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Editorial

Reactive Nitrogen in the Agri-Environment: Role in Influencing Crop Protection

Gaseous nitrogen (N_2) constitutes the major component (78%) of the atmosphere *albeit* being inert and does not undergo any chemical reaction till it is converted into reactive-N (N_r).Reactive nitrogen, is present in several organic and inorganic compounds and of vital importance to all life processes being components of nucleic acids (genetic material), amino acid (building blocks of proteins) and enzymes (biochemical catalysts). The availability of N_r often limits plant growth, which is why sufficient supply of N_r is very important in food production and is mostly supplied through manures or chemical fertilizers. However, excessive amounts of N_r poses a danger to human health and the viability of ecosystems and top five threats of excessive release of N_r are water quality, air quality, greenhouse balance and ozone layer, ecosystems and biodiversity and soil quality (WAGES). Diverse economic sectors including agriculture, transportation, industry, and energy have increased their share of nitrogen pollution and related greenhouse gas (GHG) emissions due to growing anthropogenic demands.Excess reactive nitrogen (N_r) balance in the ecosystem and environment is a significant issue globally, and for India too.

Nitrogenous fertilizer is the major agricultural input into the cereal-based cropping systems. Rice and wheat cover the highest cropped area in India at 36.95 million hectares (ha) and 26.69 million ha, respectively. India is the second largest N-fertilizer (20 million tons in 2021-22) consuming country in the World after China. However, only 1/3rd of the nitrogen applied to rice and wheat through fertilisers, is taken up by the plants in the form of nitrate (NO_3). The remaining 2/3rd remains in the soil and leaks into the environment causing a cascade of environmental and health impacts.

N pollution adversely impacts soil health by affecting soil biodiversity and organic carbon content, thereby defeating the very purpose of fertilizer use. Although, use of N fertilizer has resulted in a steady increase in crop yields in the country, indiscriminate use has brought extensive negative impacts on ecosystems and environment. Recovery efficiency of N applied through fertilizer and manure by the plant and ultimately to the grain, has declined from ~90% in 1960 to ~37% in 2017. Aided by continuing government subsidy, the scenario has prompted farmers applying more of N fertilizers to get desired increase in yield, leading to economic loss as well as leakage of reactive-N to the environment.Nitrogen fertilisers are also one of the major emitters of N_2O, a potent greenhouse gas. Between 2000 and 2018, N_2O emission has increased by 47 per cent in the Indian environment. This has directly affected air quality in India by worsening air pollution by the formation of $PM_{2.5}$ because of the rising atmospheric burdens of various N_r species.

Although it is apparent that the N availability influence plant disease scenario, mainly by increasing the tissue susceptibility through physiological changes. Data indicate that increased use of N fertilizers affected crop disease incidence, while cases are also reported in which a decrease in N fertilization increases the severity of the disease, especially with a few diseases like brown spot of rice, suggesting a complex relationship between them. Concern about the role of chemical fertilizer in general and N-fertilizer in particular on plant disease incidence increased in parallel with the extensive use of synthetic fertilizer that began in the late ‘60s and early ‘70s. Classical research in the early and mid ‘70s at National Rice Research Institute (previously Central Rice Research Institute), Cuttack, both in the greenhouse and field conditions with natural and artificial inoculation of the crop, for two major diseases of rice, *viz.* blast and bacterial blight, tried to explore the link between N-fertilizers and diseases. It was explained that high level of N-fertilizer application resulted into spread of both bacterial blight and rice blast due to lush plant growth facilitating easy secondary infections causing intense spread of the disease in the field. Even the rice false smut disease is found to have higher incidence coupled with higher nitrogen use during reproductive stage.Subsequently, multiple instances have been reported wherein N fertilizer increased the disease incidence, for example, downy mildew, powdery mildew, leaf rust and stem rot.

As far as the host is concerned, the association between N nutrition and plant defence is measured in terms of physical, bio-chemical and genetic details. Pathogen infection and disease severity depend not only on nitrogen dose but on the disease in question throwing out four different possibilities: (a) disease severity increases with increased N fertilization, of course only up to a certain amount of N fertilization; (b) pathogen infection may decrease with increasing amounts of N; (c) increased N dose having no effect on disease incidence, and (d) disease incidence is reduced or unaffected by N nutrition up to a certain level of N, whereas high levels of N increase disease severity. High N application usually results into succulence in plant parts with thin cell walls, thereby having negative effect on physical defences and the production of anti-microbial secondary metabolites, arising through phenylterpenoid pathways resulting in animbalance in the networking of defense-related system. Further, N nutrition can also influence defence *via* amino acid metabolism and hormone production to affect downstream molecular responses. Nitric oxide (NO) influence on transcriptional regulation affecting the defense-related genes may play significant role under these situations.

Nitrogen the key influencer of plant health, has been widely shown to affect plant physiology, growth and plant-associated microbiota having profound impacts on plant protection. It is also to be seen whether different form and types of fertilizer-N can influence plant disease and to what extent. In view of the decreasing nitrogen use efficiency among the current crop varieties, plant scientists are focussing their research on developing varieties that can grow on low N input and high nitrogen use efficiency. Coupled with the development of new fertilizer forms and types, crop varieties with high nitrogen use efficiency expected to be available in near future and changing climate pattern, it is required to investigate the cultivar-nutrient-environment-disease nexus in a greater detail.

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