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EFFECT OF INTEGRATED NUTRIENT MANAGEMENT UNDER REDUCED TILLAGE ON YIELD AND NUTRIENT UPTAKE OF WHEAT (*Triticum aestivum* L.)

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ABSTRACT: A field experiments was conducted during 1999-2000 and 2000-2001 at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi in split-plot design with three replications to assess the effect of INM on wheat under reduced tillage. The field experiment was initiated with green manure crop of Dhaincha (Sesbaniacanabena) which was followed by rice and finally test crop of wheat was taken. Recommended does of N,P and K(120:60:60) were applied to rice and grain and straw yields were recorded during both the years. Four main plot treatments comprising of tillage methods and green manuring and seven sub plot treatments comprising of different combination of chemical and organic nitrogen sources were tested. The maximum yield of grain and straw; N,P and K content in grain and straw and their uptake were recorded under conventional tillage with green manuring(M_4) and minimum was under reduced tillage without green manuring (M_1) during both the years. The subplot treatment S_7 where in 4t ha^{-1} of sludge was added in addition to 100% N through chemical sources gave maximum grain and straw yield and N concentration and uptake. However, the highest P,K concentration in grain and straw were achieved by applying 50% N through urea and 50% N through sludge. P uptake was found to be maximum in S_7 and minimum in S_4. Grain and straw removed maximum Kin S_7 whereas minimum K removal was recorded with S_1 during both the years of experimentation.
Keywords: Wheat yield, NPK content and uptake, reduced tillage, INM.

INTRODUCTION

Both rice and wheat are heavy feeders of nutrients and a system yielding 6.95 tons ha^{-1} of rice and 3.86 tonsha^{-1}of wheat may remove as much as 3.16 kg N 28 kg P and 342 kg K apart from significant amount of different secondary and micro- nutrients (Hedge and Pandey, 1989). The removal of nutrients per unit area in the rice-wheat cropping system at an average productivity levels is much higher than the average fertilizer application. Unless the system is provided with adequate amount of required plant nutrient there will greater drain of the native soil fertility and the soil will not be able to sustain the high productivity on 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. Through a number of reports are there advocating the use of integrated nutrient management (INM) (Roy, 1992) and reduced tillage systems (Roy and Sarkar, 1993) individually for rice-wheat sequence but not much work has been done combining the two. The present experiment has, therefore, been carried out to investigate the effect of INM of wheat under reduced tillage in rice-wheat cropping system.

MATERIALS AND METHODS

Thoroughly planned 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 green manure crop of Dhaincha (*Sesbaniacanabena)*and after its incorporation at 45 days after sowing rice seedlings were transplanted. Recommended doses of N, P and K (120:60:60) were applied to rice and straw and grain yields were recorded during both the years. Response of wheat to four main plot treatments, i.e., reduced tillage without green manuring (M_1), reduced tillage with green manuring (M_2), conventional tillage without green manuring (M_3) conventional tillage with green manuring (M_4) and seven sub plot treatments, i.e., 100 % N through urea (S_1), 100 % N through urea + biofertilizer (*Azotobacter*) (S_2), 75 % N through urea + 25 % N through paddy left over & sludge + biofertilizer (S_3), 50 % N through urea + 50 % N through paddy left over & sludge + biofertilizer (S_4), 75 % N through urea + 25 % N through sludge + biofertilizer (S_5), 50 % N through urea + 50 % N through sludge + biofertilizer (S_6), 100 % N through urea + 4 tons ha^{-1} of sludge + biofertilizer (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 rest of the plots, entire rice plants were harvested. Required quantity of fertilizer nitrogen, phosphorus and potassium were applied to wheat through urea, single super phosphate (SSP) and muriate of potash (MOP), respectively. 120 kg ha^{-1} of nitrogen was considered as full dose (100 % N). Recommended doses of phosphorus and potassium i.e. @ 60 kg ha^{-1} of both were applied uniformly as basal dose to all the plots. Sludge as organic source of nitrogen was incorporated 20 days before sowing of wheat whereas half the dose of fertilizers N as urea was given as basal application. Remaining half dose of nitrogen was applied in two equal splits at tillering and flowering stages. Wheat seed was inoculated using *Azotobacter* culture. The important initial soil characteristics of the experimental field were-soil type/taxonomic class sandy loam, bulk density 1.52 Mg m^{-3}, particle density 2.63Mg m^{-3}, pH 7.8, E.C. 0.25 $dSm^{-1}$and organic carbon 0.43%. Available N,P and K (kg ha^{-1}) were 205, 22 and 230, respectively. The bulk density and water holding capacity of the soil samples were determined by gravimetric (core cutter) and circular brass box method (Chopra and Kanwar, 1991).The organic carbon of the soil samples was estimated by Walkley and Black's wet chromic acid digestion method (1934). The pH and electrical conductivity (E.C.) were measured in1: 2.5 soil: distilled water suspension with the help of pH meter and E.C. meter, respectively. The plant available N, P and K were determined by alkaline permanganate method (Subbiah and Asija, 1956), Olsen's method (1965) and ammonium acetate extract with the help of flame photometer (Jackson, 1967), respectively. The processed straw and grain samples were digested in sulphuric- selenium- salicylic acid andH_2O_2system(Novozamsky*et al.*, 1983) and stored in plastic bottles for estimation of nitrogen, phosphorus and potassium. Total nitrogen was determined by colorimetric method as described by Tandon (1993). Total phosphorus was determined by vanadomolybdophosphoric acid yellow colour method (Tondon,1993). Total potassium was determined flame-photometrically (Jackson, 1973).

RESULTS AND DISCUSSION

Grain and straw yield of wheat

The conventional tillage with green manuring produced maximum grain and straw yield which was significantly higher than other main plot treatments. Treatment M_1 and M_3 produced significantly lower grain and straw yield when compared to corresponding tillage treatments with green manuring. Results earlier reported by Rai and Yadav (1979) reported 20 % less seedling establishment under zero-tillage as compared to conventional tillage which ultimately resulted in poor grain and straw yield. These were 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. Similar findings were also reported by Aggrawal*et al.*(1992). Grain and straw yield of wheat was affected significantly by green manuring in both tillage practices. Green manuring with conventional tillage increased the availability of nutrients in soil and enhanced the microbial activity responsible for organic matter decomposition and mineralization. A significant residual effect of green manure incorporation to rice on succeeding crop has been reported by Goswami *et al*. (1988) and Thakur *et al*. (1995). Similar finding were also reported by Aggrawal*et al.*(1997).

The application of chemical source of nitrogen alone (urea) and in combination with organic manures (rice residues and sludge + *Azotobacter*) affected significantly the grain and straw yields of wheat. The maximum grain and straw yield of wheat was recorded in case of the treatment supplying 100 % N through urea + 4 tons ha^{-1} of sludge + *Azotobacter*(S_7) which was significantly higher than other sub plot treatments, except the treatment comprising of 75 % N through urea + 25 % N through sludge + *Azotobacter*(S_5). Similar findings were reported by Ravankar*et al.*(2001). In a similar study, Pathak and Sarkar (1997) assessed the effectiveness of application of various combination of urea with rice residue and other organic manures in supplying N to rice-wheat cropping sequence. They found that straw and urea combination registered lower straw yield of rice than integrated use of conventional manures and urea. Paddy straw being a wide C:N ratio organic material containing higher proportion of cellulose, lignin and low nitrogen content caused immobilization which resulted in locking up of available nutrients by microorganisms.

Nitrogen Content in wheat grain and straw

Various treatments produced significant differences in nitrogen concentration in wheat grain during both the years of experiment (Table-2). Conventional tillage with green manuring (M_4) produced maximum N, P and K concentration in wheat grain and straw which was significantly higher than other main plot treatments. The minimum N, P and K concentration in wheat grain and straw was observed in case of reduced tillage without green manuring (M_1). Green manuring proved to be beneficial under both the tillage practices.

The application of chemical fertilizer (urea) alone and in combination with organic sources (rice residue and sludge + *Azotobacter*) affected significantly the N, P and K concentration in wheat grains and straw. The maximum N concentration was recorded in case of the treatment supplying 100 % N through urea + 4 tons ha^{-1} of sludge +*Azotobacter* (S_7). The

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treatment $S_7$was found to produced significantly higher N content in wheat grain and straw than other sub plot treatments S_5 and S_2 during 1999-2000 and S_5 during 2000-2001. The maximum phosphorus and potassium concentration in wheat grain and straw was recorded in the treatments supplying 50 % N through urea + 50 % N through sludge + *Azotobacter* (S_6). O'Conner *et al.* (1986) also reported that the sludge addition in calcareous soil increases the water and Na HCO_3extractable P as well as the uptake of P by plants. The minimum phosphorous concentration in wheat straw was obtained with the treatment comprising of 100% N through urea (S_1). K was deficient with sallow or no-tillage only under unusually wet conditions on poorly drained soils. Bower *et al*. (1944) also reported the reduced soil aeration as a possible cause for reduced of potassium absorption. In general, increasing application of organic sources increased potassium concentration in wheat grain. The break down of organic matter which leads to release of the nutrient ions to the soil solution proceeds at a faster rate under aerated condition. Aerobic decomposition of organic matter is characteristics by the complete breakdown of carbohydrate into organic acid. The aerobic organisms are responsible for organic matter decomposition which results in nitrate being released to the soil solution at much narrow C: N ratio.

It is observed the concentration of N, P and K at tillering stage was significantly higher with incorporation of organic matter than the under fertilizer during both the years of experimentation. An increase in supply of N fertilizer increased the concentration of N and K in plant at tillering stage and their uptake in grain and straw. The mean concentration of these nutrients in plant and their uptake in grain and straw were highest with highest level of nitrogen applied and lowest in control. Maximum N, P and K content were observed at early stage of crop growth which decreased gradually with the advancement of crop growth. These findings are in line with Tiwari *et at.*(1980).

Nitrogen uptake by wheat crop

Total nitrogen uptake by wheat at harvest was influenced significantly by various treatments during both the years (Table-2). The conventional tillage with green manuring (M_4) gave maximum nitrogen, phosphorus and potassium uptake was observed in case of reduced tillage without green manuring (M_1).Singh and Singh (1992) also found that total N uptake of wheat was higher in conventional tillage when compared to zero-tillage system. This was due to better yield of grain and straw and higher concentration of N in conventional tillage. Similar findings were also reported by Hammel (1995) who stated that apparent decrease in root function may have resulted from higher surface layer impedance, or possibly greater root disease pressure under minimum tillage. Peterson *etal.*(1984).Reported that N uptake by wheat plants having a restricted root system is lower than that in those having a large root system, even if the N supply is adequate and equal under both situations. It is therefore 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, P and K uptake was recorded in case of the treatment supplying 100% N through urea + 4 tons ha^{-1} of sludge + *Azotobacter* (S_7) which was significantly higher than other subplot treatments. This may be due to increased nitrogen content of soil with application of sludge (Frequez*et al.*, 1990). Increase in total N uptake by wheat with increased application of sewage sludge was reported by Gupta *et al.* (1989, 1993). Similar results were also reported by Naphade (1986) in case of total N uptake in rice crop. The minimum uptake of N was observed due to treatment s_4 during both the years. Present findings are in tune with the findings of Sharanppa and Shivaraj (1997) who reported higher uptake of P and K due to green manuring. 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.

The effect of treatments on P and K uptake was much pronounced as some treatments both, per cent content of phosphorous and potassium as well as total dry matter production. The increased application of sludge has been reported to increase Olsen's available phosphorous (Gupta *et al.*, 1989, 1993). The green manuring which conventional tillage gave better impact on yield of grain and straw and also on nutrient concentration of grain and straw. The minimum uptake of potassium by wheat was recorded in the case of 100% N through urea (S_1).

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Table 1. Effect of tillage and INM on nutrient content in straw and grain of wheat

Treatments	N content in grain (%)		N content in straw (%)		P content in grain (%)		P content in straw (%)		K content in grain (%)		K content in straw (%)	
	1999-2000	2000-2001	1999-2000	2000-2001	1999-2000	2000-2001	1999-2000	2000-2001	1999-2000	2000-2001	1999-2000	2000-2001
M_1 (Reduced tillage)	1.76	1.71	0.483	0.468	0.289	0.285	0.109	0.106	0.357	0.364	1.53	1.51
M_2 (Reduced tillage with green manuring)	1.82	1.79	0.499	0.494	0.297	0.289	0.116	0.110	0.384	0.384	1.60	1.59
M_3 (Conventional tillage)	1.79	1.74	0.501	0.488	0.293	0.287	0.112	0.109	0.363	0.374	1.57	1.55
M_4 (Conventional tillage with green manuring)	1.88	1.83	0.537	0.517	0.308	0.297	0.118	0.116	0.386	0.393	1.65	1.63
CD (P = 0.05)	0.022	0.034	0.019	0.007	0.007	NS	0.002	0.0014	0.006	0.004	0.017	0.029
S_1 (100 % N through Urea)	1.80	1.76	0.507	0.482	0.284	0.277	0.105	0.102	0.318	0.320	1.40	1.38
S_2 (100 % N through Urea + BF)	1.86	1.80	0.527	0.507	0.294	0.280	0.106	0.104	0.324	0.330	1.43	1.41
S_3 (75 % N through Urea + 25 % N through rice residue & sludge + BF)	1.77	1.72	0.500	0.477	0.289	0.285	0.112	0.109	0.361	0.370	1.61	1.58
S_4 (50 % N through Urea + 50 % N through rice residue & sludge + BF)	1.72	1.69	0.454	0.439	0.301	0.298	0.119	0.115	0.409	0.414	1.66	1.66
S_5 (75 % N through Urea + 25 % N through sludge +BF)	1.87	1.82	0.535	0.534	0.291	0.284	0.113	0.110	0.374	0.380	1.64	1.63
S_6 (50 % N through Urea + 50 % N through sludge + BF)	1.75	1.70	0.467	0.457	0.321	0.305	0.124	0.118	0.418	0.423	1.69	1.66

S_7 (100% N through Urea + 4 tons ha^{-1}of sludge + BF)	1.91	1.87	0.543	0.544	0.295	0.295	0.118	0.114	0.403	0.412	1.66	1.65
1.65CD (P = 0.05)	0.059	0.055	0.024	0.014	0.012	0.013	0.003	0.003	0.013	0.012	0.048	0.051
MxS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2. Effect of tillage and INM on yield and nutrients uptake by wheat crop

Treatment	Grain yield (q ha^{-1})		Straw yield (q ha^{-1})		N uptake (kg ha^{-1})		P uptake (kg ha^{-1})		K uptake (kg ha^{-1})	
	1999-2000	2000-2001	1999-2000	2000-2001	1999-2000	2000-2001	1999-2000	2000-2001	1999-2000	2000-2001
M_1 (Reduced tillage)	36.74	39..33	57..62	59..28	92..57	95..91	16..89	17..32	101.21	99..85
M_2 (Reduced tillage with green manuring)	39.25	41..89	60..08	61.16	101.46	105.31	18.58	18..86	110.82	112.74
M_3 (Conventional tillage)	37..62	40..35	58..39	60..05	96..16	99.72	17..62	18..12	105.25	108.27
M_4 (Conventional tillage with green manuring)	39..94	43..06	61..07	62..34	108.18	111.49	19..51	20.18	115.92	113.58
CD (P = 0.05)	0.39	1.17	1..88	1..69	3.69	2.65	0.38	0.47	2.80	2.89
S_1 (100 % N through Urea)	38..83	41.14	59..22	60..74	99.76	102.59	17..26	17..68	95..80	97.13
S_2 (100 % N through Urea + BF)	39..05	41..57	61..44	62..70	104.90	106.55	18..23	18..21	100.57	102.74
S_3 (75 % N through Urea + 25 % N through rice residue & sludge + BF)	37.73	40..58	57..07	58..63	95..69	98.71	17..30	18..16	105.59	107.22
S_4 (50 % N through Urea + 50 % N through rice residue & sludge + BF)	35..84	39..03	53..90	55..39	85..81	90..37	17..20	17..98	104.40	104.76

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S_5 (75 % N through Urea + 25 % N through sludge +BF)	39..54	42..37	63..48	64..58	108.74	111.81	18..73	19..48	118.71	110.16
S_6 (50 % N through Urea + 50 % N through sludge + BF)	36..93	39..8	55..03	56..27	90..20	94..26	18..68	18..83	108.64	110.38
S_7 (100% N through Urea + 4 tons $ha^{-1}$of sludge + BF)	40..76	43..61	64..80	66..64	113.79	117.51	19..66	20..84	124.39	127.89
CD (P = 0.05)	0.76	0.57	3.80	2.76	5.33	4.23	0.78	0.61	5.82	4.24
MxS	Significant	Significant	NS	NS	NS	NS	NS	NS	NS	NS