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Research Communication

Nitrogen-management strategy through leaf-colour chart and SPAD meter for optimizing the productivity in irrigated wheat (*Triticum aestivum*)

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ABSTRACT

A field experiment was conducted during the winter (*rabi*) season of 2020–21 at Bihar Agricultural University, Sabour, Bhagalpur, to study the effect leaf-colour chart (LCC) and SPAD meter on productivity of irrigated wheat (*Triticum aestivum* L.). The experiment, having 8 treatments, was laid out in a randomized block design. The first 4 treatments (T_1 to T_4) were LCC-based, T_5 and T_6 were the SPAD meter-based management practices and T_7 was considered as fixed-time N management (FTNM) and T_8 was kept as control where no N was applied. The SPAD-based treatments T_5 and T_6 received 140 kg N/ha which was higher than all the other N management treatments resulted 13% higher ears/m^2 and 18% higher grains/ear over the LCC-based N-management treatments. Among the LCC-based practice, treatment T_4 recorded significantly highest grain yield (4.01 t/ha) but was lower (10.4%) than that of grain yield achieved in T_5 treatment. The LCC-based treatments T_1 to T_3 though received a lower dose of N fertilizer (19%; average of T_1 to T_3) compared to the FTNM (T_7), returns maintained the similar yield components with the FTNM. Therefore, use of farmers' friendly and cost-effective tool LCC is very useful which saved the N fertilizer (19%) without hampering the yield components. Thus, LCC and SPAD may be effective tool for efficient need-based fertilizer N management using LCC and SPAD meter in improving crop growth for higher productivity in rational manner.

***Key words*:** Leaf colour chart, N use efficiency, SPAD meter, Wheat

Nitrogen (N) is one of the most important as well as limiting elements in most of the soils and the major input in wheat (*Triticum aestivum* L.) cultivation. As the wheat is a long-day plant, the productivity depends on the environmental conditions and improved agronomic practices like smart nutrient management which plays a significant role in crop growth and productivity. At the time when N application is not synchronized with crop demand, the N losses from the soil plant system are enormously directing to low N fertilizer-use efficiency (Khatik *et al*., 2021). In Indo-Gangetic Plain of eastern India, wheat is grown with the specific recommendation of 120 kg N/ha with 50% application as basal followed by 2 in equal splits-at crown-root initiation stage (CRI) and at maximum tillering (MT) stage-concur with irrigation. Considering the farmers' perspective, there is a non-availability of adequate information to determine the time of split application of N. Hence, the great challenge for researchers/farmers is to convert the applied N in grain yield with maximum N-use efficiency. The N-use efficiency can be raised when the application will coincide with most crucial growth stages that reduce the N losses. Using smart gadgets such as leaf-colour chart (LCC), based on spectral properties of leaves and chlorophyll or SPAD (Soil Plant Analysis Development) meter based on light transmittance through leaves for guiding real-time N top-dressings in wheat became popular in developed Countries (Singh *et al*., 2021; Zhang *et al*., 2021). In the Indo-Gangetic plains of eastern India, the studies on nitrogen management in wheat using SPAD meter and leaf LCC are very limited. This study emphasizes maintaining grain yield with adequate application of N using canopy sensors.

The experiment was conducted at the Bihar Agricultural University, Sabour, Bhagalpur during the winter (*rabi*) season of 2020–21. The geographical location of Bhagalpur comes under Middle Gangetic plains of India at 25°15' 4" N and 78°2' 45" E with 37.19 m above the mean sea level under Agro-Climatic Zone III A (NARP, Zone of the state)

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of Bihar. It is characterized by subtropical climate with hot and desiccating summer, cold winter and moderate annual rainfall. The soil was sandy clay loam (51% sand, 22% silt and 21% clay), low to medium in fertility status (176 kg available N/ha, 18 kg available P/ha and 133 kg available K/ha), neutral (*p*H 7.2) and low in cation-exchange capacity [19.2 cmol (+)/kg]. The experiment was comprised 8 treatments and conducted in a randomized block design with 3 replications using LCC and SPAD meter to emphasize the need-based N application. The LCC value was kept as < 4.0 and < 4.5 in combination with N application in split (25 and 30 kg N/ha), i.e. treatments T_1 to T_4. Treatments T_5 and T_6 were SPAD-based N recommendation and here in the study it was 42.0 (SPAD threshold) for T_5. In the treatment T_6, the SPAD threshold was adjusted, and the range was 40–42 (SPAD threshold) in 3 conditions of N applications in split (*i*) if SPAD < 40 then 40 kg N/ha; (*ii*) if SPAD 40– 42 then 30 kg N/ha and (*iii*) if SPAD > 42 then 20 kg N/ha. The T_6 treatment was supplied by 40 kg/ha N as basal, followed by 30 kg at 25 days after sowing (DAS) and thereafter SPAD-based recommendation at 45 and 65 DAS, as these stages are the high affinity of N fertilizer. The treatment details are explained in Table 1.

The basal dose of fertilizer was applied @ 40 kg N/ha at the time of sowing in all the treatments except fixed-time N recommendation (FTNM) as T_7 and control (T_8). In FTNM, basal dose of fertilizer was applied @ 60 kg N/ha at the time of sowing and remaining N was top-dressed equally at 25 days after sowing (DAS) crown-root initiation and 45 DAS maximum tillering of the crop @ 30 kg N/ha in each split. Along with N in basal, 60 kg P_2O_5 and 40 kg K_2O/ha were applied at the time of sowing in all the treatments including the control (T_7). The N fertilizer was top-dressed when the mean LCC and SPAD values were recorded below the threshold value, starting from 25 DAS up to ear emergence at 7 days interval in wheat. The seeds of wheat cultivars were sown at a row spacing of 20 cm. The dimension of each treatment plot was about 5.0 m × 3.4 m. The sources of chemical fertilizer were urea, single superphosphate and muriate of potash. The LCC developed by the Punjab Agricultural University, Ludhiana, was used to measure the leaf-colour intensity. The SPAD and LCC readings were taken on 10 random plants and whenever the green colour of 6 out of 10 leaves were recorded below the critical value, nitrogen was applied as per the LCC value. In case of SPAD, a mean of 10 readings/plot were taken as the representative SPAD value. The data related to each parameter were analyzed statistically by using the standard method of analysis of variance in the study.

The maximum length of ear (11.2 cm), ear/m^2 (347) and grains/ear (54) were observed in SPAD-based management treatment (T_5) against application of 140 kg N/ha with 40 kg N/ha as basal followed by 5 split applications of N as per need on the basis of SPAD index (< 42.0) (Table 2). The N dose received in treatment of 40 kg N/ha (basal) + 30 kg N/ha as top-dressing whenever LCC reading was < 4.5 (T_4) to 40 kg N/ha (basal) + 30 kg N/ha (25 DAS) + SPAD-based N management at 45 and 65 DAS (T_6) (137 kg/ha; average of T_4 to T_6) was found 34.3% higher than the N received in treatment of 40 kg N/ha (basal) + 25 kg N/ha as top-dressing whenever LCC reading was < 4.0 (T_1) to 40 kg N/ha (basal) + 25 kg N/ha as top-dressing whenever LCC reading was < 4.5 (T_3) (102 kg/ha; average of T_1 to T_3) and in contrary resulted higher number of ears as well as grains/ear in T_4 to T_6 (Table 2). The SPAD-based management strategies (T_5) recorded significantly higher number of ears (16%) and higher number of grains (18%) over treatment FTNM (T_7) where N was applied as farmers' management practice. The results clearly indicated the importance of N where the higher dose affected the yield-attributing characters. In our study, both the SPAD-based management treatments received 140 kg N/ha which was higher than all the other N-management treatments and it was a valid reason for higher yield component (13% ears/m^2 and 18% grains/ear; average of T_5 and T_6 treatments over the average of T_1 to T_4 and T_7) in T_5 and T_6 treatments over the other N-management treatments. The increased N dose was considered on the basis of SPAD index and LCC scores. These results are agreement with those of Singh *et al.,* (2012); Duttarganvi *et al.,* (2014); Ghosh *et al.,* (2020) and Kumar *et al*., (2021). Though the 1000-grains weight did not vary significantly among the N-management

Table 1. Details of treatments of experimental plot

T_1	40 kg N/ha (basal) + 25 kg N/ha as top-dressing whenever LCC reading is < 4.0
T_2	40 kg N/ha (basal) + 30 kg N/ha as top-dressing whenever LCC reading is < 4.0
T_3	40 kg N/ha (basal) + 25 kg N/ha as top-dressing whenever LCC reading is < 4.5
T_4	40 kg N/ha (basal) + 30 kg N/ha as top-dressing whenever LCC reading is < 4.5
T_5	40 kg N/ha (basal) + 20 kg N/ha in split whenever SPAD index will be < 42
T_6	40 kg N/ha (basal) + 30 kg N/ha (25 DAS) + SPAD-based N management at 45 and 65 DAS (SPAD threshold: 40–42 in 3 conditions of N applications in split; (*i*) if SPAD < 40 then 40 kg N/ha, (*ii*) if SPAD 40–42 then 30 kg N/ha and (*iii*) if SPAD > 42 then 20 kg N/ha)
T_7	Fixed time N recommendation
T_8	Control (No N)

Table 2. Effect of different nitrogen management practices using LCC and SPAD meter on yield attributes and 1000-grains weight of wheat crop

Treatment	N rate (kg/ha)	Number of split (N)	Length of ear (cm)	Ears/m²	Grains/ear	1000-grains weight (g)
T_1	90	2	9.2	279	41	39.7
T_2	100	2	9.4	292	45	39.8
T_3	115	3	9.6	299	44	40.4
T_4	130	3	10.1	315	49	39.3
T_5	140	5	10.7	324	51	40.0
T_6	140	3	11.2	347	54	39.1
T_7	120	2	9.3	291	44	40.5
T_8	0	0	6.5	198	38	37.3
SEm±	-	-	0.4	10.6	2.7	0.6
CD (P=0.05)	-	-	1.1	32	8	1.8

T_1, 25 kg N/ha with LCC < 4; T_2, 30 kg N/ha with LCC < 4; T_3, 25 kg N/ha with LCC < 4.5; T_4, 30 kg N/ha with LCC < 4.5; T_5, 20 kg N/ha with SPAD index < 42; T_6, 30 kg N/ha (25 DAS) + SPAD-based N- management at 45 DAS and 65 DAS; T_7, fixed-time N recommendation; T_8, control (No N); LCC, leaf-colour chart; SPAD Meter, soil plant analysis development meter; DAS, days after sowing

treatments, but Zhang *et al*., (2021) reported that, top-dressing of N fertilizer effectively increased the grain yield by increasing 1000-grains weight and the grains/m².

The maximum grain yield (4,482 kg/ha) was observed in the SPAD-based management treatment T_5 against the total 140 kg/ha N application with 5 splits which was found statistically at par with the treatments T_6 (4,373 kg/ha) having the same 140 kg N/ha in 3 splits excluding basal dose under SPAD-based management strategy. It was observed that LCC-based treatments T_1 to T_3 received a lower dose of N fertilizer (19%; average of T_1 to T_3) over the FTNM and in returns maintained the similar yield components with the FTNM where 120 kg N/ha was applied as recommended dose. Therefore, it can be revealed that, use of farmers' friendly and cost-effective tool LCC is very useful in saving the N fertilizer (19%) resulted higher N-use efficiency than the FTNM without hampering the yield components. Singh *et al*., (2017) also reported that, N fertilizer application through LCC can sustain the grain yield of wheat crop. Among the LCC-based practices, treatment T_4 recorded significantly higher grain yield (4,015 kg/ha) but was found statistically lower (10.4%) than that of grain yield achieved in T_5. Here in the study, the fixed-time N-management treatment (T_7) was not able to produce similar result neither with LCC nor SPAD-based practices. The treatment T_7 resulted in 3,529 kg/ha which was found significantly 12.1% lower from T_4 (LCC < 4.5) and 21.2% lower than that of grain yield obtained in T_5 (SPAD 42.0). The control recorded significantly lower grain yield than the other treatments. The straw yield showed the linear trend with the N application rate and as the N application increased the straw yield responded accordingly. The maximum straw yield was observed in treatment T_5 (6,433 kg/ha) against 140 kg N/ha which was statistically at par with the treatment T_4 and T_6 but was found to be significantly superior to treatments T_1 to T_3 under LCC-based N-management practices. Moreover, the T_5 and T_6 treatments resulted in 14 and 13% higher straw yield, respectively, as compared to T_7 treatment. The FTNM resulted similar straw yield with T_1 to T_3 with 19% higher N application. This indicates that judicious (timely and adequate) use of N fertilizer through SPAD can considerably increase the straw yield. As per the trend noticed in the yield components the grain and straw yields were also found maximum (4,482 and 6,433 kg/ha) in T_5 treatment. The increment in grain yield in the treatments T_4, T_5 and T_6 using LCC and SPAD over T_7 clearly indicated the actual time and amount of fertilizer N application than that of recommended practices (Fig. 1). The treatment T_7 received 120 kg N/ha which was the recommended N dose resulted in 3,529 kg/ha grain yield found almost similar with the national average productivity is 3,419 kg/ha (USDA, 2021). Therefore, the fertilizer N can be saved using LCC gadget without hampering the grain yield (Singh *et al*., 2021). The grain yield further increased in this study (25%; average of T_5 and T_6 over T_7) owing to increment of fertilizer N by 14% (140

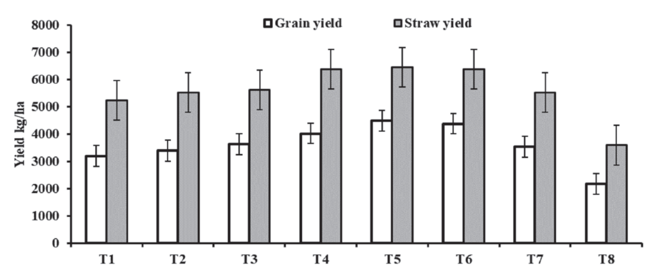

Fig. 1. Effect of nitrogen-management practices using LCC and SPAD meter on grain yield and straw yield of wheat crop T_1, 25 kg N/ha with LCC < 4; T_2, 30 kg N/ha with LCC < 4; T_3, 25 kg N/ha with LCC < 4.5; T_4, 30 kg N/ha with LCC < 4.5; T_5, 20 kg N/ha with SPAD index < 42; T_6, 30 kg N/ha (25 DAS) + SPAD-based N-management at 45 DAS and 65 DAS; T_7, fixed-time N recommendation; T_8, control (No N); LCC, leaf-colour chart; SPAD Meter, soil plant analysis development meter; DAS, days after sowing

kg N/ha) over the FTNM as per the SPAD index. The use of SPAD index can enhance the grain yield was also reported by Singh *et al*., (2012) and Reena *et al*., (2017).

The blanket N application often fails to meet the adequate N to the stressed crops. In present study, around 25% grain yield can be increased over the FTNM using SPAD-meter considering 14% higher application N. The maximum straw and grain yields in SPAD-based treatment where 5-split applications of N was done, proved that more of splits ultimately proved the higher economic output. It was also observed that, the grain yield under FTNM remained at par with LCC-based treatments and those LCC-based treatments received only 102 kg N/ha (average of T_1 to T_3) which was around 19% lower than the N received in FTNM.

The results indicated that, use of LCC not only saves the fertilizer N but also improves the nitrogen-use efficiency by saving of N over the FTNM. Therefore, it can be concluded that using LCC and SPAD meter, the farmers can save N fertilizer without hampering the grain yield.

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