



Site-specific nutrient management under conservation agriculture-based spring wheat in Trans-Gangetic Plains of India

MOHAMMAD HASANAIN¹, V K SINGH^{1*}, S S RATHORE¹, KAPILA SHEKHAWAT¹, R K SINGH¹,
B S DWIVEDI¹, ARTI BHATIA¹ and P K UPADYAYA¹

ICAR-Indian Agricultural Research Institute, New Delhi 110 012, India

Received: 12 November 2020; Accepted: 18 December 2020

ABSTRACT

The experiment was conducted during 2018–19 and 2019–20 at ICAR-IARI research farm, to see the effect of crop establishment and nutrient management options on growth and yield of wheat under maize-wheat system. The experiment was laid out in split plot design with 03 replications, comprising conventional tillage without residue (CT-R), conventional tillage with 3 t/ha residue (CT+R), permanent raised bed without residue (PRB-R) and permanent raised bed with 3 t/ha residue (PRB+R) in main plot and nutrient management, viz. soil test-based (STB), Nutrient Expert[®] based (NE) and NE+ GreenSeeker[™] based recommendations (NE+GS) in sub-plot. A significantly ($P \leq 0.05$) higher crop growth, viz. plant height, dry matter accumulation and leaf area index under PRB+R compared to other crop establishment technique. Differentlyield parameters (yield, grain straw ratio and harvest index) and yield attributes of wheat grown under PRB+R were significantly higher ($P \leq 0.05$) over other crop establishment technique. A significantly ($P \leq 0.05$) higher crop growth, yield attributes, grain yield (5.01 and 5.05 t/ha), grain: straw ratio (0.65 and 0.65) and harvest index (39.31 and 39.36) of wheat were recorded with NE+GS based fertilization during 2018-19 and 2019-20, respectively. Pearson correlation matrix analyzed for different growth and yield parameters showed a significant positive correlation (r) among themselves. Study infer that growing of wheat on the permanent raised bed along with 03 t/ha residue retention on surface and precision nutrient prescription using NE and GreenSeeker[™] optical sensor showed promise for sustainable high productivity in intensively cultivated Trans-Gangetic Plains.

Keywords: Conservation agriculture, Crop growth, Site-specific nutrient management, Trans-Gangetic Plain, Wheat yield

Wheat is the most important cereal crop and staple food of world and occupies 30.6 m ha area in India with production of 97.11 mt. Intensive tillage in wheat over past several decades resulted in deterioration of soil quality, increasing pest infestation, declining factor productivity, lowering of ground water table, increasing cost of cultivation etc., posing a serious threat to environmental health and yield sustenance (Gangwar *et al.* 2005, Jat *et al.* 2005). Conservation agriculture (CA)-based resource conservation technologies has proven to be an efficient method to produce more at less incurred cost, while reducing environment pollution and promoting conjunctive use of organics (avoids residue burning) (Parihar *et al.* 2016). In CA system nutrient cycling through cover crop act as a ‘nutrient pump’ to enhance and conserve available nutrient pools from which plant roots feed (Jat *et al.* 2011, Singh *et al.* 2016).

In Indo-Gangetic plains (IGP) farmers often apply excess N, sub-optimum P but ignore K and other micro-

nutrients (Dwivedi *et al.* 2001 and Singh *et al.* 2016). Site specific nutrient management (SSNM) approach has potential to improve yield, soil health, and nutrient use efficiency in different crops (Singh *et al.* 2015a; 2015b). Decision support tools like Nutrient Expert[®] which follow the principle of SSNM have further opened the avenue for targeted yield based nutrient use under varying crop management scenarios (Majumdar *et al.* 2013). Although the adoption of CA under principal cropping systems of the IGP is increasing, management of nutrients in CA based system are still lacking. An integration of SSNM with CA based system may further provide opportunities to enhance production profitability and resource use efficiency. Scattered studies conducted elsewhere reveal that NE based nutrient management not only leads to higher resource use efficiency but also curtails the application rates under CA-based No-till system (Sapkota *et al.* 2014). Therefore, present study aims to see the effect of different SSNM strategies and CA practices on growth, yield and yield parameters of wheat crop.

MATERIALS AND METHODS

The experiment was conducted during 2018–19 and 2019–20 at ICAR-IARI research farm New Delhi. The soil

Present address: ICAR-Indian Agricultural Research Institute, New Delhi. *Corresponding author e-mail: vkumarsingh_01@yahoo.com.

of the experimental site was sandy clay loam, low in organic carbon (0.30%) and available N (237.0 kg/ha), medium in available P (17.0 kg/ha) and K (265 kg/ha), having pH 8.2. The experiment was conducted in split plot design with three replications, comprising four treatments in main plot, viz. conventional tillage without residue (CT-R), conventional tillage with 3 t/ha residue (CT+R), permanent raised bed without residue (PRB-R) and permanent raised bed with 3 t/ha residue (PRB+R) and 3 nutrient management options, such as soil test-based (STB), Nutrient Expert[®] based (NE) and Nutrient Expert[®] based + GreenSeeker based (NE+GS) recommendations in sub-plots. The field operations included one ploughing followed by two cross harrowing and levelling to ensure proper drainage in CT plots, while for making/reshaping of ridges, the bed planter was used. The fertilizers were applied as per the treatment. Wheat cv. HD 2967 with 100 kg seed/ha was sown using zaaboo seed drill in CT and a bed planter in permanent ridge beds at 20cm (row to row) spacing. The total number of irrigations (including pre sowing) applied in wheat were 7, 6, 5 and 4 in PRB-R, PRB+R, CT-R and CT+R plots, respectively. The crop was harvested manually from net plot area of 4 m × 4 m, sun dried for 3 days, threshed and grain and straw yield were recorded.

The plant height (cm) of 05 tagged plant was measured from ground level at maximum tillering and ear emergence stage. For dry matter accumulation plants from 01meter row length were cut from ground level at maximum tillering and ear emergence stage, air-dried for 2-3 days followed by oven-drying at 60-65°C for 48 h and dry weight was recorded. The number of effective tillers/m² were counted at maximum tillering stage using quadrates (25 cm × 25 cm) from the sampling row. The leaf area of 1 m row length was measured with the help of leaf area meter (Model LI-COR-3100) at maximum tillering and ear emergence and the leaf area index was calculated. The yield attributes, viz. number of spikes/m², length of spike, number of grains/spike, grain weight/spike and 1000 grain weight (g) were recorded from 05 plants from each plot at harvest. For treatment comparison in the field experiment the “F-test” was used (Cochran and Cox 1957) and least significance difference (LSD) was computed to determine statistically significant treatment differences (Table 1 and 2).

RESULTS AND DISCUSSION

Effect on crop growth: Growth parameters measured at maximum tillering, viz. plant height, number of tillers/m², dry matter accumulation and leaf area index were significantly ($P<.05$) higher under PRB+R over other crop establishment options during 2018-19 and 2019-20. On the other hand, lowest values of these parameters were recorded with CT-R (27.34 to 30.07 cm, 339 to 342 cm, 35.8 to 139.1 g/m² and 1.61 to 1.67) at this stage (Table 1). A similar crop growth trend was noticed at ear emergence also during both the years. The increased growth parameter on raise bed may be argued as “border effect”. Since wheat crop were grown on PRB (30 cm row spacing), whereas it was 20 cm apart

Table 1 Effect of crop establishment and nutrient management options on growth parameters of wheat

Treatment	Plant height (cm)			No of tillers/m ²			Dry matter accumulation (g/m ²)			Leaf area index (LAI)				
	Maximum tillering		Ear emergence stage	Maximum tillering		Ear emergence stage	Maximum tillering		Ear emergence stage	Maximum tillering		Ear emergence stage		
	2018-19	2019-20		2018-19	2019-20		2018-19	2019-20		2018-19	2019-20		2018-19	2019-20
Crop establishment technique														
CT-R	27.34	30.01	86.63	89.13	338.7	341.6	135.8	139.1	420.3	440.3	1.61	1.67	2.66	2.73
CT+R	32.56	35.06	95.72	97.04	354.6	357.9	144.6	147.9	434.6	454.6	1.75	1.90	2.88	2.94
PRB-R	38.66	41.16	101.76	103.92	369.4	372.8	159.5	162.8	449.5	469.5	1.91	1.94	2.93	3.05
PRB+R	44.75	47.25	113.96	116.41	384.2	387.5	173.0	175.3	466.0	484.2	2.42	2.48	3.47	3.54
SEm±	1.10	1.37	1.71	1.85	3.57	3.77	2.59	1.81	4.06	3.98	0.02	0.02	0.03	0.02
LSD (P<0.05)	3.81	4.75	6.0	6.41	12.34	13.03	8.96	6.26	14.04	13.78	0.08	0.06	0.09	0.07
Nutrient management option														
SSTB	32.09	34.71	94.55	97.14	346.8	350.0	146.3	148.8	428.0	448.0	1.77	1.82	2.81	2.94
N	35.96	38.46	99.24	101.28	362.9	366.3	152.9	156.3	442.9	462.9	1.95	2.00	2.99	3.07
N+GS	39.43	41.93	104.75	107.13	375.4	378.6	160.4	163.8	456.8	475.4	2.05	2.16	3.16	3.20
SEm±	1.22	0.88	1.19	1.28	3.96	4.15	1.98	2.18	4.08	4.15	0.03	0.03	0.03	0.02
LSD (P<0.05)	3.66	2.63	3.56	4.0	11.87	12.44	5.93	6.54	12.24	12.45	0.09	0.08	0.09	0.07

NS: Non-significant

Table 2 Effect of crop establishment and nutrient management options on yield and yield attributes of wheat

Treatment	Spikes/m ²		Spike length (cm)		Grains/spike		Grain weight/spike (g)		1000 grain-weight (g)		Grain yield (t/ha)		Grain: straw		Harvest index	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
<i>Crop establishment technique</i>																
CT-R	312.00	316.11	8.13	8.38	37.95	38.84	2.25	2.30	35.60	36.60	4.34	4.37	0.60	0.61	37.63	37.70
CT+R	328.69	331.69	9.50	9.79	43.39	44.50	2.50	2.55	39.12	40.12	4.69	4.73	0.63	0.63	38.62	38.69
PRB-R	341.66	344.88	10.66	10.80	45.75	46.64	2.84	2.89	41.62	42.62	4.94	4.97	0.65	0.65	39.32	39.37
PRB+R	355.89	358.56	11.31	11.64	48.90	50.35	3.38	3.43	44.27	45.27	5.44	5.47	0.68	0.69	40.56	40.72
SEm±	3.13	3.10	0.34	0.28	0.53	0.56	0.06	0.04	0.21	0.33	0.03	0.04	0.01	0.01	0.23	0.30
LSD (P<0.05)	10.8	10.73	1.14	0.95	1.83	1.93	0.21	0.13	0.74	1.14	0.10	0.14	0.02	0.03	0.80	1.03
<i>Nutrient management option</i>																
STB	326.23	328.31	9.20	9.46	40.70	41.61	2.38	2.43	36.84	37.84	4.72	4.75	0.64	0.64	38.87	38.92
NE	332.41	335.82	9.64	9.84	43.84	45.01	2.76	2.81	40.20	41.20	4.83	4.86	0.64	0.64	38.92	39.08
NE+GS	345.04	348.54	10.91	11.17	47.45	48.62	3.09	3.14	43.41	44.41	5.01	5.05	0.65	0.65	39.31	39.36
SEm±	1.95	2.16	0.13	0.12	0.93	1.22	0.06	0.05	0.42	0.51	0.02	0.02	0.00	0.00	0.12	0.14
LSD (P<0.05)	6.0	6.48	0.4	0.36	2.78	3.67	0.17	0.15	1.26	1.54	0.05	0.06	0.01	NS	0.35	NS

NS: Non-significant

in CT plots, therefore, crop intra competition for light and other resources were lesser on PRB. Also, residue retention on bed had added advantage in terms of thermo-regulation and moisture availability which led better crop growth.

Fertilizer use as per NE+GS had highest plant height (39.43 to 41.93 cm) which was significantly ($P<0.05$) higher than STB but remained at par with NE based fertilizer use at maximum tillering and ear emergence stage during both the years (Table 1). Application of fertilizer as per NE+GS also had highest dry matter accumulation, number of tillers and LAI at both the stages of crop in during the study followed by NE and STB fertilizer use. The major cause for higher gain under NE+GS based fertilizer use may be visualized as optimized nutrient availability due to NE based recommendation and real time N use through GreenSeeker led to synchronization between supply and demand of nutrients for plant growth (Giller *et al.* 2004, Singh *et al.* 2018).

Yield attributes: Different yield attributes of wheat, viz. number of spikes/m², number of grains per spike, grain weight per spike and 1000-grain weight were significantly ($P<0.05$) higher under PRB+R as compared to other crop establishment options, irrespective of nutrient management (Table 2). After PRB+R, the treatments that were next in the order were PRB-R, CT+R and CT-R. Among nutrient management option highest number of spikes/m² was found with NE+GS (345.04/m²) during first year which was significantly higher over NE (332.41/m²) and STB (326.23/m²) fertilizer use. The trend remained the same in succeeding year also. The treatment NE+GS had highest spike length (10.91 cm and 11.17 cm) which was significantly higher than NE and STB during first and second year, respectively. The other yield parameters, viz. number of grains/spike, grain weight/spike and 1000 grain weight were also maximum with NE+GS and significantly higher over NE and STB fertilizer use.

Wheat productivity: Among different crop establishment practices PRB+R outperform over other options for producing wheat grain during both the years (Table 2). The grain yield for 2018–19 under PRB+R, PRB-R, CT+R and CT-R were 5.344, 4.94, 4.69 and 4.34 t/ha, respectively. The corresponding values for 2019–20 were 4.37, 4.73, 4.97 and 5.47 t/ha, respectively. These results may be visualized in terms of improved soil and microclimatic condition coupled with better nutrient supply (Singh *et al.* 2018). Residue retention on bed negate the effect of terminal heat stress and reduces nutrient losses (Das *et al.* 2014, Singh *et al.* 2016). The grain: straw ration and HI were also found to be higher with PRB+R over other options and it followed a trend of PRB+R>PRB-R>CT+R>CT-R. Among the nutrient management options NE+GS (5.01 and 5.05 t/ha in 2018–19 and 2019–20, respectively) had significantly higher wheat yield as compared to NE and STB fertilizer use. The yield gain with NE + GS was mainly accrued due to optimum nutrient supply as per crop demand through judicious fertilizer input and optimized indigenous soil nutrient supply (Sapkota *et al.* 2014).

Pearson correlation matrix: Pearson correlation analysis between different growth, yield parameters and grain yield of wheat showed a strong positive correlation ($P=0.01$ or 0.05) among the parameters indicating direct bearing of these parameters on overall performance of wheat crop (data not shown). Such positive correlation further explains our results that PRB+R along with NE+GS optical sensor-based nutrient management resulted better growth, yield attributes and subsequently the grain yield.

Results from present study clearly demonstrate that higher crop growth, yield attributes and yield of wheat can be achieved by it growing on permanent raised bed along with 03 t/ha residue retention and precision nutrient prescription using Nutrient Expert® decision support tool and GreenSeeker. Future research needs to be built upon ecological impact and soil health to advocate the technology as sustainable option for wheat production in IGP.

ACKNOWLEDGEMENTS

The authors sincerely acknowledge the necessary services and supplies received from the Division of Agronomy, ICAR-Indian Agricultural Research Institute, New Delhi for conducting this research work.

REFERENCES

- Cochran W G and Cox G M 1957. *Experimental Design*, 2nd Edition. John Wiley and Sons, New York.
- Das T K, Bhattacharyya R, Sudhishri S, Sharma A R, Saharawat Y S and Bandyopadhyay K K. 2014. Conservation agriculture in an irrigated cotton–wheat system of the western Indo-Gangetic Plains: crop and water productivity and economic profitability. *Field Crops Research* **158**: 24–33.
- Dwivedi B S, Shukla A K, Singh V K and Yadav R L. 2001. Results of participatory diagnosis of constraints and opportunities (PDCO) based trails from the state of Uttar Pradesh. (In) Subba Rao A and Srivashtav S (Eds.), *Development of farmers' Resource-Based Integrated Plant Nutrient Supply System: Experience of a FAO-ICAR-IIFCO Collaborative Project and AICRP on Soil Test Crop Response Correlation*. IISS, Bhopal, India, pp 50–75.
- Gangwar K S, Singh K K, Sharma S K and Tomar K. 2005. Alternate tillage and crop residue management in wheat after rice in sandy loam soil of Indo-Gangetic plains. *Soil and Tillage Research* **6**: 230–35.
- Giller K E, Chalk P M, Doberman A, Hammond L, Hever P and Ladha J K. 2004. Emerging technologies to increase the efficiency of use of fertilizer nitrogen. (In) Mosier A R, Syers J K and Freney J R (Eds), *Agriculture and the Nitrogen Cycle: Assessing the Impacts of Fertilizer Use on Food Production and the Environment*, Paris, France, pp 35–51.
- Jat M L, Sharma S K, Gupta R K, Zaidi P K, Rai H K and Sreenivasan G. 2005. Evaluation of maize-wheat cropping system under double no-till practice in Indo-Gangetic Plains of India. (In) *Proceedings of 9th Asian Regional Maize Workshop*. Beijing, China, September 5–9.
- Jat M L, Saharawat Y S and Gupta R. 2011. Conservation agriculture in cereal systems of south Asia: Nutrient management perspectives, *Karnataka Journal of Agricultural Sciences* **24**(1): 100–05.
- Majumdar K, Jat M L, Pampolino M, Dutta S and Kumar A. 2013. Nutrient management in wheat: current scenario, improved strategies and future research needs in India. *Journal of Wheat Research* **4**:1–10.
- Parihar C M, Yadav M R, Jat S L, Singh A K, Kumar B, Chakraborty S D, Jat M L, Jat R K, Saharawat Y S and Yadav O P. 2016. Long term effect of conservation agriculture in maize rotations on total organic carbon, physical and biological properties of a sandy loam soil in north-western Indo-Gangetic Plains. *Soil Tillage Research* **161**: 116–28.
- Sapkota T B, Majumdar K, Jat M L, Kumara A, Dalip K, Bishnoi A J, McDonald D and Pampolino M. 2014. Precision nutrient management in conservation agriculture-based wheat production of Northwest India: Profitability, nutrient use efficiency and environmental footprint. *Field Crops Research* **155**: 233–44.
- Singh V K, Dwivedi B S, Tiwari K N, Majumdar K, Rani M, Singh Susheel K and Timsina K. 2015a. Optimizing nutrient management strategies for rice–wheat system in the Indo-Gangetic Plains of India and adjacent region for higher productivity, nutrient use efficiency and profits. *Field Crops Research* **164**: 30–44.
- Singh V K, Shukla A K, Dwivedi B S, Singh M P, Majumdar K, Kumar V, Mishra R P, Rani Meenu and Singh S K. 2015b. Site-specific nutrient management under rice-based cropping systems in Indo-Gangetic Plains: yield, profit and apparent nutrient balance. *Agricultural Research* **4**(1): 365–77.
- Singh V K, Singh Y, Dwivedi B S, Singh S K, Majumdar K and Jat M L. 2016. Soil physical properties, yield trends and economics after five years of conservation agriculture-based rice-maize system in north-western India. *Soil Tillage Research* **155**: 133–48.
- Singh V K, Dwivedi B S, Yadvinder-Singh, Singh S K, Mishra R P, Shukla A K, Rathore S S, Shekhawat Kapila, Majumdar K and Jat M L. 2018. Effect of tillage and crop establishment, residue management and K fertilization on yield, K use efficiency and apparent K balance under rice-maizesystem in north-western India. *Field Crops Research* **224**: 1–12.
- Tiwari K N, Sharma S K, Singh V K, Dwivedi B S and Shukla A K. 2006. Site-specific nutrient management for increasing crop productivity in India. Results with rice-wheat and rice-rice systems. PDCSR, Modipuram and PPIC-India Programme, Gurgaon 112.