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Tillage: Water and fertilizer effects on productivity: Profitability and soil health in rice under rice-wheat cropping system in *Typic ustochrept* soil of Uttar Pradesh

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Abstract
Tillage practices and nitrogen (N) sources are important factors affecting rice production. This study aimed to investigate the effects of N fertilize, irrigation strategies and tillage practices on crop productivity, NUE and soil properties in the rice field of western Uttar Pradesh. Among the yield attributes number of grains per panicle, panicle length (cm), numbers of spikelet's per panicle and test weight were increased in transplanted basmati rice on wide raised beds and transplanted basmati rice after puddling plots, respectively. The improvement in grain yield 8.4 and 8.9 percent under transplanted basmati rice after puddling and transplanted basmati rice on wide raised beds plots, respectively over transplanted basmati rice on narrow raised beds practices. Average over the N treatments, higher ANUE was recorded under alternate wetting drying treatments (W_2 and W_3) than that of the continuous submergence (W_1).The physiological N use efficiency (PNUE) values ranged from 33.0 to 45.1 kg grain/kg N uptake with decreasing values as the N doses increased. Results also indicated that rice transplanted on wide raised beds and transplanted rice under reduced tillage plots consumed more moisture from the deeper profile layer than conventional tillage practice Transplanted basmati rice after puddling recorded higher bulk density and more contribution from top layer. The B: C ratio under the treatments was in the descending order of $N_4$160 kg N ha^{-1} > N_5 200 kg N ha^{-1} > $N_3$120 kg N ha^{-1} > N_2 80 kg N ha^{-1} > N_1 control.

Keywords: Conservation tillage, productivity, profitability, irrigation strategy

Introduction
Holistic management of arable soil is the key to dealing with the most complex, dynamic, and interrelated soil properties, thereby maintaining sustainable agricultural production systems, the lone foundation of human civilization. Any management practice imposed on soil for altering the heterogenous body may result in generous or harmful outcomes (Derpsch *et al*., 2010; Ramos *et al*., 2011) [17, 18]. Unsuitable management practices cause degradation in soil health as well as decline in crop productivity (López-Garrido *et al*., 2012) [19]. Reducing disturbance of soil by reduced tillage influences several interconnected properties of the natural body.
Soil quality indicator is used to determine the capacity of the soil to perform its major functions (Larson & Pierce 1991) [12] under different soil and crop management practices, although its quantification has remained a challenge. Soil physical characteristics have played major role in creating optimum physical soil quality for optimum root growth but the major challenges being these cannot be improved quickly and easily (Karlen & Cambardella 1996) [11]. Soil bulk density (BD) has often been identified as an indicator of soil quality (Imaz *et al*. 2010) [9] partly due to its influence on most of soil state and rate variables, and partly due to the ease and reproducibility of its measurement. This parameter has specific importance in rice based system considering the facts that years of continuous rice-wheat rotation has resulted in a compact sub-soil layer (15–20 cm), with characteristically high bulk density (Aggarwal *et al*. 1995) [1] and lower saturated hydraulic conductivity (HC), restricting root growth (Hassan & Gregory 1999) [8]. Stability of soil aggregate (water stable aggregates; WSA) is another early indicator of soil quality for crop establishment, water infiltration and resistance to erosion and compaction (Nichols & Toro 2011) [15]. Greater amount of stable aggregates and the increase in portion of large to small aggregates have been indicative of improvement in soil quality.
Till date most of the published literature highlighted the individual impact of tillage, water or nutrient management on changes in soil properties.

However, studying the combined effect of tillage-water-nutrient management in rice-wheat cropping system is a new and unexplored area of research, despite a few reports available on N recovery, C sequestration, nutrient cycling, soil quality and crop yield (Singh *et al*., 2008; Bhaduri *et al*., 2014, [16, 4], and soil physical environment (Bajpai & Tripathi 2000) [3]. Hence the present study was carried out with the hypotheses that the alternate input management (viz. intermittent drainage, non-puddling, and no-tillage) might significantly influence the soil quality in rice under rice wheat system, thus a conservation of energy, human resource and minimization of cost of production can be realized. We have also sought to identify the most sensitive soil physical parameter(s) as a guidance to monitor the interactions of tillage-water-nutrient in the intensive rice crop in *Typic ustochrept* soil of Uttar Pradesh.

Materials and Methods

Experimental site

The field experiment was established in 2016 at Sardar Vallabhbhai Patel University of Agriculture &Technology, Meerut research farm (29^0 04', N latitude and77^0 42' E longitude a height of 237m above mean sea level) U.P., India. The region has a semi-arid sub-tropical climate with an average annual temperature of 16.8 ^{0}C. The highest mean monthly temperature (38.9 ^{0}C) is recorded in May, and the lowest mean monthly temperature (4.5 ^{0}C) is recorded in January. The average annual rainfall is about 665 to 726 mm (constituting 44% of pan evaporation) of which about 80% is received during the monsoon period. The predominant soil at the experimental site is classified as *Typic ustochrept*. Soil samples for 0–15 cm depth at the site were collected and tested prior to applying treatments and the basic properties were low available nitrogen, low organic carbon, available phosphorus, available potassium medium and alkali in reaction.

Experimental design and management

A detailed description of different tillage systems is necessary to compare the influence of tillage practices on environmental performance (Derpsch *et al*., 2014) [6]. Four tillage crop establishment methods T_1- RT-TPR, transplanted rice after reduced tillage;T_2- N Bed-TPR, transplanted rice on narrow raised beds; T_3- W Bed-TPR, transplanted rice on wide raised beds; T_4- CT-TPR, conventional tillage puddled transplanted rice in main plots and five nitrogen management practices were N_1-Control (N0P0K0); N_2- 80 kg N ha^{-1}; N_3-120 kg N ha^{-1}; N_4-160 kg N ha^{-1}; N_5-200 kg N ha^{-1} allotted to sub-plots in a split-plot design and replicated thrice. The gross and net plot sizes were 8 m×3.2 m and 6.0 m×2.0 m, respectively and treatments were superimposed in the same plot every year to study the cumulative effect of treatments. The tillage and crop establishment methods comprised of (i) conventional tillage (CT): In conventional tillage there were three tillage operations. The first tillage was performed in the pre-monsoon season (April/May) and the second one was performed in May/June, some 20–25 days after the first tillage. The third tillage was conducted during June at deeper depth (>15cm) using a tractor drawn cultivator. Nitrogen was applied as per treatments. 60- 40- 25 kg P K and Zn ha^{-1} were applied in all treatments, except N_1 through soil application in the form of Di-ammonium phosphate, Sulfate of potash and 21% Zinc sulphate, respectively. Whole amount of phosphorus (P), potash (K) and zinc (Zn) with 1/3 of nitrogen (N) was applied at the time of transplanting and at seed bed preparation. Remaining dose of nitrogen fertilizer was applied in two equal splits at the time of booting (3 weeks after transplanted) and panicle initiation stage, (6 weeks after transplanted) treatment wise. Nursery seedlings of 21 days older was uprooted manually from nursery plots and then transplanted in the main field on Ist forth night of July by keeping row to row distance of 20 cm, respectively. Irrigation was withheld about two week before harvesting when physiological maturity appeared and then crop was harvested.

Weed management

The plots would be then kept weed-free throughout the growing season. Butachlor @ 1300 g a.i.ha^{-1} at 2 days after transplanting (DAT) followed by a spray application of bispyribac sodium (Nomne gold) @ 25 g a.i.ha^{-1} at 25-30 DAT for narrow and broad leaf weeds. Additionally, one hand-weeding in transplanted rice was done to keep the plots weed-free.

Nitrogen use efficiency

Nitrogen harvest index (NHI) represents the crop ability in partitioning the total N uptake between the different plant organs (Anderson *et al*., 1984) [2]. Therefore, nitrogen harvest index (NHI) was defined as the ratio of seed nitrogen uptake to total biomass nitrogen uptake. There are different definitions that describe the nitrogen utilization efficiency. By using the total N uptake by seed and straw and the amount of applied N as fertilizer, the apparent N recovery (NUE) for different N treatments are calculated by Eq. I). Nitrogen yield efficiency (NYE) or agronomic nitrogen efficiency is used to describe the utilization of N inputs in relation to the level of N applied (Fageria and Baligar, 2005) [7]. Therefore, by using the applied N as fertilizer and seed yield, the NYE in different N treatments was calculated by Eq. (II) (Craswell and Godwin, 1984) [5]. The physiological N efficiency (NPE) was also determined by Eq. (III).

$$NUE = \frac{Nui - Nuc}{Nfi - Nfc} \qquad (I)$$

$$NYE = \frac{Yi - Yc}{Nfi - Nfc} \qquad (II)$$

$$NPE = \frac{Yi - Yc}{Nui - Nuc} \qquad (III)$$

Where NUE is the apparent N recovery or nitrogen use efficiency, Nui and Nuc are the total N uptake by seed and straw in different N treatments and control, respectively (kg ha^{-1}), and Nfi and Nfc are the applied N as fertilizer in different N treatments and control, respectively (kg ha^{-1}). Yi and Yc defined as the seed yield indifferent N treatments and control, respectively (kg ha^{-1}).

Statistical analysis

Statistical analysis was performed by the Windows-based SPSS program (Version 10.0, SPSS, 1996, Chicago, IL). The SPSS procedure was used for analysis of variance to determine the statistical significance of treatment effects. Duncan's Multiple Range Test (DMRT) was used to compare means through least significant difference (LSD).The 5.0% probability level is regarded as statistically significant.

Results and Discussion

Yield and yield attributes

The effective tillers m^{-2} varied with different tillage practices and significantly higher effective tillers m^{-2} were recorded with CT-TPR conventional till puddle transplanted rice (T_4) treatment which was at par with transplanted rice on wide raised beds WBED-TPR (T_3) and gave 15.8, 12.8 and 17.8, 14.2 percent more effective tillers m^{-2} as compared to reduced till transplanted rice RT-TPR (T_1) and transplanted rice on narrow raised beds NBED-TPR (T_2). Irrigation strategies W_2 and W_3 produced significantly higher average number of effective tillers m^{-2} (276.5, 292.7 and 264.4, 279.6) as compare to W_1 during the years of study. However, number of effective tiller's m^{-2} was recorded up to N_4 treatment of 160 kg N ha^{-1} and number of effective tiller's m^{-2} decline with N_5 treatment of 200 kg N ha^{-1} treatments N_2, and N_3 were at par with each other but recorded significantly higher number of effective tiller's m^{-2} to N_1 treatment during experimentation.

Panicle length may also serve as one of the criteria for assessing the grain yield in cereal crops. The scrutiny of data revealed that N_4 treatment significantly increased panicle length over N_5 treatment. Treatments N_3 and N_2 were statistically at par among themselves with respect to panicle length. Table 1 showed that panicle length increased with change in land configuration during the years of study. Longer panicles were obtained with WBED-TPR (T_3) as compared to RT-TPR (T_1) and this level of tillage was statistically at par with NBED-TPR (T_2). However, CT-TPR (T_4) conventional tillage puddle transplanted rice under flat land configuration to *basmati* rice increased panicle length over reduced till unpuddled transplanted rice.

Table 1 advocated that the maximum number of spikelet's panicle^{-1} was recorded significantly superior in T_3 treatment as compared to all other treatments except T_4 in both the years. T_4 and T_1 were at par with each other; however, they recorded significantly more number of spikelet over T_2 treatment which recorded minimum number of spikelet's panicle^{-1} (67.6 and 69.1) during 2016 and 2017. Water management differences with respect to the average number of spikelet's panicle^{-1} were also found to be non-significant. W_2 and W_3 produced statistically higher average number of spikelet's panicle^{-1} (71.8, 70.4 and 74.5, 73.9) as compare to W_1. Moreover, nitrogen management effects were also found to be significant. N_1 and N_2 produced significantly lower average number of spikelet's panicle^{-1} (65.7, 69.8 and 66.1, 70.4) as compare to rest of the nitrogen management during 2016 and 2017. N_4 produced significantly greater number of spikelet's panicle^{-1} (72.9 and 74.7) as compared to all treatments except N_3.

Table 1 exhibited that transplanted of rice on wide raised beds (T_3) techniques produced significantly more grains panicle^{-1} over all other treatments but was statistically at par with transplanted of rice on flat beds conventional till puddled technique (T_4), respectively. The differences in number of grains panicle^{-1} among the treatments T_1 and T_4 were non-significant but significantly superior over T_2. Nitrogen management differences with respect to the average number of grains panicle^{-1} were also found to be significant. N_1 and N_2 produced significantly lower average number of grains panicle^{-1} as compare to rest of the nitrogen management. Nitrogen level N_4 produced significantly greater number of grains panicle^{-1} as compared to all treatments except N_3 and N_5.

Thousand grain weight (1000 grain weight), as it is called the test weight of the desired output, is referred to be considered as one of the most significant agronomic parameters ever trusted that contributes in having a reconnaissance over the possible production of a lot (grain yield). Table 1 revealed that T_3 treatment of sowing techniques significantly increased 1000 grain weight over all other treatments but was statistically at par with T_4 and T_1 treatments. However, T_1 treatment produced significantly higher grain weight as compared toT_2, respectively. Nitrogen management differences with respect to the average test weight were also found to be significant. Treatment N_1 produced significantly lower average test weight as compare to rest of the nitrogen management. Nitrogen level N_4 produced significantly highest test weight as compared to all treatments except N_2, N_3 and N_5.

Grain yield was significantly influenced by different levels of nitrogen application. Significantly higher grain yield of (50.15 q ha^{-1}) were obtained in N_4 treatment which remained statistically at par with N_5 treatment. N_3 (120 kg Nha^{-1}) recorded significantly higher grain yield over N_2 (80 kg Nha^{-1}) and N_1 "control" treatments. N_1 which recorded minimum grain yield (30.65 qha^{-1}) during experimentation. The higher growth finally resulted into significant increase in grain yield through yield attributes namely number of effective tillers, number of grains per panicle and test weight [Table 1]. This increase was because of increased the number of grains per panicle

Table 1 revealed that the straw yield increased significantly with the every successive increase in moisture supply by moisture retention and land configuration. TreatmentsT_3 and T_4 were at par with each other, however, they recorded significantly higher straw yield over rest of the treatments. Treatment T_2 (rice transplanted on narrow raised beds) recorded minimum straw yield 51.85 q ha^{-1}. The percentages increased in straw yield due to various modes of tillage crop establishment treatments over narrow raised beds practices were 24.5, 17.1 and 9.1 percent during experimentation at T_4, T_3 and T_1, respectively. Similar trend have been observed by Naresh *et al*., 2014 [13].

Table 1: Effects of tillage crop establishment techniques and nitrogen strategies on yield attributes and yield of rice

Treatments	No. of spikelet's panicle^{-1}	No. of grains panicle^{-1}	1000 grain weight (g)	Grain yield (qha^{-1})	Straw Yield (qha^{-1})
Tillage crop establishment methods					
T_1 RT-TPR	71.3	134	20.48	41.64	57.07
T_2 NBed-TPR	68.4	131	19.72	40.04	51.85
T_3 WBED-TPR	73.4	140	22.05	44.68	62.55
T_4 CT-TPR	72.9	137	21.85	47.38	68.69
C D (P=0.05)	1.84	3.62	3.29	6.92	9.69
Nitrogen strategies					
N_1 (Control)	65.9	119	16.43	30.65	36.78
N_2 80kg Nha^{-1}	70.1	128	18.83	33.57	42.78
N_3 120kg Nha^{-1}	72.7	140	20.75	44.33	58.35
N_4 160kg Nha^{-1}	73.8	143	21.95	50.15	67.70
N_5 200kg Nha^{-1}	71.1	137	20.20	47.55	66.57
C D (P=0.05)	2.46	7.98	4.39	5.18	8.84

Moisture extraction pattern

The soil profile was divided in four layers (0-15, 15-30, 30-60 and 60-90 cm) and the maximum amount of water was extracted (absorbed) from 0-15 cm layer followed by 15-30 cm, 30-60 cm, and minimum from 60-90 cm. The moisture extraction from the surface layer (0-15 cm) was increased slightly with conventional tillage and reduced tillage practices. Similarly, the moisture extraction was decreased slightly with increase in profile depth and furrow irrigated raised beds, respectively. Data also indicated that rice transplanted on wide raised beds and transplanted rice under reduced tillage plots consumed more moisture from the deeper profile layer than conventional tillage practice and vice-versa. The moisture extraction from the surface layer (0-15 cm) was increased slightly with increase in irrigation frequency during the years of study. Similarly, the moisture extraction was decreased slightly with increase in profile depth and irrigation frequency. Water management practices W_1 the moisture extraction was decreased with increase in profile depth. However, W_2 and W_3 the moisture extraction was increase in profile depth more as compared to W_1. Similar results have been reported by Naresh *et al*. (2014) [13].

Table 2: Soil profile water extraction patterns under different treatments

Treatments	Total Soil Water Extraction in 2016 (mm)				Total Soil Water Extraction in 2017 (mm)				Total moisture depletion (mm)	
	Depth of soil (cm)									
	0-15	15-30	30-60	60-90	0-15	15-30	30-60	60-90	2016	2017
Tillage crop establishment methods										
T_1 RT-TPR	331	249	170	91	280	216	136	74	841	706
T_2 NBed-TPR	295	205	135	69	231	152	94	48	704	525
T_3 WBED-TPR	310	226	195	118	240	177	186	86	849	689
T_4 CT-TPR	359	298	158	76	318	250	115	59	891	742
Mean	323.8	244.5	164.5	88.5	267.3	198.8	132.8	66.8	821.3	665.5
Water management practices										
W_1 CS	326	242	116	57	307	228	106	56	741	697
W_2 IS 02 day	268	194	132	67	246	186	123	61	661	616
W_3 IS 05 day	229	169	164	82	218	157	148	76	644	599
Mean	274.3	201.7	137.3	68.7	257.0	190.3	125.7	64.3	682	637.3

Organic carbon

Organic carbon content in plough layer of the soil after harvest revealed that improved significantly in treatments where wheat was grown with conservation tillage (Table 3). Treatments T_3 transplanted rice on wide raised beds practices plots having statistically higher organic carbon percent over conventional tillage puddled transplanted rice (T_4). Water management methods did not vary significantly to organic carbon content of the soil during the year of study. The organic carbon content of the soil did not vary significantly with varying nitrogen management. However, maximum organic carbon content was obtained with N_4 and N_5 closely followed by other nitrogen management practices. Different levels of nitrogen application to basmati rice had failed to impart any significant effect on organic carbon content in plough layer of the soil after harvest. Similar result have been reported by Jat *et al.* (2009) [10] and Naresh *et al.*, 2015 [5].

Available nitrogen

The tillage crop establishment influenced the available nitrogen in soil significantly. During 2016 T_3 (transplanted rice on wide raised beds) recorded the higher available nitrogen in soil (182.05 N kg ha^{-1}) and T_1 (unpuddled transplanted rice under reduced tillage) (181.66 N Kg ha^{-1}) remained statistically at par with it. The reduction in available nitrogen in soil was 25.1 and 24.9% compared to T_1 (unpuddled reduced tillage transplanted rice), and T_3 (transplanted rice on wide raised beds), respectively. There was available nitrogen in soil improvement due to better moisture due to more residues in raised beds and reduced tillage; respectively over conventional practices (Table 3). Moreover, the higher available nitrogen in soil in relation to nitrogen management, treatment N_5 recorded statistically (182.08 and 186.60 N kg ha^{-1}) higher available nitrogen rest of the treatments except N_4 and N_3 but the difference of N_2, N_3 and N_4 were at par. Treatment N_1 "control" recorded lowest available nitrogen in soil. Solubilisation of nutrient from native sources may be led to increased available nitrogen in soil after the harvest of crop.

Available phosphorus and potassium

The perusal of the data indicated that available phosphorus and potassium status of the soil after the harvest of crop was not differed significantly due to crop establishment practices, water management and nitrogen levels to basmati rice during the years of study. The maximum available phosphorus and potassium in soil was in N_5 (kg N ha^{-1}) being at par with N_3 and N_4 and was sstatistically higher over N_1 and N_2.

Table 3: Effect of tillage crop establishment, water management practices and nitrogen levels on soil organic carbon, available NPK (kg ha^{-1})

Treatments	Organic carbon (%)		Available N (kg ha^{-1})		Available P (kg ha^{-1})		Available K (kg ha^{-1})	
	2016	2017	2016	2017	2016	2017	2016	2017
Tillage crop establishment methods								
T_1 RT-TPR	0.41	0.41	181.66	185.57	12.30	13.11	149.41	147.13
T_2 NBed-TPR	0.41	0.42	179.00	182.54	11.50	12.84	148.12	146.85
T_3 WBED-TPR	0.42	0.42	182.05	186.62	13.69	14.95	150.78	148.95
T_4 CT-TPR	0.40	0.40	180.48	184.79	13.40	14.07	150.26	148.31
C D (P=0.05)	NS	NS	1.45	1.82	NS	NS	NS	NS
Water management practices								
W_1 CS	0.40	0.40	181.95	185.70	13.65	14.85	150.35	149.15
W_2 IS 02 day	0.41	0.42	181.60	185.26	13.25	14.15	150.05	148.95
W_3 IS 05 day	0.42	0.42	181.25	185.08	13.15	13.90	149.95	148.76

C D (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Nitrogen levels								
N_1 (Control)	0.40	0.40	179.00	181.10	11.35	12.07	148.09	146.55
N_2 80kg Nha^{-1}	0.41	0.41	179.50	182.54	12.76	12.85	149.49	147.18
N_3 120kg Nha^{-1}	0.41	0.41	180.11	183.76	12.90	13.69	150.10	148.77
N_4 160kg Nha^{-1}	0.42	0.41	181.44	185.55	13.40	14.37	150.30	149.05
N_5 200kg Nha^{-1}	0.42	0.42	182.08	186.60	13.76	14.95	150.49	149.25
C D (P=0.05)	NS	NS	2.78	4.43	NS	NS	NS	NS

Nitrogen Use Efficiency

Agronomic N use efficiency (ANUE) ranged from 13.1 to 22.9% under different tillage, water and N treatments (Table 4). Average over the N treatments, higher ANUE was recorded under alternate wetting and drying treatments (W_2 and W_3) than that of the continuous submergence (W_1). Study also revealed that average ANUE was higher at 80 kg N ha^{-1} (22.9%) but not at higher doses of N (14.9% at 200 kg N ha^{-1}). The NHI in water management treatments did not vary greatly, ranging from 56.8 to 58.9%. The level of significance was also not consistent for NHI among different N treatments. The physiological N use efficiency (PNUE) values ranged from 33.0 to 45.1 kg grain/kg N uptake with decreasing values as the N doses increased (Table 4). The PNUE values tend to decrease with increasing N doses due to higher N uptake and higher N concentrations in both the grain and straw. But PNUE values in W_1, W_2 and W_3 were comparable and statistically non-significant. Values of AR ranged from 34.1 to 56.2% among different N and water management treatments. The higher AR was recorded under 160 kg N ha^{-1} (N_4) due to higher grain yield. This was because of the more difference of grain yield between the zero N (N_1) and N_4 treatments (about 1.92 t ha^{-1}).

Table 4: N efficiency parameters under different planting methods, water and nitrogen management practices

Treatments	2016				2017			
	NHI (%)	**PNUE**	**ANUE (%)**	**AR (%)**	**NHI (%)**	**PNUE**	**ANUE (%)**	**AR (%)**
Tillage crop establishment methods								
T_1 RT-TPR	56.9	41.1	15.6	39.8	57.8	42.3	16.2	40.3
T_2 NBed-TPR	55.5	38.2	12.9	37.0	56.3	39.1	13.4	38.9
T_3 WBED-TPR	63.3	45.8	19.8	55.1	65.3	46.7	20.6	57.4
T_4 CT-TPR	60.6	44.2	18.0	55.7	61.6	45.8	19.8	58.1
C D (P=0.05)	6.13	4.78	4.66	5.48	7.86	4.73	4.89	6.83
Water management practices								
W_1 CS	58.6	36.7	15.2	47.9	59.3	41.4	15.4	48.2
W_2 IS 02 day	57.8	37.8	15.7	46.8	58.7	42.6	15.9	47.9
W_3 IS 05 day	56.4	41.4	16.8	45.7	57.2	45.2	16.3	46.8
C D (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Nitrogen levels								
N_1 (Control)	37.9	28.7	13.5	26.9	38.6	29.1	13.8	27.3
N_2 80kg Nha^{-1}	38.5	44.3	21.7	35.3	39.7	45.8	24.1	36.4
N_3 120kg Nha^{-1}	53.3	43.8	20.3	44.9	54.2	45.3	23.9	45.6
N_4 160kg Nha^{-1}	57.6	38.6	18.3	53.3	58.4	38.9	19.7	55.8
N_5 200kg Nha^{-1}	57.0	33.2	14.6	52.6	58.1	34.6	15.2	54.9
C D (P=0.05)	NS	NS	NS	8.41	NS	NS	NS	10.55

Profitability

The cost of cultivation of rice crop increase with the increasing of water regimes and nitrogen levels although the increase was very nominal. Different planting technique the cost of cultivation was highest in T_4 conventional tillage puddled transplanted rice followed by narrow raised beds unpuddled transplanted rice (T_2) and it was lowest in reduced tillage transplanted practices plots. However, the highest net profit, B: C ratio was recorded in (T_3) rice transplanted on wide raised beds. This may be because of higher water and nitrogen use efficiency than other planting techniques as well as comparatively higher increase in grain yield. The minimum net profit, gross income, B: C was observed in (T_2) rice transplanted on narrow raised beds treatment, respectively (Table 5). The B: C ratio was highest (1.43 & 1.66) in the crop grown with W_2 IS 02 day and lowest (1.18 & 1.40) in the crop grown with W_1 continuous submergence of water application. The B: C ratio under the treatments was in the descending order of W_2 IS 02 day> W_3 IS 05 day> W_1. It was clear from the study that increase in nitrogen level up to 160 kg N ha^{-1} (N_4) increased the available nutrient in soil, which may be attributed to increased the cost of cultivation, gross income, net profit and B: C ratio because of more increase in grain yield and gross income in comparison to increase in cost of cultivation. The B: C ratio under the treatments was in the descending order of $N_4$160 kg N ha^{-1} > N_5 200 kg N ha^{-1} > $N_3$120 kg N ha^{-1} > N_2 80 kg N ha^{-1} > N_1 control.

Similar result has been reported by Naresh *et al.* (2015) [14].

Table 5: Effect of planting technique, irrigation strategies and nitrogen levels on profitability

Treatments	Cost of cultivation (Rs ha^{-1})		Gross return (Rs ha^{-1})		Net returns (Rs ha^{-1})		B: C ratio	
	2016	2017	2016	2017	2016	2017	2016	2017
Tillage crop establishment methods								
T_1 RT-TPR	32845	33945	72947.00	76214.25	40102.00	42269.25	1.22	1.24
T_2 NBed-TPR	35520	36040	67630.50	74660.75	32110.50	38620.75	0.92	1.07
T_3 WBED-TPR	34780	35050	83352.50	89037.50	48572.50	53987.50	1.40	1.54
T_4 CT-TPR	38420	40810	86220.50	92508.75	47800.50	51698.75	1.24	1.27
Water management practices								
W_1 CS	35650	36780	77715.00	88112.50	42065.00	51332.50	1.18	1.40
W_2 IS 02 day	31790	32150	77302.50	85662.50	45512.50	53512.50	1.43	1.66
W_3 IS 05 day	28950	29350	70125.00	76562.50	41175.00	47212.50	1.42	1.61
Nitrogen levels								
N_1 (Control)	29750	30115	48675.00	58035.00	18925.00	27920.00	0.64	0.93
N_2 80kg Nha^{-1}	33520	33750	58872.50	62944.25	25352.50	29194.25	0.76	0.87
N_3 120kg Nha^{-1}	33950	34125	73197.50	83037.50	39247.50	48912.50	1.15	1.43
N_4 160kg Nha^{-1}	34415	34670	82767.50	93713.75	48352.50	59043.75	1.41	1.70
N_5 200kg Nha^{-1}	34760	34960	77220.00	88147.50	42460.00	53187.00	1.22	1.52

Conclusion

The data acquired from the 02-year, rice experiment revealed that tillage and nutrient management practices had significant effects, of varying magnitude, on yield and attributes. It was clear from the study that increase in nitrogen level up to 160 kg N ha^{-1} (N_4) increased the available nutrient in soil, which may be attributed to increased the cost of cultivation, gross income, net profit and B: C ratio because of more increase in grain yield and gross income in comparison to increase in cost of cultivation. The B: C ratio under the treatments was in the descending order of $N_4$160 kg N ha^{-1} > N_5 200 kg N ha^{-1} > $N_3$120 kg N ha^{-1} > N_2 80 kg N ha^{-1} > N_1 control. In conclusion, Nitrogen plays a significant role in building-up/restoring soil health and productivity in *Typic ustochrept* soil inherently low in organic matter and nutrients.

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References

1. Aggarwal GC, Sidhu AS, Sekhon NK, Sandhu KS, Sur HS. Puddling and N management effects on crop response in a rice–wheat cropping system. Soil Till Res. 1995; 36:129-139.
2. Anderson EL, Kamprath EJ, Moll RH. Nitrogen fertility effects on accumulation, remobilization, and partitioning of N and dry matter in corn genotypes differing in prolificacy. Agro J. 1984; 76:397-404
3. Bajpai RK, Tripathi RP. Evaluation of non-puddling under shallow water tables and alternative tillage methods on soil and crop parameters in a rice–wheat system in Uttar Pradesh. Soil Till Res. 2000; 55:99-106.
4. Bhaduri D, Purakayastha TJ. Long-term tillage, water and nutrient management in rice–wheat cropping system: assessment and response of soil quality. Soil Till Res. 2014; 144:83-95.
5. Craswell ET, Godwin DC. The efficiency of nitrogen fertilizers applied to cereals in different climates. Adv Plant Nutrition. 1984; 1:1-55
6. Derpsch R, Franzluebbers AJ, Duiker SW, Reicosk DC, Koeller K, Friedrich T *et al*. Why do we need to standardize no-tillage research? Soil Till. Res. 2014; 137:16-22.
7. Fageria NK, Baligar VC. Enhancing nitrogen use efficiency in crop plants. Adv. Agron. 2005; 88:97-185
8. Hassan MM, Gregory PJ. Water transmission properties as affected by cropping and tillage systems. Pak J Soil Sci. 1999; 16:29-38.
9. Imaz MJ, Virto I, Bescansa P, Enrique A, Fernandez-Ugalde O, Karlen DL. Soil quality indicator response to tillage and residue management on semi-arid Mediterranean cropland. Soil Till Res. 2010; 107:17-25
10. Jat ML, Gathala MK, Ladha JK, Saharawat YS, Jat AS, Kumar Vipin *et al*. Evaluation of precision land levelling and double zero till systems in the rice–wheat rotation: Water use, productivity, profitability and soil physical properties. Soil Tillage Research. 2009; 105:112-121.
11. Karlen DL, Cambardella CA. Conservation strategies for improving soil quality and organic matter storage. In: Carter MR, Stewart BA, editors. Structure and organic matter storage in agricultural soils. Advances in soil science. Boca Raton (FL): CRC Press, 1996.
12. Larson WE, Pierce FJ. Conservation and enhancement of soil quality. Evaluation of sustainable land management in developing world. Bangkok: International Board for Soil Research and Management, 1991.
13. Naresh RK, Tomar SS, Samsher P, Singh SP, Kumar D, Dwivedi A *et al*. Experiences with rice grown on permanent raised beds: effect of water regime and planting techniques on rice yield, water use, soil properties and water productivity. Rice Sci. 2014; 21(3):170-180
14. Naresh RK, Rathore RS, Dhaliwal SS, Yadav RB, Kumar Dipender, Singh SP *et al*. Crop Establishment Methods: Foliar and Basal Nourishment of rice (*Oryza sativa*) Cultivation Affecting Growth Parameters, Water Saving, Productivity and Soil Physical Properties. Paddy Water Environ. 2015; 14(3):373-386.
15. Nichols KA, Toro M. A whole soil stability index (WSSI) for evaluating soil aggregation. Soil Till Res. 2011; 111:99-104.
16. Singh AK, Tripathi R, Chopra UK. Evaluation of CERES-Wheat and Crop Syst models for water–nitrogen interactions in wheat crop. Agric Water Manage. 2008; 95:776-786
17. Derpsch R, Friedrich T, Kassam A, Hongwen L. Current status of adoption of no-till farming in the world and

some of its main benefits, International Journal of Agricultural and Biological Engineering. 2010; 3(1):1-25,
18. Ramos ME, Robles AB, Sánchez-Navarro A, González-Rebollar JL. Soil responses to different management practices in rainfed orchards in semiarid environments, Soil and Tillage Research. 2011; 112(1):85-91.
19. López-Garrido R, Deurer M, Madejón E, Murillo JM, Moreno F. Tillage influence on biophysical soil properties: the example of a long-term tillage experiment under Mediterranean rainfed conditions in South Spain, Soil and Tillage Research. 2012; 118:52-60.