Nitrogen Balance Trials in Bihar: Improving Fertilizer Use Efficiency for Farmers, Communities, and the Climate

When fertilizer is applied in balance, plants have their fill and grow strong and produce healthy yields; when applied in excess, fertilizer does not increase yields, wastes critical money – both for country and farmer, pollutes water, degrades the soil and releases nitrous oxide, a greenhouse gas that is 270 times more potent than carbon dioxide at trapping heat. On average, 60% of synthetic fertilizer weighing 30 million metric tons used by farmers every year is in excess of crop requirements and wasted.

How are Bihar's farmers using fertilizer?

Farmers in Bihar are applying more fertilizer today than ever before. Since 1980, per hectare application of total NPK fertilizers in Bihar has increased from 21.45 kilogram per hectare (kg/ha) to roughly 224.2.25 kg/ha in 2022-23. However, this increase has not led to a commensurate increase in productivity of major cereals (rice and wheat) as average yields are significantly lower at 2.53 tons per hectare (t/ha) compared to the national average of 3.15 t/ha.

As farmers over-apply synthetic fertilizer, the nutrient balance of agricultural soils has deteriorated. From an ideal ratio of 4:2:1 of nitrogen, phosphorous and potassium (NPK), average nutrient balance has increased to 14.4:4.5:1, indicative of excessive nitrogen use. This nutrient imbalance and excessive nitrogen fertilizer use further degrades soil health, reducing its ability to maintain and protect crop yields.

As climate change impacts sustainability of yields, farmers feel that to protect yields, they need more fertilizer. Most of the parameters that influence yields – rainfall, soil quality, pest and disease attacks, cannot be fixed quickly. Whereas fertilizer volume and timing of application is one of the few things that farmers can still control.

EDF is helping farmers use balanced fertilizer

Farmers need nutrient advisory that is personalized to their crop and farm conditions and protects yields. The Environmental Defense Fund (EDF) has developed a model called N(itrogen)-balance to help assess how much nutrient is needed for the crops by making it easier for farmers to measure how much nitrogen is added to a farm field, minus how much is removed during harvest, to figure out what's extra. When crop yield is good, but the nitrogen balance is high, N-Balance shows farmers that they can reduce fertilizer without losing yields. When crop yield is poor despite high nitrogen, N-Balance shows farmers they should look for problems that aren't related to fertilizer. Essentially, it gives farmers the power to get fertilizer right.

EDF and partners including Samagra Shikshan Evam Vikas Sansthan and Pradan are piloting N-balance with 20,000 farmers growing rice and wheat in seven districts in Bihar - West Champaran, East Champaran, Sitamarhi, Muzaffarpur, Vaishali, and Nawada.

Results from N-balance trials in Bihar

In 2022, EDF and partners collected data from 16,603 rice farmers in seven districts in Bihar to evaluate fertilizer use practices and collect data on yields and costs incurred by farmers. Within this group, three out of four farmers were found to be overapplying nitrogen fertilizer (mainly in the form of urea) above the recommended dose necessary to protect crop yields. Even amongst farmers who were found to be over-applying fertilizer, close to 60% received yields lower than 3.5 t/ha. Higher fertilizer applications are not helping protect and increase yields.

In 2023, EDF and partners provided 9,480 farmers with agronomic advisory for rice crop. Of this, 3475 farmers with high N-balance scores were randomly selected to receive personalized fertilizer recommendations for their largest plot EDF and partners deployed multiple modes of communication to convey timely and actionable advisory to farmers including – farm visits, digital and mobile reminders, and farmer meetings. At the end of the rice harvest, farmers were surveyed again to evaluate the impact of N-balance in helping reduce excess fertilizer and protect yields. The results of our trials for 2023 rice season are as follows:

1. 2370 farmers followed N-balance to modify fertilizer applications and reduced their average urea application by 67 kgs/ ha. Considering the size of the plots (average size of 0.2 ha), every farmer reduced their fertilizer use by 14.1 kgs.
2. Even with balanced fertilizer use, none of the farmers suffered any yield loss. In fact, 1605 farmers reported an increase in overall yield vis-à-vis last year with an average increase of 8 quintals per hectare.
3. Average yields of rice crop in 2023 were 3.58 t/ha, better than yields received in 2022 season – 2.93 t/ha.
4. Through the pilot, target group of farmers were able to save a total of 33.6 metric tons of urea fertilizer

Scaling N-balance in Bihar

EDF is committed to helping farmers in Bihar use fertilizer better to protect and sustain crop yields. And this will have a significant impact on farmer incomes, government costs and the environment. If all of Bihar's 11.6 million rice farmers were to adopt N-balance to optimize their fertilizer application in 2023, they would have saved 1.6 lakh metric ton of urea, costing over 800 crores. In doing so, Bihar's farmers would also be able to bring real climate benefits by reducing nitrous oxide emissions by 756 metric tons.

Looking ahead:

To build more evidence that farmers need balanced fertilizer to protect yields, EDF is collaborating with Dr. Rajendra Prasad Central Agriculture University and Bihar Agriculture University and simultaneously working with NGOs in the state to build wider adoption of N-balance among farmers. EDF is also collaborating with the Bihar Agriculture Management and Training Institute to train extension officials on how to deliver better advisory on fertilizer management to farmers.

EDF and partners are excited with the successful preliminary results from N-balance trials in Bihar which validate that balanced fertilizer use can protect yields. For 2023-24 wheat season, over 9,600 farmers used N-balance and in the current rice season, over 14,000 farmers are using N-balance to reduce fertilizer over-use.