

Leaf colour chart based nitrogen management in wheat under zero till condition of West Bengal

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The climatic potential yield of irrigated wheat is about 5-7 t/ha in West Bengal but the actual yield obtained was much less i.e. 2.77 t/ha in 2017-18 resulting in a yield gap of 45-60%. Improper nutrient management is one of the major factors for such yield gap. In West Bengal, most of the wheat crop is preceded by long-duration transplanted rice varieties such as Jalprabha (IET-11870), Saraswathi (IET-11271), Swarna (MTU-7029) and delayed harvest of paddy, delays the sowing of wheat towards the end of November to middle of December which is one of the major constraints of wheat cultivation in rice fallows. Hardly 10-15 days remain available between harvest of rice and timely sowing of wheat which puts tremendous pressure on land preparation and sowing of succeeding crop in time. Growing labour shortage in hightime also delays wheat sowing which affects the productivity of wheat adversely. As a result, zero tillage (ZT) technology has been increasingly adopted in this region to reduce cultivation cost and increase input use efficiency in wheat cultivation. Site Specific Nutrient Management-Nutrient Expert (SSNM-NE) is a recently developed precision nutrient management technology guided by the DSS (Decision Support System) software for improving crop yield, environmental quality and overall agricultural sustainability specifically in South-Asian Indo-Gangetic Plains Region (IGPR). Nutrient expert enables crop advisors to develop SSNM recommendations using existing site information. As fertilizer, nitrogen (N) has generally been managed following two or three split applications of preset rates of the total amount of N recommendation, and improvement in N use efficiency could not be achieved beyond a limit. Wheat leaf colour chart (LCC) is a diagnostic tool for monitoring the relative greenness of a leaf as an indicator of plant N status. N-scheduling through the use of LCC to achieve the best results regarding improved grain yield and economic returns over fixed time N application. A predetermined dose of N is applied using wheat LCC when a critical value or critical colour shade is obtained. It was observed that wheat yield and profit between 2016-17 to 2018-19 has an increasing trend.

Keywords: Leaf colour chart, N top-dressing, Nutrient expert, Wheat, Zero tillage

WHEAT (*Triticum aestivum* L.) is a cereal crop grown in the largest cultivated area in the world. India's share in global wheat production was recorded at 15.36% in the year 2017-18. In India, wheat is the second most important staple grain food only after rice. India had witnessed a record production of 99.70 MT wheat in 2017-18. India Gangetic Plain Region (IGPR) extends from the arid and semi-arid

environments in Rajasthan and Punjab to the humid and per-humid deltaic plains in West Bengal over a length of about 1,600 km and a width of 320 km. Rice-wheat cropping system is the major cropping system in the IGPR covering an area of around 10 mha. Decline in land productivity, particularly of rice-wheat system has been observed over the past few years in the per-humid deltaic plains of

West Bengal despite the application of optimum irrigation, recommended nutrient doses and new tillage techniques which is a matter of concern. The production of cereals must increase by 1.2 to 1.5% annually to meet the rising demand and ensure food security. Therefore, there is an immediate need to operationalise the efficient nutrient management and tillage technology together for a successful increment in

productivity and profitability of wheat (Table 1).

Zero tillage technology in wheat and its adoption in West Bengal

In this technique, wheat is directly seeded into the undisturbed soil after rice harvesting using zero-till seed-cum-fertilizer drill machine (Fig. 1). In this machine, seed and fertilizer are placed into narrow slits created by T shaped furrow openers. This technique was first adapted in the high yielding, more mechanized areas of north-western India and Pakistan where a lot of money was being invested in land preparation. Total energy requirement is 20,279 MJ/ha for zero tillage which is much lower than 23,631 MJ/ha for broadcast sown wheat. Benefit-cost ratio is highest for zero tilled wheat and lowest for broadcast sown wheat. Zero tillage leads to an increase in bulk density of soil and decrease in pore space especially macropores. Infiltration rate in zero tilled fields is lower compared to conventionally tilled fields. The moisture retention in zero tillage has been observed to be higher due to more micropores. In a long-run, there may be organic matter build up in the soil due to reduction in burning and retention of crop residues at the surface. Residue retention is also responsible for temperature moderation i.e. higher

Table 1. Recommended seed rate, sowing time and spacing for wheat in NEPZ

Sowing condition	Seed rate (kg/ha)	Time of sowing	Spacing (cm)
Irrigated timely sown	100	November, 10-30	20-23
Irrigated late sown	125	December, 01-25	15-18

Table 2. Trend of wheat productivity in the last 5 years as influenced by different sowing time, tillage techniques and nutrient recommendations under irrigated condition at instructional farm, UBKV, WB

Year	Grain yield (t/ha) under CT with AICW&BIP* recommendation in late sown condition	Grain yield (t/ha) under ZT with AICW&BIP* recommendation in timely sown condition	Grain yield (t/ha) under ZT with NE** recommendation for TY 5.5 t/ha in timely sown condition
2014-15	2.93	3.12	3.66
2015-16	3.49	3.59	3.71
2016-17	3.50	3.71	3.76
2017-18	3.18	3.36	4.16
2018-19	3.01	3.50	4.47

Notes: TY: Target Yield, AICW&BIP: All India Co-ordinated Wheat and Barley Improvement Project, UBKV: Uttar Banga Krishi Viswavidyalaya, WB: West Bengal

*AICW&BIP recommendation for irrigated wheat in NEPZ for timely sown condition is 150:60:40 kg/ha N:P₂O₅:K₂O and for late sown condition is 120:60:40 kg/ha N:P₂O₅:K₂O (Singh *et al.* 2016)

**NE recommendation (target yield of 5.5 t/ha) for Pundibari, Cooch Behar is 140:75:78 kg/ha N:P₂O₅:K₂O during 2014-15 to 2015-16 and 125:60:78 kg/ha N:P₂O₅:K₂O during 2016-17 to 2018-19

temperature during winter and lower temperature during summer in the micro-climate of the crop. In West Bengal, *kharif* rice is generally sown at the last week of June to the second fortnight of July depending on the onset of monsoon. The main reason for delayed wheat sowing is transplanted rice cultivation with long-duration varieties such as Jalprabha (170-180 days), Saraswathi (160-170 days), Swarna (140-150

days). It is almost impossible to sow wheat crop in time after harvesting rice (Table 2). Introduction of zero-till ferti-cum-seed drill in West Bengal during early 2008-09 made it possible to sow wheat timely in freshly harvested untilled paddy fields utilizing the residual soil moisture which not only facilitates the seed germination but also improves the soil fertility and soil physical properties of the wheat field.



Fig. 1. Zero till fertilizer-cum-seed drill sowing of wheat (left) and opened furrow with placed seed and fertilizer (right)

Balanced fertilizer application in wheat

Crop yield is correlated with fertilizer application. The role of chemical fertilizers has become obvious in increasing crop yield with the introduction of high yielding varieties responding to fertilizers. Most of the soils are only able to supply a fraction of the nutrients required by the crops. Balanced fertilizer application is necessary to provide an adequate amount of nutrients in the required proportion for realizing the maximum yield. When only N and phosphorus (P) is applied, available potassium (K) decreases significantly over time. Due to wheat cultivation with no K application or very less K application following different recommendations, water-soluble and exchangeable K are decreased from their initial status. This is the reason that these soils are now deteriorating in available K though Indian soils were rich in available K in ancient times. It is established that the current productivity of a crop can be doubled by growing locally recommended high yielding varieties and by increasing and balancing fertilizer application rates to correct multiple nutrient deficiencies, site and crop-specific balanced fertilization in addition to maintaining food security also help in sustaining soil and environment health due to improved nutrient use efficiency.

Nutrient Expert use in wheat cultivation

Adoption of generalized fertilizer recommendations for K over larger areas ignoring the spatial nutrient variability among the small agricultural holdings has resulted in falling productivity with extensive K mining from soils besides exhibiting K deficiency over larger areas. An approach for addressing such concerns is SSNM (Fig. 2), which takes into account spatial variations in K fertility status. SSNM has successfully been tried in India using different approaches and demonstrated a potential not only to increase crop yields and farmer profits but also shown increasing evidence of environmental friendliness owing to its balanced and

crop need-based nutrient application. NE for wheat, a new nutrient decision support tool, is based on the principles of SSNM and recommends balanced application of nutrients based on the crop requirement. The tool was a joint development of wheat stakeholders in India including representatives from national research and extension system, private industries, International Maize and Wheat Improvement Centre (CIMMYT), and International Plant Nutrition Institute (IPNI). It enables crop advisors to rapidly develop field specific fertilizer recommendations for increasing yield and economic benefits of wheat farmers as compared to the existing practices. SSNM-NE is the recently developed precision nutrient management technology guided by DSS software for improving crop yields, environmental-quality and overall agricultural sustainability specifically in South Asian IGPR. The guidelines provided by this software assume the following conditions:

- No serious limitation of water (i.e. drought) throughout the growing period,
- Any problem on acidity and micronutrients are properly addressed,

- Use of high-yielding wheat varieties,
- No major damage caused by pests and diseases,
- Proper placement of fertilizer is practiced.

The software also requires some easily available informations such as :

- Current farmers' yield
- Farmers' fertilization practice
- Attainable yield of a location
- Managing residues in the current wheat crop
- Nutrient credits or adjustments from organic inputs
- Nutrient carryover from previous crop
- Result of omission plot trial (if available)
- Estimation of expected N, P and K responses in the farmers' field through the information of soil type, soil colour, organic matter content, soil analysis information (if available) and soils known for P fixation.

NE has recommended 140:75:78 kg/ha N:P₂O₅:K₂O during 2014-15 to 2015-16 and 125:60:78 kg/ha N:P₂O₅:K₂O during 2016-17 to 2018-19 for target yield of 5.5 t/ha for wheat farmers of Pundibari, Cooch Behar, West Bengal using the above mentioned information.

Nutrient Expert® for Wheat - SSNM Rates

Name and/or Location: Pundibari, West Bengal; Site 1; Bihar, India Field size: 1 ha

SSNM Rates
Fertilizer N, P and K requirements are based on yield goal (i.e. attainable yield) and expected yield responses to fertilizer application.

1. Attainable yield for your location: 5.5 t/ha
2. Management of wheat residues after harvest: Remove all the aboveground residues from the field
3. Application of organic fertilizers (e.g. manure): 0.0 t/ha
4. Residual benefit from your previous crop: n/a
5. Results of omission plot trials in the location or district: No
6. Account for P and K credits: Yes

N response 3.0 t/ha		P response 1.5 t/ha				K response 0.75 t/ha			
N response (t/ha)	Fertilizer N (kg/ha)	Yield t/ha	5.0	5.5	6.0	Yield t/ha	5.0	5.5	6.0
2.5	125	P response (t/ha)	Fertilizer P ₂ O ₅ (kg/ha)			K response (t/ha)	Fertilizer K ₂ O (kg/ha)		
3.0	140	1.25	65	68	70	0.5	63	68	72
3.5	155	1.5	72	75	78	0.75	73	78	82
		1.75	80	83	85	1.0	83	88	92

N credits: 0 kg N/ha Final N Rate: 140 kg N/ha

P credits: 0 kg P₂O₅/ha Final P Rate: 75 kg P₂O₅/ha

K credits: 0 kg K₂O/ha Final K Rate: 78 kg K₂O/ha

NUTRIENT EXPERT

Fig. 2. NE recommendation (target yield of 5.5 t/ha) for Pundibari, Cooch Behar during 2014-15 to 2015-16

Wheat Leaf Colour Chart based nitrogen top-dressing

Leaf colour greenness guides in-season need-based fertilizer N top-dressings in wheat. Colour of the top fully exposed leaf is measured from a disease free plant by comparison with different shades of green colour on a LCC in the morning (8:00-10:00 AM) or afternoon (4:00-6:00 PM) under the shade of the body and border rows are skipped at the time of taking observations (Fig. 3). Wheat grain yields were significantly correlated with this technique. A dose of 25 kg N/ha should be applied at planting (i.e. basal). At first irrigation (crown root initiation stage) leaf greenness cannot be quantified properly using LCC due to small leaf size and thus it does not lead to adequate fertilizer N management decision. N application should coincide with crop growth and its requirement. At second irrigation (maximum tillering stage), leaf colour of the first fully exposed disease free leaf served as the best indicator of inherent soil N supply as well as crop N needs and thus helped to guide need-based fertilizer N top-dressing for improving agronomic N use efficiency (ANUE) in wheat. Highest ANUE (26.98) is recorded



Fig. 3. Wheat LCC (top) and using it in the field condition of UBKV instructional farm (below)

(Table 3) under NE recommendation + LCC based N top-dressing treatment than other general recommendations and even NE recommendation alone. After completion of 68-70% fertilizer N dose, remaining N top-dressing just before the second irrigation based on wheat LCC reading is beneficial and profitable. Wheat LCC based N application depending on the colour of leaf to be $\geq$ LCC 4 or $<$ LCC 4 resulted in high yield levels as well as improved recovery efficiencies of fertilizer N. The purpose of using wheat LCC is to apply an adequate

amount of N, avoid excess application of N fertilizer in wheat cultivation and their serious impact on the ecosystem which helps to determine N demand of the crop and prevent unwanted N losses.

Economics

In case of production economics, the result showed that ZT with SSNM-NE (target yield 5.5 t/ha) based nutrient management and wheat LCC reading based N top-dressing treatment gives the highest net return (₹ 45,292/ha) and benefit-cost ratio (2.36:1). It is higher than ZT with SSNM-NE alone (i.e., ₹ 38,326/ha and 2.14:1, respectively) (Table 4).

Almost ₹ 7,000/ha higher profit is obtained when wheat LCC based N management is blended with SSNM-NE under ZT.

SUMMARY

NE is easy to use and very effective software for field specific nutrient recommendation of wheat. Timely sown ZT wheat yield is higher than late sown CT wheat with AICW&BIP recommendation. It will increase more when ZT technology combines with NE recommendation and wheat LCC reading based N top-dressing. Higher grain yield and profit under ZT with increment in ANUE through NE based NPK dose which provides balanced fertilization and wheat LCC based N management which plays an important role in optimizing the rate and time of N application. This technique also reduces the cost of cultivation under zero tillage. Wheat farmers concerned about the productivity and profitability of their crop this improved package of production systems should adopt.

Table 3. Trend of yield and ANUE of wheat in recent 3 years as influenced by NE recommendation (TY 5.5 t/ha) + LCC based N top-dressing under ZT at instructional farm, UBKV, WB

Treatment	Year	Grain yield (t/ha)	ANUE
ZT with SSNM-NE (TY 5.5 t/ha)	2016-17	4.13	20.69
+ LCC based N just before	2017-18	4.60	24.14
2 nd irrigation	2018-19	4.92	26.98

Note: ANUE: Agronomic Nitrogen Use Efficiency

Table 4. Cost of cultivation and gross return as influenced by tillage options and nutrient management practices in wheat at instructional farm, UBKV, WB during 2017-18

T options with NM practices	Cost of cultivation (₹/ha)	Gross return (₹/ha)
CT (late sown) with AICW&BIP recommendation	39,710	53,760
ZT with AICW&BIP recommendation	31,907	57,264
ZT with SSNM-NE (TY 5.5 t/ha)	33,611	71,937
ZT with SSNM-NE (TY 5.5 t/ha) + LCC based N	33,391	78,683

Notes: T: Tillage, NM: Nutrient Management

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