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**Research Communication**

# Efficient nitrogen management in wheat (*Triticum aestivum*) using leaf-colour chart and chlorophyll meter for optimizing growth, yield and nitrogen-use efficiency

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## ABSTRACT

A field experiment was conducted at Pantnagar, Uttarkahand, during the winter (*rabi*) season of 2014–15, to study the effect of modern tools such as leaf colour chart (LCC) and chlorophyll meter (SPAD meter) on growth, yield and nitrogen-use efficiency in wheat [*Triticum aestivum* (L.) emend. Fiori & Paol.] crop. Application of N as 25 kg as basal + 40 kg (at LCC 4,5 and SPAD 35, 40) and 25 kg as basal + 40 kg at crown-root initiation + 40 kg at SPAD 40 (total 105 kg N/ha) resulted statistically similar growth and yield attributes, viz. shoot density, dry-matter accumulation, leaf-area index, number of spikes/m$^2$, number of grains/spike, 1,000-grain weight, grain yield and higher values of agronomic efficiency, recovery efficiency than recommended nitrogen management with the saving of 30% or 45 kg N/ha. Although result was at par in case of both, threshold value of LCC and SPAD, application of 40 kg N/ha at LCC 5 and SPAD 40 was found to be more effective than LCC 4 and SPAD 35. Higher returns of ₹3,292 were obtained in the recommended practice compared to next best treatment, i.e. application of 25 kg N as basal + 40 kg at SPAD 40. Therefore LCC and SPAD can be effective tool for efficient fertilizer N management in wheat.

***Key words*** **:** Leaf-colour chart (LCC), Recovery efficiency, Soil plant analysis development (SPAD), Total nitrogen uptake, Wheat

Nitrogen is essential, primary nutrient and important limiting factor determining the yield of wheat and together with rice; these 2 crops consume huge amount of nitrogenous fertilizers. However, nitrogen-use efficiency in rice and wheat is low. A world-wide evaluation shows that the fertilizer N recovery efficiency is around 30% in wheat with current practices (Krupnik *et al.*, 2004). The major reason of low N-use efficiency is fixed-time splitting of N applications advocated in current recommendation or N application is not synchronized with crop demand, as well as the use of nitrogen in excess to the requirement.

A potential solution has been tried to regulate the timing of nitrogen application in rice and wheat using a chlorophyll meter (SPAD meter) or a LCC to determine the N needs of plant (Singh *et al*., 2002). The concept is based on the result that show close link between leaf chlorophyll and nitrogen content. Maiti and Das (2006) reported that SPAD and LCC can save up to 50 and 60 kg N/ha, respectively, without yield decrement in wheat over the fixed-timing N treatment where 150 kg N/ha was applied in 3 splits.

As the information on use of LCC and SPAD for real-time nitrogen management in wheat is meager, a field experiment on silty clay-loam soil (234, 24 and 187 kg in available NPK respectively) was conducted in randomized block design (RBD) at Pantnagar, Uttarakhand, during the winter (*rabi*) season of 2014–15. Treatment consisted of different nitrogen-management practices including control (no N), recommended N (50 kg as basal + 50 kg at crown-root initiation + 50 kg at maximum tillering), 25 kg as basal + 30 kg (at LCC 4, 5 and SPAD 35, 40), 25 kg as basal + 40 kg (at LCC 4,5 and SPAD 35, 40), 25 kg as basal + 30 kg at CRI + 30 kg at SPAD 40 and 25 kg as basal + 40 kg at CRI + 40 kg at SPAD 40. Wheat crop (var. 'HD 2967') was sown on 14 November, 2014 using seed rate of 100 kg/ha and spacing of 20 cm. A basal dose

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of 60 kg $P_2O_5$/ha and 40 kg $K_2O$/ha using diammonium phosphate and muriate of potash was applied in all the treatments except in the control where single superphosphate was applied as a source of phosphorus. For nitrogen, diammonium phosphate and urea were used as a source of nitrogen in all the treatments and applied according to treatments. The SPAD meter and LCC were used for measurements of 10 topmost fully expanded leaves at 7 days interval at a specified time and averaged for each plot. All the data for wheat were statistically analyzed with the help of statistical programme-STPR-3 of Department of Mathematics, Statistics and Computer Science, Pantnagar.

All the growth parameters like shoot density, dry matter, leaf-area index (LAI) at 60 and 90 days after sowing (DAS) were the highest (Table 1) in recommended nitrogen (150 kg N/ha) management; however, they were at par with nitrogen management including application of N as 25 kg as basal + 40 kg (at LCC 4, 5 and SPAD 35, 40) and 25 kg as basal + 40 kg at CRI + 40 kg at SPAD 40 (total 105 kg N/ha). This might be because of nitrogen application based on LCC and SPAD was done as per the crop need rather than at fixed time. This caused favourable effect of N on cell-division and tissue organization that ultimately improved tiller formation and dry-matter accumulation. Our result confirms the findings of Huang *et al*. (2008). The similarity in leaf-area index (LAI) in recommended and need-based nitrogen application through LCC and SPAD with 45 kg (30%) lower dose than recommended was due to close match of photosynthetic rate and total biomass production and accordingly utilized nitrogen more efficiently to increased vegetative growth. However, 25 kg as basal + 30 kg (at LCC 4,5 and SPAD 35, 40) and 25 kg as basal + 30 kg at CRI + 30 kg at SPAD 40 (total 85 kg/ha) was significantly lower than treatments where a total of 105 kg N was applied based on LCC and SPAD and recommended practice. This might be due to lesser than required nitrogen uptake (Table 1) for better growth, photosynthetic rate and ultimately LAI owing to lower total nitrogen application in above treatments. Kumar *et al*. (2013) also reported similar finding. Treatment comprised application of N as 25 kg as basal + 40 kg at CRI + 40 kg at SPAD 40 was statistically similar to N as 25 kg as basal + 40 kg (at LCC 4, 5 and SPAD 35, 40) and recommended N management indicated that crop requires 40 kg N/ha at CRI stage under current season and situation and that can be applied as prescriptive dose without looking into the SPAD or LCC values for nitrogen application. However, this might change with time and cropping system followed.

It was also observed that numerically higher value of chlorophyll content and SPAD was found in treatments where N was applied as 25 kg as basal + 40 kg (at LCC 4,

**Table 1.** Effect of nitrogen management using leaf-colour chart and chlorophyll meter on growth, yield attributes, grain yield, N uptake, recovery efficiency and net returns in wheat

| Treatment | Total dose of N (kg/ha) | Shoots/m² | | Dry matter (g/m²) | | LAI | | Chlorophyll content (mg/g) | | Spikes/m² | Grains/ spike | 1,000-grain weight (g) | Grain yield (t/ha) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 60 DAS | 90 DAS | 60 DAS | 90 DAS | 60 DAS | 90 DAS | 60 DAS | 90 DAS | | | | |
| Control (no N) | 0 | 190 | 178 | 38 | 238 | 2.43 | 1.60 | 1.3 | 1.3 | 126 | 30.6 | 28.6 | 1.29 |
| Recommended N | 150 | 428 | 413 | 182 | 700 | 4.08 | 2.90 | 1.7 | 1.7 | 358 | 49.2 | 46.4 | 4.33 |
| *30 kg N at LCC 4 | 85 | 322 | 302 | 116 | 578 | 3.42 | 2.39 | 1.5 | 1.5 | 239 | 35.3 | 35.6 | 2.63 |
| *40 kg N at LCC 4 | 105 | 413 | 395 | 160 | 660 | 3.92 | 2.52 | 1.8 | 1.8 | 342 | 47.2 | 44.0 | 3.80 |
| *30 kg N at LCC 5 | 85 | 350 | 330 | 120 | 581 | 3.54 | 2.46 | 1.5 | 1.5 | 270 | 36.3 | 36.0 | 2.73 |
| *40 kg N at LCC 5 | 105 | 418 | 402 | 163 | 673 | 4.02 | 2.59 | 1.8 | 1.8 | 344 | 47.8 | 44.0 | 4.06 |
| *30 kg N at SPAD 40 | 85 | 355 | 335 | 122 | 590 | 3.48 | 2.44 | 1.5 | 1.5 | 274 | 37.5 | 38.3 | 2.78 |
| *40 kg N at SPAD 40 | 105 | 432 | 410 | 168 | 676 | 4.03 | 2.74 | 1.8 | 1.8 | 349 | 48.3 | 44.3 | 4.11 |
| *30 kg N at SPAD 35 | 85 | 341 | 321 | 118 | 565 | 3.12 | 2.43 | 1.5 | 1.5 | 266 | 35.3 | 35.6 | 2.66 |
| *40 kg N at SPAD 35 | 105 | 417 | 398 | 162 | 664 | 4.00 | 2.60 | 1.8 | 1.8 | 342 | 47.6 | 43.4 | 3.93 |
| *30 Kg N at CRI+30 kg at SPAD 40 | 85 | 360 | 335 | 124 | 585 | 3.59 | 2.43 | 1.5 | 1.5 | 273 | 37.3 | 36.0 | 2.74 |
| *40 Kg N at CRI + 40 kg at SPAD 40 | 105 | 419 | 402 | 169 | 674 | 4.02 | 2.73 | 1.8 | 1.8 | 346 | 47.8 | 44.2 | 4.06 |
| SEm± | | 11.0 | 11.4 | 11.0 | 22.2 | 0.28 | 0.20 | 0.08 | 0.08 | 9.43 | 2.31 | 2.82 | 0.19 |
| CD (P=0.05) | | 32.4 | 33.6 | 32.2 | 65.3 | 0.84 | 0.61 | 0.24 | 0.24 | 27.68 | 6.78 | 8.28 | 0.57 |

*25 kg N/ha was applied as basal, recommended N 150 kg N/ha in 3 equal splits, i.e. 50 kg/ha as basal, 50 kg/ha at crown-root initiation (CRI) stage and 50 kg/ha at maximum tillering stage

5 and SPAD 35, 40) and 25 kg as basal + 40 kg at CRI + 40 kg at SPAD 40 (total 105 kg N/ha) but did not differ significantly from recommended nitrogen (150 kg N/ha) management. This might be due to the fact that nitrogen content of plant tissue was maintained at higher level which reflected the high chlorophyll content and SPAD meter reading.

The highest values of yield-contributing characters like number of spikes/m$^2$, number of grains/spike and 1,000-grain weights were recorded in recommended nitrogen management which was at par with treatments having a total application rate of 105 kg N. This trend was similar to what observed earlier in shoot/m$^2$, dry matter, and LAI and might be owing to synchronization of nitrogen supply with demand of crop leads to statistically similar growth and biomass production. Higher photosynthetic rate reflected in better reproductive growth too. No-N control treatment recorded significantly less yield attributes due to reduced dry-matter accumulation and later on the poor grain-filling too. No supply of nitrogen in the control treatment resulted in to reduced dry-matter accumulation, leaf area to intercept solar radiation and absorb $CO_2$ which ultimately led to reduced photosynthetic efficiency and thus significantly less values of yield attributes (Noureldin *et al.,* 2013). Finally, need-based use of fertilizer N using LCC and SPAD resulted in statistically similar grain yield (Table 1) with that of recommended N. Singh *et al*. (2014) also reported similar finding.

Though total nitrogen uptake was the maximum in recommended management practice, it was at par with treatments which included application of N as 25 kg at basal + 40 kg (at LCC 4, 5 and SPAD 35, 40) and 25 kg as basal + 40 kg at CRI + 40 kg at SPAD 40 (total 105 kg N/ha). The total N uptake in SPAD and LCC-based N plot was slightly lower compared to the highest level of fixed-timing N plot, which might be attributed to less N application through the use of SPAD and LCC which also preserved N without any yield reduction. Recovery efficiency was influenced by different nitrogen management treatments (Fig. 1). It was found that treatments of application of N as 25 kg as basal + 40 kg (at LCC 4, 5 and SPAD35, 40), 25 kg as basal + 40 kg at CRI + 40 kg at SPAD 40 (total 105 kg N/ha) resulted in higher numerical value of recovery efficiency than recommended nitrogen management

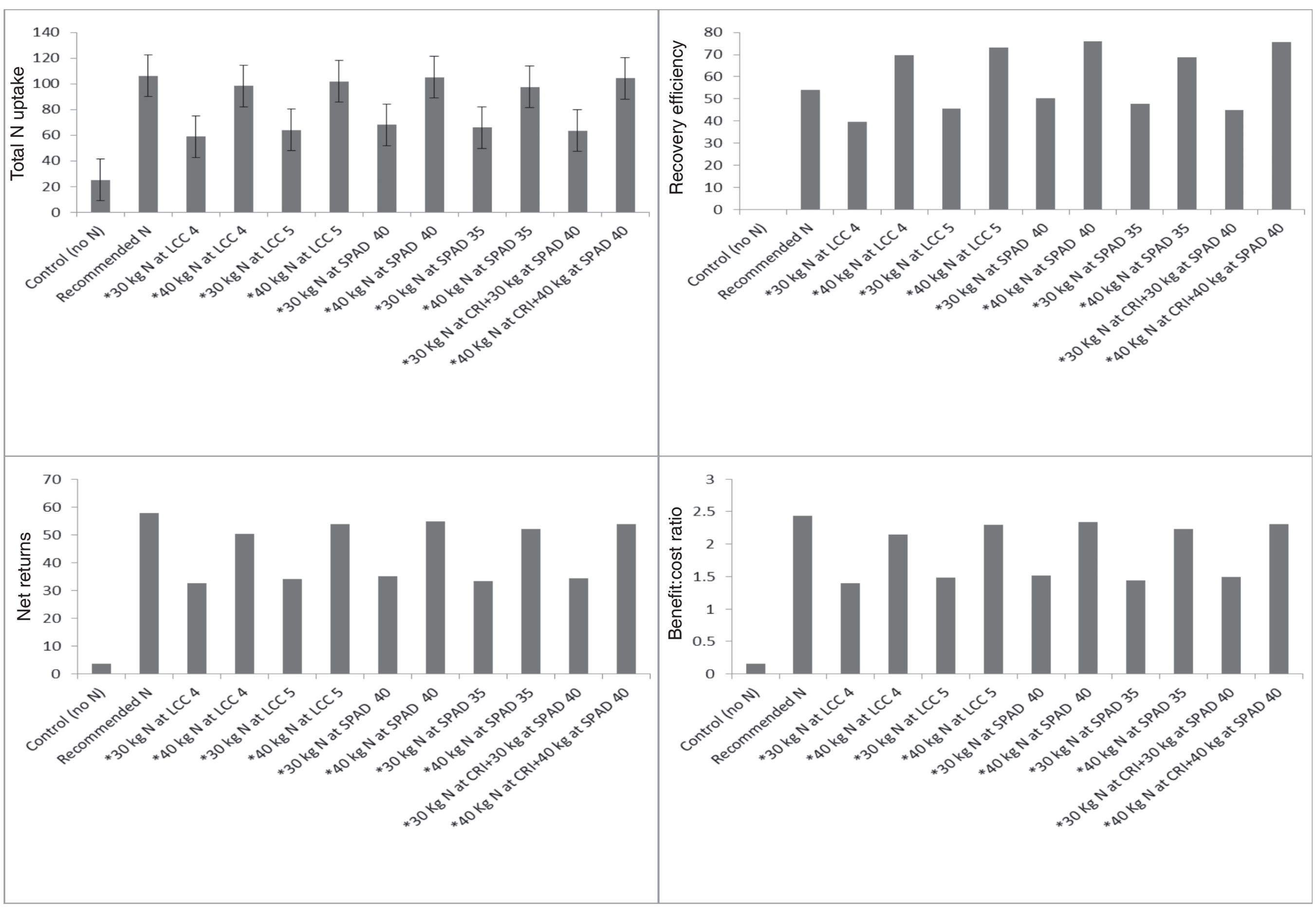


**Fig. 1.** Total N uptake (kg/ha), recovery efficiency (%), net returns (× 10$^3$₹) and benefit: cost ratio as influenced by different treatments. Error bar show CD (P=0.05) values

treatment and treatments included application of N as 25 kg as basal + 30 kg (at LCC 4, 5 and SPAD 35, 40) and 25 kg as basal + 30 kg at CRI + 30 kg at SPAD 40 (total 85 kg/ha) respectively. Net returns and benefit: cost ratio were found the highest in the recommended nitrogen management, followed by treatment included N 25 kg as basal + 40 kg at SPAD 40 (105 kg/ha).

On the basis of this 1-year study it is concluded that 25 kg N as basal + 40 kg N at SPAD 40 (105 kg/ha) resulted in at par grain yield and higher agronomic efficiency and recovery efficiency compared to recommended N (150 kg N/ha), although higher net returns and benefit: cost ratio were obtained in the recommended N practice. There could be substantial fertilizer saving with use of real time N management.

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