7. Soil Organic Matter Management

7.1 Significance of soil organic matter

Soil organic matter comes from plant and animal remains. It influences the physical, chemical and biological properties of soil. It improves soil physical conditions viz soil structure, water holding capacity, aeration, soil erosion etc. It's a storehouse of plant nutrients, chiefly N,P & S. It serves as a food and energy for beneficial organisms viz N_2 fixing bacteria (e.g *Rhizobium, Azobtobacter*), earthworms.

7.2 Organic matter status in Bangladesh soils

A good soil should have at least 2.5% organic matter, but in Bangladesh most of the soils have less than 1.5%, and some soils even less than 1% organic matter. The organic matter content of top soils under high land and medium high land situation has been declining over time. It is believed that the declining productivity of this country's soils is the result of depletion of organic matter due to increasing cropping intensity, higher rates of decomposition of organic matter under the prevailing hot and humid climate, use of lesser quantities of organic manure, little or no use of green manure practices etc. The highest depletion of organic C has been reported in soils of Meghna River Floodplains (35%). Depletion occurs in soils of Madhupur Tract (29%), Brahmaputra Floodplains (21%), Old Himalayan Piedmont Plains (18%), Gangetic Floodplains (15%).

7.3 Management of soil organic matter

There is no doubt that the soil organic matter is constantly undergoing changes and needs to be replenished continuously to maintain soil productivity. The major sources of soil organic matter include animal manure, crop residues, household and farmyard wastes, municipal sewage sludge, industrial refuse, green manuring practices and other organic wastes of various kinds.

A large variety of organic wastes are available in the country that can be used as potential manure to improve our soils. These are household waste (human excreta, non-edible vegetable, food and fruit parts, after-meal waste etc.), farmyard waste (animal dung and urine, feed/fodder refuse, harvested crop residues, poultry excreta etc.), agro-industrial wastes (sugarcane trash, oil cakes, bagasse, molasses, bone meal, blood meal, fish meal, rice husk, brans, saw dust etc.), sewage sludge, and farm waste (crop residues, weeds, dead animals, water hyacinth etc.). Organic wastes like kitchen wastes, non-edible vegetable, food and fruit parts, slaughter house waste, dead animals etc. are generally thrown away or dumped into ditches/ponds/canals to fill up and not used as organic fertilizer. The important organic wastes/practices which have great potential in increasing soil organic matter and thus crop productivity are discussed below:

Crops residues

Leftover parts of various crops after harvest are called crop residues. Substantial quantities of crop residues are produced in the country every year. But little or no care is given for its use. In most cases, crop residues are burnt or removed away to clean the land causing huge loss of this

potential resource. Crop residues of all kinds including roots, straw & stalks and vegetable tops are valuable as a source of organic matter and plant nutrients. Crop residues can be recycled either by composting or by way of mulch or by direct incorporation in the soil.

Animal manure

It includes the excreta (dung and urine) of the domestic animals. Stubbles used as bedding of animals also become part of the manure. In Bangladesh, cowdung is the most important animal manure, although a big portion of the cowdung produced in the country is used as fuel.

Fresh animal manure should not be applied to standing crops, because the heat and CO_2 generated during vigorous decomposition is harmful for the young roots. Substantial quantities of animal manure produced in Bangladesh are lost due to careless handling. Nutrient content of the preserved manure is also reduced due to same reason. Animal manure should be stored in pits preferably under a roof. The urine of cattle is rich in nitrogen and should be preserved with the dung. The manure in the pit should be kept moist in order to reduce the volatilization of nitrogen in gaseous forms. The rotting of animal manure, when kept in pits, is complete in 3-4 months. Microbial inoculants, if available, may be used to reduce the rotting time.

Compost

The organic fertilizer that is produced by decomposing different waste materials of plant and animal origin is called compost. Ingredients that are used to make compost include dead leaves, straw, weeds, water hyacinth, household wastes like non-edible food, fruit and vegetable parts, after-meal wastes, municipal garbage, saw dust, wastes of leather factory, sugar mill bagasse, rice husk etc. Municipal and leather wastes should be treated to make them free from heavy metals and other toxic substances. The materials should be placed in layers, one above another. Each layer may be 25-30 cm thick. Heaps should preferably be 1.5 - 2.0 meter wide and not more than 1.5 meter in height. In order to promote microbial activities, thin (4-5 cm) layers of soil or fresh cowdung should be placed in between the layers of materials in the heap. Top of the heap should also be covered with soil. The heap should be kept moist, by spraying water at regular intervals. After 1.5 - 2 months the layers should be reversed in a new heap to allow uniform decomposition. Depending on the condition of the weather and the type of raw materials used, preparation of compost takes 4 - 6 months. High temperature and high humidity favour rapid decomposition. Addition of small quantities of urea and triple superphosphate hastens the rotting of raw materials like straw, sugarcane trash, rice husk etc. which decomposes very slowly. Microbial accelerator, if available, may also be used for rapid decomposition.

Vermicomposting : It is the process of using earthworms to convert organic wastes such as manure or household refuse to valuable compost. The earthworm inhabits organic matter lying on soil surface; eat fallen leaves and other non-decomposed litter. It has also been found to be especially efficient in breaking down the toughest organic wastes like sugarcane trash.

Concentrated organic manure

These are oil cake, slaughter house wastes, fish meal, guano and poultry manure which are rich in NPK. Being popular as animal feed, oil cakes are costly and should be applied to high value

crops only. Cakes should be decomposed in water for 10-12 days if applied near the base of young seedlings.

Green manure

Green manure refers to crops that are grown and ploughed down at the appropriate stage of growth. In some countries, farmers collect fresh leaves from the forests and apply to the soil. This is called green leaf manure. Green manure adds substantial quantities of organic matter and nitrogen to soils.

Any herbaceous plant may be used for green manuring, but plants of the family leguminosae are preferred because of the added advantage of getting fixed nitrogen. The common GM plants include dhaincha *(Sesbania aculeata)*, African dhaincha *(S. rostrata)*, sunhemp (*Crotalaria juncea*), cowpea, grasspea, soybean, mungbean, blackgram etc. The crops should be ploughed down when the plants are of 50-55 days old. Rhizobial inoculation would be useful to obtain higher biomass in a given period over uninoculated legumes. Dhaincha needs to be incorporated to soil within a week before T. Aman rice planting. A green manure crop may add 10 - 15 ton of biomass (fresh weight) per hectare and 60-120 kg of N/ha to the soil.

Azolla

Dual culture of *Azolla* in wetland rice is a unique technology to produce green biomass for incorporation as green manure. It can be practiced in Boro and T.Aman rice cropping. Inoculation of 0.5-1.0 kg/sq.m Azolla inoculum after 7-10 days of transplanting is recommended which may produce 10 ton/ha within 2-3 weeks. Azolla produced and incorporated twice in this way may produce yield equivalent to 80 kgN/ha as urea in one season.

Blue green algae

Blue green algae can add upto 3-8 ton organic carbon in a cropping season. Many other microorganisms (*Azotobacter, Azospirillum, Rhizobium, Bacillus, Pseudomonas,* etc.) that produce growth hormones help in better seed germination and root development, thus contributing considerably in the increase of organic matter in soil.

7.4 Organic farming

Organic farming is defined as the farming without the use of soluble, fertilizers or synthetic pesticides. It is a system of agriculture that encourages healthy soils and crops through such practices as nutrient recycling of organic matter (such as compost and crop residue), crop rotations, proper tillage and the avoidance of synthetic fertilizers and pesticides. Its economic viability depends on the higher price that customers will pay for organically grown food because yields are generally lower than from conventional farming.

Practices under organic farming

In organic farming, various farming practices are followed with the crops to harness organic matter, nutrients and water essential for crop growth. Genetically synergist species are normally

selected. Some of such practices are alley cropping, mixed/intercropping, cover crop, green manuring and mulching.

Materials used in organic farming

Organic fertilizers : Farmyard manure, compost, green manure, biological nitrogen fixating (BNF) plants and other products of organic origin are used as organic fertilizers instead of chemicals in organic farming. Moreover, liquid decomposed dungs (1-2 weeks) plus certain broad-leaf plant leaves are also used as top dressing to vegetables.

Organic insecticides: Recipes of leaf, stem, shoot, root or bark of certain species are used as insecticides in organic farming.

Organic wastes: Organic wastes are products, by-products or refuse of organic origin (plant/animal/aquatics) produced through rural/urban production, consumption or processing having conventionally little or no human-use value and considered as garbage or waste materials. These are normally obtained in the food chain of human, animals, plant and aquatics and finally used in the soil.

7.5 Use of biofertilizer

Biofertilizers are microbial inoculants consisting of living and active strains of specific bacteria, algae, fungi, alone or in combination, used for application to seed, soil or composting areas with the objective of increasing crop productivity. They help in the biological nitrogen fixation, solubilization of insoluble phosphate, stimulating plant growth or in decomposition of organic matter.

Rhizobial biofertilizer

Rhizobial biofertilizer/inoculants are made with bacterial strains, reported to fix atmospheric N_2 in symbiosis with legumes. They are the members of five bacterial genera: *Rhizobium, Mesorhizobium, Bradyrhizobium, Sinorhizobium* and *Azorhizobium*. The beneficial effect of these organisms in increasing yield of leguminous crops (lentil, chickpea, cowpea, mungbean, blackgram, pigeonpea, grasspea, pea, groundnut and soybean) results from the activity of its root nodules which fix atmospheric nitrogen making available for the plants.

Procedure for application of rhizobial biofertilizers

a. Take an amount of seed in a container/bowl.
b. Add sugarcane molasses (2-3% for large seeds viz. groundnut, soybean etc. and 3-5% for small seeds viz. lentil, mungbean, etc.) and mix with seeds to make them sticky.
c. Add peat based inoculant (2-3% for large seeds and 3-5% for small seeds) to sticky seeds.
d. Mix seeds with inoculum until they are coated and appear uniformly black.
e. Dry seeds under shade on a paper. Do not dry in direct sunlight.
f. There should be a minimum 24-hour gap between seed treatment with fungicide and biofertilizer application.Use double quantity of biofertilizer in case of pesticide treated seeds.
g. Sow the inoculated seeds and cover the seeds with soil immediately.

Azolla

Azolla is a floating fern, fixes atmospheric N_2 in symbiosis with *Anabaena azollae*. In low land rice, the average N contribution by these N fixers is equivalent to 25-40 kg N/ha. Azolla can be used both as a green manure and as a dual crop after transplanting depending on water availability.

As a dual crop, inoculate azolla in standing water @ 3-4 t/ha 1-2 weeks after transplanting of rice. After 3-4 weeks, water needs to be drained out and azolla can be buried in the soil where it is growing with a weeder or other suitable implement. Repeated incorporation of azolla is needed. Azolla can be grown more than once for the same rice crop to get an additional benefit.