Nutrient Expert®–Wheat: A Tool for Increasing Crop Yields and Farm Profit

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The Nutrient Expert®–Wheat fertiliser decision support tool-based fertiliser recommendation was compared with existing fertiliser management practices in 109 on-farm sites in Punjab, Haryana and Bihar. The tool addressed the spatial and temporal variability in soil nutrient supply as well as the difference in tillage. The tool-based recommendation also improved yield and profitability over farmers' fertilisation practices and State recommended fertiliser rates for wheat.

Nutrient Expert®–Wheat (NE) is a nutrient decision support tool that helps wheat farmers to implement 4R Nutrient Stewardship at their farms. This is particularly useful for smallholder system of South Asia where precise nutrient management in small and marginal farms is a challenge, especially due to the infrastructural constraints for soil testing. NE provides wheat farmers a balanced nutrient recommendation based on the concept of site–specific nutrient management (SSNM). The on-farm application of SSNM entails using a set of nutrient management principles to supply crop nutrient requirements tailored to a specific field or growing environment (Pampolino et al., 2012). It aims to account for indigenous nutrient sources, including crop residues and manures; and apply fertiliser at optimal rates and at critical growth stages to meet the deficit between the nutrient needs of a high-yielding crop and the indigenous nutrient supply. SSNM integrates information from different scales to make field-specific decisions on N, P and K management. Originally based on laboratory analysis of plant nutrient uptake, the method was adapted to use yield responses measured in omission plots compared with NPK.

NE–Wheat for South Asia was developed in consultation with the International Maize and Wheat Improvement Center (CIMMYT), partners from the National Agricultural Research & Extension System, and representatives of stakeholder groups such as fertiliser industry, seed industry and NGOs. The development process of NE–Wheat included data acquisition from current and historical studies from major wheat growing States in India, development of algorithms and decision rules in consultation with partners and stakeholders, and finally validation of the tool across wheat growing regions of the country.

The NE validation trials compared NE–Wheat tool-based fertiliser recommendation with Farmer Fertiliser Practice (FFP) and State Recommendation (SR) in farmers' fields. The NE recommendation for an individual field was used in two treatments based on the splitting of N. NE1 considered N application at three equal splits (33% basal + 33% after 25 days + 33% after 45 days) and NE2 considered N application in two splitting (50% or 80% as basal and 50% or 20% after 45 days).

The on-farm validation trials (n=109) were conducted across major wheat-growing states of India that included Bihar, Haryana and Punjab in the year 2010-11 and 2011-12. The current study reports the data from 53 trials conducted in 2010-11 that included 10 in Bihar, 21 in Haryana, and 22 in Punjab, and 56 trials in 2011-12 in Bihar (n=11), Haryana (n=26), and Punjab (n=19). Among these 109 trials a total of 65 trials were conducted under conventional tillage (CT) and 44 trials (22 trials each year) were conducted under zero tillage (ZT).

Abbreviations and notes: N = nitrogen; P = phosphorus; K = potassium.

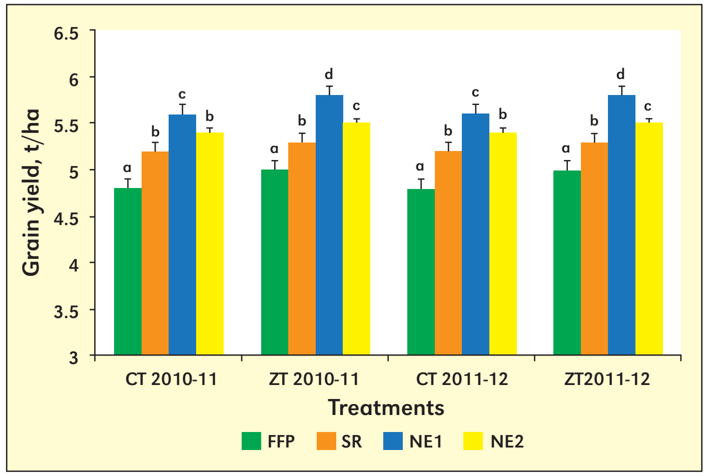

Figure 1. Grain yield of wheat across different nutrient management and tillage practices. Yield with different letters are significantly ($p \leq 0.01$) different.

The present study showed a significant ($p \leq 0.01$) increase in wheat yield through NE1 and NE2 nutrient management treatments over FFP and SR in all the seasons (**Figure 1**) and years. The yield of wheat was higher in ZT over CT across sites and years. In more than 13,500 on-farm trials conducted to evaluate different resource conservation technologies in rice and wheat in India, Nepal and Bangladesh during 2007–2008, reduced-till and zero-till drill-seeded wheat, zero till drill-seeded wheat with residue mulch, broadcast wheat in high-moisture soil without any tillage, and bed-planted drill-seeded wheat—performed better than the farmers' practice of conventional till broadcast wheat (IRRI, 2009).

Wheat yields were significantly ($p \leq 0.01$) higher in NE1 compared to NE2 under both CT and ZT suggesting that an extra split of N helped increase grain yield. Applying N in wheat through three splits (33:33:33) or by two splits (50:50) are common practices among farmers in India. Often the three-split option produces better yields as applications are better matched with high physiological demand stages of the crop (Singh et al., 2002). On the other hand, the two-split option helps save labour cost of applying an extra split, which can be substantial in relatively large fields. However, generally it is observed that two-splits works equally well as three-splits in heavy soils, while three-splits produce better yields in lighter soils (Singh et al., 2002). It is likely that the abrupt increase in wheat yields (**Figure 2**) in the NE1 treatment over all other

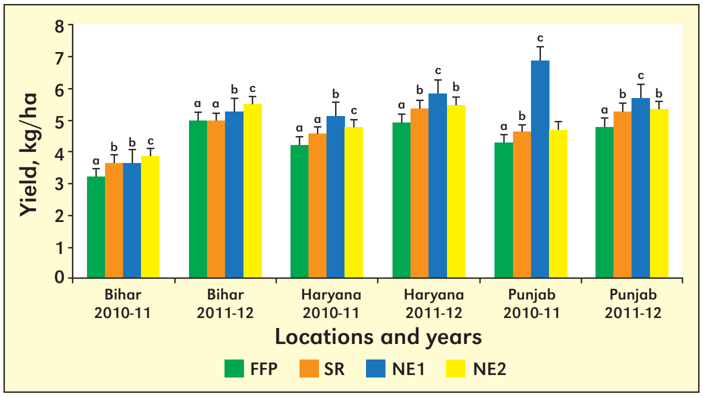

Figure 2. Grain yield of wheat across different nutrient management practices across different states. Yield with different letters are significantly ($p \leq 0.01$) different.

treatments might be due to the light texture of the soils where trials were set up.

While considering the performance of NE across different states, the present study also highlights that both NE1 and NE2 have significantly ($p \leq 0.05$) higher grain yield across the treatments in all the three study states (**Figure 2**). This suggests that nutrient recommendations from NE, generated through proper assessment of growing environment and target yields, were more suitable than generalised state recommendations or practices by farmers based on their perception. Better performance of the NE recommendations over the other practices across a large area in the Indo-Gangetic Plains (IGP) also establishes the efficacy of the tool.

We looked at the difference in nutrient application under different treatments in the three states over two seasons (**Table 1**). In the case of Bihar, N application rates did not differ among the treatments in 2010-11 but FFP rates were higher in 2011-12 than the other treatments. The P_2O_5 application rates were lowest in NE in 2010-11, while there was no significant difference among the treatments in 2011-12. The K_2O application rates were significantly higher with NE than FFP and SR in both the years. In general, nutrient application rates in FFP and NE were comparatively higher in 2011-12 and **Figure 2** shows that yield levels were higher that year than the previous wheat season.

The N application rates in Haryana in 2010-11 were the same for NE and FFP, which were both lower than SR. In 2011-12, however, the NE tool recommended less N than SR or FFP. For P_2O_5, application rates recommended by NE were lower than FFP and SR but the trend reversed in 2011-12 and NE recommended more P than SR and FFP. The K_2O recommendations by NE were higher than FFP and SR in both the years.

The NE tool recommended higher N, P_2O_5 and K_2O than FFP and SR in Punjab in 2010-11. The NE and SR recommended similar rates of N, which was lower than FFP, and P_2O_5 application rate remained the same for all the treatments in 2011-12. Potassium application rates were higher in NE. It is evident that NE recommendations were different in both the years and across states. This suggests that the tool-based recommendations are addressing the spatial, as well as temporal variability, reflecting the farm-to-farm changes in management.

Overall, the N application rates in the FFP treatment were significantly higher than the other treatments across tillage and years (**Figure 3**). The N doses in NE were at par with SR. The P_2O_5 application rates were significantly ($p \leq 0.05$) higher in NE as compared to FFP and SR under both the tillage practices and year (**Figure 4**). The K_2O applications were significantly ($p \leq 0.05$) increased in NE1 and NE2 over FFP and SR at both CT and ZT (**Figure 5**). Farmers in Punjab, Haryana and Bihar generally neglect K application in wheat. Potassium application in rice-wheat system, that is prevalent

Table 1. Fertiliser rates across three different states. Within states dose followed by different letters in superscript are significantly ($p \leq 0.05$) different.

Year	State	Treatments	N (Rates, kg/ha)	P_2O_5 (Rates, kg/ha)	K_2O (Rates, kg/ha)
2010-11	Bihar	FFP	124[a]	48[a]	34[a]
		SR	120[a]	60[b]	40[b]
		NE1	115[a]	41[c]	57[c]
		NE2	115[a]	41[c]	57[c]
	Haryana	FFP	166[a]	58[a]	0[a]
		SR	150[b]	60[b]	60[b]
		NE1	170[a]	43[c]	81[c]
		NE2	168[a]	45[c]	76[d]
	Punjab	FFP	144[a]	53[a]	3[a]
		SR	125[b]	62[b]	30[b]
		NE1	158[c]	71[c]	87[c]
		NE2	158[c]	71[c]	87[c]
2011-12	Bihar	FFP	142[a]	64[a]	33[a]
		SR	120[b]	60[a]	40[b]
		NE1	128[b]	64[a]	78[c]
		NE2	128[b]	64[a]	78[c]
	Haryana	FFP	174[a]	58[a]	2[a]
		SR	150[b]	60[b]	60[b]
		NE1	140[c]	63[c]	86[c]
		NE2	140[c]	63[c]	85[c]
	Punjab	FFP	142[a]	64[a]	33[a]
		SR	120[b]	60[a]	40[b]
		NE1	128[b]	64[a]	78[c]
		NE2	128[b]	64[a]	78[c]

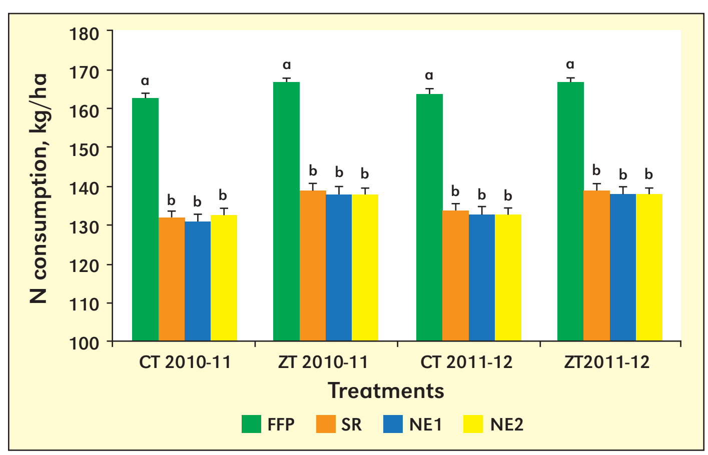

Figure 3. Fertiliser N rates across different treatments while considering all the locations. Rates with different letters are significantly ($p \leq 0.05$) different.

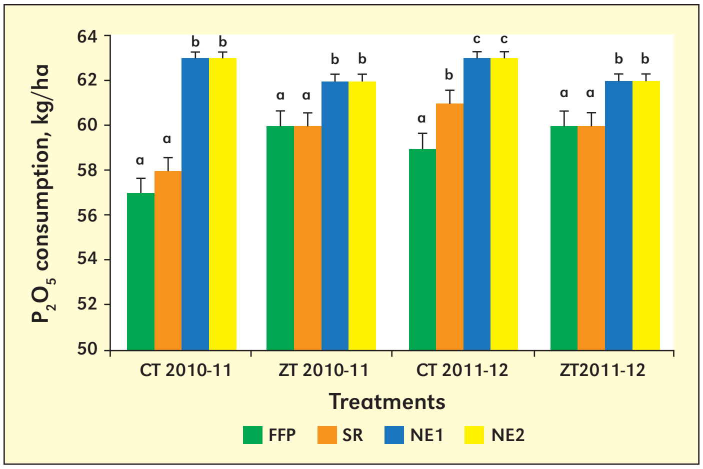

Figure 4. Fertiliser P_2O_5 rates across different treatments while considering all the locations. Rates with different letters are significantly ($p \leq 0.05$) different.

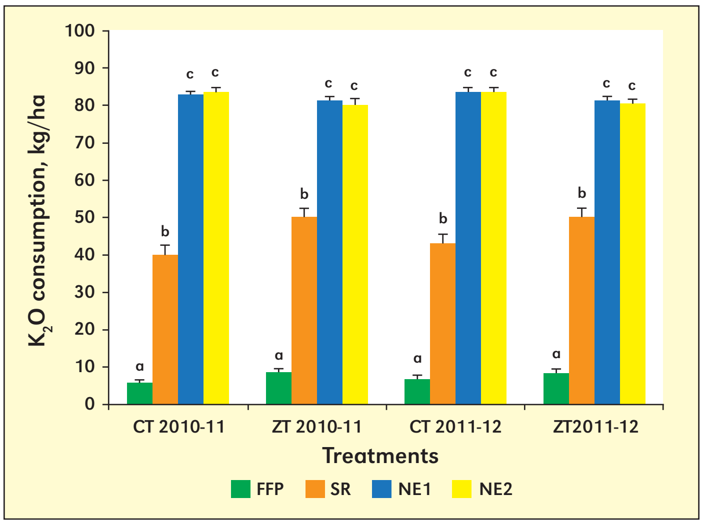

Figure 5. Fertiliser K_2O rates across different treatments while considering all the locations. Rates with different letters are significantly ($p \leq 0.05$) different.

in these three states, is far below the required amount. The NE tool, while assessing the cropping system nutrient balance identified a large deficit in K application and recommended high rates to reduce the negative (input-output) K balance in the fields.

Economics

The benefit:cost (B:C) ratios of the treatments were estimated using the cost of inputs and value of the output. The results were represented considering the B:C ratio of the FFP treatment as a unit (**Figure 6**). Both the NE treatments and the SR increased the economic benefit over FFP.

Results showed that the B:C ratio of NE1 were higher than

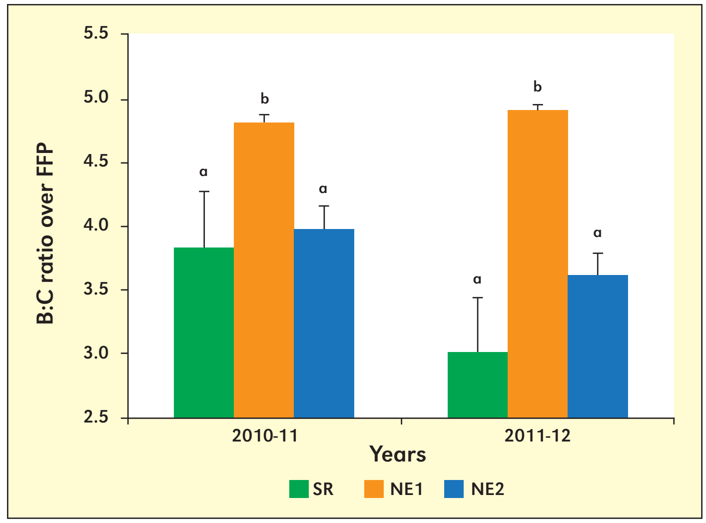

Figure 6. Benefit:Cost ratio over FFP. Ratio with different letters is significantly ($p \leq 0.05$) different. Cost of N: ₹12/kg (on the basis of Urea); Cost of P_2O_5: ₹45/kg (on the basis of single superphosphate); Cost of K_2O: ₹27/kg (on the basis of potassium chloride); Value of maize grain: ₹11/kg.

that of SR and NE2 in both 2010-11 and 2011-12 cropping years (**Figure 6**). A combination of appropriate rate estimation and better splitting of the nitrogen improved yield in the NE1 treatment over the other practices.

Summary

NE–Wheat validation trials in the year 2010–11 and 2011–12, across three different states of the Indo-Gangetic plains, showed that the NE tool-based fertiliser recommendation increased wheat yield and economic benefit for farmers. Large-scale implementation of the tool provides the opportunity to bridge nutrient-related yield gaps in wheat and increase farm profitability in an environmentally sustainable manner. BC-SA

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