MEETING REPORT

Reactive nitrogen assessment in South Asia*

The nitrogen (N) cycle is anthropogenically the most disturbed nutrient cycle having adverse impacts on majority of ecological compartments and resultant ecosystem services. Such perturbations adversely impact food security, energy, industry, human health, biodiversity, environment and climate change. Reactive nitrogen (Nr) includes inorganic (from both sides of the redox range, including NH_3, NH_4^+, NO_x, N_2O, NO_2^-, NO_3^-) and organic (urea, amines) variants that readily interact in the environment. Anthropogenic creation of Nr is primarily from the use of fertilizer-N, and from the combustion of fossil fuels. Large part of this Nr leaks into the environment and upsets the biogeochemical cycle of N. With the demands of the society increasing spatially and temporally, other sources of Nr like industry, energy generation and waste also contribute to this alteration. Thus, identification of all the significant sources of Nr flows and their relative contribution to the national/regional/global N cycle is important for making informed decisions on the policy of sustainable N management. USA, through the North American Nitrogen Center (www.nitrogennorthamerica.org) and Europe, through the European Nitrogen Assessment (http://www.nine-esf.org/sites/nine-esf.org/files/ena_doc/..../ENA_pre.pdf), have already made progress on collating information on the Nr status on a continental scale.

South Asia consisting of Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka, is home to about 24% of the global population with only 4.9% of the world's land mass, 15.4% of the global arable land, 2.98% of the world's forest area and 4% of the world's coastline. Agriculture being the major activity in the South Asian region, use of chemical N-fertilizers has grown expansively during the last three decades with negative impacts on ecosystems and environment. Among the major South Asian countries, fertilizer N consumption (kg/ha) follows the order: Bangladesh (144.7) > Pakistan (101.8) > India (98.5) > Sri Lanka (78.2). Total fertilizer nutrient consumption in Asia is 60% of the global use. Unfortunately, use efficiency of external N supply is as low as 30–35% and terminal use efficiency is still lower. Thus, for a vegetarian diet the efficiency is 14% whereas for a non-vegetarian diet it is merely 4%. Hence, 86% or 96% of N, which is unaccounted for depending upon the food choice, represents the tentative loss. This issue was discussed in a workshop attended by more than 30 delegates, including representatives from various South Asian countries, members of the International Nitrogen Initiative (INI) and select Indian researchers. The workshop was expected to help identify groups of researchers and organizations/institutes in South Asia to decide on collation, evaluation, analysis, re-evaluation, synthesis, documentation and communication on reactive-N status in the region.

Infrared atmospheric sounding interferometer (IASI) satellite pictures for global ammonia column (mg m^{-2}) indicate massive atmospheric column over the Indo-Gangetic Plains and adjoining areas, suggesting South Asia to be a hotspot for N losses, especially from N-fertilizer use and livestock sector. The International Nitrogen Management System (INMS) which focuses on collating various scientific evidences to sensitize policymakers and the public on the multiple benefits and threats of Nr, is working on different country clusters, including South Asia (India, Sri Lanka, Bangladesh, Nepal and Maldives), East Asia (China, Japan, South Korea, Philippines), Lake Victoria Basin (Burundi, Kenya, Rwanda, Tanzania, Uganda), Latin America (Brazil, Paraguay, Uruguay, Argentina, Bolivia) and Black Sea (Dnieper, Dniester and Danube).

The Chief Guest S. Ayyappan (National Academy of Agricultural Sciences, India) mentioned that long-term studies by Indian researchers have made available voluminous data that need to be compared and integrated with those from countries of South Asia at the first stage of consolidation. However, there is need for farm-level verification and field validation of the data, and related modelling exercise. With the lowering response of crop varieties to N-fertilizer, farmers tend to apply more and more fertilizers. Hence alternative strategies need to be explored that could minimize both loss of this valuable nutrient and reduce pollution from fertilizer overuse. It is necessary to delve into possibilities of sharing and exchanging data on a regular basis through a network of the institutions working in the area of N-use. It is also necessary to develop awareness programmes through social media for judicious use of N-fertilizers to contribute to the well-being of society.

The workshop reviewed reports from Bangladesh, Nepal and Sri Lanka. Bangladesh has developed innovative approaches to increase N-fertilizer use efficiency, and use of urea super granules (USGs), deep placement of urea, bio-organic fertilizers and low-input crop variety is drawing attention of the planners and policymakers. Such measures have increased rice yield by 15–20% and reduced use of N-fertilizer by 20–30%. Livestock and poultry serving the growing protein demand, also help Bangladesh to obtain organic manure equivalent to 0.66 million tonnes of urea. Nepal reported that agriculture being the mainstay of the country's economy, those practising subsistent farming, rely heavily on local inputs like FYM, forest litter, crop residues and compost. Intensive farming and commercial cropping consume chemical N-fertilizers according to the need and availability, and are often misused. Sri Lanka imported 0.6 million tonnes of fertilizer in 2012, of which ~50% was urea. Nearly 60–65% of the imported urea was used in rice cultivation, while the rest was applied to plantation crops and vegetable cultivation. Massive amount of N is lost in various ways, including losses as N_2O, accounting for ~52% of total urea applied. Also, subterranean aquifers get contaminated and nitrate contamination in the groundwater of Sri Lanka in some areas was reported as high as >10 mg/l, and average value of >5 mg/l in shallow groundwater.

*A report on the workshop 'Reactive Nitrogen Assessment in South Asia' held as one of the International Nitrogen Management System events during 26 and 27 February 2016 at the National Agricultural Science Complex, New Delhi and organized by the Indian Nitrogen Group (ING-SCON) and South Asian Nitrogen Centre, New Delhi.

Reporting on 'Integration of N science and policies – industry view', R. K. Tewatia (Fertiliser Association of India, New Delhi) informed that South Asia accounts for 11% of global N production and 19% of global N consumption. All the South Asian countries are deficit in fertilizers and raw materials, and depend on import to bridge the demand. There has been remarkable growth in the production and consumption of N fertilizers in India after 1960s and currently, India is globally the second largest producer and user of N-fertilizer. Fertilizer industry recognizes 4R Nutrient Stewardship as an appropriate framework to guide decision for sustainable N-management and desires to improve farmers' awareness on the issue. The Task Force on 'Balanced Use of Fertilizers' recommended the following policy changes: (a) promote fortified and customized fertilizer to correct deficiencies of secondary and micronutrients (2008); (b) promote neem-coated urea (2008); (c) extend subsidy to S and micronutrients (Zn and B) under NBS (2010), (d) introduce new grades of water soluable fertilizers by notifying their general specifications (2015), and (e) promote city compost (2016). It is hoped that such pragmatic policy on behalf of the Government will induce improvement of N-use in Indian agriculture.

Indian experts, while reviewing other sectors, mentioned that growth of NO_x emission during 2001–2011 was 2972 Gg/yr CO_2-e (69%), up from 1487 Gg/yr CO_2-e during 1991–2001. Global models projecting 2050 scenario of NO_x emission in South Asia with 2010 as the base year indicate high emission in the Indian subcontinent. There is also evidence of large-scale transport of pollutants from South Asia to East Asia, and vice versa. It was noted that (1) dry deposition of Nr is more important than wet deposition of NH_3-N; (2) among the various Nr, gaseous ammonia contributes highest N in the atmosphere in India; (3) there is higher content of NH_4-N than NO_3-N in rain water and (4) the Indo-Gangetic region has significantly higher rate of wet deposition of NH_3-N. Such high values of atmospheric Nr are affecting the health of the inhabitants, with recent focus on the quality of Delhi air. Other sectors like fisheries, forestry and grasslands, coastal environment and mangroves, soil health, energy, industry and transport were also discussed.

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MEETING REPORT

Chemoecological approaches for insect borer pest management*

A wide range of agricultural, horticultural and forest trees are vulnerable to insect borer pests causing serious loss to the economy. Cryptic nature of the borers causes the infestations to be overlooked until sizeable damage has occurred. Employing chemical or biological control has not yielded desirable results in suppressing these, as interventions hardly reach the target site/insect. However, the hazard of pesticides remains. Understanding the ecological interaction mediated by cues, especially odours between borers and their host will aid in the development of clean and green technologies.

Semiochemicals are organic compounds that transmit chemical messages. Insects perceive the stimuli from air with olfactory receptors and use them for intra- and inter-species communication. India has islands of expertise in the field of chemical ecology that is scattered across the country. In an attempt to collate the expertise, facilitate interactions and form a cohesive group to solve the problems posed by borer pests, a round table on semiochemicals for borer pest management was organized recently. The meeting was attended by research scientists and students from ICAR institutes; CSIR-Indian Institute of Chemical Technology (IICT), Hyderabad; National Centre for Biological Sciences (NCBS), Bengaluru, and Central Coffee Research Institute, Balehonnur.

Abraham Verghese (ICAR-National Bureau of Agricultural Insect Resources (NBAIR)) traced the genesis of Consortia Research Platform (CRP) on borers. He mentioned that working in isolation would be of little use and hence called for sharing knowledge and facilities to achieve the goals. The round table on semiochemicals for borer pest management would bring together experts and novices to share their ideas. This will help generate ideas in solving the problem caused by borer pest and avoid duplication so as to effectively utilize the resources.

Exchange of ideas cutting across disciplines will generate technologies that would help solve problems associated with pests. One such achievement is the development of a sealer-cum-healer, a technology that could be used with ease by farmers in containing the borer damage in tree crops like mango and cashew.

A. Krishnamoorthy (ICAR-Indian Institute of Horticultural Research (IIHR), Bengaluru) informed that cryptic nature of borers causes greater dependence on semiochemicals for pest management. Teamwork while sharing the expertise and responsibilities among partner institutes will help develop robust semiochemical-based pest management. He mentioned that nanotechnology will aid in the development of dispensers having extended release that will trap insects effectively during the entire crop period irrespective of weather conditions.

In the technical session, N. Bakthavatsalam (ICAR-NBAIR) outlined the principles involved in semiochemical research and its status in horticultural sector in India. He touched upon the role of odour-binding proteins in olfaction, techniques related to monitoring, mass trapping, mating disruption and auto confusion as potential concepts for borer management. P. D. Kamala Jayanthi (ICAR-IIHR) emphasized that a thorough understanding of the bio-ecology of

*A report on a meeting 'Semiochemicals for Borer Pest Management' organized by the ICAR-National Bureau of Agricultural Insect Resources, Bengaluru in association with ICAR-Consortium Research Platform on Borers on 6 August 2015.