Integrated Plant Nutrient Management

Article · September 2018

CITATIONS
6

READS
1,734

1 author:

Bijay Singh
Punjab Agricultural University
248 PUBLICATIONS **5,086** CITATIONS

SEE PROFILE

Bijay Singh

INM
Integrated Nutrition Management
Excellence in Plant Nutrition

Integrated Plant Nutrient Management

During 1960s and 1970s, the Green Revolution could bring notable increases in the production of cereal-grains in Mexico, India, Pakistan, the Philippines, and other developing countries. Increased cereal production resulted from the introduction of high yielding strains of wheat, rice, and maize but in order to reap the potential of the new high yielding seeds, farmers rapidly increased the use of mineral fertilisers, pesticides and irrigation. Between 1970 and 1990, mineral fertiliser application in developing countries shot up by 360 per cent.

Organic manures are being used as source of nutrients as well as for general benefits of soil and crop plants since the beginning of settled agriculture. When the Green Revolution introduced high-yielding cereal varieties, mineral fertilisers almost replaced organic manure to supply plant nutrients. Organic manures became a secondary source of nutrients because:

1. enough quantity of manures were not available with the farmers to meet nutritional needs of high yielding varieties , and
ii. due to low nutrient content in manures it was not practicable to handle large quantities of manures.

But soon after using only the mineral fertilisers to supply plant nutrients, both farmers and researchers could observe that yields are plateauing or even decreasing even with increasing fertilisers doses and soil health in some regions was declining.

Integrated Plant Nutrient Management (IPNM)

With increasing awareness about soil health and yield sustainability, organic manures regained importance as components of IPNM strategies, which emerged as one of the key features of sustainable soil management. The IPNM strives to maintain and possibly improve fertility and health of the soil for sustained crop productivity on long-term basis. Nutrients supplied through fertilisers are used as supplement to nutrients supplied by different organic sources available at the farm such as animal manures, biological N fixation, crop residues (CR), green manures (GM) or imported to the farm as sewage sludge, food industry waste. Small and marginal farmers were attracted to adopt IPNM also because of continuously increasing price of fertilisers and availability of some organic nutrient sources at the farm.

Increased crop productivity through IPNM

Soon after the introduction of mineral fertilisers, sufficient evidence became available that combined application of N, P and K fertilisers (NPK) and organic manures can generally achieve higher crop yields than fertilisers or

manures applied alone. The IPNM can positively influence growth and activity of plant roots through improved physical and chemical environment in the rhizosphere soil and lead to increased nutrient use efficiency by managing soil nutrient supply in the root zone within a reasonable range that matches the quantity required by the crop and is synchronized in terms of time and crop growth.

During last 2 to 3 decades, IPNM has emerged as an effective agricultural paradigm to ensure food security through increased production of rice and wheat, particularly in countries with developing economies such as in China and in South Asia. A large number of investigations in these regions have shown a significant positive impact on yield of rice and wheat through integrated management of different organic materials and fertilisers. (Figure 1)

Positive effect of IPNM on different crops

In recent years, besides rice and wheat, positive effect of IPNM in terms of yield has been recorded in cotton, maize, potato, barley, lentil, sunflower, finger millet, mustard, kinnow and several vegetable crops. In semi-arid tropics too, IPNM practices have been found superior to mineral fertilisers alone in realizing either at par or higher yield levels of chickpea, wheat, soybean, pearl millet, maize and groundnut and substituting the use of 50% of mineral fertilisers

Figure 1. Performance applying farmyard manure (FYM) and fertilisers as integrated plant nutrient management vis-à-vis fertiliser alone in rice

through effective recycling of on-farm wastes. Wheat is grown in winter season so that mineralization of organic sources of nutrients is slow as compared to in the summer when rice and maize are grown in South Asia. Therefore, IPNM in wheat is less popular than in rice or maize. Although in some studies positive effect of IPNM on wheat yield has been reported, substantial residual effect of organic materials applied to preceding summer season crops of rice, maize or soybean has been observed in wheat by several researchers.

Improved sustainability of crop production systems

Long-term application of fertilisers and organic manures either alone or together as IPNM in different crops and cropping systems may lead to changes in soil nutrient stocks and nutrient supplying capacity, which may influence sustainability of yield of crops. Long-term experiments provide opportunity to compute rate of change of yield over time as well as sustainable yield index to study the impact of IPNM strategies on sustainability of crop production. Sustainable yield index (SYI) is computed as $(Ya-\sigma)/Ymax$ where Ya is the mean yield, σ is the standard deviation of yield, and Ymax is the maximum yield obtained under a set of management practices. Low values of standard deviation suggest high sustainability of the system.

Long-term experiments conducted in India

In several long-term experiments on rice-wheat cropping system conducted for 12 to 15 years at different locations in India (Yadav et al., 2000), farmyard manure (FYM), GM and CR were applied in combination with NPK fertilisers to rice whereas to wheat only fertiliser NPK was applied. When pooled data across the locations were used to fit linear regressions, highly significant annual increase in yield of both rice and wheat with IPNM treatments was observed, indicating thereby the advantage of combined use of manures plus fertilisers over fertilisers alone in sustaining crop yields. In another 12 long-term fertility experiments on rice-wheat cropping system in the Indo-Gangetic plains of South Asia (Ladha et al., 2003), average yield change in rice was significantly higher with the application of FYM and GM along with 50% NPK as compared with the only 100% NPK treatment.

Long term trials initiated

During 1971 and 1996, several long-term experiments were initiated all over India to study the nutritional aspects of different cropping systems (AICRP-LTFE, 2013). The local fertiliser N, P and K recommendations constituted the standard reference treatment and the IPNM treatment consisted of applying local NPK recommendations along with 10 t FYM ha-1. In 2011-12, the yield data of these experiments was used to compute SYI of rice, wheat and maize. Data in Table 1 show that SYI of the IPNM treatment was conspicuously higher than those for the fertiliser only treatment convincingly proving that practising IPNM can ensure high yield

Table 1. Sustainable yield index (SYI) of rice, wheat and maize in 2011-12 as influenced by fertiliser alone and integrated use of fertiliser and farmyard manure (IPNM) in long-term experiments on different cropping systems initiated during 1971 to 1996 at different locations in India

Long-term experiment			Nutrient supply treatments		
Location	**Year of start**	**Cropping system [1]**	**Control**	**NPK [2]**	**NPK + FYM [3]**
Rice					
Barrackpore	1971	Rice-wheat	0.15	0.35	0.40
Pantnagar	1971	Rice-wheat	0.13	0.41	0.50
Pattambi	1996	Rice-rice	0.33	0.48	0.61
Bhubaneswar	2002	Rice-rice	0.26	0.66	0.60
Wheat					
Barrackpore	1971	Rice-wheat	0.11	0.38	0.41
Pantnagar	1971	Rice-wheat	0.15	0.51	0.61
Ludhiana	1971	Maize-wheat	0.14	0.70	0.78
New Delh i	1971	Maize-wheat	0.38	0.74	0.82
Maize					
Ludhiana	1971	Maize-wheat	0.03	0.29	0.44
Palampur	1972	Maize-wheat	0.01	0.35	0.53
Udaipur	1996	Maize-wheat	0.34	0.67	0.79

1The first crop listed in the cropping system represents the summer season crop to which IPNM treatment was given
2 NPK: N, P and K dose as per the local recommendation for different crops
3 NPK + FYM: N, P and K dose as per the local recommendation + 10 t farmyard manure ha-1
Source: AICRP-LTFE, 2013

sustainability over that observed with fertiliser alone.

IPNM for improving/maintaining soil health

The optimal use of inorganic and organic sources of plant nutrients is of fundamental importance not only for nutrition of crop plants but also for improving/maintaining soil health. Build-up of soil organic matter (SOM) due to application of organic nutrient sources improves soil physical properties like soil structure and water holding capacity, increases capacity of the soil to buffer changes in the pH, increases the cation exchange capacity, reduces phosphate fixation, serves as a reservoir for essential micronutrients and favours growth of soil fauna and microorganisms, which are the primary agents that manipulate the decomposition and release of mineral nutrients in the soil ecosystems. Using a meta-analysis based on 49 sites and 130 observations from all over the world, Maillard and Angers (2014) reported that cumulative manure-C input explained at least 53% of the variability in SOM stock differences compared to mineral fertilized treatments. A number of researchers have reported that the IPNM increased SOM more effectively than the appli-

cation of fertilisers alone. Since the turn of the century, data from a number of long-term experiments have revealed that IPNM leads to build up of SOM in different cropping systems.

Organic manures

Organic manures typically increase soil microbial biomass through the supply of C-rich organic compounds to the generally C-limited microbial communities in arable soils. Thus, soil health related microbial indicators such as soil microbial biomass, soil bacterial community diversities and soil enzyme activities are also significantly improved by integrated management of organic manures and mineral fertilisers rather than application of fertilisers alone.

Mitigation of global warming

Nitrous oxide is an important greenhouse gas contributing to global climate change. It is produced through soil microbial processes of nitrification and denitrification, and contributes to roughly 6% of the overall radiative forcing in the atmosphere. Addition of easily decomposable organic C in the form of organic amendments may increase microbial activities and induce anaerobic conditions, which may lead to increased losses of nitrous oxide via denitrification. But in several investigations under both upland crops and lowland rice, integrated application of inorganic fertilisers and organic sources of nutrients resulted in reduced or no significant effect on nitrous oxide. A few studies reported increased emission but the trends were obviously linked not only to the quantity and quality of organic amendments but also to soil biotic and abiotic factors.

The message

Fertilisers have played a vital role in increasing crop productivity. However, environmental issues have been linked with indiscriminate use of fertilisers. Combined use of organic nutrient sources and fertilisers following the concepts of IPNM guarantees optimal use of fertilisers to achieve high crop production levels but with minimal adverse effects on the environment.

References

AICRP-LTFE (2013), *Annual Report of All India Coordinated Research Project on Long-Term Fertiliser Experiments to Study Changes in Soil Quality, Crop Productivity and Sustainability,* Indian Institute of Soil Science, Bhopal, India, pp. 1-42.

Ladha, J. K., Pathak, H., Tirol-Padre, A., Dawe, D. and Gupta, R. K. (2003) In: Ladha, J. K., et al. (Eds), *Improving the Productivity and Sustainability of Rice-Wheat Systems: Issues and Impacts,* American Society of Agronomy Special Publication 65, ASA, CSSA, SSSA, Madison, WI, U. S. A. pp. 45-76.

Maillard, É. and Angers, D.A. (2014) *Global Change Biol.,* 20, 666-79.

Yadav, R. L., Dwivedi, B. S., Prasad, K., Tomar, O. K., Shurpali, N. J. and Panday, P. S. (2000b) *Field Crops Res.,* 68, 219-46.

Bijay Singh, Punjab Agricultural University, Ludhiana, Punjab, India