Precision Nutrient Management in No-till Wheat: A Case Study for Haryana

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Poor understanding of nutrient management in no-tillage-based wheat spurred a comparison of various available strategies.

The greatest overall benefit was generated with Nutrient Expert®-based fertilizer recommendations supplemented with GreenSeeker®-guided N application.

Wheat is the second most important cereal crop in India occupying about 29 million ha, which contributes to 37% of the country's foodgrain production. Nearly 50% of the total wheat production in India comes from the Northwestern (NW) plain zone. Surveys done in this region have revealed that farmers often apply greater than recommended rates of fertilizer N and P, but ignore the application of K and other secondary and micronutrients. This leads to reductions in crop yield, nutrient use efficiency, farmer profit, and also increases environmental risks associated with the loss of unutilized nutrients through gaseous emissions or leaching. The Intergovernmental Panel on Climate Change (IPCC) loosely assumes that 1% of fertilizer N applied in the field is emitted as N_2O, but this fraction can be much higher in areas with imbalanced fertilization like in NW India.

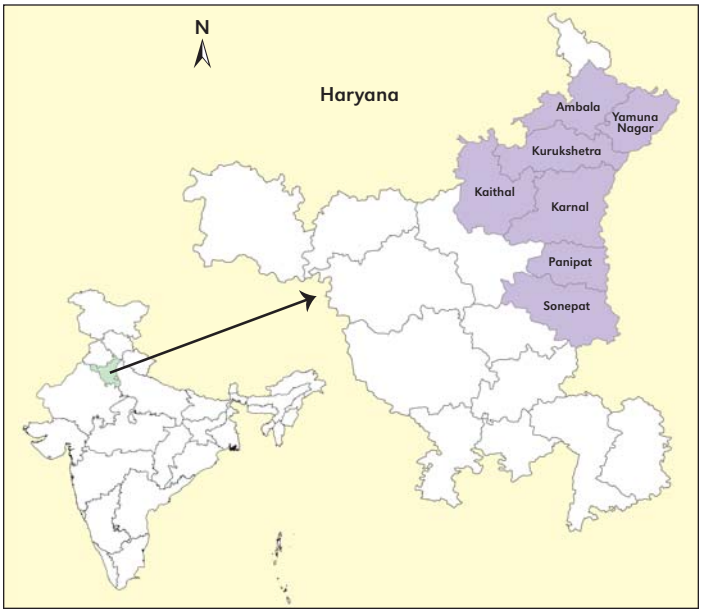
Recent advances in the development of precision nutrient prescription tools like Nutrient Expert® (NE), a decision support system (Pampolino et al., 2012), GreenSeeker® (GS) handheld sensors, and leaf color charts (LCCs) have shown promise in increasing crop productivity and nutrient use efficiency of crops and minimizing environmental footprints (Satyanarayana et al., 2012).

In a collaborative effort between the International Maize and Wheat Improvement Center (CIMMYT) and the International Plant Nutrition Institute (IPNI) to test, pilot and upscale NE-based fertilizer management, on-farm participatory research was conducted in seven districts (Karnal, Kurukshetra, Kaithal, Ambala, Sonepat, Panipat, and Yamunanager) of Haryana to evaluate and compare NE-based strategies in conventional and no-till wheat production systems. For this, 15 on-farm experiments were established in 2010-11 and 2011-12. The four nutrient management treatments included: (1) NE-based recommendation; (2) NE+GS: NE recommendation supplemented with GS-guided application of N; (3) SR: state fertilizer recommendation; and (4) FFP or the farmers fertilization practice. These treatments were compared for agronomic productivity, economic profitability and total greenhouse gas emissions. Total greenhouse gas emissions from wheat production were estimated using the Cool Farm Tool (Hillier et al., 2011). This tool uses information about soil and climatic characteristics, tillage and residue management, crop management practices such as fertilizer and pesticide applications, energy use and total output.

Grain Yield and Economic Profitability

Averaging data for two years, results showed that the highest grain yields were obtained using NE-based nutrient management (NE and NE+GS) strategies followed by SR and FFP (**Figure 1**). Grain yields were not significantly different between NE and NE+GS. Similarly, net returns were also significantly different among various nutrient management strategies. However, net return was not different significantly among NE, NE+GS and SR (**Figure 1**). The total cost of production was not significantly different among the different nutrient management strategies tested (data not shown). Therefore, lower grain and straw yield were mainly responsible for lower net returns under FFP as compared to other nutrient management strategies.

Imbalanced fertilizer application due to non-application of fertilizer K (Sapkota et al., 2014) was probably the main reason for lower grain yield under FFP compared to other treatments. Nutrient recommendations in NE-based strategies were derived after accounting for the native nutrient supplying capacity of soil, nutrient balance in the concerned field at the cropping system level and yield target and therefore, were possibly more balanced compared to the other treatments.



Study districts in the Haryana state.

Global Warming Potential

Estimated GWP, as affected by nutrient management strategy, was significant for both GWP per t wheat yield and GWP per US$ net return. For example, FFP resulted in higher GWP per t of wheat yield whereas NE-based recommendation followed by GS-based N application resulted in the lowest GWP

Abbreviations and notes: GWP = global warming potential; N = nitrogen; P = phosphorus; K = potassium; N_2O = nitrous oxide; US$1 = ₹64.

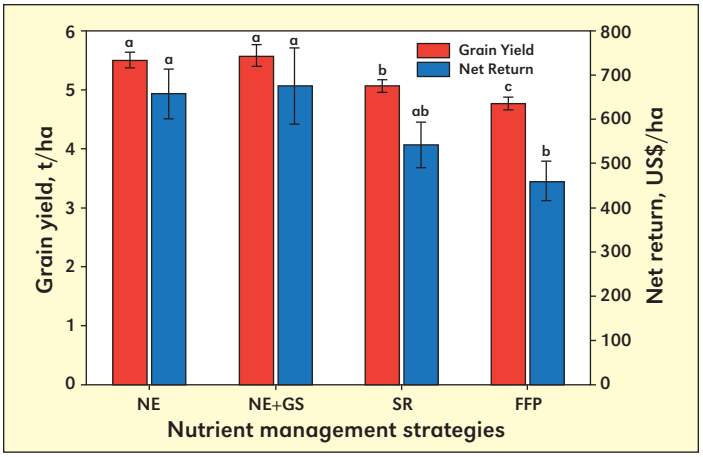


Figure 1. Wheat grain yield and net returns under no-tillage system as affected by different nutrient management strategies in Haryana. The data is the mean of two years from 15 farmers' fields (i.e., n=30). Means followed by different letters within same variable are significantly different based on LSD 0.05. Vertical bars show standard errors of the means. NE: Nutrient Expert®, NE+GS: Nutrient Expert® supplemented with GreenSeeker®, SR: State recommendation, and FFP: farmers' fertilizer practice.

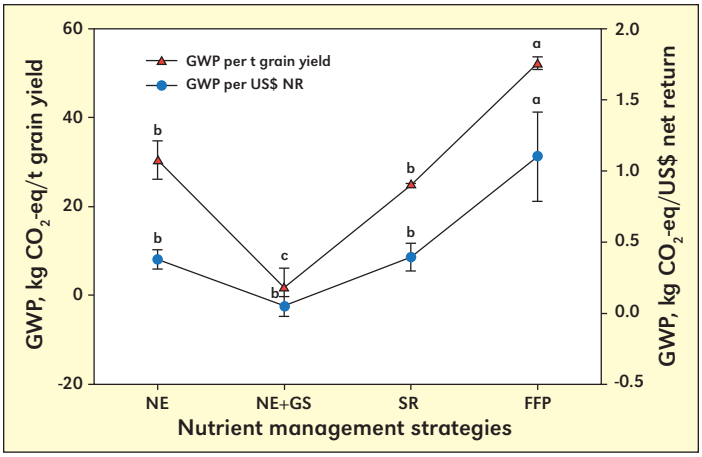


Figure 2. Total Global Warming Potential (GWP) per t grain yield and per US$ net return (NR) under different nutrient management strategies in no-till wheat production systems in Haryana. The data is the mean of two years from 15 farmers' fields (i.e., n=30). Means followed by different letters within same variable are significantly different based on LSD 0.05. Vertical bars show standard errors of the means. NE: Nutrient Expert®, NE+GS: Nutrient Expert® supplemented with GreenSeeker®, SR: State recommendation, and FFP: farmers' fertilizer practice.

Table 1. Cost of key inputs and outputs used for economic analysis during two wheat growing seasons.

Particulars	2010-11	2011-12
Minimum support price of wheat grain, ₹/kg	11.20	12.85
Market price of wheat straw, ₹/kg	2.50	2.50
Labor wage, ₹/person/day	150 to 200	200 to 250
Urea, ₹/kg	4.70	5.36
Diammonium phosphate, ₹/kg	10.00	18.20
Potassium chloride, ₹/kg	9.00 to 10.00	11.00 to 12.00
Zinc sulfate, ₹/kg	20.00	25.00
Seed, ₹/kg	16.25	18.00
Seed treatment, ₹/kg	1.25	1.25
Diesel cost, ₹/L	36.49	39.92
Electricity charge, ₹/kWh	0.30	0.30
Hiring cost of harrow/tiller, ₹/ha/pass	550 to 625	750 to 800
Planking cost, ₹/ha/pass	250 to 375	350 o 500
Land rent, ₹/ha/season	35,000	37,500
Interest on working capital, percent/year	12.00	12.00

US$1 = ₹64.

per t of wheat (**Figure 2**). A similar trend was observed for GWP per US$ of net return.

Broadcast application of relatively larger amounts of N fertilizer under FFP was mainly responsible for higher total GWP as compared to other nutrient management strategies. Further, lack of K fertilizer in FFP probably reduced recovery of other nutrients by wheat, thereby reducing yield. This ultimately resulted in higher GWP per unit of produce under FFP. Our estimates show that no-till wheat production under a NE-based recommendation supplemented with GS-guided N management can be carbon neutral both in terms of yield and net return. This effect can be attributed to better nutrient use efficiency from in-season precision N application (i.e., rate and number of split applications matching the physiological demand of wheat). This probably reduced residual nitrate-N in soil profile, thereby minimizing the N loss in the form of N_2O emissions.

Summary

Both grain yield and net return were higher with NE-based strategies compared to FFP and SR. The estimated total carbon footprint (i.e., GWP per t of wheat grain production and per US$ of net return) was also lower for NE-based strategies than other nutrient management strategies. Thus, the use of precision nutrient management tools such as Nutrient Expert® and GreenSeeker® are important for increasing wheat yields and farmer profits yet minimizing the environmental footprint of wheat production.

Acknowledgements

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References

Hillier, J., C. Walter, D. Malin, T. Garcia-Suarez, L. Mila-i-Canals, and P. Smith. 2011. Environ. Model. Softw. 26:1070-1078.

Pampolino, M.F., C. Witt, J.M. Pasuquin, A.M. Johnston, and M.J. Fisher. 2012. Computers and Electronics in Agric. 88:103-110.

Sapkota, T.B., K. Majumdar, M.L. Jat, A. Kumar, D.K. Bishnoi, A.J. McDonald, and M. Pampolino. 2014. Field Crops Res. 155:233-244.

Satyanarayana, T., K. Majumdar, M. Pampolino, A.M. Johnston, M.L. Jat, P. Kuchanur, D. Sreelatha, J.C. Sekhar, Y. Kumar, and R. Maheswaran. 2012. Better Crops-South Asia 6:18-21.

V. Govil, and S.K. Singh. 2014. Agron. J. 105:471-481.