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Site specific nutrient management for enhancing crop productivity

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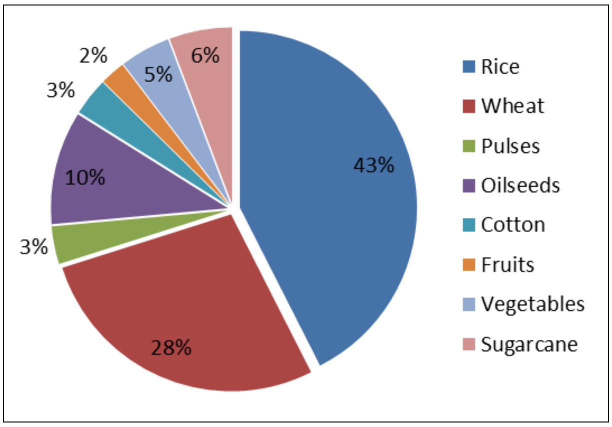
Abstract
Nutrient supply management plays an important role in ensuring self-satisfaction in food production. The high cost of chemical fertilizers, along with the increasing pollution problem, has increased interest in health management tools. Field nutrient management (SSNM) increases and controls yield by optimizing the balance of nutrient supply and demand. When nutrients are applied according to the SSNM strategy, maize, wheat, rice and rabi yields are higher than recommended fertilizer use (RDF) and agricultural fertilization. Based on the L1e3af color map, the app works best with agriculture and national recommendations for greater food use. R5 instantaneous nitrogen application, LCC ≤ 5 @ 30 kg N/ha i.e. The highest rice yield was recorded at T1h3e when applied 5 times at 150 kg/day. The use of LCC also leads to savings of 10 to 40 kg N/ha compared to nitrogen application time. Compared with fixed nitrogen application, SPAD-based nitrogen application has better nitrogen utilization and can increase crop yield.

Keywords: Site specific nutrient management, recommended dose of fertilizer, LCC, SPAD, n-management

Introduction

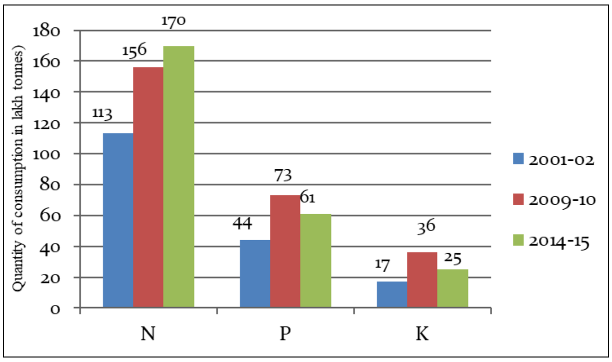
Fertilizer consumption in India has increased significantly in the last 40 years. India has now become self-sufficient in food production, especially due to increased use of chemical fertilizers. India ranks second in the world after China in agricultural fertilizer use. All India Total fertilizer production (N + P + K) increased by 5.6% 2021-22. Nitrogen consumption increased by 3.8% at 17.60 MMTP$_2$O$_5$ increased by 7.07 MMT Increased by 15.9% in 2015-16 and 19.44 MMT in 2021-22, >K$_2$O consumption MMT decreased by 7.9%< br> and this time it is 7.83 respectively. Total production per hectare increased from 131.6 kg in 2014-15 to 138.9 kg in 2015-16 and 146.7 kg in 2021-22, an increase of 5.6%. The most common inputs are fertilizer, followed by wheat, legumes and oilseeds. 16 and 19.44 MMT in 2021-22; K$_2$O consumption decreased by 7.9% and 7.83 times to 2.33 million tons. Use of the total surplus increased by 5.6% from 131.6 kg per hectare in 2014-15 to 138.9 kg per hectare in 2015-16 and 146.7 kg per hectare in 2021-22. Most fertilizers are used for cereals, followed by wheat, legumes and oilseeds.

W3 In order to promote the balanced use of fertilizers, the government has implemented the Nutrient Based Subsidy (NBS) policy since April 2010, announcing the payment of subsidies for nutrients. Following the policy published by the National Bureau of Statistics, the prices of phosphate and potash fertilizers have increased significantly due to the increase in the prices of phosphate and potash fertilizers and raw materials in the world. Data, but the price of urea is still Rs. 5360 per tonne. Different prices of urea, phosphorus and potassium fertilizers have affected the consumption patterns of nitrogen, phosphorus and potassium fertilizers (Figure 2). Between 2001-02and 2009-10, nitrogen consumption increased by 38%, phosphorus consumption by 66% and potassium consumption by 118%. After the introduction of the Office for National Statistics policy, nitrogen consumption increased by 9% from 2009-10 to 2014-15, while phosphorus and potassium consumption decreased by 16% and 30% respectively. So NBS policy will be reduced unnecessarily. It causes food quality to deteriorate as farmers use less phosphorus and potassium, which are important for soil and plant health.



Source: (FAI, 2012)

Fig 1: Fertilizer consumption of crops in India



Source: Department of Agriculture, cooperation and Farmers Welfare

Fig 2: Consumption of fertilizers in terms of nutrients

Nutrient Management

Why Nutrient Management is Important?

Food supply management plays an important role in achieving self-sufficiency in food production. The high cost of chemical fertilizers and increasing pollution problems have increased interest in sanitation management. In this case, S2i4te's specialized food management systems based on changes in crop demand and soil resources may provide the best tools.

Site Specific Nutrient Management

- SSNM prepares the fertilizer system to meet crop needs and increase productivity and profitability. This can be done using existing information on local food production, food from organic fertilizers, irrigation water, rainwater and crops required for planting, room water and target yields of the final crop/farm. Location management is an important aspect of precision agriculture and can be applied to any crop or field. It combines the needs of plants at different growth stages with the soil's ability to provide nutrients and uses this information for areas in the region that require different management. SSNM provides guidance on land. SSNM can check or increase Increase yields while saving farmers money by using better fertilizers. Its goal is to deliver nutrients at the right price and time to ensure successful crop production and efficient use of nutrients.
- Provides nutrients to plants when needed.

Key messages

1. Site-specific nutrient management (SSNM) optimizes soil diversity in situ and over time to meet crop needs.
2. SSNM increases crop productivity and efficient use of fertilizers.
3. SSNM reduces agricultural greenhouse gas emissions by reducing excessive use of chemical fertilizers. Greenhouse gas emissions can sometimes be reduced by up to 50%.

4 R's of SSNM

Site-specific nutrient management (SSNM) aims to optimize soil nutrient supply over time and space to meet crop needs from four important factors. These principles, known as the "4 Rs," date back to at least 1988 and were developed by the International Institute of Plant Nutrition.
They are:

- Right Product.
- Right Rate.
- Right Time.
- Right Place.

Right product / source

Matching Fertilizer Products are food plants and soil to ensure a balanced food supply matching species.

Right rate

Consider the nutrients available in the soil and match the amount of fertilizer used to the amount your crops need. Excessive use of chemical fertilizers will cause environmental pollution, fuel emissions and waste of money. Too little fertilizer can damage the soil and cause soil degradation.

Right time

By evaluating the quality of the crops, we ensure that nutrients reach the crops when they are needed. This may mean separate mineral fertilizers or combining organic and mineral nutrients to provide nutrients at a slower rate.

Right place

It is important to locate and control nutrients away from the crop and deep into the soil to reduce the amount of nutrients available to the crop.

Benefits of the practice

- **Higher profits:** SSNM can increase and maintain profits by optimizing the balance between supply and demand and providing better quality food. May improve overall nutrition utilization and provides a greater return on fertilizer investment.
- **Reduces nitrogen oxide emissions:** Agricultural emissions account for 70-90% of nitrous oxide ($N2O$) emissions, mostly from nitrogenous fertilizers. SSNM reduces $N2O$ emissions by reducing the total amount of nitrogen fertilizer used or fertilization time according to crop needs, thus preventing nitrogen evaporation, leaching and runoff.
- **Improves disease resistance:** Increased dietary NPK from SSNM may cause to increased disease resistance.
- **Variable economic benefit:** For SSNM to be profitable to farmers, SSNM must achieve:

a) Cost savings through reduced fertilizer use.
b) The price of crops exceeds the cost of acquiring and using SSNM technology. While farmers generally benefit from higher quality crops, increased yields can increase profits or initially higher prices.

SSNM Approach (3 steps)

Step 1: Establish a grain yield target

- Selective benefits from farmers' crop management and also

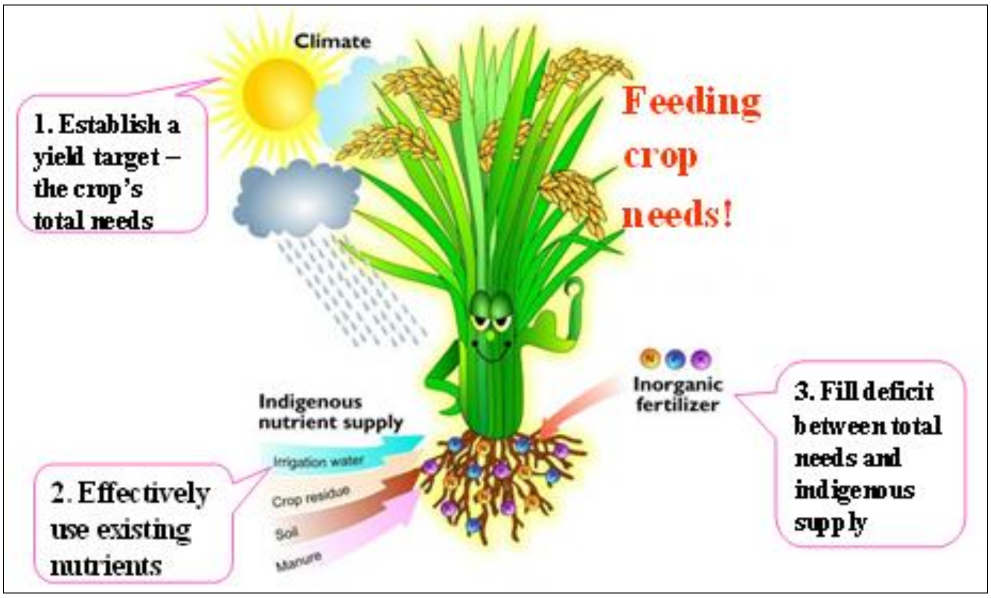
improved food management during the regular season.
- It shows all the nutrients the crop required to receive before it grows.
- Depends on location and season (depending on climate, variety and crop management).

Step 2:
Effectively use existing nutrients
- Estimated availability of unhygienic food (at home).
- Use nutrients, fertilizer use history, soil type and residue, an d crop management to estimate local production

Define traditional foods as foods that are limited in production.

Step 3: Apply fertilizer to fill the gap between crop demand and local supply
- Apply the required amount of nitrogen fertilizer frequently during the growing season to meet the crop's additional nitrogen need.

Provide adequate phosphorus and potassium to prevent nutrient deficiencies and maintain soil fertility.



SSNM: A key ingredient for managing nitrogen

Fig 3: The three basic steps of SSNM approach

Nitrogen provided by soil and organic matter is rarely sufficient to produce high yields, and supplemental nitrogen is often necessary to achieve higher yields. When nitrogen application is inconsistent with crop needs, nitrogen loss from the soil-plant system becomes greater, resulting in reduced nitrogen fertilizer use efficiency. Therefore, using nitrogenous fertilizers according to the needs of plants is important for higher efficiency and nitrogen use. Nitrogen treatment is now based on regular measurement of the nitrogen status of the plant and the appearance of nitrogen deficiency symptoms, especially in the leaves. Therefore, the key to nitrogen management is now a method to rapidly assess leaf nitrogen, which correlates with photosynthetic rate and biomass production and is a variable of crop nitrogen requirements throughout the growing season. Chlorophyll meter, also known as SPAD (Soil Plant Analysis Development), provides rapid and reliable assessment of crop nitrogen based on leaf area. It was used in rice. The high cost of chlorophyll measuring devices puts it out of reach of many Asian farmers. Nitrogen control by leaf color (LCC) is an inexpensive alternative to the chlorophyll meter. The primary color of the LCC should be defined to guide N application. SSNM provides: Farmers use nitrogen fertilizers in different batches to ensure there is enough nitrogen in the mix with plants that require nitrogen. Bijay-Singh *et al.* (2009) [8] stated that leaf color chart (LCC) and chlorophyll measuring device (SPAD) are important tools in determining nitrogen in rice and determining nitrogen application time.

SSNM can be
1. Prescriptive.
2. Corrective.

1. **Prescriptive N management:** Based on information obtained before planting.
2. **Fix N m management:** After planting or rely on information generated in the forest stand. For example, use color card (LCC) and Chlorophyll Meter (SPAD).

Nutrient use based on SSNM strategy leads to higher yields of maize, wheat, rice, and rabi than recommended fertilizer use (RDF) and agricultural fertilization (Biradar *et al.* 2012) [3]. According to SSNM, the average yield was 7.02 t/ha for corn, 8.34 t/ha for rice, 3.79 t/ha for wheat, 2.56 t/ha for rabbi, while the target average was 7 t/ha. It was determined as 9 t/ha. 3.75 tonnes/ha and 2.75 tones/ha. Separately. Crop yield decreased in FFP compared to RDF and SSNM.

Table 1: Various doses of nutrient applied in SSNM, RDF & FFP

Crop	Yield Target (t/ha)	Nutrient Applied [kg/ha] ($N:P_2O_5:K_2O:Zn:Fe$)		
		SSNM	RDF	FFP
Rice	9.0	215:100:215:5:5	150:75:75	113-166:50-108:21139
Maize	7.0	250:110:195:5:5	150:75:37.5	102-160:20-105:30-138
Chilli	2.25	150:62:90:5:5	100:50:50	58-100:40-57:38-40
Cotton	2.75	160:85:150:5:5	120:60:60	80-102:42-80:42-98
RabiJowar	2.75	80:40:80:3:3	50:25:0	10-16:17-25:0-37
Wheat	3.75	120:60:105:5:5	100:75:50	43-100:43-57:35-85
Chick pea	2.75	85:55:95:3:3	25:50:0	22-45:50:15-75
Sunflower	2.75	216:75:135:5:5	60:75:60	70-100:40-80:37-75

Table 3: Effects of site-specific management of intercrops on different crops (Summary)

Crop	Average yield target (t/ha)	Average grain yield (t/ha)			CD@ 5%
		SSNM	RDF	FFP	
Maize	7	7.02	5.98	5.44	0.48
Rice	9	8.34	7.47	6.74	0.63
Wheat	3.75	3.79	3.22	2.85	0.28
Rabi jowar	2.75	2.56	2.09	1.89	0.18
Sunflower	2.75	2.44	2.01	1.8	0.15
Chickpea	2.75	2.39	1.99	1.89	0.1
Cotton*	2.75	2.55	2.21	2.01	0.17
Chili**	2.25	2.18	1.94	1.76	0.16

*Seed cotton yield, **Dry chili yield
***Source*:** (Biradar *et al*., 2012) [3]

SPAD meter
The SPAD meter was developed in Japan for nitrogen management in rice (*Oryza sativa*) and is now widely used for rapid, non-destructive measurement of chlorophyll concentration. The SPAD meter / chlorophyll meter is a reliable tissue analysis tool that is a diagnostic tool for nutritional nitrogen. The most commonly used chlorophyll analyzer is the handheld Minolta SPAD-502 (Varinderpal-Singh *et al*., 2010) [9]. Instantly measures leaf nitrogen or chlorophyll content by compressing tissue that is not protected in the device. It uses two LEDs (Light Emitting Diodes) that emit red light with a peak wavelength of 650 nm and infrared radiation with a peak wavelength of 940 nm. Red and infrared light is distributed to the leaves. Some of the light is absorbed and the rest is transmitted by the leaf; where silicon photodiode detectors convert it into an electrical signal. The amount of light reaching the photodiode detector is inversely proportional to the amount of chlorophyll in the light path. Leaf chlorophyll content is displayed in arbitrary units (0-99.9). SPAD meter reading has no units and must be measured based on chlorophyll content or nitrogen content and green leaf. It has two methods:

1. Fixed threshold value approach
2. Sufficiency index value approach

Fixed threshold value approach
Fertilizer N is applied when the SPAD value is lower than the critical value. The SPAD threshold represents the reduction limit and must be defined first. Nitrogen fertilization should be below this threshold to prevent losses. Peng *et al*. (1996) [6] were pioneers in determining SPAD values that farmers could apply in the field. The SPAD value of the "Y leaf" was monitored every 7-10 days until the beginning of flowering, 15 days after planting. In field trials, using 35 significant SPAD reads led to similar results (higher agricultural productivity) with less nitrogen compared to time-separated or recommended separation methods (Peng *et al*. 1996) [6]. In South India, a SPAD value of 35 is suitable for nitrogen management based culture in crop cultivation. However, the SPAD measurement threshold of 35 is not universal and will vary depending on the growing area. For example, the threshold value should be lowered to 32 during the rainy season when the weather is stable for most of the growing season. Hussain *et al*. (2003) [5] found a significant SPAD value of 37.5 suitable for nitrogen top dressing application in plants. Pakistan.

Sufficiency index value Approach
The appropriate parameter is defined as the SPAD value of the test film expressed as a percentage of the SPAD value of the reference material or binder. Apply N fertilizer when the adequate level is lower than the set value. The advantage of this method is that it can be evaluated separately for different soils, seasons and varieties, since the SPAD starting point is created by the excess fertilization method used. Huseyin *et al*. (2000) evaluated the management of nitrogenous fertilizers against high nitrogen use based on an adequate (90%) approach. Monitor the required parameters every 7-10 days until flowering reaches 50%, top-dress with 30 kg N ha-1 and when it drops below the critical value of 90%, top-dress with 30 kg N ha-1. The yield of different types of rice is similar to nitrogen fertilization, but the amount of N-1 is reduced by 30 kg.

The empirical relations were developed to help guide amount of in-season fertilizer N top dressings as:

N= [6+ (7 × D) × 1.14 with SPAD-502 chlorophyll meter]

Where, D= Difference between average SPAD meter readings from the test field & the over fertilized reference plot or strip.

Measuring SPAD value in the field

1. SPAD readings every 10-15 days, starting from 14 DAT for transplanted rice and 21 DAS for wet rice seeds, with readings continuing until the first (10%) flower.
2. Use the lowest leaf of the plant to measure SPAD (Varinder pal-Singh *et al*., 2007) [7].
3. Readings are taken on one side of the midrib of the leaf blade.
4. Take an average of 10-15 readings based on the SPAD value for each field or chart.

When the SPAD value falls below the critical value, nitrogenous fertilizer should be applied immediately to prevent loss. The critical SPAD value for rice in northern India is 37.5. When 35 SPAD value is used as the base rate in the application of 30 kg Nha-1 in rice, a total of 30 or 60 kg is used (except for the PR111 variety planted with a base dose of 30 kg Nha-1) (Table 3). Therefore, grain yield and nitrogen uptake of rice in these applications were lower than the recommended values for the 120 kg Nha-1 application period.

Table 3: Rice grain yield, nitrogen uptake and total nitrogen fertilizer use for two crops using demand-driven fertilizer nitrogen management standards (based on 35 and 37.5 SPAD thresholds) in Ludhiana

Treatment	Total N applied (Kgha^{-1})	Grain yield (tha^{-1})	Total N uptake (Kgha^{-1})	Total N applied (Kgha^{-1})	Grain yield (tha^{-1})	Total N uptake (Kgha^{-1})
	PR 106			**PR 111**		
Recommended splits, N_{120}	120	6.1^{a}	111^{a}	120	6.5^{a}	110^{a}
N_{30} at SPAD<35, N_{30} basal	60	4.9^{b}	86^{b}	90	5.9^{a}	90^{cb}
N_{30} at SPAD<35, no basal	30	5.1^{b}	75^{c}	60	5.4^{b}	88^{c}
N_{30} at SPAD<37.5, N_{30} basal	90	5.8^{a}	88^{b}	90	6.3^{a}	96^{cb}
N_{30} at SPAD<37.5, no basal	90	6.4^{a}	93^{b}	90	6.4^{a}	97^{b}

Source: (Bijay-Singh *et al*., 2002) [2]

LCC

Leaf Color Chart (LCC) is a beautiful material that can accommodate many shades of green, from light yellow-green to dark green. The first LCC was developed in Japan (Furuya 1987). An improved six-panel LCC (IRRI-LCC, six panels) was developed by the International Rice Research Institute (Los Banos, Philippines) (IRRI) in collaboration with agricultural studies in several Asian countries (IRRI 1996). Researchers at Zhejiang Agricultural University in China developed LCC (ZAU-LCC) with eight green colors (3, 4, 5, 5.5, 6, 6.5, 7 and 8) and followed it with indica, japonica and they tested it on hybrid rice. Calibrated (Yang *et al*., 2003) [11]. The Leaf Color Chart is a useful new tool for immediate or crop needs for nitrogen management in rice, corn and wheat. LCC is the visual and context of plant nitrogen deficiency and is a cheap, easy to use and useful alternative to the chlorophyll meter / SPAD meter (Soil Plant Analysis Development). Here, nitrogen is placed by comparing the leaf color with the panel color. It measures the intensity of leaf color based on the nitrogen status of the leaf. LCC is the best tool for utilizing high levels of nitrogen in wheat, corn and rice, regardless of the nitrogen source such as organic, biochemically fixed nitrogen or chemical fertilizers. Therefore, it is an environmentally friendly tool in the hands of farmers. There are two ways to synchronize fertilization with plant needs using LCC:

1. Real time N management approach
2. Fixed time N management approach

Real-time N management approach

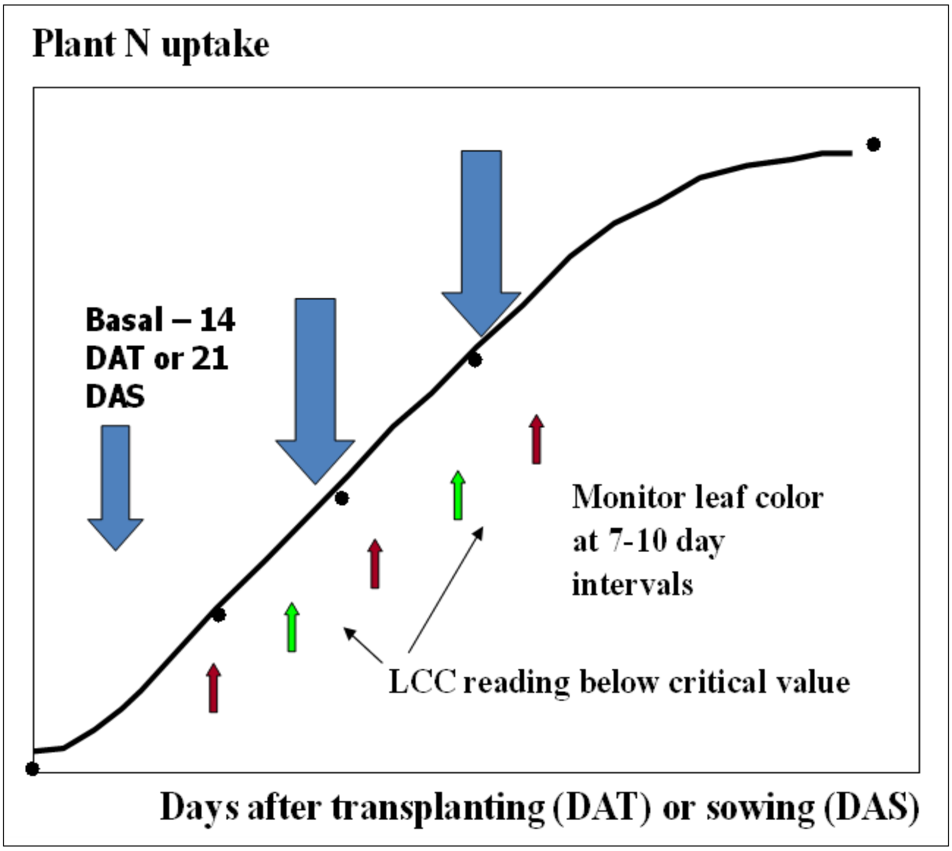
Starting 15 days after planting or 21 days after planting, monitor the LCC score of the "Y leaves" every 7-10 days until the beginning of flowering. Nitrogen fertilizer. Currently, local guidelines for the use of LCCs have been developed in large areas where irrigated rice is grown in Asia. Of the six IRRI-LCC groups, LCC chroma 4 was found to be a score for transforming coarse grain rice varieties popular in the Indo-Gangetic plains

(Bijay-Singh *et al*. 2002; Hussain *et al*. 2003) [2, 5].

The 6-group IRRI-LCC critical score in the lower Gangetic plains of Bangladesh is 3.5. 2 and 3.5 were reported as significant LCC values for fragrant rice and fragrant rice and transplanted half-dwarf indica rice/transplanted hybrid rice, respectively (IRRI-LCC, four groups).

Real-time N Management

1. Apply N early
2. Monitor leaf color
3. Apply N when LCC reading is below critical value

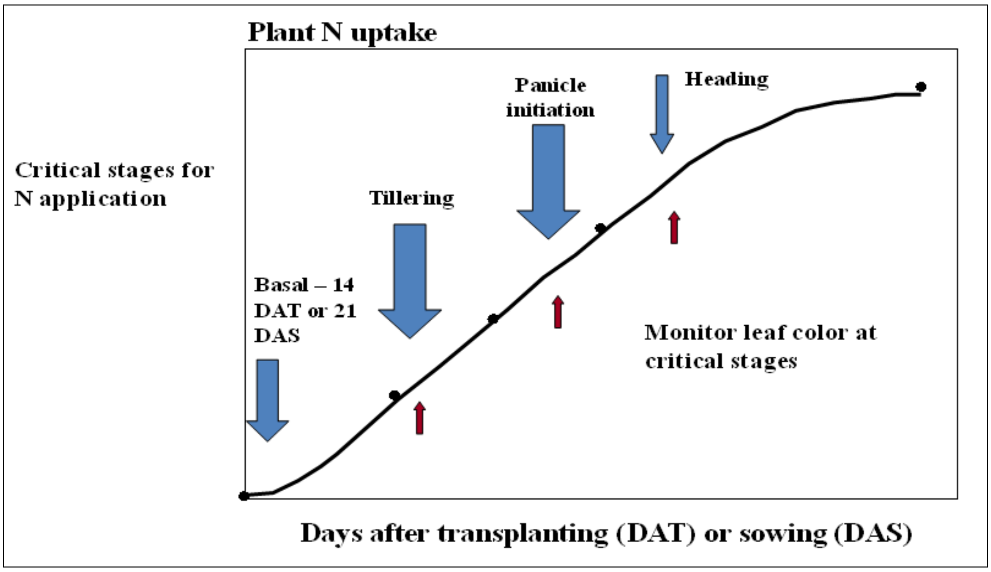


Fixed-time variable rate dose approach

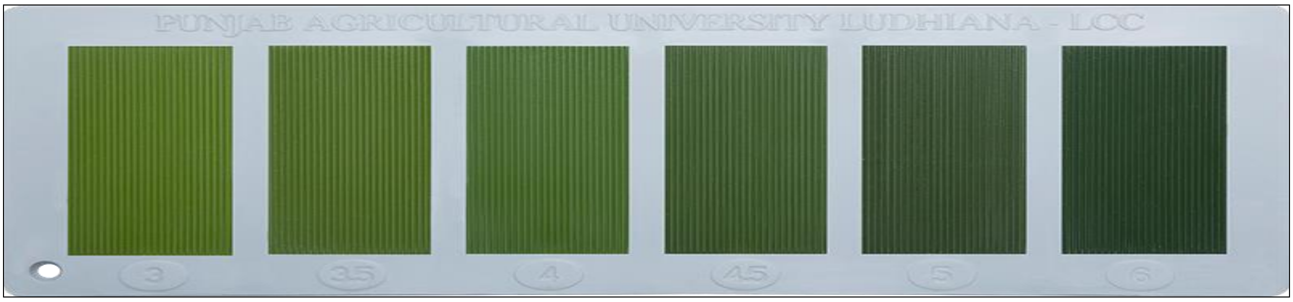
It involves applying nitrogenous fertilizers to plants according to their growth stage. Instead of monitoring leaf color every 7-10 days, LCC monitors leaf color only during the crop's critical growth period to adjust nitrogen applications (up or down) based on leaf color. Farmers can measure leaf color before applying nitrogen during tiller and cluster emergence. If the LCC score is higher than the average leaf color, use less nitrogen fertilizer. If average leaf color is lower, use more nitrogen fertilizer. Adjust nitrogen rates during active tillering and cluster formation to ensure more nitrogen is used in fields and years when plants need high nitrogen and less nitrogen is used in fields and years when plants need less spraying.

Fix time-adjustable dose N Management

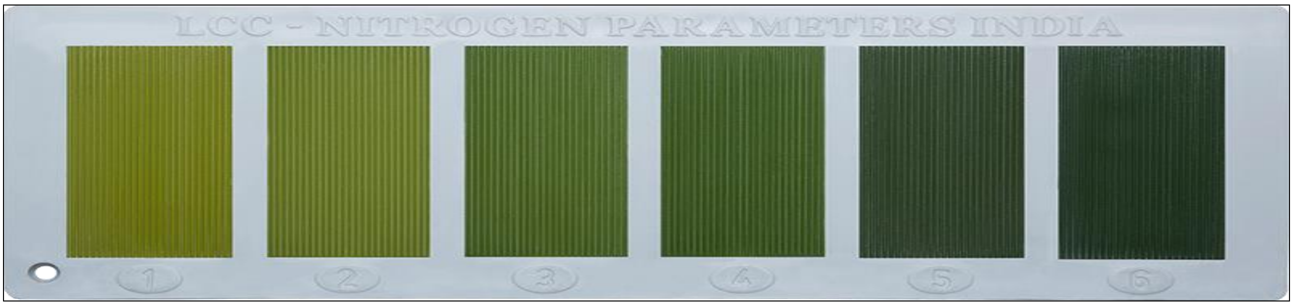
1. Apply early N.
2. Top Dress N at Predeter mined critical time (growth stages).
3. Adjusting N dose up or down based LCC reading.



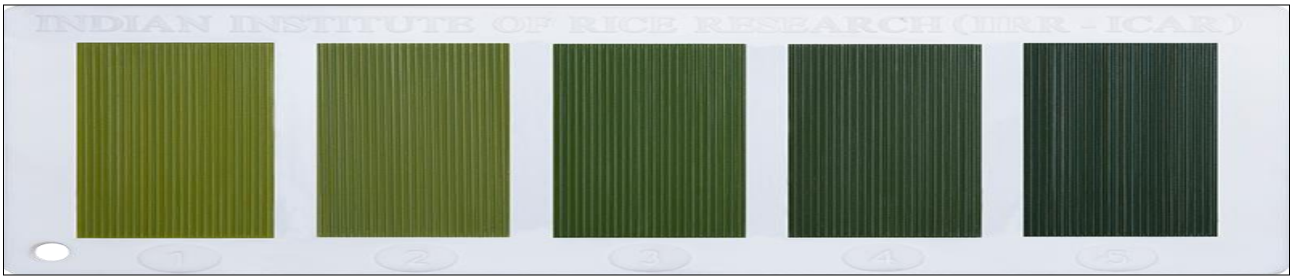
Different LCCs



6 Panel PAU LCC for rice, wheat and maize



6 Panel IRRI LCC



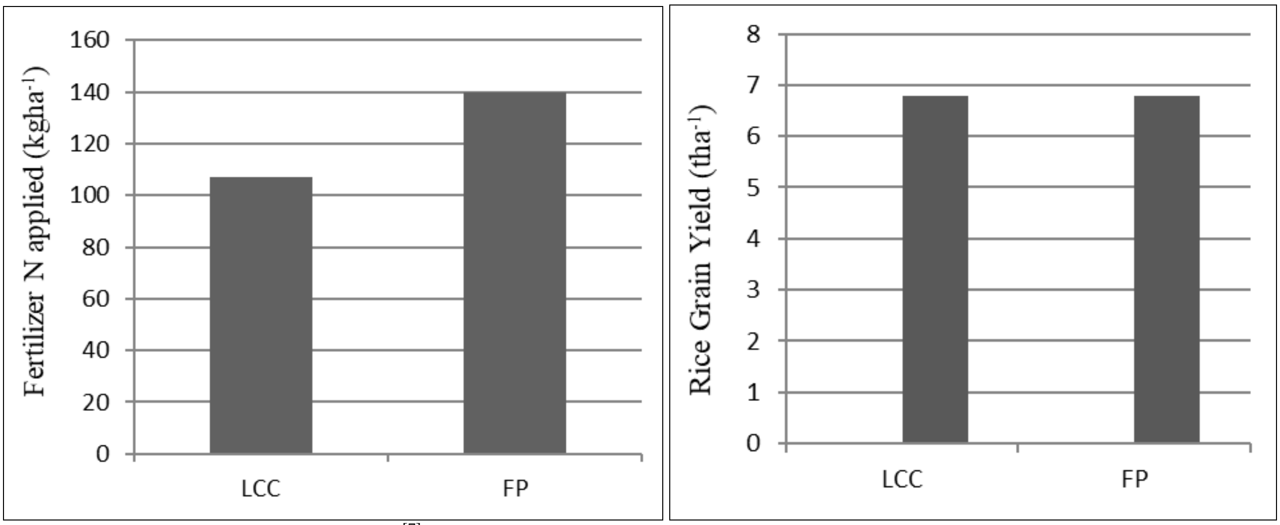
5 Panel IIRR LCC for rice (for Southern states of India)

5 Panel NRRI LCC for rice (for eastern states of India)

Table 4: Evaluation of Leaf Color Chart (LCC) based real-time N management in rice vis-à-vis fixed time blanket recommendations / FPP in Punjab

Year, No. of exp.	Treatment	AE_N (Kg grain per Kg N)(Agronomic Efficiency)	RE_N (%) (Recovery Efficiency)
2000.n=8	-B,LCC	27.4a	43a
	+B,LCC	28.1a	42a
	Blanket/FFP	20.8b	30.9b
2001, n=8	-B,LCC	19.8a	39a
	+B,LCC	21.6a	45a
	Blanket/FFP	15.4b	29b
2002, n=11	-B,LCC	19.2a	58a
	+B,LCC	16.4a	53a
	Blanket/FFP	11.3b	40b

Source: Varinder pal-Singh *et al*., (2007) [7] In all years, nitrogen use efficiency (NUE) in LCC treatment with or without basal nitrogen application was significantly higher than recommended nitrogen uses or agriculture (Table 4). The average AEN across villages and years in the LCC region ranged from 16.4 to 28.1 kg grains per kg nitrogen, while the recommended use by farmers ranged from 11.3 to 20.8 kg grains per kg nitrogen. The average nitrogen recovery efficiency in the LCC was 42.1, 45.4 and 52.7%, respectively, while the average nitrogen recovery efficiency achieved under the farm agreement in 2000, 2001 and 2002 was 30.9, 29.1 and 39%, respectively. It was 8. The increase in NUE achieved using LCC is due to better synchronization of nitrogen fertilizer application time. Fertilizer nitrogen application rate and crops need nitrogen fertilizer. LCC reduced nitrogen fertilizer from 10-45 kg in 2000, from 0-60 kg in 2001, and from 40-82 kg in 2002. LCC-assisted nitrogen fertilizer management resulted in savings of 36 kg Nha^{-1} compared to FP without any reduction in yield (Fig. 4).



Source: Varinder pal-Singh *et al.*, (2007) [7]

Fig 4: Average fertilizer N applied and grain yield of rice in 350 on-farm trials comparing LCC- based N management with FPP in Punjab

Table 5: Relative economics of different treatment combinations (Mean of 2012 & 2013)

Treatments (N/ha)	Cost of cultivation (₹.)	Total returns (₹.) Grain +straw)	Net returns (₹.)	B:C ratio
Jhelum				
Control	35980	75830.35	39870.85	0.77
Recommended N	37415	123491.00	80519.34	1.78
LCC≤3@20Kg	36937	117052.70	75949.84	1.66
LCC≤3@30Kg	37056	121133.40	80764.34	1.75
LCC≤4@20Kg	37175	129796.80	88754.08	1.94
LCC≤4@30Kg	37415	134200.80	91885.92	2.02
LCC≤5@20Kg	37415	140160.60	99175.77	2.16
LCC≤5@30Kg	37773	145075.60	103425.80	2.24

Source: Bhat *et al.*, (2012) [1]

Bhat *et al.*, 2012 [1] reported the best results for LCC≤5@30kgha-1 treatment (Table 5). This is true because nitrogen supply is stable and synchronized with peak nitrogen demand when crops are more abundant. Increased availability of nutrients at different levels of the body will promote better utilization of photosynthetic equipment from rice.

Conclusion

Management of specific nutrients in the field reduces production costs while successfully increasing crop yields and the use of efficient techniques. Effective nutrient management through LCC and SPAD can save 16-23% nitrogen. The use of LCC and SPAD is efficient and effective. LCC-based management is the lowest cost and easiest to manage; making it the best choice for competitive N applications for crop needs.

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