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Real Time Nitrogen Fertilization Using Precision Tools for Enhancing Productivity of Wheat (*Triticum aestivum* L.)

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ABSTRACT

A field experiment was conducted at Instructional Farm, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat during rabi 2015-16 and 2016-17 to study the real time nitrogen fertilization using leaf colour chart (LCC) and chlorophyll meter (SPAD meter) in wheat (Triticum aestivum L.). Treatments consists of N application based on LCC threshold (4.0) and SPAD values (30, 35 and 40) compared with fix time nitrogen application (120 kg ha^{-1}), were imposed through RBD replicating thrice. The results revealed that top dressing of 80 kg N ha^{-1} in two equal splits at LCC 4 or SPAD 40 significantly improved growth and yield attributes viz., plant height, number of effective tillers per m row length, spike length and test weight along with higher grain and straw yields, grain protein content and economic returns over fixed time application of 60 kg N ha^{-1} each at sowing and 25 DAS. The results of the study implied that top dressing 80 kg N ha^{-1} in two equal splits when LCC threshold 4.0 or SPAD 40 are found to be effective as a decision tool for optimum N application in wheat.

Key words: *Wheat, Triticum aestivum, Nitrogen, Chlorophyll meter, SPAD meter, Leaf Colour Chart, LCC.*

INTRODUCTION

Wheat is a crop of global significance. It is grown in diversified environments. It is a staple food of millions of people. Wheat is the second most important crop in India next to rice. The fertilizer is essential as well as expensive input in agricultural production. It plays a leading role in increasing crop production by almost 41%. Among the primary nutrients, nitrogen though an expensive input is very important as it is intimately involved in the process of photosynthesis and directly reflected in the total dry matter production. An adequate supply of nitrogen can increase the yield as much as 60%. Top dressing by split application of N is needed when the crop has a great need for N and when the rate of N uptake is large[3].Crop-demand based N application is one of the important options to reduce N loss and to increase N use efficiency of a crop.

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Chlorophyll meter (SPAD) or leaf colour chart (LCC) can be used for adjustment of fertilizer N application based on actual plant N status[2]. Need based N application would result in greater agronomic and physiological efficiency of N fertilizer than the commonly practiced method. Ali[1] revealed that the requirement of N fertilizer based on SPAD reading was found 15 and 40 kg N SPAD meter lower compared to conventional N management during wet and dry seasons, respectively.

The nitrogen is the most limiting nutrient in almost all the soils. Blanket fertilizer recommendations over large areas are not efficient because N supply varies widely from field to field. Crops thus require different amounts of nutrients in different fields, depending on native nutrient supply and crop demand. It is more beneficial if N inputs could be adjusted to actual crop conditions and nutrient requirements. The LCC and SPAD meter can be used to monitor plant N status *in situ* in the field and to determine the right time of N top dressing to crop. LCC and SPAD meter are reliable, quite simple and useful tools to assist farmers in decision making regarding top-dress N application to crops. Either the farmers are under utilizing or over applying the N fertilizer to wheat. There is need to improve N management to achieve maximum grain yield and fertilizer use efficiency. Nitrogen management with LCC and SPAD not only suggests the saving with no yield loss by revising the blanket N fertilizer recommendation but also improves N use efficiency.

MATERIAL AND METHODS

A field experiment was conducted at Instructional Farm, College of Agriculture, Junagadh Agricultural University, Junagadh (21.5°N, 70.5°E and 60 m above mean sea level) during *rabi* (post-rainy) season of 2015-16 and 2016-17. The mean maximum temperature during crop growth period ranged between 28.2 to 35.8°C in 2015-16 and 27.3 to 36.6°C in 2016-17 and minimum temperature between 10.4 to 19.4C in 2015-16 and 11.7 to 18.7 C in 2016-17. The experimental soil was calcareous clayey, alkaline in reaction (pH 8.0-8.1) with EC 0.49-0.47 dS m^{-1}, medium in available nitrogen (251.8-258.0 kg ha^{-1}), medium in available phosphorus (29.5-30.9 kg ha^{-1}) and available potash (192.6-196.0 kg ha^{-1}). Experiment was laid out in randomized block design and with three replications. Treatments included; T_1: 60 kg N ha^{-1} as basal + 60 kg N ha^{-1} at 25 DAS, T_2: 40 kg N ha^{-1} as basal + 40 kg N ha^{-1} at 25 DAS + 40 kg N ha^{-1} at 45 DAS, T_3: 40 kg N ha^{-1} as basal + 80 kg N ha^{-1} in two equal splits when LCC=4, T_4: 40 kg N ha^{-1} as basal + 80 kg N ha^{-1} in two equal splits when SPAD threshold 30, T_5: 40 kg N ha^{-1} as basal + 80 kg N ha^{-1} in two equal splits when SPAD threshold 35, T_6: 40 kg N ha^{-1} as basal + 80 kg N ha^{-1} in two equal splits when SPAD threshold 40, T_7: 40 kg N ha^{-1} as basal + 60 kg N ha^{-1} in two equal splits when LCC=4, T_8: 40 kg N ha^{-1} as basal + 60 kg N ha^{-1} in two equal splits when SPAD threshold 30, T_9: 40 kg N ha^{-1} as basal + 60 kg N ha^{-1} in two equal splits when SPAD threshold 35, and T_{10}: 40 kg N ha^{-1} as basal + 60 kg N ha^{-1} in two equal splits when SPAD threshold 40. Wheat crop (var. GW-366) was sown on 25 November 2015 and 20 November 2016 using seed rate of 120 kg ha^{-1} at row spacing of 22.5 cm. A basal dose of 60 kg P_2O_5 ha^{-1} and 60 kg K_2O ha^{-1} using Di-ammonium Phosphate (DAP) and Muriate of Potash (MOP) was applied in all the treatments. Crop was grown under fully irrigated conditions. Two hand weeding were done 30 and 45 days after sowing to reduce the crop-weed competition. No serious incidence of any insect-pest or disease was observed in the crop. Plants were harvested after attaining physiological maturity. A ‘six panel’ LCC was used to match leaf colour and SPAD 502 plus in five plants in each plot starting from 21 DAS. LCC measurements were taken following guidelines as laid out by IRRI (http://nitrogenparameters.com/irri.html).

Methodology used for LCC reading

- Starting from 15 DAS, LCC readings were taken from randomly selected 5 plants in each plot.
- Observations were taken from the top most, fully expanded and healthy leaf of

each of the 5 plants by matching colour shade of LCC and average score was worked out.

- Readings were taken by placing the middle part of the leaf on top of the LCC's colour strips for comparison.
- Leaf was not detached.
- Readings were taken at same time of the day (8:00-10:00 AM).
- The LCC was not exposed to direct sunlight during readings.
- The same person has taken the first up to the last LCC reading.
- If average reading below the critical LCC value, N was given as per treatments.
- LCC readings were repeated after 7 days and same 5 plants were observed.

Methodology used for SPAD meter value

- Starting from 15 DAS, SPAD readings were taken from randomly selected 5 plants in each plot.
- Observations were taken from upper fully expanded and healthy three leaves of each 5 tagged plants.
- Readings were taken by first calibrating the instrument and then inserting the sample to be measured into the sample slot of the measuring head.
- Care was taken that the sample completely covers the receiving window.
- Extremely thick parts, such as the veins of a leaf were not attempted to measure. If measuring a leaf that has many fine veins, several measurements were taken and averaged for best results.
- Leaf was not be detached.
- Readings were taken at same time of the day (8-10 AM).
- When using the meter in direct sunlight, the meter was shaded with body to prevent the sunlight from affecting measurements.
- If average reading below the critical SPAD value, N was given as per treatments. SPAD readings were repeated after 7 days and same 5 tagged plants were observed.

Leaf chlorophyll content was analysed as per method suggested by Sadasivam and Manickam. Economic analysis of the data was done based on the prevailing cost of inputs/ operations and price of the marketable produce.

RESULTS AND DISCUSSION

Correlation between SPAD reading, LCC value and leaf chlorophyll content

To validate SPAD reading and LCC value, 50 leaf samples were analysed for chlorophyll content at 50 DAS during 2015-16 and 2016-17. A positive and highly significant correlation was found between SPAD reading, LCC value and leaf chlorophyll content (Table 1) which indicates that the SPAD and LCC could be effectively used to decide the timings of fertilizer N application in standing crop for better synchronization of crop N demand with supply. Based on the linear regression equations, SPAD=47.79 or LCC=4 were worked out as the critical values. Leaf N status is closely related to photosynthetic rate and biomass production, and it is a sensitive indicator of changes in crop N demand within a growing season (IRRI). The chlorophyll or soil plant analysis development (SPAD) meter, and its inexpensive and simple alternative, the LCC can be used for rapid and reliable monitoring of relative greenness of the leaf as an indicator of leaf N status[9].

Effect on growth and yield

Significantly the highest value of the plant height, dry matter per plant, and number of tillers per m row length at harvest were observed with the real time application of 40 kg N ha^{-1} as basal + 80 kg N ha^{-1} in two equal splits when SPAD threshold 40 (T_6), which remained statistically at par with T_3 (40 kg N ha^{-1} as basal + 80 kg N ha^{-1} in two equal splits when LCC=4), T_{10} (40 kg N ha^{-1} as basal + 60 kg N ha^{-1} in two equal splits when SPAD threshold 40), T_7 (40 kg N ha^{-1} as basal + 60 kg N ha^{-1} in two equal splits when LCC=4) and T_5 (40 kg N ha^{-1} as basal + 80 kg N ha^{-1} in two equal splits when SPAD threshold 35) in most of the cases over the fixed time application of 60 kg N ha^{-1} as basal + 60 kg N ha^{-1} at 25 DAS (Table-2). This could be attributed to better synchronization of N supply with crop N demand leading to higher N uptake due to application of 40 kg N ha^{-1} as basal + 80 kg N ha^{-1} in two splits at SPAD 40 or LCC 4 which improved in leaf chlorophyll content supports photosynthetic rate leading to higher growth and biomass production. The enhanced growth with SPAD based nitrogen application was reported by Reena *et al.*[6] and Hasan *et al*[6].

Real time application of 40 kg N ha^{-1} as basal + 80 kg N ha^{-1} in two equal splits when SPAD threshold 40 (T_6) excelled yield attributes *viz.,* number of spikelets per spike, length of spike, number of grains per spike, grain weight per spike, 1000-grain weight and grain yield (Table-2), followed by T_3 (40 kg N ha^{-1} as basal + 80 kg N ha^{-1} in two equal splits when LCC=4), T_5 **(**40 kg N ha^{-1} as basal + 80 kg N ha^{-1} in two equal splits when SPAD threshold 35), T_7 (40 kg N ha^{-1} as basal + 60 kg N ha^{-1} in two equal splits when LCC=4) and T_{10} (40 kg N ha^{-1} as basal + 60 kg N ha^{-1} in two equal splits when SPAD threshold 40) over the fixed time application of 60 kg N ha^{-1} as basal + 60 kg N ha^{-1} at 25 DAS. Significant improvement in overall growth of the crop increased photosynthetic efficiency. Thus greater availability of photosynthates, metabolites and nutrients to develop reproductive structures seems to have resulted in increased productive plants, and ultimately increased crop yield. The present findings are in close agreement with the results obtained by Singh[9], Jat *et al.*[7], Ghosh *et al.*[5] and Hasan *et al*[6].

Effect on quality

Quality parameters *viz.,* SPAD value at 30 DAS and 60 DAS, grain protein content significantly improved under the treatment T_6 (40 kg N ha^{-1} as basal + 80 kg N ha^{-1} in two equal splits when SPAD threshold 40), which remained statistically at par with application of 40 kg N ha^{-1} as basal + 80 kg N ha^{-1} in two equal splits when LCC=4 (T_3), 40 kg N ha^{-1} as basal + 80 kg N ha^{-1} in two equal splits when SPAD threshold 35 (T_5), 40 kg N ha^{-1} as basal + 60 kg N ha^{-1} in two equal splits when LCC=4 (T_7) and 40 kg N ha^{-1} as basal + 60 kg N ha^{-1} in two equal splits when SPAD threshold 40 (T_{10}) over the fixed time nitrogen application (Table-3).

Significant improvement in grain protein content might be due to its dependence on nitrogen content. In the present investigation, higher nitrogen content in grain and subsequently higher nitrogen uptake by grain was recorded with the above mentioned treatments that lend to support to enhance protein content under the effect. While higher SPAD value is due to the higher availability of nitrogen which is important constituent of chlorophyll and increased chlorophyll content indicates higher SPAD value.

Effect on nutrients uptake

Real time top dressing of nitrogen significantly influenced total NPK uptake by crop. Significantly the highest total NPK uptake by crop was recorded under the treatment T_6 (40 kg N ha^{-1} as basal + 80 kg N ha^{-1} in two equal splits when SPAD threshold 40), which remained statistically at par with application of 40 kg N ha^{-1} as basal + 80 kg N ha^{-1} in two equal splits when LCC=4 (T_3), 40 kg N ha^{-1} as basal + 80 kg N ha^{-1} in two equal splits when SPAD threshold 35 (T_5**)** and 40 kg N ha^{-1} as basal + 60 kg N ha^{-1} in two equal splits when LCC=4 (T_7), 40 kg N ha^{-1} as basal + 60 kg N ha^{-1} in two equal splits when SPAD threshold 40 (T_{10}) in some cases over the fixed time application (Table-3). Significant improvement in uptake of nitrogen might be attributed to their respective higher concentration in grain as well as in straw and associated with higher grain and straw yields. This might also be attributed to better availability of nutrients in the soil under these treatments. The results of present investigation are in close agreement with the findings of Singh[9], Duttarganvi *et al.*[4] and Singh *et al*[10].

Economic returns

While there was negligible increase in cost of cultivation due to real time application of 80 kg N ha^{-1} in two splits at SPAD 40 or LCC 4, but it increased net returns (Rs. 44691 ha^{-1}) over fixed time application of 60 kg N ha^{-1} (Table-3). The B:C ratio was also improved to 1.98 due to real time application of 80 kg N ha^{-1} in two splits at SPAD 40 or LCC 4 from 1.52 in fixed time application of 60 kg N ha^{-1}.

Table 1: Correlation between SPAD reading, LCC value and leaf chlorophyll content in wheat (Averaged over two years)

Sr. No.	Variable	r	Linear equation
1.	SPAD and LCC	0.9054**	Y = 30.0522 + 4.4347X
2.	SPAD and chlorophyll	0.8919**	Y = 23.3166 + 8.7322X
3.	LCC and Chlorophyll	0.8515**	Y = -0.7203 + 1.7020X
4.	LCC and SPAD	0.9054**	Y = -4.7672 + 0.1848X
5.	Chlorophyll and SPAD	0.8919**	Y = -1.5125 + 0.0911X
6.	Chlorophyll and LCC	0.8515**	Y = 1.1290 + 0.4260X

Table 2: Effect of SPAD and LCC based real time nitrogen application on growth, yield attributes and yield of wheat (Pooled over two years)

Treatments		Plant height (cm)	Dry matter per plant (g)	Tillers per m row length	Spikelets per spike	Length of spike (cm)	Grains per spike	Grain weight per spike (g)	1000-grain weight (g)	Grain yield (kg ha^{-1})
T_1:	60 kg N ha^{-1} as basal + 60 kg N ha^{-1} at 25 DAS	86.92	20.38	82.33	13.17	7.52	34.50	2.29	39.06	3352
T_2:	40 kg N ha^{-1} as basal + 40 kg N ha^{-1} at 25 DAS + 40 kg N ha^{-1} at 45 DAS	91.22	19.41	87.33	13.33	7.60	34.83	2.43	39.25	3383
T_3:	40 kg N ha^{-1} as basal + 80 kg N ha^{-1} in two equal splits when LCC=4	93.17	20.68	101.33	16.00	8.63	41.00	3.31	46.94	4325
T_4:	40 kg N ha^{-1} as basal + 80 kg N ha^{-1} in two equal splits when SPAD threshold 30	88.03	19.00	84.17	13.17	7.60	34.00	2.33	38.16	3293
T_5:	40 kg N ha^{-1} as basal + 80 kg N ha^{-1} in two equal splits when SPAD threshold 35	88.63	20.89	98.00	14.50	8.55	40.00	2.56	46.35	4202
T_6:	40 kg N ha^{-1} as basal + 80 kg N ha^{-1} in two equal splits when SPAD threshold 40	98.58	23.74	105.50	16.33	8.75	43.33	3.48	48.30	4477
T_7:	40 kg N ha^{-1} as basal + 60 kg N ha^{-1} in two equal splits when LCC=4	88.28	22.07	99.50	15.33	8.55	39.33	3.18	45.48	4168
T_8:	40 kg N ha^{-1} as basal + 60 kg N ha^{-1} in two equal splits when SPAD threshold 30	85.50	17.74	79.00	12.00	6.85	30.83	2.04	37.76	3128
T_9:	40 kg N ha^{-1} as basal + 60 kg N ha^{-1} in two equal splits when SPAD threshold 35	86.75	19.91	85.83	12.83	7.53	32.92	2.26	37.91	3252
T_{10}:	40 kg N ha^{-1} as basal + 60 kg N ha^{-1} in two equal splits when SPAD threshold 40	92.50	22.76	99.00	15.50	8.48	38.67	3.29	45.85	4178
	LSD (P=0.05)	4.67	1.83	8.51	1.67	0.74	4.74	0.44	5.18	562

Note: 60 kg P2O5 ha^{-1} + 60 kg K2O ha^{-1} were applied uniformly to all the plots as basal application. Deficiency of S and micronutrients in soil was corrected.

Table 3: Effect of SPAD and LCC based real time nitrogen application on quality parameters, nutrients uptake by grain and economics in wheat (Pooled over two years)

Treatments		Protein content of grain (%)	Leaf SPAD value 30 DAS	Leaf SPAD value 60 DAS	Nitrogen uptake (kg ha-1)	Phosphorus uptake (kg ha-1)	Potash uptake (kg ha-1)	Net returns (Rs. ha-1)	B:C ratio
T1:	60 kg N ha-1 as basal + 60 kg N ha-1 at 25 DAS	9.92	33.48	41.27	75.55	16.97	63.51	23324	1.52
T2:	40 kg N ha-1 as basal + 40 kg N ha-1 at 25 DAS + 40 kg N ha-1 at 45 DAS	10.27	34.82	42.41	83.70	18.91	67.86	24084	1.54
T3:	40 kg N ha-1 as basal + 80 kg N ha-1 in two equal splits when LCC=4	11.26	36.36	45.87	128.68	29.29	92.95	42236	1.94
T4:	40 kg N ha-1 as basal + 80 kg N ha-1 in two equal splits when SPAD threshold 30	9.79	33.95	40.88	77.95	17.62	61.00	21201	1.47
T5:	40 kg N ha-1 as basal + 80 kg N ha-1 in two equal splits when SPAD threshold 35	11.09	35.62	46.04	120.44	26.53	90.03	39320	1.87
T6:	40 kg N ha-1 as basal + 80 kg N ha-1 in two equal splits when SPAD threshold 40	11.54	37.03	47.23	136.08	31.96	100.49	44691	1.98
T7:	40 kg N ha-1 as basal + 60 kg N ha-1 in two equal splits when LCC=4	10.57	36.08	45.17	109.27	27.29	86.57	39391	1.88
T8:	40 kg N ha-1 as basal + 60 kg N ha-1 in two equal splits when SPAD threshold 30	9.06	32.67	39.78	64.37	14.62	53.77	18201	1.40
T9:	40 kg N ha-1 as basal + 60 kg N ha-1 in two equal splits when SPAD threshold 35	9.58	33.20	40.49	70.77	17.85	60.76	20711	1.46
T10:	40 kg N ha-1 as basal + 60 kg N ha-1 in two equal splits when SPAD threshold 40	10.84	35.53	42.84	115.67	26.16	86.82	39044	1.87
	LSD (P=0.05)	0.46	1.13	2.34	10.23	2.01	9.18		

CONCLUSION

On the basis of the results obtained from present two-year field experimentation, it seems quite logical to conclude that higher production and net returns from wheat (var. GW-366) can be secured by real time top dressing of 80 kg N ha^{-1} in two equal splits when SPAD=40 or LCC=4 besides basal application of 40-60-60 kg N-P_2O_5-K_2O ha^{-1} on calcareous clayey soil under South Saurashtra Agro-climatic Zone of Gujarat in India.

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