Fertilizers As Sources Of Plant Nutrients

Introduction

Generally, it is agreed that there are 17 essential plant nutrient elements. Three major essential elements H, C, O, are obtained from atmosphere and water through photosynthesis. The other 14 essential mineral elements supplied by the soil, of which 12 are usually managed in agriculture through the use of fertilizers. These consists of the macro-nutrients (N, P, K, Mg, Ca, S), and the micro-nutrients (B, Cu, Zn, Fe, Mn, Mo). The other 2 are Cl & Ni. There are a few other elements, such as Na, Si, Se, V and Co, which are not essential, but may be beneficial to some plants either directly or indirectly.

Fertilizers are any solid, liquid or gaseous substances containing one or more plant nutrients. They are either applied to the soil, directly on the plant (foliage) or added to aqueous solutions (fertigation), in order to maintain soil fertility, improve crop development, yield and, or crop quality. Organic fertilizers are fertilizers derived from organic matter - animal matter, human excreta or vegetable matter (e.g. compost, manure). Inorganic fertilizers are those made from or containing material that does not come from plants or animals, and therefore exclude carbon-containing materials except ureas.

Main nutrients in oil palm

In oil palm as in many other crops, the main nutrients that are supplied as fertilizers are Nitrogen (**N**), Phosphorus (**P**) and Potassium (**K**). However, because of inherent soil deficiencies, as well as the high nutrient removal by the oil crop, the supply of other nutrients such as Magnesium (**Mg**), and Boron (**B**) are also often necessary. Other nutrient elements inputs such as Sulphur (**S**), Copper (**Cu**), Zinc (**Zn**), and Iron (**Fe**) may also be necessary for palms grown in certain soils.

N-Fertilizers

The commonly used N-fertilizers in Malayisa are ammonium sulphate (AS), ammonium chloride (AC), and Urea. Nitrogen is also present in some P-fertilizers such as di-ammonium phosphate (DAP) or other nitrogen phosphates (NPs). There are other less used N-fertilizers such as ammonium nitrate (AN), calcium ammonium nitrate(CAN), and ammonium sulphate nitrate (ASN).

P-Fertilizers

The most commonly used P source for oil palm has been ground rock phosphates because of the notion that these are the best sources for acidic soils of the region which are able to dissolve the otherwise water insoluble phosphate rock. The most commonly used materials in Malaysia today are from the Middle East, and these have a total P_2O_5 content of about 28%, and a citrate soluble P_2O_5 content of between 6 - 9%. For the P to become available to the palms, the phosphate rocks have to be finely ground in order to maximize the surface area of the particles for effective dissolution by the soil acids. Most materials imported today do not meet the SIRIM standards in their particle fineness. Practically, for the P to be available, it has to remain on the soil for a prolonged period due to its poor solubility. In reality, this may not be the case as heavy and intense rainfall often results in the undissolved particle being washed away with the other surface sediments in the water runoff. The use of more soluble forms of phosphorus fertilizers such as DAP, MAP or TSP warrants serious considerations both from an agronomic as well as economic stand-point.

K-Fertilizers

The K-fertilizer most commonly used in the country is potassium chloride (MOP). Other K-fertilizers used are Korn-Kali (K+Mg), Korn-Kali+B (K+Mg+B), and potassium sulphate (SOP). Korn-Kali fertilizers contain both MOP and Kieserite within each granule, and also Borate in the "+B" grades. SOP is used in chlorine (Cl) sensitive crops, whose quality or yield are affected by Cl, such as tobacco, citrus, tomatoes, coffee, potatoes and soybean. It is also recommended for crops grown on saline soils.

Mg-Fertilizers

Kieserite, the magnesium sulphate mineral, is the main Mg fertilizer used in the country. The synthetic form – magnesium sulphate is also used. Korn-Kali and Korn-Kali+B also contain Mg in a balanced proportion to K. Other magnesium containing materials such as dolomite and magnesite are not immediately soluble, and are used usually as liming materials, and are not as fertilizers for corrective applications.

B-Fertilizers

Until about twenty years ago, the very soluble sodium borate has been the only source of B used although it has been long established B is phloem immobile in oil palm. The small amount of between 100 – 150g of sodium borate per palm is applied in a single application a year. B from sodium borate is taken up in excessive levels immediately after application, and thereafter, the B availability in the oil is quickly reduced because of leaching losses. The phenomena of good frond-17 B-levels, despite deficiency symptoms showing, testifies to the inadequacy of this practice. The splitting of the B requirements of the palm into as many rounds as possible has been shown to be a far more effective way of supplying the micronutrient, and this is only possible when B can be incorporated into more rounds. The use of Korn-Kali+B, either as straight applications or as a component in bulk blends, is an example of how this is easily achieved. Less soluble but fully available forms of B, such as calcined Ulexite, are used in many countries throughout the world as a suitable source for B-immobile crops. This was introduced into oil palm some twenty years ago, and today, it is available as a straight fertilizer, or in combination with Kieserite which serves as carrier for the micronutrient and a Mg source as well.

Other micronutrients

The application of other micronutrients like Copper (Cu), Zinc (Zn), and Iron (Fe) in certain soils such as ultrabasic, deep peat or sandy soils may be necessary when deficiency symptoms occur. Common sulphates of the metal are the cheapest sources, and can be applied on the soil, as a foliar spray, or as incorporated in a mud ball. Chelated forms of these metals are also used as they are less easily fixed. They are more expensive, but the rates applied usually can be reduced because of the higher efficacy.

Sulphur

The Sulphur (S) status of soils in Malaysia and Indonesia has been studied very briefly by some. S is an important nutrient especially in oil producing crops, and is also a very easily leached nutrient in high rainfall areas. The prolonged use of non-S containing fertilizers such as Urea for N, and dolomite for Mg, may result in S-deficiency in the soil. S is usually needed in the same proportions as Mg, and thus Kieserite and Korn-Kali are ideal sources for S. Ammonium sulphate supplies large amounts of S as well.

Multi-nutrient fertilizers

Some plants, especially the annual crops such as rice, has different demands for the different nutrients at different stages of its development, and therefore the nutrient types and amount have to be timed accordingly. For perennial crops such as the oil palm which has a large trunk that serves as a reservoir of nutrients, the timing of fertilizer application is more dependent on the weather conditions. Typically, the total fertilizers per palm per year need to be split into at least 4 rounds. In most locations in Malaysia, the year-end monsoon period does not allow fertilizer application due to heavy leaching and run-off losses, and the fair to good weather months for fertilization per year may be limited to only about 8 months. As a result of this, many plantations find it difficult to apply many rounds of straight fertilizers, and the use of multi-nutrient fertilizers in the form of powder mixtures, granular bulk blends, or compound fertilizers becomes a necessary choice.

Fertilizer blends

Fertilizer mixtures or blends are the physical mixing of two or more fertilizer components to achieve a combination of various kinds – N-K, N-P-K, N-P-K-Mg, N-P-K-Mg+B, P-Mg, Mg+B, etc. When the components are all in granular form, it is called a granular blend. The components in a blend can segregate into less homogenous distribution as it is handled before use. Segregation occurs most when the components are not similar in size, resulting in the fine materials settling to the bottom of the packaging. Segregation is therefore less in granular blends, and within such blends, when the components are of similar granule size. A good blend can be achieved when the number of granular components can be minimized (e.g. to two or three), and be of similar proportions (e.g. 40:60, 50:50). Similarly, if a component is small (e.g. 5% of granular borate) compared to the rest, a good blend is harder to achieve.

Most fertilizers can be blended with each other, with varying compatibility. Poor compatibility usually involves reduced critical relative humidity, causing the mix to turn wet and physically unmanageable, e.g. urea with nitrate based fertilizers or single superphosphate.

Part of the work of the agronomist is to be able to derive the nutrient levels required for the various fields, and then to convert the straight requirements into equivalent mixtures. The use of at least two to three common blends for all fields, with one to two rounds of special blends or straights to correct for deficiencies is a most practical approach.

Compound fertilizers

Fertilizers can also be blended and then granulated to fix the nutrients and prevent segregation. The commonly used term for such fertilizers is to call it a compound fertilizer. Granulation can occur either by a wet-granulation process or a dry-granulation process. The wet-granulation process, as the name suggests, uses a wet-phase (urea-melt, or steam, or water, or combinations of the above) to cause granule formation. Drying is necessary after the granulation before the granules are sieved to obtain the desired size. In such a process, the binding of the components into individual granules with the desired proportions is hard to achieve, and the management of the hygroscopic nature of the urea is difficult. Products typically are more variable in analysis. In the dry granulation method, the components are accurately measured, mixed, and then compacted immediately in a hardened flake. The flakes are then broken down into smaller granules, and then sieved to get the desired product. Ideally, no wetting and drying is involved. Urea is seldom used in compaction granulation, so the associated problems are also avoided. Consistent product analysis is easier to achieve.

In evaluating a compound fertilizer, the nutrient percentages alone do not tell the full story. It is important to know what are the sources of raw materials used, e.g. source of N, solubility of P and Mg. It is also important to know the granulation process used to produce the fertilizer.

Complex fertilizers

The afore-mentioned compound fertilizers which are actually granulated blends, are not to be confused with a higher grade compound fertilizer, sometime referred to as complex fertilizers. These use either pipe-cross reactors to chemically melt NH_3, acids containing S or P, and other nutrients such as K and micronutrients into a granular fertilizer with a specific nutrient content, or use the nitrophosphate process involving the reacting of phosphate rock with nitric acid, and then adding other nutrient sources to achieve a complete formula. Such products achieve very high product consistency in analysis, and are also more expensive to produce.

Stabilized fertilizers

Stabilized fertilizers are those to which a N-stabilizer has been added in order to extend the time the N component of the remains in the soil in the urea-N or ammoniacal-N forms. Broadly, there are two types of N-stabilizers:

1. Nitrification inhibitors which inhibits the biological oxidation of ammoniacal-N to nitrate-N. This has the net effect of less leaching losses of nitrate-N, and higher uptake by plant of ammoniacal-N. Examples: DCD, DMPP
2. Urease inhibitors which inhibits the hydrolysis of urea by the urease enzyme. This can reduce volatilization losses, and increase N-uptake by the plants. Examples: NBPT, 2-NPT.

As environmental concerns are given more attention, the use of such fertilizes in more developed countries has gained importance. Fertilizers with the nitrification inhibitor DMPP are presently available in ENTEC, Novatec and Sato-Kali Special Plus fertilizers in Malaysia. Fertilizers with the urease inhibitor, UTEC, are also available.

Slow-release and controlled release fertilizers

Slow-release fertilizers are fertilizers which contain certain nutrient or nutrients that are released slowly into the soil due to its complex chemical structure. The nutrient is usually N, and examples are urea formaldehyde (UF), crotonylidene diurea (CDU) or isobutyledene-diurea (IBDU). The rate of release is slowed down, and depends on many factors such as the soil microorganisms, moisture content, and soil temperature.

Controlled release fertilizers are fertilizers containing water soluble nutrients, the release of which in the soil is controlled by a protective, water-insoluble coating applied to it. The duration of release is principally affected by the soil temperature, and can be controlled to a certain extent by the choice of coating material and its thickness. Nutrient release is achieved when osmotic pressure builds up within the encapsulated granules, resulting in dissolution, nutrient release, and lengthened duration of release. A blend of controlled release fertilizers of different release durations can be used to tailor the right amounts of nutrients to be released as desired over a period of say six to nine months. This is useful in certain conditions, e.g. poor manpower supply, fertilization of “supply” palms, poor accessibility areas.

Conclusion

Each of the fertilizer sources above, has its own characteristics, and understanding them enables the user to decide which to use, not just from the price per nutrient basis, but also on the basis of its effectiveness which may be affected, apart from its inherent properties, by the weather, soil type, etc. The user is encouraged to understand the concepts of nutrients versus fertilizers; the conversion from one to the other; the nature of the various forms of nutrients and fertilizers; and then to use what is best for his circumstances.

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