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Validation of LCC and SPAD meter for nitrogen management in wheat and their effect on yield, nutrients uptake and post-harvest soil fertility

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Abstract

A field experiment was conducted at Instructional Farm, College of Agriculture, JunagadhAgricultural 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 thresholds (4.0) andSPAD values (30, 35 and 40) compared with fix time nitrogen application (120 kg/ha) were imposed through RBD replicating thrice. The results revealed that application of 40 kg N/ha as basal + top dressing of 80 kg N/ha in two equal splits at LCC 4 or SPAD 40 significantly increased yield, improved nutrient uptake by crop and sustainedpost-harvest soil fertility over fixed time application of 60 kg N/ha as basal + 60 kg N/ha at 25 DAS.The results of the study implied that 40 kg N/ha as basal + top dressing of 80 kg N/ha when LCC threshold 4.0 or SPAD value 40 are found to be effectiveas a decision tool for optimizing N application in wheat.

Keywords: Wheat, *Triticum aestivum*, nitrogen, chlorophyll meter, leaf colour chart

Introduction

The fertilizer is essential as well as expensive input in agricultural production. Fertilizer plays a leading role in increasing crop production by almost 41%. Of the agronomic factors known to augment wheat yield, the true rate and status of the plant nutrients mainly nitrogen, phosphorus and potassium are more widely understood today with micronutrients as trace element than they were a decade ago. There is a correlation between fertilizer use and agricultural production, its effect being manifested quickly on the plant growth and ultimately on crop yields (Bruinsma, 2003) [4].

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. 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. Crop-demand based N application is one of the important options to reduce N loss and to increase N use efficiency of a crop.

Wheat is a crop of global significance. It is grown in diversified environments. It is a staple food of millions of people. Approximately one-sixth of the total arable land in the world is cultivated with wheat. Wheat is the second most important crop in India next to rice. In Indian agriculture, wheat assumes a special significance on account of its utilization as food, feed and fodder besides several industrial uses.

The value of soil test prior to planting to evaluate fertilizer requirement for wheat is not well-understood. The soil testing or leaf analyses are expensive and time-consuming. In addition, tissue testing is a destructive method, which limits its use as a diagnostic tool for nutrient use efficiency of cereal plants.

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 (Dobermann and Fairhurst, 2000) [5]. Crop-demand based N application is one of the important options to reduce N loss and to increase N use efficiency of a crop.

Chlorophyll meter (SPAD) or leaf colour chart (LCC) can be used for adjustment of fertilizer N application based on actual plant N status (Balasubramanian *et al*., 1999) [3]. Need based N application would result in greater agronomic and physiological efficiency of N fertilizer than the commonly practiced method. 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 a great need for N and when the rate of N uptake is large (Dobermann and Fairhurst, 2000) [5]. Ali (2005) [2] revealed that N application at SPAD reading 15 to rice was found to save 40 kg N/ha.

Materials 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 abovemean 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 19.4°C in 2015-16 and 11.7 to 18.7°C in 2016-17. Theexperimental soil was medium black calcareous clayey and alkaline in reaction (pH 8.0-8.1) with EC 0.49-0.47 dS/m, medium in available nitrogen (251.8-258.0kg/ha), medium in available phosphorus (29.48-30.89 kg/ha) and available potash (K) (192.6-196.0 kg/ha).

Treatments included; T_1: 60 kg N/ha as basal + 60 kg N/ha at 25 DAS, T_2: 40 kg N/ha as basal + 40 kg N/ha at 25 DAS + 40 kg N/ha at 45 DAS, T_3: 40 kg N/ha as basal + 80 kg N/ha in two equal splits when LCC=4, T_4: 40 kg N/ha as basal + 80 kg N/ha in two equal splits when SPAD threshold 30, T_5: 40 kg N/ha as basal + 80 N/ha in two equal splits when SPAD threshold 35, T_6: 40 kg N/ha as basal + 80 kg N/ha in two equal splits when SPAD threshold 40, T_7: 40 kg N/ha as basal + 60 kg N/ha in two equal splits when LCC=4, T_8: 40 kg N/ha as basal + 60 kg N/ha in two equal splits when SPAD threshold 30, T_9: 40 kg N/ha as basal + 60 kg N/ha in two equal splits when SPAD threshold 35, and T_{10}: 40 kg N/ha as basal + 60 kg N/ha in two equal splits when SPAD threshold 40.Experiment was laid out in randomized block design and with three replications. Wheat crop (var. GW-366) was sown on 25th November 2015 and 20th November 2016 using seed rate of 120 kg/ha and row spacing of 22.5 cm. A basal dose of 60 kg P_2O_5/ha and 60 kg K_2O/ha using di-ammonium phosphate and muriate of potash was applied in all the treatments. Deficiency of S and micronutrients in soil was corrected before sowing. Crop was grown under fully irrigated conditions and irrigations were applied at IW:CPE of 1.0. 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 15 DAS. Plant and soil samples were analysed for N, P, K, S and micronutrients as per standard procedures.

Result 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 LCC can be used for rapid and reliable monitoring of relative greenness of the leaf as an indicator of leaf N status (Singh *et al.*, 2002) [11].

Table 1: Correlation and regression between SPAD reading, LCC value and leaf chlorophyll content in wheat

Sr. No.	Variables	r			Linear regression equation (pooled)
		2016	2017	pooled	
1.	SPAD and LCC	0.8695**	0.9227**	0.9054**	Y = 30.0522 + 4.4347X
2.	SPAD and chlorophyll	0.9132**	0.8904**	0.8919**	Y = 23.3166 + 8.7322X
3.	LCC and Chlorophyll	0.8897**	0.8335**	0.8515**	Y = -0.7203 + 1.7020X
4.	LCC and SPAD	0.8695**	0.9227**	0.9054**	Y = -4.7672 + 0.1848X
5.	Chlorophyll and SPAD	0.9132**	0.8904**	0.8919**	Y = -1.5125 + 0.0911X
6.	Chlorophyll and LCC	0.8897**	0.8335**	0.8515**	Y = 1.1290 + 0.4260X

Effect on yield

Application of 40 kg N/ha as basal + 80 kg N/ha in two equal splits when SPAD threshold 40(T_6), excelled yield(Table 2) followed by T_3 (40 kg N/ha as basal + 80 kg N/ha in two equal splits when LCC=4), T_5(40 kg N/ha as basal + 80 kg N/ha in two equal splits when SPAD threshold 35), T_7 (40 kg N/ha as basal + 60 kg N/ha in two equal splits when LCC=4) and T_{10} (40 kg N/ha as basal + 60 kg N/ha in two equal splits when SPAD threshold 40) over the fixed time application of 60 kg N/ha as basal + 60 kg N/ha 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 (2002) [11], Jat *et al.* (2008) [9], Ghosh *et al.* (2013) [7] and Hasan *et al.* (2016) [8].

Effect on content of nutrients

Application of 40 kg N/ha as basal + 80 kg N/ha in two splits at SPAD 40 or LCC 4, significantly enhanced content of NPK by grain and straw (Table2), followed by T_3 (40 kg N/ha as basal + 80 kg N/ha in two equal splits when LCC=4) and T_5 (40 kg N/ha as basal + 80 kg N/ha in two equal splits when SPAD threshold 35). These might be due to the higher photosynthetic activity in plant as evident from increase in biomass accumulation at successive duration and plant height reveals higher availability of metabolites from shoot to root. This might have promoted growth of root as well as their functional activity resulting in higher extraction of nutrients from soil environment to aerial parts.

Table 2: Effect of SPAD and LCC based real time nitrogen application on yield, nutrients content and uptake by grain and straw of wheat (Pooled over two years)

Treatments	Grain yield (Kg/ha)	Nutrient content in grain (%)			Nutrients content in straw (%)			Nutrients uptake by grain (kg/ha)			Nutrients uptake by straw(kg/ha)		
		N	P	K	N	P	K	N	P	K	N	P	K
T_1: 60 kg N/ha as basal + 60 kg N/ha at 25 DAS	3352	1.59	0.30	0.40	0.43	0.14	0.98	53.2	10.1	13.6	22.3	6.91	49.9
T_2: 40 kg N/ha as basal + 40 kg N/ha at 25 DAS + 40 kg N/ha at 45 DAS	3383	1.64	0.35	0.42	0.53	0.14	1.03	55.7	11.7	14.4	28.0	7.16	53.5
T_3: 40 kg N/ha as basal + 80 kg N/ha in two equal splits when LCC=4	4325	1.80	0.45	0.46	0.81	0.16	1.16	78.0	19.4	20.1	50.7	9.92	72.9
T_4: 40 kg N/ha as basal + 80 kg N/ha in two equal splits when SPAD threshold 30	3293	1.57	0.33	0.39	0.53	0.13	0.97	51.7	11.0	12.8	26.2	6.53	48.2
T_5: 40 kg N/ha as basal + 80 kg N/ha in two equal splits when SPAD threshold 35	4202	1.78	0.40	0.46	0.74	0.15	1.15	74.8	17.1	19.3	45.7	9.44	70.7
T_6: 40 kg N/ha as basal + 80 kg N /ha in two equal splits when SPAD threshold 40	4477	1.85	0.46	0.49	0.83	0.17	1.23	82.9	20.9	21.9	53.2	11.05	78.6
T7: 40 kg N/ha as basal + 60 kg N/ha in two equal splits when LCC=4	4168	1.69	0.44	0.45	0.67	0.15	1.12	68.5	18.3	18.8	40.8	9.00	67.8
T_8: 40 kg N/ha as basal + 60 kg N/ha in two equal splits when SPAD threshold 30	3128	1.45	0.28	0.31	0.40	0.12	0.93	45.7	8.9	9.8	18.7	5.74	44.0
T_9: 40 kg N/ha as basal + 60 kg N /ha in two equal splits when SPAD threshold 35	3252	1.53	0.34	0.38	0.42	0.14	0.99	50.0	11.3	12.5	20.7	6.55	48.3
T10: 40 kg N/ha as basal + 60 kg N/ha in two equal splits when SPAD threshold 40	4178	1.74	0.41	0.45	0.71	0.15	1.13	72.6	17.3	19.1	43.1	8.82	67.8
C.D. at 5%	562	0.07	0.03	0.03	0.04	0.01	0.07	9.9	1.9	2.6	4.9	1.15	8.8

Table 3: Effect of SPAD and LCC based real time nitrogen application on nutrients availability in soil after harvest of wheat (Pooled over two years)

Treatments	Post-harvest availability of nutrients							
	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)	Heat soluble S (ppm)	DTPA extractable Fe (ppm)	DTPA extractable Zn (ppm)	DTPA extractable Cu (ppm)	DTPA extractable Mn (ppm)
T_1: 60 kg N/ha as basal + 60 kg N/ha at 25 DAS	213	22.01	180.92	13.86	4.90	1.18	0.305	5.11
T_2: 40 kg N/ha as basal + 40 kg N/ha at 25 DAS + 40 kg N/ha at 45 DAS	225	23.05	181.83	14.98	5.31	1.28	0.302	5.27
T_3: 40 kg N/ha as basal + 80 kg N/ha in two equal splits when LCC=4	272	22.02	193.12	19.91	5.88	1.91	0.395	6.50
T_4: 40 kg N/ha as basal + 80 kg N/ha in two equal splits when SPAD threshold 30	249	24.89	184.16	12.75	4.88	1.22	0.258	5.03
T_5: 40 kg N/ha as basal + 80 kg N/ha in two equal splits when SPAD threshold 35	273	22.50	187.63	19.51	5.72	1.76	0.360	5.70
T_6: 40 kg N/ha as basal + 80 kg N /ha in two equal splits when SPAD threshold 40	293	22.04	199.35	20.44	6.02	2.01	0.407	6.83
T7: 40 kg N/ha as basal + 60 kg N/ha in two equal splits when LCC=4	258	23.21	188.81	19.44	5.68	1.80	0.333	6.72
T_8: 40 kg N/ha as basal + 60 kg N/ha in two equal splits when SPAD threshold 30	210	21.48	178.51	9.37	4.72	0.59	0.203	3.36
T_9: 40 kg N/ha as basal + 60 kg N /ha in two equal splits when SPAD threshold 35	214	23.07	181.67	12.09	5.07	0.97	0.240	3.83
T10: 40 kg N/ha as basal + 60 kg N/ha in two equal splits when SPAD threshold 40	266	20.34	189.72	19.64	5.75	1.90	0.392	6.38
C.D. at 5%	17	1.86	7.99	0.87	0.38	0.07	0.024	0.38

Effect on uptake of nutrients

Significantly the highest NPK uptake by grain and straw (Table 2) was recorded under the treatment T_6 (40 kg N/ha as basal + 80 kg N/ha in two equal splits when SPAD threshold 40), which remained statistically at par with application of 40 kg N/ha as basal + 80 kg N/ha in two equal splits when LCC=4 (T_3), 40 kg N/ha as basal + 80 kg N/ha in two equal splits when SPAD threshold 35 (T_5),40 kg N/ha as basal + 60 kg N/ha in two equal splits when LCC=4 (T_7) and 40 kg N/ha as basal + 60 kg N/ha in two equal splits when SPAD threshold 40 (T_{10}) in some cases. These might be due to the nutrient uptake is a function of yield and nutrient concentrations in plant. Thus, significant improvement in uptake of nitrogen might be attributed to their respective higher concentration in grain and 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 agreements with the findings of Singh (2002) [11], Maiti and Das (2006) [10], Duttarganvi *et al*. (2014) [6] and Singh *et al*. (2015) [12].

Effect on post-harvest soil fertility

Post-harvest soil fertility analysis revealed that different nitrogen top dressing treatments significantly affected the available nitrogen, available phosphorus, available potassium, heat soluble sulphur, and micronutrients (Table 3) in the soil. Significantly higher values of these nutrients were recorded under the treatment T_6 (40 kg N/ha as basal + 80 kg N/ha in two equal splits when SPAD threshold 40), followed by application of 40 kg N/ha as basal + 80 kg N/ha in two equal splits when LCC=4 (T_3), 40 kg N/ha as basal + 80 kg N/ha in two equal splits when SPAD threshold 35 (T_5), 40 kg N/ha as basal + 60 kg N/ha in two equal splits when LCC=4 (T_7) and 40 kg N/ha as basal + 60 kg N/ha in two equal splits when SPAD threshold 40 (T_{10}) in most of the cases over the fixed time N application.

The significant build-up of available nitrogen status under these treatments could be ascribed to adequate and timely supply of nitrogen to meet the crop demand. The increased status of potassium might be due to enhanced mineralization owing to better root growth under these treatments. The results of present investigation strongly support the findings of Alam (2006) [1] and Duttarganvi *et al.* (2014) [6].

Conclusion

On the basis of the results obtained from present two-year field experimentation, it seems quite logical to conclude that higher production ofwheat (var. GW-366) along with higher nutrients uptake and post-harvest availability of nutrients in soil can be secured by real time top dressing of 80 kg N/ha 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 on calcareous clayey soil under South Saurashtra Agro-climatic Zone of Gujarat in India.

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