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Research Articles

Nitrogen and residue management effects on performance of happy seeder sown wheat

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ABSTRACT

A field experiment was conducted during *rabi* 2016–17 and 2017–18 to evaluate the influence of different residue and nitrogen management practices on soil physico-chemical properties, root density, weed growth and grain yield of happy seeder sown wheat. Experiment was conducted in randomized block design consisting of eleven residue and nitrogen management treatments in four replications. The results inferred that weed biomass was significantly less in chopped straw treatments (C) as compared to unchopped treatments (NC). Treatments receiving 150 kg N/ha had higher root density than 125 kg N/ha treatments at all soil depths during both years. Soil physical and chemical properties were not significantly affected but there was improvement in these properties after two years of residue retention. Grain yield (5.42 and 5.36 t/ha) was maximum in treatment where 150 kg N (30 kg at chopping of straw and 120 kg as per recommendation) was applied along with 5 t/ha FYM ($C+N_{30+120}+FYM_5$), which was significantly better than NC + N_{125}, C + N_{125}, C + FYM_5 + N_{125} and C + N_{20+105} treatments but statistically at par with rest of the treatments.

Keywords: Chopping of straw, Nitrogen, Residue management, Root density, Soil health

In recent years, rice residue management is the center point of agronomic research particularly in Indo-gangetic plains (IGPs). Poor management of rice residue in terms of burning has created many problems. To vacate fields for the timely sowing of wheat, majority of the rice straw is burnt *in situ* by the farmers because residues interfere with tillage and seeding operations for the next crop. Burning of rice stubble is rapid and cheap option for farmer which causes atmospheric pollution as well as adversely affects human health. Besides, it also results in the loss of plant nutrients and organic carbon of the soil. A paradigm shift is required to make it more practicable for the farmers without stressing natural resources and already concussed ecosystem. With the success of happy seeder, direct drilling of wheat in to combine harvested paddy fields is possible. But its success depends on a lot of factors; one of them is nitrogen management. Management of nitrogen (N) in conservation agriculture is crucial due to presence of large amounts of residues. Crop residues are categorized as of good quality if it has high N content, low lignin and cellulose content, lower C: N and lignin: N ratio and they often lead to higher N mineralization rates. They have positive effect on N availability to plants. On the contrary, low quality crop residues have lower N mineralization rates which reduce the quantity of available N to plant roots due to N immobilization process (Gentile *et al.* 2009 and Manzoni *et al.* 2008).

There have been quite a few studies that studied the pattern of N availability in straw amended soils. The presence of residues on surface of soil or incorporated into soil, creates altogether different conditions in soil, which result into a number of complexities in terms of nutrient dynamics particularly N. There is a need for long and extensive research under various residue management scenarios to explore strategies for improved N utilization. Hence to evaluate different N management strategies in happy seeder sown wheat, present investigation was conducted.

MATERIALS AND METHODS

An experiment was conducted at research farm of Punjab Agricultural University, Ludhiana, Punjab situated at 30°54′N latitude, 75°48′E longitude and altitude of 247 m amsl (*rabi* 2016-17 and 2017-18). The soil of experimental field was loamy sand in texture with normal *p*H (7.4), low in organic carbon (0.28%) and available N (195.3 kg/ha), medium in available P (23.1 kg/ha) and high in available K (217.8 kg/ha). Total rainfall received in wheat season was 100.2 and 86.4 mm in 2016-17 and 2017-18, respectively. The experiment was laid out in randomized block design with four replications having 11 combinations (NC+ N_{125} - No chopping of paddy straw and 125 kg N/ha, C+ N_{125}

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- Chopping of paddy straw and 125 kg N/ha, C + FYM_5+ N_{125} - Chopping of paddy straw + FYM 5 t/ha + 125 kg N/ha, C + N_{20+105} - Chopping of paddy straw + 20 kg N/ha at chopping of straw and 105 kg N/ha afterwards as recommended, C + N_{30+95} - Chopping of paddy straw + 30 kg N/ha at chopping of straw and 95 kg N/ha afterwards as recommended, C + N_{20+130} - Chopping of paddy straw + 20 kg N/ha at chopping of straw and 130 kg N/ha afterwards as recommended, C + N_{30+120} - Chopping of paddy straw + 30 kg N/ha at chopping of straw and 120 kg N/ha afterwards as recommended, C + FYM_5 + N_{20+105} - Chopping of paddy straw + FYM 5 t/ha + 20 kg N/ha at chopping of straw and 105 kg N/ha afterwards as recommended, C + FYM_5 + N_{30+95} - Chopping of paddy straw + FYM 5 t/ha + 30 kg N/ha at chopping of straw and 95 kg N/ha afterwards as recommended, C + FYM_5 + N_{20+130} - Chopping of paddy straw + FYM 5 t/ha + 20 kg N/ha at chopping of straw and 130 kg N/ha afterwards as recommended and C + FYM_5 + N_{30+120} -Chopping of paddy straw + FYM 5 t/ha + 30 kg N/ha at chopping of straw and 120 kg N/ha afterwards as recommended). Paddy straw after combine harvesting of preceding rice was chopped by using paddy straw chopper cum spreader into small pieces and a pre-sowing irrigation was applied to field. FYM was applied on fresh weight basis immediately after chopping of straw. Wheat crop was sown on 15 November during 2016 and on 12 November during 2017. Sowing was done with turbo happy seeder at row spacing of 20 cm. The variety PBW 677 was sown during both years using a seed rate of 100 kg/ha. Nitrogen was applied as per treatments. Phosphorus (62.5 kg P_2O_5/ha) and potassium (30 kg K_2O/ha) were applied as per PAU recommendations. Nitrogen was applied through urea, phosphorus through single super phosphate and potassium through muriate of potash. Wheat was harvested on April 18 and April 15 during 2017 and 2018, respectively. Grain yield was recorded as per the standard procedure. After threshing, cleaning and drying, the grain yield (t/ha) was recorded and reported at 14% moisture content. The weeds were counted from two randomly selected spots by quadrat of one square meter from each plot. For recording weed biomass, weeds were first sun dried and then dried in the oven at 60°C to constant weight. The root density was computed layer wise. It was expressed as weight of roots per unit volume of soil and calculated as follows:

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

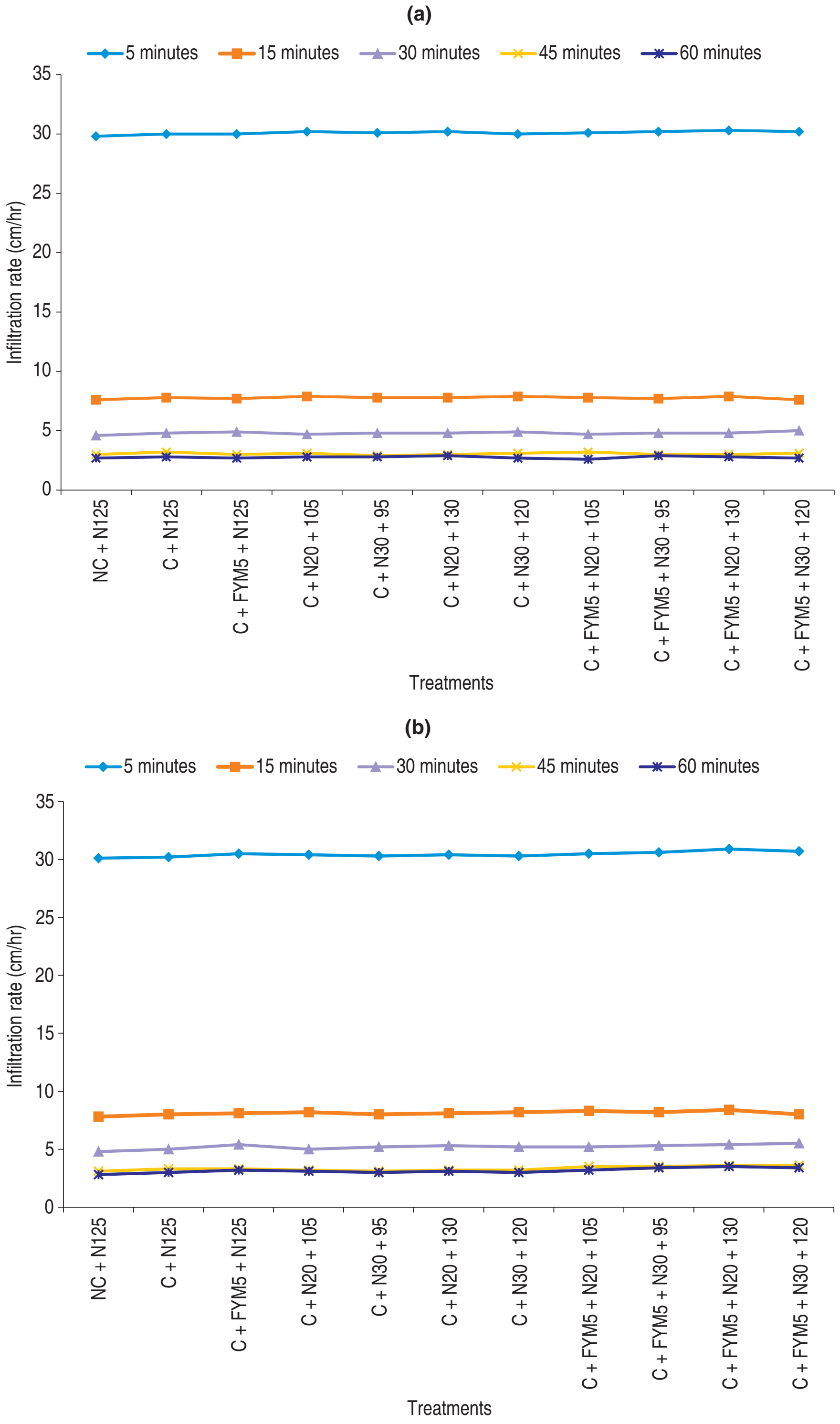

Fig 1 Infiltration rate of soil as affected by different treatments (a) 2016-17 and (b) 2017-18.

The organic carbon in the soil is determined by rapid titration method given by Walkley and Black (1934), available N by alkaline potassium permanganate method given by Subbiah and Asija (1956), available P by the 0.5 M sodium bicarbonate method given by Olsen *et al*. (1954) and available K by ammonium acetate extraction method (Jackson 1967). Infiltration rate was measured *in-situ* by double ring infiltrometer method according to Reynolds *et al.* (2002) and bulk density by core sampler method as detailed by Blake (1965). Statistical analysis was performed using randomized block design as per procedure given by Cochran and Cox (1967). All the comparisons were made at 5% level of significance. Pooled means were calculated by keeping year as main plot factor and treatments as sub plot factor using factorial RBD design.

RESULTS AND DISCUSSION

Weed biomass: The experimental field was mainly dominated by *Phalaris minor.* Major broadleaved weeds were *Rumex dentatus*, *Chenopodium album*, *Melilotus indica*, *Medicago denticulata*, *Coronopus didymus*, *Anagallis arvensis*, *Trigonella polycerata* and *Rumex spinosus*. The weed biomass was significantly higher in plot where paddy residue was not chopped and spread before sowing (Table 1). Lower weed biomass in chopped straw plots might be due to presence of straw mulch on soil surface, which significantly reduced weed emergence. Weed biomass in chopped straw treatments was reduced by 7.3 and 17.0 % over unchopped straw at 35 and 100 DAS, respectively in the year 2016-17. The corresponding reduction in 2017-18 was 9.1 and 15.9%. Reduction in biomass with application of rice residue mulch is also reported by Kumar (2017).

Root density: Out of total root mass about 75.0% mass was recorded in upper 0-15 cm soil depth (Table 1). Maximum root density was in treatment C + FYM_5 + N_{30+120} while minimum root density was in NC + N_{125}.Treatments receiving 150 kg N/ha had higher root density than 125 kg N/ha treatments at all soil depths during both years. Singh (2011) also reported higher root density in happy seeder sown wheat at 150 kg N/ha. It was also observed that root density was on an average 46.0, 52.2, 10.0 and 15.4% more in chopped straw treatment in 0-15, 15-30, 30-60 and 60-90 cm soil layers than unchopped straw treatment, respectively during 2016-17 and the trend was similar in 2017-18. Presence of chopped straw as mulch moderated the soil temperature and availability of water and improved soil structure which resulted in better root growth (Mal 2017 and Chakraborty *et al.* 2010).

Infiltration rate: Initially infiltration rate was very high but it decreased as the time elapsed from 5 to 60 min. (Fig 1 a, b). High infiltration rate was observed in treatments where straw mulch was present due to chopping of paddy straw. This might be attributed to less compaction of soil by rain drop impact and more porosity created by mulch due to burrowing activity of some species (Kaur 2016). There was improvement in infiltration rate after two years of experiment. In no tilled plots, there were old root channels and rotting roots. These channels probably provided numerous pathways for water flow, attributed to higher infiltration rates in no tillage to pore continuity and an established macro porosity in the preceding years (Alam *et al.* 2014).

Bulk density: Bulk density was not significantly affected by different residue and nitrogen management practices (Table 2). However, slightly lower bulk density was recorded in chopped straw treatments due to presence of straw mulch. This might be due to prevention of crust formation on soil surface by rain drop impact and surface irrigation. Reduction in bulk density was observed in 2018 as compared to 2016 after two years of residue retention under zero tillage. Alam

Table 1 Root density and weed biomass in happy seeder sown wheat as affected by different residue and nitrogen management practices (pooled data of two years)

Treatment	Root density (g/m^3) (Mean of two years)				Weed biomass (g/m^2)			
	Soil depth				Before herbicide application (35 DAS)		100 DAS	
	0-15 cm	15-30 cm	30-60 cm	60-90 cm				
NC + N_{125}	2128	366	162	93	4.7 (20.8)	4.8 (21.5)	3.1 (8.6)	3.2 (9.1)
C + N_{125}	2144	370	167	94	4.3 (17.2)	4.4 (19.4)	2.8 (6.6)	2.8 (7.0)
C + FYM_5 + N_{125}	2174	385	177	105	4.5 (19.3)	4.5 (19.5)	2.7 (6.4)	2.9 (7.5)
C + N_{20+105}	2174	374	170	99	4.4 (18.5)	4.3 (18.0)	2.6 (5.3)	3.0 (8.1)
C + N_{30+95}	2187	369	172	101	4.3 (17.7)	4.4 (18.8)	2.6 (5.5)	2.7 (6.5)
C + N_{20+130}	2169	368	181	108	4.4 (19.1)	4.5 (19.2)	2.8 (6.9)	2.9 (7.5)
C + N_{30+120}	2194	376	185	111	4.5 (16.2)	4.3 (18.1)	2.5 (4.8)	2.7 (6.4)
C + FYM_5 + N_{20+105}	2301	399	175	104	4.4 (18.2)	4.4 (18.2)	2.6 (5.3)	2.6 (6.1)
C + FYM_5 + N_{30+95}	2294	392	178	107	4.3 (17.4)	4.4 (18.3)	2.6 (5.4)	2.7 (6.5)
C + FYM_5 + N_{20+130}	2319	401	182	113	4.3 (17.8)	4.5 (19.0)	2.5 (4.9)	2.6 (5.9)
C + FYM_5 + N_{30+120}	2336	412	195	119	4.4 (18.1)	4.3 (16.8)	2.8 (6.5)	2.7 (6.5)
CD (P=0.05)	-	-	-	-	0.3	0.3	0.3	0.2

Weed biomass data were subjected to square root transformation $\sqrt{x+1}$. Values in parentheses are original.

Table 2 Bulk density (0-15 cm depth), organic carbon, available nutrients in soil and grain yield as affected by different residue and nitrogen management practices

Treatment	Bulk density (g/cm^3)		Organic carbon (%)		Available nutrients in soil						Grain yield (t/ha)		
					N (kg/ha)		P (kg/ha)		K (kg/ha)				
	2016	2018	2016	2018	2016	2018	2016	2018	2016	2018	2016-17	2017-18	Pooled mean
NC + N_{125}	1.59	1.55	0.26	0.27	191.21	192.24	22.15	22.20	215.56	216.60	4.58	4.45	4.52
C + N_{125}	1.58	1.54	0.28	0.30	193.33	194.83	22.50	22.55	214.80	216.90	4.77	4.64	4.71
C + FYM_5 + N_{125}	1.56	1.50	0.25	0.29	194.24	196.80	22.75	23.65	215.45	217.50	4.80	4.71	4.76
C + N_{20+105}	1.58	1.55	0.26	0.28	193.85	194.30	22.30	22.95	215.30	216.95	4.95	4.85	4.90
C + N_{30+95}	1.57	1.54	0.28	0.30	192.12	193.22	22.45	22.90	216.10	217.80	5.01	4.93	4.97
C + N_{20+130}	1.57	1.55	0.27	0.29	194.20	196.14	22.55	22.85	215.35	216.70	5.20	5.17	5.19
C + N_{30+120}	1.55	1.53	0.26	0.28	195.62	196.50	23.10	23.70	215.15	216.65	5.25	5.19	5.22
C + FYM_5 + N_{20+105}	1.56	1.51	0.28	0.32	193.57	196.50	22.90	23.10	215.35	218.20	5.13	5.08	5.11
C + FYM_5 + N_{30+95}	1.58	1.52	0.26	0.31	193.53	196.70	22.75	23.90	215.40	218.25	5.22	5.16	5.19
C + FYM_5 + N_{20+130}	1.59	1.52	0.27	0.33	194.20	196.96	22.68	23.70	215.45	219.10	5.35	5.25	5.30
C + FYM_5 + N_{30+120}	1.57	1.51	0.26	0.32	194.90	197.10	22.54	23.80	215.50	218.50	5.42	5.36	5.39
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.45	0.41	0.29

et al. (2014) and Meena *et al.* (2015) also recorded reduction in bulk density under conservation tillage.

Organic carbon (OC): There was improvement in OC status of soil after two years cropping under zero tillage with residue retention (Table 2). Mean OC content in 2016 was 0.27%, which increased to 0.30% in 2018. The crop residue retained on the soil surface undergoes decomposition over a period of time and add organic matter to soil. The higher amount of OC in surface soil layer in mulched treatments might be due to higher accumulation of crop residue which also increases the availability of mineral nutrition (Chaudhary *et al.* 2017 and Ella *et al.* 2016)

Available soil nitrogen (N), phosphorus (P) and potassium (K): There was increase in the availability of these nutrients in soil after two years of cropping under zero tillage conditions with residues (Table 2). Treatments in which FYM was applied along with chemical fertilizers showed more increase in their availability in soil. Kesarwani *et al.* (2017) also reported increase in availability of N, P and K in conservation agriculture in rice-wheat cropping system.

Grain yield: Different residue and nitrogen management practices had a significant bearing on grain yield of happy seeder sown wheat during both the years and in pooled data as well (Table 2). Treatment C + FYM_5 + N_{30+120} produced maximum grain yield (5.42 and 5.36 t/ha) during both years. However, it was statistically at par with C + N_{20+130}, C + N_{30+120}, C + FYM_5 + N_{20+105}, C + FYM_5 + N_{30+95} and C + FYM_5 + N_{20+130} treatments but significantly better than all other treatments. During 2016-17, grain yield of C + FYM_5 + N_{30+120} was also at par with C + N_{30+95} treatments. Lowest grain yield (4.58 and 4.45 t/ha) was recorded in NC + N_{125} during both years. Similar trend was observed in the pooled data. Treatments in which 20/30 kg N was applied at the time of chopping of paddy residue had positive effect on grain yield. These treatments produced yield increments of 10.0 and 11.4% over treatments where N was not applied at the time of chopping. Increasing N from 125 to 150 kg/ha in happy seeder sown wheat improved grain yield by 7.8–8.5% but not up to the level of significance. Presence of rice residue mulch in chopped straw treatments helped in conservation of soil moisture in the root zone, which ultimately helped in enhancing grain yield. Higher moisture status increased root proliferation and thus increased the availability of nutrients to crop roots which was well reflected in terms of grain yield. These results are in conformity with the findings of Kesarwani *et al.* (2017), Tripathi *et al.* (2015) and Yadvinder-Singh *et al.* (2009) who reported higher grain yield of zero till wheat under paddy straw mulch at higher N levels

Retention of rice residues as mulch combined with happy seeder sowing suppressed weed growth, increased root density and grain yield of wheat. Physico-chemical properties of soil were improved after two years of residue retention. Application of 20 or 30 kg nitrogen at the time of chopping of straw (10 days before sowing) in addition to recommended schedule of N resulted in higher grain yield.

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