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Mini Review

Some Aspects of Nitrogen Management and Its Real Time Application in Direct Seeded Rice Using Leaf Color Chart

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Abstract

Proper application of nitrogen (N) fertilizer is vital to improve the growth and grain yield of rice crop. As there prevails more aerobic period in direct seeded rice, nitrogen loss is generally more in such environment. Therefore, nitrogen recommendation for direct seeded rice is slightly higher (22.5-30 Kg ha^{-1}) than that under the transplanted rice. Insufficient and/or inappropriate nitrogen fertilizer application is highly critical to the crops. Optimal nitrogen management strategies aim at matching the nitrogen fertilizer supply to the actual crop demand. Leaf color is generally used as a visual and subjective indicator of the rice crop need for nitrogen fertilizer. The Leaf Color Chart is a simple and inexpensive tool for real time nitrogen management in rice. It helps farmers to improve their decision-making process in nitrogen management. It provides the idea of when and how much nitrogen fertilizer to apply based on relative greenness of the rice leaf. In overall, LCC based nitrogen management improves productivity and profitability of the rice crop by nitrogen saving and ensuring its higher use efficiency.

Keywords: direct seeded rice; leaf color chart; nitrogen saving; grain yields

Introduction

Rice (*Oryza sativa* L.) is one of the most popular cereal crops in the world. It is a staple food for nearly half of the world's population. More than 90% of this rice is produced and consumed in Asia (Pathak *et al*., 2011). Total global rice production was 472.96 million mt. from the area 159.44 million ha with the productivity of 4.4 mt ha^{-1} (USDA, 2018).

Puddled rice transplanting is the burdensome and time consuming crop establishment method with more labor and water requirement which are becoming scarce too. It destroys the soil physical properties by dismantling the soil aggregates and ultimately affects the growth and productivity of succeeding wheat crop (Bhurer *et al*., 2013). Pathak *et al*. (2011) reported that climate change may cause the variability of monsoon rainfall and also the risks of early season drought. So, direct seeded rice (DSR) can be an alternative method to conventional transplanted rice as it avoids puddling and transplanting of young seedlings and requires less water, labor, time, drudgery and cultivation cost (Ali *et al*., 2012). The direct seeded rice matures 7-10 days earlier than the transplanted rice and thus allows timely sowing of succeeding wheat crop which assists to improve the system productivity (Giri, 1988). Moreover, the grain yield obtained from the DSR is found comparable to that of

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the transplanted rice if managed properly (Gill *et al*., 2014). Some of the major challenges found in dry direct seeded rice are high weed infestation (Joshi *et al*., 2013) and more nitrogen (N) loss through denitrification, volatilization, leaching and runoff than in conventional transplanted rice (Kumar and Ladha, 2011). Farmers generally do blanket application of nitrogen fertilizer in splits, which may produce optimum yields, but cannot help increase N use efficiency beyond a limit. Large field-to-field variability of soil nitrogen supply, agro-climatic conditions and varietal differences further lowers fertilizer N use efficiencies when broad-based blanket recommendations are used (Singh *et al*., 2010). Therefore, nitrogen management is considered as one of the most challenging parts of the direct seeded rice to achieve higher grain yield and nitrogen use efficiency (Ali *et al*., 2012).

Real time (also called need based) nitrogen management requires periodic assessment of nitrogen status in standing crop and its application according to the need of the crop (Witt *et al*., 2004). In this context, Chlorophyll meter (SPAD) or Leaf Color Chart (LCC) can be used to assess the actual plant nitrogen status (Balasubramanian *et al*., 1999). LCC provides the guideline for effective nitrogen management by giving the idea of when and how much nitrogen fertilizer to apply for maintaining and optimizing nitrogen status in rice plants to ensure high grain yield (Sathiya and Ramesh, 2009). So, this review article is prepared based on research findings related to need based N management using LCC in direct seeded rice.

Nitrogen Requirement for Rice Crop

Nitrogen is an essential nutrient for rice production and plays an important role in sustaining high yields (Liu *et al*., 2007). Nitrogen is required for chlorophyll formation which gives the leaves green color and enables the plants to gain energy for nutrient uptake and growth. The chlorophyll content of leaf determines the ability of plant to utilize solar radiation and is directly related to leaf nitrogen content, which depends on nitrogen uptake (Richardson *et al*., 2002). As there prevails more aerobic period in DSR, Nitrogen loss is generally more in such environment. Therefore, generally nitrogen recommendation for DSR is slightly higher (i.e 22.5-30 Kg ha^{-1}) than that under the transplanting method although recommended P and K are same under both methods (Pathak *et al*., 2011; Kumar and Ladha, 2011; Gathala *et al*., 2011).

Nitrogen Loss from Rice Fields

The main nitrogen fertilizer used for rice in Asia is urea but is not used efficiently and the rice crop recovers only about 40% of applied nitrogen (De Datta, 1986). The unique condition of the rice fields can promote nitrogen losses through nitrification, denitrification, ammonia volatilization and leaching and that not only lead to decrease in nitrogen use efficiency but also to soil, water and atmospheric pollution (Zhao *et al*., 2010). The losses of NH_3 from different upland and lowland cropping systems found to be from negligible amount to 50 % of total nitrogen applied depending upon the method of its application and environmental conditions (Keller and Mengel, 1986). Yu *et al*. (2013) found that 23.9 % of total applied nitrogen through urea lost by volatilization from rice field. Sahu and Samant (2006) reported 10-40% of applied nitrogen lost through denitrification whereas Russo (1996) found 15-45% of surface applied ammonium fertilizer loss through nitrification-denitrification process in rice soils. Similarly, Reddy and Patrick (1975) reported that more frequency of alternate wetting and drying (2 days interval) of soil causes higher N loss (24.3%) as compared to less frequency of alternated wetting and drying (64 days interval, 12.9% loss) due to nitrification-denitrification which is the main feature of DSR.

Time of Nitrogen Application in Rice Crop

The demand for nitrogen by a growing crop is not constant through the growing season, being highest uptake associated with the period of most rapid growth stage. The main concern is that the timing of nitrogen fertilizer application so that it is taken up by the plant when it is really needed. Plants with deficiency of nitrogen during a high demand period may not produce full yield potential even with high nitrogen rates applied too late. Therefore, application timing can play a critical role in optimizing crop response, higher use efficiency and reducing the fertilizer cost (Pagani *et al*., 2013; Hossain and Islam, 1986).

Direct seeded rice requires very little or no supply of nitrogen fertilizer during first 3-4 weeks. Much of the nitrogen fertilizer applied as basal dose is not utilized by the crop and lost from the root zone. Therefore, to obtain high efficiency of nitrogen fertilizer, the major part of total nitrogen needs to be applied at the stage of 3-4 weeks after germination and rest at PI stage (Krishnaiah, 1998). Mahajan and Chauhan (2011) mentioned that nitrogen requirement of DSR at different growth stages can be met by increasing the number of splits and doses of nitrogen.

Real Time Nitrogen Management

In real time nitrogen management, the timing of nitrogen fertilizer applications is determined through periodic monitoring of crop nitrogen status (Witt *et al*., 2004). Cassman *et al*. (1994) reported that monitoring of plant N status is important in improving the balance between crop N demand and N supply from soil and applied fertilizer. Real-time N management was developed based on the physiology of rice leaf photosynthesis, tillering and leaf area growth to optimize canopy development and increase biomass accumulation and yield formation (Peng *et al*., 2003).

Crop-demand based nitrogen application is one of the important options to reduce nitrogen loss and increase nitrogen use efficiency of a crop. Leaf color chart can be used for adjustment of fertilizer nitrogen application based on plant nitrogen status (Balasubramanian *et al*., 1999). It is quick and non-destructive method for estimating leaf N status (IRRI, 1996). LCC measures leaf greenness and the associated leaf N by visually comparing light reflection from the surface of leaves and the LCC.

Leaf Color Chart (LCC)

A leaf color chart is a simple and inexpensive diagnostic tool used to measure green color intensity of rice leaves to assess the nitrogen requirements by non-destructive method (Nchimuthu *et al*., 2007). It is an important tool that enables farmer to adjust the nitrogen fertilizer application based on crop demand (Ali *et al*., 2012; Witt *et al*., 2005). It was jointly developed by the International Rice Research Institute (IRRI) and the Philippine Rice Research Institute (PhilRice) from a Japanese prototype in late 1990s (Shukla *et al*., 2004). It is made of high quality plastic material (8×3 inches) (Singh, 2008). It consist of six color shades ranging from light yellowish green (No 1) to dark green (No: 6) color strips fabricated with veins resembling those of rice leaves (Sathiya and Ramesh, 2009; Nchimuthu *et al*., 2007). The LCC used in Asia are typically a durable plastic strip about 7 cm wide and 13 to 20 cm long, containing four to six panels that range in color from yellowish green to dark green as in Fig 1 (Hushmandfar and Kimar, 2011).

Guidelines for Using the Leaf Color Chart

- Take LCC readings once every 7 to 10 days, starting from 14 days after transplanting (DAT) for transplanted rice and from 21 days after sowing to flowering for DSR.
- Choose the topmost fully expanded leaf color measurement because it reflects the N status of rice plants. The leaf color is measured by placing the middle part of the leaf on LCC and comparing the leaf's color with its color.
- During measurement, provide shade with your body, because leaf color reading is affected by Sun's angle and sunlight intensity. If possible, the same person should take LCC readings at the same time of the day.
- Take readings of ten leaves at randomly chosen in a plot. Alternately, if more than five leaves show reading below the set critical value, top dress N fertilizer to correct N deficiency (Ramanathan *et al*., 2003).
- Generally, critical value for semi dwarf high yielding varieties 4.0. If the average value fall below 4.0, top dress N fertilizer (20-30 Kg ha^{-1}) to correct N deficiency (Yoseftabar, 2013).

Grain Yield and Nitrogen Saving In LCC Based Management

It is important to manage nitrogen fertilizer more efficiently by making its application based on actual needs of rice plant so that a large fraction of applied nitrogen is translocated into grains (Singh and Singh, 2003). When N application is non-synchronized with crop demand, nitrogen losses from the soil-plant system are large, resulting in low N fertilizer use efficiency (Follett and Follett, 1992). Nitrogen management based on LCC cv. 4 helped to avoid excess application of nitrogen to rice and reduced nitrogen requirement from 12.5 to 25% without causing yield reduction (Bajpai *et al*., 2002). Likewise, some research findings related to yield and nitrogen saving in LCC based nitrogen management is presented in the Table 1.

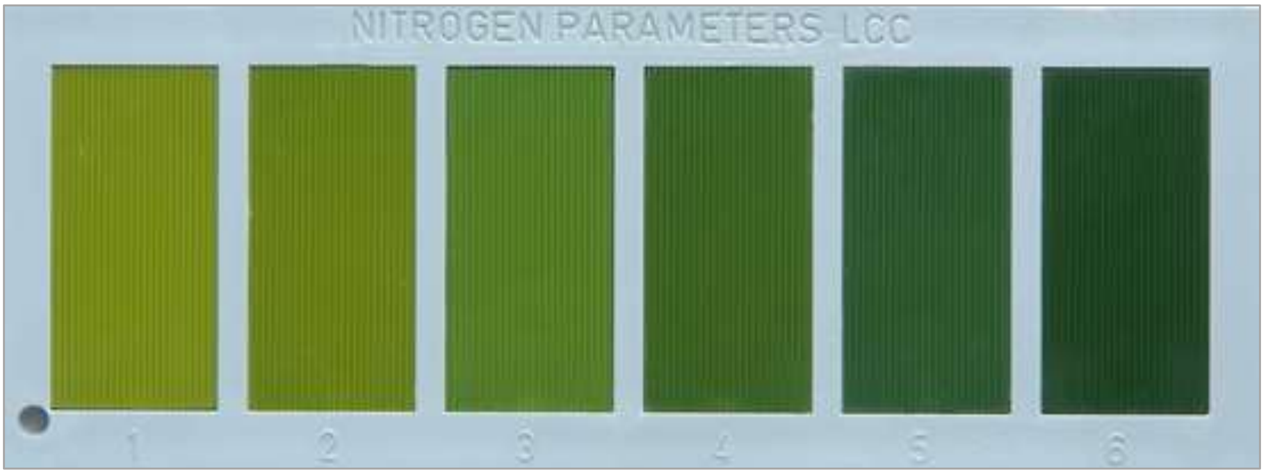

Fig. 1: Six panel LCC developed by IRRI and PhilRice

Table 1: Total nitrogen applied, yield and nitrogen saving in LCC based practices and recommended practice of split application.

References	Practices/Treatments	Total N applied (Kg ha^{-1})	Yield (t ha^{-1})	N saving (Kg ha^{-1})
Balasubramanian and Hill, 2002	Nitrogen applied based on LCC cv.4 Vs. Recommended dose in three equal splits	-	Increase grain yield of 2% to 8%	8 to 22
Jayanthi *et al.*, 2007	LCC cv. 3 @30 Kg N ha^{-1} at 7 days interval	90	2.81	10
	Recommended dose in three equal splits	100	2.55	
Singh *et al.*, 2014	LCC based N application	60 to 150	4.0 to 9.6	20-75
	Blanket application of N	80 to 225	3.8 to 9.1	
Hushmandf and Kimar, 2011	(LCC cv. 4 @20 Kg N ha^{-1} at 7 days interval)	60	Comparable yield	60
	(Recommended dose in four equal splits)	120		
Maiti *et al.*, 2004	(LCC based N application) Vs. (Recommended dose of 150 Kg N ha^{-1} in there equal splits)	-	Comparable yield	20–42.5

Conclusion

It is concluded that leaf color chart (LCC) is an easy to use and cost effective tool for monitoring chlorophyll of rice leaf. LCC based nitrogen management helps farmers to estimate the real time plant nitrogen demand of the crop and assures nitrogen saving without compromising their yields.

References

Ali MA, Ladha JK, Rickman J, Lales JS and Alam MM (2012) Evaluation of drill seeding patterns and nitrogen management strategies for wet and dry land rice. *Bangladesh Journal of Agricultural Research* **37**(4): 559-571.

Bajpai RK, Upadhya SK, Jhosi BS and Tripathi RS (2002) Productivity and economics of rice (*Oryza sativa* L.) - Wheat (*Triticum aestivum* L.) cropping system under integrated nutrient supply system. *Indian Journal of Agronomy* **47**: 20-25.

Balasubramanian V and Hill JE (2002) Direct seeding of rice in Asia: emerging issues and strategic research needs for the 21st century. In: Pandey S, Mortimer M, Wade L, Tuong. TP, Lopez K, Hardy B (Eds), Direct Seeding: Research Strategies and Opportunities. International Rice Research Institute, Los Baños, Philippines, pp 15–42.

Balasubramanian V, Morales AC, Cruz RT and Abdulrachman S (1999) On farm adaptation of knowledge-intensive nitrogen management technologies for rice systems. *Nutrients Cycle in Agro-ecosystems* **53**(1): 59-69. DOI: 10.1007/978-94-011-5078-1_5

Bhurer KP, Yadav DN, Ladha JK, Thapa RB and Pandey KR. (2013) Efficacy of various herbicides to control weeds in dry direct seeded rice (*Oryza sativa* L.). *Global Journal of Biology, Agriculture and Health Sciences* **2**(4): 205-212.

Cassman KG, Kropff MJ and Yan ZD (1994) A conceptual framework for nitrogen management of irrigated rice in high-yield environments. In: Viramani (Eds.) Hybrid Rice Technology: New Developments and Future Prospects, IRRI, Los Banos, Philippines, p. 296, 1994.

De Datta SK (1986) Improving N fertilizer efficiency in lowland rice in tropical Asia. *Fert Res* **9**: 171-186. DOI: 10.1007/BF01048702

Follett RH, Follett RF and Halvorson AD (1992) Use of a chlorophyll meter to evaluate the nitrogen status of dry land winter wheat. *Communications in Soil Science and Plant Analysis* **23**: 687–697. DOI: 10.1080/00103629209368619

Gathala MK, Ladha JK, Kumar V, Saharawat YS, Sharma PK, Sharma S and Pathak H (2011) Tillage and crop establishment affects sustainability of South Asian rice-wheat system. *Agronomy Journal* **103**(4): 961-971. DOI: 10.2134/agronj2010.0394

Gill JS, Walia SS and Gill RS (2014) Direct seeded rice: An alternative rice establishment technique in north-west India – A review. *International Journal of Advanced Research* **2**(3): 575-386.

Giri GS (1988) Effects of rice and wheat establishment techniques on wheat grain yield. In: Hobbs PR, Bhandari R (Eds.). *Proceedings of rice-wheat research end of project workshop*, India, pp. 65-68.

Hossain SMA and Islam MS (1986) Fertilizer management in Bangladesh. *Advances in Agronomy Research in Bangladesh* 48-54.

Hushmandfar A and Kimar A (2011) Callibrating the leaf color chart for rice nitrogen management in northern Iran. *African Journal of Agricultural Research* **6**: 2627-2633.

IRRI (1996) Use of Leaf Color Chart (LCC) for N Management in Rice. Crop Resource Management Network, Technological Brief 2. International Rice Research Institute Philippines.

Jayanthi T, Gali SK, Angadi VV and Chimmad VP (2007) Effect of leaf colour chart based nitrogen management on growth and yield parameters of rainfed rice. *Karnataka Journal of Agricultural Science* **20**(2): 272-275.

Joshi E, Kumar D, Lal B, Nepalia V, Gautam P and Vyas AK (2011) Management of direct seeded rice for enhanced resource use efficiency. *Plant Knowledge Journal* **2**(3): 119-134.

Keller GD and Mengel DB (1986) Ammonia volatilization from nitrogen fertilizers surface applied to no-till corn. *Soil Science Society of America Journal* **50**(4): 1060-1063. DOI: 10.2136/sssaj1986.03615995005000040045x

Krishnaiah K (1998) Rice (*Oryza sativa*) research in India. *Indian Journal Agricultural Science* **68**(8): 385-395.

Kumar V and Ladha JK (2011) Direct Seeding of Rice: Recent Developments and Future Research Needs. *Advances in Agronomy* **11**: 297-413. DOI: 10.1016/B978-0-12-387689-8.00001-1

Liu LJ, Xu W, Wu CF and Yang JC (2007) Characteristics of growth, development and nutrient uptake in rice under site-specific nitrogen management. *Chinese Journal of Rice Science* **21**(2): 167–173.

Mahajan G, Chauhan BS and Gill MS (2011) Optimal nitrogen fertilization timing and rate in dry-seeded rice in northwest India. *Agronomy Journal* **103**(6): 1676-1682. DOI: 10.2134/agronj2011.0184

Maiti D, Das DK, Karak T and Banerjee M (2004) Management of nitrogen through the use of leaf color chart (LCC) and soil plant analysis development (SPAD) or chlorophyll meter in rice under irrigated ecosystem. *The Scientific World Journal* **4**: 838-846. DOI: 10.1100/tsw.2004.137

Nchimuthu G, Velu V, Malarvizhi P, Ramasamy S and Gurusamy L (2007) Standardization of leaf colour chart based nitrogen management in direct wet seeded rice (*Oryza sativa* L.). *J Agro* **6**(2): 338-343.

Pagani A, Sawyer JE and Mallarino AP (2013) Site-specific nutrient management for nutrient management planning to improve crop production, environmental quality, and economic return. *Extension and Outreach Publications.* Iowa State University, 2013. (Available online at: http://lib.dr.iastate.edu/extension_pubs/116)

Pathak H, Tiwari AN, Sankhyan S, Dubey DS, Mina U, Singh VK, Jain N and Bhatia A (2011) Direct-seeded rice: Potential, performance and problems – A review. *Current Advances in Agricultural Sciences* **3**(2): 77-88.

Peng SB, Buresh RJ, Huang JL, Yang JC, Wang GH, Zhong XH and Hardy B (2003) Principles and practices of real-time nitrogen management: a case study on irrigated rice in China. In: Rice Science: Innovations and Impact for Livelihood. Proceedings of the International Rice Research Conference. Beijing, China, pp.433-446.

Ramanathan S, Chandrasekaran B, Rajendran R, Stalin P, Jayaraj T, Valliappan K and Buresh RJ (2003) Site-specific nutrient management (SSNM) for rice in Cauvery delta zone of Tamil Nadu. Tamil Nadu Rice Research Institute, IRRI-CIMMYT-CSISA project, pp.3-8

Reddy KR and Patrick Jr WH (1975) Effect of alternative aerobic and anaerobic conditions on redox potential,organic matter decomposition and nitrogen loss in a flooded soil. *Soil Biology and Biochemistry* **7**: 87-94. DOI: 10.1016/0038-0717(75)90004-8

Richardson AD, Duigan SP and Berlyn GP (2002) An evaluation of noninvasive methods to estimate foliar chlorophyll content. *New phytologist* **153**(1): 185-194. DOI: 10.1046/j.0028-646X.2001.00289.x

Russo S (1996) Rice yield as affected by the split method of N application and nitrification inhibitor DCD. *Cahiers Options Mediterraneennes* **15**: 43-53.

Sahu SK and Samant PK (2006) Nitrogen loss from rice soils in Orissa. *Orissa Review,* Department of Soil Science and Agricultural Chemistry, Bhubaneswar, India.

Sathiya K and Ramesh T (2009) Effect of split application of nitrogen on growth and yield aerobic rice. *Asian Journal of Experimental Science* **23**(1): 303-306.

Shukla AK, Ladha JK, Singh VK, Dwivedi BS, Balasubramanian V, Gupta RK, Sharma SK, Singh Y, Pathak H, Pandey PS, Padre AT and Yadav RL (2004) Calibrating the leaf color chart for nitrogen management in different genotypes of rice and wheat in a system perspective. *Agronomy Journal* **96**: 1606–1621. DOI: 10.2134/agronj2004.1606

Singh B (2008) Crop demand-driven site-specific nitrogen applications in rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L.): some recent advances. *Indian journal of agronomy* **53**(3):157-166.

Singh V, Singh B, Singh Y, Thind HS and Gupta RK (2010) Need based nitrogen management using the chlorophyll meter and leaf color chart in rice and wheat in South Asia: a review. *Nutr Cycl Agroecocys* **88**: 361-80. DOI: 10.1007/s10705-010-9363-7

Singh V, Singh B, Thind HS, Singh Y, Gupta RK, Singh S and Balasubramanian V (2014) Evaluation of leaf colour chart for need-based nitrogen management in rice, maize and wheat in north-western India. *Indian Journal of Research* **51**(3, 4): 239-245.

Singh Y and Singh B (2003) Using leaf color chart to make nitrogen recommendations in rice. Extension Folder. Dept. of Soils, PAU, Ludhiana, India. p.6.

USDA (2018) World Agricultural Production. United States Department of Agriculture. Circular Series WAP 2-18. (Accessed on 3rd Feb, 2018 from https://apps.fas.usda.gov/psdonline/circulars/production.pdf

Witt C, Buresh RJ, Balasubramanian V, Dawe D and Dobermann A (2004) Principles and promotion of site-specific nutrient management. In: Dobermann *et al*. (Eds.) Increasing productivity of intensive rice systems through site-specific nutrient management. Science Publishers, Enfield, NH, USA and IRRI, Los Banos, Philippines, p. 410.

Witt C, Pasuquin JMCA, Mutters R and Buresh RJ (2005) New leaf color chart for effective nitrogen management in rice. *Better Crops* **89**(1): 36-39.

Yoseftabar S (2013) Evaluation use leaf color chart in rice for nitrogen management. *Scientia Agriculturae* 3(3):66-69.

Yu QG, Jing YE, Yang SN, Fu JR, Sun WC, Jiang LN and Qiang WANG (2013) Effects of nitrogen application level on rice nutrient uptake and ammonia volatilization. *Rice Science* **20**(2): 139-147. DOI: 10.1016/S1672-6308(13)60117-1

Zhao L, Wu L, Dong C and Li Y (2010) Rice yield, nitrogen utilization and ammonia volatilization as influenced by modified rice cultivation at varying nitrogen rates. *Agricultural Sciences* **1**(1):10. DOI: 10.4236/as.2010.11002