Evaluation of Nutrient Expert™ for Wheat

By A. Kumar, K. Majumdar, M.L. Jat, M. Pampolino, B.R. Kamboj, D.K. Bishnoi, V. Kumar and A.M. Johnston

On-farm nutrient omission trials in Haryana under contrasting tillage and residue retention treatments showed that wheat yield varied across sites. Site-specific nutrient recommendations from Nutrient Expert, a recently developed wheat nutrient decision support tool, increased wheat yields and farmer profits over existing farmer fertiliser practices and generalised recommendations under both tillage scenarios.

Nutrient Expert (NE) for wheat is a recently developed (2010-11), easy-to-use, computer-based, interactive decision support tool that can rapidly provide nutrient recommendation for wheat grown in a farmer field, either in the presence or absence of soil testing data (Pampolino et al., 2012). This tool has been developed from extensive on-farm research data on wheat grown under variable soil and climatic conditions. Nutrient Expert for wheat estimates attainable yield for a farmer's field based on the growing conditions, determines the nutrient balance in the cropping system based on yield and fertiliser/manure applied to the previous crop and combines this information with expected N, P and K response in the concerned field to generate a site-specific nutrient recommendation for wheat. The major objectives of the present study were to: (1) assess the variability in soil nutrient supplying capacities in Haryana soils under CT and CA practices and (2) evaluate on-farm performance of NE for wheat.

Sixty-four (64) on-farm nutrient omission trials (47 under CA and 17 under CT) were set up in 2009-10 and 2010-11 by IPNI and the International Maize and Wheat Improvement Centre (CIMMYT) under the Cereal Systems Initiative for South Asia (CSISA) project. The trials covered variable wheat growing environments in Karnal, Kurukshetra, Kaithal, Ambala, Yamunanagar, Panipat, and Sonepat districts of Haryana. The study area falls under the northwestern plain agro-climatic zone. The annual precipitation ranges from 400 to 600 mm and soil textures range from sandy loam to silty clay loam. Wheat was planted using CT or CA practices under irrigated ecology. For CT, 2 to 3 harrowing, 1 to 2 cultivations, and 1 to 2 planking operations were done during field preparation and wheat was sown using a zero-till multi-crop planter (Jat et al., 2010). For CA, a Turbo Happy seeder (Sidhu et al., 2007) was used for seeding wheat in full rice residue while the zero-till multi-crop planter was used for partial residue retention (standing stubbles of rice residue). The following four treatments were assessed in the on-farm experiments: Ample NPK; Omission of N with full P and K; Omission of P with full N and K; and Omission of K with full N and P. Ample NPK rates for wheat were 150 to 180 kg N, 90 kg P_2O_5 and 100 kg K_2O per hectare for yield targets between 5 to 6 t/ha. Nutrients were applied in excess of the actual requirement of wheat crop, following the omission plot experiment protocol, to ensure no limitation of nutrients except the omitted one. Deficient secondary and micronutrients were applied to each plot as per the state recommended application rates.

Common abbreviations and notes: N = nitrogen; P = phosphorus; K = potassium; CT = conventional tillage; CA = no-till or conservation agriculture; FP = farmer (fertiliser) practice; SR = state (fertiliser) recommendation; CRI = crown root initiation; DAS = days after seeding; IPNI = International Plant Nutrition Institute.

An omission plot trial site in Haryana with differential residue retention. Mr. Anil Kumar on (left) and Dr. Pampolino (right).

Nutrient recommendations from the NE were also evaluated against existing nutrient management practices under CT and CA in 40 farmer participatory trials during winter 2010-11 and 2011-12. These NE trials had five treatments including: T_1: NE (80:20) – NE recommendation with N split as 80% basal and 20% at second irrigation (40 to 45 DAS); T_2: NE (33:33:33) – NE recommendation with N split as 33% basal, 33% at CRI stage (20 to 25 DAS) and 33% at second irrigation (40 to 45 DAS); T_3: SR (50:50) with N split as 50% basal and 50% at CRI stage; T_4: FFP; T5: NE 80 GS (GreenSeeker™) variable rate – 80% of the NE N recommendation applied basally and further application of N based on optical sensor-guided prescriptions at Feekes 7/8 based on the calibration curve of Bijay-Singh et al., 2011. The average NPK rates in the NE evaluation trial are given in **Table 1**.

Effect of Tillage on Spatial Variability in Wheat Yield and Nutrient Supplying Capacity

Average wheat yield in the ample NPK plot across all sites

Table 1. NPK rates used in different treatments in the Nutrient Expert evaluation trial.

Tillage Practice	Nutrient Expert (80:20)			Nutrient Expert (33:33:33)			State recommendation			Farmer's practice			Nutrient Expert (80: Greenseeker® variable rate)		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
No-till (CA)	156	53	82	156	53	82	150	60	60	170	58	1	150	51	76
Conventional tillage (CT)	156	53	86	156	53	86	150	60	60	170	58	1	151	53	83

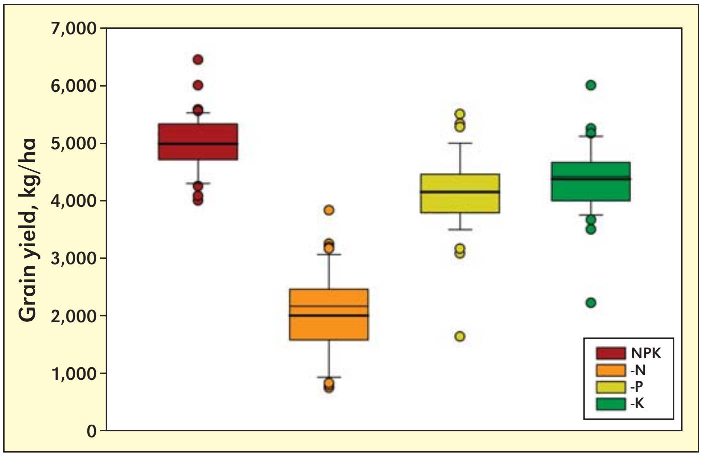

Figure 1. Wheat yield variability under no-till across sites. The error bars represent 10th to 90th percentile of the data, and the thick line represents the mean.

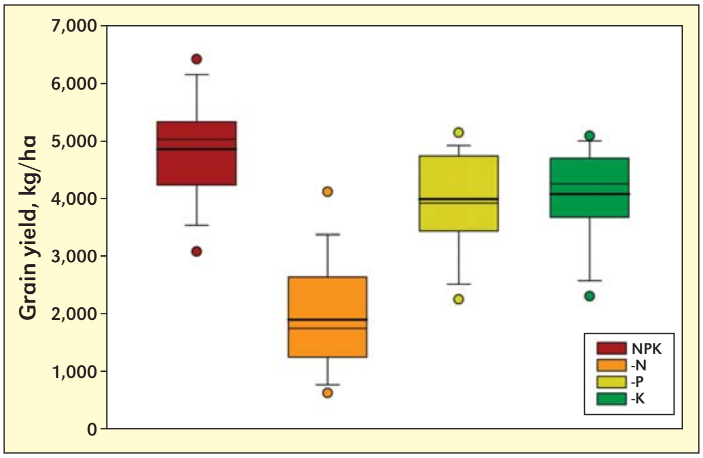

Figure 2. Wheat yield variability under conventional till across sites. The error bars represent 10th to 90th percentile of the data, and the thick line represents the mean.

under CA (n=47) was 4,992 kg/ha (**Figure 1**). Omission of N, P and K from the ample NPK caused variable yield loss, with an average yield loss of 60%, 17% and 13%, respectively. This data confirms that a large spatial variability exists in nutrient supplying capacities among farmer fields across sites due to historical differences in crop and fertiliser management. Average wheat grain yield in CT plots (n=17) was 4,885 kg/ha (**Figure 2**). Average yield losses in the CT wheat due to omissions of N, P and K were similar to no-till wheat. However, yield variability was much higher in CT wheat when compared with CA wheat. This was also evident through higher error estimation in the ample NPK, N omission, P omission, and K omission plot yields in the CT wheat (data not shown). Conventionally-tilled plots received a number (3 to 4 passes) of preparatory tillage operations before planting of wheat. The number of tillage operations, depth of tillage, and extent of residues incorporated during tillage may vary between farmers' fields and may compound the inherent variability due to historical management differences between CT fields. In contrast, spatial variability among farmers' fields under CA is influenced by historical management only.

Nitrogen, P or K responses in the contrasting tillage practices, estimated by subtracting the omission plot yields from

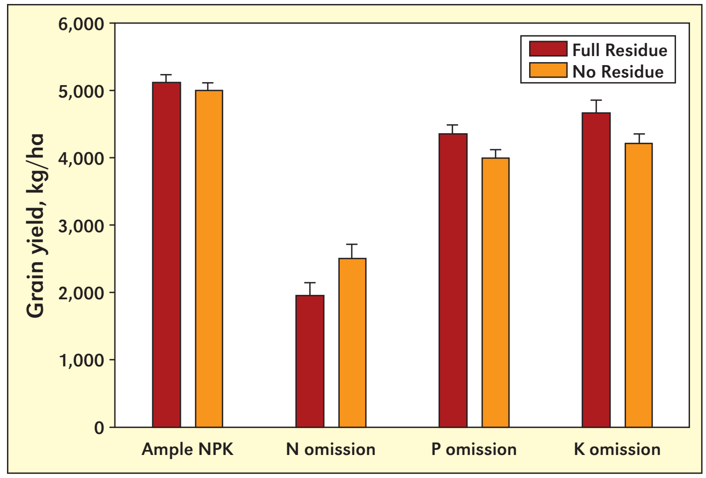

Figure 3. Effect of residue management on wheat grain yield under no-till. The bars represent the standard error.

the ample treatment yield, was not significantly different (data not shown). No-till wheat is planted in Haryana under various residue management scenarios, such as full retention of residues from the previous rice crop, partial retention of rice residue (anchored rice stubbles), and complete removal/burning of residues. The effect of differential residue management within CA on the yield of wheat was estimated (**Figure 3**). A comparison of yield in ample NPK, N omission, P omission, and K omission plots under full residue retention and complete removal of residues showed higher yields when the full residue of the previous rice crop was retained. The N omission plot yield was higher under complete removal of rice residue. Higher availability of nutrients from retained residues in the ample NPK and P or K omission plots probably increased yields, while greater immobilisation of N in the full residue retained plots caused yield decline in the N omission plots.

On-farm Performance of Nutrient Expert for Wheat

Validation of the NE decision support tool in wheat showed that the NE-based recommendation significantly improved wheat yield over FP and SR (**Table 2**). Farmers in intensive production systems of northwest India are using higher rates of N fertilisers with very little or no K. As K plays a key role in several physiological processes including stress tolerance and grain filling (1,000-grain weight) in wheat, imbalanced use of N and P, and omitting K results in poor grain filling

Table 2. Effects of nutrient management and tillage practices on wheat grain yield (kg/ha) [average of two years (2010-11 and 2011-12, n=29)].

	Tillage management systems	
Nutrient management	No-till (CA)	Conventional Till (CT)
Nutrient Expert (80:20)	5,174 b[1] A[2]	4,970 b A
Nutrient Expert (33:33:33)	5,521 a A	5,239 a B
State recommendation	5,093 b A	4,969 b A
Farmer's practice	4,766 c A	4,532 c B

[1]Within column, means followed by the same small letter are not significantly different at p = 0.05 using Tukey's HSD test; [2]Within rows, means followed by the same capital letter are not significantly different at p = 0.05 using Tukey's HSD test.

and lower yields. Application of the NE-recommended N rates in three equal splits performed better than applying 80% of the recommended N rate as a basal application. The NE tool, validated under both CA and CT, effectively captured the biophysical differences between the two tillage practices. The validation trial results also showed that wheat yield in farmers' plots (**Table 2**) across sites were higher under conservation tillage practices.

In another set of farmers' participatory field trials, the NE-based recommendations were supplemented with GreenSeeker™ optical sensor-based N prescriptions at Feekes 7/8 and then compared with SR and FP. The results of these trials (n=11) revealed that wheat yields with NE and NE+GS recommendations were at par but significantly higher than FP under both the scenarios (**Table 3**). No-till practices in wheat are now quite popular, particularly in northern India, and a nutrient management decision support tool that can handle contrasting scenarios of tillage will be more acceptable for use.

Economic assessment of the different fertiliser management options again showed the usefulness of NE-based fertiliser recommendations in improving farmer profits under both the tillage scenarios (**Table 4**). Among the NE-based treatments, N applied in three equal splits at critical wheat growth stages produced maximum profits due to higher yields in this treatment.

Conclusions

Better understanding of indigenous nutrient supplying capacity of soils under varying growing environments (tillage, residue management practices etc.) and utilising this information to guide nutrient management in wheat can improve yields and economics over existing practices. The Nutrient Expert decision tool can be an effective tool for farmers, industry agronomists and government extension personnel to provide field-specific nutrient recommendation to individual wheat farmers for improved yields and farm profits. BC-SA

Table 3. Effect of nutrient management and tillage practices on wheat grain yield (kg/ha) [average of two years (2010-11 and 2011-12, n=11)].

Nutrient management	Tillage management systems No-till (CA)	Conventional till (CT)
Nutrient Expert (80:20)	5,334 b[1] A[2]	5,089 b A
Nutrient Expert (33:33:33)	5,800 a A	5,323 ab B
State recommendation	5,240 b A	5,069 b A
Farmer's practice	4,815 c A	4,551 c A
Nutrient Expert (80: Greenseeker variable rate)	5,530 ab A	5,410 aA

[1]Within column, means followed by the same small letter are not significantly different at p = 0.05 using Tukey's HSD test; [2]Within rows, means followed by the same capital letter are not significantly different at p = 0.05 using Tukey's HSD test.

Mr. Kumar is Extension Agronomist at CSISA, Haryana; e-mail: akbana@rediffmail.com; Dr. Majumdar is Director, IPNI South Asia Program, Gurgaon, Haryana; Dr. Jat is Cropping System Agronomist at CIMMYT, New Delhi; Dr. Pampolino is Agronomist, IPNI South East Asia Program, Malaysia; Dr. Kamboj is Hub Manager, CSISA Haryana Hub at Karnal; Dr. Bishnoi is Research Scientist CSISA Haryana Hub at Karnal; Dr. Kumar is Senior Scientist at CIMMYT, CSISA Research Platform, Karnal, Haryana; Dr. Johnston is Vice President and IPNI Asia and Africa Group Coordinator, Saskatoon, Canada.

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Table 4. Economics of different fertiliser management options (n=29).

Treatment	Tillage[1]	Fertiliser (NPK) cost, Rs/ha (A)	Wheat yield, kg/ha (B)	Returns[2], Rs/ha (C)	Returns over fertiliser cost, Rs/ha (D = C-A)	Additional fertiliser cost over FP, Rs/ha (E)	Additional gain in returns over FP, Rs/ha (F)	Per unit gain over FP, (G = F/E)
Nutrient Expert (80:20)	CA	6,226	5,161	62,541	56,315	842	4,129	4.90
Nutrient Expert (33:33:33)	CA	6,226	5,507	66,774	60,548	842	8,361	9.93
State recommendation	CA	6,065	5,079	61,524	55,460	681	3,273	4.81
Farmer's practice	CA	5,384	4,754	57,570	52,187	0	0	0.00
Nutrient Expert (80:20)	CT	6,291	4,955	60,164	53,874	907	4,495	4.96
Nutrient Expert (33:33:33)	CT	6,291	5,223	63,426	57,135	907	7,757	8.55
State recommendation	CT	6,065	4,956	60,139	54,074	681	4,696	6.90
Farmer's practice	CT	5,384	4,519	54,762	49,378	0	0	0.00

[1]CA = conservational agriculture (no-till); CT = conventional tillage; [2]Cost of N = Rs. 22.5/kg (NE), Rs. 22.74/kg (SR), Rs. 21.02 (FFP); P_2O_5 = Rs. 30.66/kg; K_2O = Rs. 13.58/kg; Wheat price = Rs. 12.03/kg. Different N prices for different treatments were used because of the large difference in Urea and DAP prices and the cost of N for each treatment was dependant on how much of Urea or DAP was used in that particular treatment.