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Evaluation of leaf colour chart based fertilizer nitrogen management technology using PAU-LCC in transplanted rice (*Oryza sativa* L.)

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Abstract
Over and untimely applications of fertilizer nitrogen (N) are the major constrains in improving fertilizer N recovery efficiency in transplanted rice. Large spatial and temporal variability further lower fertilizer N recovery efficiency when broad based blanket recommendations are followed. The field experiment was carried out using four rice varieties (PR 121, PR 122, PR 123 and PR 124) laid in split plot design with eight treatments and three replications to study need based fertilizer nitrogen management using PAU- leaf colour chart in transplanted rice. Close linear relationship (R^2=0.732, n= 504) between PAU-LCC score and SPAD meter readings suggests that PAU-LCC can be used as economical substitute to SPAD for making need based fertilizer N topdressings in transplanted rice. The PAU-LCC 4 guided N applications produced grain yield equivalent to soil test based N applications with the saving of 60 kg N ha^{-1}. Whereas, PAU-LCC 4.5 guided N management improved grain yield production by 8.47 percent with the use of fertilizer N equivalent to soil test based N management. The basal N dose can be delayed till 10 DAT while using threshold leaf greenness of PAU-LCC 4.5 in different rice varieties.

Keywords: PAU-leaf colour chart, chlorophyll meter, nitrogen, rice

Introduction
Nitrogen (N) is the extensively used fertilizer nutrient element in transplanted rice and its consumption has increased substantially in the last decades. Nitrogen is unique among the major nutrients since it originates from the atmosphere, and its transformations and transport in the pedosphere and hydrosphere are mediated almost entirely by biological processes. The atmosphere contains a large, well-mixed, biologically unavailable pool of N, of which a relatively small part is converted to biologically available or reactive pool of N. Biological N fixation is the primary source of reactive N. However, industrial N fixation has become major contributor in agriculture, since meeting the growing demand for food has forced large increases in the use of N fertilizer.
The continual increase in the use of fertilizer N has altered the global N cycle. The inadequate and excessive fertilizer N use at inappropriate timings increases the escape of reactive fertilizer N to atmosphere (Bhatia *et al.*2012) [3]. The N use efficiency in rice is generally very low (20-40 per cent) depending upon the source and the timings of fertilizer N application, crop and water management and agro-ecological conditions (Bijay-Singh and Yadvinder-Singh 2003) [5]. The nitrogen use efficiency (NUE) varies with yield potential of variety and growth environment (Ladha *et al.* 1998) [17]. The low nitrogen use efficiency has been mainly due to inefficient splitting of fertilizer N application which results in fertilizer N use in excess of crop requirement (Ladha *et al.*2000) [16]. Inefficient splitting of fertilizer N doses does not synchronize with crop demand and a large part of applied fertilizer N is lost by leaching and denitrification. The plant N need for nitrogen vary greatly from field to field, season to season and year to year because of high variability among fields, seasons and years in soil N-supplying capacity (Cassman *et al.* 1996, Dobermann *et al.* 2003) [9, 12].
The general fertilizer nitrogen (N) recommendation for irrigated rice typically consists of fixed rates and timings for large rice growing tract having similar climate and landforms. In the North-westerns India, a blanket fertilizer recommendation is to apply 120 kg N ha^{-1} at 0, 21 and 42 days after transplanting (DAT). These blanket fertilizer recommendations have well served the purpose but cannot help increase N use efficiency beyond a limit. Due to large field to field variability of soil N supply, efficient use of N

Fertilizer is not possible when broad-based blanket fertilizer recommendations for fertilizer N are used (Bijay-Singh *et al.* 2012) [6]. Adoption of blanket fertilizer recommendation causes improper usage in some cases and leads to wastage through leaching, volatilization, run off, denitrification etc (Balasubramanian *et al.* 1999) [2]. Blanket fertilizer recommendations ignore temporal and spatial variability and thus, the farmers generally use spectral properties of leaves as an indicator to plant N need but use inappropriate threshold leaf colour darkness and apply excessive fertilizer N. Application of higher N dose at wrong times enhances insect-pests incidence, reduces harvest index, may cause lodging, increases cost of production, enhances the escape of reactive N from soil plant system to atmosphere and thus causes pollution.

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 (Varinderpal-Singh *et al.* 2010) [24]. The efficient N management strategies include adjustment of the early fertilizer N application to match the relatively low demand of young rice plants and varying times of fertilizer N application to match crop demand during growing season (Buresh 2007)[7]. The need based use of nitrogen avoids excessive use of nitrogen, minimises insect pest incidence, reduces escape of reactive N to atmosphere and thus also provides economic benefits to farmer.

The conventional tissue testing procedures were traditionally used to estimate in-season crop N demand (Yadava 1986, Roth *et al.* 1989) [29, 20]. The procedure of leaf sampling and analysis to assess the nutrient status of growing plant is laborious, time-consuming and expensive because it takes 1-2 weeks from tissue sampling to deciding a fertilizer recommendation which is not practically feasible proposition with large number of fields. The soil analysis do not take into account the dynamic changes in soil N supply and N inputs from other sources such as irrigation water or biological N fixation during the crop growth period (Nayyar *et al.* 2006, Yadvinder-Singh *et al.* 2003) [19, 30]. The use of spectral properties of rice leaves is the best possible solution that can help farmers to take instant decisions for need based in-season fertilizer N topdressings (Varinderpal-Singh *et al.* 2007, Bijay-Singh and Singh 2017) [25, 4].

The chlorophyll or SPAD meter quantifies green colour intensity of plant leaves by measuring chlorophyll content in terms of transmittance of radiation in the red and near infrared region (Debaeke *et al.*2006) [11]. It indirectly measures the chlorophyll content and provides an assessment of leaf nitrogen status (Chubachi *et al.* 1986, Jiang and Vergara 1986, Yadava 1986) [29, 15].However, the cost of GreenSeeker and SPAD meter restricts its widespread use by farmers in developing countries.

The LCC has emerged as potential and economical substitute to SPAD meter and GreenSeeker optical sensor for synchronizing in-season demand and supply in field crops (Bijay-Singh and Singh, 2017) [4]. It is an economical, simple and farmer's friendly tool which helps farmers to decide proper time and amount of fertilizer N application. It helps to produce high yield with improved N use efficiency in rice (Yadvinder-Singh *et al.* 2007, Varinderpal-Singh *et al.* 2007, Varinderpal-Singh *et al.*2014) [25, 23], maize (Varinderpal-Singh *et al.* 2011) [27] and wheat (Varinderpal-Singh *et al.* 2012). The LCC being a simple and farmers' friendly gadget can be easily used even by illiterate farmers to decide time of fertilizer N application.

Materials and methods

Experimental site and soil characteristics

Field experiment was conducted during 2015 rice season (June-October) on a Typic Ustipsamment at the experimental farm of the Punjab Agricultural University, Ludhiana, (30°56' N, 75°52' E), located in the northwestern India. The climate of Ludhiana is subtropical, semi-arid type of climate with an annual rainfall of 774 mm and most of it (75 to 80 per cent) is received during the rainy season i.e. June to September. The mean monthly temperatures during the rice season range between 25° and 33.8°C. The composite soil samples were taken from 0-15 cm depth before starting the experiment. The soil samples were mixed thoroughly, air dried in shade, crushed to pass through a 2 mm sieved and analysed for physical and chemical characteristics' in experiment as reported in Table 1.

Experimental design

The field experiment was laid out in split plot design with eight treatments and three replications. The experiment consisted of eight fertilizer N management treatments No-N control, soil test based N application and six PAU-LCC guided N applications treatments using three threshold leaf greatnesses *i.e.* LCC 4, LCC 4.5 and LCC 5 with and without basal N dose of 30 kg N ha^{-1}.

Soil and crop management

The experimental field was properly ploughed, leveled and puddled for transplanting. The layout contains 96 plots measuring 22.1 m^2 each. The 30 days old seedlings of rice cultivars (PR 121, PR 122, PR 123 and PR 124) were transplanted at row to row spacing of 20 cm and plant to plant spacing of 15 cm in different plots.

Table 1: Different physic-chemical characteristics of experimental soil at 0 to 15 cm depth at the start of the experiment

Soil properties	Value
Mechanical properties	
Sand (per cent)	73.20
Silt(per cent)	21.80
Clay (per cent)	5.00
Soil texture	Sandy loam
Chemical properties	
Electrical conductivity (dSm^{-1}) (1:2)	0.15
pH (1:2)	6.93
Organic Carbon (per cent)	0.49
Available N (kg ha^{-1})	92.4
Available P (kg ha^{-1})	9.7
AvailableK (kg ha^{-1})	98.9
Available Fe (mg kg^{-1})	37.8
Available Mn (mg kg^{-1})	12.5
Available Zn (mg kg^{-1})	4.1
Available Cu (mg kg^{-1})	2.4

Nitrogen in the form of urea was applied as per treatments. A dose of phosphorus, potassium and zinc was incorporated at the rate of 30 kg P ha^{-1} (through single super phosphate), 30 kg K ha^{-1} (muriate of potash) and 25 kg Zn ha^{-1} (Zinc sulphate) into soil before last puddling. The Butachlor 50 EC liquid formulation (@ 1200 ml acre^{-1}) mixed with 60 kg sand was broadcasted uniformly in standing water at 2 days after transplanting. Nominee gold 10 SC @ 250 ml ha^{-1} was applied at 30-35 days after transplanting. Hand weeding was done to eradicate the left over weeds. Insect-Pest control measures were followed as per package of practices of Punjab agricultural university, Ludhiana. The Plots were flooded for

2 weeks after transplanting, thereafter irrigated at 2 days intervals. Although soil did not remain flooded for more than 8 to 16 hour after irrigation, anaerobic conditions prevailed for more than 75 per cent of the rice growth period. The crop was harvested manually at ground level with the help of sickle at biological maturity. The harvested crop was threshed manually. Grain and straw weight was recorded.

LCC and SPAD meter measurements

The IRRI-LCC had been developed at International Rice Research Institute, Philippines and contains six strips of different green colour intensity *i.e.*1, 2, 3, 4, 5 and 6. The PAU has developed a new LCC (PAU-LCC) that contains new shades of green colour *i.e.* 3, 3.5, 4, 4.5, 5 and 6. It provides more precise measurement of green colour intensity of rice leaves to guide need based fertilizer N application in different rice varieties. The inclusion of strip number 3.5 and 4.5 in PAU-LCC provides a solution to differentiate the varieties with minor differences in spectral properties of leaves. The leaf colour of first top fully exposed leaf was measured with LCC under body shade. Fifteen disease free rice hills were selected randomly from a plot. Placing the middle part of the youngest fully expanded leaf on the top of the colour strips in the chart, the colour of the leaf of the 15 selected plants was measured. When eight or more leaves were read below the set critical value, urea was applied as per treatment. The SPAD meter was calibrated every time before recording data. The readings were recorded at 10 day intervals starting from 10 DAT till initiation of flowering. Fifteen rice leaves were chosen at random in each plot. The topmost fully expanded leaf was inserted into the sample receiving window. The measuring head was kept completely closed until a beep was heard and measurement value appear on the display. The SPAD meter readings were automatically recorded in the meter. The head was opened and the reading of the next leaf was recorded similarly. The odd values were deleted by pressing the button ‘one data clear’. Fifteen plants per plot were read and the average value is recorded as SPAD value for plot. After noting the average SPAD value of the plot, the meter was cleared for the next set of readings by pressing the ‘all data clear’ button.

Emitting and/or receiving windows of the chlorophyll meter were cleaned with a soft cloth before taking measurements. Precautions were taken to avoid extremely thick, insect or disease affected leaves.

Plant sampling

At maturity, rice crop was harvested manually and grain yields were recorded from a net area of 12 m^2 from the different treatment plots. The plant samples collected from each plot were oven dried at 60°C to constant weight and dry weight was recorded. Dried samples were ground in grinder for estimating N content. Nitrogen concentration in, leaf, grain and straw was determined by digesting the samples in H_2SO_4, followed by total N analysis by a micro-Kjeldahl method.

Statistical analysis

The data were analyzed using split plot design. Correlation of PAU-LCC, chlorophyll meter with grain yield and N uptake was worked out using Crop Stat andStatistical Package for the Social Sciences (SPSS).

Results and discussions

Fertilizer N application scheduling using PAU-LCC in different rice varieties

The need based fertilizer N application scheduling decisions were derived from per cent leaf greenness above the specified threshold leaf greenness of different varieties measured using PAU-LCC (Table 2). The leaf colour greenness of different varieties (PR 121, PR 122, PR 123 and PR 124) was recorded at 10 days interval starting from 10 DAT to initiation of flowering. The varieties PR 121, PR 123 and PR 124 matured early and LCC data was recorded from 10 DAT to 50 DAT, whereas flower initiation was late in variety PR 122 and leaf greenness was measured from 10 DAT to 60 DAT of rice. The fertilizer N (30 kg N ha^{-1}) was applied whenever leaf greenness of more than 60 per cent leaves was less than threshold leaf greenness. A fixed amount of 40 kg fertilizer N ha^{-1} was applied in soil test based treatment at 0, 21 and 42 DAT. A basal dose of 30 kg N ha^{-1} in T3, T5 and T7 was applied at transplanting of rice. At 10 DAT the leaf greenness of more than 60 per cent leaves was more than specified threshold leaf greenness in T3 and T4 but was less in T5, T6, T7 and T8 (Table 2),thus lead to application of 30 kg N ha^{-1} in T5, T6, T7 and T8.At 20 DAT the leaf greenness of more than 60 per cent leaves was again more than threshold leaf greenness in T3 and T4 treatments of all the four varieties and thus lead to No-N application at 20 DAT. Application of N dose at 10 DAT in T5 and T6 improved leaf greenness in variety PR 122, however it was below the specified threshold of LCC 4.5 in varieties PR 121, PR 123 and PR 124. Thus another fertilizer N dose of 30 kg N ha $^{-1}$ was applied at 20 DAT in PR 121, PR 123 and PR 124 in T5 and T6 treatments. In T7 and T8, the leaf greenness was less than the specified threshold of LCC 5 in all the varieties and thus 30 kg N ha^{-1} was applied irrespective of the rice varieties.

At 30 DAT, leaf greenness of PR 121 and PR 122 was darker than the threshold LCC 4 in T3 and T4 and lead to No-N application. However in varieties PR 123 and PR 124, the leaf greenness of T4 fall below the threshold LCC 4 and lead to application of 30 kg N ha^{-1}. The leaf greenness of T3 was above LCC 4 in both PR 123 and PR 124 attributed to basal N application in this treatment which was not given in T4.The leaf greenness of T5 and T6 did not cross LCC 5 in all the rice varieties and lead to application of another dose of 30 kg N ha^{-1} at 30 DAT in all the varieties.

The fertilizer N applied at 30 DAT in treatment T4 (PR 123 and PR 124), T5 and T6 improved leaf greenness above the threshold leaf greenness in T4, T5 and T6 of all the varieties. The leaf greenness of T3 in all the varieties was also above LCC 4 in all the varieties. Thus no urea was applied at 40 DAT in T3, T4, T5 and T6 of all the varieties. The leaf greenness in T7 and T8 was again less than threshold LCC 5 and lead to application of 30 kg N ha^{-1} in all the varieties.

At 50 DAT, leaf greenness of more than 60 per cent leaves was less than threshold LCC 4 in T3 of all the varieties and thus leads to application of 30 kg N ha^{-1} irrespective of the varieties. The T4 of varieties PR 123 and PR 124 were darker than LCC 4 but variety PR 121 and PR 122 showed demand for fertilizer N based on leaf colour greenness. The first N dose of 30 kg N ha^{-1} was given in T4 of PR 121 and PR 122 at 50 DAT.However, more than of 60 per cent leaves of the varieties PR 123 and PR 124 were darker than threshold leaf greenness in T4. It may be due to application of fertilizer N at 30 DAT in T4 treatment of PR 123 and PR 124 that maintained threshold leaf greenness till 50 DAT. The varieties PR 121, PR 123 and PR 124 entered flowering stage by 60 DAT, thus the LCC data was recorded only for PR 122 at 60

DAT. The leaf greenness of more than 60 per cent leaves was more than threshold LCC 4 in T4; however leaf greenness was less than threshold LCC 4 in T3, less than threshold LCC 4.5 in T5 and T6 and less than threshold LCC 5 in T7 and T8, respectively. Thus fertilizer N dose of 30 kg N ha^{-1} was applied in T3, T5, T6, T7 and T8 of PR 122 at 60 DAT.

Relationship of spectral properties of different rice varieties measured using PAU-LCC and SPAD meter

The data on all the sampling dates was pooled in Fig. 1. The data revealed a close linear relationship (R^2= 0.732, n= 504). Since both gadgets consider leaf greenness as an indicator of leaf N concentration, the data in the Fig.1 suggests that PAU-LCC can be used as a reliable substitute of SPAD meter to guide need based N application in transplanted rice. Sen *et al.* (2011) [21] found linear relationship between SPAD value and LCC score in NDR-359 and Sarju 52 variety of rice. Yang *et al.*(2002) [31] suggests that Leaf color chart can substituted for chlorophyll meter to estimate leaf N status of rice (*Oryza sativa* L.) and to schedule need based fertilizer N application. Cabanngon *et al.* (2011) [8] found linear relationship (R^2 = 0.700) between LCC score and SPAD value in IR72 variety of rice.

Table 2: Detail of fertilizer N applied in different treatments

Treatment		PR 121		PR 122		PR 123		PR 124	
			Time of fertilizer application (DAT)	Total Fert N	Time of fertilizer application (DAT)	Total Fert N	Time of fertilizer application (DAT)	Total Fert N	Time of fertilizer application (DAT)
T1	NO-N	0		0		0		0	
T2	40+40+40	120	0,21,42	120	0,21,42	120	0,21,42	120	0,21,42
T3	30+LCC 4	60	0,50	60	0,50	60	0,50	60	0,50
T4	0+LCC 4	30	50	30	50	30	30	30	30
T5	30+LCC 4.5	150	0,10,20,30,50	150	0,10,30,50,60	150	0,10,20,30,50	150	0,10,20,30,50
T6	0+LCC 4.5	120	10,20,30,50	120	10,30,50,60	120	10,20,30,50	120	10,20,30,50
T7	30+LCC 5	180	0,10,20,30,40,50	210	0,10,20,30,40,50,60	180	0,10,20,30,40,50	180	0,10,20,30,40,50
T8	0+LCC 5	150	10,20,30,40,50	180	10,20,30,40,50,60	150	10,20,30,40,50	150	10,20,30,40,50

Fertilizer N management effects on grain yield and total N uptake of transplanted rice

The data pertaining to the effect of different N management technologies on grain yield production and total N uptake are provided in Table 3. The results showed that grain and total N uptake do not differ significantly among four varieties (PR 121, PR 122, PR 123 and PR 124).

The effect of fertilizer N management on grain yield and total N uptake of fertilizer N was significant in all the varieties. The grain yield produced in NO-N control treatment was less than the soil test based and PAU-LCC based N management treatments, indicating that inherent soil N fertility of experimental field was not sufficient to ensure optimum N supply throughout the growth period of crop. The fertilizer N in all the PAU-LCC based treatments was applied as per demand of the plant in comparison to fertilizer N application at fixed growth stages in soil test based N application treatment. The maximum grain yield was harvested in T5 treatment when leaf colour greenness equivalent to PAU-LCC 4.5 was used as threshold leaf greenness to schedule need based fertilizer N topdressings. The statistically equivalent grain yield production in T5 and T6 suggested that basal N application did not improve grain yield production when PAU-LCC shade 4.5 was used as threshold greenness and thus can be avoided for achieving high NUE. However, basal N dose is important when lighter leaf greenness of PAU-LCC 4 is used as threshold leaf greenness (T3). The use of threshold PAU-LCC 4 lead to grain yield production statistically equivalent to soil test based N application (with the saving of 60 kg N ha^{-1}). The use of PAU-LCC 4.5 as threshold leaf greenness led to numeric increase in grain yield production in comparison to soil test based N application with the use of equivalent fertilizer (120 kg N ha^{-1}), although the values were statistically non-significant. The numeric increase in grain yield production with the application of equivalent fertilizer N was attributed to synchronization in plant N demand and fertilizer N supply when fertilizer N topdressings were scheduled using PAU-LCC 4.5 as a diagnostic tool. The PAU-LCC guided fertilizer N topdressings were made at 10, 20, 30 and 50 DAT in PR 121, PR 123 and PR 124 and at 10, 30, 50 and 60 DAT in PR 122, whereas soil test based N applications were applied at 0, 21 and 42 DAT. The results revealed that threshold PAU-LCC 4 guided N applications can produce grain yield equivalent to soil test based N applications with the saving of fertilizer N, whereas PAU-LCC 4.5 guided N applications may improve grain yield production with the use of fertilizer N equivalent to soil test N dose. The researchers reported different threshold leaf greenness for different rice varieties grown in different geographical region. Maiti *et al.*(2004) [18] observed threshold LCC 5 superior over LCC 4 for achieving high NUE in IET-4094 variety of rice. Sen *et al.* (2011) [21] reported threshold LCC greenness for NDR 359 and Sarju 52 to be ≤ 5, while for HUBR 2-1 it was ≤ 4. Houshmandfar and Kimaro (2011) [14] found that the threshold LCC 4 with 25 kg N ha^{-1} for Torom-Hashemi and LCC 4 with 35 kg N ha^{-1} for GRH-1 are suitable for guiding N application to achieve the highest grain yield. The total N uptake of T2 was statistically at par with T3 treatment. Maximum total N uptake was obtained in T5 and was statistically at par with T6, T7 and T8 and significantly higher than T2, T3 and T4 treatments. The total N uptake of T2 was statistically at par with T3 treatment. The data revealed that using high N dose causes more vegetative growth and thus high N uptake without any advantage in grain yield production and thus can be avoided for achieving better NUE. The threshold PAU-LCC 4 led to grain N uptake equivalent to soil N application with the use of only 60 kg N ha^{-1} in comparison to the application of 120 kg N ha^{-1} in soil test based N application treatment. However, the use of threshold PAU-LCC 4.5 led to significantly higher N uptake than soil test based N application with the use of equivalent fertilizer N dose of 120 kg N ha^{-1}. Win *et al.* (2003) [28] also reported usefulness of PAU-LCC based N applications in achieving better total N uptake in different rice varieties.

The use of threshold leaf greenness of PAU-LCC 4.5 (with basal N dose) or PAU-LCC 5 lead to high N use without any improvement in grain yield production and thus led to unacceptable and poor fertilizer N use efficiencies.

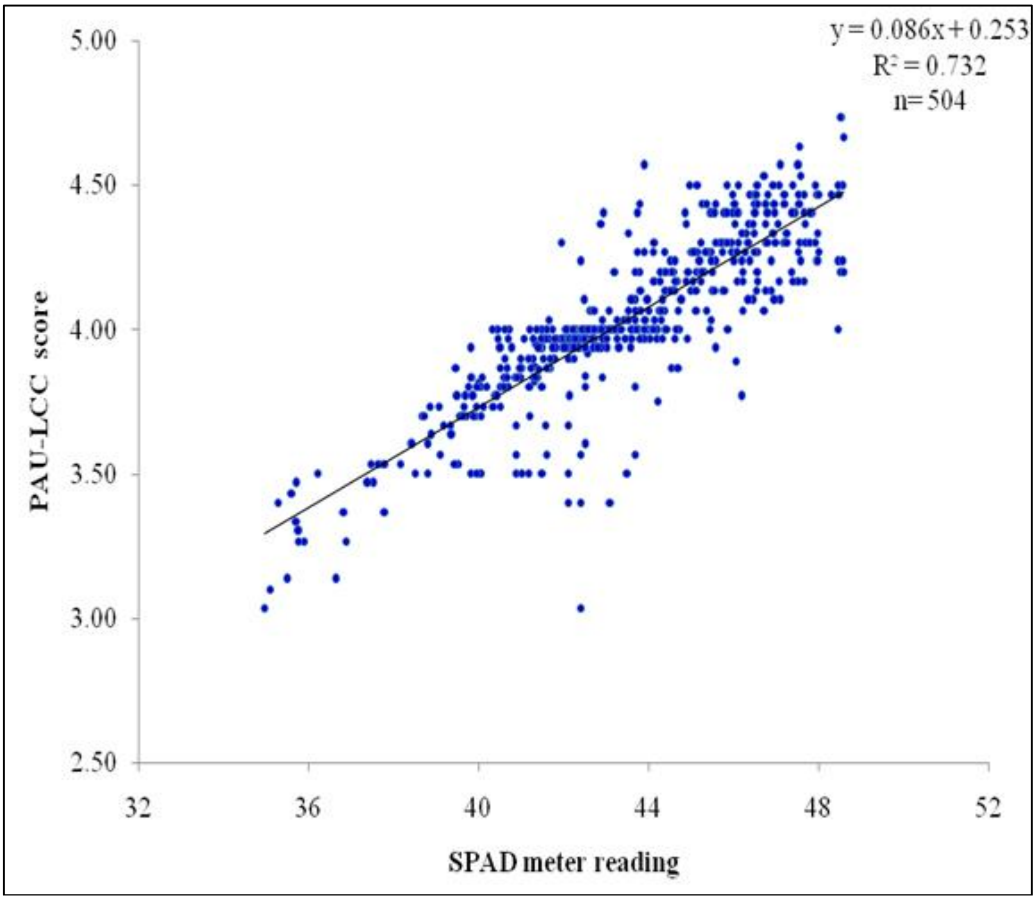

Fig 1: Relationship of PAU-LCC score and SPAD meter reading across the growth stages and rice varieties

Table 3: Effect of PAU-LCC based fertilizer N management on grain yield and total N uptake of different rice varieties

Varieties	Treatments								
	T1 No-N	T2 soil test N	T3 30+LCC 4	T4 0+LCC 4	T5 30+LCC 4.5	T6 0+LCC 4.5	T7 30+LCC 5	T8 0+LCC 5	Mean
Grain yield (t ha^{-1})									
PR 121	3.65	6.48	6.47	5.03	7.21	7.31	7.20	7.28	6.33
PR 122	3.53	6.67	6.78	4.87	7.00	6.93	5.73	6.27	5.97
PR 123	3.94	6.29	6.37	4.93	7.27	7.25	6.60	7.21	6.23
PR 124	3.77	6.51	6.48	4.97	6.72	6.67	6.35	6.68	6.02
Mean	3.72	6.49	6.52	4.95	7.05	7.04	6.47	6.86	
LSD (0.05)	Varieties= NS; Treatments= 0.66; Varieties x Treatments= NS								
Total N uptake (kg ha^{-1})									
PR 121	53.7	109.8	101.5	75.0	132.9	127.5	131.5	130.0	107.7
PR 122	52.7	109.0	103.0	76.3	125.3	125.4	121.0	120.8	104.2
PR 123	59.1	115.4	111.9	75.3	135.2	134.0	125.7	137.1	111.7
PR 124	56.4	111.0	103.6	75.2	131.6	124.8	122.9	125.9	106.4
Mean	55.5	111.3	105.0	75.5	131.2	127.9	125.3	128.5	
LSD (0.05)	Varieties= NS; Treatments= 12.0; Varieties x Treatments= NS								

Conclusions

Close linear relationship between SPAD meter readings and PAU-LCC scores suggests that PAU-LCC can be used as reliable and economical substitute of SPAD meter for scheduling need based fertilizer N applications in different rice varieties. The need based fertilizer N application using PAU-LCC 4 as threshold greenness is the best N management option to achieve grain yield equivalent to soil test based N application. However, PAU-LCC 4.5 based N application may help improve grain yield production of applied fertilizer nitrogen in new rice varieties. Basal N dose may be delayed till 10 DAT when leaf greenness equal to LCC 4.5 is used as threshold leaf greenness. However, basal N dose is required while using leaf greenness equivalent to PAU-LCC 4 as threshold leaf greenness.

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