FARM BULLETIN

NO. 7

MANURES

and manuring

INDIAN COUNCIL OF AGRICULTURAL RESEARCH
NEW DELHI

This is the seventh of a series of bulletins planned by the Indian Council of Agricultural Research to meet the paucity of literature in a simple, yet authoritative form and dealing with farming and animal husbandry subjects. Each of the Bulletins is so written as to give a general picture of farming practices in vogue in the country, and suggest improvements based on research results. The Bulletins, it is hoped, will be found useful by the farmer, the agricultural student and the Extension worker alike.

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MANURES AND MANURING

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Contents

MANURES AND MANURING

PLANTS, like human beings, must have food. They need several kinds of food for their normal healthy growth. The food is obtained mainly from three sources, viz., air, water and soil. From these foods, plants build up substances that go into the production of bread, milk, meat, vegetables, fruits, etc. The field, where the plants grow, is really an outdoor chemical factory where the plant foods are converted, with the help of sunlight, into food for man and beast.

There are 14 food elements or nutrients which plants need for their growth. They are carbon, oxygen, hydrogen, nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, iron, manganese, boron, copper and zinc. Every one of these elements is needed by our crops from which men and animals get their food supply. Just as young boys and girls need certain quantities of the necessary food for their growth, so also an exact amount of each plant food nutrient is required by each crop. If the supply of any one of these nutrients is too small to meet what is needed for proper growth, the crop will not grow well and, consequently, the yield will be reduced.

As mentioned above, the growing crop obtains its nutrients partly from air and water and partly from the soil. Air supplies mainly carbon and oxygen, and in some cases, nitrogen also. Water supplies hydrogen and oxygen, while the soil supplies the rest of the plant food nutrients.

We shall now see how the plant gets its food nutrients from air, water and soil.

Nutrients from air

The air contains carbon dioxide, a gas that we constantly breathe out. This is a compound made up of carbon and oxygen. The plant leaves have small openings or pores in their surface through which air, and along with it carbon dioxide, enters the leaves. Through the effect of sunlight and the green colouring matter called chlorophyll present in the leaves, the carbon and oxygen of the carbon dioxide unite with the hydrogen of the water brought up by the roots, and sugars are formed. From these sugars, starch, cellulose and other similar compounds are formed which make up the plant body. This process is the basis of all plant growth.

Though large quantities of nitrogen are present in the air, plants are unable to make use of this nutrient, as it is present in the form of a gas. However, there are certain plants known as legumes, such as pulses, groundnut, *sann*, *dhaincha*, lucerne, berseem, etc., which are able to make use of the nitrogen gas through the activities of a certain type of bacteria that live in their roots and form nodules. These bacteria possess the power of taking nitrogen from the soil and converting it into a form which the legume plant utilizes for its own growth. When the legume plant dies or after it is harvested, the nitrogen present in its roots, stems and leaves is added to the soil where it may later be used by other plants. The growing of legume crops is helpful in adding nitrogen to the soil and maintaining soil fertility.

Water is made up of hydrogen and oxygen. The plant roots absorb water from the soil. When it reaches the leaves, hydrogen combines, as explained above, with the carbon dioxide of the air, and sugars are formed.

Nutrients from soil

Let us look into the kinds and the supply of plant food nutrients in the soil. We must know more about them in order to understand how the soil may be kept fertile.

The plant food elements in the soil are found both in the organic matter and mineral particles. The soil organic matter was derived from plants. The plants growing on the soil absorb the food elements from the organic matter. Practically the whole of the nitrogen present in the soil is in the organic matter and is present in the form of protein or other related compounds. The nutrients present in the mineral particles of the soil are all derived from the rocks and minerals from which the soil was formed.

Nitrogen, calcium, phosphorus and potassium are commonly known as the primary plant food elements in the soil. Of all the elements present in the soil, these four are used in rather large amounts by crops and are, therefore, of special importance. The soil often contains too little of these elements to meet crop needs. For this reason, it is necessary to add these elements to the soil in the form of manures and fertilizers.

Protein is a substance of great value in human food and in the feed of animals. It builds and strengthens the muscles. Nitrogen and phosphorus are of special importance in the building up of protein in plants. For this reason, crops must have plenty of these elements to build up large amounts of protein. Calcium is needed in large quantities, especially by legumes. It is of special value in the production of protein in these crops. Potassium is necessary for building up sugars and starches, though the element itself does not form a part of these substances. Magnesium is closely related to calcium and has somewhat the same effect on the crops. Sulphur is used by crops in about the same way as phosphorus, i. e., in the formation of protein.

Iron, manganese, boron, copper and zinc, though necessary for crop growth, are needed in very small amounts. They are often called 'trace' or 'minor' elements or micronutrients. They are usually present in the soil in sufficient quantities for the normal requirements of the plants. Some soils, however, contain such exceedingly small quantities of one or other of these elements that either the crop growth suffers or, in some cases, crops develop diseases.

There are some rare elements which are not necessary for plant growth but which plants take up through their roots. Two of these, iodine and cobalt, though of no use to the plant, are important for the health of animals and men.

Though carbon, hydrogen and oxygen are almost unlimited in quantity for the requirements of crops, the amounts of the other food nutrients in the soil are comparatively very small. The limited quantities of these nutrients make it difficult for crops to secure enough of them for proper growth.

This means that the plant food elements in the soil are much more important for the proper growth of crops than those in the air and water. Successful farming, therefore, depends upon retaining in or adding to the soil enough plant food nutrients for growing large and healthy crops.

NUTRIENTS AND PLANT GROWTH

AS explained earlier, sufficient supplies of proper plant food nutrients are necessary to produce large and healthy crops which keep people healthy and strong. This is important not only to the farmer but to all the people of the country. We shall now see how the various plant food nutrients in the soil, especially their excess or deficiency, affect the growth of crops and control their activities.

We need consider here only the three major or primary plant food elements, viz., nitrogen, phosphorus and potassium in their relation to crop growth. These plant food elements are usually taken up by the plant from the soil by means of the fine root hairs. For this, it is necessary that the elements must be in a state of solution or in a liquid condition. Most soils do not supply these elements in a state of solution quickly enough for maximum growth. It is, therefore, necessary to assist the plant by supplying the elements in a more soluble or available form.

Nitrogen

As explained earlier, nitrogen is of special importance in the formation of protein in plants. It forms a constituent of every living cell in the plant. Where nitrogen is present in sufficient quantities in the soil, plants acquire a healthy green colour which is neither too dark nor too light, growth of the plant is fairly rapid and the crop matures normally and gives high yields.

A nitrogen-starved plant is yellowish or light green in colour and remains stunted. Such a plant ripens prematurely and the crop gives poor yield. The kernels of cereals and the seeds of other crops do not attain their normal size, and become shrivelled and light in weight. In the case of fruit trees, the leaves drop off early and fruits acquire unusual colours.

An excess of nitrogen, on the other hand, delays ripening by encouraging more vegetative growth. The leaves acquire a dark green colour, become thick and leathery, and, in some cases, crinkled. They also become soft and sappy. The plant becomes more liable to the attack of certain fungi and its resistance to disease is lowered. In the case of cereal crops, the straw becomes weak and the crop very often lodges. In the case of crops such as barley, potatoes, sugarcane, fruits, etc., excess nitrogen deteriorates the quality of the crop. An excessive amount of nitrogen induces succulence, a condition which is desirable in the growing of fodder crops and certain vegetables.

Phosphorus

Phosphorus is concerned in the formation of nucleo-proteins in the plant. It influences cell division and the formation of fat and albumen.

The effects of phosphorus on the growing plant are very marked. In the seedling stage, the root growth is increased. Thereby it helps to establish the seedlings quickly. It hastens leaf development and encourages greater growth of shoots and roots. The ears emerge more rapidly. It thus hastens the maturity of the crop.

It is of special importance in the production of seed or grain. It stimulates the development of roots, particularly of the root crops. Phosphorus has a special action on leguminous crops. It hastens a change in the soil bacteria which form nodules necessary for good growth.

The symptoms of phosphorus deficiency are not so quickly recognised as those of nitrogen. The leaves of cereal plants become dull greyish green in colour. The deficiency is characterized by slow growth and low yields.

Potassium

Potassium is essential for photosynthesis, i. e., for converting carbon dioxide and hydrogen into sugars. It is, therefore, of special value for crops like sugarcane, potatoes, etc., which are rich in sugars and starch. It is also essential in the development of chlorophyll. It slows down the effects resulting from excessive nitrogen and prevents too rapid maturation resulting from too much phosphorus. It improves the health and vigour of the plant enabling it to withstand adverse climatic conditions. It helps increase the resistance of the plant to diseases and pests. It strengthens the straw of cereals and keeps the plant green and functioning longer than it would otherwise do. It improves the quality of crops like tobacco, potato, cotton, sugarcane, vegetables and fruits. An optimum supply of potassium is necessary for the production of the best quality of grain and fruit.

A deficiency of potassium brings about chlorosis, i.e., yellowing of leaves and leaf scorch in the case of fruit trees. It is also responsible for the 'dying back' of the tips of shoots. Potassium in excessive quantities does not interfere with the normal development of most crops.

FERTILE AND INFERTILE SOILS

NOW that the various plant food elements have been discussed, we should know what is meant by fertile and infertile soils.

A fertile soil is one which supplies enough of necessary plant food elements to produce large crops of good quality. An infertile soil, on the other hand, supplies such small amounts of one or more of the necessary plant food nutrients that it cannot produce large crops. Most soils are fertile when they are virgin or first brought under cultivation, but they become infertile through careless and wasteful farming practices.

In order to understand how the fertility of the soil is maintained, we shall try to learn how a virgin soil loses its fertility when it is brought under cultivation.

Cultivation destroys most of the vegetation which once protected the soil. A good deal of the organic matter that was stored in it is burnt up and lost. Much of the plant food in the soil is lost through farming. Crops remove large quantities of plant food elements from the soil. A 2,000-pound crop of rice removes about 30 pounds nitrogen, 20 pounds phosphorus, 60 pounds potassium and 30 pounds calcium from one acre of land. In the same way, a 1,400-pound crop of tobacco absorbs and removes about 87 pounds nitrogen, 102 pounds phosphorus, 61 pounds potassium and 84 pounds calcium per acre.

Another way in which plant food is lost from the soil is by erosion. On an average, about 40 tons of silt are lost by erosion every year from an acre which carries away about 100 pounds of nitrogen. The soil also loses some of its plant food elements by leaching or water passing through it. Of the plant food elements removed this way, the largest quantities are those of nitrogen and calcium.

Our soils have suffered losses in all the ways mentioned above with the result that they are poor in organic matter, nitrogen and phosphorus. Though most of them are well-supplied with potassium and calcium, they are highly eroded. If we have to feed our ever increasing population, we must adopt ways and means of keeping up the fertility of our soils. We must add organic matter, nitrogen and phosphorus to the soil, prevent loss of silt by erosion and adopt other ways and means of maintaining soil fertility.

The quantity of organic matter in the soil can be increased by adding bulky organic manures such as farmyard manure, compost and green manure. Nitrogen and phosphorus can be added in the form of fertilizers and manures. The nitrogen content of the soil can also be increased by growing leguminous crops in rotation, or by incorporating leguminous crops as green manure. In the case of sour or acid soils, ground limestone can be added to make them sweet or neutral.

We have learnt that all soils contain plant nutrients. Most soils, however, contain too little of these nutrients to produce sufficiently large crops. Some soils, though they contain sufficient quantities of plant food elements, are not able to supply them quickly to meet the requirements of the growing crop. Hence the necessity of adding manures and fertilizers arises.

Most manures contain plant food elements in an insoluble form, but they quickly release them in an available form after they are applied to the soil. Fertilizers, on the other hand, contain plant nutrients in a soluble or readily available form for the immediate use of the crop. Moreover, fertilizers are more concentrated than manures, as they contain much larger quantities of plant nutrients.

Experience has shown that fertilizers when applied over a long period produce certain harmful effects in the soil. If, however, they are used in conjunction with bulky organic manures like farmyard manure, compost, etc., they are quite harmless. The bulky organic manures supply organic matter or humus in which our soils are so deficient. They also keep the soil in 'good heart' and offset the bad effect of some of the fertilizers on the soil.

NITROGENOUS FERTILIZERS AND MANURES

Of all the plant food elements, nitrogen is one in which all the soils in this country are deficient. Though there are plentiful supplies of nitrogen in the air, it cannot be utilized directly by plants unless it is combined with other elements by chemical or biological means and converted into a form in which it can be readily utilized by the plants.

There are a number of nitrogenous manures and fertilizers available in the market. We shall now see what these manures and fertilizers are and how much nitrogen each contains. We shall also study some of their important characteristics, mode of usage, etc.

The principal artificial nitrogenous fertilizers are sodium nitrate, ammonium sulphate, ammonium nitrate, nitro-chalk, ammonium sulphate nitrate, calcium nitrate, potassium nitrate, calcium cyanamide and urea. To us, however, ammonium sulphate, ammonium sulphate nitrate and urea are of interest, as they have been found, as a result of experiments carried out in this country, to be suitable for our soil and climatic conditions. The others are either not so useful or are definitely harmful.

Ammonium sulphate

Ammonium sulphate is the most widely used fertilizer in our country. It is a white crystalline powder and contains 20 to 21 per cent nitrogen. It is easy to handle and stores well in dry conditions. As it is soluble in water, it becomes rapidly available to the crop after it is applied to the soil. It has been found useful for all crops and for a wide variety of soils.

It, however, produces acidity in the soil. In the case of acid soils, therefore, it should be used along with ground limestone or chalk. Lime neutralizes the acidity and keeps the soil sweet. It should always be used in conjunction with bulky organic manures like farmyard manure and compost.

Ammonium sulphate can be applied either at sowing time or as a topdressing, i. e., during the growing period of the crop. It can also be applied prior to sowing. It should not be applied along with he seed. After it is applied to the soil, it is absorbed and retained by the soil particles, and hence there is no danger of the fertilizer being lost from the soil by drainage. It is, therefore, very suitable for wet land crops like paddy and jute.

Ammonium sulphate nitrate

Ammonium sulphate nitrate is obtained as a fine white crystalline product. It is also produced in a granular form when it has a dirty white colour. It contains 26 per cent nitrogen, a part of which (19.5 per cent) is in ammoniacal form and the rest (6.5 per cent) in nitrate form. It is soluble in water and is readily available to crops.

Owing to the presence of nitrate, it supplies immediately absorbable nitrogen for the young plant. It is useful for all crops and is suitable for application to all types of soil. It produces acidity in the soil but to a much less extent (about half) than ammonium sulphate. Addition of lime to acid soils is necessary, but it should be applied in less quantities or less frequently when ammonium sulphate nitrate is applied to the soil.

Like ammonium sulphate, this fertilizer has good keeping quality and produces equally good effect on most crops. It can be applied prior to sowing, at sowing time or as a top-dressing. It should not, however, be applied along with the seed.

Urea

Urea is a highly concentrated nitrogenous fertilizer containing 45 to 46 per cent nitrogen. It is obtained in the form of fine white crystals. It is also produced in the form of granules and pellets.

It is soluble in water and is very hygroscopic, i. e., it absorbs moisture from the air very readily. On account of this property, it presents considerable difficulty in storage, especially in humid regions. To overcome this difficulty, the crystals of urea are coated with an inert material which does not allow them to absorb moisture.

It takes a few days after urea is applied to the soil, to become available for the nutrition of plants. It is, therefore, likely to be washed out from the soil if the soil is wet or if there is free water in it. It should not, therefore, be applied when the soil contains free water or is likely to remain wet for three or four days after application.

It also produces acidity in the soil, but only to one-third the extent of ammonium sulphate. Its application, therefore, requires much less liming of the soil.

Urea may be applied either as a topdressing or at sowing time. When applied at sowing time, it should not be allowed to come into contact with the seed. It is suitable for application to all crops on all soils except when the soil is wet as explained above.

On account of its highly concentrated nature, it is better to mix it with earth or sand for distributing it uniformly over the field.

Oilcakes

The important organic nitrogenous manures are the various oilcakes, dried blood, fish manure, etc. A large variety of oilcakes is produced in the country, some of which are used for feeding cattle and the others for manuring crops. Ordinarily, oilcakes like groundnut cake, *til* cake, coconut cake and cotton seed cake, which are useful as cattle feeds, should not be used as manure. Other oilcakes like castor cake, *neem* cake, *karanj* cake and *mahua* cake are non-edible, as they contain a harmful or toxic substance which makes them unsuitable for feeding cattle. These non-edible oilcakes are a good source of nitrogenous manures. In addition to these, such of the edible oilcakes which are mouldy or rancid or contain very large amounts of fibre, can also be used as manure.

The amount of nitrogen varies with the type of oilcake. It ranges from 2.5 per cent in *mahua* cake to five per cent in *neem* cake. In addition to nitrogen, all oilcakes contain small quantities (one to two per cent) of phosphoric acid and potash.

Oilcakes are quick-acting organic nitrogenous manures. Though they are insoluble in water, their nitrogen becomes quickly available in about a week or 10 days after application. The *mahua* cake is, however, an exception as its nitrogen does not become available till about two months after application. It should, therefore, be applied about two months before the time of sowing, provided the soil is moist.

Oilcakes should be well powdered before application so that the manure is spread uniformly. They can be applied a few days prior to sowing or at sowing time or as a topdressing after the crop has made a certain amount of growth. Country *ghani* or *gana* oilcakes usually contain a little more oil than the hydraulic or expeller pressed oilcakes. Owing to the greater amount of oil, country *ghani* oilcakes are somewhat slow-acting, as the oil prevents the conversion of nitrogen into an available form.

A list of oilcakes and other manures and fertilizers, together with the percentage amount of manurial constituents they contain, is given in the table on pages 16 and 17. All oilcakes have been found to give good results with almost every crop and on all types of soil.

Bloodmeal

Dried blood or bloodmeal contains 10 to 12 per cent nitrogen and one to two per cent phosphoric acid. It is a very quick-acting manure and is effective on all crops on all types of soil. It should be used in just the same way as oilcakes.

Fish manure

Fish manure is available either as dried fish or as fishmeal or powder. In those parts of the country where fish oil is extracted, the residue can be used as manure. Fish manure contains, in addition to nitrogen, fairly large quantities of phosphoric acid. The manurial constituents present in it vary with the type of fish. It is a quick-acting organic nitrogenous manure and is suitable for application to all crops on all soils. It should preferably be powdered before use.

TABLE

Plant food elements contained in fertilizers and manures

Name of fertilizer	Nitrogen (per cent)	Phosphoric acid (per cent)	Potash (per cent)
Artificial fertilizers			
Ammonium sulphate	20.6	—	—
Ammonium sulphate nitrate	26.0	—	—
Urea	46.0	—	—
Superphosphate (single)	—	16.0 to 20.0	—
do. (double)	—	30.0 to 35.0	—
do. (triple)	—	45.0 to 50.0	—
Muriate of potash	—		50.0 to 60.0
Sulphate of potash	—		48.0 to 52.0
Organic manures			
(Non-edible oilcakes)			
Castor cake	4.3	1.8	1.3
Cotton seed cake (undecorticated)	3.9	1.8	1.6
Karanj or *honge* cake	3.9	0.9	1.2
Mahua or *ippi* cake	2.5	0.8	1.8
Neem cake	5.2	1.0	1.4
Safflower cake (undecorticated)	4.9	1.4	1.2
Undi or *punna* cake	3.6	1.5	2.0
(Edible oilcakes)			
Coconut cake	3.0	1.9	1.8

TABLE (*contd.*)

Name of fertilizer	Nitrogen (per cent)	Phosphoric acid (per cent)	Potash (per cent)
Cotton seed cake (decorticated)	6.4	2.9	2.2
Groundnut cake	7.3	1.5	1.3
Jambo cake	4.9	1.6	1.9
Linseed cake	5.5	1.4	1.3
Niger cake	4.7	1.8	1.3
Rapeseed cake	5.2	1.8	1.2
Safflower cake (decorticated)	7.9	2.2	1.9
Sesame or *til* cake	6.2	2.0	1.2
Manures of animal origin			
Dried blood	10.0	1.5	1.0
Fish manure	4.0 to 10.0	3.0 to 9.0	0.3 to 1.5
Bonemeal (raw)	3.0 to 4.0	20.0 to 25.0	—
Bonemeal (steamed)	1.0 to 2.0	25.0 to 30.0	—
Bulky organic manures			
Farmyard manure	0.5 to 1.5	0.4 to 0.8	0.5 to 1.9
Compost (urban)	1.0 to 2.0	1.0	1.5
Compost (rural)	0.4 to 0.8	0.3 to 0.6	0.7 to 1.0
Green manure (various, average)	0.5 to 0.7	0.1 to 0.2	0.8 to 0.6

PHOSPHATIC FERTILIZERS AND MANURES

PHOSPHATIC fertilizers contain phosphoric acid, the principal manurial constituent, in two forms : (1) soluble or readily available form and (2) insoluble or non-available form. Some fertilizers contain only the available form, others only the non-available form, while there are some which contain both the forms.

Superphosphate

Among the phosphatic artificial fertilizers, superphosphate is the most generally used fertilizer in India. It is a brownish grey powder and is manufactured in three grades, viz., single, double and triple superphosphate. Single superphosphate contains 16 to 20 per cent phosphoric acid, double superphosphate 30 to 35 per cent and triple superphosphate 45 to 50 per cent. At present, only single superphosphate is available in the market. The whole of the phosphoric acid in superphosphate is in the water-soluble form which is readily available for the nutrition of plants.

It is suitable for all crops. It can be applied to all soils except those that are acid. It should be applied before or at the time of sowing or transplanting. The best method of using it is to put it in the soil to a depth of four to six inches by means of a drill. It should be applied one to two inches away on either side of the row of seeds. Although superphosphate readily dissolves in water, it does not wash out from the soil.

Superphosphate usually contains some free acid which is responsible for the rotting of bags in which it is packed. It should be stored in a dry place to reduce the damage due to rotting.

Bonemeal

Bonemeal is another widely used phosphatic fertilizer. It contains a small quantity of nitrogen also. It is obtained in two forms : (1) raw bonemeal and (2) steamed bonemeal. Ordinary or raw bonemeal contains three to four per cent nitrogen and 20 to 25 per cent phosphoric acid. Steamed bonemeal contains one to two per cent nitrogen and 25 to 30 per cent phosphoric acid. Nitrogen is present in the organic form which becomes slowly available to crops on decomposition in the soil. The phosphoric acid present in bonemeal is in an insoluble form, but becomes available to the crop after bonemeal is applied to the soil. The more finely powdered the bonemeal, the better it is. Bonemeal having particles not larger than 3/32 inch in size is considered suitable for use as manure.

Bonemeal may be applied to the soil either at sowing time or just before it. It should not be used as a topdressing. It may be either drilled or broadcast. It is particularly suitable for application to soils having an open texture with good drainage, or to acid soils. It is less effective on heavy and calcareous soils. It is suitable for application to all crops.

POTASSIC FERTILIZERS

As explained earlier, most of our soils contain sufficient amount of potash. There are, however, some soils which are found to give increased yields when potassic fertilizers are applied. Potassic fertilizers should, therefore, be applied to such soils as are known to respond to their application. Sandy soils are known to respond to potash. There are certain crops like tobacco, potato, onion, fruit trees, tomato, etc., to which potassic fertilizers can also be applied to improve the quality and appearance of their produce.

There are two potassic fertilizers in common use : (1) muriate of potash (potassium chloride) and (2) sulphate of potash (potassium sulphate).

Muriate of potash contains 50 to 60 per cent potash, the whole of which is readily available. Though it is soluble in water, it is not lost from the soil, as it is absorbed by the soil particles. It can be applied at sowing time or prior to sowing.

Sulphate of potash contains 48 to 52 per cent potash. It dissolves readily in water and becomes available to the crop almost immediately. It can be applied at any time up to sowing. It is better than muriate of potash for crops like tobacco, fruit trees, potato, etc., where quality is of prime importance.

BULKY ORGANIC MANURES

WE have already learnt that fertilizers should be applied along with bulky organic manures to keep the soil in good condition. There is a variety of bulky organic manures, viz., farmyard manure, compost, green manure, etc., that can be used for keeping up the organic matter content of the soil. The bulky organic manures contain very small quantities of plant food elements, and hence they do not contribute much to the increase of plant food supply in the soil. The value of these manures, however, depends on the amount of humus they produce or add to the soil.

Farmyard manure

One of the most commonly used bulky organic manure is farmyard manure. The amount of plant food elements present in it is very variable. It contains 0.5 to 1.5 per cent nitrogen, 0.4 to 0.8 per cent phosphoric acid and 0.5 to 1.9 per cent potash. It also contains fairly large quantities of lime (0.5 to 4.0 per cent). The plant food elements are present in an insoluble form, but they are slowly made available after the manure is mixed with the soil.

Farmyard manure should be well rotted before it is applied to the soil. It should be applied well in advance of the sowing or planting time, and mixed well with the soil. It is useful for application to all soils and on all crops. Farmyard manure has a residual effect, i. e., its beneficial effect on the crop is not confined to the season of application but persists over a number of years.

Compost is prepared from waste vegetable and other refuse mixed with night-soil or cow-dung and urine. The compost prepared from town wastes and night-soil usually contains 1.0 to 2.0 per cent nitrogen, about 1.0 per cent phosphoric acid and about 1.5 per cent potash. In the village compost, the amount of nitrogen varies from 0.4 to 0.8 per cent, phosphoric acid from 0.3 to 0.6 per cent and potash from 0.7 to 1.0 per cent. It is used in just the same way as farmyard manure, and is useful for application to all soils and on all crops.

Green manure

Green manuring is another method of adding organic matter to the soil. A leafy crop, more usually a legume, is ploughed in and mixed with the soil when it is about to flower. This practice is known as green manuring. The crops that are usually grown for green manuring are *sann*, *dhaincha*, *shevri*, *chavli*, berseem, *lobia*, *guar*, etc. Non-leguminous crops like sunflower, *bhang*, mustard, etc., so also leaves of trees and bushes can be used for green manuring.

Like other bulky organic manures, green manuring supplies a lot of humus. It also adds nitrogen to the soil. The amount of nitrogen varies according to the type of crop grown for green manuring. On an average, it contains 0.5 to 0.7 per cent nitrogen. The best time for turning in the green manure crop is when it is at the flowering stage. There should be sufficient moisture in the soil when the crop is buried to facilitate its decomposition. An application of superphosphate or bonemeal to the green manure crop further adds to its manurial value.

HOW MUCH FERTILIZER TO APPLY ?

INDIA is a vast country. Soil and climatic conditions vary considerably from place to place. No definite manurial schedules can, therefore, be prescribed, even for one and the same crop, for all regions. Each state has obtained certain information as a result of investigations carried out on Government farms and research institutes for the last 50 years, which gives an idea of the manurial requirements of some of the crops under its own soil and climatic conditions. It is recommended that the state agriculture department should invariably be consulted for the exact quantity and type of fertilizer or manure to be applied. However, a broad idea regarding the quantities of fertilizers that may be profitably used for increasing crop production is given in the following paragraphs.

We have studied the conditions under which a fertilizer or manure can or cannot be used. As a general rule, bulky organic manures like farmyard manure or compost should invariably be applied to all soils. A dose of three to five cartloads (3,000 to 5,000 pounds) per acre is sufficient for crops grown in areas of scanty rainfall, i. e., areas receiving less than 30 inches of rainfall. If sufficient farmyard manure or compost is not available, it may be applied to a part of the field, say one-third or one-fourth the area, in rotation every year, so that all parts of the field receive manure once in three or four years. In areas of assured rainfall, a dose of 5 to 10 cartloads per acre is the usual practice. For irrigated crops, 10 to 20 cart-loads of manure or even more may be applied. Green manure may be substituted for farmyard manure or compost in irrigated areas or in areas of assured rainfall.

Artificial fertilizers and other concentrated manures should invariably be used along with farmyard manure or compost or other bulky organic manures. They should not, however, be used in areas of scanty rainfall.

Grain crops

To crops like *jowar* and *bajra* which are usually grown in areas of scanty rainfall, an application of three to five cartloads of farmyard manure or compost is sufficient. If these crops are grown under irrigation, an application of 15 to 20 pounds nitrogen per acre may be given. In areas which are known to be deficient in phosphoric acid, an additional dose of 10 to 20 pounds phosphoric acid per acre will help increase yields.

In the case of paddy which is usually grown in heavy rainfall areas or under irrigation, an application of 30 to 40 pounds nitrogen and 20 to 40 pounds phosphoric acid is recommended. Half the dose of nitrogen may be given at the time of the final puddling of the soil and the other half about one month after transplanting. The whole dose of phosphoric acid should preferably be given at puddling time. Wherever paddy is grown in acid soils or lateritic soils, it is preferable to apply phosphoric acid in the form of bonemeal.

The main feature of the Japanese method of cultivation of paddy is heavy manuring of the crop both in the nursery and in the field. In the nursery or seed-bed, one maund (80 pounds) of compost or farmyard manure is applied for every 100 sq. ft. of the area. A mixture consisting of equal parts of ammonium sulphate and superphosphate is next sprinkled at the rate of one pound for every 100 sq. ft.

In the field, 15 to 20 cartloads of compost or farmyard manure per acre is applied. If the field has been green manured, half this quantity, i. e., 7 to 10 cartloads, is sufficient. A mixture of 100 pounds ammonium sulphate and 100 pounds superphosphate per acre is next applied at puddling time. A second dose of 100 pounds ammonium sulphate and 100 pounds superphosphate is applied one month after the seedlings are transplanted.

Wheat is grown both as a dry and as an irrigated crop. When grown as a dry crop, it is rarely manured, but it is advisable to apply about five cartloads of farmyard manure or compost. If sufficient rain has been received during August and September, an application of 15 to 20 pounds nitrogen per acre at sowing time helps to give increased yields. For irrigated wheat, an application of 30 to 40 pounds nitrogen, together with a dose of 20 to 30 pounds phosphoric acid in the case of phosphate-deficient soils, in addition to farmyard manure or compost, is recommended.

For irrigated maize, an application of 30 to 40 pounds nitrogen per acre is recommended. In phosphate-deficient soils, a dose of 20 to 30 pounds phosphoric acid per acre may be included with advantage. Nitrogen may be given in two doses, half at the time of sowing and the other half as a topdressing after about four weeks.

Pulse crops

Pulse crops are legumes and they are generally not in need of nitrogenous manures or fertilizers, as they usually obtain their nitrogen from the air with the help of nodule bacteria, as already explained. An application of superphosphate in addition to farmyard manure or compost, at the rate of 40 to 50 pounds phosphoric acid per acre, is likely to prove profitable.

Root and tuber crops

Tuber and other root crops like potato and sweet potato respond well to the addition of artificial fertilizers, provided the soil is well-supplied with farmyard manure or compost. Addition of phosphoric acid helps root development. Tubers containing starch, like potatoes, are further benefited by the application of potassic fertilizers, especially to those soils, like sandy soils, which are usually deficient in potash.

Potatoes usually require heavy manuring. In addition to a dose of 15 to 20 cartloads of farmyard manure or compost, 50 to 70 pounds nitrogen and an equal quantity of phosphoric acid help increase yields. Potash at the rate of 40 to 50 pounds per acre may also be applied to soils deficient in this element.

Sweet potato may be fertilized in the same way as potato.

Onion also requires heavy manuring. In addition to farmyard manure or compost (15 to 20 cartloads), about 40 pounds nitrogen and 20 pounds phosphoric acid per acre give increased yields. Potash may be added at the rate of 20 to 30 pounds per acre wherever necessary.

Garden crops

All vegetables respond well to fertilizers and manures. In addition to liberal dressings of farmyard manure or compost (20 to 40 cartloads), addition of nitrogen gives considerably increased yields.

Leafy vegetables like spinach respond well to dressings of nitrogenous fertilizers. An application of 20 cartloads of farmyard manure, together with 40 to 50 pounds of nitrogen per acre, gives good yields. It is better to give the fertilizer as a topdressing about 10 to 15 days after sowing.

Vegetables forming heads like cabbage and cauliflower respond to heavy applications of farmyard manure (20 to 30 cartloads). In addition, they need about 40 pounds nitrogen and 20 pounds phosphoric acid per acre.

Fruit vegetables like tomato, brinjal and cucurbits require

20 to 40 pounds of nitrogen per acre in addition to 20 cartloads of farmyard manure or compost.

Pod-forming vegetables like beans and peas do not need nitrogen. About 10 cartloads of farmyard manure, together with about 20 pounds phosphoric acid per acre, is usually sufficient.

Root vegetables like carrot and raddish, require, in addition to heavy applications of farmyard manure (20 cartloads), about 20 pounds nitrogen per acre. An application of potash at the rate of 20 to 25 pounds per acre is advantageous.

Fruit crops

The fertilizer requirements of fruit trees vary considerably. A few recommendations are made for some of the important fruits grown in the country.

In the case of mango, about 100 pounds of farmyard manure, ½ pound nitrogen, one pound phosphoric acid and ½ pound potash per tree, are applied while preparing the pit for planting the seedling. One year after planting, 20 pounds farmyard manure, ¼ pound nitrogen, ½ pound phosphoric acid and ⅛ pound potash per tree are given. From the second year onwards, the above quantities are increased by 10 pounds farmyard manure, ¼ pound nitrogen, ½ pound phosphoric acid and ⅛ pound potash per tree every year up to nine years. From the 10th year onwards, the dose per tree would be 100 pounds farmyard manure, 2½ pounds nitrogen, 2½ pounds phosphoric acid and 1¼ pounds potash.

In the case of banana, 40 pounds farmyard manure is added to each pit at the time of planting and a mixture containing ¼ pound nitrogen, ¼ pound phosphoric acid and one pound potash is applied to each plant.

To grapevine, 40 pounds farmyard manure per vine is given at planting and 80 pounds thereafter every year at the time of pruning. In addition to this, each vine is given a dressing of ¼ pound nitrogen, ¼ pound phosphoric acid and ¼ pound potash at the time of pruning.

For citrus trees, 100 pounds farmyard manure or compost is added to each pit while planting. Thereafter, a mixture containing one pound nitrogen, one pound phosphoric acid and one pound potash is applied per plant.

Other crops

Sugarcane requires very heavy manuring. In addition to 30 to 40 cartloads of farmyard manure, a dose of nitrogen, 100 pounds in the northern states and 300 pounds in the southern states, has been found to give good yields. Nitrogen may be given partly as oilcake (½ to ⅔) and partly as artificial fertilizer. In addition to this, an application of 50 pounds phosphoric acid is recommended.

Cotton responds well to good manuring. In addition to farmyard manure or compost (5 to 10 cartloads), nitrogen at the rate of 25 to 30 pounds per acre in the case of a rain-fed crop and 30 to 40 pounds in the case of irrigated cotton gives increased yields. A dose of about 30 pounds phosphoric acid further helps the crop. Nitrogen may be given in two equal doses, one at the time of sowing and the other six to eight weeks after that.

For tobacco, 10 to 20 cartloads of farmyard manure or compost per acre is applied before planting. A dose of 40 pounds nitrogen, 20 pounds phosphoric acid and 75 pounds potash per acre is very beneficial. Potash and phosphoric acid are applied at the time of the final preparation of the field. Nitrogen may preferably be given as a topdressing six weeks after transplanting.

Ginger, turmeric and *suran* require very heavy manuring.

Thirty to forty cartloads of farmyard manure or compost is added to the soil before planting. Nitrogen at the rate of 60 to 70 pounds per acre is applied in two equal doses as a topdressing, the first four to five weeks after planting and the other four to five weeks thereafter.

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