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Effects of Crop Residue Management and Nitrogen Fertilizer on Soil Nitrogen and Carbon Content and Productivity of Wheat (*Triticum aestivum* L.) in Two Cropping Systems

T. Pandiaraj[1]*, S. Selvaraj[1], and N. Ramu[1]

ABSTRACT

The objective of this study was to investigate the effects of addition of pulses in crop sequences, crop residue management, and application of fertilizer N on soil nitrogen content, soil organic carbon, nutrient uptake, and its consequences for wheat yields. The field experiments were carried out from 2009 to 2012 in the sub-humid and sub-tropical zone of northern India. The treatments were (i) crop residue retained (+Residue) or (ii) removed (-Residue), (iii) 120 kg N ha^{-1} applied to wheat, (iv) 150 kg N ha^{-1} to maize, and (v) a control with no nitrogen applied to either wheat or maize. The cropping systems consisted of a rotation of wheat and maize or wheat and green gram. Postharvest incorporation of crop residues significantly ($P< 0.05$) increased the wheat grain and straw yields during 2010-2011 and 2011-2012. On average, crop residues incorporation increased the wheat grain yield by a factor of 1.31 and straw yield by 1.38. The wheat crop also responded strongly to the previous legume (green gram); grain yield increased by a factor of 1.89 and straw yield by 2.05, compared to the control. Application of fertilizer N to the preceding maize crop exerted a strong carryover effect on grain (1.18) and straw yield (1.26) wheat. Application of N fertilizer to wheat increased grain and straw yields by, respectively, a factor of 1.69 and 1.79 on average. The overall conclusion is that an improved crop residue management, combined with application of fertilizer N or incorporation of legumes greatly improves the N economy of cereal cropping systems and enhances crop productivity in soils with a low N content on the short term.

Keywords: Crop rotation, Legume, Maize, Organic carbon.

INTRODUCTION

Crop residues are those parts of the plants left in the field after the harvestable parts of the crops (grain, tubers, roots, etc.) have been removed. Crop residues at times have been regarded as waste materials that require disposal, but it has become increasingly realized that they are important natural resources and not wastes (CTIC, 2004). The recycling of crop residues has the advantage of converting the surplus farm waste into useful products for meeting nutrient requirements of crops. It also maintains the soil physical and chemical condition and improves the overall ecological balance of the crop production system. Research have shown that the return of crop residues on fragile soils improved the tilth and fertility of soil, enhanced crop productivity, reduced the wind and water erosion, and prevented nutrients losses by run-off and leaching (Lal, 1980; Lal *et al*., 1980; Maurya and Lal, 1981; Bukert *et al*., 2000). Despite these advantages, farmers in India prefer to remove crop residues off the field to feed livestock or use them as a fuel or as building/construction materials.

Nitrogen deficiency is one of the major yield limiting factors for cereals (McDonald,

[1] Department of Agronomy, University of Agriculture and Technology, GBPUAT, Pantnagar – 263142, India.
* Corresponding author; e-mail: pan_dian83@yahoo.co.in

1989), hence fertilizer nitrogen application is an essential input for crop productivity in most agricultural systems of the world (Ahmad, 1998; Spiertz, 2010). In the case of wheat, the most commonly grown cereal, around 30 kg N ha^{-1} is needed in a plant available form (usually as nitrate) for each ton of grain produced. However, the capacity of soils to supply the required quantities of N (30-80 kg ha^{-1}) declines rapidly without external nitrogen input. With continued cereal cropping, the N supplied from the mineralization of soil organic matter must be supplemented by other sources (McDonald, 1992). In industrialized countries, N is supplied in ample amounts as chemical fertilizer; however, in most developing countries including India, this is not possible because of high cost of fertilizer, low per capita income, and limited credit facilities available to most of the farmers (Bellido and Bellido, 2001). As a result, farmers either use the available organic sources or the crop receives hardly any fertilizer (Herridge *et al.* 1995). To meet the required level of plant nutrients, the farmers in India are indispensably inclined to use commercial fertilizers. During the last few years, the price of fertilizers has shown unprecedented hike and the availability of fertilizers at proper times has been a matter of serious concern. It is in such systems that the inclusion of a legume in the cropping system can play an increasingly important role to maintain soil fertility and sustain crop productivity. Mineral N in the root zone soil is often higher in cereal–legume cropping system than in cereal monoculture (Heenan and Chan, 1992; Badruddin and Meyer, 1994; Dalal *et al.*, 1998). This increase in N has been attributed to both nitrate saving by legumes (Evans *et al.*, 1991) and/or mineralization of the N rich residues (Evans *et al.*, 1991; Campbell *et al.*, 1992). Keeping in mind the long term sustainability and productivity of soils, crop residue management and cereal-legume rotation should be investigated urgently.

The objectives of this study were to investigate the effect of crop residue management, incorporating pulses in the crop rotation and application of fertilizer N on total soil nitrogen content, soil organic carbon, nutrient uptake, and crop production. This paper, though, presents the results of a 3-years field experiment on the yields of wheat and on soil fertility parameters.

MATERIALS AND METHODS

Climate and Soil Characteristics

The experiment was conducted at the Norman E. Borlaug Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar, India. This site is located at 29°N latitude, 79.3°E longitude and an altitude of 243.8 m above mean sea level in the *Tarai* belt of Shiwalik range of the Himalayan foothills. It falls under the sub-humid and sub-tropical climatic zone. Experimental site was silt-loam in texture with a pH around 6.9-7.2. Other soil characteristics were: low in organic matter (< 1.0%), low status of available mineral N (247 kg ha^{-1}) and medium available P (21.6 kg ha^{-1}).

Experimental Design and Sowing

The experiment was conducted in a split plot design with two residue management treatments (main plots), eight crop rotations and N fertilizer treatments (sub-plots), and four replications (Table 1). The experiment started in October 2009 with wheat and pea in the winter period followed by maize and green gram in summer. The sequence of cropping continued for five seasons and ended in May 2012, after the harvest of winter crops (wheat and vegetable pea).

All crops were sown by hand drilled into 5 cm depth. Row spacing was 20 cm for wheat, 30 cm for vegetable pea and green gram, and 60 cm for maize crops. Maize and wheat were either unfertilized (0N) or fertilized (+N) with 120 kg N ha^{-1} (wheat) or 150 kg N ha^{-1} (maize) as urea, half at sowing and half with the second irrigation. Vegetable pea and greengram received only 25 kg N ha^{-1} as a

Table 1. Treatments (residues, crop rotation and fertilizer N) in cropping system at experimental site.

Residue	Winter crops	Summer crops
Residue incorporation	Wheat 0N	Maize 0N
or residue no incorporation	Wheat 0N	Maize +N
	Wheat 0N	Green gram
	Wheat +N	Green gram
	Wheat +N	Maize 0N
	Wheat +N	Maize +N
	Vegetable pea	Maize 0N
	Vegetable pea	Maize +N

starter dose at sowing. Triple superphosphate (39 kg P ha^{-1}) and potassium sulphate (42 kg K ha^{-1}) were added to all plots at sowing. Wheat (var. PBW 343) and vegetable pea (var. Arkil) were sown in the last week of October and harvested in the 2nd week of April. Maize and greengram were sown in 1st week of June and harvested in the 1st week of September. Grain and crop residues samples were taken for N analysis. Immediately after grain harvest, above-ground residues of all crops were either completely removed (-Residue) or retained and incorporated into about 15 cm depth (+Residue) using a disc harrow and rotovator. All plots were sampled to a soil depth of 0–30 cm after the harvest of wheat and analyzed for mineral N (NH_4-N and NO_3-N) and organic carbon.

Laboratory Analysis

All samples were dried at 80°C in a hot air oven to a constant mass, weighed and then finely ground (< 0.1 mm) and analyzed for total N (Bremner and Mulvaney, 1982). The soil samples were air-dried for one day, ground and then sieved (< 2 mm) and analyzed for mineral N (NH_4-NandNO$_3$-N) (Keeney and Nelson, 1982) and organic carbon (Nelson and Sommers, 1982).

Statistical Analysis

The data were analyzed using general linear models procedure of SAS (SAS Institute, 1998). Means were compared between treatments by LSD (least significant difference) at $P< 0.05$ confidence level using Student's *t*-test.

RESULTS AND DISCUSSION

Total Soil Mineral N

Results revealed that crop residues incorporation increased the mineral N content of soil during three years, but the effect was significant (P< 0.05) only during the winter of 2011. Incorporation of crop residues resulted in 1.22 times increase in soil mineral N over the plots with residues removed (Table 2). Kumar and Goh (2002) and Surekha *et al.* (2003) reported significant increases in soil N content due to crop residue incorporation. Results further revealed that inclusion of greengram in a crop rotation significantly (P< 0.05) increased the mineral N content of soil during 2010 and 2011 compared with the continuous cereal treatment (Table 2). On average, mineral N content of the soil was 5.53 µg g^{-1} soil in treatment following maize 0N-wheat 0N rotation compared with 7.13 µg g^{-1} soil in treatment following wheat 0N-greengram. The addition of greengram in crop rotation with wheat enhanced the mineral N fertility by 1.29 times.

Increase in mineral N content of soil due to greengram is of great practical significance to subsequent crops in N starving situations. These results agree with those reported by Badruddin and Meyer (1994) and Dalal *et al.* (1998). Bullock and Bullock (1992) and Karlen *et al.* (1994) reported that the N

Table 2. Effect of crop residues on total soil mineral N (μg g^{-1}) in the surface layer (0-30 cm) after harvest of wheat.

Treatments	Residue ×Year			Average
	2009	2010	2011	
+Residue	8.99	10.08	12.14	10.40
-Residue	7.79	8.86	9.02	8.56
Time increase by residue over non residue	1.15	1.14	1.34	1.22
Treatments	Legume N×Year			Average
	2009	2010	2011	
Wheat 0N after maize 0N	5.47	5.21	5.52	5.53
Wheat 0N after green gram	5.36	7.42	8.60	7.13
Time increase by legume over cereal	-	1.42	1.55	1.29
Treatments	N current×Year			Average
	2009	2010	2011	
+N (Current crop)	11.47	13.26	16.01	13.75
-N (Current crop)	4.23	5.28	6.10	5.14
Time increase by current N over non-current N	2.97	2.51	2.62	2.68
Treatments	N previous×Year			Average
	2009	2010	2011	
+N (Previous crop)	9.65	12.27	12.51	11.48
-N (Previous crop)	8.30	9.46	10.59	9.45
Time increase by previous N over nil- previous N	1.16	1.36	1.18	1.22
Average [a] (Year effect)	8.39	9.47	10.58	9.48

[a] It is the average of all + and -residue treatments to calculate the temporal effect.
* Significant at 0.05 level of probability using LSD test; ** Significant at 0.01 level of probability using LSD test, ns: Non-significant (Year: **; Residue: **, N current: **, N previous: ns; Interactions: Year×Residue: *; Year×Legume N: *; Year×N current: ns, Year×N previous: **).

rotation benefit of legumes to succeeding crops was equivalent to a fertilizer replacement value of about 100 kg ha^{-1}. Our results showed that application of fertilizer N to the current wheat had significant (P> 0.05) effect on mineral N content of soil after harvest during three years (Table 2). The average mineral N content of soil was 2.68 times higher in treatment receiving fertilizer N during three years (2009–2011) compared with maize 0N–wheat 0N treatment. Our results further demonstrated that fertilizer N applied to previous maize had no significant (P> 0.05) effect on soil mineral N after harvest of the following wheat in each season. However, the average mineral N content of soil was 1.22 times higher in treatment receiving fertilizer N by previous maize during three years (2009–2011) compared with maize 0N–wheat 0N treatment.

Soil Organic Carbon

Results demonstrated only small improvement in soil organic C content both by bringing legume in crop rotation and by crop residues incorporation in soil during three years period (Table3). However, organic matter in soil as a whole was typically slow to respond to management changes and treatment effects may not be easily measured within short period of time as suggested by Langdale *et al.* (1990) and Power *et al.* (1998).

Table 3. Effect of cropping systems and crop residues on organic carbon (C g kg^{-1} soil) in the surface layer (0–30 cm) after harvest of wheat.

Treatments	Residue×Year			Average
	2009	2010	2011	
+Residue	5.10	5.16	5.59	5.28
-Residue	5.02	5.07	5.21	5.10
Time increase by residue over non residue	0.42	0.51	1.07	1.04
Treatments	Legume N×Year			Average
	2009	2010	2011	
Wheat 0N after maize 0N	5.08	5.11	4.81	5.00
Wheat 0N after green gram	5.23	5.39	5.59	5.40
Time increase by Legume over cereal	1.03	1.05	1.16	1.08
Treatments	N current×Year			Average
	2009	2010	2011	
+N (Vurrent crop)	4.97	5.02	5.44	5.14
-N (Current crop)	5.05	5.02	5.21	5.09
Time increase by current N over non-current N	-	-	1.04	1.00
Treatments	N previous×Year			Average
	2009	2010	2011	
+N (Previous crop)	5.03	5.16	5.42	5.20
-N (Previous crop)	4.93	5.11	5.16	5.07
Time increase by previous N over nil-previous N	1.02	1.00	1.05	1.03
Average [a] (Year effect)	5.06	5.14	5.29	5.14

[a] It is the average of all + and -residue treatments to calculate the temporal effect.
* Significant at 0.05 level of probability using LSD test, ns: Non-significant (Year: *; Residue: ns, N previous: ns; Interactions: Year×Residue: *; Year×Legume N: ns; Year×N current: ns, Year×N previous: ns).

Total N Uptake

Results showed that N application and inclusion of a legume (green gram) in the cropping system significantly ($P < 0.05$) increased the N uptake by wheat crop (Table 4). Crop residues retention increased N uptake in grain by 1.32 times and in straw by 1.67 times compared with the treatments where residues were removed. Similar results were also reported by Stevenson and van Kessel (1996). The positive effect of residues retention on N uptake by wheat crop could be attributed to N supply from crop residues and/or improvement in physical and chemical conditions of soil as reported by Utomo *et al.* (1990); Stevenson and van Kessel, (1996). Greengram treatment increased the N uptake in wheat grain by 2.09 times and in straw by 2.57 times under 0N cropping system. These results agree with those reported by Staggenborg *et al.* (2003).

The premium for high protein wheat seed is yet another reason why producers should consider crop rotation that includes pulse crops. Our data further revealed that fertilizer N applied to previous maize in wheat–maize rotation substantially enhanced the N uptake in grain and straw of wheat during both 2010/2011 and 2011/2012 compared with the unfertilized wheat treatment. The carry over effect of fertilizer N applied to previous maize was evident in the following N fertilized as well as unfertilized wheat. The effect was, however, more evident in the N unfertilized than in the fertilized wheat. On average,

Table 4. Effect of cropping systems and crop residues on grain and straw N uptake (kg ha^{-1}) of wheat.

Treatments	Residue×Year					
	Grain N			Straw N		
	2010/2011	2011/2012	Average	2010/2011	2011/2012	Average
+Residue	35.82	47.19	41.56	16.50	26.61	21.55
-Residue	29.46	33.38	31.42	12.65	13.09	12.87
Time increase by residue over non residue	1.22	1.41	1.32	1.30	2.03	1.67
	Legume N×Year					
Treatments	Grain N			Straw N		
	2010/2011	2011/2012	Average	2010/2011	2011/2012	Average
Wheat 0N after maize 0N	15.25	16.36	15.81	5.38	6.93	6.16
Wheat 0N after green gram	25.97	40.08	33.03	10.86	20.79	15.83
Time increase by Legume over cereal	1.71	2.45	2.09	2.02	3.00	2.57
	N current×Year					
Treatments	Grain N			Straw N		
	2010/2011	2011/2012	Average	2010/2011	2011/2012	Average
+ N (Current crop)	43.71	51.08	47.40	20.13	28.70	24.42
- N (Current crop)	28.10	27.30	27.70	15.18	14.21	14.70
Time increase by current N over non-current N	1.56	1.87	1.71	1.33	2.02	1.66
	N previous×Year					
Treatments	Grain N			Straw N		
	2010/2011	2011/2012	Average	2010/2011	2011/2012	Average
+N (Previous crop)	31.08	41.33	36.21	17.89	22.46	20.18
-N (Previous crop)	26.88	25.51	26.20	12.36	13.46	12.91
Time increase by previous N over nil-previous N	1.16	1.62	1.38	1.45	1.67	1.56
Average [a] (Year effect)	32.64	40.29	36.49	14.58	19.85	17.06

* Significant at 0.05 level of probability using LSD test; ** Significant at 0.01 level of probability using LSD test, ns: Non-significant (For grain N: Year *; Residue **; N current **, N previous **; Interactions: Year×Residue *, Year×Legume N **, Year×N current: ns, Y×N previous *; For straw N: Year *; Residue **; N current **, N previous **, Interactions: Year×Residue *; Year×Legume N **; Year×N current ns, Year×N previous: ns.

[a] It is the average of all + and -residue treatments to calculate the temporal effect.

fertilizer N applied to previous maize increased uptake in the following wheat grain by 1.38 times and in straw by1.56 times. Tejada and Gonzalez (2003) found similar responses of fertilizer N applied to maize on the following wheat in a rain-fed environment. Kumar and Goh (2002) observed substantial carry over effect of fertilizer N applied to wheat on the following maize crop. Fertilizer N applied to the current wheat significantly increased the N uptake in both grain and straw of wheat in 2010/2011 and 2011/2012. On average, fertilizer N applied to the current wheat increased the N uptake in wheat by 1.71 times and in straw by 1.66 times compared to that in maize 0N–wheat 0N treatment.

The carry over benefits of fertilizer N applied to previous maize was unexpected and contrary to the general belief of the region's farmers and agricultural advisors that N fertilizer has little residual value. There are, however, reports where fertilizer N to the previous maize exerted strong carry over effects on the following 0N wheat (Kumar and Goh, 2002). Our results are consistent with those of the influence of fertilizer N on soil mineral N discussed in the previous section of this text. These results agree with Feigenbaum *et al.* (1984) who reported recovery of 8–10% of fertilizer N by the second wheat crop and Staggenborg *et al.* (2003) who reported that grain N content increased as applied N increased.

Grain Yield

Results revealed that residues incorporation, fertilizer N application and the involvement of a legume in crop rotation significantly (P< 0.05) influenced the grain yield of wheat during 2010-2011 and 2011-2012 (Table 5). The incorporation of crop residues significantly (P< 0.05) increased the grain yield of wheat by 1.22 times in 2010-2011 and 1.38 times in 2011-2012 with an average increase of 1.31 times compared with the residues-removed treatments. These results agree with those reported by Lopez-Bellido *et al.* (1996), Kuo and Jellum (2002), Kumar and Goh (2002) and Surekha *et al.* (2003). Similarly, Kouyate *et al.* (2000) also reported an increase in cereal grain and stover yield when crop residues were incorporated compared with treatments where residues were removed. The wheat grain yield was also significantly (P< 0.05) greater for treatment following green gram than following 0N maize. The corresponding increase in grain yield of wheat due to green gram was 1.59 times in 2010/2011 and 2.17 times in 2011/2012, with an average increase of 1.89 times under 0N cropping systems.

The rotational benefits of legume (green gram) on succeeding crop are consistent with the results reported from elsewhere (Mason and Rowland, 1990; Ranells and Wagger, 1996 and Clark *et al*. 1997). Similarly, many studies (Evans *et al*. 1991; Chalk *et al*.1993; Smiley *et al*., 1994) have verified that N is a key factor in the response of cereals following legumes compared with cereals following non-legumes. Stevenson and van Kessel (1996), Clark *et al*. (1997) and Chalk (1998) reported that cereals derived both yield and N benefits from rotations with grain legume compared with cereal monoculture. The cereal in the legume–cereal rotation may benefit from the transfer of biologically fixed N, and from mineral N (Ta and Faris, 1987).

Among the cropping system, those which had a history of applied N fertilization produced 1.11 and 1.23 times (average 1.32 times) more grain yield in 2010-2011 and 2011-2012, respectively, than plots which received no fertilizer N in previous season. These results are in line with earlier reports where fertilizer N applied to previous maize exerted strong carry over effect on the following wheat (Peoples and Herridge, 1990; Ranells and Wagger, 1996). The application of fertilizer N to current wheat significantly (P< 0.05) increased the grain yield by 1.48 times in 2010/2011 and 1.91 times in 2011/2012 (average 1.69 times)

Table 5. Effect of cropping systems and crop residues on grain yield and straw yield (kg ha^{-1}) of wheat.

Treatments	Residue×Year					
	Grain yield			Straw yield		
	2010/2011	2011/2012	Average	2010/2011	2011/2012	Average
+Residue	2472	3097	2785	4196	4945	4571
-Residue	2018	2241	2130	3206	3397	3302
Time increase by residue over non residue	1.22	1.38	1.31	1.31	1.46	1.38
	Legume N×Year					
Treatments	Grain yield			Straw yield		
	2010/2011	2011/2012	Average	2010/2011	2011/2012	Average
Wheat 0N after maize 0N	1209	1324	1267	1671	1896	1784
Wheat 0N after green gram	1922	2877	2400	2959	4387	3673
Time increase by Legume over cereal	1.59	2.17	1.89	1.77	2.31	2.05
	N current ×Year					
Treatments	Grain yield			Straw yield		
	2010/2011	2011/2012	Average	2010/2011	2011/2012	Average
+ N (Current crop)	2965	3374	3170	5215	5548	5382
- N (Current crop)	1997	1765	1881	3136	2871	3004
Time increase by current N over non-current N	1.48	1.91	1.69	1.66	1.93	1.79
	N previous×Year					
Treatments	Grain yield			Straw yield		
	2010/2011	2011/2012	Average	2010/2011	2011/2012	Average
+N (Previous crop)	2263	2608	2436	3986	4117	4052
-N (Previous crop)	2036	2105	2071	3109	3313	3211
Time increase by previous N over nil- previous N	1.11	1.23	1.18	1.28	1.24	1.26
Average[a] (Year effect)	2245	2669	2458	3701	4171	3937

* Significant at 0.05 level of probability using LSD test; ** Significant at 0.01 level of probability using LSD test, **ns**:Non-significant (**For grain yield**: Year *; Residue **; N current **, N previous **; **Interactions**: Year×Residue **; Year×Legume N *; Year×N current: ns, Year×N previous: ns; **For straw yield**: Year: ns; Residue **; N current **, N previous **, **Interactions**: Year×Residue: ns; Year×Legume N **; Year×N current: ns, Y×N previous= ns).

[a] It is the average of all + and -residue treatments to calculate the temporal effect.

compared with unfertilized control treatments. The effects of fertilizer N on wheat yields are consistent with the low organic matter fertility of the soil of this site.

Straw Yield

Results presented in Table 5 indicated that the impact of crop residues incorporation, fertilizer N applications, and inclusion of a legume in cropping system on straw yield of wheat was significant ($P < 0.05$) in both years. Results showed that return of crop residues to soil significantly ($P < 0.05$) increased the yield of straw in both years. The data revealed that incorporation of crop residues resulted in 1.38 times increase during both years compared with the residues-removed treatment. These results agree with Ambast *et al*. (2006) and Erenstein (2009).

Previous legume crop (green gram) had a significant ($P < 0.05$) impact on the straw yield of succeeding wheat in both 2010-2011 and 2011-2012. The corresponding increases in straw yield were 1.77 times in 2010/2011 and 2.31 times in 2011-2012 with an average of 2.05 times for the treatment following greengram than that following 0N maize. Results have revealed that fertilizer N applied to previous maize had strong carry over effect on straw yield of the following wheat during both 2010-2011 and 2011-2012. Application of fertilizer N to previous maize crop produced 1.28 and 1.24 times more straw yield in 2010-2011 and 2011-2012, respectively, compared with wheat 0N-maize 0N treatment. Similar responses to previous fertilizer N treatment were also observed for the grain yield of wheat in 2010-2011 and 2011-12. Similarly, fertilizer N applied to current wheat increased straw yield by 1.66 times in 2010/2011 and 1.93 times in 2011/2012 with an average increase of 1.79 times over the 0N wheat. These results agree with those reported by Thakur and Papal (2005).

CONCLUSIONS

Results clearly indicated that retention of crop residues, inclusion of a legume in cropping systems, and application of fertilizer N significantly increased the soil mineral N, and grain and straw yields of wheat. Residues retention on average increased the grain yield by 1.31 times, straw yield by 1.38 times and N uptake by 1.32 times in grain and 1.67 times in straw of wheat. Green gram in rotation with wheat enhanced grain yield of wheat by 1.89 times, straw yield by 2.05 times and N uptake by 2.09 times in grain and 2.57 times in straw of wheat. Nitrogen applied to previous maize showed strong carry over effect on crop and N yields of the following wheat. Fertilizer N applied to current wheat, however, provided the greatest benefits to wheat productivity. Fertilizer N increased the grain yield of wheat by as much as 1.69 times, straw yield by 1.79 times, and N yield by 1.71–1.66 times. Certainly, considering the benefits of legumes, we would expect that its inclusion in cropping systems would reduce fertilizer N requirements. To conclude, returning crop residues to the soil improves the N economy of the cropping systems and enhances crop productivity through the additional N and other soil benefits. Farmers who traditionally remove residues for fodder and fuel will require demonstration of the relative benefits of residues return to soil for sustainable crop productivity.

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اثر مدیریت بقایای گیاهی و کود نیتروژن روی نیتروژن و کربن آلی خاک و عملکرد گندم (*Triticum aestivum* **L.**) در دو سامانه کاشت

ت. پاندیاراج، س. سلواراج، و ن. رامو

چکیده

هدف این پژوهش بررسی اثرات افزودن حبوبات در تناوب کشت و مدیریت بقایای گیاهی و مصرف کود نیتروژن روی نیتروژن و کربن آلی خاک و پیامد های آن روی عملکرد گندم بود. آزمایش های صحرایی در این مورد طی سال های ۲۰۰۹ تا ۲۰۱۲ در مناطق نیمه مرطوب و نیمه استوایی شمال هند اجرا شد. تیمارها عبارت بودند از (۱) حفظ بقایای گیاهی، (۲) برداشت بقایای گیاهی، (۳) ۱۲۰ کیلو گرم نیتروژن در هکتار برای گندم ، (۴) ۱۵۰ کیلو گرم در هکتار نیتروژن برای ذرت و (۵) تیمار شاهد بدون مصرف نیتروژن در گندم و ذرت. سامانه های کشت شامل تناوب گندم و ذرت یا گندم و ماش سبز بود. زیر خاک (مخلوط) کردن بقایای گیاهی بعد از برداشت به طور معنی داری($p < 0.05$) عملکرد دانه و کاه را طی سال های ۲۰۱۱-۲۰۱۰ و ۲۰۱۲-۲۰۱۱ افزایش داد. به طور میانگین، زیر خاک کردن بقایای گیاهی عملکر دانه را با ضریب ۱/۳۱ و عملکرد کاه را با ضریب ۱/۳۸ افزایش داد. نیز، گندم نسبت به نوع گیاه قبلی(ماش) که لگوم بود واکنش قوی داشت: عملکرد دانه با ضریب ۱/۸۹ و عملکرد کاه با ضریب ۲/۰۵ نسبت به شاهد افزایش نشان داد. همچنین، مصرف کود نیتروژن در گیاه قبلی اثرات انتقالی قوی روی عملکرد دانه گندم (ضریب ۱/۱۸) و کاه (ضریب ۱/۲۶) نشان داد.مصرف کود نیتروژن در گندم عملکرد دانه و کاه را به طور میانگین به ترتیب با ضریب ۱/۶۹ و۱/۷۹ افزایش داد. نتیجه کلی این که در خاک های دارای کمبود نیتروژن ، با مدیریت صحیح بقایای گیاهی همراه با مصرف کود نیتروژن و یا زیر خاک کردن لگوم ، اقتصاد نیتروژن در سامانه کشت بهبود یافته و بهره وری در کوتاه مدت ارتقا می یابد.