JOURNAL OF PURE AND APPLIED MICROBIOLOGY, June 2018. Vol. **12**(2), p. 1001-1010

Real Time Nitrogen Management through Organic and Inorganic Sources in Wheat

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http://dx.doi.org/10.22207/JPAM.12.2.64

(Received: 07 April 2018; accepted: 23 May 2018)

A field experiment was conducted at College Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand (Gujarat) to study real time nitrogen management through organic and inorganic sources during *rabi* season of the years 2013-14 and 2014-15 on loamy sand soil, low in organic carbon and available nitrogen, medium in available phosphorus and high in available potassium. Significantly higher growth parameters viz; periodical plant height, periodical dry matter accumulation and periodical number of tillers per metre row length were found with application of 60 kg N/ha in two equal splits at 52 and 66 DAS when LCC=4. Results further revealed that yield attribute viz; number of effective tillers per meter row length, length of spike, number of spikelets per spike, number of grains per spike and test weight was found significantly higher under the same treatment. Though appreciably higher grain (4111 kg/ha) and straw yield (5343 kg/ha) of wheat were observed under treatment with 60 kg N/ha application in two splits when LCC=4, it was found alike for 60 kg N/ha application in two splits at 25 and 45 DAS when LCC=5 and 40 kg N/ha application in two splits at 50 and 62 DAS when LCC=4.

Keywords: Organic, Inorganic, crop, wheat, real time.

Among the cereal crops wheat, rice and corn together make up three-fourth of the world's grain production. Wheat being a global crop, has been cultivated in all the continents of the world with covering approximately one-sixth of the total arable land in the world and supplying about 20% of the food calories for the world's growing population. In India, wheat is the second most important crop next to rice occupying an area of 29.25 million hectares with production 85.93 million tonnes and productivity of 2938 kg ha^{-1} in India. In Gujarat, irrigated wheat occupies an area of 1.11 million hectares with production of 3.06 million tonnes and productivity of 3155 kg ha^{-1} (Anon.,2017).

Of the agronomic factors known to augment wheat yield, nutrients contribute to about 41%, particularly 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. Some of the estimates on the uptake of nutrients have shown that a healthy wheat crop of one hectare removes 140 kg nitrogen,

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50 kg phosphorus, 10 kg potassium, 210 g zinc, 341 g manganese and 65 g copper (Takkar and Nayer, 1983). These figures clearly illustrate the high demand of this crop for nutrient elements. The fertilizer recommendations need to be matched to genetic materials and agro-climatic situations to exploit potential yield of wheat.

Among the primary nutrients, nitrogen being a constituent of chlorophyll, plays very important role in harvest of solar energy and thereby photosynthesis which is directly reflected in the total dry matter production. Nitrogen use efficiency is very low due to its movable nature, its real time management as per crop need is very indispensable. Out of many techniques involved with nitrogen management, the emerging technologies are the determination of the plant for N status in combination with soil testing. The premise is that the plant may be a better indicator of actual N status than inference from soil test. At the beginning of the season, a fixed N recommendation is given, but crop development and related N needs are strongly influenced by unexpected factors during the growing season. Therefore, the predictive recommendations need to be adapted to the crop N status.

Leaf colour chart (LCC) is the promising, cost effective, an inexpensive, eco-friendly, easy to use and simple alternative to chlorophyll meter /SPAD (soil plant analysis development), tool developed in recent years for real time need-based N management in rice crop which measures leaf colour intensity that is related to leaf N status. LCC is an ideal tool to optimize N use in rice, wheat and maize at high yield levels, irrespective of the source of N applied *viz*., organic manure, biologically fixed N or chemical fertilizers. Now a day, it is manufactured with 4 colours called Four Panel LCC and 6 colours called Six Panel LCC. Moreover, LCC is provided with water-proof laminated instruction sticker in the required regional language. Despite wheat being the major crop of Gujarat, practically no research work on validation and use of LCC in wheat has been carried in the state. Considering the facts and to bridge the research gap highlighted above, the present experiment on real time need based nitrogen management through organic and inorganic fertilizer in wheat was carried out.

MATERIALS AND METHODS

A field experiment was conducted at the College Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand (Gujarat) to study real time need based nitrogen management through organic and inorganic fertilizer in wheat during *rabi* season of the years 2013-14 and 2014-15. The soil of the experimental field was loamy sand having good drainage and fairly moisture retention capacity with pH ranging from 7.8 to 8.20. The experimental soil was low in organic carbon (0.42-0.48 %) and nitrogen (243-266 kg ha^{-1}), medium in available phosphorus (42-55 kg ha^{-1}) and high in available potassium (289-321 kg ha^{-1}). Total ten treatments confined only to top dressing of nitrogen were taken in a randomized block design with four replications for wheat crop var. GW 366 as shown in Table-1.

A basal dose of 60 kg P_2O_5 ha^{-1} was applied through DAP, while 50 % of recommended dose of nitrogen i.e. 60 kg N ha^{-1} was applied through two sources viz; 30 kg N ha^{-1} through Vermicompost and 30 kg N ha^{1} in the form of urea to all the plots just before sowing in the furrows. Nitrogen was top dressed in the form of urea as per treatment.

Methodology was used for taking LCC readings

1. Starting from 21 DAS, LCC readings were taken from randomly selected 5 plants in each plot.
2. 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.
3. Readings were taken by placing the middle part of the leaf on top of the LCC's colour strips for comparison.
4. Leaf was not detached.
5. Readings were taken at same time of the day (8:00-10:00 AM).
6. The LCC was not exposed to direct sunlight during readings.
7. The same person has taken the first up to the last LCC reading.
8. If average reading below the critical LCC value, N was given as per treatments.
9. LCC readings were repeated after 7 days and same 5 plants were observed.

The crop was sown at a depth of 4-5 cm keeping inter row spacing of 22.5 cm using recommended seed rate of 120 kg ha^{-1} during 3rd week of November during both the years.

Grain protein content (%)

Protein content in grain was determined by multiplying nitrogen percentage by a factor 6.25 (Gassi *et al*., 1973). The modified kjeldahl method was adopted to find out nitrogen content in wheat grain (Jackson, 1974).

RESULTS AND DISCUSSION

Effect of growth parameters

Growth parameters *viz*., periodical plant height, total dry matter accumulation, number of tillers per m row length and number of effective tillers per m row length (Table 2) were significantly influenced by different treatments. Though at initial growth stage different treatments did not display their significant impact on plant height, total dry matter accumulation and numbers of tillers at 30 DAS, at later stage significant effects of the treatments were observed. At 60 DAS and at harvest, treatment t_6 (60 kg N ha^{-1} applied in two equal splits when LCC=4) being at par with treatments T_9 (60 kg N ha^{-1} in two equal splits when LCC=5) and T_5 (40 kg N ha^{-1} in two equal splits when LCC=4) revealed significantly higher plant height, dry matter accumulation, number of total and effective tillers per meter row length on pooled basis. An increase in plant height, dry matter accumulation as well as total and effective numbers of tillers per meter row length under Treatment T_6 (60 kg N ha^{-1} in two equal splits when LCC=4) were found greater over the treatment T_2 (40 kg N ha^{-1} in two equal splits when LCC=3) on pooled basis to the tune of 23.13 %, 92.32%, 21.18 % and 26.83 %, respectively.

The improvement in growth parameters with application of nitrogen in 2 splits (30+30 kg N ha^{-1}) when LCC=4 might have resulted in better and timely availability of nitrogen for their utilization by plant as judged from nitrogen content of grain and straw (Table 3). Favourable influence of nitrogen to produce larger cells with thinner cell walls and its contribution in cell division and cell elongation as well as it favours cellular metabolisms and thereby growth of the plant and that of phosphorous also increased the root growth and number of total tillers in cereals, enzymatic reactions and metabolism. Similarly continuous supply of N to plants synchronized with crop demand which lead to application of higher quantity of nitrogen. The upsurge in plant vigor in terms of height, number of total and effective tillers plant^{-1}, ensued to higher photosynthetic area and better interception of solar radiation with higher levels of N fertilizer which was found to be useful in utilizing the radiant energy more efficiently, and thereby improved carbohydrate synthesis and production of more dry matter plant^{-1}. The enhanced growth with LCC based nitrogen application was reported by Sathiya and Ramesh (2009), Sen *et al.* (2011) and Mathukia *et al.* (2014) in wheat.

Effect on yield attributes

The yield attributes such as length of spike, number of spikelet per spike, number of grains per spike, grain weight per spike and 1000-grain weight differed significantly due to top dressing of nitrogen at different times (Table-3).

Table 1. Treatment details

	Treatments	1st LCCDAS	2nd LCCDAS
T_1	60 kg N ha^{-1} at 35 DAS	35	-
T_2	40 kg N ha^{-1} in two equal splits when LCC=3	62	70
T_3	60 kg N ha^{-1} in two equal splits when LCC=3	60	72
T_4	60 kg N ha^{-1} when LCC=3	60	-
T_5	40 kg N ha^{-1} in two equal splits when LCC=4	50	62
T_6	60 kg N ha^{-1} in two equal splits when LCC=4	52	66
T_7	60 kg N ha^{-1} when LCC=4	52	-
T_8	40 kg N ha^{-1} in two equal splits when LCC=5	21	38
T_9	60 kg N ha^{-1} in two equal splits when LCC=5	25	45
T_{10}	60 kg N ha^{-1} when LCC=5	25	-

Table 2. Effect of real time management of nitrogen through organic and inorganic sources on growth parameters of wheat (Pooled over 2 years)

Treatments	Plant height at 30 DAS(cm)			Dry matter accumulation (g)			Number of tillers per m row length			Number of effective tillers per m row length
	30DAS	60 DAS	At Harvest	30DAS	60 DAS	At Harvest	30DAS	60 DAS	At Harvest	At Harvest
T_1 60 kg N ha^{-1} at 35 DAS	32.62	80.81	90.12	3.86	12.02	18.54	43.25	76.88	99.67	89.50
T_2 40 kg N ha^{-1} in two equal splits when LCC=3	31.80	74.93	87.56	3.82	10.94	13.01	42.06	70.77	96.59	80.23
T_3 60 kg N ha^{-1} in two equal splits when LCC=3	32.28	76.02	89.23	3.83	11.33	17.02	42.16	73.28	98.30	86.05
T_4 60 kg N ha^{-1} when LCC=3	32.43	80.08	89.68	3.85	11.44	17.27	42.50	73.96	99.18	87.52
T_5 40 kg N ha^{-1} in two equal splits when LCC=4	33.61	87.87	100.14	3.94	14.85	23.75	45.03	88.30	110.21	96.65
T_6 60 kg N ha^{-1} in two equal splits when LCC=4	34.19	94.84	107.82	3.97	16.04	25.02	47.34	98.04	117.05	101.76
T_7 60 kg N ha^{-1} when LCC=4	33.23	84.71	92.64	3.89	12.68	20.32	44.43	78.90	103.03	92.92
T_8 40 kg N ha^{-1} in two equal splits when LCC=5	33.34	86.03	98.69	3.91	12.99	20.48	44.78	80.44	105.20	95.86
T_9 60 kg N ha^{-1} in two equal splits when LCC=5	33.99	89.33	104.21	3.96	15.47	24.05	46.00	90.63	114.76	99.85
T_{10} 60 kg N ha^{-1} when LCC=5	32.79	83.03	92.29	3.86	12.24	19.02	43.76	77.99	101.29	91.14
S.Em±	1.00	2.78	3.10	0.07	0.27	0.46	1.48	2.75	3.12	2.90
C.D. (p=0.05)	NS	7.87	8.79	NS	0.76	1.29	NS	7.77	8.82	8.21
C.V %	9.32	9.95	9.88	5.63	6.28	7.02	10.12	10.32	9.10	9.60

Table 3. Effect of real time management of nitrogen through organic and inorganic sources on yield attributes of wheat (Pooled over 2 years)

Treatments	Number of effective tillers per m row length at harvest	Length of spike (cm)	Number of spikelets per spike	Number of grains per spike	Grain weight per spike (g)	Test weight (g)
T_1 60 kg N ha^{-1} at 35 DAS	89.50	7.35	14.12	37.28	1.94	43.55
T_2 40 kg N ha^{-1} in two equal splits when LCC=3	80.23	6.67	12.78	34.41	1.78	40.34
T_3 60 kg N ha^{-1} in two equal splits when LCC=3	86.05	6.83	13.28	34.93	1.85	41.14
T_4 60 kg N ha^{-1} when LCC=3	87.52	7.14	13.55	35.95	1.91	42.77
T_5 40 kg N ha^{-1} in two equal splits when LCC=4	96.65	8.07	14.76	38.96	2.17	47.95
T_6 60 kg N ha^{-1} in two equal splits when LCC=4	101.76	8.71	15.82	41.02	2.28	50.54
T_7 60 kg N ha^{-1} when LCC=4	92.92	7.81	14.25	38.34	2.04	46.46
T_8 40 kg N ha^{-1} in two equal splits when LCC=5	95.86	7.90	14.30	38.76	2.13	46.89
T_9 60 kg N ha^{-1} in two equal splits when LCC=5	99.85	8.25	14.97	40.42	2.17	48.93
T_{10} 60 kg N ha^{-1} when LCC=5	91.14	7.70	14.21	38.22	2.00	44.98
S.Em±	2.90	0.16	0.34	0.98	0.05	0.99
C.D. (p=0.05)	8.21	0.44	0.96	2.77	0.15	2.80
C.V %	9.60	6.22	7.16	7.83	7.61	6.63

Table 4. Effect of real time management of nitrogen through organic and inorganic sources on yield and harvest index of wheat (Pooled over 2 years)

Treatments	Grain yield(kg ha^{-1})			Straw yield(kg ha^{-1})			Harvest index (%)		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
T_1 60 kg N ha^{-1} at 35 DAS	2972	3163	3067	4178	4434	4306	41.64	41.39	41.52
T_2 40 kg N ha^{-1} in two equal splits when LCC=3	2597	2888	2743	3648	4056	3852	41.61	41.52	41.57
T_3 60 kg N ha^{-1} in two equal splits when LCC=3	2819	2979	2899	3917	4178	4047	41.69	42.18	41.94
T_4 60 kg N ha^{-1} when LCC=3	2917	3056	2986	4156	4380	4268	41.20	41.03	41.12
T_5 40 kg N ha^{-1} in two equal splits when LCC=4	3722	3972	3847	4900	5072	4986	43.59	43.85	43.72
T_6 60 kg N ha^{-1} in two equal splits when LCC=4	3975	4247	4111	5244	5442	5343	43.17	43.90	43.53
T_7 60 kg N ha^{-1} when LCC=4	3472	3636	3554	4689	4736	4712	42.42	43.43	42.93
T_8 40 kg N ha^{-1} in two equal splits when LCC=5	3536	3712	3624	4778	4871	4825	42.87	43.15	43.01
T_9 60 kg N ha^{-1} in two equal splits when LCC=5	3875	4033	3954	5056	5133	5094	43.41	43.93	43.67
T_{10} 60 kg N ha^{-1} when LCC=5	3403	3539	3471	4489	4694	4592	43.15	43.01	43.08
S.Em±	154	215	123	279	246	173	1.54	2.09	1.30
C.D. (p=0.05)	447	623	347	812	714	491	NS	NS	NS
C.V %	9.26	12.19	10.91	12.42	10.48	11.45	7.26	9.82	8.64

Table 5. Effect of real time management of nitrogen through organic and inorganic sources on chlorophyll content, protein content as well as nitrogen content and uptake and of wheat (Pooled over 2 years)

Treatments	Leaf chlorophyll content 30 DAS (mg g^{-1} tissue)	Leaf chlorophyll contentat 60 DAS (mg g^{-1} tissue)	N content in grain (%)	Protein content in grain (%)	N content in straw (%)	Nitrogen uptake by grain (kg ha^{-1})	Nitrogen uptake by straw (kg ha^{-1})
T_1 60 kg N ha^{-1} at 35 DAS	1.819	2.845	1.50	9.40	0.75	45.90	32.06
T_2 40 kg N ha^{-1} in two equal splits when LCC=3	1.773	2.710	1.24	7.74	0.61	34.06	23.64
T_3 60 kg N ha^{-1} in two equal splits when LCC=3	1.792	2.767	1.29	8.05	0.64	37.39	25.64
T_4 60 kg N ha^{-1} when LCC=3	1.810	2.823	1.37	8.59	0.68	41.02	28.97
T_5 40 kg N ha^{-1} in two equal splits when LCC=4	1.854	2.942	1.62	10.14	0.80	62.78	39.82
T_6 60 kg N ha^{-1} in two equal splits when LCC=4	1.899	3.082	1.67	10.44	0.82	68.42	44.07
T_7 60 kg N ha^{-1} when LCC=4	1.835	2.894	1.56	9.76	0.77	55.45	36.12
T_8 40 kg N ha^{-1} in two equal splits when LCC=5	1.844	2.917	1.59	9.95	0.78	57.60	37.98
T_9 60 kg N ha^{-1} in two equal splits when LCC=5	1.869	2.987	1.64	10.27	0.81	64.66	41.06
T_{10} 60 kg N ha^{-1} when LCC=5	1.823	2.859	1.53	9.59	0.76	53.12	34.71
S.Em±	0.03	0.05	0.02	0.16	0.01	2.17	1.41
C.D. (p=0.05)	NS	0.14	0.06	0.43	0.04	6.14	3.99
C.V %	4.69	4.93	4.73	4.71	5.93	12.49	12.41

The yield attributes *viz.* length of spike, number of spikelet per spike, number of grains per spike , grain weight per spike and 1000-grain weight were found significantly higher under treatment T_6 (60 kg N ha^{-1} in two equal splits when LCC=4) which was found identical with treatments T_9 (60 kg N ha^{-1} in two equal splits when LCC=5) for length of spike and number of spikelet per spike, treatments T_9, T_5 and T_8 for number of grains per spike , grain weight per spike and treatments T_9 and T_5 (40 kg N ha^{-1} in two equal splits when LCC=4) for test weight over treatment T_2 (40 kg N ha^{-1} in two equal splits when LCC=3), T_3 (60 kg N ha^{-1} in two equal splits when LCC=3) and T_4 (60 kg N ha^{-1} when LCC=3) in pooled analysis.

The higher length of spike (8.71 cm) , spikelet per spike (15.82), grain weight per spike (2.28 g) and test weight at harvest and (50.54 g) at harvest recorded in treatment T_6 (60 kg N ha^{-1} in two equal splits when LCC=4) which accounted 30.58, 23.78, 20.08 and 25.28 % higher over the least responding treatment T_2 (40 kg N ha^{-1} in two equal splits when LCC=3) on pooled analysis. Greater availability of photosynthates, metabolites and nutrients to develop reproductive structures seems to have resulted in enhanced productive plants, length of spike, number of spikelet per spike, number of grains per spike, grain weight per spike and 1000-grain weight with these treatments. The present findings are within the close vicinity of those reported with LCC by Debnath and Bandyopadhyay (2008), Stalin (2008) and Sathiya and Ramesh (2009) in wheat.

Effect on yield

A close perusal of data on grain yield, straw yield and harvest index (Table 4) indicated that treatment T_6 (60 kg N ha^{-1} in two equal splits when LCC=4), being at par with treatments T_9 (60 kg N ha^{-1} in two equal splits when LCC=5) and T_5 (40 kg N ha^{-1} in two equal splits when LCC=4) produced significantly the higher grain yield and straw yield over treatments T_2 (40 kg N ha^{-1} in two equal splits when LCC=3), T_3 (60 kg N ha^{-1} in two equal splits when LCC=3), T_4 (60 kg N ha^{-1} when LCC=3) and T_1 (60 kg N ha^{-1} at 35 DAS) While, harvest index remained unchanged due to different treatments.

Significantly higher grain (4111 kg ha^{-1}) and straw yield (5343 kg ha^{-1}) to the tune of 49.87 and 38.70 % were recorded under treatment T_6 (60 kg N ha^{-1} in two equal splits when LCC=4) which were found higher over least producing treatment T_2 (40 kg N ha^{-1} in two equal splits when LCC=3) on pooled basis.

Since, yield of the crop is a function of several yield components which are dependent on complementary interaction between vegetative and reproductive growth of the crop. As most of these growth and yield attributes showed significantly positive correlation with grain yield of wheat evidently resulted in higher yield in treatments which get timely nitrogen appears to be on account of their influence on dry matter production and indirectly via increase in plant height, number of total tillers, number of effective tillers and possibly a result of higher uptake of nutrients. The present findings are in close agreement with the results obtained by Sathiya and Ramesh (2009), Thind (2010), Sen *et al.* (2011) and Mathukia *et al.* (2014) in wheat.

Effect on quality parameters

Grain protein content (Table 5) significantly influenced by different treatments. This quality parameter was significantly improved under treatments T_6 (60 kg N ha^{-1} in two equal splits when LCC=4), T_9 (60 kg N ha^{-1} in two equal splits when LCC=5) and T_5 (40 kg N ha^{-1} in two equal splits when LCC=4) over treatment T_2 (40 kg N ha^{-1} in two equal splits when LCC=3) and T_3 (60 kg N ha$^{-1\ 1}$ in two equal splits when LCC=3). Treatment T_6 (60 kg N ha^{-1} in two equal splits when LCC=4) recorded higher grain protein content at harvest (10.44 %) which accounted 34.88 % higher over the treatment T_2 (40 kg N ha^{-1} in two equal splits when LCC=3) in pooled analysis.

Significant improvement in grain protein content might be due to its dependence on nitrogen content. In the present investigation, higher nitrogen content in grain (Table 5) and subsequently higher nitrogen uptake by grain (Table 5) were recorded with the above mentioned treatments that lend to support to enhance protein content under the effect. This could explained on the basis of better availability of required nutrients in crop root zone and enhanced photosynthetic and metabolic activity resulting in better partitioning of photosynthates to sinks, which reflected in quality enhancement in terms of protein content and protein yield. This finding was closely associated with those of Jayanti *et al.* (2007), Stalin (2008), Sathiya and Ramesh (2009), Thind (2010), Sen *et al.* (2011) and Mathukia *et al.* (2014) in wheat.

Effect on nutrient content and uptake by crop

The nitrogen content in grain and straw and nitrogen uptake by grain and straw (Table 5) significantly influenced by different treatments. Significantly the higher value of these parameters were recorded with application of 60 kg N ha^{-1} in two equal splits when LCC=4 (T_6) and it was at par with application of nitrogen in 2 splits (30+30 kg N ha^{-1}) when LCC=5 (T_9) and T_5 (40 kg N ha^{-1} in two equal splits when LCC=4) in respect of nitrogen content in grain and total uptake of nitrogen and with application of 60 kg N ha^{-1} in two equal splits when LCC=5 (T_9) and 40 kg N ha^{-1} in two equal splits when LCC=4 (T_5) in respect of nitrogen content in straw and nitrogen uptake by grain and straw over application of 40 kg N ha^{-1} in two equal splits when LCC=3(T_2) and that of 60 kg N ha^{-1} in two equal splits when LCC=3 (T_3).

The higher grain and straw nitrogen content at harvest recorded in treatment T_6 (60 kg N ha^{-1} in two equal splits when LCC=4) (1.67 %) and (0.82 %) which accounted 34.67 and 34.42 % higher over the treatment T_2 40 kg N ha^{-1} in two equal splits when LCC=3 in pooled analysis.

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. 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 Maiti and Das (2006).

CONCLUSION

On the basis of above discussion it can be concluded that in sandy loam soil of middle Gujarat, real time nitrogen management practices involving 60 kg N ha^{-1} and 60 kg P_2O_5 as a basal and remaining 60 kg N ha^{-1} in two equal splits at 52 and 66 DAS by using LCC 4, followed by 60 kg N ha^{-1} in two equal splits at 25 and 45 DAS by using LCC 5 and application of 40 kg N ha^{-1} in two equal splits at 50 and 62 DAS by using LCC 4 in wheat proved significantly higher in respect of yield and available N after harvest as compared to fixed time nitrogen management application.

ACKOWLEDGEMENT

We are acknowledge our sincere thanks to Anand Agricultural University and Department of Agronomy, B. A. College of Agriculture, Anand for providing opportunity and gave support for conducting doctoral research.

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