

Real-time nitrogen management in rice

through leaf colour chart

Nitin N Gudadhe* and K A Shah

Navsari Agricultural University, Navsari, Gujarat 396 450

Rice production was 121.46 million tonnes in the year 2020–21. Rice yield is directly proportional to nitrogen (N) availability to crop with its effect on plant growth and reproduction. Global N requirement is more than 110 MT and half of it is being utilised for major cereal crop production. Though there is continuous improvement in nitrogen use efficiency of rice over the years with increased rice yield, >50% N fertiliser applied to rice remains unused. This unabsorbed N fertiliser in the soil is a threat to the environment due to the leaching and the atmospheric release of N_2O . Nitrogen losses in rice are more due to its blanket application at critical growth stages by farmers. It is more important to feed crops than soil to save N losses. Assessment of real-time N requirements in rice is very important to save the expensive N fertilisers and also to save N losses at the same time. Leaf colour chart (LCC) is an easy-to-use farmer-friendly, cost-effective, eco-friendly diagnostic tool that helps to decide the time and quantity of N fertiliser to be applied to rice. Yield and nitrogen use efficiency is ensured by this real-time nitrogen management tool. LCCs were distributed among farmers of Navsari district as a field-level demonstration and it has increased rice yield up to 9.5% with an enhancement of nitrogen use efficiency by 13% over farmers' practice of blanket application of N fertilisers.

Keywords: Leaf colour chart, Nitrogen management, Rice genotypes

RICE is the principal cereal crop of Asia. It accounts for about 90% of global rice production and consumption. Improvement in nitrogen use efficiency is very important in rice to sustain higher crop yield and at the same time reduction in N losses through ammonia volatilization, nitrate leaching, and denitrification. Nitrogenous fertilisers are expensive inputs but farmers tend to apply blanket N application to achieve higher rice productivity. Nitrogen use efficiency decreases as an increase in N fertiliser use and rarely exceeds >40% in rice. To increase nitrogen use efficiency in rice, it is necessary to anticipate the actual amount of N required and match the correct time of its application. Real-time nitrogen management can be useful to avoid excessive application of fertiliser N by

matching it with real-time N requirement to rice plants. LCC is a diagnostic tool that can be useful for site-specific N applications as per crop demand. LCC is a promising N management tool in rice crops for replacing blanket N application across rice-growing areas. In the present study real-time N management in rice was evaluated at farmers' fields for achieving higher rice yield and nitrogen use efficiency by application of N at critical growth stages by synchronizing crop N demand and N supply.

Leaf colour chart: LCC was jointly developed by IRRI and RRI, Philippines to measure the required quantity of nitrogen fertilisers to be applied to the rice fields to harvest maximum productivity. LCC is based on the leaf greenness and is associated with N content in the leaf which has

a direct relation with photosynthetic rate and rice yield. Six-panel LCC is a combination of yellowish-green to dark green colour which is matching the rice leaves colour ranges and is designed to show whether rice plants are hungry for N or not. LCC measures leaf colour intensity which is directly related to the N status of the leaf. LCC is easy to use farmers friendly, cost-effective, eco-friendly diagnostic tool to monitor the relative greenness of rice leaf which indicates the N status of the leaf and helps to decide the time and quantity of N fertiliser to be applied to the rice crop. Yield and nitrogen use efficiency is ensured by this real-time nitrogen management tool.

Technological intervention of LCC: Navsari district of Gujarat falls under heavy rainfall zone. Rice is the main crop of this region. Department



Six-panel leaf colour chart.



Checking real-time N requirement in rice through LCC.

technological intervention i.e. LCC. Application of N as per LCC panel 4 at tillering and panicle initiation stage had increased paddy grain yield from 4285–4742 kg/ha and the straw yield ranged from 4539–5093 kg/ha, however, application of N fertilisers through farmers' practice recorded a reduction in paddy grain (3946–4367 kg/ha) and straw yield (4539–5093 kg/ha). The average increase in paddy grain yield (4475 kg/ha) was 8.15% through LCC 4 over farmers' practice (4138 kg/ha). Application of 100 kg/ha N was mostly done through urea and ammonium sulphate, 33% of which was applied at transplanting, 40 and 27% N was applied at tillering and panicle stage initiation respectively through LCC 4.

Uptake of nitrogen: Nitrogen uptake was estimated through N content from both paddy grain and straw. N application through LCC 4 increased N uptake of 80.80–94.85 kg/ha over farmers' practice which had recorded N uptake ranging from 71.30–80.24 kg/ha. Average N uptake through LCC 4 was 86.45 kg/ha over farmers' practice (75.41 kg/ha). Comparatively N uptake through LCC 4 application was more as compared to farmers' practice, as N content in paddy grain and straw was increased and simultaneously paddy grain yield was also increased because of real-time N management.

Improved nitrogen use efficiency: As compared to farmers'

of Agronomy and Krishi Vigyan Kendra, NAU, Navsari have jointly supplied LCC as a technological intervention to the rice-growing farmers of Mandir, Vedcha, and Hasapore villages of Navsari district for the summer season of 2020. Farmers were selected randomly for this technological intervention. The preference was given to educated and willing farmers who can understand the philosophy behind the real-time need for N fertiliser to rice crops through LCC. Proper training for the use of leaf colour charts was given to the farmers at KVK, Navsari. LCC readings were taken every week from 21 days after transplanting for N application at tillering and panicle initiation stage. For the LCC count, ten healthy plants with fully

expanded leaves were selected. N fertilisers were applied when panel number 4 of LCC (LCC 4) matched at least six plants out of ten plants at tillering and panicle initiation stage. Farmers of the above villages were asked to apply 33% N as a basal dose and top-dress 40 and 27% N at tillering and panicle initiation stage through LCC 4, simultaneously farmers were asked to apply N as per their conventional practice through the blanket application of N. Results of N application through LCC and farmers practice were compared and inferences were drawn.

Grain and straw yield enhancement: Results of farmers' field trials in three villages of Navsari district were compared between farmers' practice (FP) and

practice, maximum N recovery efficiency (RE_N) through LCC-based N application of 13.01% was observed in Mandir village and minimum RE_N was observed in Vedcha village of Navsari district (9.49%). The average increase in N recovery efficiency of all villages was 11.04%.

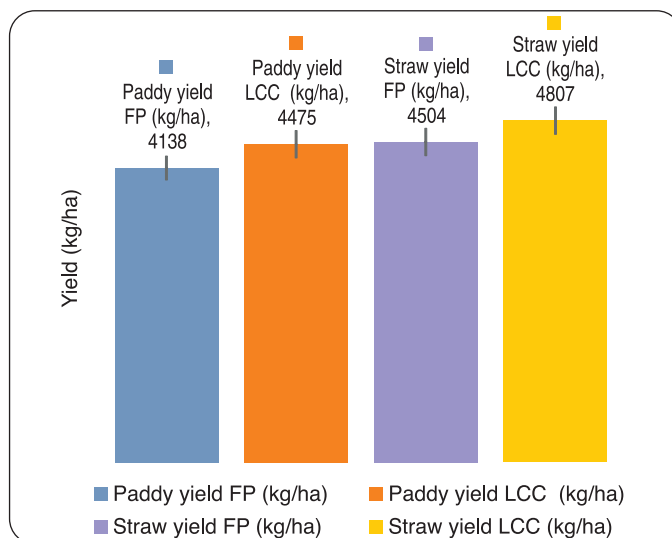
Agronomic efficiency intensification:

Agronomic efficiency of LCC-based N application was calculated over regular farmers' practice of N application. The average increase in agronomic efficiency of various villages of Navsari district was 3.38 kg/kg. The farmer's data showed that application of N fertiliser through LCC observations had recorded maximum agronomic efficiency in Mandir village (4.12 kg/kg), however minimum agronomic efficiency was observed in Vedcha village (2.97 kg/kg) of Navsari district.

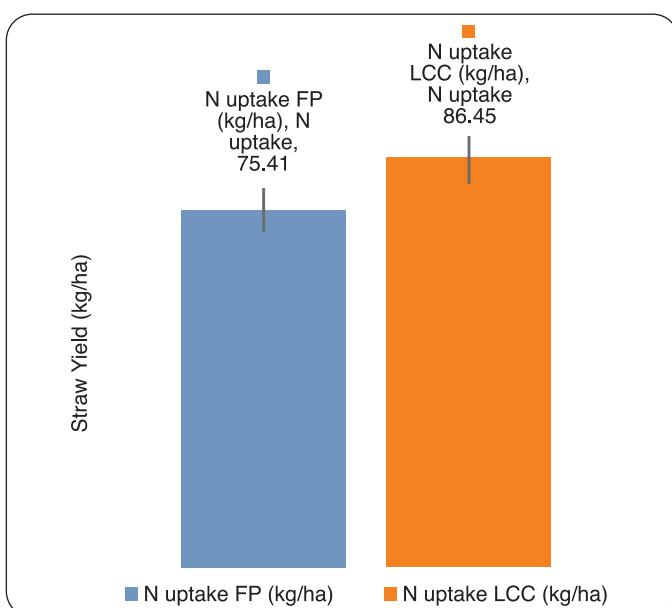
Reduction in N losses:

N_2O is a dominant greenhouse gas with a global warming potential of >300 times over CO_2 . The review shows that the application of N fertilisers through the monitoring of LCC can reduce N_2O emission (15.0%) as compared to the conventional method of N fertiliser application by the farmers in puddled transplanted rice. This is because the N application through LCC is on a real-time basis, which means rice crop is fed only when there is a real-time requirement of nitrogen to the crop. Hence utilisation of N is more as compared to N losses through leaching.

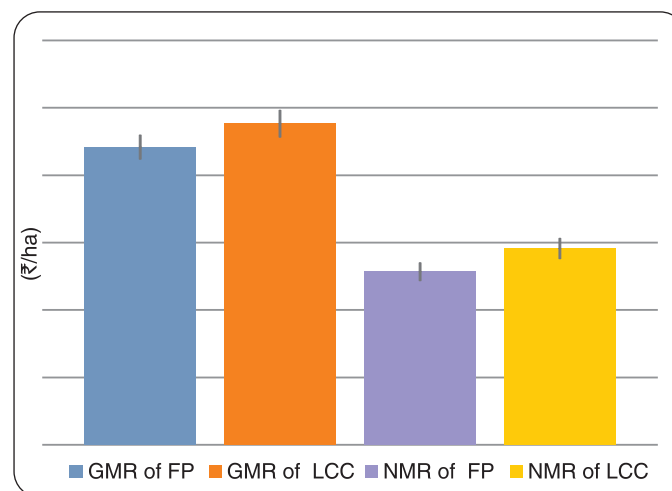
Nitrogen use efficiency: LCC-



Yield comparison between LCC-based N application and farmers' practice.



Effect of recommended LCC panel on uptake of rice over farmers' practice.



Economics of LCC-based N application.

based nitrogen recommendation can enhance nitrogen use efficiency as

compared to farmers' practice by 9.49%–13.01% at farmers' fields in transplanted lowland rice. Field trials also demonstrated that application of N through LCC-based recommendation i.e. panel number 4 had produced the highest paddy grain yield and nitrogen recovery efficiency over LCC 3, LCC 5, and farmer's practice.

Monetary benefit:

Results of farmers' field experiments showed that at the same level of N fertiliser application, yield advantage of 300–400 kg/ha can be achieved through recommended LCC 4 as compared to the conventional method of rice farming by local farmers. Conventional rice farming has generated a gross monetary return (GMR) of ₹84,074–93,547, net monetary returns (NMR) of ₹48,274–55,147. On the contrary, LCC-based N application has recorded a higher gross monetary return of ₹91,001–1,00,136/ha, net monetary returns of ₹55,301–62,566/ha, and a benefit-cost ratio of 2.55–2.65. Farmers can get additional net returns of ₹6892/ha through the adoption of LCC-based N application over conventional farmers' practice.

Farmer's success:

Mrs. Shashikalaben K Patel is the farmer of Mandir village of Navsari district (Gujarat) who has successfully adopted and disseminated the technology to other fellow farmers. Initially, she had a practice of rice cultivation with the blanket application of N fertiliser at transplanting as a basal dose and the

remaining two doses as a top dressing at tillering and panicle initiation stage without real-time need. Hence losses of N fertilisers were more through N_2O emission and leaching through other means. She came in contact with scientists of the Department of Agronomy, N M College of Agriculture and Krishi Vigyan Kendra, Navsari Agricultural University, Navsari through various extension programs run by the University and adopted the technology of Leaf Colour Chart for real-time application of N fertiliser to rice crop at tillering and panicle initiation stage. She is using this technology for the last four seasons of the rice crop. Through technological interventions, it was observed that paddy grain yield was increased by 9.52% with a nitrogen recovery efficiency of 13.01% over blanket application of N through conventional methods. LCC-based N application had received the highest gross monetary returns (₹1,00,136/ha), net monetary returns (₹62,566/ha), and benefit-cost ratio of 2.65.

Upscaling option: The Uttar Pradesh State Government has adopted the technology of LCC for



Woman farmer using LCC.

their RKVY program. On the same line, this technology can be included in various programs like FFP, NFSM, RKVY, etc. of Central and State Governments. LCC technology can be suggested as a recommendation for Government Programmes e.g. Soil Health Card Programme of Gujarat Government for nitrogenous fertiliser application in crops like rice.

Technology adoption: The unit price of LCC is ₹150 which consists of four, five, and six-panel charts and

user guides cum recommendations for N application for real-time N application. Training of various stakeholders including farmers can be conducted. Based on feedback and farmers' field trials, LCC-based N application has resulted in rice yield enhancement, N fertiliser savings, an increase in nitrogen use efficiency, curtailment of greenhouse gases emission, and earning a high benefit-cost ratio.

SUMMARY

Real-time N management in rice crop through LCC at tillering and panicle initiation may not only increase paddy grain yield (>9.5%) but can also curtail NO_2 emission, NO_3 leaching and can enhance gross

monetary returns up to ₹1,00,136 per ha, net monetary returns, up to ₹62,566 per ha and benefit-cost ratio of 2.65 over the conventional method of N fertiliser application. Farmers can get additional net returns of ₹6892 per ha through the adoption of LCC-based N application.

*Corresponding author's e-mail: nitbioworld@gmail.com

An android based nitrogen fertilizer recommendation app for riceNxpert

ICAR-NRRI developed 'riceNxpert' an android based mobile application to monitor the leaf N content based on leaf greenness and determine real time N fertilizer requirements to synchronize the demand and supply. The N application using riceNxpert produced higher yield in rice compared to the blanket recommendation. Farmers can download riceNxpert to their smart phone from google play store or ICAR-NRRI website or resilienceindia.org. By using this application, images of 10 fully expanded healthy leaves are taken by mobile phone placing a white sheet on the back of the leaf during 8–10 AM from 14 days after sowing or 21 days after transplanting at 3–5 days interval. On basis of leaf colour analysis riceNxpert makes real time N recommendation in terms of urea for top dressing in different rice ecologies.



Graphical user interface of riceNxpert; riceNxpert being



Source: ICAR Annual Report (2020)