On-farm Evaluation of Real-time Nitrogen Management in Rice

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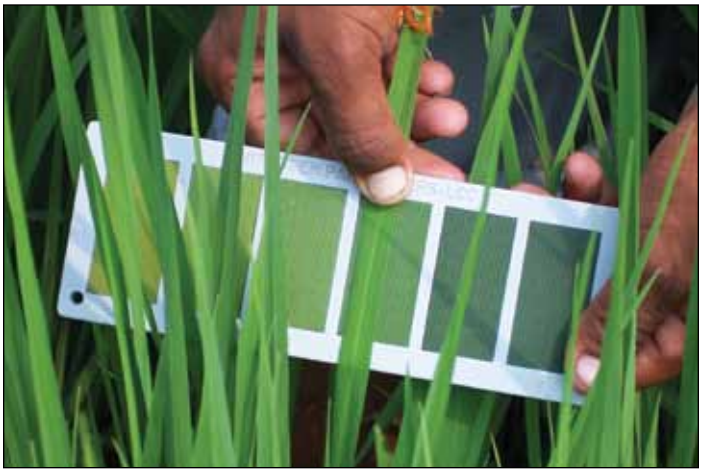
On-farm trials were carried out to evaluate real-time and fixed-date variable rate strategies of need-based N management in rice using a leaf color chart (LCC) in relation to blanket recommendations for the State and farmer practice. The strategy of fixed-date variable rate N management produced yields similar to those obtained with the real-time N management or blanket recommendation strategies, although significant differences in N use efficiency were obtained.

Current fertilizer N recommendations in India typically consist of fixed rate and timings for large rice growing tracts. These "blanket" recommendations have served their purpose in producing good yields, but they are limited in their capacity to increase nutrient use efficiency. And many times, to ensure high yields, farmers apply fertilizer N rates even higher than the blanket recommendation. Over-application of N in cereal crops leads to further lowering of N fertilizer recovery efficiency. The blanket recommendations are also not responsive to temporal variations in crop N demand.

Use of N in excess of crop requirement and inefficient splitting of N applications are the main reasons for low N use efficiency in rice. Since improving the synchrony between crop N demand and the N supply from soil and/or the applied N fertilizer is likely to be the most promising strategy to increase N use efficiency, the split application of fertilizer N is going to remain an essential component of fertilizer N management strategies in rice. Real-time corrective N management is based on periodic assessment of plant N status, and the application of fertilizer N is delayed until N deficiency symptoms start to appear. Thus, a key ingredient for real-time N management is a method of rapid assessment of leaf N content that is closely related to photosynthetic rate and biomass production and is a sensitive indicator of changes in crop N demand within the growing season.

As rice leaf color is a good indicator of leaf N content, the LCC, developed through collaboration of the International Rice Research Institute (IRRI) with agricultural research systems of several countries in Asia, serves as a visual and subjective indicator of plant N deficiency. With its 4- or 6-color panels of different shades of green, the LCC is used as a reference tool and is becoming popular as an inexpensive and easy-to-use tool for estimating leaf N content and managing fertilizer N in rice.

LCC-based, real-time N management can be practiced in rice by monitoring leaf color at 7- to 10-day intervals during the growing season. Fertilizer N is applied whenever the leaves are less greenish than a threshold LCC value, which corresponds to a critical leaf N content (Bijay-Singh et al., 2002, Varinderpal-Singh et al., 2007, Yadvinder-Singh et al., 2007). Many times, farmers prefer less frequent monitoring of leaf color as they are strongly accustomed to applying fertilizer N at growth stages as per the blanket recommendation. An alternative fixed-time option involves application of moderate rates of N at transplanting, and at 21 days after transplanting (DAT), coupled with monitoring of leaf color only at panicle initiation around 42 DAT and applying fertilizer N as guided by the leaf color ... all critical growth stages requiring a sufficient supply of N. Applications of fertilizer N can be adjusted upward or downward based on leaf color, which reflects the crop's relative need for N. We conducted on-farm trials during two rice seasons to evaluate both approaches relative to the blanket recommendation and farmer practice of applying fertilizer N to rice.



This is an example of the 6-color LCC used in gauging rice leaf color.

On-farm field trials were carried out in different districts in Punjab, India, during the 2008 and 2009 rice seasons. A 6-panel LCC manufactured by Nitrogen Parameters, Chennai, India, was used for evaluating N status of rice leaves as defined by their greenness. At each site, fields varying from 1,000 to 2,000 m^2 in size were divided into four plots in which fertilizer N was applied as per the following strategies:

1. Farmer fertilizer practice
2. Blanket fertilizer recommendation: 120 kg N/ha in three equal split rates at transplanting and 21 and 42 DAT
3. Real-time N using LCC: A basal dose of 30 kg N/ha + 30 kg N/ha whenever color of the first fully opened leaf from the top was less than shade 4 of the 6-color panel LCC; starting 15 DAT up to initiation of flowering
4. Fixed-date variable rate N management: 30 kg N/ha basal + 40 kg N/ha at 21 DAT + 30 or 45 kg N/ha at 42 DAT depending upon leaf color being > or < than shade 4 of the 6- color panel LCC

The amount of fertilizer N applied at different dates within the four treatments was recorded.

In 2008, 30-to-35 day old rice seedlings were transplanted at different field locations during June 25 to July 1. In 2009,

Abbreviations: N = nitrogen.

Table 1. Evaluating real time N management and fixed time variable dose N management strategies using leaf color chart vis-à-vis farmer fertilizer practice and blanket recommendation in rice at on-farm locations in Punjab, India, during 2008 and 2009.

	Farmer fertilizer practice		Blanket fertilizer recommendation[1]		Real-time N management using LCC[2]		FDVR[3] (N_{30} + N_{40}+ $N_{30/45}$)	
Village /district	Fertilizer N applied, kg/ha	Grain yield, t/ha	Fertilizer N applied, kg/ha	Grain yield, t/ha	Fertilizer N applied, kg/ha	Grain yield, t/ha	Fertilizer N applied, kg/ha	Grain yield, t/ha
2008 rice season								
Mrar Kalan, Muktsar	133	7.38	120	7.50	90	7.20	115	7.55
Pakhi Kalan, Faridkot	153	8.80	120	8.40	90	8.48	115	8.55
Hakumat Singh Wala, Ferozepur	150	8.40	120	8.30	120	8.53	115	8.33
Chuhana, Gurdaspur	146	6.05	120	5.98	90	5.88	115	6.00
Kala Manjh, Hoshiarpur	150	7.13	120	7.00	120	6.83	115	7.00
2009 rice season								
Tehna 1, Faridkot	180	7.40	120	6.80	90	6.90	115	6.95
Tehna 2, Faridkot	169	6.80	120	7.00	90	6.80	115	6.80
Pakka 1, Faridkot	135	8.00	120	7.60	60	7.20	100	7.40
Pakka 2, Faridkot	127	6.00	120	7.20	90	7.00	115	7.00
Wara Draka, Faridkot	115	8.00	120	9.00	90	8.80	115	9.00
Dusanjh, Moga	180	7.35	120	8.00	60	7.80	100	8.05
Bhaloor, Moga	180	6.80	120	6.40	90	6.30	115	6.30
Samalsar, Moga	160	7.80	120	7.20	90	7.28	100	7.15
Wara Bhai Ka 1, Ferozepur	116	7.20	120	7.28	60	7.15	100	7.20
Wara Bhai Ka 2, Ferozepur	140	6.00	120	6.00	90	5.85	115	5.95

[1]120 kg N/ha in three equal split rates at transplanting and 21 and 42 DAT.
[2]Basal rates of 30 kg N/ha + 30 kg N/ha whenever color of the first fully opened leaf from the top was less shade 4 of the LCC; starting 15 DAT up to initiation of flowering.
[3]Fixed-date variable rate N management: 30 kg N/ha basal + 40 kg N/ha at 21 DAT + 30 or 45 kg N/ha at 42 DAT depending upon leaf color to be ≥ or < than LCC shade 4.

transplanting dates were between June 17 and July 15. The experimental soils had pH values (soil: water 1: 2) ranging from 7.7 to 8.7, organic carbon ranging from 0.22 to 0.56%, and texture ranging from sandy loam to clay loam. The names of villages and districts where different trials were established are listed in **Table 1**. The experiments were harvested from October 3 to October 30 in 2008 and from October 10 to November 01 in 2009. An area ranging from 40 to 60 m^2 in the centre of each treatment plot was used to estimate grain yield (14 % moisture) at harvest.

Results

Compared to the blanket fertilizer N recommendation of 120 kg N/ha, the 15 farmers following their own practice applied 115 to 180 kg N/ha to rice **(Table 1)**. Except for two farmers who applied 115 and 116 kg N/ha, all others applied substantially higher amounts of fertilizer N to rice. While in the fixed-date variable rate treatment one could apply either 100 or 115 kg N/ha, fertilizer N rates in the leaf color-based, real-time fertilizer N management treatment varied from 60 to 120 kg N/ha.

Grain yields recorded were similar across four strategies at all locations, thus revealing that higher amounts of N application as per farmer fertilizer practice compared to the three other strategies (i.e., blanket, real time, and fixed-date variable rate) were not advantageous. The grain yields recorded in the LCC-based real-time N management and fixed-date variable rate strategies were similar to those obtained with the blanket rate of 120 kg N/ha at all 15 locations. These results from the real-time N management strategy were obtained by applying 60 to 120 kg N. This large variation in N application rates suggests that the strategy can guide N application to rice as per need of the crop while not adversely affecting yield.

Partial factor productivity (PFP_N), a measure of N use efficiency defined as yield of harvested portion divided by amount of N fertilizer applied (Snyder and Bruulsema, 2007) is plotted as an average for each treatment across sites in **Figure 1**. Real-time N management performed the best, while the fixed-date variable N rate application appears to hold promise despite needing further refinement. These results are in-line with those reported by Varinderpal-Singh et al. (2007) and Yadvinder-Singh et al. (2007) from other on-farm locations in Punjab. Although yield levels obtained by following the

Blanket N recommendations cannot achieve the N use efficiency of real-time split applications based on monitoring.

The LCC is gaining in popularity as an inexpensive tool for estimating leaf N content and managing fertilizer N in rice.

fixed-date variable rate strategy were similar to those recorded for real-time N management, the former allowed application of either 100 or 115 kg N/ha compared to the 60 to 120 kg N/ha range in the latter. This suggests that fixed-date variable N application, as was designed in this study, needs to be modified to allow for N application across a wider seasonal range. It is proposed here that this can be done either by introducing the element of variable rate N application at the 21 DAT stage or by including another date for fertilizer application as per leaf color just before flowering (around 60 days).

Conclusions

In summary, farmers had a general tendency towards applying up to 60 kg N/ha more fertilizer N than the blanket recommendation of 120 kg N/ha without capturing a yield benefit. Real-time N management based on applying fertilizer N whenever leaf color was less than critical greenness resulted in application of 60 to 120 kg N/ha with rice yields being equivalent to those obtained with the blanket recommendation. Following the strategy of fixed-date variable rate N management, either 100 or 115 kg N/ha was applied, and yields were equal to those produced by real-time N management or the blanket recommendation. For easy adoption by farmers, the fixed-date variable rate strategy needs to be modified to allow the application of N across a wider seasonal range. BC

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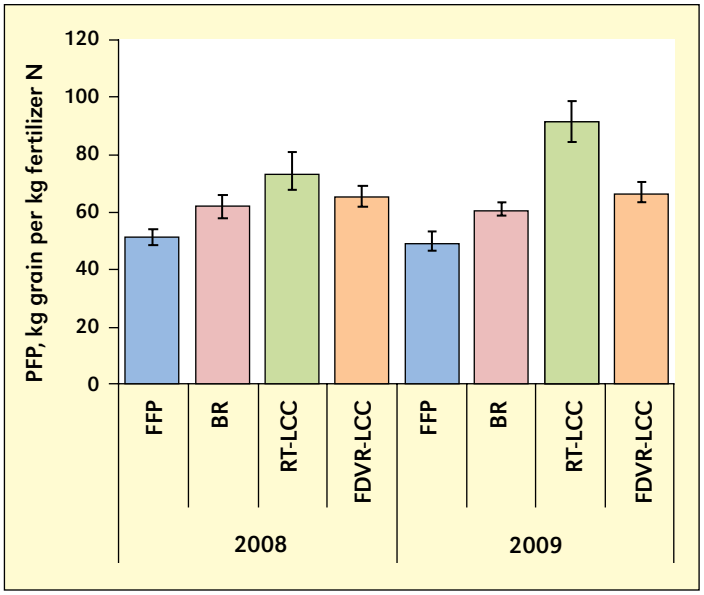

Figure 1. Partial factor productivity (PFP_N) of different N management strategies in rice averaged over 5 and 10 on-farm experiments in 2008 and 2009, respectively. [FFP = Farmer fertilizer practice; BR = Blanket recommendation; RT-LCC = Real time N management using leaf color chart; and FDVR-LCC = Fixed-date variable rate N management using LCC].

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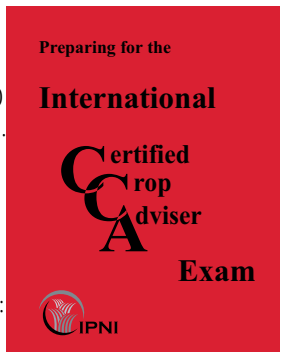

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