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Integrated Effect of INM and Reduced Tillage on Economic Yield, Nutrient Uptake of Wheat (*Triticum aestivum* L.) and Soil Properties

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Abstract: A field experiment was conducted for two consecutive years at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The experiment was laid in a split-plot design with three replications to assess the effect of INM on yield and nutrient uptake of wheat and soil properties under reduced tillage. Dhaincha (*Sesbania canabaena)* was cultivated as a green manure crop followed by rice and finally test crop of wheat. Recommended doses of N, P and K (120:60:60) were applied to rice. The grain and straw yields were recorded in both the years. The maximum grain yield, N content in grain and total nitrogen uptake by wheat were recorded under conventional tillage with green manuring (M_4), and the minimum was under reduced tillage without green manuring (M_1) during both the years. The sub-plot treatment wherein 4 t ha^{-1} of sludge was added with 100% N through chemical source gave maximum grain and straw yield, N concentration and its uptake. In the main plot treatment, the organic carbon content was highest under reduced tillage with green manuring (M_2) followed by S_7 conventional tillage with green manuring. In sub-plot treatment, maximum organic carbon content was observed with the treatment receiving 50% N through +50% N through rice residue and sludge+*Azotobacter,* which was significantly higher than other subplot treatments. Maximum available soil nitrogen was obtained under conventional tillage with green manuring, which was significantly superior to other main plot treatments, except the treatment having reduced tillage with green manuring. The treatment (S_7) significantly higher available N at harvest than other subplot treatments, barring treatment S_5 during the first year.

Keywords: *Wheat yield, N content and uptake, reduced tillage, INM, organic carbon, available N*

Introduction

Agriculture faces significant challenges to meet the need of food production without increasing the area under cultivation. Higher production of wheat under rice-wheat crop rotation systems can be fulfilled by adopting improved cultural practices such as integrated nutrient management and reduced tillage systems. The reduced tillage systems reduce the soil disturbance and retain crop residues at the soil surface which helps in the

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improvement of soil fertility status, water infiltration and nutrient availability (Lal 2004). Integrated nutrient management refers to the balanced application of all essential plant nutrients to the soil system for improved productivity to both soils and the crop (Six *et al*. 2002). The balanced application of essential plant nutrients is met out by applying different sources of nutrients such as organic fertilizer, inorganic fertilizer and bio-fertilizers. Both rice and wheat are heavy feeders of nutrients and a system yielding 6.95 t ha^{-1} of rice, and 3.86 t ha^{-1} of wheat may remove as much as 3.16 kg N, 28 kg P and 342 kg K apart from the significant amount of different secondary and micro-nutrients (Hegde and Pandey 1989). The removal of nutrients per unit area in the rice-wheat cropping system at an average productivity level is much higher than the average fertilizer application. Unless the system is provided with an adequate amount of required plant nutrient, there will be higher exploitation of the native soil fertility and the soil will not be able to sustain the high productivity on a long term basis (Nambiar *et al.* 1992). Incorporation of nutrients through fertilizer and organic manures become indispensable for sustaining the productivity of rice-wheat cropping system. Further to reduce the cost of cultivation, various reduced tillage systems have been recommended for rice-wheat sequence. Though a number of reports advocate the use of INM) (Roy 1992) and reduced tillage systems individually for the rice-wheat sequence, but not much work has been done combining the two. Therefore, the present experiment has been carried out to investigate the effect of INM of wheat under reduced tillage in the rice-wheat cropping system.

Materials and Methods

Field experiments were conducted during 1999-2000 and 2000-2001 at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The experiments were carried out in split-plot design with three replications. The field experiment was initiated with the green manure crop of Dhaincha (*Sesbania canabaena*) and its incorporationin soil 45 days after sowing in the main plot treatments. Recommended doses of N, P and K (120:60:60) were applied to the rice, and rice seedlings were transplanted. The response of wheat to four main plot treatments: (i) reduced tillage without green manuring (M_1), (ii) reduced tillage with green manuring (M_2), (iii) conventional tillage without green manuring (M_3) and (iv) conventional tillage with green manuring (M_4) and seven sub-plot treatments, *i.e.* 100% N through urea (S_1), 100% N through urea + bio-fertilizer (*Azotobacter*) (S_2), 75% N through urea + 25% N through paddy leftover and sludge + bio-fertilizer (S_3), 50% N through urea + 50% N through paddy left over and sludge + bio-fertilizer (S_4), 75% N through urea + 25% N through sludge + bio-fertilizer (S_5), 50% N through urea + 50% N through sludge + bio-fertilizer (S_6), 100% N through urea + 4 tonnes ha^{-1} of sludge + bio-fertilizer (S_7) were evaluated.

Plots were demarcated in each strip, and only rice panicles were harvested in the plots where rice residue incorporation was required. In the rest of the plots, entire rice plants were harvested. 120 kg ha^{-1} of nitrogen was considered as full dose (100% N). The recommended dose of phosphorus and potassium @ 60 kg ha^{-1} each were applied as basal dose in all the plots in forms of single super phosphate (60 kg ha^{-1}) and muriate of potash, respectively. Sludge as organic source of nitrogen was incorporated 20 days before sowing wheat whereas half the dose of fertilizers N (60 kg ha^{-1}) as urea was given as a basal application. Remaining half dose of nitrogen was applied in two equal splits at tillering and flowering stages. Wheat seeds were inoculated with *Azotobacter* culture. The initial sandy loam soil had bulk density 1.52 Mg m^{-3}, particle density 2.63 Mg m^{-3}, pH 7.8, E.C. 0.25 dS m^{-1} and organic carbon 0.43%. Available N, P and K were 205, 220 and 230 kg ha^{-1} respectively.

The bulk and particle density were determined the procedures outlined by Chopra and Kanwar (1991). The organic carbon of the soil was estimated by wet chromic acid digestion method (Walkley and

Black1934). The pH and electrical conductivity (E.C.) were measured in 1:2.5 soil: distilled water suspension with the help of pH meter and EC meter, respectively. The available N, P and K were determined by alkaline permanganate method (Subbiah and Asija 1956), Olsen's method (1954) and ammonium acetate extract with the help of flame photometer (Jackson 1973), respectively. The processed straw and grain samples were digested in sulphuric- selenium- salicylic acid and H_2O_2 system (Novozamsky *et al*. 1983). Total phosphorus was determined by vanadomolybdophosphoric acid yellow colour method (Tandon 1993). Total potassium was determined flame-photometrically (Jackson 1973).

Results and Discussion

Soil properties

In general, higher pH was recorded under the tillage treatment without green manuring in the first year (Table 1). Conventional tillage (M_3) had higher pH than reduced tillage (M_1). Frequez *et al.* (1990) attributed this to decreased mineralization of added organic sources and thereby, formation and release of acid-forming ions in soil solution. The organic carbon content was highest under reduced tillage with green manuring (M_2) followed by conventional tillage with green manuring (M_4) (Table 1). Mixing of soil is reduced in a zero-tillage system, leading to higher organic matter (Bongki 1996; Singh *et al.* 1998). The highest organic carbon content was observed in S_4 treatment which was significantly higher than other sub-plot treatments in both the years of experiment. This may be ascribed to more organic matter added through rice residue, sludge and green manure. This is in agreement with the findings of Kumar and Mishra (1991) and Dang and Verma (1996).

Treatment M_4 had the maximum N (Table 2) which was significantly superior to other main plot treatments. In reduced tillage systems, the processes of mineralization and nitrification are slower due to higher population of anaerobic microbes resulting in a lesser amount of available N (Thomas *et al*. 1973; Doran 1980 and Singh *et al.* 1998). Conventional tillage with green manuring gave significantly higher available N content in post-harvest soil. The increase in available N content was presumably due to the release of N after decomposition of green manures. These results are in agreement with the findings of Thakur *et al.* (1995) and Sharma *et al.* (2001). The maximum available N was recorded in the treatment S_7, which was significantly higher than other sub-plot treatments, except the treatment S_5 during the first year (1999-2000). The higher available N content of S_7 may be ascribed to extra nitrogen through sludge and to a higher release of native N in available to enhanced better microbial activity caused by sludge. The minimum value was recorded in S_1 treatment.

Yield of wheat

The conventional tillage with green manuring produced maximum grain and straw yield (Table 2), which was significantly higher than other main plot treatments. Treatments M_1 and M_3 had significantly lower grain and straw yield than corresponding tillage treatments with green manuring. The results are in agreement with that of Singh *et al.* (1998) who reported that conventional tillage gave 16-25% more grain yield than reduced tillage in wheat. Green manuring with conventional tillage increased the availability *via* enhanced microbial activity. A significant residual effect of green manure incorporation to rice on succeeding crop has been reported by Thakur *et al*. (1995) and Ravankar *et al.* (2001).

Nitrogen content and uptake of N in wheat

Conventional tillage with green manuring (M_4) produced maximum N concentration in wheat grain which was significantly higher than other main plot treatments. The minimum N concentration in wheat grain and straw was observed in treatment having reduced tillage without green manuring (M_1). The maximum N concentration in wheat (grain and straw)

Table 1. Effect of different treatments properties of post harvest soil

Treatments	pH (1:2.5)		Organic carbon (g kg^{-1})		Available N (kg ha^{-1})	
	1999-2000	2000-2001	1999-2000	2000-2001	1999-2000	2000-2001
M_1(Reduced tillage)	7.65	7.64	4.78	4.91	225.05	227.52
M_2(Reduced tillage with green manuring)	7.59	7.58	5.04	5.13	235.42	240.23
M_3 (Conventional tillage)	7.66	7.65	4.73	4.85	227.06	229.79
M_4 (Conventional tillage with green manuring)	7.63	7.62	5.02	5.10	238.57	242.13
CD (P = 0.05)	0.04	NS	0.05	0.03	3.80	2.54
Sub plot treatments						
S_1 (100% N through Urea)	7.70	7.69	4.62	4.66	216.80	222.73
S_2(100% N through Urea + BF)	7.68	7.67	4.67	4.72	218.84	224.62
S_3 (75% N through urea + 25% N through rice residue & sludge + BF)	7.64	7.64	5.21	5.32	231.95	233.40
S_4 (50% N through urea + 50% N through rice residue & sludge + BF)	7.59	7.57	5.33	5.41	236.54	238.69
S_5 (75% N through urea + 25% N through sludge +BF)	7.63	7.62	4.74	4.88	233.46	236.78
S_6 (50% N through urea + 50% N through sludge + BF)	7.57	7.56	4.86	5.08	239.02	241.80
S_7 (100% N through urea + 4 tons $ha^{-1}$of sludge + BF)	7.61	7.59	4.82	4.94	244.04	246.41
CD (P= 0.05)	NS	NS	0.15	0.03	11.35	4.68
MxS	NS	NS	NS	Significant	NS	NS

Table 2. Effect of different treatments on yield, N content and total N uptake by wheat

Treatments	Yield (q ha^{-1})		N content (%)		Total N uptake (kg ha^{-1})	
	1999-2000	2000-2001	1999-2000	2000-2001	1999-2000	2000-2001
M_1 (Reduced tillage)	36.74	39.33	1.76	1.71	92.57	95.91
M_2(Reduced tillage with green manuring)	39.25	41.89	1.82	1.79	101.46	105.31
M_3 (Conventional tillage)	37.62	40.35	1.79	1.74	96.16	99.72
M_4 (Conventional tillage with green manuring)	39.94	43.06	1.88	1.83	108.18	111.49
CD (P = 0.05)	0.39	1.17	0.022	0.034	3.69	2.65
Sub plot treatments						
S_1 (100% N through Urea)	38.83	41.14	1.80	1.76	99.76	102.59
S_2 (100% N through Urea + BF)	39.05	41.57	1.86	1.80	104.90	106.55
S_3 (75% N through urea + 25% N through rice residue & sludge + BF)	37.73	40.58	1.77	1.72	95.69	98.71
S_4 (50% N through urea + 50% N through rice residue & sludge + BF)	35.84	39.03	1.72	1.69	85.81	90.37
S_5 (75% N through urea + 25% N through sludge +BF)	39.54	42.37	1.87	1.82	108.74	111.81
S_6 (50% N through urea + 50% N through sludge + BF)	36.93	39.8	1.75	1.70	90.20	94.26
S_7 (100% N through urea + 4 tonnes ha^{-1}of sludge + BF)	40.76	43.61	1.91	1.87	113.79	117.51
CD (P= 0.05)	0.76	0.57	0.059	0.055	5.33	4.23
MxS	Significant	Significant	NS	NS	NS	NS

was recorded inthe treatment receiving 100% N through urea + 4 tonnes ha^{-1} of sludge +*Azotobacter* (S_7) were significantly higher than other sub-plot treatments (S_5, S_2) during 1999-2000 and S_5 during 2000-2001 (Table 2).

Nitrogen uptake

The conventional tillage with green manuring (M_4) had maximum uptake. Singh and Singh (1993) reported that total N uptake of wheat was higher in conventional tillage than zero-tillage system due to higher yield of grain and straw and the higher concentration of N in conventional tillage. Peterson *et al.* (1984) reported that N uptake by wheat plants having a restricted root system is lower than those having a large root system, even if the N supply is adequate and equal under both situations. Therefore, it is seen that moderation of the hydro-thermal regime under conventional tillage + FYM/green manuring could have improved root growth, especially in the surface layers, and the uptake of nutrients by wheat crop.

The maximum total N uptake was recorded in the treatment with 100% N through urea + 4 tonnes ha^{-1} of sludge + *Azotobacter* (S7), which was significantly higher than other sub-plot treatments. The reason might be due to increased N content of the soil with the application of sludge (Frequez *et al.* 1990). The minimum uptake of N was observed in S_4 treatment in both the years. The green manuring with conventional tillage had a larger effect on grain and straw yield and their N contents. Bhagat and Verma (1990) reported that the conventional tillage with FYM improved root growth, especially in surface layers and uptake of nutrients by wheat crop.

Conclusions

It is concluded that the substitution of 25% chemical nitrogen through organic sources could be done without sacrificing straw and grain yield of wheat. Substitution beyond 25% could lead to yield reduction during the initial years. Nitrogen uptake of wheat is significantly affected by tillage treatments. Conventional tillage induces higher N uptake than reduced tillage. However, the maximum amount of nitrogen is removed when 4 tonnes ha^{-1} of sludge is applied in addition of 100% N through urea

References

Bhagat, R.M. and Verma, T.S. (1990). Impact of rice straw management on soil physical properties and wheat yield. *Soil Science* **152**, 108-115.

Bongki, Y., Injon, P., Heekwon, K., Bongkoo, H. and Roy, I. (1996). Application levels and method of nitrogen fertilizer on no-tillage in infant rice seedlings on tidal reclaimed paddy field. *Research Development Association Journal of Agriculture Science* **38**, 285-290.

Chopra, S.L. and Kanwar J.S. (1991). 'Analytical Agricultural Chemistry'. Third Edition. (Kalyani Publishers, Ludhiana: India).

Dang, Y.P. and Verma, K.S. (1996). Direct and residual effect of press mud cakes in rice-wheat cropping system. *Journal of the Indian Society of Soil Science* **44,** 448-450.

Doran, J.W. (1980). Soil microbial and biochemical changes with reduced tillage. *Soil Science Society of America Journal* **44**, 765-771.

Frequez, P.R., Francies, R.E. and Dennis, G.L. (1990). Sewage sludge effect on soil and plant quality in a degraded semi-arid grassland. *Journal of Environmental Quality* **19**, 324-329.

Hegde, D.M. and Pandey, R.K. (1989). Rice-wheat system in India. Report of 20th Asian Rice Farming Systems Working Group Meeting. Bogor, Indonesia. pp. 225-227.

Jackson, M.L. (1973). 'Soil Chemical Analysis'. (Prentice Hall of India Pvt. Ltd., New Delhi).

Kumar, V. and Mishra, B. (1991). Effect of two type of press mud cake on growth of rice-maize and soil properties. *Journal of the Indian Society of Soil Science* **39,**109-113.

Lal, R. (2004). The potential of carbon sequestration in soils of South Asia. In 'Conserving Oil and Water for Society: Sharing Solutions'. 13th International Soil Conservation Organization Conference, Brisbane, pp. 1-6.

Nambiar, K.K.M., Soni, P.N., Vats, M.R., Sehgal, K. and Mehta, D.K. (1992). All India Coordinated Research Project on Long-term Fertilizer Experiment. Annual Report 1987-1988/1988-1989. ICAR, New Delhi.

Novozamsky, I., Houba, V.J.G., Eck, R.V. and Ark, W.V. (1983). A novel digestion technique for multi element plant analysis. *Communications in Soil Science and Plant Analysis* **14**, 239-248.

Olsen, S.R., Cole, C.V., Watanabe, F.S. and Dean, L.A. (1954). Estimation of available phosphorus in soil by extraction with sodium bicarbonate. Circular 939. (USDA: Washington, D.C.).

Peterson, C.M., Klepper, B., Pumphrey, F.V. and Rickman, R.W. (1984). Restricted rooting decreases tillering and growth of winter wheat. *Agronomy Journal* **76,** 861- 863.

Ravankar, H.N., Sarup, P.A., Topre, R.K., Rathod, V.B. and Deshmukh, P.W. (2001). Productivity, nutrient availability and their uptake in sorghum-wheat sequence under long-term fertilization in Vertisol. *Agricultural Science Digest* **21**, 141-144.

Roy, R.N. (1992). Integrated plant nutrition system-an overview: Infertilizers, organic manure, recyclable wastes and bio-fertilizers. In 'Fertilizer Development and Consultation Organization' (Eds. Tandon, H.L.S.) pp.1-11.(New Delhi, India).

Sharma, M.P., Bali, S.V. and Gupta, D.K. (2001). Soil fertility and productivity of rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system in an Inceptisol as influenced by integrated nutrient management. *Indian Journal of Agricultural Sciences* **71**, 82-86.

Singh, G. and Singh, O.P. (1993). Effect of tillage practices and fertility on yield and economics of linseed (*Linum usitatissimum*) grown after rice (*Oryza sativa*). *Indian Journal of Agricultural Sciences* **63**, 647-648.

Singh, P., Aipe, K.L., Prasad, R., Sharma, S.N. and Singh, S. (1998). Relative effect of zero-tillage and conventional tillage on growth and yield of wheat (*Triticum aestivum* L.) and soil fertility under rice (*Oryza sativa* L.) - wheat cropping system. *Indian Journal of Agronomy* **43,** 204-207.

Six, J., Feller, C., Denef, K., Ogle, S., MoraesSa, J.C.D. and Albrecht, A. (2002). Soil organic matter, biota and aggregation in temperate and tropical soils-Effect of no tillage. *Agronomie* **22**, 755-775.

Subbiah, B.V. and Asija, G.L. (1956). A rapid procedure for the estimation of available nitrogen in soil. *Current Science* **25**, 259-260.

Tandon, H.L.S. (1993). Methods of analysis of soils, plants, water and fertilizers. In 'Fertilizer Development and Consultation Organization'. pp.143. (New Delhi, India).

Thakur, R.C., Bindra, A.D., Sood, R.D. and Bhargava, N. (1995). Effect of fertilizer application and green manuring on physico-chemical properties of soil and grain yield in rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping sequence. *Indian Journal of Agronomy* **40**, 4-13.

Thomas, G.W., Blevins, R.L., Phillips, R.E. and Mohan, M.A. (1973). Effect of killed sold mulch on nitrate movement and corn yield. *Agronomy Journal* **65**, 736-739.

Walkley, A. and Black, I.C. (1934). An experimentation of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil Science* **34**, 29-38.