Effect of tillage and precision nitrogen management practices on Nuptake and Nutrient Use Efficiency (NUE) in wheat in western UP

ABSTRACT

At the Crop Research Center of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, (U.P.), during the rabi seasons of 2021–22 and 2022–23, an investigation titled "**Effect of tillage and precision nitrogen management practices on N uptake and Nutrient Use Efficiency (NUE) in wheat in western UP** " was conducted. The experiment was carried out using a split plot design with three replications. The treatments included four precise nitrogen treatments (N1-Control, N2-State recommendations, N3-LCC based nitrogen Application, and N4- SPAD based treatments) as sub plot treatments, and three conservation tillage treatments (C1- Conventional tillage, C2- Reduced tillage, and C3- Furrow irrigated raised bed (FIRB)} as main plots.The soil of the experimental site was sandy loam having low organic matter (0.43%), low in available nitrogen, low in available phosphorus and high in available potassium. The maximum Nuptake and NUE was recorded under furrow irrigated raised beds plots during both the years. The maximum total Nuptake and NUE was recorded under SPAD and was at par with LCC treatments.

INTRODUCTION

The world's most significant food crop is wheat. Grown over 217 million hectares of land in 122 countries worldwide, it produced 781.7 million tons of wheat in 2021–2022. The yearly global consumption of wheat is estimated to be 777 million tons, and it is anticipated to rise over the next several years **(Anonymous, 2022)**.

India is the world's leading producer of wheat. It is currently producing more wheat than the United States of America and ranks second only to China. In India, 31.6 million hectares of wheat were planted in 2021–2022, yielding 109.52 million tons of grain and 3464 kg ha–1 of productivity **(Anonymous, 2021)**.Even though rice is the most popular staple meal in India, wheat is more popular in the food market due to its superior nutritional qualities when compared to rice, which is consumed by a larger population. During the crop growing period, the soil moisture regime and the current weather patterns have a significant impact on wheat genotype productivity.

According to **Anonymous (2019)**, six states in India—Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Rajasthan, and Bihar—produce 91% of the country's wheat. As the nation's leading producer of wheat, Uttar Pradesh has the potential to significantly contribute to the growth of the nation's wheat output.

The most significant limiting factor affecting wheat output is nitrogen. Because nitrogen is a component of protein, chlorophyll, alkaloids, vitamins, hormones, protoplasm, and chlorophyll, healthy crop production requires an adequate amount of nitrogen. In the end, nitrogen produces more dry matter and higher yields. Application of nitrogen to wheat crops is beneficial, while too much nitrogen cannot be tolerated. On the other hand, excessive nitrogen application to wheat increases the risk of NO_3 pollution of ground water

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and reduces nitrogen recovery efficiency.The crop's production may suffer if nitrogen stress persists during the "critical growth stage" of the crop.

The precise nutrient management method makes use of comprehensive site-specific data to manage the nutrients that crops require. With the use of precise techniques and equipment, producers can enhance the efficiency and effectiveness of nutrients, maintain or boost yields, reduce nutrient losses from fields, and safeguard surface and ground water supplies by implementing a precision nutrient management plan. The 4 R's (Right rate, Right source, Right application method, and Right application time) guarantee that the crop receives the right amount of nutrients where they are needed thanks to precision nutrition management approaches.

The majority of Indian farmers apply nitrogen fertilizer in split applications; nevertheless, there are significant variations in the number of splits, amount of nitrogen applied each split, and application time. LCC improves fertilizer use efficiency by managing nitrogen over a vast region. Using the LCC method resulted in an average nitrogen savings of 25 kg ha^{-1} without compromising production **(Balasubramanian, 2012)**.

Conventional tillage methods in agricultural production systems raise labor and energy expenses, which reduces economic returns **(Kumar et al., 2013)**. Additionally, by speeding up the oxidation and breakdown of organic matter, vigorous plowing causes a decrease in soil organic matter and degrades the characteristics of the soil **(Naresh et al., 2012)**. Conventional or traditional agriculture practices come with a host of additional restrictions.

The timely planting of crops is seriously threatened by the scarcity of labor and the rising expense of it **(Jat et al., 2014)**. Numerous researchers have attested to the fact that excessive residue burning and various types of soil degradation are causing the land quality in this area to deteriorate **(Das et al., 2013)**.

Based on CA principles, farmer-led agricultural production system transformation is already taking place globally (157 mha) and is gaining traction as a new paradigm for the twenty-first century, according to empirical data collected globally **(Kassam et al., 2015)**. It is anticipated that the alterations in the physical and biological characteristics of the soil brought about by CA practices will change the kinetics and direction of chemical and biochemical reactions, changing the dynamics of nutrients in the soil **(Sapkota et al., 2016)**. However, each CA principle calls for a series of actions tailored to the specifics of the area, which has an impact on nutrient dynamics and soil processes **(Lal, 2015)**.These field operations have an impact on crop productivity because they modify the chemical and physical properties of the soil and conserve water **(Bonfil et al., 2009)**.

Wheat yield and soil physical qualities are influenced by significant factors such as manure application and soil tillage. Among all agricultural production factors, tillage accounts for up to 20% of the total **(Ahmad et al., 2016)**. Soil is frequently harmed by the use of intensive and pointless traditional tillage techniques. When wheat is planted after puddled rice as opposed to non-puddled rice, a yield reduction of 8–9% has been noted **(Kumar and Ladha, 2011)**.In a similar vein, traditional wheat farming requires extensive land preparation that includes multiple passes with discs, tine harrows, and planking to

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produce a friable seedbed. If wheat is not sown by mid-November, there will be a yield loss of 15–60 kg $ha^{-1}day^{-1}$ due to intensive tillage **(Pathak et al., 2013)**. As a result, the move to reduced and zero-tillage is currently receiving a lot of attention and focus in an effort to increase crop productivity and water usage efficiency **(Dawelbeit and Babiker, 2007)**.

MATERIAL AND METHODS

Split plot design was used for the experiment, with three replications. The treatments included four precise nitrogen treatments (N1-Control, N2-State recommendations, N3-LCC based nitrogen application, and N4- SPAD based treatments) as sub plot treatments, and three conservation tillage treatments (C1-Conventional tillage, C2-Reduced tillage, and C3- Furrow irrigated raised bed (FIRB)) as main plots. Row spacing was maintained at 20 cm, with a gross plot size of 5 x 4.8 and a net plot size of 4 x 4. A seed rate of 100 kg ha^{-1} was employed, and 150:75:60 kg ha^{-1} of NPK was advised. The variety used was DBW-222.LCC measurements beginning at 15 DAS. Random selections were made from each plot so that five plants could be measured for LCC. From the highest, fully extended, and healthy leaf of each of the five plants, observations were made by correlating the color shade of the LCC with the average score. By comparing the leaf's center with the LCC's color strips, readings were acquired. You shouldn't break off a leaf. Daily readings were obtained between 8:00 and 10:00 a.m. There won't be direct sunshine on the LCC when readings are taken. The same person will conduct each LCC reading from the first to the last. In the event that the average measurement is less than the critical LCC value, N was given in accordance with the treatments.When LCC readings were obtained again after 7 days, the same 5 plants were discovered.

When the color of the leaves was less than the strip's threshold color (4), 20 kg N ha^{-1} was given. At 15 DAS, SPAD readings started. A random selection of five plants per plot were used to get SPAD readings. Every one of the five tagged plants had its top three healthy, fully grown leaves observed. The sample to be examined was placed into the sample slot on the measuring head once the device had been calibrated.It was very carefully made sure the sample completely covered the reception window. It was not attempted to measure very thick portions, like leaf veins.For leaves with lots of tiny veins, several measurements were taken and averaged for best results. Breaking off a leaf was not allowed. Every day between 8 and 10 AM, readings were taken. If the average SPAD value dropped below the crucial value, N was applied to the fields at a rate of 20 kg ha^{-1} if the SPAD readings were less than 45.Nitrogen was obtained by precision nitrogen treatments at a rate of 135 kg ha^{-1} as opposed to 150 kg ha^{-1} for the SR treatment.

Results :

Field preparation

Crop will be grown following the recommended package of practices, crop production measures shall be applied on need basis and crop will be established using following tillage systems.

1. Reduced- tillage (RW): In this approach, there is still some tillage *per se*, but there are far fewer preliminary tillage operations. Using a zero-till drill and an inclined planting plate, seeds are sown in rows 20 cm apart.

2. Furrow irrigated raised bed (FIRB): Using a tractordrawn multi-crop raised bed planter with inclined plate metering for planting wheat, the soil is tilled by two harrowing,

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followed by one field levelling (using awooden board). The furrows separating the beds, which have a top width of 140 cm and a height of 12 cm, areeach 30 cm broad. Each bed contains seven rows of wheat, spaced 20 cm apart.

3. Conventional tillage (CTW): This system uses two harrowing, two ploughing (using a cultivator), and oneplanking (using a wooden plank) after the harvest of the rice to achieve good tilth. Wheat is then seeded in rows 20 cm apart using a seed drill with a dry fertiliser attachment.

Nutrient content and uptake in wheat

Nitrogen content in grain and straw (%)

Treatment FIRB (C_3) recorded significantly maximum nitrogen content in grain and straw of wheat as compared to all other treatments. Reduced tillage plots recorded significantly lowest nitrogen content in grain and straw than rest of the tillage technique treatments during both the year of study.

Among the different precise nitrogen management treatments, the highest nitrogen content in grain and straw was obtained with SPAD (N_4) based nitrogen application followed by LCC (N_3) based nitrogen application treatment during both the years. Significantly lowest nitrogen content in grain and straw was obtained in the control treatment during both the years.

Table1:Effect of conservation tillage and precise nitrogen management techniques on N content and uptake by wheat

Treat ments	N content (%)				N uptake (kg ha^{-1})				Total N uptake (kg ha^{-1})	
	Grains		Straw		Grains		Straw			
	21-22	22-23	21-22	22-23	21-22	22-23	21-22	22-23	21-22	22-23
Conservation tillage (Main plot)										
C_1	1.51	1.47	0.44	0.43	76.5	73.5	29.3	28.9	105	101
C_2	1.41	1.40	0.42	0.40	62.6	61.4	26.1	24.4	88.7	85.8
C_3	1.61	1.59	0.50	0.49	88.2	86.0	34.5	31.8	122	117
SEm±	*0.03*	*0.04*	*0.007*	*0.008*	*1.9*	*2.1*	*1.2*	*1.0*	*1.5*	*1.7*
C D	*0.11*	*0.14*	*0.02*	*0.03*	*5.8*	*6.3*	*3.9*	*3.4*	*4.9*	*5.3*
Precise nitrogen management (Sub plot)										
N_1	1.23	1.26	0.39	0.40	43.1	45.3	19.2	18.7	62.3	64.0
N_2	1.50	1.46	0.44	0.43	76.5	73.4	29.8	27.8	106	101
N_3	1.63	1.61	0.49	0.47	88.1	85.6	34.8	33.8	121	117
N_4	1.70	1.67	0.52	0.51	93.6	91.6	36.6	35.4	130	127
SEm±	*0.05*	*0.04*	*0.009*	*0.01*	*2.7*	*3.0*	*0.68*	*0.74*	*2.9*	*3.8*
C D	*0.17*	*0.13*	*0.03*	*0.05*	*8.2*	*9.0*	*2.01*	*2.22*	*9.4*	*11.6*

Nitrogen uptake in grain and straw (kg ha^{-1})

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The highest nitrogen uptake by grains and straw of wheat was obtained due to moisture retention along with FIRB (C_3) practice, which was significantly higher than rest of the treatment during both the year of experimentation. The lowest nitrogen uptake by grains and straw of wheat was observed in reduced tillage (C_2) than rest of tillage techniques during both the year of study.

Among the different precise nitrogen management treatments, the highest nitrogen content in grain and straw was obtained with SPAD (N_4) based nitrogen application which was at par with LCC (N_3) based nitrogen application treatments but significantly higher than rest of the treatments during both the years. Significantly lowest nitrogen content in grain and straw was obtained in the control treatment during both the years.

Total nitrogen uptake (kg ha^{-1})

The highest total nitrogen uptake by wheat crop was obtained due to moisture retention along with furrow irrigated raised beds practice, which was significantly higher than rest of the treatment during both the year of experimentation. The lowest total nitrogen uptake by wheat crop was observed in reduced tillage (C_2) than rest of tillage techniques during both the year of study.

The data on precise N management had significant variation in total nitrogen uptake during both the year of study. The maximum total nitrogen uptake was recorded with the SPAD (N_4) which remained statistically at par with LCC (N_3) based nitrogen application treatments but significantly high than rest of the treatments during both the years. Lowest total nitrogen uptake was obtained in control plot during both the years.

Nutrient Use Efficiencies

Partial Factor Productivity (PFP)

Significantly higher values of partial factor productivity of nitrogen fertilizer was obtained with FIRB plots (C_3) during both the years of experimentation. The values of partial factor productivity of nitrogen fertilizer were remained statistically at par in FIRB and CT treatments during both the years. The significantly lowest value of partial factor productivity of nitrogen fertilizer was observed in reduced tillage (C_2). Among precise nitrogen management practices, significantly higher partial factor productivity of nitrogen fertilizer was obtained in SPAD (N_4) based nutrient management plots which was at par with LCC (N_3) treatments but significantly higher than rest of the treatments during both the years of experimentation. Lowest value of partial factor productivity of nitrogen fertilizer was obtained for control treatments during both the years of experimentation.

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Table 2: Effect of conservation tillage and precise nitrogen management techniques on PFP of N, P and K in wheat

Treatments	PFP (kg grain/kg of nutrient applied)					
	Nitrogen		Phosphorus		Potassium	
	21-22	22-23	21-22	22-23	21-22	22-23
Conservation tillage (Main plot)						
CT	29.49	29.37	67.64	67.02	84.55	83.78
RT	26.17	25.91	59.24	58.57	74.05	73.22
FIRB	30.63	31.68	71.30	72.96	89.13	90.19
SEm±	*0.61*	*0.71*	*2.05*	*0.64*	*0.62*	*1.22*
C D (P=0.05)	*2.35*	*2.81*	*8.12*	*2.51*	*2.43*	*4.78*
Precise nitrogen management (Sub plot)						
Control	-	-	-	-	-	-
SR @ 150:75:60	33.92	34.01	67.84	68.03	84.80	85.04
LCC Based N	39.46	40.09	71.03	72.16	88.79	90.20
SPAD Based N	40.68	40.84	73.22	73.51	91.52	91.88
SEm±	*0.51*	*0.65*	*1.01*	*0.97*	*0.95*	*1.22*
C D (P=0.05)	*1.53*	*1.95*	*3.07*	*2.90*	*2.91*	*3.75*

Agronomic Nutrient Use Efficiency (ANUE)

Significantly higher values of ANUE of nitrogen fertilizer was obtained with FIRB plots (C_3) during both the years of experimentation. The values of ANUE of nitrogen fertilizer were remained statistically at par in FIRB and CT treatments during both the years. The significantly lowest value of ANUE of nitrogen fertilizer was observed in reduced tillage (C_2). Among precise nitrogen management practices, significantly higher ANUE of nitrogen fertilizer was obtained in SPAD (N_4) based nutrient management plots which was at par with LCC (N_3) treatments but significantly higher than rest of the treatments during both the years of experimentation. Lowest value of ANUE of nitrogen fertilizer was obtained for control treatments during both the years of experimentation.

Table 3: Effect of conservation tillage and precise nitrogen management techniques on ANUE of N, P and K in wheat

Treatments	ANUE (kg grain/kg of nutrient applied over control)					
	Nitrogen		Phosphorus		Potassium	
	21-22	22-23	21-22	22-23	21-22	22-23
Conservation tillage (Main plot)						
CT	8.27	8.72	14.55	16.12	19.71	21.45
RT	6.90	8.37	12.37	12.91	16.92	15.24
FIRB	9.45	9.80	17.78	19.85	22.44	24.63
SEm±	*0.35*	*0.06*	*0.58*	*0.40*	*0.74*	*0.52*
C D (P=0.05)	*1.31*	*0.22*	*2.06*	*1.32*	*2.62*	*2.10*
Precise nitrogen management (Sub plot)						
Control	-	-	-	-	-	-
SR	7.84	8.50	15.68	16.99	19.60	21.24

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LCC	10.49	11.74	18.88	21.12	23.59	26.41
SPAD	11.70	12.48	21.06	22.47	26.33	28.09
SEm±	*0.28*	*0.52*	*0.53*	*0.97*	*0.66*	*1.22*
C D (P=0.05)	*0.84*	*1.54*	*1.57*	*2.90*	*1.96*	*3.63*

Apparent nutrient recovery (ANR)

Significantly higher values of ANR of nitrogen fertilizer was obtained with FIRB plots (C_3) during both the years of experimentation. The values of ANR of nitrogen fertilizer were remained statistically at par in FIRB and CT treatments during both the years. The significantly lowest value of ANR of nitrogen fertilizer was observed in reduced tillage (C_2). Among precise nitrogen management practices, significantly higher ANR of nitrogen fertilizer was obtained in SPAD (N_4) based nutrient management plots which was at par with LCC (N_3) treatments but significantly higher than rest of the treatments during both the years of experimentation. Lowest value of ANR of nitrogen fertilizer was obtained for control treatments during both the years of experimentation.

Table 4: Effect of conservation tillage and precise nitrogen management techniques on ANR of N, P and K in wheat

Treatments	**ANR (%)**					
	Nitrogen		**Phosphorus**		**Potassium**	
	21-22	**22-23**	**21-22**	**22-23**	**21-22**	**22-23**
Conservation tillage (Main plot)						
CT	46.3	39.8	9.9	16.2	13.4	13.2
RT	41.4	40.4	15.4	13.2	9.9	10.6
FIRB	47.6	45.4	17.7	16.3	12.7	13.6
SEm±	*1.4*	*1.1*	0.5	*0.6*	*0.4*	*0.4*
C D (P=0.05)	*5.1*	*4.2*	1.9	*2.3*	*1.5*	*1.6*
Precise nitrogen management (Sub plot)						
Control	-	-	-	-	-	-
SR @	20.0	16.6	11.0	11.8	11.0	14.4
LCC	31.8	28.4	16.8	14.7	16.8	18.8
SPAD	35.4	31.0	17.7	16.0	17.7	20.9
SEm±	*1.7*	*1.1*	1.1	*1.2*	*0.8*	*0.9*
C D (P=0.05)	*5.2*	*3.3*	3.5	*3.6*	*2.5*	*2.9*

DISCUSSION

The tillage crop establishment practices increased the N, P and K uptake by the crop with increase in moisture availability during the year of study. The nitrogen and phosphorous uptake was more through the grain (67 % of total N and 63 % of total P) and potassium was more through the straw (82 % of total) than grain. The higher N and P uptake in grain because of its chemical composition due to higher amino acid and protein content in grain require more N and P, whereas, higher K content in straw is because of its higher content is required for providing strength to stem by forming cellulose, lignin and pectin. The higher N, P and K uptake was mainly because of higher grain and straw yield in FIRB followed by CT. Similar trend has been observed by **Ingle *et al.*, 2007**.

The higher uptake and content of N, P and K in grain and straw under precision nitrogen treatments (LCC and SPAD) was because of more availability of these nutrients,

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which encouraged the crop growth and finally higher grain and biomass yield. The precision N management based nutrient prescriptions are more balanced as per the crop requirement and soil fertility status. Thus, precision nitrogen treatments might have contributed for higher N, P and K uptake as more splits of N application in LCC and SPAD treatments must have decreased N losses due to denitrification, ammonia volatilization and leaching which in turn increased N uptake and N uptake facilitates P and K uptake in crops. Similar findings were reported by **Godebo*et al.*, 2021**.

Nitrogen, phosphorus and potassium partial factor productivity (PFP) obtained was significantly higher with precision N management. Among precision N management practices, SPAD produced significantly higher nitrogen, phosphorus and potassium PFP, respectively. Significantly higher N, P and K agronomic nutrient use efficiency (ANUE) and apparent nutrient recovery (ANR) was obtained with precision N management. PFP, ANUE and ANR of N, P and K of LCC treatments was at par with that of SPAD treatments while above stated nutrient use efficiencies was significantly lower for SR treatments. Split application in case of precision nitrogen management techniques would have decreased nitrogen loss through nitrification and volatilization and increased its uptake and use by wheat crop. The precision N management based nutrient prescriptions are more balanced as per the crop requirement and soil fertility status. Thus, balanced nutrient recommendation might have contributed for higher nutrient use efficiency. A more balanced N, P and K nutrition practiced in the precision N management-based practices might also have contributed to increase. Similar result was also observed by **Mahajan (2018)** and **Gawdiya (2020).**

CONCLUSION

Use of different tillage practices gave significant result in respect to N, P and K content in grain and straw during both the year of study. Different tillage practices have significant variation in total N, P and K uptake during the year of study. The maximum total N, P and K uptake and NUE was recorded under furrow irrigated raised beds plots during both the years. Total N, P and K uptake and NUE,*i.e.*, Partial Factor Productivity, Agronomic Nutrient Use Efficiency and Apparent Nutrient Recovery all these indices showed that SPAD and LCC performed best during both the years of treatment. Yield and nutrient content was highest in SPAD and LCC treatments and application of fertilizer was less (~ 32kg urea) which resulted in better NUE.

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