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Response of Rice Genotypes (*Oryza sativa* L.) to Leaf Colour Chart Based Nitrogen Management Under Temperate Environment

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ABSTRACT

Field experiment was conducted during *Kharif* seasons of 2012 and 2013 to study the response of rice genotypes (*Oryza sativa* L.) to real time nitrogen management guided by leaf colour chart (LCC). The pooled data showed that var. Shalimar Rice-2 recorded significantly higher value of yield attributes and grain yield (7.32 Mg ha^{-1}) as compared to var. Jhelum (6.58 Mg ha^{-1}). Agronomic efficiency and apparent N recovery was significantly higher in SR-2 compared to Jhelum. LCC ≤5 @ 30 kg N ha^{-1} (150 kg N ha^{-1} applied in 5 splits) recorded significantly higher grain yields (8.15 Mg ha^{-1}) but remained at par with 120 kg N ha^{-1} applied in 6 splits through LCC ≤5 @ 20 kg N ha^{-1} (7.88 Mg ha^{-1}), as compared to recommended dose of 120 kg N (7.15 Mg ha^{-1}). Nitrogen use efficiency and quality parameters (protein and amylose content) were significantly higher with LCC-based N management than the recommended N management.

Key Words: Economics; Genotypes; Leaf Colour Chart; N Use Efficiency; Yield

INTRODUCTION

Rice is one of the important cereal crop grown in India. Improper and injudicious use of nutrients is one of the major hurdles in increasing the rice productivity. Among the major plant nutrients nitrogen is the most critical element in crop production (Nachimuthu et al. 2007). It is vital for maintaining and improving crop growth and yield (Koyama 1981). Nitrogen losses from the soil-plant system are large leading to low fertilizer N-use efficiency when N application is not synchronizing with crop demand (Maiti and Das 2013). The best measure could be to synchronize N application with active crop growth demand (Ravi et al. 2007). Improvement in the synchrony between crop N demand and the N supply from soil or the applied N fertilizer is likely to be the most promising strategy to improve N use efficiency (Porpavai et al 2002). Gadgets like chlorophyll meter and inexpensive leaf colour chart (LCC) are simple, quick and non-destructive in-situ tools for measuring relative content of chlorophyll in leaf that is directly proportional to leaf N content. The use of leaf colour charts were evaluated in N fertilizer management to achieve the synchrony of N supply and demand, and to improve fertilizer N-use efficiency in rice (Avijit et al. 2011), but there is a need to work out appropriate criteria for using need based N management strategy in rice. Combination of preventive location specific split schedule with corrective LCC based N management creates another impressive strategy for attaining high N use efficiency, and hence the present study was taken.

MATERIALS AND METHODS

Field experiment was conducted during kharif season of

2012 and 2013 at Research Farm, Sher-e-Kashmir University of Agricultural sciences and Technology of Kashmir, Shalimar, Srinagar (34-08′ N latitude and 74-83′ East longitude and 1587 m above the mean sea level). The soil of the experimental field was silty clay loam containing 0.92% organic C, with pH 6.6, EC 0.22 dS m^{-1}, available N 308.96 kg ha^{-1}, P 33.38 kg ha^{-1} and ammonium acetate extractable K 169.26 kg ha^{-1}. During crop cycle, the area receives 690 mm of mean annual rainfall most of which occurs from December to April. Rainfall received during the rice-growing season (June to September) was 222.2 and 375 mm during 2012 and 2013, respectively. The mean monthly minimum temperatures during the rice growing seasons varied from 9.94 to 19.36 ºC and 9.51to 19.11 ºC and the maximum mean monthly temprature from 22.14 to 32.36 ºC and 22.96 to 32.50 ºC, during 2012 and 2013, respectively.

The treatments included two rice genotypes viz. Shalimar Rice-2 and Jhelum, eight rates of N application (control, recommended practice and LCC ≤ 3, 4 and 5 @ 20 and 30 kg N ha^{-1}). In recommended practice, Nwas applied in 3 equal splits (120 kg N ha^{-1}) at transplanting (basal), mid-tillering and panicle initiation. For leaf colour chart-based N management, LCC readings were taken at 4 days interval starting from 12 days after treatment (DAT) till 50% flowering. 10 disease free hills were selected at random from the sampling area in each plot. From each hill, top most fully expanded leaf was selected and LCC readings were taken by placing the middle part of the leaf on the chart and the leaf colour was observed by keeping the sun blocked by body as sun light affects leaf colour reading. Whenever the green colour of more than 5 out of 10 leaves were observed equal to or below a set critical limit of LCC score, nitrogen was applied as per the treatments in both the varieties (Table 1). Thirty five days old seedlings of rice genotypes were transplanted manually at 15 × 15 cm in the second week of June. All the treatment plots received uniform dose of 60 kg P ha^{-1}, 30 kg K ha^{-1} and 15 kg zinc sulphate ha^{-1} as basal dose before transplanting. Standard crop production practices were followed for weeding, irrigations and crop protection management to grow the crop.Rice was harvested manually in the third week of September. Grain yield and straw were expressed on the basis of q ha^{-1} at 18 % moisture content. Grain and straw samples were dried finely ground to pass through a 0.5 mm sieve. Nitrogen content in grain and straw were determined by micro-Kjeldahl method. The agronomic efficiency (AEN) and apparent recovery (ARN) of added N were calculated as per the standard formulae (Cassman et al. 1998). Economics were calculated by considering the prevailing sale price of rice and the cost of cultivation. Analysis of variance (ANOVA) was performed using SPSS. Least significance difference at 0.05 level of probability was used to test the significance of differences among treatment means (Cochran and Cox 1957).

Table 1. Total quantity of nitrogen (kg) applied under different treatments in rice cultivars *viz* Jhelum and SR-2 during 2012 and 2013.

Treatments	Number of splits	Total N applied
Absolute control	0	0
Recommended dosage of N	3	120
LCC ≤ 3 at 20 kg N ha^{-1}	4	80
LCC ≤ 3 at 30 kg N ha^{-1}	3	90
LCC ≤ 4 at 20 kg N ha^{-1}	5	100
LCC ≤ 4 at 30 kg N ha^{-1}	4	120
LCC ≤ 5 at 20 kg N ha^{-1}	6	120
LCC ≤ 5at 30 kg N ha^{-1}	5	150

Agronomic efficiency (kg grain kg^{-1} N applied) of added N was calculated as:

$$AEN = \frac{\text{[Grain yield in N-fertilized plots] - [Grain yield in zero-N plot]}}{\text{[Quantity of N fertilizer applied in N-fertilized plot]}}$$

Recovery efficiency of added N (REN was calculated as:

$$REN\ (\%) = \frac{\text{[Total N uptake in N-fertilized plot] - [Total N uptake in zero N plot]}}{\text{[Quantity of N fertilizer applied in N-fertilized plot]}} \times 100$$

RESULTS AND DISCUSSION

Number of Tillers

Cultivar SR-2 produced significantly higher number of tillers m^{-2} at all the periodic stages as compared to Jhelum (Table 2). Moreover, number of tillers m^{-2} increased up to 60 DAT and thereafter decreased till harvest. The number of tillers decreased after flowering possibly due to senescence of the secondary tillers and

Table 2. Effect of real time nitrogen management on number of tillers m^{-2} in rice genotypes (Pooled over two years).

Treatments	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT	70 DAT	80 DAT	90 DAT	Harvest
Varieties									
Jhelum	304.65	368.05	412.74	433.76	420.63	407.31	389.86	382.87	376.21
SKAU-341	313.65	379.69	424.56	444.76	431.59	426.59	415.04	412.10	409.04
SEm±	2.46	3.28	3.42	4.12	3.81	5.22	4.14	2.73	3.46
CD ($P \leq 0.05$)	7.40	9.85	10.28	12.47	11.44	15.67	12.42	8.21	10.40
Nitrogen Management									
Control	272.20	315.61	351.07	372.84	363.51	358.50	354.25	351.78	349.72
Recommended	305.46	369.09	413.47	437.67	424.84	420.67	417.00	413.70	411.34
LCC ≤ 3@ 20 N kg ha^{-1}	296.16	356.67	401.66	423.84	412.01	408.67	402.84	400.98	398.67
LCC ≤ 3@ 30 N kg ha^{-1}	301.17	363.21	408.42	430.84	417.01	413.17	408.26	406.20	404.84
LCC ≤ 4 @ 20 N kg ha^{-1}	318.00	387.60	436.60	455.01	439.84	433.34	423.01	419.03	416.67
LCC ≤ 4 @ 30 N kg ha^{-1}	330.37	402.81	451.01	467.67	451.01	444.00	432.92	429.00	426.84
LCC ≤ 5 @ 20 N kg ha^{-1}	336.10	414.51	461.71	480.17	468.34	461.84	439.17	435.72	431.42
LCC ≤ 5 @ 30 N kg ha^{-1}	345.85	425.73	474.27	487.51	477.84	470.42	445.17	441.45	438.75
SEm±	4.68	7.23	7.21	6.54	8.44	8.92	4.22	3.84	4.47
CD ($P \leq 0.05$)	14.06	21.71	22.65	19.64	25.41	26.76	12.66	11.52	13.43

DAT = Days after treatment

Table 3. Effect of real time nitrogen management on effective panicles m^{-2} and yield in rice cultivars (Pooled data over two years).

Treatments	Effective panicles m^{-2}	Panicle length (cm)	Panicle weight (g)	Fertile grains /panicle	Test weight (g)
Varieties					
Jhelum	374.44	21.07	2.39	72.56	24.19
SKAU-341	404.93	21.91	2.58	74.99	24.83
SEm±	3.64	0.20	0.05	0.70	0.09
CD ($P \leq 0.05$)	10.92	0.57	0.14	2.12	0.29
Nitrogen management					
Control	348.22	14.43	1.58	53.24	22.57
Recommended	411.39	22.45	2.11	76.80	24.26
LCC ≤ 3@ 20 N kg ha^{-1}	400.38	19.75	2.00	72.49	24.03
LCC ≤ 3@ 30 N kg ha^{-1}	404.05	21.41	2.07	75.94	24.16
LCC ≤ 4 @ 20 N kg ha^{-1}	417.39	22.63	2.57	79.57	24.44
LCC ≤ 4 @ 30 N kg ha^{-1}	427.05	22.86	2.60	81.77	24.68
LCC ≤ 5 @ 20 N kg ha^{-1}	431.17	23.35	2.66	84.09	24.86
LCC ≤ 5 @ 30 N kg ha^{-1}	438.94	25.07	2.87	87.31	25.53
SEm±	6.71	0.40	0.08	1.44	0.21
CD ($P \leq 0.05$)	20.21	1.14	0.24	5.33	0.63

tertiary tillers. The results are in agreement with the findings of Laza et al. (2004). Nitrogen application through LCC ≤5 @ 30 and 20 kg N ha^{-1} produced the highest number of tillers m^{-2} at all the growth stages over other LCC scores and recommended nitrogen level. Similarly, application of nitrogen through LCC ≤4 @ 30 and 20 kg N ha^{-1} produced significantly more number of tillers than LCC ≤ 3@ 30 and 20 kg N ha^{-1}

and recommended nitrogen level. Irrespective of crop growth stage, the number of tillers varied in accordance with the quantity of N applied, higher value was recorded in treatments receiving a higher quantity of nitrogen. This might be due to application of nitrogen as per crop chlorophyll content at different crop growth intervals, eventually leading to better utilization of nitrogen for growth and development (Gupta et al 2011).

Yield Attributes

Data indicated that yield attributes were significantly influenced by rice genotypes and LCC based N management (Table 3). SR-2 recorded significantly highest number of panicles m^{-2}, panicle length, panicle weight, filled grains panicle^{-1} and test weight as compared to Jhelum. This might be due to their genetic makeup. Besides, more LAI, tillers m^{-2} and dry matter in SR-2 might also have resulted in higher values of yield attributes as compared to Jhelum. Avijit et al. (2011) have also reported variation in the grain yield of different rice cultivars.LCC ≤ 5 @ 30 and 20 kg N ha^{-1} recorded significantly highest number of panicles m^{-2}, panicle length, panicle weight and filled grains panicle^{-1} as compared to LCC ≤ 4 @ 30 and 20 kg N ha^{-1}, LCC ≤ 3@ 30 and 20 kg N ha^{-1} and recommended N level. Maximum number of early formed tillers under favourable N (LCC) nutrition tends to bear more number of panicles. It was be due to higher availability and uptake of N which is a substrate for synthesis of organic compounds, which constitute protoplasm and chloro-phyll. Higher value of yield attributes in LCC 5 over other LCC scores and recommended nitrogen level was attributed to increased N application in splits synchro-nizing the nutritional demand of rice at all the growth stages. These results are supported by the findings of Avijit et al. (2011).

Biological Yield and Harvest Index (HI)

Data on the yields and HI of rice genotypes presented in Table 4 show that SR-2 recorded significantly higher grain, straw, biological yield and harvest index than cultivar Jhelum. Rice yield is dependent on the number of panicles m^{-2} and grains per panicle which were significantly higher in SR-2 and resulted in higher grain yield. SR-2 also produced significantly higher dry matter than Jhelum contributing to higher yield. The findings of Avijit et al. (2011) also support these results. LCC ≤ 5 @ 30 and 20 kg N ha^{-1} recorded significantly higher grain yield than LCC ≤4 @ 30 and 20 kg N ha^{-1}, LCC ≤3 @ 30 and 20 kg N ha^{-1} and recommended application of nitrogen. Higher grain yield obtained in LCC ≤5 @ 30 and 20 kg N ha^{-1} was due to more nitrogen applied in more splits compared to other levels. Application of nitrogen at LCC 5 matched the crop demand at different growth stages and reduced the losses resulting in highest grain yield. The increased availability of nutrients at distinct physiological phases would have supported better assimilation of photosynthates towards grain and also due to the favourable effect on the yield characters. Application of higher dose of N promoted more biomass (significant increase in straw and biological yield) which is also attributed to higher number of tillers and higher N uptake. These results are also in conformity with the findings of Maiti and Das (2006) and Ravi et al. (2007).

Table 4. Effect of real time nitrogen management on grain, straw and biological yield (Mg ha^{-1}) and harvest index (%) in rice cultivars (Pooled data over two years).

Treatments	Grain	Straw	Biological Yield	Harvest Index
Varieties				
Jhelum	6.58	8.21	14.79	44.58
SKAU-341	7.33	8.70	15.96	45.47
SEm±	0.23	0.15	0.38	0.09
CD (P≤0.05)	0.70	0.46	1.14	0.28
Nitrogen management				
Control	4.07	5.92	9.98	40.72
Recommended	7.15	8.57	15.72	44.48
LCC ≤ 3@ 20 N kg ha^{-1}	6.77	8.15	14.92	45.36
LCC ≤ 3@ 30 N kg ha^{-1}	7.01	8.41	15.41	45.68
LCC ≤ 4 @ 20 N kg ha^{-1}	7.42	8.86	16.28	45.60
LCC ≤ 4 @ 30 N kg ha^{-1}	7.54	9.04	16.58	45.45
LCC ≤ 5 @ 20 N kg ha^{-1}	7.8.8	9.28	17.16	45.92
LCC ≤ 5 @ 30 N kg ha^{-1}	8.15	9.59	17.74	45.97
SEm±	0.09	0.09	0.19	0.15
CD (P≤0.05)	0.29	0.28	0.57	0.44

Nitrogen Use Efficiency

Data pertaining to nitrogen use efficiency is presented in Table 5. Pooled data showed that different LCC scores had significant effect on agronomic efficiency (AE) and Apparent N recovery (ANR), however the two rice genotypes did not showed significant variation with respect to AE and ANR. It was observed that both AE and ARN declined with increased application of nitrogen under LCC guided N management but recorded higher NUE over recommended dose of nitrogen. Application of nitrogen through LCC ≤ 3 @ 20 kg ha^{-1} (80 kg N ha^{-1}) recorded highest AE followed by LCC ≤ 4 @ 20 kg ha^{-1} (90 kg N ha^{-1}). Highest apparent recovery of nitrogen (ANR) was recorded by LCC ≤ 4 @ 20 kg N ha^{-1} and LCC ≤ 5 @ 20 kg N ha^{-1} (100 and 120 kg N ha^{-1}) whereas recommended nitrogen level observed lowest AE and ANR followed by LCC ≤ 5 @ 30 kg ha^{-1} (150 kg ha^{-1}).. Improving the synchronization between crop N demand and the available N supply is a pivotal measure to enhance nitrogen use efficiency. These results indicated that the application of N, based on LCC effectively matched the rice crop N demand. Singh et al(2006) also reported that the higher fertilizer N-use efficiency was recorded with need-based N management using LCC 3 rather than LCC 5 and LCC 4.

Table 5. Effect of real time nitrogen management on agronomic efficiency (kg grain kg^{-1} N applied), apparent nitrogen recovery (%), protein (%) and amylase content (%) in rice cultivars (Pooled data over 2012 and 2013).

Treatments	Agronomic Efficiency	N recovery (%)	Protein (%)	Amylose (%)
Varieties				
Jhelum	30.47	41.46	7.06	17.11
SKAU-341	29.40	40.06	7.18	17.28
SEm±	0.29	0.20	0.02	0.08
CD (P≤0.05)	0.87	NS	NS	NS
Nitrogen management				
Control	-	-	7.06	16.63
Recommended	20.51	31.76	7.18	15.71
LCC ≤3@ 20 N kg ha^{-1}	33.79	41.05	7.18	17.22
LCC ≤3@ 30 N kg ha^{-1}	31.29	40.44	7.24	16.94
LCC ≤4 @ 20 N kg ha^{-1}	32.68	42.20	7.30	15.95
LCC ≤4 @ 30 N kg ha^{-1}	28.86	36.92	7.36	15.76
LCC ≤5 @ 20 N kg ha^{-1}	31.79	41.10	7.42	15.84
LCC ≤5 @ 30 N kg ha^{-1}	27.15	35.69	7.54	15.29
SEM ±	0.80	0.77	0.07	0.13
CD (P≤0.05)	2.40	2.32	0.23	0.39

Protein and Amylose Content (%)

Protein and amylose content (%) were not significantly affected by rice cultivars during both the years of experiment, however, SR-2 recorded higher values of protein content and amylose content as compared to Jhelum (Table 5). Similar variation in the protein and amylose content was also reported by Sikander et al., (2008). Application of nitrogen through LCC ≤ 5 @ 30 and 20 kg N ha^{-1} and LCC ≤ 4 @ 30 kg N ha^{-1} recorded significantly higher protein content in grain as compared to other LCC treatments and recommended nitrogen level (Table 6). This might be due to the fact that fertilized plants efficiently utilize the micronutrients during their growth and development, resulting in increased synthesis of proteins and other biological molecules (Ahmad et al 2009). Dong et al (2007) found that the crude protein content increased and that higher protein levels accumulated in the grain with increased amount of nitrogen applied. The highest amylose content (17.22 and 16.94 %) was recorded with LCC ≤ 3 @ 20 kg N ha^{-1} and LCC ≤ 3 @ 30 kg N ha^{-1} whereas, LCC ≤ 5 @ 30 and 20 kg N ha^{-1} recorded the lowest amylose content (15.29 %). This might be due to the fact that starch branching enzyme (Q-enzyme) activity increased when the nitrogen level increased from 0 kg ha^{-1} to 150 kg ha^{-1}. Moreover, the activity of Q-enzyme was significantly and negatively correlated with the amylose content, suggesting that nitrogen application could regulate the activity of Q-enzyme, thereby affecting the physical and chemical properties of rice (Dong et al 2007). Muhammad et al (2013) recorded decrease in the amylose content with an increase in the crude protein content with nitrogen application or uptake.

CONCLUSION

It is concluded that the LCC is a facile and cheap tool for efficient N management in transplanted rice genotypes under temperate conditions of Kashmir. The application of 150 and 120 kg N ha^{-1} in 5 and 6 equal splits through LCC ≤5 @ 30 kg N ha^{-1} and LCC ≤5 @ 20 kg N ha^{-1} was best for grain yield, agronomic efficiency and apparent recovery of N in account of applied N fertilizer.

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REFERENCES

Ahmad, S.; Zia-ul-Haq, M.; Ali, H.; Ahmad, A.; Khan, M.; Khaliq, T.; Husnain, Z.; Hussain, A. and Hoogenboom, G. 2009. Morphological and quality parameters of *Oryza sativa* L. as affected by population dynamics, nitrogen fertilization and irrigation regimes. Pakistan Journal of Botany 4:1259–1269.

Arumugaperumal, N, 2000. Studies on Plant Density and Nitrogen Management in Hybrid Rice (CORH 2) under Thambiraparani Command area. M.Sc. (Ag.) Thesis, TNAU, Coimbatore, India 189 pages.

Avijit, S.; Srivastava, V.K.; Singh, M.K.; Singh, R.K. and Suneel, K. 2011. Leaf colour chart vis-a-vis nitrogen management in different rice genotypes. American Journal of Plant Science 2(2): 223-236.

Bijay, S.; Yadvinder,J.K.; Ladha, K.F.; Bronson, V.; Balasubramanian, S.J. and Khind, C.S. 2002. Chlorophyll meter and leaf colour chart-based nitrogen management for rice and wheat in Northwestern India. Agronomy Journal 94(4): 821-829.

Cassman, K.G.; Peng, S.; Olk, D.C; Ladha, J.K.; Reichardt, R.; Dobermann, A. and Singh, U.1998.Opportunities for increased nitrogen use efficiency from improved resources management in irrigated lowland rice systems. Field Crop Research 56:7-38.

Cohran, W.G. and Cox, G.M. 1957. Experimental Design. John Wiley, New York. 640 pages.

Dong M.H.; Sang, D.Z.; Wang, P.; Wang, X.M. and Yang, J.C. 2007. Changes in cooking and nutrition qualities of grains at different positions in a rice panicle under different nitrogen levels.Rice Science14: 141-148.

Ganajaxi, M.H.D.; Hedge, Y. and Angadi, V.V. 2001. Effect of planting dates and nitrogen levels on the grain yield of aromatic rice genotypes under rainfed conditions. Karnataka Journal of Agricultural Sciences 14(3): 758-759.

Gupta, R.K.; Varinderpal S.; Yadvinder, S. and Bijay, S.; Thind, H.S.; Ajay, K. and Monika, V. 2011. Need-based fertilizer nitrogen management using leaf colour chart in hybrid rice (*Oryza sativa*). Indian Journal of Agricultural Sciences 81(12): 1153–1157.

Laza, R.C.; Peng, S.; Akita, S.; Saka, H. 2004. Effect of panicle size on grain yield of IRRI-released indica rice cultivars in the wet season. Plant Production Science 73(3): 271-276.

Maiti, D. and Das, D.K. 2006. Management of nitrogen through the use of leaf colour chart (LCC) and soil plant analysis development (SPAD) in wheat under irrigated ecosystem. Archives of Agronomy and Soil Science 52(1): 105-112.

Muhammad, M.; Muhammad, A.S.; Syed, N.A.A. and Munawar, I.2013.Rice cultures and nitrogen rate effects on yield and quality of rice (*Oryza sativa* L.).Turkish Journal of Agriculture and Forestry 37: 665-673.

Nachimuthu, G.; Velu, V.; Malarvizhi, P.; Ramasamy, S. and Gurusamy, L. 2007. Standardisation of Leaf Colour Chart based nitrogen management in direct wet seeded rice (*Oryza sativa* L.). Journal of Agronomy 6(2): 338-343.

Porpavai,S.; Muralikrishnasamy; Nadanassababady,T.P.;Jayapaul, T.P. and Balasubramanian, V. 2002. Standardising critical Leaf Colour Chart values for transplanted rice in Cauvery New Delta. Agricultural Science Digest 22(3): 207–208.

Ravi, S.; Ramesh, S. and Chandrasekaran, B. 2007. Exploitation of hybrid vigour in rice hybrid (*Oryza sativa* L.) through green manure and leaf colour chart (LCC) based N application. Asian Journal of Plant Sciences 6(2): 282-287.

Reddy, M.B.G. and Pattar, P.S. 2006. Leaf colour chart-a simple and inexpensive tool for nitrogen management in transplanted rice (*Oryza sativa*). Indian Journal of Agricultural Sciences 76(5): 289–92.

Sikander, M.S.I.; Rahman, M.M.; Islam, M.S.; Yeasmin, M.S. and Akhter,M.M. 2008. Effect of nitrogen level on aromatic rice varieties and soil fertility status. International Journal of Sustainable Crop Production 3(3): 49-54.

Singh, B,; Gupta, R.K.; Singh, Y.; Gupta, S. K.; Singh, J.; Bains, J.S. and Vashishta, M. 2006. Need-based nitrogen management using leaf colour chart in wet directseeded rice in northwestern India. Journal of New Seeds 8(1): 35-47.

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