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AGRO-INPUTS BUSINESS MANUAL – PART I

PLANT NUTRIENTS AND FERTILIZERS

AGRICULTURAL GROWTH PROGRAM – AGRIBUSINESS AND MARKET DEVELOPMENT (AGP-AMDE ETHIOPIA)

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ROLE OF PLANT NUTRIENTS IN CROP PRODUCTION

INTRODUCTION

Plants are living and, like humans and animals, they require food for growth. A seed, when planted, requires 16 elements called "nutrients" to grow into a mature plant that bears grains, fruits, flowers, etc. Under ideal conditions, soil should provide most of the nutrients needed for a plant to grow normally. But after repeated cultivation over time, soils may become depleted of plant nutrients and are therefore unable to produce a bumper crop. A farmer who plants on unhealthy soil will harvest a poor crop.

To obtain desired crop yields and maintain soil fertility, a farmer should supply to the soil all nutrients removed by a crop. Soil nutrients can be replenished from natural organic sources including animal manure, leaving soils fallow for a period of time, green manuring and cultivation of legume crops. Although economical, these sources are often not in adequate amounts making it necessary to use manufactured inorganic sources of plant nutrients, which are typically inorganic fertilizers.

Each plant nutrient has its own role; applying one nutrient in excess cannot compensate for lack of another. Thus a farmer should understand the functions of each nutrient, the stages of plant growth when a nutrient is most needed and the proper time of application. Similarly, farmers should know about improved crop varieties and safe methods of using plant protection products. Trained agro-dealers and extension workers are a good source of this information for farmers.

This manual provides basic information about plant nutrients, inorganic fertilizers and organic sources, seeds and crop protection products. Written in easy-to-understand language with pictures and diagrams, it is specially prepared for agro-dealers who sell agricultural inputs and provide information and guidance to farmers.

It is our hope that the manual will not only benefit agro-dealers but also extension workers and farmers, increasing and improving their knowledge of agro-inputs.

CHAPTER 1.

PLANT NUTRIENTS AND THEIR FUNCTIONS IN PLANT GROWTH

WHAT ARE PLANT NUTRIENTS?

Plants provide food for human beings and animals in the form of fruits (apples, tomatoes), leaves (spinach, clover), grain (maize, rice), stems (sugarcane, broccoli) and roots (cassava, potato).

With an increase in population, the need for food is increasing, creating a greater demand for agricultural products.

Like human beings and animals, plants need food to grow, stay healthy and produce food for us.

Unlike human beings and animals, who do not produce their own food but get it from plants (and indirectly from animals), plants produce their own food.

Plants are living organisms like birds and animals.

For growth plants require food and suitable environment.

Plants cannot move around in search of food and depend on soil for food/nutrients.

Plants meet their nutritional requirements through soil. They also produce food through a process called *"photosynthesis."* In the presence of chlorophyll (the green matter mainly in the leaves), air and sunlight, plants combine carbon dioxide from the air and water (containing nutrients and minerals from the soil) to form the different types of foods – proteins, carbohydrates, oils and fats, minerals and vitamins.

The minerals/elements from the soil are the nutrients that plants "eat" to grow and stay healthy. These can be called plant foods. Organic manure and other materials together with mineral fertilizers, containing these nutrients, supplement what soils are not able to provide as food to plants. For soils to remain healthy and fertile, it is necessary to replenish all nutrients that are removed by a crop.

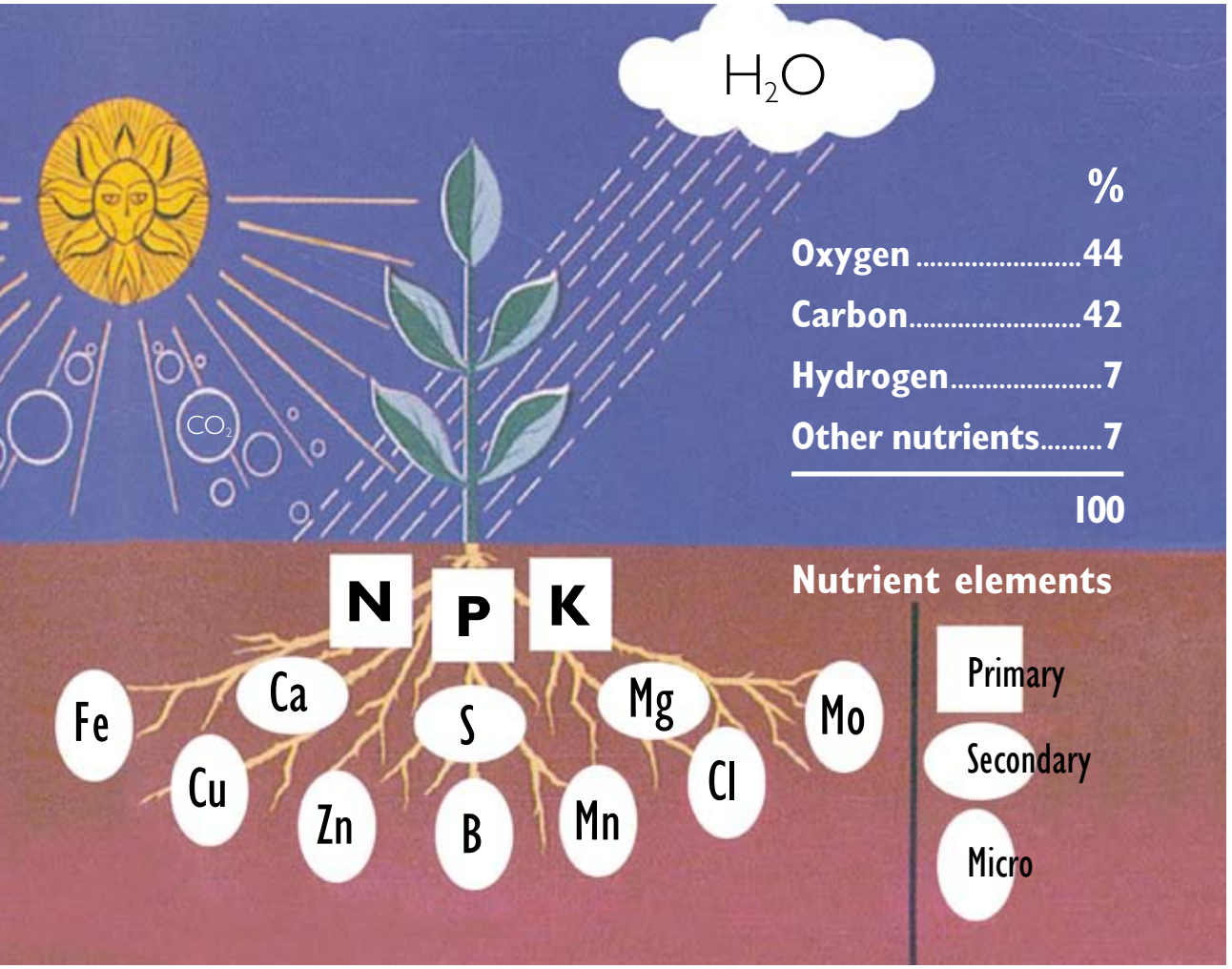

Figure 1. Process of Photosynthesis Through Which Plants Manufacture Their Food

NUTRIENT REQUIREMENTS OF PLANTS

Plants need 16 minerals or nutrients to grow and develop flowers, grains and fruits. The nutrients are consumed through absorption from soil, or the air. Three nutrients are obtained from the air – carbon dioxide, oxygen and hydrogen – and account for about 93 percent of the plant's food need. The other 13 nutrients are taken through the soil. These nutrients are absorbed by the roots and used by the plants.

CLASSIFICATION OF PLANT NUTRIENTS

Plant nutrients have been classified into the following three groups based on their role in plant growth and the amounts consumed.

1. **Primary/major nutrients**
   These are nitrogen (N), phosphorus (P) and potassium (K), which are critical to plant growth and are required in large quantities.

2. **Secondary nutrients**
   These are calcium (Ca), sulfur (S) and magnesium (Mg), which are required in relatively smaller quantities, but are important for healthy plant growth.

3. **Micronutrients/trace elements**
   These are seven nutrients namely iron (Fe), copper (Cu), zinc (Zn), boron (B), manganese (Mn), chlorine (Cl) and molybdenum (Mo), which are required in minute quantities.

NUTRIENT DEFICIENCY SYMPTOMS IN PLANTS

The absence of any one of the above-listed plant nutrients in the soil impedes healthy plant growth and limits its ability to produce food. In this section we show how deficiencies in the primary nutrients manifest in crops.

NITROGEN DEFICIENCY SYMPTOMS

- The plant growth is slow.
- The plant will be stunted with its leaves turning yellow.
- The plant will mature early, limiting the yields.

PHOSPHORUS DEFICIENCY SYMPTOMS

Phosphorus deficiency is more pronounced in highly acidic or calcareous soils. The deficiency of phosphate in the soils leads to:

- Weak root formation.
- Lodging of the plants.
- Stunted growth and low yields.

POTASSIUM DEFICIENCY SYMPTOMS

Leaves show burning impact starting at the tip of the leaves and heading toward the base. This is also called "choruses."

- Plants become susceptible to disease.
- Fruits and grains lose brightness and have a dull appearance.

FUNCTIONS OF VARIOUS NUTRIENTS IN CROP PRODUCTION

FUNCTIONS OF THE PRIMARY NUTRIENTS

NITROGEN

Nitrogen (N) can be obtained from urea, ammonium nitrate, ammonium sulfate, calcium ammonium nitrate and anhydrous ammonia. Nitrogen performs the following functions:

- Helps in the formation of chlorophyll and improves the general vegetative growth of plants.
- Helps in the production of proteins, which are essential components of plant food and nourishment.

Plants show a quick response to nitrogen. The leaves turn green and healthy. The impact of nitrogen is clearly visible in the upper portion of a plant (above-the-ground) as it increases the vigor and appearance of healthy crops.

PHOSPHORUS

Phosphorus (P) can be obtained from NPKs, SSP, TSP and DAP. The release of phosphorus is generally slow and unused phosphorus remains in the soil for a longer period. Phosphorus performs the following functions:

- Helps in the development of the root system. Roots become strong and penetrate deep into the soil, enabling plants to absorb moisture and nutrients.
- Improves the energy supply to plants.
- Accelerates the process of ripening of crops.
- Impact of phosphorus is realized in the grain formation, particularly in oil seeds.

POTASSIUM

Potassium (K) can be obtained from muriate of potash (MOP), sulfate of potash (SOP) and NPKs. It performs the following functions:

- Improves crop tolerance against moisture stress.
- Helps in regulating the water and energy supply to standing crops.
- Improves the quality of fruits, vegetables and grains, bringing brightness and luster to the crop produce.

- Helps in early ripening of crops.
- Helps plant develop resistance to diseases.

FUNCTIONS OF SECONDARY NUTRIENTS

SULFUR

- Increases the supply of proteins in the plant.
- Helps increase the oil content in oil seed crops such as groundnuts, sunflowers and soybeans.

CALCIUM

- Improves the cell structure and thus accelerates the process of growth of plants.
- Helps in fast division of plant cells, leading to quicker growth.

MAGNESIUM

- Magnesium is a component of chlorophyll and therefore helps in the production of the green matter in plant leaves.
- Helps in the transfer of energy in plants.

FUNCTIONS OF THE MICRONUTRIENTS (SEE TABLE 1)

Table 1. Functions of Micronutrients or Trace Elements

MICRONUTRIENT	FUNCTIONS
Boron	Helps in the development of cell walls and promotes seed setting.
Chlorine	Improves the process of photosynthesis and thereby helps in formation of green matter.
Copper	Helps in hydration of plant tissues. Activates the enzyme activity. Helps in the formation of chlorophyll.
Iron	Improves respiration in plants. Helps in the formation of chlorophyll.
Manganese	Promotes enzyme activity.
Molybdenum	Helps in fixation of nitrogen in leguminous crops and reduces nitrate formation.
Zinc	Helps plants in synthesis of proteins and improves their availability to plants. Accelerates activity of enzymes.

EXTRACTION (REMOVAL) OF NUTRIENTS FROM THE SOIL BY CROPS

The amount of primary, secondary and micronutrients removed by crops from soils is shown in Tables 2–4.

Table 2. Removal of Primary Nutrients by Selected Crops

CROP	YIELD (T/HA)	NUTRIENTS REMOVED (KG/HA)		
		N	P_2O_5	K_2O
Rice	3.0	84	14	89
Wheat	3.0	125	22	92
Maize	5.0	170	35	175
Sorghum	2.5	65	10	48
Soybean	2.5	125	43	101
Sugarcane	88.0	180	26	270
Groundnut	2.0	170	30	110
Cassava	45.0	202	32	286
Tomato	41.0	84	21	185

Source: Secondary and Micronutrients in Agriculture, FDCO, New Delhi, India

Table 3. Removal of Secondary Nutrients by Selected Crops

CROP	YIELD (T/HA)	NUTRIENTS REMOVED (KG/HA)		
		CA	MG	S
Rice	3.0	21	9	9
Wheat	3.0	16	14	14
Maize	5.0	27	39	19
Sorghum	2.5	16	12	7
Sugarcane	88.0	132	–	26
Cassava	45.0	131	108	15
Onion	37.0	16	18	34
Tomato	41.0	31	8	28

Coffee	2.0	143	33	27
Chickpea	1.5	28	11	13
Soybean	2.5	35	19	22
Pigeon pea	1.2	23	15	9
Groundnut	2.0	39	20	15
Mustard	1.5	63	13	26
Sunflower	0.6	40	16	7

Source: Secondary and Micronutrients in Agriculture, FDCO, New Delhi, India

Table 4. Removal of Micronutrients From the Soil by Selected Crops

CROP	REMOVAL PER TON OF CROP PRODUCE *(GRAMS PER TON OF CROP PRODUCE)*					
	ZN	FE	MN	CU	B	MO
Rice	40	153	675	18	15	2
Wheat	56	624	70	24	48	2
Maize	130	1,200	320	130	–	–
Sorghum	72	720	54	6	54	2
Pearl millet	40	170	20	8	–	–
Cassava	45	120	45	5	15	–
Potato	9	160	12	12	50	0.3
Chickpea	38	858	70	113	–	–
Pigeon pea	31.6	960	106	20.6	–	–
Soybean	76.8	46	83	29	–	–
Groundnut	109	288	93	35.7	–	–
Mustard	100	1,122	95	16.6	–	–
Sunflower	46	107.5	181	38	–	–

Source: Secondary and Micronutrients in Agriculture, FDCO, New Delhi, India

NB: Because the chlorine requirement of plants is very low, it is not included in the above table.

SOURCES OF PLANT NUTRIENTS

The nutrient requirements of crops are met from three major sources:

- The soil.
- Organic manures.
- Mineral/chemical fertilizers.

SOIL

Soil is a natural source of plant nutrition for wild and cultivated plants. Due to repeated cultivation and removal of plant nutrients, most soils have been depleted of their nutrients, particularly the primary nutrients, and are unable to cope with the demand. Some soils, due to excessive presence of some elements have become acidic or alkaline and cannot support proper growth of the crops.

It is therefore important for farmers to know the fertility status of their soils by getting them analyzed. Corrective measures should then be taken to improve soil fertility. The presence of primary nutrients in most soils is generally very low. Sandy and sandy-loam soils have poor nutrient-retaining capacity and need adequate and repeated supply of nutrients through external sources. Soil should not be treated as a source of plant nutrition but as a medium of crop production.

ORGANIC MANURE

Organic manures include a wide range of materials such as cattle and poultry dung and urine (farmyard manure), municipal/urban waste, crop residues, green manures, etc. Organic manures are the main source of organic matter and supply primary and secondary nutrients and micronutrients.

Organic manures also improve the physical structure of soil, enhance their water retaining capacity and create favorable conditions for growth of several soil organisms already present in the soil, which are friendly to crop production.

Table 5. Nutrient Content of Some Commonly Used Organic Manures

MANURES	NUTRIENT CONTENT (% DRY WEIGHT BASIS)			TOTAL NUTRIENTS
	N	P_2O_5	K_2O	NPK
Cattle manure	0.5–1.0	0.15–0.20	0.5–0.6	1.15–1.80
Poultry manure	2.87	2.90	2.35	8.12
City compost	1.5–2.0	1.5	1.5	4.0–4.5
Rural compost	0.5–1.0	0.5	0.5	1.2–1.7

FARMYARD MANURE

Farmyard manure, which is primarily from cow dung and urine, is a natural source of plant nutrition and contains most of the plant nutrients, but in small amounts when calculated on dry weight basis. The nutrient value of farmyard manures can be improved by maturing the fresh animal dung in pits, covered with soil for two to three months.

GREEN MANURE

Plowing and burying young plants into the soil at a tender stage is called green manuring. Legumes are the most suitable crops for green manuring. The quantity of nitrogen (and other nutrients) supplied by green manure differs from crop to crop. A good crop of *Sesbania* can release 55 kg of nitrogen per hectare (equal to 150 kg of ammonium nitrate [AN] or 122 kg of urea). Similarly, 100 kg of green manure is equal to 280 kg of cattle manure.

It is, however, important to note that green manures give best results when combined with moderate doses of mineral fertilizers. Green manure improves the physical properties of the soil, increases water-retaining capacity and allows roots to penetrate over a wider area.

The nutrient balance ratio in green manure is higher than in cattle manure.

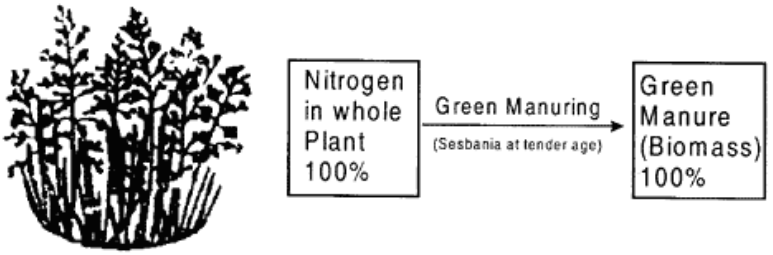

Figure 2. Flowchart showing nutrient balance in green manure

COMPOST MANURE

A large quantity of crop residues in the form of straw (stover) is produced every year. Maize, sorghum and millet stalks are some of the common crop residues. Crop residues contain plant nutrients that can be converted into organic manures by composting, mulching or direct incorporation into the soil.

To prepare compost manure at the farm level, crop residues should be chopped into small pieces of 5–6 cm in size, placed in pits and covered with soil. A homogenized fungal culture should be added at the rate of 300 g/ton of solid material. A good moisture level must be maintained. The composting mass should be turned upside down every two weeks. Within 8–10 weeks, good quality compost manure becomes ready for use.

Ground phosphate rock or SSP can also be incorporated to further improve quality of compost manure. Compost manure is also prepared from city waste through decomposition. Composts can also be enriched with nitrogen-fixing bacteria and phosphorus-solubilizing fungi.

The benefits of compost manures are similar to those of other organic manures such as cattle and green manures. The nutrient contents of some crop residues are shown in Table 6.

Table 6. Nutrient Content of Crop Residue Manure

CROP RESIDUE	NUTRIENT CONTENT (%)			
	N	P_2O_5	K_2O	TOTAL
Maize residue	0.59	0.31	1.31	2.21
Wheat straw	0.49	0.25	1.28	2.02
Sorghum straw	0.40	0.23	2.17	2.80
Pearl millet straw	0.65	0.75	2.59	3.99
Pulses straw	1.60	0.15	2.00	3.75

Source: FAO Field Document Numbers 15 and b 24

OILCAKE MANURE

The residues left over after extraction of oil from oilseeds by mechanical processes are called oilcakes. They are natural sources of plant nutrients. Through simple technologies, oilcakes from castor seeds, cotton seeds, groundnut, karanj (*Pongamia pinnata*), rapeseed, neem seeds and sunflower seeds can be converted into good quality organic manure. The oilcake manures can be further enriched by mixing with mineral fertilizers to increase their nutrient value.

Table 7. Nutrient Content of Some Oilseed Cakes

OILCAKE	NUTRIENT CONTENT (%)			
	N	P_2O_5	K_2O	TOTAL
Castor seed	5.5	1.8	1.0	8.3
Cotton seed	3.9	1.8	1.7	7.4
Groundnut	4.5	1.7	1.5	7.7
Karanj seeds	3.9	1.0	1.3	6.2
Neem	5.2	1.0	1.4	7.6
Rapeseed	5.1	1.8	1.0	7.9
Sunflower seed	4.8	1.4	1.2	7.4

Source: Secondary and Micronutrients in Agriculture–FDCO, New Delhi, India

Farmer showing the impact of fertilizer use on demonstration plot as compared to control plot.

CHAPTER 2.

MINERAL FERTILIZERS – THE MAJOR SOURCE OF PLANT NUTRIENTS

WHAT IS MINERAL FERTILIZER?

Mineral or chemical fertilizer is defined as a manufactured product that contains a minimum of one plant nutrient essential for plant growth.

Example of a bag of mineral fertilizer.

CHARACTERISTICS OF MINERAL FERTILIZERS

- They are manufactured products.
- They are rich sources of plant nutrients.
- When exposed to the atmosphere, most tend to cake upon absorbing moisture.
- Most provide only one plant nutrient, e.g., nitrogen, phosphorus or potassium.
- They do not contain organic matter.
- Cause quick response from plants by being immediately available on application.
- If stored properly, can remain in good condition for a long period.

FERTILIZER APPLICATION, BY PROVIDING REQUIRED PLANT NUTRIENTS, GREATLY IMPACTS GROWTH OF CROPS!

CLASSIFICATION OF FERTILIZER PRODUCTS

On the basis of nutrient contents, mineral fertilizers are grouped into four classifications as shown in Table 8.

Table 8. Classification of Mineral Fertilizers

CATEGORY OF FERTILIZERS	CORRESPONDING FERTILIZER PRODUCTS
Nitrogenous Fertilizers	Ammonium nitrate (AN)
	Ammonium sulfate (AS), urea
	Calcium ammonium nitrate (CAN)
Phosphate Fertilizers	Single superphosphate (SSP)
	Triple superphosphate (TSP)
Potassic Fertilizers	Muriate of potash (MOP)
	Sulfate of potash (SOP)
Multi-nutrient Fertilizers	Diammonium phosphate (DAP)
	Compound 20:20:10 (nitrophosphate)
	NPK mixtures of different grades (granulated or powdered)

TYPES AND NUTRIENT CONTENTS OF FERTILIZERS

SINGLE-NUTRIENT FERTILIZERS

Fertilizers that contain only one major nutrient are called straight or single-nutrient fertilizers, e.g., urea contains only nitrogen or triple superphosphate, which contains only phosphorus.

Comparing prilled urea (left) with granulated DAP.

Physically-blended NPK.

Chemically-blended NPK.

MULTI-NUTRIENT FERTILIZERS

These contain two or more nutrients, e.g., diammonium phosphate, which contains nitrogen and phosphorus. Some are blended to contain two or three primary nutrients, some secondary nutrients and micronutrients, and are therefore also called "complete" fertilizers.

Granulated fertilizer – irregular size.

PRILLED, GRANULATED, POWDERED AND CRYSTALLINE FERTILIZERS

Dry fertilizer products are generally available in the following four physical forms.

Prilled fertilizer is produced by solidification of the droplets of melted liquid as it falls down a tall "prilling" tower. Prills are small spherical bead-like objects that are regular in shape and vary in size. Urea, AN and a few other fertilizers are available in the prilled form.

Granulated fertilizers are produced in granulators through the agglomeration or accretion processes. Granules are generally bigger than prills, irregular in shape and very similar in size. Urea, DAP, TSP, CAN and many other fertilizers are available in the granular form. Granulated fertilizers are useful in making dry blends because they do not segregate as easily as the prilled fertilizers.

POWDER FERTILIZERS

Some fertilizer material is available in the powder form like SSP.

Many farmers have difficulties in using such material and, as a result, very little fertilizer is marketed as a powder form.

Single superphosphate in powder form.

CRYSTALLINE FERTILIZERS

Products such as ammonium nitrate, ammonium sulfate and muriate of potash are also available in the crystalline form.

A perception exists that a dark-colored DAP or a pink-colored MOP is of superior quality but that is not always true.

If the products contain the stated nutrients and are water soluble per specifications, the color of the products is not important.

Crystalline fertilizer – example is MOP.

THE NUTRIENT CONTENT OF FERTILIZERS

LABELING FERTILIZER BAGS

It is required by law in most countries to label the fertilizer bag. The information printed on the bag usually includes:

- Name of the product.
- Net contents by weight.
- Guaranteed analysis (nutrient content).

- Name of manufacturer/supplier.
- Brand name (if any).
- Country of origin.

Urea bag marked 46-0-0 indicates that it contains 46 percent by weight of nitrogen and has zero contents of P_2O_5 and K_2O.

DAP bag marked 18-46-0 shows that it has 18 percent content of N, 46 content of P_2O_5 and zero content of K_2O.

Fertilizer bags containing all three nutrients can have markings such as 15-15-15 or 17-17-17 indicating that it contains 15 percent or 17 percent each of all three nutrients. A bag marked 8-18-20 would indicate contents of 8 percent N, 18 percent P_2O_5 and 20 percent K_2O.

The matter present other than the nutrients is called the inert material or filler that carries the contents. Normally, the inert material is of no use to the crops but is necessary in the production of fertilizers.

Generally only the major nutrients are indicated on the labels or bags. However, if the fertilizer contains some secondary or micronutrient, this is also listed on the bags.

For example: 10-20-20 + 10S plus 1Zn indicates 10 percent nitrogen, 20 percent P_2O_5, 20 percent K_2O, 10 percent S and 1 percent of zinc (as Z).

CALCULATING NUTRIENT CONTENT IN FERTILIZER BAG

Fertilizer is supplied mainly in 50-kg bags that are marked with the nutrient contents. The simplest way to calculate the nutrient content in a 50-kg bag is to divide the percent nutrient shown by two. Examples are shown below:

- Urea: 50-kg bag 46-0-0 contains 46/2 = 23 kg nitrogen.
- DAP: 50-kg bag 18-46-0 contains 18/2 = 9 kg N; 46/2 = 23 kg P_2O_5; or total of 32 kg nutrients.
- NPK: 50-kg bag 10-20-20 contains 10/2 = 5 kg N; 20/2 = 10 kg P_2O_5; and 20/2 = 10 kg K_2O; or a total of 25 kg nutrients.

In a 25-kg fertilizer bag, the nutrient percent must be divided by four.

Table 9. Nutrient Content of Some Mineral Fertilizers

FERTILIZER PRODUCT	NUTRIENT CONTENT (%)			
	N	P_2O_5	K_2O	TOTAL NUTRIENTS
Urea	46.0	–	–	46
Anhydrous ammonia	81	–	–	81
Ammonium nitrate	34.5	–	–	34.5
Ammonium sulfate[a]	20.6	–	–	20.6
CAN	26	–	–	26
SSP	16	–	–	16
TSP	46	–	–	46
Phosphate rock	–	29–37	–	29–37
MOP	–	–	60	60
SOP	–	–	50	50
DAP	18	46	–	64
COMPOUND/MIXED FERTILIZERS[b]				
NPK 28:28:0	4	18	15	37
NPK 17:17:17	28	28	0	56
NPK 15:15:15	17	17	17	51
NPK 23:10:10	15	15	15	45

a Ammonium sulfate also contains 20 percent sulfur.

b Compound/mixed fertilizers differ in nutrient content from country to country and manufacturer to manufacturer.

Table 10. Some Available Materials and Sources of Secondary Micronutrients

NUTRIENT	FERTILIZER MATERIAL	CONTENT
Sulfur	AS	24% S
	SSP	12% S
	Potassium sulfate	18% S
	Ammonium phosphate sulfate	15% S
	Gypsum	13%–18% S
	Iron pyrites	22%–24% S
	Elemental sulfur	84%–100% S
	Magnesium sulfate	13% S
	All sulfate salts of micronutrient	13%–19% S
Calcium	Agricultural limestone	80%–95% $CaCO_3$
	Basic slags	
	Dolomite	20%–45% CaO
	Gypsum	40% CaO
	SSP	25%–30% CaO
	Phosphate rock	39%–48% CaO
	LCFC slag	54% CaO
	CAN	10%–20% CaO
Magnesium	Magnesite	40% MgO
	Magnesium sulfate	16% MgO
	Chelated Mg	2%–10% MgO
	Dolomite	5%–20% MgO
	LCFC slag	7% MgO

Boron	Borax (deca)	11.3% B
	Borax (penta)	15% B
	Boric acid	17.5% B
	SOLUBOR	20.5% B
	Boronated SSP	0.18% B
Copper	Copper sulfate	24% Cu
	Chelated Cu	5%–12% Cu
Iron	Ferrous sulfate	19% Fe
	Chelated products	5%–10% Fe
	Chelated iron (FCO)	12% Fe
Manganese	Manganese sulfate	30.5% Mn
	Chelated products	5%–12% Fe
Molybdenum	Ammonium molybdate	54% Mo
Zinc	Zinc sulfate	21% Zn
	Zinc sulfate monohydrate	33% Zn
	Chelated Zn (FCO)	12% Zn
	Other compounds	4%–13% Zn
Chlorine	Potassium chloride	48% Cl
	NPK complexes	Varies

CHAPTER 3.

RECOMMENDED TIME AND METHODS OF FERTILIZER APPLICATION

RECOMMENDED TIME OF FERTILIZER APPLICATION

Plants need the correct quantities of nutrients at the right time during their growth period. Timely application of fertilizers and manures enables plants to meet the nutritional requirements and promote growth.

The delayed application, or fertilizers applied by wrong method of application, results in low use efficiency and loss of expensive nutrients. It is estimated that 15-20 percent of fertilizer nutrients are lost through leaching or volatilization in the smallholder farming conditions. Such losses can be minimized by applying fertilizers at the right time and by the correct methods.

To know the right methods and time of fertilizer application, it is necessary to understand the following terms related to fertilizer application.

BASAL APPLICATION

This is when fertilizers and manures are applied before or at the time of planting of seeds or seedlings. Similarly, fertilizers such as SSP, TSP, DAP, MOP, SOP, NPK mixtures, organic manures and green manures, etc., which should be applied before planting, are called "basal fertilizers."

Basal fertilizers are applied mainly as a source of phosphates and potash (P and K) to provide nourishment to the root system. P and K nutrients get absorbed into the soil particles and stay in the soil for long periods as compared to nitrogen. The roots must reach the available P and K fertilizers to use them. If a crop cannot use the applied basal fertilizers, they remain in the soil for a long time. Plants need basal fertilizers mainly at the early stages of their growth. The benefits of P and K (basal fertilizers) have already been discussed elsewhere.

TOPDRESSING

When fertilizers are applied to a standing crop on the topsoil, the method is also called topdressing. Fertilizers such as urea, AN, AS and CAN should be applied through this

method and are known as "topdressing fertilizers." Urea is the most popular topdressing fertilizer. Topdressing fertilizers contain mainly nitrogen (N) as a single nutrient. Benefits of N have already been discussed elsewhere. After spreading topdressing fertilizer like urea it is necessary to cover the applied fertilizer with the soil using a hand hoe.

The right time of application of basal and topdressing fertilizers for different crops is shown in Table 11. Farmers are advised to follow the guidelines given to minimize the loss of fertilizer nutrients.

Table 11. Recommended Time of Fertilizer Application

CROPS	BASAL FERTILIZERS (SSP, TSP, MOP, SOP and all grades of NPK)	TOPDRESSING FERTILIZERS (AS, Urea, AN, CAN, etc.)
Maize, sorghum, cotton, sugarcane, sunflower	Apply before or at the time of planting seed.	Apply in two to three split doses starting two weeks after germination.
Millet, rice	Apply before or at the time of planting seed.	Apply in two to three split doses starting two weeks after germination.
Soybeans, groundnuts	Apply before or at the time of planting seed, including recommended nitrogenous fertilizers.	Not essential but when recommended based on soil test, follow the above method.
Wheat, rice	Apply before or at the time of planting seed.	Apply in two to three split doses starting two weeks after germination.

RECOMMENDED METHODS OF FERTILIZER APPLICATION

Fertilizers can be applied by manual and mechanical methods. A majority of smallholder farmers apply fertilizers manually or with the help of small hand tools. Some of the simple methods of fertilizer application are summarized as follows.

Farmers applying fertilizer and planting seed using the manual drilling method.

MANUAL DRILLING METHOD FOR BASAL FERTILIZERS

The drilling method is used to apply basal fertilizers such as granulated SSP, TSP, DAP and NPK. A furrow is made with a plow drawn by a pair of oxen or manually using hand tools.

Fertilizer is placed manually in the furrow and covered with the soil. Another person follows and places seed in the furrow. After application, fertilizers and seeds are covered by planking.

As an improved practice, some farmers use a drill made of a funnel and a pipe, which is tied to the plow. Fertilizer is poured through the funnel into the furrow created by the plow. A second person plants the seed by hand, which falls over the fertilizer covered by the soil.

Furrows can also be made manually using hand tools. Basal fertilizers are applied in the furrow and covered with soil before planting the seed.

MECHANICAL DRILLING METHOD (SEED-CUM-FERTILIZER DRILL)

This is an improved method over manual drilling. A seed-cum-fertilizer drill is used to apply the seeds and fertilizers.

The drill has two compartments. Fertilizer is placed in the first compartment and seed is placed in the second compartment. Fertilizer gets delivered through pipes into the furrows created by the plow. Seed is delivered by another pipe connected to the seed compartment (Figure 3).

Figure 3. Mechanical drilling method

This method is economical, and both fertilizer and seeds get properly delivered in the furrow at a controlled depth. The distance between the furrows and the depth of fertilizer and seeds can be adjusted as required.

HAND BROADCASTING METHOD

Through this method (see Figure 4), fertilizer is manually spread by hand on top of the soil, either before planting or in standing crops. Fertilizer is taken in a small container.

Holding the container in one hand, the farmer broadcasts the fertilizer with the other hand. The farmer applying fertilizer either walks backward or forward as fertilizer is applied.

Figure 4. The broadcasting method of topdressing fertilizer application

The manual broadcasting method is very common among smallholder farmers. This method can be used for both basal and topdressing fertilizers. In addition to being economical, the broadcasting method provides freedom to the farmer to adjust the quantity of fertilizer to be applied in a particular area.

Farmer using the manual broadcast method.

The disadvantage of this method is the uneven and unequal distribution of fertilizers. The quantity applied may differ from place to place, and some areas in the field may not receive fertilizer. This drawback, however, can be overcome by proper planning as follows:

- The field should be divided into four equal portions. Each portion should be marked by making a line, or by fixing some landmarks in the field.

- The available quantity of fertilizer should be divided into four equal parts. Each portion of the field is then allocated one quarter of the divided fertilizer.
- The farmer applying fertilizers should walk in a zigzag movement as shown in Figure 5. Fertilizer application in this manner can be well distributed throughout the whole farm.

To minimize the loss of fertilizers through volatilization (during high temperatures) or leaching (during the rains), the applied fertilizers should be covered with soil using handheld tools. Farmers must remember that in the broadcasting method, covering of fertilizers with soil is necessary to minimize fertilizer losses.

Farmer covering fertilizer with soil to minimize fertilizer losses.

MECHANICAL FERTILIZER BROADCASTING

Mechanical broadcasters that work on the same principle as the hand broadcast method are available in the market and are very efficient, spreading the fertilizer evenly. They are also time-saving. Generally, the mechanical broadcasters are driven by tractor, cover a large area and are suitable for large commercial farmers.

A tractor at work broadcasting fertilizer.

FURROW AND SIDE PLACEMENT METHODS

In this method (see Figure 5), a furrow is made using hand tools such as a shovel or spade, and basal fertilizer is placed in the furrow by hand. The furrow is then covered with soil, and seeds then placed or planted on top of the fertilizer at the same time. The furrows are generally made close to the row of standing crop hence the method being called "side placement."

Figure 5. Furrow Application of Fertilizer

Urea, AN and CAN are then applied by hand in the furrows and covered with soil. The only precaution here is that the furrow should not be made very deep; a depth

of 3–4 inches is ideal. This method is recommended for smallholder farmers. It is economical with minimal losses.

HOLE PLACEMENT METHOD

In the application of basal fertilizers, holes of 3–4 inches in diameter and 6–8 inches deep are dug manually with hand tools. In the hole (see Figure 6), basal fertilizer or a mixture of basal and a small quantity of topdressing fertilizer is applied with a cup and covered with soil. Seed is then placed over the fertilizer and covered with soil.

The number of holes to be made in a field is determined by the recommended distance between plants and rows for the crop being planted. This is a very effective method that prevents fertilizer loss, provides immediate nutrition to growing roots and retains moisture.

Hole placement is the best option in uneven fields, and an appropriate method for tree crops and kitchen gardening. The hole placement method is, however, labor-intensive and slow and is recommended for smallholder farmers, particularly in hilly areas.

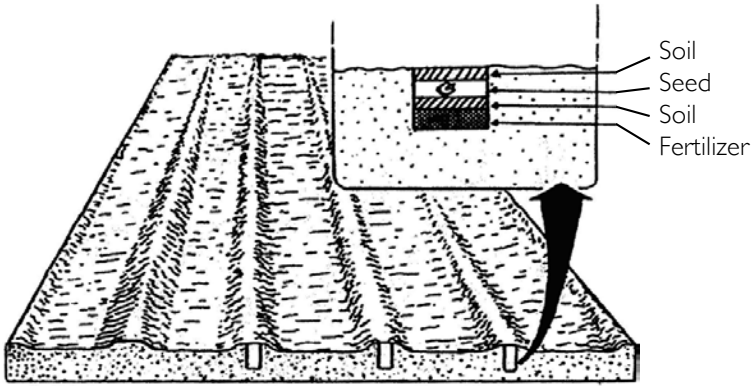

Figure 6. The 'hole placement' method

APPLICATION BY CUP

This is similar to the 'hole application' method, whereby the farmer digs with a small hand tool around the plant and applies basal fertilizers like DAP and NPK with a small cup. It is an economical method for smallholder farmers.

Applying small amounts of fertilizer by hand using a small measure such as a bottlecap is an economical method for smallholder farmers.

RING PLACEMENT METHOD

In the ring placement method (see Figure 7), a round, ring-type furrow is made around the plant, mainly a tree or bush. Fertilizer is then applied in the furrow and covered with soil. This is a simple and economical method of application of basal and topdressing fertilizers, especially in the case of fruit trees. The ring should not be very wide.

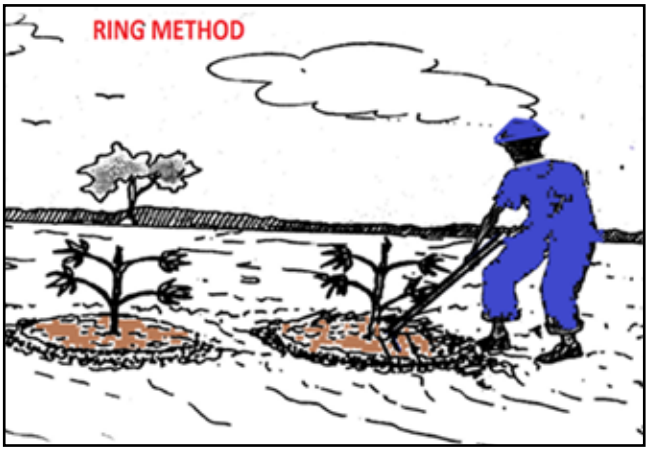

Figure 7. The 'ring placement' method of fertilizer application

The diameter of the ring may range from 8 to 20 inches depending upon the crop. For fruit trees such as mango, citrus and papaya, a 20-inch diameter is recommended. This method is also labor-intensive but economical for smallholder farmers, particularly

under uneven soil conditions. The method is also good for home gardens, fruit trees and ornamental plants.

RIDGE APPLICATION METHOD

This is a recommended method for both basal and topdressing fertilizers. It is an appropriate method for vegetable or horticultural crops. Fertilizer is applied on the ridge near the plants or seeds and covered with a hoe (see Figure 8). This is an economical method with minimum wastage of fertilizers.

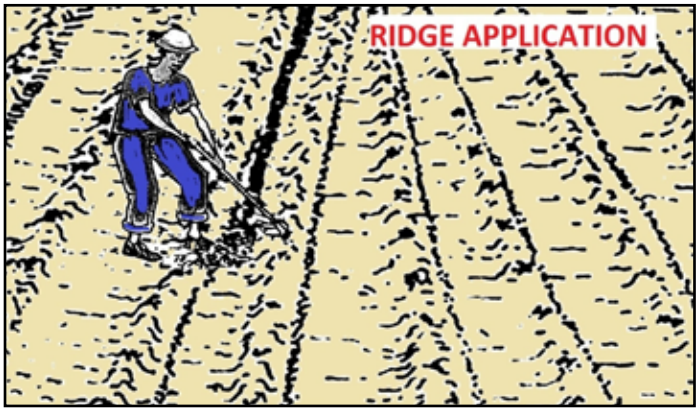

Figure 8. Ridge placement method

FOLIAR APPLICATION OF FERTILIZER

Foliar fertilizer application is used mainly for topdressing fertilizers such as urea and some liquid fertilizers. These are dissolved in water and sprayed on standing crops with the help of a spray pump. This method is similar to the application of crop protection products.

Foliar application is generally recommended for the application of micronutrients and growth-promoting materials. Commercial farmers generally use this method for horticultural crops. It is important to calculate the correct quantity of fertilizers and water to be used for spraying.

Foliar application is also useful under drought or water-stress conditions. Crops may show immediate results when applied under nitrogen or micronutrient-deficiency conditions. Urea with a high percentage of biuret, above 0.5 percent, is not recommended for foliar application.

MIXING OF FERTILIZERS

Some farmers mix different fertilizer products for balanced fertilization and to provide most of the plant nutrients at one time. Mixed fertilizers are generally applied before planting or at the time of planting.

All fertilizers, however, are not compatible. Mixing of incompatible fertilizers can result in slurry, which is difficult to handle. By mixing the right type of fertilizers, a farmer can make his own NPK blend. See Table 12, which shows types of fertilizers that can be mixed.

SOME TIPS ON FERTILIZER USE

- Do not mix fertilizers and seeds particularly when handling high-soluble fertilizers such as urea, AS and CAN.
- Mix only those fertilizers that are compatible (refer to Table 12).
- AN can be mixed with all fertilizers.
- SSP, TSP and ammonium phosphate should not be mixed with lime and phosphate rock.
- MOP and SOP can be mixed with most fertilizers.
- When fertilizer and seed mixing is considered necessary, mix just before planting.
- Do not apply fertilizers in rain or if heavy rain is expected immediately after planting.
- Avoid application of topdressing fertilizers early in the morning. It is preferable to apply in the afternoon or during the cooler part of the day.
- Follow the fertilizer recommendations made by the department of agriculture.

Table 12. Fertilizer Mixing Guide

	POTASSIUM CLO	POTASSIUM SUL	SULPHATE OF POT MAG	AMM. NITRATE	CAL.AMM. NITRATE	UREA	SSP - TSP	AMM. SULPHARE	BASIC SLAG	ROCK PHOS. (POWDER)	LIME
POTASSIUM CLO	✓	✓	✓	✓	●	●	✓	✓	✓	✓	✓
POTASSIUM SUL	✓	✓	✓	✓	●	●	✓	✓	✓	✓	✓
SULPHARE OF POT MAG	✓	✓	✓	✓	●	●	✓	✓	✓	✓	✓
AMM. NITRATE	✓	✓	✓	✓	✓	●	✓	✓	☹	●	☹
CAL.AMM. NITRATE	●	●	●	✓	✓	●	✓	✓	☹	✓	✓
UREA	●	●	●	●	●	✓	●	●	●	●	●
SSP - TSP	✓	✓	✓	✓	●	●	✓	✓	☹	☹	☹
AMM. SULPHATE	✓	✓	✓	✓	●	●	✓	✓	☹	☹	☹
BASIC SLAG	✓	✓	✓	☹	☹	●	☹	☹	✓	✓	✓
ROCK PHOS. (POWDER)	✓	✓	✓	●	✓	●	☹	☹	✓	✓	✓
LIME	✓	✓	✓	☹	✓	●	☹	☹	✓	✓	✓

✓ Fertilizer that can be mixed.

● Fertilizer that can be mixed shortly before use.

☹ Fertilizer that cannot be mixed (for chemical reaason).

NB. Bonemeal, which is often used as a "drier", may be mixed with other fertilizers.

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