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Research Paper

Effect of residue management on productivity and economics of pearlmillet (*Pennisetum glaucum*)-based cropping system under zero-till condition

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ABSTRACT

A field study was conducted at New Delhi during 2010-11 and 2011-12 to assess the effect of residue management practices, *viz.* no residue, crop residue @ 5t/ha and green *Leucaena* twigs @ 10 t/ha on productivity and profitability of rainy-season pearlmillet {*Pennisetum glaucum* (L.) R. Br. emend. Stuntz} followed by winter-season crops, *viz*. wheat {*Triticum aestivum* (L.) emend Fiori & Paol.}, chickpea (*Cicer arietinum* L.) and mustard {*Brassica juncea* (L.) Czern. & Cosson.}. Both rainy and winter-season crops were grown with zero-tillage following recommended package of practices under rainfed conditions. Pearlmillet recorded significantly higher grain yield (2.23 t/ha) with the application of *Leucaena* twigs in 2010, but produced comparatively higher yield with crop residues (1.58 t/ha) than *Leucaena* twigs (1.41 t/ha) in 2011. Chickpea with crop residue recorded significantly higher seed yield (1.95 t/ha) than with *Leucaena* twigs (1.56 t/ha). Economic analysis showed the highest returns from pearlmillet with *Leucaena* twigs in 2010 and after chickpea with crop residue in 2011. System productivity and net returns/₹ invested were higher with *Leucaena* twigs in pearlmillet–chickpea, followed by pearlmillet–mustard and pearlmillet–wheat cropping system.

Key words : Economics, *Leucaena*, Pearlmillet, Productivity, Residue management, Zero-till

Growing pearlmillet during rainy season followed by wheat, chickpea and mustard during winter is the common cropping sequence in the drylands of north-western India. However, the average productivity of these crops is less than half of that in irrigated ecosystem. In irrigated condition of north-west India, >20 diversified cropping systems are practiced (Gill and Ahlawat, 2006), but in the rainfed areas, only a few systems have been documented, of which, pearlmillet–wheat was found to be the most profitable (Lal *et al*., 2004). Conservation tillage practices (zero-tillage + mulching) are a viable approach to retain soil moisture and nutrients under semi-arid dryland situations. Application of organic materials as mulch is considered poor conductor of heat to effectively reduce soil temperature, maintain soil moisture and increase soil fertility (Vaidya *et al.*, 1995). Prunings of *Leucaena* twigs as green manure have been found effective for both rainy and winter-season crops (Sharma and Acharya, 2000; Sharma and Behera, 2009; Sharma *et al.*, 2010). Research findings from several locations in Indo-Gangetic plains showed that zero-tillage technology led to saving on land preparation costs by about ₹2,500/ha and reducing diesel consumption by 50–60 liters/ha (Sangar *et al*., 2005). Further, it has also been reported that yield of crops can be increased up to 30% by using optimal level of energy input (Chaudhary *et al.*, 2006). There is dearth of information on crop residue and *Leucaena* management under dryland conditions. The present experiment was conducted to study the effect of residue retention on system productivity and profitability in pearlmillet-based cropping system under zero-till conditions.

MATERIALS AND METHODS

Field experiments were conducted on a fixed site during rainy (June-October) and winter seasons (October-April) of 2010-11 and 2011-12 at the Research Farm of the Indian Agricultural Research Institute, New Delhi (28.4° N, 77.1° E, 228 m above mean sea level). The soil was sandy-loam in texture, with pH 7.5, bulk density 1.55 Mg/m^3, field capacity 18.7% (w/w), organic C 0.40%, $KMnO_4$-oxidizable N 147.2 kg/ha, 0.5 N $NaHCO_3$-extractable P 17.0 kg/ha, 1.0 N NH_4OAc- exchangeable K

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225.1 kg/ha. The average annual rainfall of Delhi during the last 10 years was 739 mm, of which, >80% occurred during the monsoon season (July-September). There was 30.6% higher rainfall in 2010-11 (953.7 mm) than in 2011-12 (662.2 mm), resembling contrastingly different weather conditions during the two years of experimentation. Winter season of 2010-11 received rainfall of 85 mm distributed timely, but there was only 34 mm rainfall distributed sparsely in 2011-12.

The field was laser leveled during November 2009 and a uniformity trial was conducted by growing wheat 'PBW-175' during 2009-10. Thereafter, continuous zero-tillage was followed to grow the experimental crops throughout under rainfed condition. Pearlmillet was grown during rainy season of 2010 with no-residue, crop residues (previous wheat) and *Leucaena* twigs, followed by winter-season crops, viz. wheat, chickpea and mustard. In 2011, pearlmillet was grown with same treatments of residue but of different winter-season crops. Thus, there were only 3 treatments for pearlmillet in 2010, while there were 9 treatment combinations in 2011 involving 3 winter crops, viz. wheat, chickpea and mustard, and 3 residue treatments. On the other hand, for winter-season crops, there were 9 treatment combinations in both seasons involving 3 cropping systems and 3 residue management. Randomized complete block design was followed to analyze the data of pearlmillet in 2010, while strip plot design was followed for all other cropping seasons. Four replications were maintained throughout, with a net plot size of 10 m^2.

Nutrient concentration and nutrient added through various residues applied were determined (Table 1) through standard methods. *Leucaena* twigs gave maximum N, while pearlmillet and wheat residue added higher amounts of K. All crops were grown with a basal application of 17.5 kg P and 16.7 kg K/ha. In addition, chickpea was supplied with 20 kg N/ha at sowing, while pearlmillet, wheat and mustard were given 30 kg N/ha as basal followed by 30 kg N/ha as top dressing about 1-2 months after sowing depending on soil moisture availability. Sowing of all crops was done with a happy seeder at 20 cm row spacing uniformly. Data on growth and yield performance of all crops were recorded. Minimum support price of the grain was taken to calculate the system equivalent yield, which was expressed as wheat-equivalent yield for seasonal crops of the year, and pearlmillet-equivalent yield for the system as a whole within a year. System profitability was worked out based on the prevailing cost of inputs and field operations. The data were analyzed as per standard analysis of variance technique using MSTAT-C software (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Performance of pearlmillet

The effect of crop residue on all yield attributes of pearlmillet except ear head length was non-significant in 2010. However, effective tillers/m^2, ear head grain weight, ear head length and girth, and 1000-grain weight showed significant variation in 2011 (Table 2). Pearlmillet after chickpea with crop residue mulching recorded significantly higher effective tillers/m^2 and 1000-grain weight than that with *Leucaena* twigs and no-residue in 2011. Application of crop residue and *Leucaena* twigs over two years in the respective plots increased the fertility status and moisture holding capacity of soil, and thus gave higher values of effective tillers/m^2, ear head grain weight, ear head length and 1000-grain weight over no-residue. The favouarble improvements in these yield attributes were due to enhanced growth parameters, leading to greater nutrient uptake, efficient partitioning of metabolites and adequate accumulation of translocation of photosynthates. Adequate supply of moisture is known to enhance the growth and dry matter production of crops directly and indirectly by increasing the availability and utilization of nutrients (Tetarwal and Rana, 2006).

Grain, stover and biological yields of pearlmillet due to residue management and preceding winter-season crops showed significant differences in 2010 and 2011 (Fig. 1). Application of *Leucaena* twigs showed significantly higher grain yield in 2010 over crop residue, which might be due to the addition of N through *Leucaena* twigs. Rapid decomposition of *Leucaena* twigs helped in greater availability of nutrients, which led to increase in growth and yield attributes, and thus, the grain yield. Crop residue having higher C:N ratio, took more time to decompose, which in the first season did not benefit pearlmillet, rather there might have some immobilization effects. Interaction

Table 1. Nutrient concentration and addition through crop residues and *Leucaena* twigs (mean values of two years)

Crop	Season	Nutrient concentration (%)			Nutrients added (kg/ ha)		
		N	P	K	N	P	K
Pearlmillet	Winter	0.39	0.116	1.72	19.5	5.8	86.0
Wheat	Rainy	0.45	0.103	1.48	22.5	5.2	74.0
Chickpea	Rainy	1.23	0.141	1.05	61.5	7.1	52.5
Mustard	Rainy	0.42	0.110	1.18	21.0	5.5	59.0
Leucaena	Rainy and winter	2.50	0.210	1.19	87.5	7.4	41.7

Table 2. Effect of crop residue and *Leucaena* twigs on yield attributes of pearlmillet after preceding winter-season crops

Treatment	Effective tillers/m^2		Grain weight/ ear head (g)		Ear head length (cm)		Ear head diameter (cm)		1,000-grain weight (g)	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Residue management										
No residue	43.8	39.5	31.7	23.1	31.0	29.5	8.60	7.05	8.39	7.82
Crop residue	44.5	45.0	32.5	32.5	34.1	38.8	8.64	8.75	9.38	9.08
Leucaena twigs	50.3	42.6	34.4	25.1	35.1	37.9	8.74	8.90	9.76	8.96
SEm±	2.33	0.89	0.80	0.88	0.88	0.33	0.22	0.12	0.15	0.16
CD (P=0.05)	NS	2.59	NS	2.57	3.05	0.95	NS	0.34	NS	0.46
Preceding crops										
Wheat	-	40.0	-	27.8	-	35.3	-	8.01	-	8.18
Chickpea	-	45.9	-	27.6	-	35.8	-	8.30	-	9.08
Mustard	-	41.2	-	25.3	-	35.1	-	8.39	-	8.59
SEm±	-	0.89	-	0.88	-	0.33	-	0.12	-	0.16
CD (P=0.05)	-	2.59	-	NS	-	NS	-	NS	-	0.46

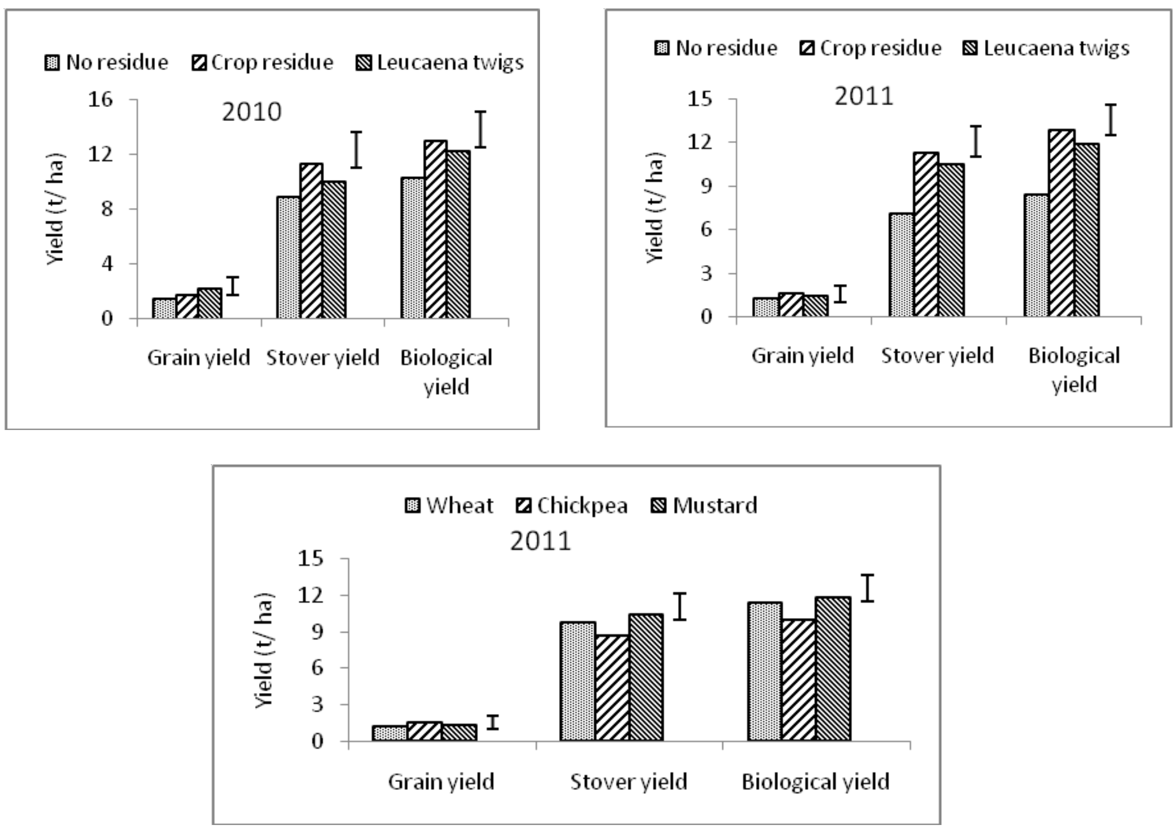

Fig. 1. Yield performance of pearlmillet as influenced by residue management and preceding winter-season crops

effect of crop residue and winter-season crops was significant on grain yield of pearlmillet in 2011. This was attributed to higher availability of nutrients and moderate soil moisture provided by the crop residue treatment. Working in semi-arid regions of Rajasthan, Singh *et al.* (2008) showed better performance of chickpea–-pearlmillet system when recommended fertilizer was applied to both the crops.

Economics of pearlmillet

Economic analysis of pearlmillet as influenced by crop residue and winter-season crops suggested that cost of cultivation was relatively higher in 2011 but net returns were almost half of that in 2010 (Table 3). The increase in production cost was due to higher labour wages (33% more in 2011) and other input costs. Further, the crop residues had some economic value, and their market prices

Table 3. Effect of crop residue and *Leucaena* twigs on economics of pearlmillet after preceding winter-season crops

Treatment	Cost of cultivation (×10^3 ₹/ha)		Net returns (×10^3 ₹/ha)		Net returns/₹ invested	
	2010	2011	2010	2011	2010	2011
Wheat–no residue	10.44	13.62	5.77	1.21	0.55	0.09
Wheat–crop residue	13.39	17.22	6.30	1.64	0.47	0.10
Wheat–*Leucaena* twigs	11.94	15.62	11.65	2.99	0.98	0.19
Chickpea–no residue	-	13.62	-	2.88	-	0.21
Chickpea–crop residue	-	17.22	-	6.74	-	0.39
Chickpea–*Leucaena* twigs	-	15.62	-	4.25	-	0.27
Mustard–no residue	-	13.62	-	3.21	-	0.24
Mustard–crop residue	-	17.22	-	3.40	-	0.20
Mustard–*Leucaena* twigs	-	15.62	-	3.09	-	0.20

Note: Common cost of cultivation for growing pearlmillet was 10.44 ×10^3 ₹/ha in 2010 and 13.62 × 10^3 ₹/ha in 2011. The variable cost for applying crop residues was 2.15 ×10^3 ₹/ha in 2010 and 3.6 ×10^3/ha in 2011. Similarly, variable cost for applying *Leucaena* twigs was 1.5 ×10^3 ₹/ha in 2010 and 2.06 ×10^3 ₹/ha in 2011.

were added to the production costs. *Leucaena* twigs were freely available and only application costs were incurred on it. Although gross returns were higher in 2011, the net returns were lower due to less yield. The highest net returns and net returns/₹ invested were obtained under *Leucaena* twigs in both years. Das and Gautam (2003) also recorded the highest pearlmillet yield and net returns with legume residue mulching.

System productivity and profitability

Productivity of winter–season crops in terms of wheat-equivalent yield, and system productivity as pearlmillet-equivalent yield showed a significant variation during both years (Table 4). The yield of winter-season crops in terms of wheat-equivalent yield was significantly higher under chickpea with *Leucaena* twigs, followed by crop residues. Mustard followed chickpea in 2010-11 but wheat ranked at the top in 2011-12 due to its better performance. System productivity in terms of pearlmillet-equivalent yield showed that pearlmillet–chickpea with crop residues was the best treatment. Better performance of wheat in 2011-12 added to more pearlmillet-equivalent yield. Legumes have the ability to fix atmospheric N_2 and thus inclusion of chickpea led to higher pearlmillet-equivalent yield in the system. The market price of mustard and chickpea were higher than wheat, which also exhibited variation on pearlmillet-equivalent yield in 2010-11.

Net returns and net returns/₹ invested were higher under *Leucaena* twigs, followed by crop residues, irrespective of preceding winter-season crops in 2010-11, but the trend was reverse in 2011-12 (Table 5). Wheat yields were 103% more in 2011-12 than 2010-11, which led to higher returns. Similarly, chickpea and mustard had higher market price than wheat, and resulted in higher economic returns. Application of *Leucaena* twigs and crop residues resulted in better yield and economic returns than no residue. Residue application might have improved physico-chemical and biological environment of the soil through the addition of nutrients and enhanced microbial activity, which led to increased system productivity (Singh *et al*., 2008).

It was concluded that pearlmillet should be followed by chickpea or mustard along with residue retention of crops or *Leucaena* twigs for higher productivity and profitability under zero-till dryland conditions of north-western India.

Table 4. Wheat-equivalent yield (t /ha) of winter-season crops under crop residues and *Leucaena* twigs after preceding pearlmillet

Residue management (A)	Winter-season crops (2010-11) (B)				Winter-season crops (2011-12) (B)			
	Wheat	Chickpea	Mustard	Mean	Wheat	Chickpea	Mustard	Mean
No residue	0.51	1.88	2.43	1.61	1.07	1.55	1.43	1.35
Crop residue	1.16	2.90	3.29	2.45	2.71	3.19	2.68	2.86
Leucaena twigs	1.12	3.53	4.08	2.91	2.20	2.19	1.94	2.11
Mean	0.93	2.77	3.26		1.99	2.31	2.02	
	A	B	A × B	A	B	A × B		
SEm±	0.01	0.04	0.07	0.03	0.04	0.06		
CD (P=0.05)	0.02	0.12	0.21	NS	0.11	0.19		

Table 5. System productivity and economics of pearlmillet–based systems as influenced by residue management

Treatment	2010-11			2011-12		
	Productivity (t/ha)	Net returns (× 10^3 ₹/ha)	Net returns/ ₹ invested	Productivity (t/ha)	Net returns (× 10^3 ₹/ha)	Net returns/ ₹ invested
Pearlmillet-wheat						
No residue	2.03	0.67	0.03	2.53	-0.03	0.00
Crop residue	3.03	6.35	0.23	4.80	20.09	0.56
Leucaena twigs	3.52	11.92	0.48	4.13	15.56	0.47
Pearlmillet-chickpea						
No residue	3.61	15.81	0.75	2.66	9.59	0.33
Crop residue	5.08	24.52	0.92	5.69	32.60	0.92
Leucaena twigs	6.32	37.16	1.54	5.75	17.42	0.53
Pearlmillet-mustard						
No residue	4.26	21.66	1.05	3.52	8.86	0.32
Crop residue	5.54	29.98	1.15	5.68	23.79	0.69
Leucaena twigs	6.95	44.29	1.87	4.45	13.88	0.44
SEm±	0.10				0.14	
CD (P=0.05)	0.29			0.41		

Note: Common costs of cultivation for growing wheat was 11.61 × 10^3 ₹/ha in 2010-11 and 15.79 × 10^3 ₹/ha in 2011-12. Similarly, the common cost of cultivation for growing chickpe was 10.71 × 10^3 ₹/ha in 2010-11 and 15.09 × 10^3 ₹/ha in 2011-12. The common cost for growing mustard was 10.23 × 10^3 ₹/ha in 2010-11 and 14.26 × 10^3 ₹/ha in 2011-12.

REFERENCES

Chaudhary, V.P., Gangwar, B. and Pandey, D.K. 2006. Auditing of energy use and output of different cropping systems in India. *Agricultural Engineering International: CIGR Journal* **8**: 652–658.

Das, G. and Gautam, R.C. 2003. Yield and water-use efficiency of pearlmillet as influenced by moisture conservation methods under rainfed conditions. *Annals of Agricultural Research* **2**(1): 78–81.

Gill, M.S. and Ahlawat, I.P.S. 2006. Crop diversification - its role towards sustainability and profitability. *Indian Journal of Fertilizers* **2**(9):125–138, 150.

Gomez, K.A. and Gomez, A.A. 1984. *Statistical Procedures for Agricultural Research.* John Willley and Sons, NY.

Lal, M., Bhati, D.S. and Nag, A.K. 2004. Economics and production potential of different cropping sequence on farmers' field. *Journal of Eco-Physiology* **7**(3/4): 143–145.

Sangar, S., Abrol, I.P. and Gupta, R.K. 2005. *Conservation Agriculture: Conserving Resources – Enhancing Productivity*, 19 p. CASA, NASC Complex, New Delhi.

Sharma, A.R. and Behera, U.K. 2009. Recycling of legume residue for nitrogen economy and higher productivity in maize (*Zea mays*)–wheat (*Triticum aestivum*) cropping system. *Nutrient Cycling in Agroecosystems* **83**: 197–210.

Sharma, A.R., Singh, R., Dhyani, S.K. and Dube, R.K. 2010. Moisture conservation and nitrogen recycling through legume mulching in rainfed maize (*Zea mays*)–wheat (*Triticum aestivum*) cropping system. *Nutrient Cycling in Agroecosystems* **87**(2): 187–197.

Sharma, P.K. and Acharya, C.L. 2000. Carry-over of residual soil moisture with mulching and conservation tillage practices for sowing of rainfed wheat (*Triticum aestivum*) in north-west India. *Soil and Tillage Research* **57**: 43–52.

Singh, R., Singh, B. and Patidar, M. 2008. Effect of preceding crops and nutrient maangemetn on productivity of wheat (*Triticum aestivum*)–based cropping system in arid region. *Indian Journal of Agronomy* **53** (4): 267–272.

Tetarwal, J.P. and Rana, K.S. 2006. Impact of cropping system, fertility level and moisture-conservation practice on productivity, nutrient uptake, water use and profitability of pearlmillet (*Pennisetum glaucum*) under rainfed conditions. *Indian Journal of Agronomy* **51**(4): 263–266.

Vaidya, V.B., Varshneya, M.C., Bote, N.L. and Naidu, J.R.V. 1995. Estimation of thermal efficiency and apparent reflectivity of mulches using soil temperature. *Journal of Maharashtra Agricultural Universities* **20**(3): 341–344.