Chapter 6
Potential of Organic Resources as Plant Nutrients in India

Abstract The nutrient content of various organic resources having the total nutrient potential of 14.85 million tonnes was estimated in 2000, which would become around 16.34 and 32.41 million tonnes by 2010 and 2025, respectively. Out of these organic resources, considerable tapable potential of nutrients ($N + P_2O_5 + K_2O$) from human excreta, livestock dung and crop residues has been worked out to the order of 5.05 million tonnes in 2000, which would be about 6.24 and 7.75 million tonnes by 2010 and 2025, respectively, for the required food grain production of the increased human population. However, use of all tapable nutrients would not be sufficient to produce the required food grains for the burgeoning human population. Thus, integrated use of the chemical, organic and biological sources of plant nutrients and their different management practices have a tremendous potential not only in sustaining agricultural productivity and soil health but also in meeting a part of chemical fertilizer requirement for different crops and cropping systems.

Keywords Organic resources • nutrient potential • chemical sources • organic and biological sources • agricultural productivity • soil health

India is endowed with a vast potential of plant nutrients locked up in organic, biological and industrial by-products. However, their use in INM system is limited, because of their alternate utilities as animal feed, fuel and building material. Major crop improvement strategies for sustainable agricultural production mainly pursue the use of natural processes such as nutrient cycles, biological nitrogen fixation and pest–predator relationship in agricultural production. For sustainable agriculture, the main organic resources used for plant nutrients are FYM, compost, crop residues, green manure, bio-fertilizers, legumes, vermicompost, biogas slurry, etc. Apart from these organic sources utilized for plant nutrients, other sources include soil reserves, human wastes, urban and rural wastes, sewage sludge, tree and aquatic wastes, agro-industrial wastes like press mud, coir pith from coconut industry, distillery waste, fruit and vegetable wastes, marine wastes, sea wastes and fishmeal, etc. (Singh and Singh, 2003a). Tandon (1997) has made projections of nutrient supply through organics for the period 2000–2025 in Table 6.1.

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Table 6.1 Some projections on availability of organic resources for agriculture in India during 2000–2025 (Adapted from Tandon [1997])

Resources	2000	2010	2025
I. Generators			
Human population (millions)	1,000	1,120	1,300
Livestock population (millions)	498	537	596
Food grain production (million tonnes)	230	264	315
II. Nutrients (theoretical potential in million tonnes of N + P_2O_5 + K_2O)[a]			
Human excreta	2.00	2.24	2.60
Livestock dung	6.64	7.00	7.54
Crop residues	6.21	7.10	22.27
Total	14.85	16.34	32.41
III. Nutrients (considerable tapable potential in million tonnes of N + P_2O_5 + K_2O)[b]			
Human excreta	1.60	1.80	2.10
Livestock dung	2.00	2.10	2.26
Crop residues	2.05	2.34	3.39
Total	5.05	6.24	7.75

[a]All data pertaining to nutrients in dung and residues are counted as twice the amount fed to the animals.
[b]Tapable = 30% of dung, 80% of excreta, 30% of crop residues.

As per the projections on the availability of organic resources for agriculture in India, it is estimated that organic resources would have a total nutrient potential of 14.85 million tonnes by 2000, which would increase to around 32.41 million tonnes by 2025, of which the tapable potential of N + P_2O_5 + K_2O would be about 5.05 and 7.75 million tonnes by 2000 and 2025, respectively. The advantages in making these projections for the organic resources are mostly derived from plants and animals. Thus, the theoretical availability of crop residues and resources of animal and human origin can be worked out from agricultural production and population projections. What is more difficult to predict and project is the actual availability of these resources which will be decided by emerging trends in their competing uses and prices they fetch from sectors other than farming.

6.1 Animal Dung and Wastes

As the fertilizer use in most Indian farming is suboptimal, organic resources can supplement available fertilizer supply. Approximately 25% of nutrient need of Indian agriculture can be met by using various organic sources. In an estimate the annual production of dung and urine from bovines in India is nearly 1,528 and 800 million tonnes, respectively. If the total amount of dung and urine produced by bovines is conserved for manurial purposes, their potential for supplying N, P_2O_5 and K_2O has been estimated to be about 7 million tonnes, i.e. 3.44, 1.31 and 2.21 million tonnes respectively. The potential availability of cattle dung in India is about 2 billion tonnes, with a nutrient potential of about 6.96 million tonnes (approximately 7 million tonnes as stated above).

Acharya and Kapur (1993) reproached the cumbersome practice of carrying and spreading of bulky wastes from cattle sheds to fields situated at a distance. Direct spreading of widely growing wastes like wild sage (*Lantana camara*) and eupatorium (*Eupatorium adenophorum*) in the standing maize crop at the recession of the monsoon is a better option. This practice not only conserves moisture for timely sowing of wheat without any pre-sowing irrigation, but also produces the highest grain yield of wheat. In another study, Acharya et al. (1998) reported that soil structure beneath wild sage and eupatorium was mellow, and therefore sowing of wheat with conservation tillage and recommended P and K doubled the grain yield of wheat compared to usual farming practices.

6.2 Crop Residues

Crop residues, another important component of the ecosystem of any country, are good sources of plant nutrients. A large amount of crop residue is annually produced in India. In areas where mechanical harvesting has been adopted, a sizeable quantity of crop residues is left in the field which can be recycled for nutrient supply. The annual production of crop residues in the country has been estimated in the range of 270–300 million tonnes. About one third of the residues produced may be recycled on the land and these can add 2.47 million tonnes of $N + P_2O_5 + K_2O$ annually, two thirds of which is potash alone. As per current estimates, organic resources can supplement 3.9–5.7 million tonnes of nutrients (Subba Rao and Srivastava, 1998). In another estimate, an annual production of crop residues in India is about 313–356 million tonnes with nutrient potential of 6.7–7.5 million tonnes (Singh and Singh, 2003b). About one third of the crop residues are available for direct recycling, amounting to 136.4 million tonnes, and if used can add 3.54 million tonnes of N, P_2O_5 and K_2O annually. Crop residues can be recycled either by composting or by way of mulch or direct incorporation in the soil.

6.3 Green Manures and Legumes

As regards green manure, traditionally India has been using dhaincha, sunn hemp, cowpea, cluster bean (guar), black gram, green gram, etc. Dhaincha and sunn hemp are more popular. On the other hand, legumes are grown for fixing atmospheric N through *Rhizobium* symbiosis, and are planted before flowering, i.e. after 6–8 weeks of growth, into the soil to improve its fertility and for raising another crop (Katiyar, 2000). According to Katyal (1991) green manures and legumes have the potential to supply N up to 50–60 kg N ha^{-1} and P_2O_5 10–60 kg N ha^{-1}, respectively.

Planting of green manure crops into the soil increases the availability of N and other plant nutrients (Singh and Singh, 2003a). One of the most conspicuous green manuring crops is dhaincha (*Sesbania aculeata*). It can grow on most of the soils, fix a large amount of N and produce on an average about 5 t of dry matter per hectare and 100 kg N ha^{-1} in about 60 days. Effects of green manure and FYM on rice and wheat yield have been recently reported (Singh et al., 2004).

6.4 Bio-Fertilizers

Projections show that possible N gains through symbiotic bacteria, asymbiotic bacteria and blue-green algae (BGA) in Indian agriculture can be equivalent to 1.00, 0.15 and 0.75 million tonnes per year, respectively (Katyal, 1991). In N economy of rice, BGA, namely *Anabaena*, *Nostoc Tolypothrix*, etc., and *Azolla* have tremendous potential which still needs to be explored. *Azolla* has a potential to fix the atmospheric N amounting to 100–150 kg ha^{-1} $year^{-1}$ and thus can save about 50% mineral fertilizer N (Subba Rao et al., 1993).

Vesicular arbuscular mycorrhizal fungi, namely *Glomus etunicatum* and *G. acrocarpus*, have a potential to substitute 15 kg P_2O_5 ha^{-1} of chemical fertilizers besides mobilizing micronutrient cations like Zn and Mn (Gupta and Chhonkar, 1995). According to Katyal (1991) bio-fertilizers have the potential to supply up to 20–50 kg N ha^{-1}. Currently more than 10,000 t of bio-fertilizers is being used in the country.

Use of bacterial cultures of *Pseudomonas* and *Bacillus* spp. and fungal culture of *Aspergillus* spp. can assist in converting insoluble phosphate into soluble phosphate, which ultimately improves the availability of phosphorous to plants.

6.5 Compost and Vermicompost (Soil Conditioner)

Organic manure prepared from plant residues (leaves, stalks, twigs, bark, etc.) and animal waste products (especially cattle dung) is called compost, and the process of preparing it is known as composting. On an average, it contains 1.01% N, 0.5% P_2O_5 and 0.8–0.9% K_2O. The availability of rural compost and city refuse in India are 285 and 14 million tonnes, respectively, which provides 4 million tonnes of plant nutrients (NPK) per year.

Vermicomposting, i.e. the technology of rearing earthworms, is an effective tool of sustainable agriculture. In India, a large number of vermicompost units established by city corporations, municipalities, besides non-governmental organizations (NGOs) provide vermicompost to numerous private entrepreneurs, especially in the states of Madhya Pradesh, Rajasthan, Uttar Pradesh, Kerala, Karnataka, etc. In the Jammu region (Jammu & Kashmir), a number of vermicompost units have now been started by many of the farmers themselves. They are using vermicompost for augmenting the yield of strawberry and other crops.

Table 6.2 Organic source required to meet 25% of India's nutrient needs in 2000 and 2050 (Adapted from Tandon [1997])

Organic resource (million tonnes)	2000	2050
Farmyard manure	200	400
Crop residues	30	50
Urban/rural wastes	10	50
Green manure	25	50

6.6 Biogas Slurry

The residual slurry that comes out of the digestion tank is called biogas slurry. For biogas slurry, India has been a pioneering country in the world in developing biogas plants. These plants produce digestive slurry, which can be applied directly in cultivated fields. Such slurry is generally richer in N than FYM, which contains about 1.5–2.0% nitrogen, 1% phosphorous and 1% potash. There are more than 3.2 million biogas plants, whose slurry (around 28 million tonnes) may be utilized as a unique organic source of plant nutrients. Biogas plants serve the dual purpose of providing fuel as well as good-quality manure. Therefore, construction of biogas plants by the farmers should be encouraged in the country.

As estimated, about 25% of the nutrient needs of Indian agriculture can be met by utilizing various organic resources. The resources required to achieve this are suggested in Table 6.2. Thus, integrated use of the chemical, organic and biological sources of plant nutrients and their different management has a tremendous potential not only in sustaining productivity and soil health but also in meeting a part of chemical fertilizer requirement of different crops and cropping systems.

Impact Points to Remember

- The annual production of crop residues is estimated to be in the range of 270–300 million tonnes. About one third of the residues produced may be recycled on the land and these can add 2.47 million tonnes $N + P_2O_5 + K_2O$ annually, two thirds of which is potash alone.
- Potential availability of nutrients ($N + P_2O_5 + K_2O$) from animal dung and urine is 7.0 million tonnes with production of 3.2 billion tonnes.
- Cattle account for about 90% of the total animal dung and nutrients.
- The results of a long-term experiment in the rice–wheat cropping system revealed that the combined use of 12 t of FYM ha^{-1} and 80 kg N ha^{-1} gave rice yield comparable to 120 kg N ha^{-1}, which means a net saving of 40 kg N ha^{-1}.
- Farmyard manure also showed considerable residual effect on the succeeding wheat crop.
- Bio-fertilizers differ from chemical fertilizers in the sense that the farmers do not directly supply any nutrient to crop plants. They, in fact, are the cultures of

some specific bacteria (*Rhizobia*, *Azotobacter*, *Azospirillum*), algae (BGA) and fungi (*Asperigillus*).

- As per current estimates, organic resources can supplement 3.9–5.7 million tonnes of nutrients.
- *Azolla* has a potential to fix the atmospheric N amounting to 100–150 N ha^{-1} $year^{-1}$ and thus can save about 50% mineral fertilizer N.
- Vesicular arbuscular mycorrhizal fungi, namely *G. etunicatum* and *G. acrocarpus*, have a potential to substitute 15 kg P_2O_5 ha^{-1} of chemical fertilizers besides mobilizing micronutrients cations like Zn and Mn.
- Green manures, bio-fertilizers and legumes have the potential to supply N up to 50–60, 20–50 and 10–60 kg N ha^{-1}, respectively.
- The availability of rural compost and city refuse in India are 285 and 14 million tonnes respectively, which provide 4 million tonnes of plant nutrients (NPK) per year.
- The earthworms in vermicompost consume nearly two to five times their body weight, and after utilizing 5–10% of the feedstock for their growth, excrete mucus coated with undigested matter as worm casts or vermicasts.
- Biogas plants serve the dual purpose of providing fuel as well as good-quality manure.
- There are more than 3.2 million biogas plants, whose slurry (around 28 million tonnes) may be utilized as a unique organic source of plant nutrients.
- As estimated, about 25% of the nutrient needs of Indian agriculture can be met by utilizing various organic resources.
- The use of organics not only helps to substitute partly for chemical fertilizers, but also improves the overall soil productivity through its beneficial effects on physical, chemical and biological properties of soils.

Study Questions

1. Explain briefly the potential of organic resources of plant nutrients in India.
2. Explain briefly the potential of bio-fertilizers in India.
3. Explain briefly the potential of compost, vermicompost and biogas slurry in India.
4. What are the different organic sources required to meet 25% of India's nutrient needs in 2050?

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