Leaf Color Chart for Real-Time N Management in Rice

Nitrogen (N) is the most important nutrient for rice but it is the most limiting element in almost all soils. Optimal N supply matching with the actual crop demand is thus vital for improving crop growth and maximizing production. Among the various strategies available for N management, leaf colour chart (LCC) for real-time N management in rice is a simple, easy and inexpensive option.

Major Management Strategies

Two major strategies followed in N management are:

- Blanket-fertilizer N recommendations
- Crop-need-based N management

Blanket-Fertilizer N Recommendations

Blanket-fertilizer N recommendations generally take into account crop response to applied N as basis to calculate the amount of N required to achieve a targeted yield. These recommendations do not consider variability in soil N supply and changes in crop demand. Farmers generally apply too much N (and little P and K and other nutrients) that results in high incidence of pests and diseases, besides lodging. The consequence of high N application is high pesticide use to control pests, more expenditure on pesticides, and reduced yield and poor grain quality due to lodging. In addition, excess N is leached into water sources that get polluted over time. Farmers suffer from more pesticide-related health risks.

Crop-Need-Based Nitrogen Management

Crop-need-based N management approach takes into account variability in soil N supply and crops' additional requirement for N fertilizer. This means that rice crops in different fields require different amounts of N input. Being need-based, it can treat deficiency on a timely basis but requires careful periodic monitoring of crop N status. The main tool used for periodic monitoring of N status is a chlorophyll meter, which can monitor plant N status precisely, but is expensive. Priced approximately US$1400 a piece, it is beyond the reach of most of the individual farmers in Asia.

The leaf color chart (LCC) is an alternative tool for real-time N management in rice. It is inexpensive (at approximately US$1 a piece), simple and easy to use. It measures leaf color intensity related to leaf N status. LCC is an ideal tool for individual farmers to optimize N use in rice at high yield levels irrespective of the source of N applied, i.e., organic manure, biologically fixed N, or chemical fertilizers. It is also ecologically-friendly.

Scientific Principle of LCC

Farmers generally use the leaf color as a visual and subjective indicator of the rice crop's need for N fertilizer. Leaf color intensity is directly related to leaf chlorophyll content which, in turn, is related to leaf N status. As indicated earlier, the two simple tools that can measure the leaf color intensity are: chlorophyll meter (SPAD) and leaf color chart (LCC). Both are related to leaf N status as follows: a leaf color reading of SPAD 36 or LCC 4 is equivalent to 1.4-1.5 g N per square meter of leaf area.

Crop Need-based N Management Main Strategy	
• Matches external/fertilizer N supply to actual crop demand and crop growing conditions in the field. • Treats N deficiency symptoms on time. • Avoids overuse of N to prevent crop losses due to pests, diseases and lodging. • Monitors crop N status at regular intervals so as to apply N fertilizer as and when needed.	
Chlorophyll Meter (SPAD)	**Leaf Color Chart (LCC)**
• It measures the leaf color intensity and thus crop N status accurately, *in situ* (in the field). • It helps determine the right time of N application to rice. • It is expensive ~ US$1400 a piece.	• It measures the leaf color intensity which is related to leaf N status, *in situ* (in the field). • It helps farmers determine the right time of N application in all practical situations. • It is simple, easy to use and inexpensive (US$1 a piece). • It is an ideal tool to optimize N use at reasonably high yield levels, irrespective of the source of N applied.

When we compare the chlorophyll meter or SPAD readings with LCC shades, the difference between two LCC shades is 4 to 5 SPAD units. Thus, the LCC cannot measure the greenness of rice leaves as accurately as the chlorophyll meter. However, field tests show that for all practical purposes, the LCC is as good as or even better than the chlorophyll meter to determine the right time of N fertilizer application for rice crops.

Suggested Critical LCC Values	
Variety/crop establishment method	**Critical value**
Semi-dwarf indica varieties, direct-seeded	3
Scented or aromatic varieties, transplanted	3
Semi-dwarf indica varieties, transplanted	4
Hybrid rice varieties, transplanted	4
Note: Local calibration is always necessary. Test different LCC threshold values.	

Development of LCC

The International Rice Research Institute (IRRI) and the Philippine Rice Research Institute (PhilRice) jointly developed the LCC from a Japanese prototype. The LCC is made of high-impact plastic. It consists of six color shades from yellowish green (No. 1) to dark green (No. 6). The color strips are fabricated with veins resembling rice leaves. The holder is grey in color.

How to Use the LCC

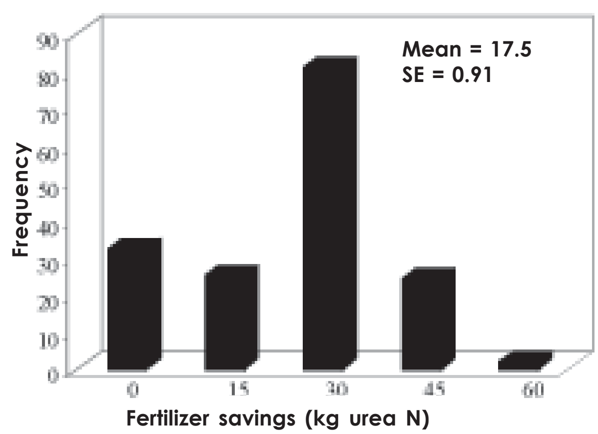
1. Start LCC readings from 14 days after transplanting (DAT) or 21 days after sowing (DAS). Take the last reading when the crop just starts to flower.
2. Randomly select at least 10 disease-free rice plants or hills in a field with uniform plant population. Select the topmost fully expanded leaf from each hill or plant.
3. Place the middle part of the leaf on a chart and compare the leaf color with LCC shades. When the leaf color falls between two shades, the mean value is taken as the reading, e.g., 2.5 for color between 2 and 3. Do not detach or destroy the leaf.
4. Measure the leaf color under the shade of your body, because direct sunlight affects leaf color readings. If possible, the same person should take LCC readings at the same time of the day every time.
5. Repeat the process at seven to ten days' intervals or at critical growth stages (early tillering, active tillering, panicle initiation and first flowering) and apply N as needed.
6. If more than five out of ten leaves read below a set critical value, apply:
   - 20-30 kg N/ha for wet season or low-yielding season
   - 30-35 kg N/ha for dry season or high-yielding season

A Typical Example of Decision-Making Process in LCC Method (TPR: S.D. variety)		
Time (DAT)	**LCC reading**	**Apply N? Yes/No**
0 (Basal)	**Nil**	**Based on local experience**
14	> 4.0	No
21	> 4.0	No
28	**< 4.0**	**Yes**
35	> 4.0	No
42	**< 4.0**	**Yes**
49	> 4.0	No
56	**< 4.0**	**Yes**

N Savings in Farmers' Fields

When averaged over 518 on-farm trials conducted in four countries during 1996-2000, farmers could save 8 to 22 kg N/ha with an increase in grain yield of 2% to 8% by using the LCC method. In Karnal district of Haryana (India) in 2001, 165 farmers evaluated the LCC method. Average saving in N was 25 kg/ha by using the LCC method without any reduction in yield (mean yield 6.37 t/ha).

N Saving by Using LCC, in Farmers' Fields at Karnal, Haryana, India



Limitations of LCC

Several factors influence LCC readings: varietal group; plant or tiller density; variability in solar radiation between seasons; status of nutrients other than N in soil and plant; and biotic and abiotic stresses that induce discoloration of leaves.

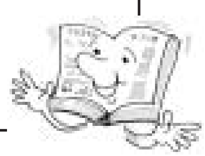
Users should clearly understand these limitations and know how to tackle them while using the LCC.

How to Overcome the Limitations

Training of national extension and development staff and farmers on the proper use of LCC is critical for its success. IRRI scientists train selected trainers in each country and they, in turn, train other local staff and farmers on the proper use of the LCC method. Often, farmers' meetings and discussion groups as well as farmers' field schools (FFS) are used for such training. During the training, they learn about the various interfering factors that affect the LCC readings and how to tackle them. They become conversant with different LCC critical values for different crop-growing conditions. Both national extension staff and farmers are trained to appreciate the need for a combined use of LCC and other methods to optimize grain yield and N fertilizer use efficiency in rice cultivation. The users should understand not only the economic advantage of efficient fertilizer management techniques, but also their impact on resource base, environmental quality and human health.

Commercialization of LCC

During commercialization of the LCC, strict maintenance of the LCC color shades is vital for its reliable use in Asia and elsewhere. Therefore, a quality certification program is imperative to certify the charts produced by various agencies in different countries, with the IRRI-produced LCC as the standard.



Popularity of LCC

As of June 2002, more than 400,000 farmers use the LCC for real-time N management in rice in different Asian countries. The number of farmers using LCC varies from 1000 in Bangladesh and Myanmar to 10,000 in India, 30,000 each in Indonesia and Philippines, and 300,000 in Vietnam.

Adapted from:

Balasubramanian, V. 2002. Leaf Color Chart for Real-Time N Mangement in Rice. Go to 'KnowledgeBytes: Using Leaf Color Chart (LCC)'. *In:* http://www.knowledgebank.irri.org/. To find out more about LCC, go to 'A complete reference guide concerning the LCC." International Rice Research Institute, Los Banos, Philippines.

Corresponding author:
V. Balasubramanian