Forage Res., **51**(1) : pp. 57-62 (2025) **http://forageresearch.in**

IMPACT OF PAU-LCC GUIDED FERTILIZER APPLICATION ON YIELD ATTRIBUTES AND PHYSIOLOGICAL PARAMETER OF BASMATI RICE

SATENDER KUMAR[1]*, DEV RAJ[1], RAJBIR GARG[2], VIKAS[1], ANKUSH KAMBOJ[1] AND PRIYANKA SANWAL[1]

[1]Department of Soil Science, CCS Haryana Agricultural University, Hisar-125 004 (Haryana), India
[2]Department of Agronomy, CCS Haryana Agricultural University, Hisar-125 004 (Haryana), India
*(e-mail: satendernarnoliya7@gmail.com)
(Received: 20 April 2025; Accepted: 27 June 2025)

SUMMARY

The suitability of PAU-LCC for N management in evolved Basmati rice (PB 1718) was evaluated at Research farm of KVK Panipat during *kharif* 2020. The investigation was carried out in a randomized block design with three replications and eleven treatments. The results of the experiment revealed that the yield and yield attributes like grain yield (4311 kg/ha), straw yield (6203 kg/ha), harvest index (43.11%) and number of tillers (246.7) was higher when nitrogen was applied according to recommended PAU-LCC band 4 (T3). Physiological parameters (Dry matter accumulation (DMA), CGR, RGR and chlorophyll content) were also affected by various nitrogen treatment, Highest mean values were recorded when N was applied as per PAU recommended LCC band 4 N management practice. The highest value of DMA (487.03 g/m^2) was observed at harvesting stage. CGR was significantly higher (8.62 g/g/m^2) at 100 DAT, maximum RGR (0.181 g/g/day) was recorded at 21 DAT and maximum chlorophyll content.

Key words: Evaluation, leaf colour chart, yield attributes, dry matter accumulation, CGR, RGR, chlorophyll

Rice (*Oryza sativa* L.) being the most important cereal crop of the world, fulfills one-third of food requirement of the world population. It provides some 700 calories per person, mostly residing in developing countries (Barai *et al*., 2009). In India, rice was cultivated in an area of 45.07 mha (ranks first) producing 122.27 mt (ranks second only after China) with a productivity of 2713 N/ha (Anonymous, 2021a). The production, productivity and area of rice crop in Haryana is respectively 4.88 million tonnes, 1.42 million hectares and 3432 N/ha (Anonymous, 2020b) which is attributed to extra -long grains, distinct aroma, good taste and high cooking quality. It is recommended to apply fertilizer nitrogen according to a pre fixed rates and at different timings during crop growth period. Application of 90 kg N/ha at 0, 21 and 42 days after transplanting (DAT) is recommended in North-Western Basmati rice growing areas of India. This research concluded by most of the researchers in past was discussed briefly, (Singh *et al*., 2012) was studied application of fertilizer in line with blanket recommendations helps to improve nutrient supply at critical growth periods but still this approach has a limited efficacy in improving nitrogen use efficiency. This drawback is largely attributed to spatial and temporal variability of soil nitrogen supply in a large area which obstruct efficient use of nitrogen fertilizer applied according to broad-based blanket fertilizer recommendations. (Raj *et al*., 2014) conclude that real time application (LCC) may can provide continuous and steady supply of nutrient N into the soil solution to match the required absorption pattern of rice to meet the physiological process which in turn produce higher number of total grains per panicle, increased quantum of fertile grain per panicle and higher grain yield and also use estimation techniques to forecasted rice yield (Sharma *et al*., 2024). (Singh *et al*. 2011) discussed, synchronizing fertilizer N application with crop demand following need-based fertilizer N management practices can produce potential yields, reduce N losses and improve N use efficiency. Nitrogen being primary nutrient is required by plants to build up vegetative biomass and plant organs. It is an inseparable component of a number of organic compounds which include proteins, alkaloids, nucleic acids and pigments. It also forms a part of nucleic acids, therefore playing crucial role in genetic makeup of plant. Photosynthesis without nitrogen is not possible as it also comprises of one of the structural components of photosynthetic pigment called chlorophyll. Availability of more nitrogen helps to improve efficiency of root system by increasing its biomass (Fageria and Barbosa, 2001). The spectral properties of rice leaves can be efficiently utilized by farmers to make foremost resolutions for requirement based in- season fertilizer N topdressings (Singh *et al.,* 2011).

MATERIALS AND METHODS

A field trial was carried out to study the ''Evaluation of leaf colour chart as nitrogen management tool for Basmati Rice" at research farm, Krishi Vigyan Kendra Panipat, of Chaudhary Charan Singh Haryana Agricultural University during the *kharif* 2020 season. The soil of experimental site was sandy loam textured, having alkaline pH (8.3), EC as 0.33 dS/m. Medium organic content of soil are (0.63%), low available N (127 kg/ha), high available P (37 kg/ha) and medium available K (166 kg/ha). The experiment was laid out in randomized block design (RBD) consisting of eleven treatments with three replications.

Treatment details: T_1 Control, T_2 RDF (30 kg N ha^{-1} basal + 30 kg N ha^{-1} 21 DAT + 30 kg N ha^{-1} 42 DAT), T_3 Recommended PAU LCC practice (30 kg N ha^{-1} basal + need based N application @ 30 kg ha^{-1} when LCC value is below 4 starting from 14 DAT), T_4 30 kg N ha^{-1} at 14 DAT + need based N application @ 30 kg ha^{-1} when LCC value is below 4 starting from 21 DAT, T_5 30 kg N ha^{-1} at 21 DAT + need based N application @ 30 kg ha^{-1} when LCC value is below 4 starting from 40 DAT, T_6 18 kg N ha^{-1} at 14 DAT + need based N application @ 18 kg ha^{-1} when LCC value is below 4 starting from 21 DAT, T_7 18 kg N ha^{-1} at 21 DAT + need based N application @ 18 kg ha^{-1} when LCC value is below 4 starting from 40 DAT, T_8 30 kg N ha^{-1} at 14 DAT + need based N application @ 30 kg ha^{-1} when LCC value is below 3.5 starting from 21 DAT, T_9 30 kg N ha^{-1} at 21 DAT + need based N application @ 30 kg ha^{-1} when LCC value is below 3.5 starting from 40 DAT,T_{10} 18 kg N ha^{-1} at 14 DAT + need based N application @ 18 kg ha^{-1} when LCC value is below 3.5 starting from 21 DAT,T_{11} 18 kg N ha^{-1} at 21 DAT + need based N application @ 18 kg ha^{-1} when LCC value is below 3.5 starting from 40 DAT. All agronomic practices such as irrigation, weeding and other cultural practices were followed as per the package and practices of CCS HAU, Hisar.

Harvest index

Harvest index (HI) is called the coefficient of effectiveness of formation of economic part of total yield. It is a characteristic of the movement of dry matter to the economic part of plant. The harvest index is expressed as the percent ratio between the economic yield and total biological yield.

Dry matter accumulation

The selected four plants were separated into stem, panicle and leaf and were air dried and then kept in oven for 72 hours at 70^{o}C. The dry matter accumulation in different plant parts was then converted to grams per square meter area basis.

Crop growth rate (CGR)

It is expressed in g m^{-2} day^{-1} and measures the dry weight obtained by a unit area of crop in a unit time. The values of plant dry weight at 1 to 15, 16 to 21, 22 to 45, 46 to 75, 76 to 100 and 100 to at harvest intervals were used for calculating the CGR by Fisher (1921).

$$\text{Crop growth rate} = \frac{W_2 - W_1}{T_2 - T_1}$$

Where, W_1 and W_2 are whole plant dry weight at T_1 and T_2 respectively.

T_1 and T_2 are time interval in days.

Relative growth rate (RGR)

It was described by Fisher (1921) which indicates the increase in dry weight per unit dry matter over any specific time interval and it was calculated by the following equation

$$\text{Relative growth rate} = \frac{\text{In}W_2 - \text{In}W_1}{T_2 - T_1}$$

Where, W_1 and W_2 are whole plant dry weight at T_1 and T_2 respectively.

T_1 and T_2 are time interval in days.

ln= natural logarithm

This parameter was calculated for the time intervals, *viz*. 1 to 15, 16 to 21, 22 to 45, 46 to 75, 76 to 100 and 100 to at harvest using the data obtained from dry weight of plants.

Chlorophyll content

Chlorophyll content was determined according to the method of Hiscox & Israelstam (1979) using dimethyl sulfoxide (DMSO).

Chl 'a' (µg/ml) - $12.19\ A_{665} - 3.45\ A_{645}$
Chl 'b' (µg/ml) - $21.99\ A_{645} - 3.32\ A_{665}$
Total chlorophyll Chl 'a' + Chl 'b'

RESULTS AND DISCUSSION

Effect of PAU-LCC based fertilizer N application on yield and yield attributes, dry matter accumulation, crop growth rate, relative growth rate and chlorophyll content discussed briefly.

Effect of PAU-LCC based fertilizer N application on yield and yield attributes

The data presented (Table 1) revealed that yield-related parameters such as yield and the number of effective tillers m^{-2} increased in PAU recommended LCC 4 based N application (T_3) treatments. Increment in these yield-attributing parameters may result in higher grain and straw yields of basmati rice compared to HAU recommended practices for N application.

PAU-LCC 4 based application produced better result with respect to grain yield, straw yield and harvest index. These results may be due to that the current recommended method of application of nitrogen at fixed split and time at specified growth stages is insufficient to synchronize supply of nitrogen with actual need of crop and there may be losses of nitrogen from soil. Basal N applied at the time of transplanting and after that need based according to LCC 4 was more efficiently utilized the N to optimize grain and straw yield, number of tillers and harvest index. Nitrogen application based on PAU-LCC 3.5 produce lower yield because N requirement of Basmati rice could not fulfilled, however several studies indicated higher yield of non-Basmati rice crop when N was applied based on LCC band 4 as compared to band 3, 3.5, 5 and 6 (Moharana *et al* (2017), Krishnakumar and Haefele (2013), Singh *et al* (2002), Singh *et al* (2008)). The present study was conducted in evolved Basmati variety (PB 1718) which have higher N requirement as compared to scented Basmati rice. It is observed that PAU-LCC band 4 recommended for N application to ordinary rice crop are also suitable for evolved Basmati variety. When amount of N applied at lower rate (18 kg/ha) than recommended amount (30 kg/ha), then lower yield was observed with the application of total amount of 72 kg/ha N as compared to 90 kg/ha, which indicates than N requirement of crops could not be fulfilled and N applied @ 30 kg/ha based on recommended band 4 are also suited for evolved Basmati variety and thus PAU recommended LCC based N application practices be used for N application in Basmati rice under Haryana condition.

TABLE 1
Effect of PAU-LCC based fertilizer N application on yield and yield attributes

Treatment	No. of tillers/ m^2	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)
T_1	115.3	2338	4051	36.67
T_2	219.0	4136	5557	40.20
T_3	246.7	4371	6203	43.11
T_4	230.0	4197	5794	40.74
T_5	196.3	3481	5218	39.98
T_6	192.0	3286	5064	39.32
T_7	190.3	3257	5034	39.29
T_8	207.3	3576	5337	40.12
T_9	180.3	3193	4973	39.11
T_{10}	183.0	3250	5001	39.50
T_{11}	176.3	3158	4915	39.10
C.D. (p=0.05)	2.3	197	332	2.02

Effects of PAU-LCC based N fertilizer application on dry matter accumulation

Dry matter accumulation (g/m^2) in basmati rice at different growth stage which was affected by time and application of nitrogen based on PAU-LCC meter according to treatment. Dry matter accumulation was significantly increased with specific growth stage (15, 21, 45, 75, 100 DAT, and at harvest), and highest the largest growth occurring 75 to 100 days after transplanting.

The highest dry matter (487.03 g/m^2) accumulation was recorded in T_3 (at harvest stage) with respect to all other treatment. This may be due to use of a basal N dosage in need-based fertilizer N management treatments resulted in higher biomass at different growth stages. PAU-LCC band 4 based N top dressings synchronizes plant N demand and fertilizer N supply so PAU-LCC band 4 based treatments generated more dry matter accumulation than PAU-LCC band 3.5 based treatments because nitrogen may improve tiller development, plant height, and translocation to panicles during the reproductive stage, resulting in enhanced total dry matter accumulation. Similar type of results reported by Bhavana *et al.,* (2020) indicated that LCC band 4 based treatments generated more dry matter accumulation than LCC band 3.5. and Sen *et al* (2011) achieved the maximum dry matter accumulation with an LCC band 4 for HUBR 2-1. The nitrogen treatments based on LCC 4.5 and LCC 5 resulted in more plant dry matter accumulation than the soil test-based N fertilizer.

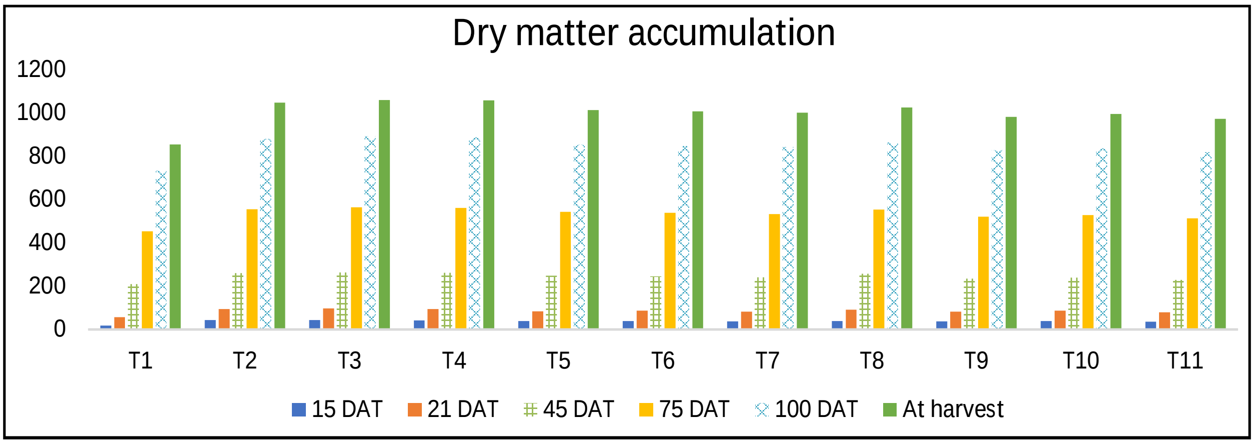

Fig. 1. Effect of PAU-LCC based nitrogen application on dry matter accumulation (g m^{-2}).

Effect of PAU-LCC based fertilizer N application on Crop growth rate

Crop growth rate (CGR) statistics revealed that growth was slow in the early stages, increased up to 100 DAT, and then decreased.

The highest CGR (8.62 g/g/m^{-2}) was obtained in T_3 treatment. The reduction in CGR as the plant matured was caused by leaf senescence. It is true that as rice matures, a large portion of photosynthesis is carried out by actively generating panicle tissues. Increase in N level and number of splits increased crop growth rate. This might be due to increase in available nitrogen for plant growth. Kumar *et al.*, (2018) suggested that CGR was increased from 15 DAT to 60 DAT for all treatments, and then decreased to 106 DAT. At 60 DAT, the highest CGR value was obtained in LCC based treatment as compared to conventional method and Ali *et. al*., (2017) reported that CGR (21.01 g m^{-2} day^{-1}) was significantly higher with nitrogen treatment based on LCC value 4 (4 splits, 132 kg N/ha) than with LCC value 3 (4 splits, 112 kg N/ha).

Effect of PAU-LCC based fertilizer N application on relative growth rate

The RGR was higher in initial growth phases, but dropped in later phases. Higher RGR during 0-30 DAT might be due to timely and adequate amount of nitrogen supplied during initial crop growth period (Sathiya and Ramesh, 2009).

RGR was significantly decreased when basal dose of N delayed to 14 DAT (T_4, T_6, T_8 except T_{10}) and further decreased when basal application delayed to 21 DAT (T_7, T_9, T_{11} and except T_5) than RGR decreased (from 96.32 cm in T_{11} to 116.81 cm in T_3). Similarly, when basal dose of N is decreased from 30 kg/ha (T_3, T_4, T_5, T_8 except T_9) to 18 kg/ha (T_6, T_7, T_{10} and T_{11}) then RGR was significantly decreased (from 0.059 g/g/day to 0.050 g/g/day). Higher RGR was recorded when N was applied PAU-LCC 4 (T_3) that of PAU-LCC 3.5 (T_{11}). The explanation for this reduction with plant age was related to senescence of leaves and a decrease in metabolic activity. Ali *et. al*., (2017) reported that RGR (0.072 g/g/day) was significantly higher with nitrogen treatment based on LCC value 4 (4 splits, 132 kg N/ha) than with LCC value 3 (4 splits, 112 kg N/ha) and Umashanker *et al.* (2005) found that RGR was maximum between 15 to 30 days DAT interval, but thereafter it declined up to 91 to 106 DAT interval.

Effect of PAU-LCC based fertilizer N application on chlorophyll content in leaves

The chlorophyll content was recorded at various growth stages of rice crop, and the data is shown in figure 4. The chlorophyll content was found maximum with the application of T_3 treatment followed by T_2 and T_4. This may be due to the higher accumulation of nitrogen content and maximum availability (90 kg N/ha) of nitrogen and less effect of environmental stress. The highest mean value of chlorophyll content was recorded at 45 DAT (66.46 µg/ml) and after that chlorophyll content was decrease till 100 DAT (55.54 µg/ml). PAU LCC band 4 provide the more nitrogen as compared to PAU-LCC band 3.5 at appropriate growth stage of rice, however in support of our study Sen *et al.* (2011) reveled that LCC 4 scored maximum chlorophyll content followed by LCC 3 and RDF.

CONCLUSION

The rice grain and straw yield was significantly affected with different nitrogen treatment and highest grain (43.71 kg/ha) and straw

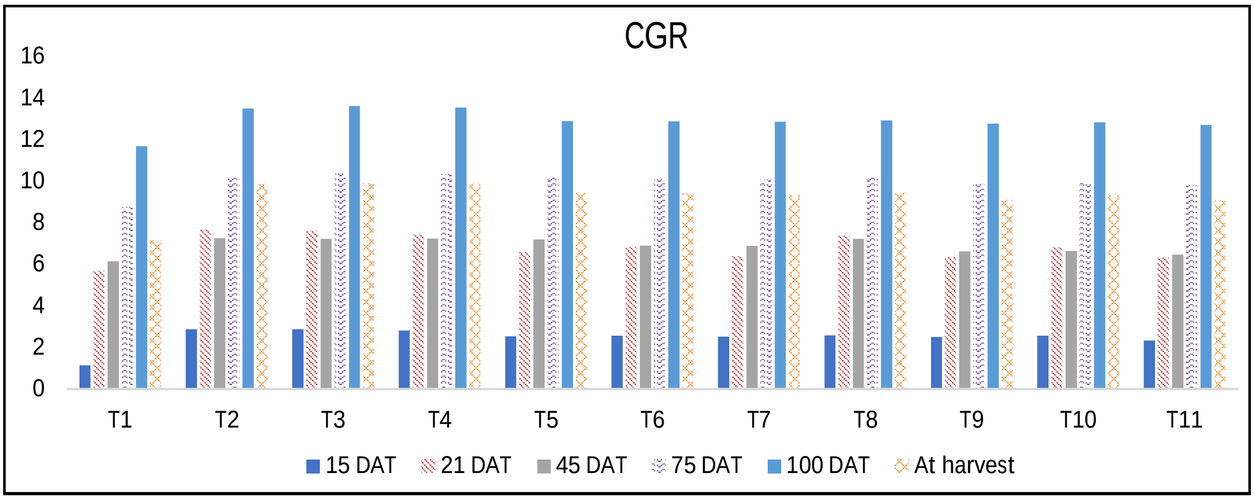

Fig. 2. Effect of PAU-LCC based nitrogen application on crop growth rate (g $g^{-1}m^{-2}$).

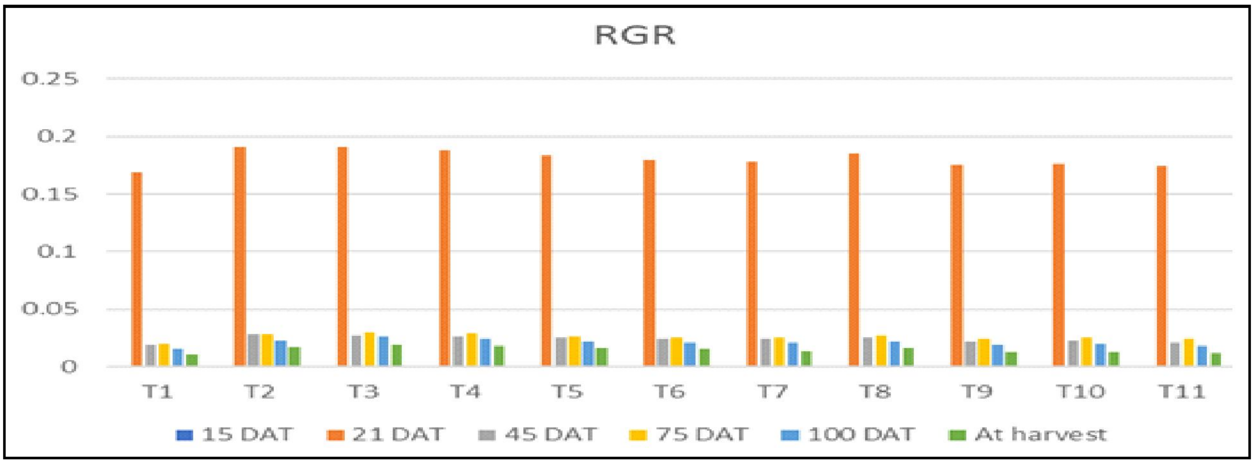

Fig. 3. Effect of PAU-LCC based nitrogen application on relative growth rate (g g^{-1} day^{-1})

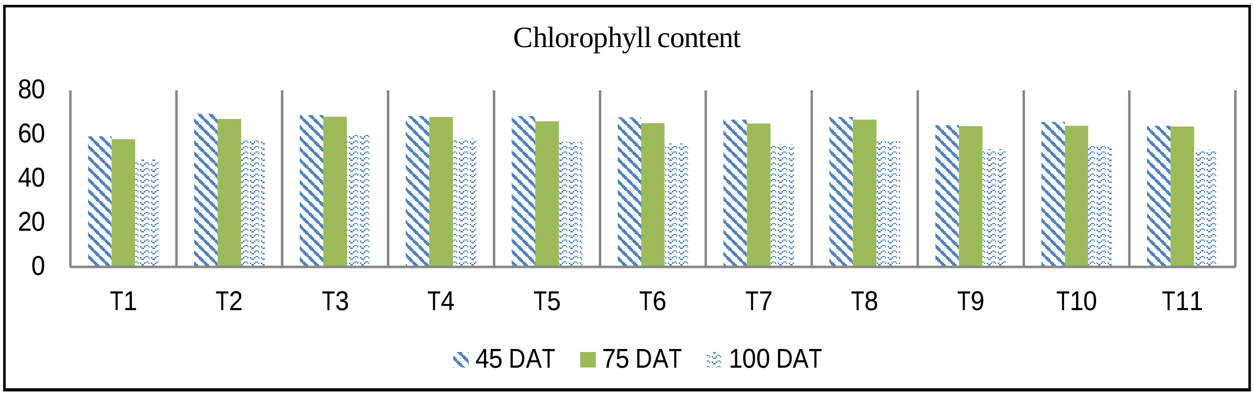

Fig. 4. Effect of PAU-LCC based nitrogen application on chlorophyll content (µg/ml)

yield (62.03 kg/ha) was observed in treatment T_3 followed by T_4 and T_2. PAU-LCC band 3.5 was not found suitable for achieving higher yield of Basmati rice. The number of tillers was found significantly higher in T_3 followed by T_4 due to synchronization of nitrogen with crop demands. The harvest index was significantly affected by different nitrogen management practices and was found higher (43.1%) in T_3 and least in T_{11} treatment (39.1%). The highest dry matter accumulation was recorded in T_3 and least in T_{11}. The dry matter was increased from 15 day after transplanting to at harvest stage. The significantly higher crop growth rate was observed in treatment T_3 (8.6 g g m^{-2}) and least in T_{11} (7.8 g/g /m^{-2}). The crop growth rate was increased from 15 day (2.5 g/g/m^{-2}) after transplanting to 100 DAT (13

g/m^{-2}) and after that it was decreased upto harvest stage (9.3 $g/g/m^{-2}$). The relative crop growth was recorded higher in T_3 (0.059 $g/g/m^{-2}$) which was significantly higher and lowest in T_{11} (0.05 g g m^{-2}). In T_3 treatment, significantly highest chlorophyll content (65.8 µg/ml) was observed and it was highest at 45 DAT. This may be due to application of more quantity of nitrogen which enhanced production of leaf N concentration and chlorophyll content.

REFERENCES

Ali, S. A., S. Elamathi, S. Singh, V. Debbarma, and G. Ghosh, 2017 : Leaf colour chart for proficient nitrogen management in transplanted rice (*Oryza sativa*) in Eastern Uttar Pradesh, India. *International Journal of Current Microbiology and Applied Sciences*, **6**(11): 5367-5372.

Anonymous, 2020b : Statistical Abstracts of Haryana, Government of Haryana.

Anonymous, 2021a : Agricultural Statistics at a Glance. Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India,

Bhavana, B., P. Laxminarayana, A. M. Latha, and T. Anjaiah, 2020 : Judicious nitrogen management using leaf colour chart for enhancing growth and yield of short duration transplanted rice (*Oryza sativa* L.). *International Journal of Current Microbiology and Applied Science*, **9**(6): 2850-2856.

Fageria, N. K. and M. P. Barbosa Filho, 2001 : Nitrogen use efficiency in lowland rice genotypes. *Communication in Soil Science and Plant Analysis*, **32**(13): 2079-2089.

Fisher, R. A., 1921 : Some remarks on the methods formulated in a recent article in the quantitative analysis of plant growth. *Annals of Applied Biology*, **7**: 367-369.

Hiscox, J. D. and G. F. Israelstam, 1979 : Different methods of chlorophyll extraction. *Canadian Journal of Botany*, **57**: 1332-1332.

Krishnakumar, S. and S. Haefele, 2013 : Integrated nutrient management and LCC based nitrogen management on soil fertility and yield of rice (*Oryza sativa* L.). *Scientific Research and Essays*, **8**(41): 2059-2067.

Kumar, P. P., Abraham, T., Pattanaik, S. S. C., Kumar, R., Kumar, U. and Kumar, A. 2018 : Effect of customised leaf colour chart (CLCC) based real time nitrogen management on agronomic attributes and protein content of rice (*Oryza sativa* L.). *Oryza*, **55**(1): 165-173.

Kubo, M. and M. Purevdorj, 2004 : The future of rice production and consumption. *Journal of Food Distribution and Research*, **35**(1): 128-142.

Moharana, S., J. M. L. Gulati, and S. N. Jena, 2017 : Effect of LCC- based nitrogen management on growth and yield of rice (*Oryza sativa* L.). *Indian Journal of Agricultural Research*, **51**(1): 49-53.

Patel, S. K., Y. Kumar, A. Kumar, P. Singh, M. Singh, and A. K. C. R. Yadav, 2019 : Relative performance of neem coated urea (NCU) on nutrient content, uptake and nitrogen use efficiency of rice (*Oryza sativa* L.). *Journal of Pharmacognosy and Phytochemistry*, **8**(2): 2374-2379.

Raj, S. K., J. S. Bindhu, and L. Girijadevi, 2014 : Nitrogen availability and uptake as influenced by time of application and N sources in semi-dry rice (*Oryza sativa* L.). *Journal of Crop and Weed*, **10**(2): 295-302

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

Sen, A., V. K. Srivastava, M. K. Singh, R. K. Singh, and S. Kumar, 2011 : Leaf colour chart vis-à-vis nitrogen management in different rice genotypes. *American Journal of Plant Sciences*, **2**: 223-236.

Sharma, A., J. Kumar, M. Redhu, P. Kumar, M. Godara, P. Ghiyal, P. Fu, and M. Rahimi, 2024 : Estimation of rice yield using multivariate analysis techniques based on meteorological parameters. *Scientific Reports*, **14**(1): 12626.

Sheron, O. P., D. S. Tonk, L. S. Kaushik, R. C. Hasija, and R. S. Pannu, 1998 : Statistical Software Package for Agricultural Research Workers. Recent Advances in information theory, Statistics & Computer Applications by D. S. Hooda and R.C. Hasija Department of Mathematics Statistics, CCS HAU, Hisar. pp. 139-143.

Singh, B., R. K. Gupta, Y. Singh, S. K. Gupta, J. Singh, J. S. Bains, and M. Vashishta, 2008 : Need-based nitrogen management using leaf colour chart in wet direct-seeded rice Northwestern India. *Journal of New Seeds*, **8**(1): 35-47.

Singh, B., V. Singh, T. Singh, H.S. Thind, A. Kumar, R.K. Gupta, A. Kaul, and M.M. Vashistha, 2012 : Fixed-time Adjustable dose site-specific fertilizer nitrogen management in transplanted irrigated rice in South Asia. *Field Crops Research*, **126**: 63-69.

Singh, B., Y. Singh, J. K. Ladha, K. F. Bronson, V. Balasubramanian, J. Singh, and C. S. Khind, 2002 : Chlorophyll meter–and leaf color chart–based nitrogen management for rice and wheat in Northwestern India. *Agronomy Journal*, **94**(4), 821-829.

Singh, V., B. Singh, H.S. Thind, A. Kumar and M. Vashistha, 2011 : Calibrating the leaf color chart for need based fertilizer nitrogen management in different maize (*Zea mays* L.) genotypes. *Field Crops Research*, **120**: 276-82.

Tari, D. B., A. Gazanchian, H. A. Pirdashti, and M. Nasiri, 2009 : Flag leaf morpho-physiological response to different agronomic treatments in promising line of rice (*Oryza sativa* L.). *American-Eurasian Journal of Agriculture & Environmental Sciences*, **5**(3): 403-408.

Umashankar, R., C. Babu, P. S. Kumar, and R. Prakash, 2005 : Integrated nutrient management practices on growth and yield of direct seeded lowland rice. *Asian Journal of Plant Science*, **4**: 23-26.