Nitrogen Management in Rice through Leaf Colour Chart under Kashmir Conditions

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Abstract - **Large field to field variability restricts efficient fertilizer management when broad based blanket recommendations are used in rice. Hence, the nutrient management for rice requires an approach that enables adjustments in nutrient applications to accommodate the site-specific needs of the crop for supplemental nutrients. This study was conducted to establish and evaluate the threshold leaf colour value to guide in-season need based fertilizer N top dressing in Pusa Sugandh-3. For this purpose various growth parameters, yield parameters, grain and straw yield were measured in both years. Almost all the measured parameters in LCC 4 @ 20 kg N ha^{-1} were significantly higher than remaining LCC and fixed time N management treatments as well as control. Following the principle that threshold value is the one which simultaneously optimizes grain yield and NUE, LCC 4 @ 20 kg N ha^{-1} was adjudged as the threshold value for real time nitrogen management in Pusa Sugandh-3.**

INTRODUCTION

Rice (*Oryza sativa* L.) is the main staple food crop in India including Jammu & Kashmir. Globally, India stands first in area (36.95 m ha) and second in rice production (120.6 m tonnes) next only to China. In Jammu & Kashmir, rice is being cultivated on an area of 261.35 thousand hectares with a production of 761.1 thousand tonnes (Economic Survey, 2010).

Fertilizer nitrogen is a key input in rice production. In the coming time, Indian agriculture is likely to witness a delicate balance between inputs and outputs of reactive N (Singh, 2014). Substantial N inputs are required to be supplied to rice ecosystems to produce sufficient and high protein food for ever increasing population but at the same time minimal loss of this nitrogen from agriculture to other ecosystems must be ensured. Therefore efficient nitrogen utilization is must to produce more food with less N inputs. In India current N fertilizer recommendation in rice consists of fixed rates and timings for vast areas of land having climatic conditions. Owing to huge field to-field soil N variability, efficient use of N fertilizer is not possible when broad-based blanket recommendations are used (Adhikari *et al.*, 1999). One of the primary uncertainties faced by farmer is decide the time and amount of fertilizer N to be applied (Lobell, 2007). These uncertainties can be reduced by knowing the N supplying capacity of the soil. Huge portions of applied N are lost due to the lack of synchrony of plant-N demand with N supply. Thus improvement in the synchrony between crop-N demand and N supply from soil and/or the applied N fertilizer is likely to be the most promising strategy to increase N-use efficiency in cereal crops. The crop demand-driven site-specific N applications have the potential to add to farmers' productivity and profits and are crucial for achieving high yield and N-use efficiency (Singh, 2008). With this background, the current study was carried out at main campus SKUAST-K Shalimar to determine optimum nitrogen rate of rice variety 'Pusa Sugandh-3' through real time management approach using leaf colour chart (LCC)..

Materials and methods:

The field experiments were conducted at the University farm of SKUAST-Kashmir; main campus Srinagar during kharif season 2013 and 2014. The site is situated at 34-08′ N latitude and 74-83′ East longitude having an altitude of 1587 m above mean sea level. The average precipitation is 780.77 mm (average of past 28 years), most of which is received from December to April in the form of snow and rains. Atmospheric temperature ranges between the lowest winter temperature of −8ºC to the highest summer temperature of 33ºC. The mean meteorological data recorded during 2013 and 2014 at Meteorological Observatory, Division of Agronomy, Shalimar are presented in Fig.1 & 2 respectively.

The experiments consisted of eight treatments laid out in randomized completely block design (RCBD) in three blocks. Treatments included a control (N_0), three fixed time N (60, 90 and 120 kg N ha-1) and four real time N management treatments. In fixed time treatments, total N was applied in split doses at three predetermined stages i.e. 50% as basal dose and 25% each at mid tillering and panicle initiation stages. In real time N management

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treatments, LCC threshold shades were maintained by applying N whenever the green colour of more than 5 out of 10 leaves were observed equal to or below the set critical limit of LCC score. The six-panel leaf colour chart used was manufactured by N Parameters Chennai (India) as per the specifications of IRRI (IRRI, 1996). LCC measurements were made from the top most fully expanded leaf at weekly interval, starting from 15 days after transplantation (DAT) up to 50% flowering. The leaf being measured was kept under shade of the body during measurements to avoid colour variance caused by direct sunlight. Unusually tall or short plants, wet and widely spaced leaves were avoided.

Initial composite surface soil sample (0–15 cm depth) was collected, homogenised, processed and analyzed for various parameters. The soil was clayey loam in texture, medium in N, P and K. Basal rates of 25 kg ha^{-1} each of P and K as diammonium phosphate and potassium chloride respectively were uniformly applied to all plots of 10 m^2 (4 m × 2.5 m). Thirty-five days old seedlings were transplanted manually at 15 cm × 15 cm distance. Pre-emergence herbicide Butachlor 5% G was applied 3 days after transplanting (DAT).

At full maturity, rice crop was harvested manually. Grain yield was adjusted to 14% moisture content and straw yield was expressed on oven dry weight basis.

Statistical analysis

The data obtained was subjected to analysis of variance using R software (version 3.2.0; Developer: R Core Team, University of Auckland, New Zealand). Significantly different treatment means were separated using Fisher's protected least significant difference (LSD) test (Steel *et al*., 1997).

Results:

Growth parameters

The data pertaining to growth parameters is presented in Table 1. Significant influence of nitrogen management on the growth of crop when measured in terms of plant height was found. At harvest, highest plant height was observed in two LCC 4 treatments. Plant height in the 'recommended' treatment was below par as compared to them and was equal to LCC 3 at 30 kg N ha^{-1}. Plant height in '50% recommended', '75% recommended' and LCC 3 at 20 kg N ha^{-1} treatments was similar followed by control. The increased plant height might be attributed to efficient synchronization between nitrogen supply and demand at all the critical stages (Singh *et al*., 2009). The optimum level of nitrogen might have encouraged the carbohydrate synthesis that resulted in the taller plants (Gupta *et al*., 2011). The results are also in close conformity with Gaddanakeri *et al*. (2007). Dry matter production at both the levels of LCC 4 was highest and at par with each other. However the 'recommended' treatment couldn't keep pace with these two treatments and came down to the level of LCC 3 at 30 kg N ha^{-1} and '75% recommended' treatments. Dry matter production at '50% recommended' level and LCC 3 at 20 kg N ha^{-1} was statistically equal to each other and lowest quantity was supported by control. At flowering stage, SPAD value of two 'LCC 4' treatments and 'recommended' treatment was at par with each other and higher than all other treatments followed by '75% recommended' treatment. Further two 'LCC 3' treatments and '50% recommended' treatment had statistically similar SPAD value. Dry matter production is dependent upon the plant's metabolic activities and its corresponding growth. Higher chlorophyll content by virtue of higher leaf N concentration (Blackmer *et al*., 1994) can lead to higher photosynthetic rate (Peng *et al*., 1995), thereby resulting in greater biomass production (Kropff *et al*., 1993). In addition to this, higher photosynthetic area as evidenced by significantly higher LAI in LCC 4 treatments (data not shown) and presence of photosynthetically active leaves for longer time (greater number of days taken to maturity) resulted in higher dry matter production (Premalatha, 2001). Improved growth parameters viz. SPAD, plant height, dry matter accumulation, tiller number etc under LCC 4 governed treatments in comparison to the fixed time treatments clearly indicates that nitrogen availability to rice was more assured in the treatments where nitrogen was applied as per LCC scores (Debtanu *et al*., 2004).

Table – 1 Plant height (cm), Dry matter (q ha^{-1}) and SPAD of Pusa Sugandh-3 as affected by variable N fertilizer treatments during 2013 and 2014

Treatments	N rate (Kg ha^{-1})	Plant height (cm)		Dry matter (q ha^{-1})		SPAD	
		2013	2014	2013	2014	2013	2014
N_0	0	81.30 d	78.86 d	80.02 d	77.27 d	28.59 d	28.28 e
N_{60}	60	85.20 c	83.56 c	106.06 c	104.44 c	36.59 c	36.26 c
N_{90}	90	85.20 c	83.73 c	109.12 b	107.37 b	36.49 b	39.08 b
N_{120}	120	91.30 b	89.03 b	111.66 b	109.81 b	43.04 a	42.74 a
LCC 3_{20}	60	85.20 c	83.30 c	112.77 b	111.66 b	33.96 c	33.45 d
LCC 3_{30}	90	89.80 b	88.73 b	104.21 c	101.95 c	34.67 c	33.48 d
LCC 4_{20}	100	96.96 a	95.63 a	110.23 b	107.88 b	42.71 a	42.39 a
LCC 4_{30}	120	96.40 a	95.10 a	118.52 a	115.68 a	42.50 a	42.11 a

Yield parameters

The data related to yield parameters is presented in table 2. The trend followed by various treatments in case of Panicle length (cm) and Panicle wt. (g) was more or less similar. LCC 4 at 20 and 30 kg N ha^{-1} produced the highest length and weight of panicles. The weight and length of panicles produced at 'recommended', '75% recommended' and LCC 3 at 30 kg N ha^{-1} were at par with each other. Moreover similar length and weight of panicles were also recorded in the treatments like '50% recommended' and LCC 3 at 20 kg N ha^{-1}. The lowest panicle length and weight was observed in control treatment. It may be due to higher availability and uptake of nitrogen which is a substrate for synthesis of organic compounds, which constitute protoplasm and chlorophyll (Krishnakumar and Stephan, 2013). Besides, high leaf area (data not shown) coupled with high chlorophyll content at flowering has been reported to affect the amount of photosynthates available to the panicle (Avijit *et al*., 2011). The variation in yield components could also attributed to the variations in growth components like plant height, total dry matter production, number of tillers m^{-2} etc (Jayanthi *et al*., 2007). The data on test weight reveals that various nitrogen related treatments had no significant effect on the test weight during both the years.

Table – 2 Panicle length (cm), Panicle wt. (g) and Test wt. (g) of Pusa Sugandh-3 as affected by variable N fertilizer treatments during 2013 and 2014

Treatments	N rate (Kg ha^{-1})	Panicle length (cm)		Panicle wt. (g)		Test wt. (g)	
		2013	2014	2013	2014	2013	2014
N_0	0	18.29 e	17.91 d	1.96 d	1.83 d	23.84 a	23.56 a
N_{60}	60	20.25 d	19.78 c	2.69 c	2.58 c	23.98 a	23.71 a
N_{90}	90	22.44 b	22.02 b	3.10 b	2.99 b	23.96 a	23.63 a
N_{120}	120	22.73 b	22.21 b	3.16 b	3.06 b	24.08 a	23.81 a
LCC 3_{20}	60	20.47 cd	20.78 c	2.73 c	2.59 c	24.17 a	23.82 a
LCC 3_{30}	90	21.29 c	21.97 b	3.08b	2.94 b	24.03 a	23.70 a
LCC 4_{20}	100	24.42 a	23.96 a	3.56 a	3.39 a	24.18 a	23.97 a
LCC 4_{30}	120	24.13 a	23.68 a	3.49 a	3.33 a	24.03 a	23.71 a

Grain Yield (t ha^{-1}), Straw Yield (tha^{-1}) and Harvest index

Grain and straw yields exhibited similar pattern of changes w.r.t various nitrogen treatments (Table 3) during both the years. Two LCC 4 treatments produced statistically similar grain and straw yield which was higher than all the remaining treatments. The yields in case of 'recommended', '75% recommended' and LCC 3 at 30 kg N ha^{-1} treatments were at par with each other. As the nitrogen rate in case of LCC 3 at 20 kg N ha^{-1} and '50% recommended' decreased, yields also decreased. Yields in omission plot (control) were lowest. Higher grain yield obtained in LCC 4 @ 20 and 30 kg nitrogen ha^{-1} based nitrogen management might be due to more number of splits compared to other levels. These results are in close conformity with the findings of Maiti and Das (2006). Application of nitrogen at LCC 4 matched the crop demand at different physiological stages and reduced the losses through denitrification, volatilization and resulted in the highest grain yield (Porpavai *et al.*, 2002). The optimum availability of nutrients at distinct physiological phases exhibits a favourable effect on the yield characters and supports better assimilation of photosynthates towards grain (Ravi *et al*., 2007). Higher straw yield with two LCC 4 treatments over other treatments could be attributed to their favourable influence on growth parameters like plant height, tiller number, dry matter accumulation etc as discussed above. Perusal of data about harvest index (Table 3) shows that it remained unchanged w.r.t various nitrogen treatments during both the years. The only treatment where it was significantly lower than remaining treatments is control.

Table – 3 Grain Yield (t ha^{-1}), Straw Yield (t ha^{-1}) and Harvest Index (%) of Pusa Sugandh-3 as affected by variable N fertilizer treatments during 2013 and 2014

Treatments	N rate (Kg ha^{-1})	Grain Yield (t ha^{-1})		Straw Yield (t ha^{-1})		Harvest Index (%)	
		2013	2014	2013	2014	2013	2014
N_0	0	3.06 e	2.86 e	5.57 d	5.31 d	35.33 b	34.91 b
N_{60}	60	5.06 cd	4.84 cd	6.33 c	6.01 c	44.42 a	44.60 a
N_{90}	90	5.39 b	5.18 b	6.58 b	6.35 b	45.01 a	44.92 a
N_{120}	120	5.53 b	5.32 b	6.81 b	6.56 b	44.80 a	44.80 a
LCC 3_{20}	60	5.09 cd	4.86 cd	6.24 c	6.00 c	44.90 a	44.72 a
LCC 3_{30}	90	5.38 b	5.17 b	6.54 bc	6.37 b	45.16 a	45.17 a
LCC 4_{20}	100	5.87 a	5.67 a	7.22 a	6.93 a	44.85 a	44.99 a
LCC 4_{30}	120	5.86 a	5.65 a	7.18 a	6.95 a	44.94 a	44.83 a

CONCLUSION:

After taking in to account the overall results of all the observed parameters, the 'LCC 4 @ 20 kg N ha^{-1}' treatment proved superior to all the treatments in almost all the parameters. This was the treatment that best synchronized the nitrogen supply with crop nitrogen demand. The threshold LCC values are known as those that simultaneously optimize grain yield and nitrogen use efficiency. Based on this, it was adjudged as the best treatment. Therefore it is strongly recommended that the threshold leaf colour value (LCC 4 @ 20 kg N ha^{-1}) established in this study may be adopted for real time nitrogen management in Pusa Sugandh-3 under temperate conditions of Kashmir valley.

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