

**NATIONAL AGRICULTURAL RESEARCH  
& EXTENSION INSTITUTE**

# **FERTILIZER MANUAL**

(Concepts, Application,  
Storage and Handling)

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## **EXECUTIVE SUMMARY**

*The successful production of crops requires a farmer to make maximum use of all available resources. One of the most important and necessary resources is fertilizer, which provides the nutrients needed by plants to grow properly and yield a quality product.*

*The use of fertilizers has become an essential and routine part of many crop production systems. Farmers do not use fertilizers just to grow big crops or to increase the nutrient content of their soils. They do so to make a living. As a result, any fertilizer practice must be technically correct to ensure it gives a fair economic return to the farmers.*

*Fertilizers are classified into two categories – inorganic and organic. Inorganic fertilizers include urea (source of N), TSP (source of P), muriate of potash (source of K) and compound fertilizers such as 15:15:15 and 12:2:17:2. Organic fertilizers (manures) are derived from the wastes of plants and animals. Decomposed organic materials (composts) are the most common organic fertilizer.*

*When fertilizers are applied, especially to fruits and vegetables, care must be taken to ensure that the fertilizers are placed near enough to the roots for absorption. Further, concentrations of fertilizers in the root zone must not be high enough to cause injury to the roots. The three general methods used for fertilizer application are broadcast (principally for rice), placement (spot and bead) and foliar).*

*Efficiency of fertilizer use by crops is of major agronomic interest. There is growing concern that fertilizers be used as efficiently as possible to minimize losses and environmental pollution. Nutrients are lost to the environment through crop removal, leaching, denitrification, volatilisation and erosion. The inefficient use of fertilizers can also result in environmental pollution. The ways through which pollution occur are eutrophication, high nitrate levels in water, soil acidification and greenhouse gas emissions.*

*Fertilizers pose little danger to the environment (principally groundwater) once stored and applied properly. The storage and handling of fertilizers is not serious issue in Guyana. Most farmers only purchase the quantities that are needed at a particular time. Some amount of storage is however required by rice farmers. Once fertilizers are to stored for extended periods, the bags should be stocked on pallets.*

## **1.0 INTRODUCTION**

The successful production of crops requires a farmer to make maximum use of all available resources. One of the most important and necessary resource is fertilizer, which provides the nutrients needed by plants to grow properly and yield a quality product.

Fertilizers account for one-third or more of crop yields. Inadequate fertility starves plants. Excess fertility is wasted and can cause physical injury and death to plants as well as pollution to the environment. It is necessary therefore to supply plants with precise and balanced amounts of nutrients needed for their optimal growth and development but avoiding excessive amounts that can be eventually lost to the environment.

The inefficient use of fertilizers is generally a cause for concern. Issues such as nitrate leaching, eutrophication and consumption of non-renewable resources originate with fertilizer use. Further, farmers need to understand the risks associated with the indiscriminate use, storage and handling of fertilizers. Additionally, they also need to be cognizant of the environmental and occupational hazards associated with the misuse of fertilizers.

The purpose of this manual is to educate farmers (both rice and other crops) on environmental and sustainability issues related to fertilizers. The basic concepts related to fertilizer use, types of fertilizers, methods of application, efficient use of fertilizers, storage, handling and environmental hazards are given prominence.

## **2.0 PLANT NUTRIENTS**

### **2.1 Introduction**

Some soils are naturally low in nutrients whilst others become depleted due to continuous cropping. Farmers are generally aware when this condition arises. They usually refer to their soils in this state as being 'run down'. Farmers invariably use fertilizers and manures to correct this problem. A fertilizer is a material that provides one or more elements (nutrients or plant food) for the growth and development of plant. The use of fertilizers has become an essential and routine part of many crop production systems. Farmers do not use fertilizers just to grow big crops or to increase the nutrient content of their soils. They do so to make a living. As a result, any fertilizer practice must be technically correct to ensure it gives a fair economic return to the farmers.

### **2.2 Plant nutrients**

Plant nutrients are chemical elements that are essential for the growth and development of plants.

#### **2.2.1 Classification**

There are 17 nutrients that are required for the growth and development of plants (Table 1). Additionally, some nutrients such as silicon (Si) are also necessary for successful rice production.

**Table 1: Classification of Elements Essentials for Plant Growth**

Classification		Elements
Macronutrients	(Available from air or water)	Carbon, Hydrogen, Oxygen
	Primary Nutrients	Nitrogen, Phosphorus, Potassium
	Secondary Nutrients	Calcium, Magnesium, Sulphur
Micronutrients		Boron, Cobalt, Chlorine, Copper, Iron, Manganese, Molybdenum, Zinc

Nine plant nutrients are required in relatively large amounts. These are referred to as the major elements or macronutrients. Of these, carbon, hydrogen and oxygen, (make up 90-95% of the dry matter of plants) are obtained from carbon dioxide and water. These nutrients are therefore not regarded as components of fertilizers. The other major elements are divided into primary nutrients (nitrogen, potassium and phosphorus) and secondary nutrients (calcium, magnesium and sulphur). The remaining eight plant nutrients are required in much smaller quantities and are known as micronutrients or minor elements.

### **2.2.2 Roles and functions of plant nutrients**

Plant nutrients obtained from the soil are essential for the growth of healthy plants. The nutrients are utilized by plants during the basic metabolic processes which are absolutely essential for the continued life of all plants. Table 2 shows the basic characteristics and deficiency symptoms of essential nutrients.

**Table 2: Classification, Characteristics and Deficiency Symptoms of Essential Nutrients**

Nutrient	Characteristics	Deficiency Symptom
<b>Primary</b>		
Nitrogen (N)	All converts to nitrate. Nitrate can leach from soil. Ammonium held to soil. Plants use mostly nitrate, some ammonium ( e.g. rice)	<ol style="list-style-type: none"> <li>1. Slow growth, stunted plants</li> <li>2. Yellow-green colour</li> <li>3. Firing of older leaf tips</li> </ol>
Phosphorous (P)	Easily tied up by soil and made unavailable to plants. Availability reduced at high or low pH and soil temperature below 50°F. Form for plant use varies with soil pH.	<ol style="list-style-type: none"> <li>1. Slow, stunted growth</li> <li>2. Purplish color to leaves/stems</li> <li>3. Delayed maturity</li> <li>4. Dark green, dead leaf tips</li> <li>5. Poor fruit/seed development</li> </ol>
Potassium (K)	Increases size and quality of fruit	<ol style="list-style-type: none"> <li>1. Tip and marginal burn on older leaves</li> <li>2. Weak stems, lodging</li> <li>3. Small fruit, shriveled seeds</li> <li>4. Slow growth</li> </ol>
<b>Secondary</b>		
Calcium ( Ca)	Major component of cell wall. Does not move within plant. Deficiency related to blossom end rot of tomato and others. Can be deficient in acid soils, but corrected by liming.	<ol style="list-style-type: none"> <li>1. Death to growing points of top and root</li> <li>2. Unusually dark green foliage, which fails to unfurl</li> <li>3. Premature blossom/bud shed</li> <li>4. Weak stems</li> </ol>
Magnesium (Mg)	Deficiency may show on sandy, acid soils. Can be corrected with dolomitic limestone during pH adjustment.	<ol style="list-style-type: none"> <li>1. Yellowing between older leaf veins.</li> <li>2. Leaves curl up along margins</li> <li>3. Marginal yellowing with 'Christmas tree' shape along midrib.</li> </ol>
Sulfur (S)	Can be deficient in acid soils.	<ol style="list-style-type: none"> <li>1. Pale green/yellow color to young leaves initially.</li> <li>2. Small week plants</li> <li>3. Retarded growth, slow maturity.</li> <li>4. Yellow between veins of corn leaves.</li> </ol>

Micronutrients (Trace elements)		
Zinc (Zn)	Terminal growth areas affected first. Deficiency can be caused by excess phosphorous.	<ol style="list-style-type: none"> <li>Decreased stem length, rosetting terminals.</li> <li>Reduced fruit bud formation</li> <li>Mottled leaves</li> <li>Stripping or banding of corn leaves</li> </ol>
Iron (Fe)	Deficiency can be induced by high manganese at low pH. Usually associated with high pH soil or excess training.	<ol style="list-style-type: none"> <li>Yellowing between dark green veins of young leaves.</li> </ol>
Manganese (Mn)	Excess may induce iron deficiency at low pH.	<ol style="list-style-type: none"> <li>Yellowing between veins of young leaves. Not as distinct as with iron.</li> </ol>
Copper (Cu)	Not usually deficient. May be linked to fruit cracking to tomato.	<ol style="list-style-type: none"> <li>Stunted growth</li> <li>Poor color</li> <li>Wilting and death of leaf tips.</li> </ol>
Boron (B)	Does not move within plant. Deficient occasionally on cole crops.	<ol style="list-style-type: none"> <li>Soft, dead spots on fruit or tubers.</li> <li>Reduced flowering and pollination</li> <li>Thick, curled, wilted, yellow leaves.</li> <li>Stunted, unvigorous plants</li> <li>'Whiptail' of cauliflower</li> <li>Cupping or rolling of leaves</li> </ol>
Molybdenum (Mo)	Essential for N fixation by legumes. May be applied with seed inoculation. Deficiency often corrected with liming.	
Cobalt (Co)	Important in N fixation in legumes	General yellowing in legumes.

### **2.2.3 Expression**

The primary nutrients (nitrogen, phosphorous and potassium) are expressed as quantities or percentages in terms of elemental nitrogen (N), phosphorous pentoxide ( $P_2O_5$ ) and potassium oxide ( $K_2O$ ). The fact that P and K content is expressed as the oxide is a relic from the past, when elemental analyses of solids were expressed in the oxide form. In fact, P and K are not present in fertilizers as oxides, but as soluble salts. Table 3 shows the conversion factors of plant nutrients (from oxide to elemental and from elemental to oxide form).

**Table 3: Conversion factor of plant nutrients (from oxide to elemental and from elemental to oxide from)**

$P_2O_5$	X	0.44	=	P
P	X	2.29	=	$P_2O_5$
$K_2O$	X	0.83	=	K
K	X	1.20	=	$K_2O$

Secondary nutrients and micronutrients are usually expressed on an elemental basis

## **3.0 FERTILIZERS – BASIC CONCEPTS**

### **3.1 Introduction**

Plants need adequate supplies of nutrients for good growth and high yields. When the soil itself cannot supply the quantities of nutrients needed by the plant, best yields would not be obtained unless the shortage of plant nutrients is made up by applying the missing substances as fertilizers. A fertilizer is a material, the main function of which is to provide plant nutrients.

### **3.2 Kinds of Fertilizers**

Fertilizers are classified into two categories – inorganic and organic. The inorganic (mineral) fertilizer is a substance in which the declared nutrients are in the form of inorganic salts obtained by extraction and/or by physical and/or chemical industrial processes. Organic fertilizers are carbonaceous materials mainly of vegetable and/or animal origin added to the soil specifically for the nutrition of plants.

Inorganic fertilizers include urea (source of N), TSP (Source of P), muriate of potash (source of K) and compound fertilizers such as 15:15:15 (Figure 1). Inorganic fertilizers could be granular, coated, slow-release, etc.

Organic fertilizers (manures) are derived from the wastes of plants and animals. Litter from poultry, cows, sheep, etc., are commonly used for fertilization. Decomposed organic materials (composts) are the most common organic fertilizers.

### **3.3 Composition of Some Common Fertilizers**

Fertilizers exist in many forms. Some compounds such as urea {CO (NH<sub>2</sub>)<sub>2</sub>}, muriate of potash (KCl) and TSP provide only one plant nutrient. Others, such as diammonium phosphate contain two nutrients (N and P). The typical composition of some common fertilizers is shown in Table 4.

**Table 4: Composition of some common fertilizers**

Name	Composition
Urea	45% - 46% N
Muriate of Potash (KCl)	60% - 62% K <sub>2</sub> O
Diammonium Phosphate (DAP)	18% N, 46% P <sub>2</sub> O <sub>5</sub>
Triple Superphosphate (TSP)	44% - 48% P <sub>2</sub> O <sub>5</sub>

### **3.4 Fertilizer Grade**

It is customary to refer to a given fertilizer product by a series of numbers separated by dashes. This set of numbers is called the grade of the fertilizer product. The content of each nutrient is always expressed as a percentage by weight, or in other words as kilograms of nutrients per 100 kg of the fertilizer product.

Usually, three numbers are used when giving the grade of a fertilizer product, and these three numbers always refer, in order, to the content of the primary nutrients: N, P and K. If other nutrients are present, the content can also be indicated in the grade of the fertilizer product. The grades of some of the common fertilizers used in Guyana are shown below.

Urea	-	46-0-0
Muriate of Potash	-	62-0-0
DAP	-	18-46-0
TSP	-	46-0-0

Many commercial fertilizers are mixtures of compounds (compound fertilizers) which provide substantial amounts of N, P and K. In Guyana, some of the commonly used mixed fertilizers are 20:20:20 and 15:15:15. Another commonly recommended fertilizer for sandy soils is 12-12-17-2. This latter mixed fertilizer contains 2kg of micronutrients in addition of 12kg of N, 12 kg of P<sub>2</sub>O<sub>5</sub> and 17 kg of K<sub>2</sub>O per 100kg of fertilizer.

### **3.5 Compound Fertilizers**

Compound fertilizers are frequently used because it is more convenient to purchase, transport, store and apply one product than several as is the case if one chooses to use individual nutrient sources such as urea, muriate of potash or TSP. However, in many instances a single dose of a compound fertilizer will not meet the nutrient needs of the crop over the entire growing season.

Compound fertilizers are often a good choice for providing a basal application of nutrients, including secondary and micro-nutrients, prior to or at planting. However, because most crops benefit from higher doses of nitrogen than other nutrients, the basal dose of compound fertilizer often needs to be followed by subsequent doses of nitrogen timed to meet the nitrogen requirements of the crop.

## **4.0 DESCRIPTION OF SOME COMMON FERTILIZERS**

### **4.1 Introduction**

In Guyana, the most commonly used fertilizers are urea, TSP, muriate of potash, 15-15-15 and 12-12-17-2. Other compound fertilizers such as 20-20-20 are also in the market. A description of some of their basic properties is presented below.

### **4.2 Urea**

On a worldwide basis, urea is the most popular solid nitrogen fertilizer. In its pure state, it is a white, crystalline organic compound. In the fertilizer form, urea may have a grayish appearance.

Urea is the recommended N fertilizer for rice. It is preferable to other N containing fertilizers for flooded rice because nitrates are reduced to gaseous nitrogen ( $N_2O$  or  $N_2$ ) in the anaerobic (no oxygen) zone of the rice paddy and hence lost to the atmosphere. Furthermore, the rice plant, unlike most other crops, can utilize the ammonium form of nitrogen efficiently.

#### **4.2.1 Behaviour of Urea in Soils**

When urea is added to the soil, it is acted upon by an enzyme called urease (very abundant in soils). The urease converts urea to ammonium ( $NH_4^+$ ) ions. In flooded soils (such as rice paddies), the  $NH_4^+$  ion is available for uptake by rice plants. This process takes a few days. This ion can also be converted to the nitrate ( $NO_3^-$ ) ion in the aerobic zone around the root hairs. These nitrate ions are then available for plant uptake.

In soils that are not flooded, urea is first converted to  $NH_4^+$  which is subsequently converted to  $NO_3^-$  by soil bacteria. The  $NO_3^-$  ion then becomes available for uptake by plants (fruits and vegetables).

#### **4.2.2 Urea Application**

Surface applications of urea are most efficient when they are washed into the soil or applied to soils that have low levels of urease. Urea moves in soils very easily once adequate moisture is available. Apart from rice, once urea is used, it must be incorporated into the soil and **MUST NOT REMAIN ON THE SURFACE**.

Soils high in organic matter tend to restrict the movement of urea. Loss of urea can occur if there is significant precipitation soon after application and before there has been sufficient time for the necessary reactions to occur.

### **4.3 Muriate of Potash**

Muriate of Potash (KCl) is the most commonly used K fertilizer. It is orangish in colour, water soluble and contains 60 to 62% K<sub>2</sub>O.

#### **4.3.1 Behaviour in Soils**

When potash is added to the soil, it dissolves in the soil moisture, releasing K<sup>+</sup> ions, which are available for plant uptake.

It is vital to maintain adequate K fertility levels in the soil because K does not move much, except in sandy and organic soils. K tends to remain where fertilization puts it. When K does move, it is usually by diffusion on slow, short trips through water films surrounding soil particles.

### **4.4 Phosphate Fertilizers**

The two most common phosphate fertilizers are diammonium phosphate (DAP) which contains 18%N and 46% P<sub>2</sub>O<sub>5</sub> and concentrated phosphate or triple superphosphate (TSP). Both TSP and DAP are used in rice cultivation. Fruit and vegetable growers utilize TSP extensively. These materials are marketed as gray, brown or white materials in either powdered or granular form.

#### **4.4.1 Behaviour in Soils**

The effectiveness of P fertilizers is determined by the properties of both P salt and the soil being fertilized as well as by the reactions between the P fertilizer and the various soil constituents. When P fertilizers are applied to the soil, these dissolve rapidly even under conditions of low soil moisture. A nearly saturated solution of the fertilizer material forms in and around the fertilizer granules.

P moves very little in most soils. It generally stays, where it is placed by fertilization. Little P is lost by leaching, though it moves more freely in sandy than in clay soils.

Nearly all P moves in the soil by diffusion, a slow and short-ranged process that depends on soil moisture. Dry conditions reduce diffusion sharply.

It has been estimated that roots of a growing crop contact only 1 to 3 percent of the soil in the surface 15 to 18 centimetres. In practical terms, this means soil must be adequately supplied with P to support optimal plant growth. The soil P level throughout the root zone should be high enough to ensure available P during every stage of growth.

## **5.0 METHODS OF FERTILIZER APPLICATION AND CROP FERTILIZATION ( VEGETABLE, FRUITS AND RICE)**

### **5.1 Introduction**

When fertilizers are applied, care must be taken to ensure that the fertilizer is placed near enough for the roots to readily absorb it while at the same time the concentration is not so high enough to cause injury to the roots. The soluble constituents of fertilizers diffuse through the soil vertically and only slightly in a lateral direction. The method of application, therefore, must ensure distribution to reach the plant roots.

There are three methods generally used for fertilizer applications. These are broadcast, placement and foliar application. Fertilizer requirements vary for the different crop types. In this manual, emphasis is placed on fertilization of fruits, vegetable and rice.

### **5.2 Broadcast**

In this method the fertilizer is spread as uniformly over the field as possible. This is commonly referred to as 'shying'. This method is suitable for crops whose seeds are broadcast as is done in rice cultivation. The fertilizer is usually broadcast after the land has been ploughed and then mixed with the soil ploughs or cultivators.

### **5.3 Placement**

Placement is when the fertilizer is put in a small area close to the plant or seed. This could be done in spots or as bands.

The spot placement: the fertilizer is put approximately 5 cm (2 inches) away from the seed and 5 cm below the soil. The fertilizer should not be left exposed on the surface of the soils. This will lead to the loss of fertilizer. This method is useful for crops such as corn, bean, pumpkin, squash, melons and cucumber which have large seeds.

In band placement: the fertilizer is placed in bands on one side or both sides of the row, about 5 cm below the seed and 5 cm away from the seed or plant. This method is useful for crops which are sensitive to direct contact with fertilizers.

Band placement is also used for tree crops such as citrus, coconuts, avocado and papaws. In this case, the fertilizer is put in a circular band around the tree. Trees are usually treated individually, the fertilizer being applied around each tree within the spread of the branches, but beginning a few meters from the trunk. Generally, the fertilizer is placed around the dripline of the plant canopy. The fertilizer must be worked into the soil as much as possible after application.

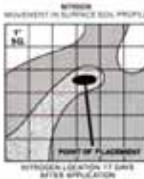
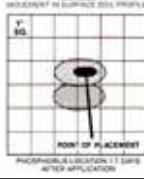
#### 5.4 Foliar application

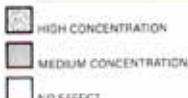
This is the application of fertilizer directly to the foliage of the plant as a liquid spray. The nutrients can be absorbed directly by plant leaves although only in limited quantities.

#### 5.5 NPK Placement and Movement

The placement and movement of N, P and K are illustrated in Figure 1.

**Figure1: NPK Placement and Movement**

<p><b>Nitrogen</b> moves through the soil rather freely during the growing season. Positioning N in the root zone is generally not critical for root interception in clean tillage systems. However, band placement of N has been shown to significantly enhance N use efficiency under reduced tillage conditions. Band placement of N can also slow the nitrification process.</p>	 <p>NITROGEN MOVEMENT IN SURFACE SOIL PROFILE POINT OF PLACEMENT NITROGEN LOCATION 17 DAYS AFTER APPLICATION</p>
<p><b>Phosphorus</b> needs most attention with its placement. This illustration shows how very limited its movement really is. Phosphorus should be placed where roots can intercept it. Banding P is the most agronomically efficient way to place it on low fertility soils. Banding ammonium-N with P enhances P uptake.</p>	 <p>PHOSPHORUS MOVEMENT IN SURFACE SOIL PROFILE POINT OF PLACEMENT PHOSPHORUS LOCATION 17 DAYS AFTER APPLICATION</p>
<p><b>Potassium</b> placement is critical. Like P, it does not move readily in the soil. Broadcast application is generally most effective, sometimes in combination with band placement. Band placement of K in conservation tillage systems can significantly improve K availability, probably related to plant rooting patterns. Deep banding K has been very important in helping overcome subsoil K deficiency in cotton.</p>	 <p>POTASSIUM MOVEMENT IN SURFACE SOIL PROFILE POINT OF PLACEMENT POTASSIUM LOCATION 17 DAYS AFTER APPLICATION</p>



## **5.6      Organic Fertilization**

Practices employed for organic fertilization include crop rotation, green manuring, mulching, use of animal manure, composted materials, liquid manures and plant teas.

In Guyana, the most commonly used materials for organic fertilization are animal manures and composted materials. Organic fertilizers have much lower nutrient contents than synthetic mineral fertilizers. Thus, large quantities (tons/ha) are required. However, they have some advantages such as slow nutrient release (mineralization), tendency not to damage roots, provision of micronutrients and improvement of soil structure.

Organic fertilizers are generally spread on the soil surface and then worked into the soil. These materials can also be left on the soil surface, initially serving as a mulch. This is a useful practice in vegetable production. For tree crops, the organic fertilizer should be placed in a circular band, approximately around the dripline. The fertilizer materials should be subsequently mulched.

## **5.7      Fertilizing Vegetables**

On small areas such as garden beds or vegetables banks, the recommended fertilizer may be broadcasted evenly, over the planting area and lightly raked in. No fertilizer should be left exposed in the soil surface. If small amounts of fertilizer are to applied (a few grams) then this should be dissolved in a watering can. The fertilizer solution should then be evenly applied over the area to be planted.

Spot placement is used when planting crops such as beans, corn, squash, pumpkins, melons and cucumbers, which have large seeds. The fertilizer should be put approximately 5 cm (2 inches) away from the seed and 5 cm (2 inches) below the soil. After placement, the fertilizer must be covered with soil.

For crops that are planted close together in rows such as corn, beans and eschalot, band placement of fertilizer is recommended. In organized planting of crops such as peppers, boulanger and tomatoes, band placement of fertilizers is also effective.

The fertilizer is placed in a shallow groove or furrow, 2.5 cm ( 1 inch) deep along the row of the plants. The distance of the band from the row varies with the crop type. For crops such as corn, and beans, the fertilizer is placed 22 cm (9 inches) from the row crop. In the case of eschallots, celery, lettuce, cabbage and pak choi, the fertilizer is placed 7-10 cm (3-4 inches) away from the row of crop.

A soil test is generally recommended for efficient fertilizer application. In the absence of a soil test, the recommendation in the Farmers' Manual (Homenauth, 2007) should be followed.

### **5.8 Fertilizing Fruit Crops**

Fertilizing fruit crops begins with the preparation of the planting holes, since most fruit crops are transplanted. Planting holes should be at least 60 cm (2 feet) across if circular or of 60 cm side, if square, and 60 cm deep. The soil from the top 30 cm of the hole should be kept separate from the soil below this depth.

The soil from each portion of the hole should be mixed with manure, compost or the appropriate mineral fertilizer. The soil from the top half of the hole, after mixing, should be put in the bottom. The remaining soil should be placed when transplanting occurs. It is always advisable that when filled, the top of the hole should be a mound about 15 to 20 cm (6 to 8 inches) higher than the surrounding area. This allows for settling of the soil and prevents water logging of the young tree.

Recommendations for fertilizer applications are dependent on the type of fruit crop. Generally, either annual or bi-annual applications of fertilizers or manures are required. When fertilizers are to applied, these should be placed in a circular band around the tree. Fertilizer application should not be beyond the drip line. This is the recommended practice for crops such a coconuts, citrus, avocado and papaw.

A slight modification of this method of incorporation is to band the fertilizer at three or four places under the tree. Again, this should not be beyond the dripline.

The various fruit crop require different rates and timing of fertilizer application. Many of these recommendations are provided in the Farmers' Manual (Homenauth, 2007).

## 5.9 Fertilizing Rice

The removal of nutrients by rice varies with variety, with crop yield as influenced by environmental conditions, and especially with the level of soil fertility. According to the GRDB (2009), a moderate yielding rice crop removes from the soil 56kg N, 34kg P<sub>2</sub>O<sub>5</sub> and 50lb K per acre). The amount of N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O taken up in the total rice crop to achieve a yield level of 7840 kg/ha are 125 kg, 67 kg P<sub>2</sub>O<sub>5</sub> and 188 K<sub>2</sub>O kg/ha, respectively.

The rates and timing of fertilizer application for rice are shown in Table 5 (GRDB, 2009).

**Table 5: Rate and Timing of Fertilizer Application for Rice**

Soil Area	Type of fertilizer	Timing of Application	Quantity	Comments
Frontland Clay Soils	Triple Super Phosphate (TSP)	Pre-plant, incorporated or pre-plant or early post-plant on drained soil.	62 kg/ha (55 lbs/ac)	If conditions are unsuitable for preplant incorporation TSP may be applied in mud during early seedling stage.
	Muriate of Potash (MOP)	Pre-plant, incorporated or pre-plant or early post-plant on drained soil.	62 kg/ha (55 lbs/ac)	If conditions are unsuitable for preplant incorporation MOP may be applied in mud during early seedling stage.
	Urea	Part of crop requirement (1/2 to 2/3) may be applied preplant and incorporated or may be delayed and applied on drained field between 18 and 21 days.  The remaining quantity (1/2 to 1/3) may be applied to actively growing crop between 42 – 45 days after sowing.	185 to 247 kg/ha or 3 to 5 bags/ha (165 to 220 lbs/ac or ½ to 2 bags/ac)	Draining fields before urea application will facilitate movement into the soil profile when fields are irrigated following application.

## **5.10 Some General Rules for Commercial Fertilizer Use**

There are some basic guidelines that farmers need to be aware of regarding the use of fertilizers. These are summarized below:

Avoid fertilizer salt injury

If too much fertilizer is banded near the seedling roots, the roots may be injured (evidenced by wilted leaves and scorched leaf tips and edges).

Rule: NO MORE THAN 90kg/ha (80lb/A) of N + K<sub>2</sub>O SHOULD BE USED IN A FERTILIZER BAND

### **1. AVOID UREA AND DAP INJURY**

If too much urea and/or DAP is banded near the seedling, injury due to NH<sub>3</sub> Toxicity (or NO<sub>2</sub>– accommodation) may result.

Rule: IN THE FERTILIZER BAND THERE SHOULD BE NO MORE THAN:

1. 22 kg N/ha (20lb/A) as UREA
2. 34 kg P<sub>2</sub>O<sub>5</sub> /ha (30 lb/a) as DAP
3. 22-34 kg N from UREA and DAP combined
4. 34-45 kg of Ammonium N from ALL sources used with DAP

## 6.0 FERTILIZER CALCULATIONS

### COMPUTING FERTILIZER RECOMMENDATIONS

Very often, farmers need information on the exact quantities of fertilizers to apply. Fertilizer recommendations are generally given in kg/ha (lb/A) and farmers may need to know how much to apply per plant as well. The following examples will illustrate how these computations could be done.

1. The recommended N rate is 40kg/ha (a) Determine the amount of urea that is needed to supply this amount of N. (b) If this farmer has 500 pepper plants, how much urea would he/she need to apply to each plant.

An assumption that would be made in all calculations is that  $\text{kg/ha} \approx \text{lb/A}$ .

- (a) Urea contains 46% N.

$$\begin{array}{ll} 46 \text{ kg of N are provided by} & 100\text{kg of urea.} \\ 1 \text{ kg of N is provided by} & \underline{100} \text{ of urea} \\ & 46 \\ 40 \text{ kg of N are provided by} & \underline{100} \times 40 \\ & 46 \\ = & \underline{88} \text{kg Urea/ha} \end{array}$$

- (b) In this case, there is need to know the recommended plant spacings. Assuming that the spacing is 1m x 1m, then there would be 10,000 plants/ha.

$$500 \text{ plants would be equivalent to } \frac{500}{10,000} = 0.05 \text{ ha}$$

$$\text{Amount of urea required} = 88 \times 0.05 = 4.4 \text{ kg}$$

$$\text{Urea requirement/plant} = \frac{4.4 \text{ kg}}{500} = 8.8 \text{g/plant}$$

Alternatively, using lb/A

Using the same spacing, this would amount to approximately 4048 plants/A

500 plants would be equivalent to  $\frac{500}{4048} = 0.12\text{A}$

Amount of urea required =  $88 \times 0.12 = 10.56 \text{ lb}$

Urea requirement/plant =  $\frac{10.56}{500} = 0.02112 \text{ oz/plant}$

(1 oz = 28g)

2. The recommended N rate is 20 kg/ha. If a compound fertilizer such as 5-10-10 were to be used, how much would be required/ha.

5 kg of N are provided by 100 kg of fertilizer.

1 kg of N is provided by  $\frac{100}{5} = 20$  kg of fertilizer

20 kg of N are provided by  $\frac{100}{5} \times 20 = 400$

= 400kg/ha (or 400 lb/A)

3. Suppose the recommended P<sub>2</sub>O<sub>5</sub> addition is 30 kg /ha and you have to use a 11-48-O fertilizer, what would be the fertilizer requirement in kg/ha?

48 kg P<sub>2</sub>O<sub>5</sub> are provided by 100 kg of fertilizer

1 kg P<sub>2</sub>O<sub>5</sub> is provided by  $\frac{100}{48} = 2.083$  kg of fertilizer

30 kg P<sub>2</sub>O<sub>5</sub> are provided by  $\frac{100}{48} \times 30 = 62.5$

= 62.5 kg/ha

4. A farmer was advised to use 100 kg/ha of 15:15:15 on his farm. Assuming that there was no 15-15-15 available but he has urea, TSP and MOP, how would he need to mix these to satisfy the recommendation?

Recommended rate	=	100 kg/ha of 15-15-15
Amount of N required	=	15 kg
Amount of P2O5 required	=	15 kg
Amount K2O of required	=	15 kg
Amount of urea required	=	<u>100 x 15 = 33kg</u> 46
Amount of TSP required	=	<u>100 x 15 = 33.3 kg</u> 45
Amount of MOP required	=	<u>100 x 15 = 25 kg</u> 60

So the farmer would need to mix 33 kg of urea, 33.3 kg of TSP and 25 kg of MOP to satisfy the recommendation.

5. The fertilizer recommendation for the “bullnose” Scotch Bonnet pepper is 1 oz of 15-5-35 at planting. If you have to use urea, TSP and MOP, what quantities of these fertilizers would be required per hectare?

Number of plants/ha = 10,000 (using a 1m x 1m spacing)  
Amount of fertilizer = 10,000 x 1 x 28 = 280 kg/ha  
1,000

Need to prepare a 280 kg mixture so that the elements are in a ratio of 15-5-35 using urea, TSP and MOP.

15 kg N requires	=	33.3 kg urea
5 kg P2O5 requires	=	11.1 kg TSP
35 kg K2O requires	=	<u>58.3 kg MOP</u> <u>102.7 kg of mixture</u>

102.7 kg of mixture contains 33.3 kg urea  
 $\therefore$  280 kg mixture contains  $33.3/102.7 \times 280 = 90.8$  kg

102.7 kg of mixture contains 11.1 kg TSP  
 $\therefore$  280 kg of mixture contains  $11.1/102.7 \times 280 = 30.3$  kg

102.7 kg of mixture contains 58.3 MOP  
 $\therefore$  280 kg of mixture contains  $58.3/102.7 \times 280 = 159$  kg

It is necessary therefore to mix 90.8 kg of urea, 30.3 kg of TSP and 159 kg of MOP to satisfy the fertilizer requirement per hectare.

#### ALTERNATIVELY in lb/A

Using a 3'x3' spacing, one acre will accommodate 4840 plants.

4840 plants will require 4840 oz or 300 lb of 15-3-35

4840 plants will require 4840 oz or 300 lb of 15-3-35

Need to prepare 300 lb mixture so that the elements are in a ratio of 15:5:35 using urea, TSP and MOP.

15 lb N requires		33.3 lb urea
5 lb P <sub>2</sub> O <sub>5</sub> requires	=	11.1 kg TSP
35 kg K <sub>2</sub> O requires	=	58.3 kg MOP
		<u>102.7 kg of mixture</u>

102.7 lb mixture contains 33.3 lb urea  
 $\therefore$  300 lb mixture contains  $33.3/102.7 \times 300 = 97.3$  lb urea

102.7 lb mixture contains 11.1 lb TSP  
 $\therefore$  300 lb mixture contains  $11.1/102.7 \times 300 = 32.4$  lb TSP

102.7 kg of mixture contains 58.3 MOP  
 $\therefore$  300 kg of mixture contains  $58.3/102.7 \times 300 = 170.3$  lb MOP

It is necessary therefore to mix 97.3 lb urea, 32.4 lb TSP and 170.3 lb MOP to satisfy the fertilizer requirements per acre.

## **7.0 ENVIRONMENTAL EFFECTS OF FERTILIZER USE**

### **7.1 Introduction**

The determination of the optimum quantities of fertilizers required by crops is considered necessary in a good agricultural management system. Efficiency of fertilizer use by crops is of major agronomic interest. There is growing concern that fertilizers be used as efficiently as possible to minimize losses and environmental pollution.

### **7.2 Loss of Soil Nutrients**

Nutrients are lost from the environment through crop removal, leaching, denitrification, volatilization and erosion.

#### **7.1.1 Crop Removal**

The nutrients that are taken up by crops are responsible for the major depletion of nutrients in the soil. Fertilizers are used to replenish these nutrients in an economical way.

#### **7.2.2 Leaching**

Leaching is a serious factor in sandy soils (light -textured ) and well drained soils. Leaching is primarily responsible for the loss of potassium, magnesium and calcium from the soil. The nitrate form of nitrogen is also very susceptible to leaching.

#### **7.2.3 Denitrification**

Denitrification is the loss of nitrogen (either in the form of nitrous oxide or nitrogen gas) from the soil. The process occurs when soils become depleted of oxygen (under waterlogged conditions).

#### **7.2.4 Volatilisation**

Volatilisation is the loss of nutrients through evaporation. This only affects ammonia. Losses can be very high when ammonia or ammonia producing fertilizers are improperly applied.

#### **7.2.5 Erosion**

Erosion is responsible for the loss of the greatest quantities of nutrients from the soil as well as causing soil degradation. Phosphorus is the nutrient most affected by erosion.

### **7.3 Plant Nutrient Mismanagement**

The mismanagement of plant nutrients has many negative environmental consequences. These arise from plant nutrient transfers out of the soil/crop system. The harmful modifications induced by these transfers are shown below:

Nitrogen is the surface water	Quality of the drinking water eutrophication
Nitrogen in ground water	Quality of drinkable water
Phosphorus in surface water	Eutrophication
greenhouse gases to the atmosphere	Climate change

### **7.4 Fertilizer Use and the Environment**

The inefficient use of fertilizers can result in environmental pollution. The ways through which pollution occurs are eutrophication, high nitrate levels in water, soil acidification and greenhouse gas emissions.

#### **7.4.1 Eutrophication**

Eutrophication is a process whereby water bodies such as trenches, canals, lakes, etc., receive excess nutrients (such as nitrate from applied fertilizer N) that cause excessive plant growth (algae, weeds, etc.). The resulting increased plant growth significantly reduces the amount dissolved oxygen in the water. This can result in the death of animal species (fauna) in the water. Visually, water may become cloudy and discoloured (green, yellow, brown or red).

Eutrophication results from high application rates of inorganic fertilizers in order to maximize crop yields. Further, the high solubilities of these fertilizers leads to increased run-off as well as leaching into the groundwater.

#### **7.4.2 High Nitrate Levels in Water**

Nitrate ion which result from the application of N fertilizers to soil can be leached into groundwater or transported into drainage canals. Levels of nitrate above 10 mg/L (10pppm) are toxic. Water with these levels of nitrate should not be used for drinking purposes.

#### **7.4.3 Soil Acidification**

The continuous use of N containing inorganic and organic fertilizers can result in soils becoming acidic. This has a bearing on the availability of soil nutrients especially phosphorus and some micronutrients. The increased acidity can be corrected with the application of lime.

#### **7.4.4 Atmospheric Effects**

Methane is emitted from croplands which become submerged. Emissions of methane are common in rice fields (lowland rice). These emissions are increased with the application of ammonium-based fertilizers and can contribute to climate change as methane is a potent greenhouse gas.

The increasing use of N fertilizers results in some loss of nitrous oxide (N<sub>2</sub>O) through denitrification. Nitrous oxide is the third most important greenhouse gas after carbon dioxide and methane.

## **8.0 STORAGE AND HANDLING OF FERTILIZERS**

### **8.1 Introduction**

Fertilizers pose little danger to the environment (principally groundwater) once stored and applied properly. The storage and handling of fertilizers is not a serious issue in Guyana. Most farmers only purchase the quantities that are needed at a particular time. Some amount of storage is however required by rice farmers. Fertilizers are always bagged when stored.

### **8.2 Storage and Handling of Fertilizers**

The bulk of the fertilizers used by farmers in Guyana is in the bagged form. There are certain basic requirements for the storage and handling of bagged fertilizers.

#### **8.2.1 Use of Pallets**

When bagged fertilizer is to be stored, the bags should be stacked to prevent them from falling. The bags should be checked for soundness and the storage area must be kept dry. For periods of long storage, pallets should be used to keep the bags off the floor or ground and out of the way of activities that might cause the bags to open.

#### **8.2.2. Handling Damaged Bags**

If a bag is accidentally damaged, re-bagging should be done. It is also advisable to use this fertilizer as soon as possible. A dry hard clean surface underneath the storage area will greatly improve the farmer's ability to recover spills and reduce the possibility of contamination.

### **8.2.3 Other Special Storage and Handling Requirements**

Storage areas should be well drained. The storage area must be properly covered to prevent rainwater from entering. It should also be adequately ventilated.

Some fertilizers such as urea are hygroscopic, i.e. they absorb water from the air which can result in 'caking' of the fertilizing. This makes handling and application very difficult. Further, this can result in over application of the fertilizer which can result in fertilizer 'burns'.

Care must also be taken to ensure that fertilizers do not remain on the handler's body. This can result in burns as well as in some cases allergies. Continuous use of the hands to handle fertilizers result in the palms feeling 'thin' (like some of outer skin membranes are lost). Hands should be thoroughly washed after fertilizers have been applied.

### **8.2.4 Special Case of Urea**

This is the fertilizer used in the largest quantity by farmers in Guyana. Consequently, special precautions must be taken with the storage and handling of urea.

- Keep away from open flames.
- Avoid contamination with foreign matter.
- Sweep up and dispose of all contaminated matter.
- Keep it separate from other materials stored, especially combustible materials.

NARI

November 2013

## NOTES

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