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Real Time Nitrogen Management Improves Yield and Economic Returns in Wheat in Vertisols of Gujarat

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A field experiment was conducted at Instructional Farm, College of Agriculture, Junagadh Agricultural University, Junagadh during Rabi 2011-12 to study the real time nitrogen management using leaf colour chart (LCC) in wheat (Triticum aestivum L.). Treatments were; fixed time N application (60 kg N ha^{-1} at 25 DAS), 60 kg N ha^{-1} at LCC 3, 60 kg N ha^{-1} in two equal splits at LCC 3, 40 kg N ha^{-1} in two equal splits at LCC 3, 60 kg N ha^{-1} at LCC 4, 60 kg N ha^{-1} in two equal splits at LCC 4, 40 kg N ha^{-1} in two equal splits at LCC 4, 60 kg N ha^{-1} at LCC 5, 60 kg N ha^{-1} in two equal splits at LCC 5 and 40 kg N ha^{-1} in two equal splits at LCC 5. Basal dose of 60 kg N ha^{-1} was applied in all the treatments. Top dressing of 60 kg N ha^{-1} in two equal splits at LCC 4 and 5 significantly improved growth attributes, chlorophyll content, yield attributes, grain and straw yield, and economic returns over fixed time application of 60 kg N ha^{-1} at 25 DAS.

INTRODUCTION

Wheat is a crop of global significance as it is the staple food of largest population group next only to rice. Among the primary nutrients, nitrogen is very important as it is intimately involved in the process of photosynthesis and thus directly related to total dry matter production. Improving fertiliser nitrogen (N)-use efficiency in wheat is vital not only to improve and sustain high crop yields but to reduce post field application N losses to the environment. Fertiliser N is an expensive input but farmers have a tendency to apply N in large amounts to minimise yield losses due to degradation of soils because of continuous cropping without investing adequately in maintaining soil quality. Bijay-Singh (1) argued that recommendations based on soil tests remain ignorant about the dynamics of N release from crop residues, organic manures and irrigation water, and are not very successful in wheat. Efficiency of fertiliser N generally declines with increased fertiliser doses, and seldom exceeds 40% (2). Lack of proper splitting of N applications, and many a times over or under N application than the crop need is one important reason for low N-use efficiency. As N requirement of wheat plant is not same throughout the growth period it is necessary to adjust fertiliser N application with the timings of plant N requirement to enhance N-use efficiency in wheat. The real time N management approach can help increase N use efficiency by matching time of fertiliser application with plant need. Leaf colour chart (LCC) is a reliable tool for real time N management (3). It can be used for rapid and reliable monitoring of relative greenness of the leaf as an indicator of leaf N status. The guidelines evolved using LCC helps adopt crop demand-driven N applications and result in high crop productivity and economic returns and reduce N losses to the environment (3,4,5,6)

MATERIALS AND METHODS

A field experiment was conducted at Instructional Farm, College of Agriculture, Junagadh Agricultural University, Junagadh (21.5^{0} N, 70.5^{0} E and 60 m above mean sea level) during *rabi* (post rainy) season of 2011-12. Climate of this region is typically subtropical characterised by fairly cool and dry winter, hot and dry summer, and warm and moderately humid monsoon with average decennial rainfall of 1072 mm falling mostly during June through September. The mean maximum and minimum temperature during crop growth period ranged between 27.5 to 36.0^{0}C and 9.4 to 21.3 ^{0}C, respectively. The experimental soil was clayey, alkaline in reaction (pH 8.0) with EC 0.36 (dSm^{-1}) at 25^{o}C, low in available nitrogen (N) (261.8 kg ha^{-1}), medium in available phosphorus (P) (13.40 kg ha^{-1}) and available potash (K) (207.2 kg ha^{-1}). Experiment was laid out in randomized block design and with three replications. Treatments included; fixed time N application (60 kg N ha^{-1} at 25 DAS), 60 kg N ha^{-1} at LCC 3, 60 kg N ha^{-1} in two equal splits at LCC 3, 40 kg N ha^{-1} in two equal splits at LCC 3, 60 kg N ha^{-1} at LCC 4, 60 kg N ha^{-1} in two equal splits at LCC 4, 40 kg N ha^{-1} in two equal splits at LCC 4, 60 kg N ha^{-1} at LCC 5, 60 kg N ha^{-1} in two equal splits at LCC 5 and 40 kg N ha^{-1} in two equal splits at LCC 5.

Basal dose of 60 kg N ha^{-1} was applied in all the treatments.

Prior to experimental crop, sunnhemp (*Crotalaria juncea*) was grown as green manure crop in experimental field during the rainy season and was turned down after 60 days of sowing with disc plowing. The experimental field was prepared by one harrowing followed by cultivation and planking. Wheat crop (var. GW-366) was sown on 10th November 2011 using seed rate of 120 kg/ha and spacing of 22.5 cm. A basal dose of 60 kg P_2O_5 ha^{-1} and 60 kg N ha^{-1} using di-ammonium phosphate and urea was applied in all the treatments. Crop was grown under fully irrigated conditions; total water applied was 550 mm in 11 irrigation schedules. Two hand weedings 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 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). The timings of LCC readings is given in **Table 1**.

Economic analysis of the data was done based on the prevailing cost of inputs/ operations and price of the marketable produce. The data collected from experiment were subjected to statistical test by following 'Analysis of variance technique' as suggested by (7).

RESULTS AND DISCUSSION

Correlation between LCC Shades, Leaf N Content and Leaf Photosynthetic Rate

A positive and highly significant correlation was found between LCC shades, leaf N content and leaf photosynthetic rate **(Table 2)** which indicates that the LCC could be effectively used to decide the timings of fertiliser N application in standing crop for better synchronization of crop N demand with supply. 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 (12). 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 (3). LCC being cheaper and user friendly thus could be used to improve fertiliser N use efficiency and improve productivity largely in developing countries where farmers cannot afford the costly and more SPAD meter.

Effect on Growth Attributes

Real time application of 60 kg N ha^{-1} in two equal splits at LCC 4, being at par with application of 60 kg N ha^{-1} in two equal splits at LCC 5, significantly improved growth attributes like plant height, dry matter production plant^{-1}, number of total tillers plant^{-1}and number of effective tillers plant^{-1} compared to that in fixed time application of 60 kg Nha^{-1} **(Table 3)**. This could be attributed to better synchronization of N supply with crop N demand leading to higher N uptake (data not given) due to real time application of 60 kg N ha^{-1} in two equal splits at LCC 4. It is assumed that better nutrition, as indicated by higher leaf N content **(Table 3)**, improved photosynthetic rate when 60 kg N ha^{-1} was applied in two equal splits at LCC 4 over fixed time application of 60 kg Nha^{-1} at 25 DAS. Improvement in leaf chlorophyll content due to application of 60 kg N ha^{-1} in two equal splits at LCC 4 over fixed time application of 60 kg Nha^{-1} at 25 DAS **(Table 3)** supports improved photosynthetic rate leading to higher growth and biomass production. The enhanced growth with LCC based nitrogen application was also reported by Singh et al., (3) and Shukla et al., (8).

Days to 50% flowering were not significantly affected by different split application treatments of N.

Table 1 – Timing of LCC readings

Treatment	1st LCC Reading (DAS)	2nd LCC Reading (DAS)
60 kg Nha^{-1} at 25 DAS	-	-
60 kg Nha^{-1} at LCC 3	58	-
30+30 kg Nha^{-1} at LCC 3	58	72
20+20 kg Nha^{-1} at LCC 3	58	68
60 kg Nha^{-1} at LCC 4	52	-
30+30 kg Nha^{-1} at LCC 4	52	66
20+20 kg Nha^{-1} at LCC 4	52	60
60 kg Nha^{-1} at LCC 5	21	-
30+30 kg Nha^{-1} at LCC 5	21	47
20+20 kg Nha^{-1} at LCC 5	21	40

Table 2 – Simple correlation between LCC shades, leaf chlorophyll content and leaf nitrogen content in wheat

Sr. No.	Variables	r
1.	LCC and Leaf chlorophyll content	0.9349**
2.	LCC and Leaf N content	0.9299**
3.	Leaf chlorophyll content and Leaf N content	0.9488**

* indicates significant at 5% level of significance (r = 0.2483)
** indicates significant at 1% level of significance (r = 0.3457)

Effect on Leaf Chlorophyll Content and Leaf Nitrogen Content

Real time application of 60 kg N ha^{-1} in two equal splits at LCC 4 significantly improved leaf chlorophyll content and leaf N content as compared to fixed time application of 60 kg N ha^{-1} at 25 DAS **(Table 3)**. It could be mainly due to matching of N supply with crop N demand leading to higher N uptake and recovery of applied N.

Effect on Yield Attributes and Yield

Real time application of 60 kg N ha^{-1} in two equal splits at LCC 4 significantly increased length of spike, number of spikelets per spike, number of grains per spike, grain weight per spike, 1000 grain weight and, grain and straw yield of wheat as compared to fixed time application of 60 kg N ha^{-1} at 25 DAS **(Table 4)**. Real time application of 60 kg Nha^{-1} in two equal splits at LCC 4 increased grain and straw yield by 27.40 and 22.61% respectively, over fixed time application of 60 kg N ha^{-1} at 25 DAS. The significant increase in growth and biomass production due to real time N management get reflected into significant increase in yield attributes and yield of wheat. However, harvest index was not significantly affected by real time N management. These results confirm the findings of Maiti and Das (9) and Shukla et al., (8).

In case of treatment 60 kg N ha^{-1} in two equal splits at LCC 4, which gave significantly highest yield, the split application of N was given at 52 and 66 days after sowing **(Table 1)**. This indicates the need for revisiting the conventional N fertiliser recommendation of split dose of 60 N ha^{-1} at 21 days after sowing.

Effect on Quality

Real time application of 60 kg N ha^{-1} in two equal splits at LCC 4 significantly increased grain protein content and protein yield

Table 3 – Effect of LCC based real time N management on growth attributes, leaf N content and leaf chlorophyll content in wheat

Treatments	Plant height at harvest (cm)	Dry matter accumulation plant^{-1} (g)	No. of total tillers m^{-1} row length	No. of effective tillers m^{-1} row length	Days to 50% flowering	Leaf nitrogen content (%)	Leaf chlorophyll content (mg g^{-1})
60 kg Nha^{-1} at 25 DAS	91.4	18.17	83.3	76.3	68.3	1.228	0.727
60 kg Nha^{-1} at LCC 3	91.0	16.69	87.7	75.3	68.0	0.941	0.547
30+30 kg Nha^{-1} at LCC 3	90.8	16.94	94.0	75.0	66.0	0.957	0.447
20+20 kg Nha^{-1} at LCC 3	89.4	12.78	82.0	70.0	65.3	0.974	0.568
60 kg Nha^{-1} at LCC 4	93.1	19.91	88.0	83.7	67.7	2.028	1.494
30+30 kg Nha^{-1} at LCC 4	105.8	24.50	112.0	99.3	70.7	1.878	1.340
20+20 kg Nha^{-1} at LCC 4	99.5	23.26	96.7	88.0	69.3	1.748	1.201
60 kg Nha^{-1} at LCC 5	93.0	18.64	95.0	86.0	68.7	2.535	1.788
30+30 kg Nha^{-1} at LCC 5	102.4	23.55	108.3	97.0	69.7	2.612	2.015
20+20 kg Nha^{-1} at LCC 5	98.0	20.07	89.7	80.7	68.0	2.586	1.911
SEm±	2.7	0.68	5.8	5.3	1.0	0.117	0.092
LSD (P=0.05)	7.9	2.03	17.4	15.7	NS	0.347	0.272

Table 4 – Effect of LCC based real time N management on yield attributes, grain and straw yield, harvest index, grain protein content, protein yield and N uptake by grain in wheat

Treatments	Length of spike (cm)	No. of spikelets spike-1	No. of grains spike-1	Grain weight spike-1	1000 grain weight (g)	Grain yield (kgha^{-1})	Straw yield (kgha^{-1})	Havest index	Grain protein content (%)	Protein yield (kg ha^{-1})
60 kg Nha^{-1} at 25 DAS	7.9	15.1	40.4	1.87	43.71	3861	5748	40.44	8.25	318
60 kg Nha^{-1} at LCC 3	7.9	14.6	38.5	1.85	43.01	3773	5708	39.58	8.02	303
30+30 kg Nha^{-1} at LCC 3	7.7	14.3	36.1	1.73	41.46	3280	5150	39.04	7.79	256
20+20 kg Nha^{-1} at LCC 3	7.3	13.7	35.1	1.62	40.79	3233	5073	38.85	6.94	224
60 kg Nha^{-1} at LCC 4	7.9	15.2	41.5	2.20	46.36	3942	5750	40.78	9.13	360
30+30 kg Nha^{-1} at LCC 4	8.7	16.7	44.7	2.50	50.08	4919	7048	41.15	11.47	564
20+20 kg Nha^{-1} at LCC 4	8.1	15.9	41.8	2.30	47.74	4608	6647	40.98	10.46	483
60 kg Nha^{-1} at LCC 5	7.9	15.2	41.2	1.96	45.03	3878	5771	40.29	8.77	340
30+30 kg Nha^{-1} at LCC 5	8.1	15.7	44.3	2.31	48.60	4810	6847	41.46	11.02	530
20+20 kg Nha^{-1} at LCC 5	8.0	15.3	41.2	2.07	46.73	4363	6237	40.85	9.33	408
SEm±	0.2	0.4	1.5	0.08	1.74	297	429	2.15	0.16	28
LSD (P=0.05)	0.7	1.3	4.4	0.24	5.16	881	1276	NS	0.46	83

over fixed time application of 60 kg N ha^{-1} at 25 DAS **(Table 4)**. This could be explained on the basis of better availability of N in the crop root zone and enhanced N uptake (data not given) and consequent increase in photosynthetic and metabolic activities resulting in better partitioning of photosynthates to sinks, which got reflected in quality enhancement in terms of grain protein content and protein yield.

Quality of foodgrains is a complex phenomenon and may be influenced by both genetic and /or environmental factors. These results are supported by the findings of Dineshkumar (10) and Singh and Singh (11).

Effect on Economic Returns

While there was negligible increase in cost of cultivation due to real time application of 60 kg N ha^{-1} in two equal splits at LCC 4 but, it increased net returns by 59.14% over fixed time application of 60 kg N ha^{-1} at 25 DAS **(Table 5)**. The B:C ratio also improved to 2.27 due to real time application of 60 kg N ha^{-1} in two equal splits at LCC 4 from 1.81 in fixed time application of 60 kg N ha^{-1} at 25 DAS. Dineshkumar (10) has also reported higher net returns and B:C ratio with LCC based real time N management.

Table 5 – Effect of LCC based real time N management on cost of cultivation, net returns and benefit : cost (B:C) ratio in wheat

Treatments	Cost of cultivation (Rs.ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
60 kg Nha^{-1} at 25 DAS	36,317	29,271	1.81
60 kg Nha^{-1} at LCC 3	36,402	27,793	1.76
30+30 kg Nha^{-1} at LCC 3	36,727	19,258	1.52
20+20 kg Nha^{-1} at LCC 3	36,406	18,784	1.52
60 kg Nha^{-1} at LCC 4	36,385	30,466	1.84
30+30 kg Nha^{-1} at LCC 4	36,710	46,582	2.27
20+20 kg Nha^{-1} at LCC 4	36,389	41,687	2.15
60 kg Nha^{-1} at LCC 5	36,368	29,506	1.81
30+30 kg Nha^{-1} at LCC 5	36,693	44,704	2.22
20+20 kg Nha^{-1} at LCC 5	36,372	37,492	2.03
SEm±	–	4770	0.13
LSD (P=0.05)	–	14172	0.39

Selling price: Grain: Rs. 15.00 kg^{-1},Straw: Rs. 1.00 kg^{-1}

CONCLUSION

It can be concluded that higher yield and net returns in wheat (var. GW-366) can be secured by real time application of 60 kg N ha^{-1} in two equal splits at LCC 4 or LCC 5 alongwith basal dose of 60 kg N ha^{-1} in a previously green manured field in clayey soil low in available nitrogen in Saurashtra region of

Gujarat in India.

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