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Nitrogen Management through Leaf Colour Chart

FARMER FRIENDLY REAL-TIME NITROGEN MANAGEMENT APPROACH FOR RESOURCE CONSERVATION IN LOWER SHIVALIK RANGE OF HIMALAYAN AGRICULTURE

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FARMER FRIENDLY REAL-TIME NITROGEN MANAGEMENT APPROACH FOR RESOURCE CONSERVATION IN LOWER SHIVALIK RANGE OF HIMALAYAN AGRICULTURE

1.0 INTRODUCTION:

Fertilizer nitrogen (N) is one of the key inputs in crop production. Cereals including rice, wheat, and maize account for more than half of the total N-fertilizer consumption in the world. Several research studies indicated that only a small proportion of fertilizer-N applied in the fields is truly utilized by the plants, while significant amount is lost through leaching, mineralisation, erosion and denitrification processes. One of the key challenges is to increase the N use efficiency (NUE) of the crops, as more than 50% of N applied using conventional fertilizers is lost to the environment. Furthermore, excessive use of fertilizers leads to ground water contamination by nitrate leaching leading to blue baby syndrome, heavy metal accumulation and several other problems. Sound management options need to be worked out to reduce N losses and to ensure N availability throughout the growing season of crops.

In Indian Himalayan region, particularly in lower Shivaliks, small, undulated, and scattered land holdings are available for cultivation. Further, overwhelming percentage of small and marginal holdings, difficult conditions, high cost and low returns on food crops; poor economic condition of the farmers etc. are main causes for low crop productivity. Rice, wheat, and maize are three important and major cereal crops of this region and consume most of the inorganic N-fertilizers, mostly urea. Among the agronomic packages of any crop, N management is the most important factor deciding the crop performance. Large field to field variability restricts efficient N-fertilizer management when broad based blanket recommendations are used in crops. To achieve higher yields and to avoid N deficiency risks, many farmers apply N-fertilizer in excess of crop requirement to get the dark green leaf colour similar to those of their neighbouring fields.

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Although, several conventional methods are available to enhance the N-fertilizer use efficiency such as appropriate choice of variety, optimum rate, time and method of application and good water management, these are insufficient to address the challenges. One strategy to enhance NUE in crops is to match the timing of N need with its application. In contrast with conventional fixed approach of N scheduling, real time monitoring of N under *in-situ* condition is followed in this system. Different tools like Leaf Colour Chart (LCC), SPAD chlorophyll meter and Green Seeker are available for the purpose. Among these tools, the LCC is an easy-to-use, low cost, non-destructive, innovative indicative tool for real time monitoring of N status using leaf relative greenness. It is a simple substitute to chlorophyll meter (SPAD). Its application in several crops like rice, maize and wheat is well established through different research studies (*Varinderpal-Singh et al., 2011; Bijay-Singh et al., 2012; Varinderpal-Singh et al., 2012*). Especially in rice, significant increase in yield and profit can be obtained using LCC, besides 20.0–42.5 kg/ha of N can be saved. In a number of cases, reduction of N fertilizer use (up to 30 kg N/ha) was obtained with the use of LCC, apparently on account of higher NUE. Since N is costly and energy requiring input, efficient use of this resource through Real-Time Nitrogen Management Approach is essential for higher productivity and energy and carbon efficiency of lower Shivalik Himalayan production systems.

2.0 LEAF COLOUR CHART (LCC):

Leaf colour chart (LCC) is a high quality plastic strip with different shades of green colour (Photo 1) and has been developed through collaboration of the International Rice Research Institute with Agricultural Research Systems of several countries in Asia (*Varinderpal-Singh et al., 2011; Bijay-Singh et al., 2012; Varinderpal-Singh et al., 2012*). It consists of six green colour shades ranging from light yellowish green (number 1) to dark green (number 6). The colour strips fabricated with veins resembling those of rice leaves help in matching colour. It is a simple, easy-to-use and cost effective (Rs. 100 for each LCC) and can be used by all the categories of farmers. LCC is a visual and subjective indicator of plant N deficiency and has emerged as a highly practical, efficient and economical substitute to chlorophyll meter for the poor and marginal farmers. It is an ideal tool to optimize N use at reasonably high yield levels, irrespective of application of organic manures and crop residues and nitrogen carryover from previous

crops. A new 4-panel LCC has been developed by IRRI for modern high yielding rice varieties in Asia, but guidelines on the use of this chart have to be adjusted for local conditions. In the improved LCC, lightest (shade 1) and darkest (shade 6) of the 6-panel LCC have been removed and shades of panel number 2, 3, 4 and 5 have been standardized.

Photo 1 Leaf colour chart (LCC) for real time N management

2.1 HOW TO USE LCC:

1. LCC recommendation in rice

- Apply a basal dose of 62.5 kg urea per hectare.
- Select 10 random rice plants grown in one beegha field (667 m^2, or 1 ha = 15 beegha).
- Select first fully exposed leaf from the top of these rice plants.
- Start matching the colour of this fully exposed leaf with the various shades of LCC at 7 days intervals after 14 days after transplanting.
- Whenever the greenness of 6 or more out of these 10 leaves is lighter than LCC shade 4, apply 62.5 kg urea per hectare.
- No urea should be applied if colour of leaves is equal to or darken than LCC shade 4.
- Use of LCC should be discontinued after initiation of flowering.

2. LCC recommendation in maize

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- Apply a basal dose of 62.5 kg urea per hectare.
- Select 10 random maize plants grown in one beegha field (667 m^2, or 1 ha = 15 beegha).
- Select first fully exposed leaf from the top of these maize plants.
- Start matching the colour of this first fully exposed leaf with the various shades of LCC at 10 days interval after 21 days after sowing.
- Whenever the greenness of 6 or more out of 10 leaves is lighter than LCC shade 5, apply 62.5 kg urea per hectare.
- No urea should be applied if colour of leaves is equal to or darker than LCC shade 5.
- Use of LCC should be discontinued after initiation of silking.

3. LCC recommendation in wheat

- Apply basal dose of 137.5 kg di-ammonium phosphate (DAP) per hectare in medium fertility soils.
- Apply 100 kg urea per hectare for timely sown wheat and 62.5 kg urea per hectare for wheat sown after mid-December at CRI stage after first irrigation.
- Select 10 random wheat plants grown in one beegha field (667 m^2, or 1 ha = 15 beegha).
- Select first fully exposed leaf from the top of these wheat plants.
- Start matching the colour of this first fully exposed leaf with the various shades of LCC only once at maximum tillering stage (2^{nd} irrigation) around 60 days after sowing.
- Whenever the greenness of 6 or more out of 10 leaves is lighter than LCC shade 4, apply 100 kg urea per hectare for timely sown wheat and 62.5 kg urea per hectare for late sown wheat.
- No urea should be applied if colour of leaves is equal to or darker than LCC shade 4.

2.2 PRECAUTIONS TO BE TAKEN DURING USE OF LCC

- Only select healthy plants which are free from insect-pest and diseases.
- Crop should be free from weeds.
- Avoid those plants which are growing at unusual places like shades, waterlogged patches in case of maize and wheat, manure dumped patches etc.
- Avoid taking plant samples from border areas of the field.

2.3 FIELD EXERCISE

Objective: To estimate nitrogen requirement of wheat crop at maximum tillering stage.

Material required: Wheat crop at maximum tillering stage (around 60 days after sowing), leaf colour chart (LCC), field book etc.

Exercise:
Location: *Kabulpur Raighati, Lakshar,* Haridwar
Name of crop: Wheat cv. HD 3086
Date of sowing: 04th November, 2016
Date of LCC reading: 04th January, 2016

Observation: LCC shades (1-6) of wheat leaves growing in different fields

Leaf No.	LCC Shade			
	Field No. 1	Field No. 2	Field No. 3	Field No. 4
1	4	5	4	4
2	3	4	4	3
3	3	4	4	3
4	4	3	4	4
5	3	3	4	4
6	4	4	5	3
7	3	4	4	3
8	3	4	3	4
9	3	3	4	3
10	4	4	4	4
	6 shades of 3 LCC	6 shades of 4 LCC	8 shades of 4 LCC	Equal shades of 3 and 4 LCC

Interpretation of the study:

In field no. 1, the greenness of 6 out of 10 leaves is lighter than LCC shade 4, so apply 100 kg urea per hectare for timely sown wheat and 62.5 kg urea per hectare for late sown wheat. In field no. 2 and 3, no urea should be applied because $\geqslant$ 60% leaves are having LCC shades of 4. In field no. 4, 50% leaves exhibit greenness of LCC shade 3 and the remaining 50% leaves of LCC shade 4, so urea should be applied according to LCC shade 3.

3.0 CASE STUDY:

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ICAR-Indian Institute of Soil & Water Conservation, Dehra Dun is promoting the use of LCC in Uttarakhand state through on- and off-campus trainings of various stakeholders (Photos 2-5). The team of ICAR-IISWC, under the DST -SARTHI (Sustainable Agriculture and Rural Transformation Holistic Initiative programme- Shivalik range) sponsored project "Ensuring Sustainable Agricultural Development and Livelihood Security in lower Shivalik Range of Uttarakhand" selected 17 villages of four blocks of Haridwar district viz. Lakshar (3 villages), Roorkee (7 villages), Narsan (5 villages) and Bahadrabad (2 villages). The project was implemented in lower Shivalik region of Uttarakhand from Dec, 2015 to March, 2018. After selection of villages, baseline agro-ecosystem analysis was done using semi-structured interview schedule supported with PRA tools. Problem-cause analysis was also carried out. Rice-wheat is the principal crop rotation of this region and urea is used as N-fertilizer for top dressing. Farmers apply urea to attain dark green colour of leaves irrespective of soil test-based recommendations.

One-hundred LCC strips were provided to farmers of project sites under training on resource conservation by using LCC. Out of 100 farmers,

Photo 2 On-farm training on leaf colour chart for real time N management

Photo 3 Field exercise on leaf colour chart in farmer's field in Haridwar district

Photo 4 On-station farmers' training on use of leaf colour chart in research farm of ICAR-IISWC, Dehra Dun

only 47 tested LCC at the time of top dressing of urea (15 days after transplanting of paddy and 60 DAS in wheat). After analyzing the data collected from farmers, it was found that use of LCC saved 100 kg per ha of urea (46 kg N) in both rice and wheat crops, which in turn curtailed the input spending by Rs. 1000 per ha [Rs. 700 (Rs. 7 per kg of urea) + Rs. 300 (manpower cost of top-dressing of urea)]. Besides, it also led to conservation of non-renewable energy of 2788 MJ per ha (46 x 60.6= 2788) which ultimately reduced the carbon emission of 60 kg Ce per ha (46 x

Photo 5 Capacity building of state agriculture officer trainees about use of leaf colour chart during regular course organised by ICAR-IISWC, Dehra Dun

1.3=60) (*Singh et al., 2016*). Use of LCC in rice, maize, and wheat crops can save 25 kg N/ha/season without affecting the productivity of crops. Further, with the use of optimum N in these crops, risk of insect pest and diseases can be minimized according to the principles of integrated pest management. This LCC being a cost effective (Rs. 100 per LCC strip), simple and farmer-friendly gadget can be easily used even by small and illiterate farmers. Thus, blanket recommendations of applying fixed N dose at fixed time intervals should be replaced with need based fertilizer N management using LCC technology in paddy, maize, and wheat crops in lower Shiwalik region of Himalaya.

4.0 POLICY ISSUE:

Rice, wheat and maize are three important crops of Uttarakhand state occupying 34, 47 and 3% area of the net sown area (7, 14,189 ha) of the state, respectively, (Table 1). District wise per ha N-fertilizer consumption is given in Table 2. Total fertilizer consumption under three important crops is calculated in Table 3, but only major plain areas of four districts namely,

Dehradun, Haridwar, Udham Singh Nagar and Nainital were considered due to significant fertilizer usage in these districts. If only 50% farmers of these four districts adopt LCC in the three important crops; Uttarakhand state can save significant amount of direct (Rs. 28.20 Crores) and indirect (Rs. 72.68 Crores) money by conserving non-renewable energy and reducing carbon emission (Table 4). If state agriculture department of Uttarakhand distributes only one LCC strip to every farmer of these four plain districts, their total expenditure will be only Rs. 5.16 Crores including capacity building of farmers on the use of LCC (Table 5). It shows, by spending only 5.16 Crores, Government may save Rs. 23.04 Crores of direct public money and Rs. 67.52 Crores on indirect money on carbon emission reduction and fertilizer subsidy.

Table 1: Area (ha) under rice, wheat and maize in Uttarakhand (2016-17).

District	Rice	Wheat	Maize
Dehra Dun (Hills)	1312	3748	3423
Dehra Dun (Plains)	7872	12,947	3604
Haridwar	13,678	47,003	546
Udham Singh Nagar	1,04,245	97,538	5
Nainital (Hills)	1781	7440	2735
Nainital (Plains)	9048	15,033	695
Uttarakhand (Hills)	1,10,812	1,68,908	17,005
Uttarakhand (Plains)	1,34,843	1,72,521	4850
Uttarakhand (Total)	2,45,655	3,41,429	21,855

Source: Agriculture Department Govt. Of Uttarakhand (http://agriculture.uk.gov.in/)

Table 2: Nitrogen-fertilizer consumption (kg/ha) under rice, wheat and maize in Uttarakhand (2011-12)*.

District	Rice	Wheat	Maize
Dehra Dun	83.0	70.0	43.0
Haridwar	100.0	102.0	40.0
Udham Singh Nagar	175.0	150.0	164.0
Nainital	105.5	105.5	105.5
Uttarakhand (Total)	113.1	113.1	113.1

*Recent data available.

Source: Agriculture Department Govt. Of Uttarakhand (http://agriculture.uk.gov.in/)

Agriculture Census Division, Department of Agriculture & Cooperation, Ministry of

Agriculture & Farmer Welfare, GOI (http://inputsurvey. dacnet. nic. in/districttables.aspx)

Table 3: Total N-fertilizer consumption (tonnes) under rice, wheat and maize in Uttarakhand (2016-17).

District	Rice	Wheat	Maize
Dehra Dun (Hills)	NC*	NC	NC
Dehra Dun (Plains)	653	906	154
Haridwar	1367	4794	22
Udham Singh Nagar	18,242	14,630	0.8
Nainital (Hills)	NC	NC	NC
Nainital (Plains)	954	1586	73
Uttarakhand (Hills)	NC	NC	NC
Uttarakhand (Plains)	15,251	19,512	548
Uttarakhand (Total)	27,784	38,616	2472

*NC – not considered due to less fertilizer usage

Table 4: Estimated total N-fertilizer saved (tonnes) and resource conservation under rice, wheat and maize in Uttarakhand, if only 50% farmers adopt LCC.

* Rs. 13 per kg of N (Source: https://www.faidelhi.org)

** Value of one tonne carbon in international market is Rs. 735.

District	Rice	Wheat	Maize	Total
Dehra Dun (Plains)	327	453	77	852
Haridwar	684	2397	11	3092
Udham Singh Nagar	9121	7315	0	16,437
Nainital (Plains)	477	793	37	1307
Uttarakhand (Plains)	10,609	10,959	125	21,693
Direct saving				
Rs. Saving (Crore)*	13.79	14.20	0.16	**28.20**
Indirect saving				
Energy saving (TJ)	642.92	664.09	7.60	1314.62
Reduced carbon emission (tonnes CE)	13,792.10	14,246.23	163.12	28,201.45
Rs. Saving (Crore) due to carbon conservation**	1.01	1.05	0.01	**2.07**
Rs. Saving (Crore) in subsidy given by govt. on urea***	34.53	35.67	0.41	**70.61**
Total saving (Rs. Crore)	49.34	50.96	0.58	**100.89**

(Source: https://www.worldbank.org/en/results/2017/12/01/carbon-pricing)
*** Rs. 15 per kg of Urea (Source: https://www.faidelhi.org/general/subsidy-fert.pdf)

Table 5: Expenditure (Rs. Crore) on distribution and capacity building of LCC

District	Total no. of farmers/no. of LCC to be distributed*	Expenditure on LCC**	Expenditure on capacity building***	Total expenditure
Dehra Dun (Plains)	51,938	0.52	0.52	1.04
Haridwar	69,477	0.69	0.69	1.38
Udham Singh Nagar	93,190	0.93	0.93	1.86
Nainital (Plains)	43,181	0.43	0.43	0.86
Uttarakhand (Plains)	257,786	2.58	2.58	5.16

*Source: Agriculture Department, Government of Uttarakhand (http://agriculture.uk.gov.in/)
:Agriculture Census Division, Department of Agriculture & Cooperation, Ministry of Agriculture & Farmer Welfare, GOI (http://inputsurvey.dacnet.nic.in /districttables. aspx)
** Cost of each LCC strip: Rs. 100/-
*** Cost of capacity building of each farmer: Assuming Rs. 100/-

5.0 DOMAIN AREAS:

Irrigated plain areas of Dehra Dun, Haridwar, Udham Singh Nagar, Nainital districts and valley areas of hilly districts of Uttarakhand state and similar areas elsewhere in Himalayan states.

6.0 AVAILABILITY OF LCC:

1. Department of Soils, Punjab Agricultural University, Ferozpur Road, Ludhiana 141 004, India
2. Nitrogen Parameters, P.B. No. 8707, Adambakkam, Chennai-600 088, India

7.0 Conclusion:

A strong policy is needed at village level, or Panchayat level by the state agriculture department of Uttarakhand for capacity building of stakeholders in programmes like *Krishi Mahotsav* and distribution of LCC should be ensured by fertilizer dealers to farmers at the time of purchasing fertilizer. By investing on simple farmer friendly LCC technology, Himalayan state

like Uttarakhand can save plentiful direct as well as indirect money which can be used for upliftment of small and marginal farmers of the state, besides conservation of natural environmental resources of the hilly state.

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