is adopted by most of the farmers in the State costs Rs. 2687 per Hectare. It is thus seen that incorporation of these options incurs expenditure to the tune of Rs.800/- to Rs.1675/- per Hectare.

Mulching: The rice straw can be collected and used as mulch, for some crops. Mulching with straw has favourable effect on the yield of maize, soybean and sugarcane crops. It also results in substantial saving in irrigation water. Rice straw mulching in the no-till sown wheat with the newly developed Happy Seeder machine is recommended. Happy Seeder does cutting, lifting and spreading the standing rice stubbles and loose straw along with sowing in one operation. The residue of rice collected and mulch application result in additional cost of Rs.2000/- per hectare. This can only be compensated by additional yield of 2 T/Ha of sugarcane and 0.20 T of soybean. The farmers feel that mulching accentuates the rodent problem in the crop, particularly sugarcane.

Composting: The collected residue can be composted by using it as animal bedding and then heaping it in dung heaps. Each kg of straw absorbs about 2-3 kg of urine from the animal shed. This was the practice in the past, where excess cereal residues were used for compost. It can also be composted by alternative methods on the farm itself and used there in the field. The residues of rice from one Hectare give about 3.2 Tons of manure as rich in nutrients as FYM. The collection of the residue can be done manually or with a little modification in the Happy Seeder machine. The Happy Seeder is a twin purpose machine, which can spread the residue in the field, or it can cut and load the straw in the trolley for collection. It has high collection efficiency as compared to manual operations. The cost of collecting the residue by this machine is approximately Rupees 1000/- per Hectare. The cost of preparing the enriched compost at the prevailing prices is Rs.1.47/- per kg of finished compost (Table 5). The total nutrient analysis of the phospho-compost for fertilizer elements, and their value for the compost prepared from one-Hectare straw is Rs.2021/- approximately, which is less than the total cost of Rs. 4600/-.

Table 5: Preparation of Phospho-Compost from Rice Straw Collected from one Hectare Rice Field.

				Cost (Rs)
1	Collection of Straw (8.0 T/Ha)			1000
2	Urea (@ 1 g/litre of Water)= 12 kg Rate=Rs 5/kg Urea			60
3	Rock Phosphate 480 kg Rate Rs 3/kg			1440
4	Water and Electricity			200
5	Labour, 20 Person @ Rs.100/ Person			2000
	Total			**4600**
	Phospho-Compost Output 3.2 Tons (Recovery 40%)			
	Price per kg of Compost			**1.47**
Compost Composition and its Price (Rs.)				
	Nutrient	**Content (%)**	**Nutrient Amount in 3.2 Tons (kg)**	**Price* (Rs)**
1	N	1.78	57	570
2	P_2O_5	2.20	70	1056
3	K_2O	2.47	79	395
4	Secondary Micronutrients and Humus			
	Total			**2021**
*Approximate price of the nutrient with subsidy on the fertilizers N @ Rs. 10/-, kg, P_2O_5 @ Rs.15/kg. and K_2O Rs.5/kg				

The organic manure affects the yield by improving the physical, chemical and biological properties of soil. The effect of the rice straw compost was measured in the field experiment on rice-wheat system (Table 6). The benefit cost ratio of compost treatment to rice and wheat along with recommended fertilizers give an economic benefit of Rs.1.28 per Rupee spent (Table 6). The application of 30 kg P_2O_5 / Ha water-soluble phosphorus, just compensates the cost of compost if environmental damage is considered due to straw burning.

Table 6: Economics of Phospho-Compost Treatments

Treatment	Price of Rice/ Wheat (Rs)	Increase in Profit over Recommended Fertilizer (Rs)	Cost of Phosphorus Saved (Rs)	Total Profit (Rs)	Benefit Cost Ratio†
Recommended Fertilizer (RF*)	72225 (4.89+7.02)§	-	-	-	-
N+Phospho-Compost(PC) @ 4T/Ha/y	74139 (4.66+7.59)	1914	900	2814	0.48
N+30 kg P_2O_5 (WS) + PC @ 4T/Ha/y	76485 (4.92+7.71)	4260	450	4740**	0.80
N+60 kg P_2O_5 (WS) + PC @ 4T/Ha/y	79287 (5.14+7.95)	7062	-	7512**	1.28

RF*= 120 kg N to Rice and Wheat each, 60 kg P_2O_5 to Wheat only, N=120 kg N/Ha to Rice and Wheat each

WS= water soluble P_2O_5 through SSP

† Cost of 4 T Phospho-Compost @ Rs 1.47 /kg

**Includes the value of additional wheat strawThe rates of paddy and wheat grain used were Rs 5900/- and 6300/- per Ton respectively and wheat straw was Rs 1000/- per Ton.

Soil Health

The incorporation of the residues in the soil has a favourable effect on soil's physical, chemical and biological properties such as pH, organic carbon, and water holding capacity and bulk density of the soil (Singh et al, 2005). Field experiments on the rice-wheat cropping system show that incorporation of crop residues can increase soil organic C and total N contents (Table 7). Incorporation of crop residues increases organic C by 14-29% over residue removal treatments in the 3-10 years of experiments conducted. In another 11 years field experiment conducted on loamy sand soil in Punjab, it has been seen that the incorporation of residues of both crops in the rice-wheat cropping system has increased the total P, available P, and K contents in the soil over the removal of residues (Table 8). The total P, and available S, were in the order of residue incorporation > residue removal > residue burning. The incorporation of crop residues on a long-term basis has been seen to increase the DTPA-extractable Zn, Cu, Fe and Mn content in the soil (Yadvinder Singh et al., 2000). The decrease in bulk density with straw addition definitely has a bearing on wheat yield in rice-wheat rotation, where soil aeration becomes a limiting factor. The incorporation of residue also prevents the leaching of nitrates. It adds a plenty of organic carbon and thus increases bacteria and fungi in the soil. In a rice-wheat rotation, Beri et al. (1992) and Sidhu et al. (1995) observed that soil treated with crop residues held 5-10 times more aerobic bacteria and 1.5 to 11 times more fungi than soil for which residues were either burned or removed. Due to increase in microbial population, the activity of soil enzymes responsible for conversion of unavailable to available form of nutrients also increases.

Table 7: Effect of Crop Residue Management on Organic C and Total N Content of Soil under the Rice-Wheat Cropping System

Reference	Type of Crop Residue	Duration of study (Years)	Residue management	Organic C (%)	Total N (%)
Beri et al. (1995)	Rice Straw in Wheat and Wheat Straw in Rice	10	Removal Burned Incorporated	0.38 0.43 0.47	0.051 0.055 0.056
Sharma et al. (1987)	Rice Straw in Wheat and Wheat Straw in Rice	6	Removed Incorporated	1.15 1.31	0.144 0.159
Yadvinder-Singh et al. (2004)	Wheat Straw, Green Manure, and Wheat Straw + Green Manure (GM) in Rice	6	Removed Incorporated GM Straw + GM	0.38 0.49 0.41 0.47	- - - -

Table 8: Effect of Crop Residue Management on Soil Fertility of a Loamy Sand Soil over 11 years of the Rice-Wheat Cropping System at Ludhiana (Beri et al., 1995)

Soil property	Crop Residue Management		
	Burned	**Removed**	***Incorporated***
Total P (mg kg^{-1})	390	420	612
Total K (g kg^{-1})	17.1	15.4	18.1
Olsen P (mg kg^{-1})	14.4	17.2	20.5
Available K (mg kg^{-1})	58	45	52
Available S (mg kg^{-1})	34	55	61

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