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Effect of precision nitrogen-management and conservation tillage practices on growth, yield attributes and productivity of wheat (*Triticum aestivum*) in western Uttar Pradesh

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Abstract

A field experiment was conducted on sandy loam at Sardar Vallabhbhai Patel university of agriculture and technology, Meerut (Uttar Pradesh) during the winter (*rabi*) season of 2017–18, to study the effect of precision nitrogen management in wheat (*Triticum aestivum* L.) grown under conservation agriculture. The treatment comprising of tillage four crop establishment methods (T₁ - Zero tillage (ZTW), T₂ - Reduced tillage (RT), T₃ - Furrow irrigation raised beds (FIRB), T₄ - Conventional tillage (CTW)) in main plot and precision five nitrogen management (F₁ - N 80:20 - N rate split as 80% basal and 20% at second irrigation, F₂ - N 33:33:33 - N rate split as 33% basal, 33% at CRI stage (20–25 DAS) and 33% at second irrigation (40–45 DAS), F₃ - N 80 - LCC - Split as 80% basal and further application of N based on LCC, F₄ - N 50:50 - N rate split as 50% basal and 50% at CRI stage and F₅ - FFP - farmers fertilization practice) in sub-plot and laid out in split-plot design with three replications. Results revealed that the maximum values of growth parameters (plant height, number of tiller, dry matter accumulation), yield attributes (number of spike, spike length, grain spike⁻¹ and test weight) and yield was recorded in furrow irrigated raised beds system than rest of the tillage practices. Among precision nitrogen management treatments, the maximum values of growth characters (plant height, number of tiller and dry matter), yield attributes (number of spikes, spike length, grain spike⁻¹ and test weight), grain and straw yield were noticed with application of fertilizer as N 80-LCC respectively. Thus, the use of furrow irrigated raised bed system along with application of nutrient as N 80 - LCC resulted the best combination for achieving higher growth, yield attributes and productivity of wheat crop.

Keywords: Fertilizer nitrogen management, LCC, productivity, conservation tillage

Introduction

Wheat (*Triticum aestivum* L.) is a widely cultivated crop in world wide. Around the world, this crop provides nearly 55% of the carbohydrates and 20% of the food calories. In India, wheat is the second most important food crop after rice and has played a very vital role in increasing and stabilizing the food production of the country. In India wheat was grown in 30.7 million ha area with production of 99.12 million tonnes and productivity of 3095 kg ha⁻¹ (Anonymous 2018) [1]. In Uttar Pradesh, wheat is grown in typical semi-arid climate which is characterized by low to moderate temperature during crop growth. The area under wheat is 9.73 million hectares with total production of 30.30 million tones with productivity of 3118 Kg ha⁻¹. Different Tillage practices might have direct or indirect impact on plant growth and development. Wheat requires soil with good tilth which require generally 4-5 tillage operations after rice crop. Land preparation operations require high input energy and also increase the cost of cultivation. Delay in sowing result in poor plant stand and finally the lower productivity of crop. Grain yield of wheat crop reported to reduce by 15.5 Kg ha⁻¹ day⁻¹ when sowing is delayed after November (Tripathi *et al.*, 2013) [5, 17]. Now-a-days the mindset of famers and scientists has changed to reduce the number of tillage operations to minimize cost of cultivation and maintain wheat production without reducing productivity and also helps to sustain natural resources. Nitrogen (N) is the most widely used fertilizer nutrient for wheat and its consumption has increased substantially in the past decades (FAOSTAT 2009) [7]. Proper nitrogen management is very important for wheat production, as it helps in achieving desired growth, yield and protein content. Improper nitrogen availability to wheat plants results in low yields and significantly reduced profits compared to a properly fertilized crop.

Efficient nutrient management programmes supply plant nutrients in adequate quantities to sustain maximum crop productivity and profitability while minimizing environmental impacts of nutrient use (Jat *et al.*, 2013) [8, 9, 13].

Precision nutrient management strategy that employs detailed site specific information to precisely manage nutrients need of crops. By precision nutrient management plan, producers will be able to improve efficiency and effectiveness of nutrients by utilizing precision techniques and tools, maintain or increase yields, and minimize nutrient losses from fields, helping to protect surface and ground water supplies. Precision nutrient management techniques ensure that the 4 R's (Right rate, Right source, Right application method, and Right application timing) provide proper amount of nutrients to the crop where it is needed. Conservation agriculture based management systems substantially influences soil processes and nutrient dynamics in soil. Conservation Agriculture (CA), comprising minimum soil disturbances, retention of rational amount of crop residues is widely promoted for resource conservation, reducing soil degradation, adapting cropping systems to climatic extremes and improving long term agricultural sustainability. The global empirical evidences shows that farmer-led transformation of agricultural production systems based on CA principles is already occurring globally (157 mha) and gathering momentum as a new paradigm for the 21st century (Kassam *et al.*, 2015) [10]. The changes in physical and biological properties of the soil associated with CA practices are expected to modify the direction and kinetics of the chemical and biochemical processes, leading to altered nutrient dynamics in the soil (Sapkota *et al.*, 2016) [13]. However, each principle of CA involves a set of practices adapted to local circumstances which affects the soil processes as well as nutrient dynamics (Lal, 2015) [12].

The purpose of the current study was conducted a field experiment to evaluate the effect of precision nitrogen-management in conservation agriculture based different tillage practices on growth, yield and yield attributes of wheat (*Triticum aestivum*) in Western Uttar Pradesh.

Materials and Methods

The field experiment was conducted during *rabi* seasons of 2017-18 at Crop Research Centre (Chirodi) farm of the Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut (U.P.) located in Indo-Gangetic plains of Western Uttar Pradesh and in North Western plains of wheat growing zone. The experiment was laid out in split plot design in twenty treatment combinations with four tillage crop establishment method - (T₁ - Zero tillage (ZTW), T₂ - Reduced tillage (RT), T₃ - Furrow irrigation raised beds (FIRB), T₄ - Conventional tillage (CTW)) in main plot and five precision nitrogen management levels - (F₁ - N 80:20, F₂ - N 33:33:33, F₃ - N 80 - LCC, F₄ - N 50:50 and F₅ - FFP) in sub-plot with three replications. Wheat crop will be sown at 100 kg seed ha⁻¹ at 20cm row spacing in conventional tillage, reduced tillage, zero tillage and 75 kg seed ha⁻¹ in FIRB systems. To control weeds in the experimented field Clodinafop 15% WP @60 g ha⁻¹ will be applied at 30 DAS followed by one hand weeding at 45 DAS. The recommended dose of fertilizer for wheat crops (155:60:60 kg N, P₂O₅ and K₂O/ha) was placed below the seed zone at sowing as per the treatment. In wheat crops full dose of P and K and N as per treatments - five nitrogen management treatments included in this study were: (1) N 80:20 - N rate split as 80% basal and 20% at second irrigation (40–45 days after sowing, DAS); (2) NE33:33:33- N rate split

as 33% basal, 33% at CRI stage (20–25 DAS) and 33% at second irrigation (40–45 DAS); (3) N 80:LCC- split as 80% basal and further application of N based on LCC (4) SR 50:50 - N rate split as 50% basal and 50% at CRI stage; and (5) FFP-farmers fertilization practice. The soil of the experimental site was sandy loam and having of 0.43% organic carbon, 221.6 kg/ha KMnO₄ oxidizable N, 15.6 kg/ha 0.5 N NaHCO₃ extractable P, 240.5 kg/ha 1.0 N NH₄OAC exchangeable K, 7.46 pH and 0.21 dS/ m EC at the beginning of experiment. Data on growth and yield attributes recorded at crop maturity and samples of wheat crop were harvested manually from the central net plot area for grain and straw yield assessment. The harvest index was computed by dividing economic yield with biological yield and multiplied with 100. All the data obtained from wheat crop were statistically analyzed using the OP Stat Software.

Results and Discussion

Growth characters

Among different Tillage Crop establishment methods and precision N-management practices in wheat, FIRB and N – 80 LCC recorded significantly the highest and conventional tillage and Farmer fertilization practices recorded significantly the lowest plant height of wheat at harvest. Similarly in wheat crop FIRB and N – 80 LCC recorded significantly the highest and conventional tillage and Farmer fertilization practices recorded significantly the lowest dry-matter accumulation at 90 DAS of wheat crop. The numbers of tillers in wheat at 90 DAS increased significantly in furrow irrigated raised bed system and N- 80 LCC based nitrogen application. There was a gradual increase in the plant height of wheat till maturity. This was mainly due to increase in the length of leaves of wheat crop up to the maturity stage. Precision nutrient management treatments recorded maximum plant height of wheat than farmers fertilizer practice as balanced application of nutrients as per crop need under N 80-LCC enhances the nutrient use efficiency (Biradar, 2012) [3]. Increase input efficiency improved N, P, K supplying capacity of soil resulting in higher plant height because nitrogen is needed for the formation of chlorophyll, phosphorus for the synthesis of nucleic acids and similarly potassium is important for the growth and elongation probably due to its function as an osmoticum and may react synergistically with indole acetic acid (Cocucci and Dallarosa, 1980) [4] which is responsible for growth and development. The nitrogen application with N 80-LCC leads to higher plant height, dry matter accumulation, number of tillers which was obtained due to enhancement in photosynthetic rate as a result of increased chlorophyll content (Maiti *et al.*, 2007). Among the different tillage, furrow irrigation raised beds system recorded significantly higher dry matter production (g/m²) than rest of tillage at maturity which might be due higher leaf area index resulting in higher photosynthetic efficiency and ultimately higher photosynthate accumulation. Similar results were also reported by (Mauriya *et al.*, 2013) [5].

Yield and yield attributes

The maximum and minimum spike length, spikelet's spike⁻¹, grains spike⁻¹, highest test weight, highest grain, straw yield, biological yield, harvest index was obtained in furrow irrigated raised bed practice and conventional tillage treatment, respectively. Among the precision nutrient management the highest spike length was recorded on nitrogen N 80-LCC which was significantly superior then rest

of the treatment. The lowest spike length, spikelet's spike⁻¹, grains spike⁻¹, highest test weight, highest grain, straw yield, biological yield, harvest index was recorded in farmer's fertilization practice treatments. Precision nitrogen management practices significantly influence the yield attributing characters *i.e.* number of spike, spike length, number of grains per spike and 1000 grain weight and the highest values were observed with N 80-LCC as enhanced nutrient availability led to an increase in leaf area, photosynthesis etc. which in turn result in the formation of healthy spike. Similar results were also reported by Khurana *et al.*, (2008) [11, 13], Singh, (2008) and Mahajan *et al.* (2013) [9, 11, 14]. Wheat sown on FIRB and under zero tillage increased the grain yield of wheat over conventional and reduced treatments during experimentation. This increase was because of increased the number of grains per spike during the year of study. Similarly, the increase in test weight was also recorded in the range of during crop season. Similar results have been reported by Ali *et al.* 2012 [2]. Significant increase in yield due to precision nutrient management may have occurred due to the fact that nitrogen application through N 80-LCC supply the nitrogen as per as requirement of crop that helps farmers to attain high yield and achieve high profitability both in the

short and medium-term. The fertilizer requirement for a field or location is estimated from the expected yield response to each fertilizer nutrient, which is the difference between the attainable yield and the nutrient limited yield. Nutrient-limited yields are determined from nutrient omission trials, while attainable yield is the yield in a typical year at a location using best management practices without nutrient limitation. Similar results were also reported by Meena *et al.* (2014) [16, 17] in Udaipur, revealed that application of site specific nutrient management treatment recorded significantly higher grain, straw and biological yield. Higher grain and biomass yield with N80 – LCC based nutrient management strategies over farmers' practice of nutrient management clearly indicated the benefit of judicious nutrient management in wheat. In precision nutrient management, plant nutrients are applied based on the site specific nutrient management principle of 'feeding crops with nutrient as and when they are needed' (IRRI, 2013) [6]. Lower grain and biomass yield with N 80:20 and state recommendation as compared with N 33:33:33 and N 80-LCC suggests a lower total nitrogen uptake by the crop in former two treatments due to inadequate nitrogen supply or availability from CRI stage onwards.

Table 1: Effect of tillage crop establishment methods and precision nitrogen management on plant height, dry-matter accumulation, and effective tillers/m² of wheat crop

Treatments	Plant height at harvest (cm.)	Dry matter accumulation at 90 DAS (g m ⁻²)	Tiller/m ² at 90 DAS
Tillage crop establishment methods (TCEM)			
T ₁ – ZTW	97.1	846.9	352.7
T ₂ – RT	93.3	840.9	333.3
T ₃ – FIRB	104.7	871.5	368.3
T ₄ – CTW	89.1	822.9	339.9
C D (P=0.05)	1.7	14.5	9.8
Precision nitrogen management			
F ₁ - N 80:20	95.6	821.1	339.2
F ₂ - N 33:33:33	98.1	864.5	360.1
F ₃ - N 80-LCC	100.1	916.9	373.0
F ₄ - SR 50:50	93.9	819.9	343.1
F ₅ - FFP	92.5	805.5	327.5
C D (P=0.05)	1.2	8.5	6.9

ZTW- Zero tillage, RT-Reduced tillage, FIRB-furrow irrigation raised bed, CTW-Conventional tillage, LCC-leaf color chart, SR-straight Recommendation, NE-nutrient expert, FFP-farmer fertilization practices

Table 2: Effect of tillage crop establishment methods and precision nitrogen management on yield and yield contributing characteristics of wheat

Treatments	Spike length (cm)	Spikelets spike ⁻¹	Grains spike ⁻¹	Test weight (g)	Grain yield (q ha ⁻¹)	Straw yield (q ha ⁻¹)	Biological yield (q ha ⁻¹)	Harvest index (%)
Tillage crop establishment methods (TCEM)								
T ₁ - ZTW	10.9	15.8	53.8	40.3	46.35	60.22	106.65	43.49
T ₂ - RT	10.6	15.5	50.5	40.0	45.31	59.71	105.03	43.14
T ₃ - FIRB	11.2	16.1	55.4	40.9	48.09	60.57	108.67	44.28
T ₄ - CTW	10.1	15.2	49.2	39.7	44.22	58.64	102.86	43.03
C D (P=0.05)	0.2	0.3	1.4	0.2	0.49	1.26	1.35	0.57
Precision nitrogen management								
F ₁ - N 80:20	10.8	15.65	51.9	40.2	45.02	58.12	103.14	43.65
F ₂ - N 33:33:33	11.2	15.84	54.4	40.4	47.37	60.76	108.13	43.80
F ₃ - N 80-LCC	11.4	16.10	58.5	40.9	48.78	65.89	114.68	42.52
F ₄ - SR 50:50	10.4	15.40	49.1	39.9	44.93	57.36	102.29	43.94
F ₅ - FFP	9.9	15.23	47.1	39.7	43.85	56.90	100.76	43.51
C D (P=0.05)	0.2	0.2	1.1	0.12	0.57	0.81	1.06	0.43

ZTW- Zero tillage, RT-Reduced tillage, FIRB-furrow irrigation raised bed, CTW-Conventional tillage, LCC-leaf color chart, SR-straight recommendation, NE-nutrient expert, FFP-farmer fertilization practices

Conclusion

Based on these experiment results, it can be concluded that the maximum growth parameters, yield attributes and yield

increase in wheat was obtained with furrow irrigated raised bed practice and nitrogen N 80-LCC which was significantly superior then rest of the treatment. It shows that these

precision nutrient management options of site-specific nutrient management based Nutrient expert and leaf color chart can be better option over other practices in conservation agriculture based wheat. In addition to this, real time N management based on Nutrient expert was also found effective in wheat under conservation agriculture. Therefore, combination of tillage and nutrient management strategy can be recommended to increase wheat production and productivity in western Uttar Pradesh.

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