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Effect of Rice Establishment Methods and Nitrogen Management options on Soil Physical Properties in Rice-Wheat System

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Abstract: *A field experiment was conducted during 2011-12 and 2012-13in silty clay loam soil to study the effect of rice establishment methods at varying levels of nitrogen on wheat in rice-wheat system at Pantnagar, Tarai region of Uttarakhand. The experiment was laid out in strip plot design with three replication. The horizontal strip were comprised of three establishment methods i.e. zero tilled transplanted rice (ZTPR), transplanted rice (TPR), and dry direct seeded rice (DDSR) and vertical strip with five nitrogen management options viz., No nitrogen applied treatment (N_0), 75 kg N ha^{-1} (N_{75}), 150 kg N ha^{-1} (N_{150}), leaf color chart based nitrogen application (LCC) and soil plant analysis development based nitrogen application (SPAD). It was observed under rice cultivation that the highest soil bulk density (1.52 g cc^{-1}) was found in ZTPR, which was being at par with TPR (1.45 g cc-1) and found significantly higher than that of DDSR (1.43 g cc^{-1}) and the highest soil infiltration rate was recorded in DDSR (1.82 mm hr^{-1}), which was significantly higher than that of ZTPR (1.70 mm hr^{-1}) and TPR (1.70 mm hr^{-1}). Under wheat cultivation the highest bulk density was recorded under ZTPR planted wheat (1.45 g cc^{-1}) which being at par with TPR planted wheat (1.43 g cc^{-1}) but significantly higher than that of DDSR planted wheat (1.42 g cc^{-1}) and the infiltration rate was significantly influenced by effect of differential rice establishment methods but varying nitrogen management options had non-significant effect during both the years.*

Key words: *DDSR, TPR, ZTPR, LCC, SPAD, bulk density, infiltration rate*

INTRODUCTION

Rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L. emend. Fiori & Paol.) are the staple food crops, which have become the integral part of human diet of 800 million people in South-East Asia. The system is fundamental to employment, income and livelihood for 700 million populations in India. The rice-wheat cropping system fulfills 80 % of the food requirement and 60 % of the nutrition requirement of Indian population **(Timsina and Connor, 2001).** During the Green Revolution period (mid -1960s), a phenomenal yield increase was observed with a corresponding increase in net cultivable area, realization of high yield with short-duration, nutrient and irrigation-responsive, high-yielding varieties. Later mechanization in this cropping system also improved the production and productivity of crops, The post-green revolution period, however, showed a decline in yield trend, mostly because of imbalanced use of fertilizer and pesticides, over-exploitation of the natural resources, particularly water, deterioration in physical conditions of the soil and emergence of new bio-types of pests and diseases. These led to yield stagnation causing concern about the future potential for productivity growth and long term sustainability in the irrigated rice-wheat system.

Traditionally rice is grown transplanted crop under puddle soil followed by seeding of wheat in well pulverized field. Though rice-wheat cropping

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system is very productive but has fatigued natural resources with decline in ground water level, soil carbon stocks, soil plant available nutrients and resulting in buildup of pest and diseases (Gupta *et al.*, 2006). Further, intensive cultivation of rice-wheat with indiscriminate use of inputs led to decline in total factor productivity, increasing energy crises and decline in farm profitability. With deteriorating resources and eroding ecological foundation, sustainability of rice-wheat system is under question. Conservation of natural resources is a step towards successful crop production. Hence, adoption of resource conserving technologies is essentially needed to revert the damage done to the natural resources. Resources conservation technologies include technologies in term of different crop establishment methods new cultivars, efficient implements reduced or minimum pre planting tillage, soil water management practices that are cost effective and environment friendly, Resource conservation technologies improve input use efficiency at low cost and preserve ecological integrity of crop production system (Abrol and Sangar, 2006). The sustainability of conventional rice-wheat system in long run has become questionable, if we regularly ignore proper use of natural resources.

Balanced and efficient fertilizer application is essential to compensate for the increased yields and hence greater removal of soil nutrients. Nitrogen management is important in wheat crops because in rice-wheat cropping system there is more depletion of nutrients as both the crops are cereal. The **Site-specific nutrient management** (SSNM) is an approach for 'feeding' wheat with nutrients as and when needed. The SSNM approach does not specifically aim to either reduce or increase fertilizer use. Instead, it aims to apply nutrients at optimal rates and times in order to achieve high crop yield and high efficiency of nutrient use by the crop, leading to high cash value of the harvest per unit of fertilizer invested. It has been realized that 15-17 t/ha annual grain yield of rice-wheat system can be achieved by applying the knowledge of SSNM **(Tiwari, 2008).**

In view of conservation of natural resources more emphasis is needed to accelerate the adoption of cost effective and environment friendly management practices such as DDSR, puddle direct seeding ZTPR, LCC and SPAD need to be screened for better wheat productivity in this system, and soil health management for sustainable production. Keeping this view, an experiment was designed with the objective see the impact of differential rice establishment methods and nitrogen on soil physical properties in rice-wheat cropping system.

MATERIALS AND METHODS

The study area comes under climate zone of western Himalyan region and is located in the foothills of Shivalik range of Himalya and represents the tarai region of Uttarakhand, it lies at 79^0 E longitude, 29^0 N latitude and 243.84 m (above mean sea level) altitude. The experiment was conducted at Dr N.E. Barlaug Crop Research Center of G.B. Pant University of Agriculture and Technology, Pantnagar, U.S. Nagar, Uttarakhand, during 2011-12 and 2012-13. The soil of experimental field at the beginning of the experiment was silty loam in texture (50.4% sand, 33.1% silt and 16.5% clay) contain 0.72% organic carbon 176.8 kg ha^{-1} available nitrogen , 26.4 kg ha^{-1} available phosphorus and 187.1 kg ha^{-1} available potassium. The pH of the soil was neutral, and it was recorded 7.3. The experiment was laid out in strip plot design with three main plots i.e. zero tilled transplanted rice (ZTPR), transplanted rice (TPR) and dry direct seeded rice (DDSR), five nitrogen management options, No nitrogen applied treatment (N_0), 75 kg N ha^{-1} (N_{75}), 150 kg N ha^{-1} (N_{150}), leaf color chart based nitrogen application (LCC) and soil plant analysis development based nitrogen application (SPAD).

RESULTS AND DISCUSSIONS

The data pertaining to soil bulk density at (0-15 cm depth and 15-30 cm depth) & infiltration rate in rice cultivation is given in Table 01 and it was revealed that differences in bulk density (0-15 cm) was significant in 2011-12 only. The ZTPR was recorded highest bulk density (1.52 g cc^{-1}) being at par with TPR (1.45 g cc-1) and found significantly higher than that of DDSR (1.43 g cc^{-1}). Similar trend was also found in 15-30cm depth, the higher bulk density under TPR might be due more compactness of the soil and due to settling of soil particles, which increased the bulk density. The results confirm the findings of Dhiman *et al*. (1998) and Gangwar *et al*. (2006). The infiltration rate has significant influence during 2012-13 only. The highest infiltration rate was recorded in DDSR (1.82 mm hr^{-1}), which was significantly higher than that of ZTPR (1.70 mm hr^{-1}) and TPR (1.70 mm hr^{-1}). The higher values of infiltration rate was recorded under dry direct seeded rice, which revealed that quality of seed bed preparation that allowed the subsequent crops to grow vigorously (Gangwar *et al*., 2006).

Table 1
Effect of different rice establishment methods at different growth stages on soil bulk density and infiltration rate of soil under rice during 2011-12 and 2012-13

Establishment methods	*Soil bulk density*				*Infiltration rate*	
	0-15 cm		*15-30 cm*			
	2011-12	*2012-13*	*2011-12*	*2012-13*	*2011-12*	*2012-13*
ZTPR	1.50	1.45	1.60	1.61	1.68	1.70
TPR	1.44	1.52	1.65	1.66	1.69	1.70
DDSR	1.41	1.43	1.52	1.53	1.79	1.82
S.Em.±	0.06	0.04	0.06	0.02	0.06	0.03
CD (P=0.05)	NS	0.10	NS	0.11	NS	0.10

ZTPR = zero tilled transplanted rice, TPR = Transplanted rice, DDSR = Dry direct seeded rice

The data pertaining to soil bulk density at (0-15 cm depth) (Table 2) under wheat cultivation it revealed that differential rice establishment methods showed significant effect during 2012-13 only, beside it varying nitrogen management options had significant effect on bulk density 0-15 cm depth. The highest bulk density was recorded under ZTPR planted wheat (1.45 g cc^{-1}) being at par with TPR planted wheat (1.43 g cc^{-1}) but significantly higher than that of DDSR planted wheat (1.42 g cc^{-1}). It is only due to higher soil compaction.

Soil bulk density at (15-30 cm) depth & Infiltration rate (mm hr^{-1})

The data pertaining to bulk density at (15-30 cm) depth (Table 01) revealed that differential rice establishment methods and varying nitrogen management options had significant effect on bulk density during both the years. The TPR planted wheat was recorded higher to bulk density (1.49 g cc^{-1} in 2011-12 and 1.48 g cc^{-1}) followed by DDSR planted wheat (1.42 g cc^{-1} in 2011-12 and 1.42 g cc^{-1} in 2012-13) was significantly higher than that of ZTPR planted wheat (1.39 gcc^{-1}). This may be due to settling of soil particles, which increased the bulk density under puddle conditions (**Gangwar *et al.*, 2006**).The infiltration rate (Table-01) was significantly influenced by differential rice establishment methods effect but varying nitrogen management options had non significant effect during both the years.

The DDSR planted wheat was obtained higher infiltration rate (1.96 mm hr^{-1} in 2011-12 and 1.97 mm hr^{-1} in 2012-13) which was significantly higher than that of TPR planted wheat (1.75 mm hr^{-1} in 2011-12 and 1.77 mm hr^{-1} I 2012-13) and ZTPR planted wheat (1.69 mm hr^{-1} in 2011-12 and 1.67 mm hr^{-1} in 2012-13) during both the years. The ZTPR planted wheat was obtained lowest infiltration rate (1.69 mm hr^{-1} in 2011-12 and 1.67 mm hr^{-1} in 2012-13) which was significantly lower than that rest of other nitrogen management options, during both the years. The DDSR planted wheat was obtained highest infiltration rate, which was revealed that quality of seed bed preparations that allowed greater amount of water to penetrate into the field and allowed the subsequent crops to grow

Table 2
Effect of different rice establishment methods and nitrogen management on soil physical properties of soil under wheat during 2011-12 and 2012-13.

Treatments	*Soil physical properties*					
	Bulk density (g/cc)				*Infiltration rate (mm hr^{-1})*	
	0-15 cm		*15-30 cm*			
	2011-12	*2012-13*	*2011-12*	*2012-13*	*2011-12*	*2012-13*
Establishment methods (Rice)						
ZTPR	1.42	1.45	1.39	1.47	1.69	1.67
TPR	1.41	1.43	1.49	1.40	1.75	1.77
DDSR	1.41	1.42	1.42	1.45	1.96	1.97
S.Em.±	0.01	0.01	0.007	0.01	0.01	0.02
CD (P = 0.05)	NS	NS	0.02	0.03	0.04	0.10
Nitrogen management (Wheat)						
N_0 (kg ha^{-1})	1.42	1.44	1.43	1.44	1.76	1.80
N_{75} (kg ha^{-1})	1.42	1.43	1.44	1.44	1.82	1.80
N_{150} (kg ha^{-1})	1.41	1.43	1.41	1.43	1.83	1.82
LCC based (kg ha^{-1})	1.42	1.44	1.43	1.44	1.80	1.81
SPAD based (kg ha^{-1})	1.41	1.43	1.41	1.44	1.84	1.83
S.Em.±	0.05	0.03	0.03	0.01	0.01	0.05
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
Interaction	NS	NS	NS	NS	NS	NS

ZTPR = zero tilled transplanted rice, TPR = Transplanted rice, DDSR = Dry direct seeded rice

vigorously. This results shown similar to findings of Ram *et al*. (2008).

The study showed that dry direct seeded rice (DDSR) system had lowest bulk density & highest infiltration rates were recorded under rice-wheat cultivation.

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