# 5. Coconut – Green Dwarf Variety

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## 5.1. Introduction

World coconut production in 2004 reached 54.7 million mt with 84% produced in Asia, by Indonesia, the Philippines and India with, respectively, 30%, 26% and 17% of this production. Brazilian coconut production in the same year was 2.9 mt, which corresponds to 5.3% of world production. The average annual growth in production between 1961 and 2004 was 2% and a world production of 60 mt is projected for 2010. In Asian countries, a large part of the coconut grown is destined for copra production for extraction of oil. However, in Brazil, coconut is used principally for the industrialized food production of coconut milk and flower (Cuenca, 1998). The production referred to above is for giant and hybrid varieties of coconut. However, in recent years, the planting of the dwarf coconut for producing coconut water has expanded significantly in Brazil, and includes the use of irrigation where the level of technology is much superior to that observed in non-irrigated plantations of the giant and hybrid varieties. This chapter aims to collate information about the nutrition and fertilization of the dwarf coconut, facilitating its use by those involved in the production of the dwarf coconut.

## 5.2. Climate, soil and morphology

### 5.2.1. Climate

The coconut requires annual temperatures around 27ºC, without great variation. Temperatures less than 15ºC may cause flower abortion, with negative effects

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on yield. Temperature, as a function of latitude, influences the altitude tolerance of the coconut. Close to the equator, the plant may be cultivated up to 750 m, but with increasing distance from the equator, the plant is grown at lower altitudes. The air relative humidity may influence plant development when it is lower than 60%. On the other hand, very high humidity may favor the development of diseases, as well as diminish the absorption of nutrients because of decreased transpiration. Not only the amount of rain, but more so its distribution has a strong influence on the growth of the plant. Total annual rainfall of around 1,500 mm, with a minimum of 125 mm rain each month, is satisfactory. Lack of rain may be compensated either by water within the soil but the depth of water table should not exceed 3 m, or by irrigation. The plant does not develop in low light intensities. Annual irradiation of 2,000 hours, with a monthly minimum of 120 hours is considered adequate (Fremond *et al.,* 1966). Weak to moderate winds may positively influence growth because of its effects on transpiration and nutrient absorption (Passos, 1998), but winds during drought periods may aggravate water deficit.

### 5.2.2. Soil

Coconut grows best in soils in soils with the certain characteristics. It does not tolerate excessively clayey soils and those that have compacted and impermeable layers, which impede root penetration or create poor aeration conditions (Fremond *et al.,* 1966). The root system develops best in sandy soils where it can exploit a greater volume of soil. The dwarf coconut has been grown on Spodosols, with sandy A and B horizons and an accumulation of organic-metallic complexes. However, some variations of the Spodosols that have a hardpan, fragipan and duripan should be avoided, because the dense soil layer limits root growth. The Fluvial Neosols (Alluvial) and Quartz Neosols (Sandy Quartz) are less naturally fertile but are also suitable for coconut. The addition of organic matter improves the chemical and physical conditions of these soils. The Latosols and Yellow Argisols in the flatlands have good potential for irrigated plantations but the occurrence of a fragipan and duripan at depths of less than 1 m could limit root growth (Embrapa, 1999).

Opening larger pits for planting may not resolve the problem of root growth in soils with compacted or hardened soil horizons, because root growth is restricted when the roots grow out of the soil in the planting pit.

### 5.2.3. Morphology

The coconut (*Coco nucifera* L.) is a monocotyledon of the Palm family. It possesses a fascicular root system made up of thick roots (primaries) whose principal function is to anchor the plant in the soil. These primary roots have little capacity for absorption, but from them come secondary roots and from these come tertiary roots from which come rootlets that are responsible for the absorption of water and nutrients (Fremond *et al.,* 1966). Cintra *et al.* (1992) showed that between 70% and 90% of dwarf coconut roots are within a 1.8 m radius of the centre of the stem and at a depth of 0.60 m. The trunk is a stem and at its apex is the only point of plant growth. The leaf is a fan type that has an elongated stalk (axis) to which the leaflets are attached. The inflorescence is a panicle, formed by the peduncle and head on which are the male flowers in the superior two thirds and the female flowers on the base. Bracts, which join to form the husk, protect the inflorescence. Both nutritional state and water stress may influence the number of female flowers, from which originate the fruits after fertilization. The fruit is a drupe, formed by an outer shell, a fibrous flesh, where large quantities of potassium (K) and chloride (Cl) accumulate, and an endocarp (shell), the hard layer around the seed. Initially, the interior of the shell is occupied by coconut water, which starts to form approximately two months after the opening of the inflorescence and reaches a maximum volume after six to seven months. The water decreases with the formation of solid albumen, at first jelly-like, which progressively solidifies (Passos, 1998).

## 5.3. Soil and crop management

Dwarf coconut seedlings are grown from seeds collected between eleven and twelve months after fertilization of the flowers. Two systems may be used for seedling production. In the conventional system, the seeds are put in a germinator where they remain for four months. During this period the seeds that germinate are transplanted to a nursery where they remain for six to eight months (Fremond *et al.,* 1966). In the alternative system, the seeds are put in the germinator, reducing the number of seeds per square meter from 30 to 20, and then the seedlings are transplanted directly to the field, at five to six months old, without going to a nursery. This system reduces production cost and time, without compromising the final quality of the seedling (Fontes *et al.,* 1998). When preparing a plantation, the ground is marked in equilateral triangles, with the main planting row in a north-south direction, to allow a greater period of direct radiation for the plants. The recommended spacing is 7.5 m, giving 204 plants/ha. To decrease any adverse effects of transplanting the seedling and provide an adequate volume of soil for the initial development of the plant in the field, planting pits are used. The pits should be opened and pre-filled with organic matter, lime and a phosphorus (P) source according to the results of soil analysis. Weed competition interferes directly with plant growth, period to maturity and productivity (Fontes *et al.,* 1998). Chemical weed control is preferred in the area covered by the crown of the plant. Post-emergence products are recommended and should be applied before the weeds flower. Glyphosate is recommended for the control, principally, of grass. Between the rows, mechanical mowing may be used. In regions with an established dry season, the occurrence of stoloniferous grasses may make ploughing necessary. This should be done sparingly and shallowly (20 cm), to avoid damage to the root system and soil structure. The latter because of the risk of soil erosion and leaching of nutrients when the rainy season comes. Planting legumes between the rows minimises weed growth and can also enrich the soil with nitrogen (N) through symbiotic fixation. Fallen leaves and clusters, from where the fruits were collected, should be spread out over the soil and mulched through mechanical mowing. These materials, especially in sandy soils, serve to improve water and nutrient retention. In situations where the coconut shell is returned to the field, it may also contribute to improve the moisture retention of the soil.

Of the coconut varieties, the dwarf coconut is the most sensitive to water deficit. In regions where there is a defined dry season, irrigation where water is available is required to produce large yields. Amongst the methods of irrigation, jet and surface dripping are the most appropriate (Nogueira *et al.,* 1998). Jets are placed in the region of greatest root growth, which occurs in a radius of up to 1.80 m from the plant (Cintra *et al.,* 1992). For dripping, a hose is connected to a lateral line around the trunk, with the drip also placed in the region of greatest root growth. The amount of water required is estimated to be between 100 and 150 L/tree. However, the actual amount depends on climatic factors so that local adjustments should be made.

For the identification of diseases and their control consult Ferreira *et al.* (1998).

Where the fruits are produced for coconut water they are collected between six and seven months old. In this stage of maturity the fruit weighs about 2.4 kg with approximately 600 ml of water, with a pH around 5.0 and Brix value at 20º about 5.8. Variations in fruit weight and water volume may be associated with nutritional problems and water deficiency which, when severe, may cause a change in the fruit’s shape, which becomes oblong.

## 5.4. Mineral nutrition

### 5.4.1. Uptake and export of nutrients

The amount of nutrients in dwarf coconut fruits were estimated using data from Ouvrier (1984) and recalculated according to Sobral (1998). For a yield of 200 fruits/plant/yr, the offtake of N, P, K, Ca, Mg, S and Cl, are approximately: 87.71; 12.44; 169.77; 6.02; 9.48; 7.85 and 92.0 kg/ha/yr, respectively. The largest offtakes are of N, K and Cl. Uexkull (1972) demonstrated the importance of Cl in coconut nutrition. By virtue of the quantity of Cl removed, the authors propose that this nutrient be considered a macro-nutrient for coconut. The demand for P, Ca Mg and S is less than that for N, K and Cl.

### 5.4.2. Functions and importance of nutrients

*Nitrogen (N)*: Lack of N causes gradual yellowing of the leaves (Plate 5.1) and a reduction of the number of female flowers. With acute deficiency, there is a decrease in the number and size of the leaves and a narrowing of the stalk, causing what is called a “pencil tip”. Sobral and Leal (1999) observed that N influenced the number of fruits of the giant coconut and considered that 17.18 g/kg as the critical N level in leaf 14. Sobral (2004) observed an increase in the number of green dwarf coconut fruits when the plant was fertigated with N as urea.

*Phosphorus (P)*: Phosphorus deficiency causes reduced growth and darker green leaves caused by a greater relative concentration of chlorophyll. The removal of P in the harvested fruits is small (Table 5.1), but in soils with very low levels of plant-available P the nutrient becomes limiting.

*Potassium (K)*: The symptoms of K deficiency are characterized by the appearance of rust colored stains on both sides of the leaves that become more intense at the extremities, and eventually developing into necrosis (Plate 5.2). For the plant as a whole, yellowing of the leaves in the middle of the crown may indicate K deficiency, followed later by the drying of the oldest leaves. The younger leaves remain green (Manciot *et al*., 1980). Potassium is exported in large quantities in the fruits. Occasionally an apparent anomaly may be seen with K. Analysis may show large amounts of K in the leaves but this does not signify good K nutrition. Potassium can accumulate in the leaves when other factors cause poor fruit yields and hence transfer of K to the fruits is limited.

*Chlorine (Cl)*: Uexkull (1972) demonstrated the importance of the nutrient Cl for coconut when the application of KCl increased the weight of albumen, from 117 to 216g, and the composition of Cl, from 0.40 to 2.33 g/kg in leaf number 14. The composition of K in the same leaf varied only from 10.9 to 11.7 g/kg, *i.e.* K was not increased by the addition of more K. The symptoms of K deficiency appear first in the oldest leaves, which yellow and have orange spots. The leaflets dry along the edges and extremities, and the fruits are smaller.

*Calcium (Ca)*: The first symptoms of Ca deficiency appear on leaf numbers 1, 2 and 3 and they become yellow and rounded, turning brown at the centre. The spots are isolated in the early stages, joining and drying later on. In young leaves, the spots are uniformly distributed, however starting from leaf number 4 the spots are concentrated at the base of the leaf. Plants with such symptoms contained only 0.85 g/kg Ca in leaf number 4 (Dufour *et al.,* 1984).

**Table 5.1.** Critical levels of macro- and micro-nutrients in leaves 9 and 14 of the green dwarf coconut.

| Nutrient | Leaf n° 9 | Leaf n° 14 |
|---|---|---|
| Macro-nutrient | ---------------------------------g/kg--------------------------------- | |
| N | 21.0 | 22.0 |
| P | 1.50 | 1.40 |
| K | 16.0 | 15.0 |
| Ca | 3.0 | 3.5 |
| Mg | 3.0 | 3.30 |
| S | 1.3 | 1.5 |
| Micro-nutrient | --------------------------------mg/kg--------------------------------- | |
| Cl | 8.0 | 7.5 |
| Na | 1.5 | 1.3 |
| B | 17.0 | 20.0 |
| Cu | 5.0 | 5.0 |
| Mn | 60.0 | 65.0 |
| Zn | 14.0 | 15.0 |
| Fe | 35.0 | 40.0 |

*Sources*: Holanda, J.S de, 2004; Raij, B. van., 2004; Sobral, L.F., 2004; unpublished data.

*Magnesium (Mg)*: The symptoms of Mg deficiency appear first in the old leaves. At the extremities of the leaflets and the parts exposed to the sun, the yellowing is more intense, while the leaves close to the trunk remain green (Plate 5.3). When the deficiency becomes severe, there is a necrosis on the extremities of the leaflets, which become dark yellow. At this stage translucent spots become visible.

*Sulphur (S)*: When S is deficient it is not translocated from the older to the newer leaves (Mengel and Kirkby, 1978). In young coconuts, when there is a deficiency of S the new leaves become yellowish (Plate 5.4) and orangey, with necrosis on the extremities of the leaflets. In the adult coconut there is a reduction of the number of living leaves, which become yellow. In the oldest leaves the stalk becomes weak and it bends around the stem. The number of fruits is small and approaches zero when the deficiency is serious. The albumen, after drying (copra), becomes thin and elastic and contains little oil (Southern, 1969).

*Boron (B)*: B deficiency is manifest in the leaflets, which are joined at the extremities. In severe cases the leaflets at the base of the stem are smaller, crest, and may even disappear. When B deficiency is very severe the point of growth completely deforms, preventing the development of the plant (Plate 5.4). In young coconuts, deficiency may be corrected by applying 30 g of borax at the axial of leaf number 4. In adult coconuts, B can be added as borax mixed with other fertilizers and added to the soil. Because the limits of deficiency and toxicity are very close, elevated doses of B may cause toxicity in the plant (Plate 5.5).

*Copper (Cu)*: Deficiency of Cu in coconuts was described by Ochs *et al.* (1993) when the plants were grown in peat soils in Indonesia. Firstly, the stems of the new leaves become flaccid and later bend. Almost simultaneously, the extremities of the leaflets start to dry, going from green to yellow, and finally, to brown – appearing burnt. When the deficiency is serious new leaves are small and chlorotic and the plant may dry completely. In Brazil, Cu deficiency was found in coconuts planted in Quartz Neosols (Sandy Quartz).

*Iron (Fe)*: The symptoms of Fe deficiency were described by Pomier (1969) when found on the Pacific Coralline Islands where the high levels of calcium carbonate render the iron unavailable. It is important to remember that in tropical soils, the presence of iron oxides is substantial.

*Manganese (Mn)*: Mn deficiency is characterized by generalized chlorosis. For coconuts grown in north-eastern Brazil, analysis of leaf number 14 showed great variability in the Mn composition. Sobral (1989), studying the nutritional state of coconuts in Sergipe, showed no direct relationship between Mn in leaves and the burned leaf symptom. It was observed, however, that there is a significant relationship between the composition of Mn in the soil and the leaf.

## 5.5. Liming and fertilizing

### 5.5.1. Determining the need for fertilizers

Determining the need of fertilizers is done best by soil and leaf analysis.

*Soil analysis*: Soil samples should be collected from within the projection of the crown, where fertilizers will be applied, taking about 20 samples to make one sample for not exceeding 10 ha. The sample should be taken at least sixty days after the last application of fertilizer, from depths of 0 to 20 cm and of 20 to 40 cm, because a large part of the plant roots are concentrated at these depths (Cintra *et al.,* 1992). When the plants are fertigated, the samples can be taken at any time and the soils should be collected from the area wetted by the emitter. For liming, the samples should be taken between the rows, at a depth of 0 to 20 cm.

*Leaf analysis*: Leaf analysis for coconut has been adapted from methods developed for the African oil palm (Rognon, 1984), and the first critical nutrient levels for the east African giant coconut were obtained in 1955 (Frémond *et al.,* 1966).

For the green dwarf coconut, the authors of this chapter have found, as a first approximation, critical levels of N, P, K, Ca, Mg, S, Cl and Na, expressed in g/kg, and of Mn, Zn, Cu, B and Fe, expressed in mg/kg, in leaves 4, 9 and 14. These data are shown in Table 5.1.

The principal requirement is that the leaf samples are taken from the middle of the crown and not from very young or very old leaves. This is because there is significant translocation of nutrients between leaves of different ages and this affects the results. Nutrient composition is also affected by leaf position. With leaf age, percent N increases and then later decreases, the levels of P, K and B decrease while those of Ca, Mg and Mn increase. In the adult coconut, the nutrient composition of leaf number 14 best expresses the nutritional state of the plant (Frémond *et al.,* 1966). In young plants, leaves number 4 and 9 may be used. Leaves 4 and 9 can be found as follows: the leaf that has not yet opened, known as the arrow, is leaf zero. The leaf immediately after this is number 1, and so forth until numbers 4 and 9 are reached. Leaf 14 can be found as follows: find the leaf where the most recent open inflorescence is developing in the axial (space between the trunk and the leaf stalk); this is leaf number 10. On the opposite side is leaf number 9, below which is leaf number 14.

To collect leaves, the plantation should be divided into homogenous areas, taking into account the plant's ages, nutritional status and plant health, as well as soil variability. In each homogeneous area, which should not exceed 10 ha, leaflets should be collected from a minimum of 20 plants. In plantations without irrigation, the samples should be collected at the start of the dry season and between the hours of 7 and 11 am. If there has been a rain of more than 20 mm, it is necessary to wait 36 hours, to avoid variations caused by nutrient leaching. Once the sample leaf has been identified, three leaflets are taken from each side at the central part of the leaf, avoiding damaged leaflets. From each leaflet, only the central 10 cm are taken and placed in a paper bag whose identification should contain the location of the sample, the date, tree number and the position of the leaf. If it is not possible to send the samples to the laboratory on the same day, they should be placed in a refrigerator, avoiding freezing.

In the laboratory, the 10 cm central segments are cleaned with cotton soaked in distilled water, and both the central vein and the laminar edges, about 2 mm, are discarded. The samples are dried in a forced air circulation oven at 70 to 80ºC for 48 hours. Temperatures exceeding 105ºC should be avoided to prevent N losses.

### 5.5.2. Liming

For the coconut, a base saturation of the soil of 60 to 70% is recommended. At this level exchangeable Al becomes insoluble and exchangeable Ca and Mg should exceed 20 $mmol_c/dm^3$. In some situations it has been observed that although these values have been reached, the levels of Ca and Mg in the leaves remain below the critical level. In this case, calcium sulphate and magnesium oxide may be used to correct the deficiency.

Liming can be over the entire area of the plantation or only within the projection of the crown. The following criteria may be used to determine how to lime. For soils with a sandy A horizon where kaolinite predominates in the clay fraction, if Al is above 5 $mmol_c/cm^3$ the whole area should be limed to reduce toxicity. The quantity should not exceed 2 mt/ha because these soils have a low retention capacity for cations. In other situations, the Al saturation should be used as a parameter, because the Al-saturation tolerance of the coconut is not yet known.

Where the Al, Ca and Mg levels are low, Ca and Mg should be applied to correct the deficiency. In this case, lime should be applied in a circular area, with the trunk at the centre and the edges at the crown projection as the outer limit (Sobral, 1998). The quantity of lime to be applied per plant is obtained by the proportion between the quantity per hectare and the calculated area of the crown projection. In all cases, incorporation is important, to correct acidity and place Ca and Mg near the roots. Where fertigation is not practised, the interval between liming and fertilization should be at least 60 days. When this advice is ignored, the rapid increase in soil pH after liming can result in N losses by volatilization, soluble P becoming less soluble and K being lost by leaching if Ca and Mg replace K on cation exchange sites.

### 5.5.3. Fertilization

Suggestions for fertilizing dwarf coconut at various stages of growth are in Tables 5.2, 5.3 and 5.4. In the first year, 160 g $P_2O_5$, as single superphosphate, should be added to soil in the planting pit. It is also recommended to apply 450 g of N/plant, but the actual amount will depend on whether the plants are to be irrigated or not and on soil texture. It is important to remember that in the first year the root system is not well developed and nutrients may be leached, especially in sandy soils. From the second year, fertilizer recommendations are based on soil analysis by the resin method. In regions where the Mehlich 1 method is used, the results may be converted to the resin method using the following equations: P (resin) = 0.6901 (Mehlich 1) + 6.3942 and K (resin) = 1.1481 K (Mehlich 1) – 1.8387. It is important to stress that these equations were obtained using non-fertilized soils, where sand is predominant in the A horizon and kaolinite is predominant in the clay fraction in this horizon.

Fertilizer recommendations for N, P and K that take into account expected productivity are shown in Table 5.3.

**Table 5.2**. Fertilizer recommendations for N, P and K for the green dwarf coconut according to plant age, based on leaf analysis for N and soil analysis for P and K.

| Age | Leaf N | | | P-resin ($mg/dm^3$) | | | K-exchangeable ($mmol_c/dm^3$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | <16 | 16-20 | >20 | 0-12 | 13-30 | >30 | <1.6 | 1.6-3.0 | >3.0 |
| yr | -------- N (g/plant) ------- | | | ------ $P_2O_5$ (g/plant) ------ | | | ------ $K_2O$ (g/plant) ------ | | |
| 0-1[(1)] | 450 | 450 | 450 | 0 | 0 | 0 | 600 | 400 | 200 |
| 1-2 | 600 | 450 | 300 | 200 | 150 | 100 | 900 | 700 | 500 |
| 2-3 | 900 | 750 | 600 | 300 | 200 | 100 | 1,200 | 900 | 600 |

[(1)]Blanket application of 450 N gr/plant.

*Sources*: Holanda, J.S de, 2004; Raij, B. van., 2004; Sobral, L.F., 2004; unpublished data.

**Table 5.3.** Fertilizer suggestions for N, P and K for the green dwarf coconut according to expected yield and based on leaf analysis for N and soil analysis for P and K.

| 1,000 fruits/ha | Leaf N (Leaf 14) (g/kg) | | | P-resin ($mg/dm^3$) | | | K-exchangeable ($mmol_c/dm^3$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | <16 | 16-20 | >20 | 0-12 | 13-30 | >30 | <1.6 | 1.6-3.0 | >3.0 |
| | -------- N (kg/ha) -------- | | | ------- $P_2O_5$ (kg/ha) ------ | | | ------ $K_2O$ (kg/ha) ------ | | |
| <20 | 180 | 120 | 80 | 80 | 60 | 20 | 200 | 150 | 100 |
| 30-30 | 220 | 180 | 100 | 100 | 70 | 30 | 250 | 200 | 120 |
| 30-40 | 260 | 200 | 120 | 120 | 90 | 40 | 300 | 240 | 150 |
| 40-50 | 300 | 220 | 140 | 140 | 100 | 50 | 400 | 300 | 180 |
| >50 | 360 | 250 | 160 | 160 | 120 | 60 | 500 | 350 | 200 |

*Sources*: Holanda, J.S de, 2004; Raij, B. van., 2004; Sobral, L.F., 2004; unpublished data.

Table 5.4 shows recommended additions of B, Cu, Mn, and Zn based on soil and leaf analysis. The levels of Cu, Mn and Zn may be converted to the Mehlich 1 method using the following equations: Mn (DTPA) = 0.5036 Mn (Mehlich 1) + 0.5435; Zn (DTPA) = 0.6379 Zn (Mehlich 1) + 0.0122; Cu (DTPA) = 1.153 Cu (Mehlich 1) – 0.1954. As for the P and K conversions given above, these equations were derived using non-fertilized soils with a predominantly sandy A horizon and kaolinite as the principle clay mineral.

**Table 5.4.** Fertilizer recommendations for B, Cu, Mn and Zn based on soil and leaf analysis.

| Nutrient/Analysis method | Soil | Leaf number and nutrient content 9 | 14 | Fertilizer |
|---|---|---|---|---|
| | $mg/dm^3$ | ----- mg/kg ----- | | g/plant |
| Boron (hot water) | 0-0.6 | <17 | <20 | Borax 50 |
| | >0.6 | ≥17 | ≥20 | - |
| Copper (DTPA) | 0-0.8 | <5 | <5 | Copper sulphate 100 |
| | >0.8 | ≥5 | ≥5 | - |
| Manganese (DTPA) | 0-5.0 | <60 | <65 | Manganese sulphate 100 |
| | >5.0 | ≥60 | ≥65 | - |
| Zinc (DTPA) | 0-1.2 | <14 | <15 | Zinc sulphate 120 |
| | >1.2 | ≥14 | ≥15 | - |

*Sources*: Holanda, J.S de, 2004; Raij, B. van., 2004; Sobral, L.F., 2004; unpublished data.

The application of fertilizers through the irrigation system (fertigation) has become a common practice in irrigated agriculture. The primary advantage of fertigation is an improved efficiency of nutrient utilization and minimal losses by leaching. A major disadvantage is the risk of chemical reactions between the fertilizers used if these are not chosen with care (Papadopoulos, 1999). For a fertilizer to be used in fertigation it needs to be water-soluble and there should be minimum risk of it causing salinity within the soil (Villas Bôas *et al*., 1999). The salinity index of a fertilizer is related to that of $NaNO_3$ to which is attributed a value of 100. Table 5.5 shows the solubility and salinity index values of some fertilizers used in fertigation. Nutrient applications for fertigation are based on the same concepts as those for conventional fertilizers and can be determined using soil and leaf analysis. For dwarf coconut, the total annual nutrient requirement is divided by the number of fertigation cycles to be made during the year to determine the quantity of nutrient to be added with each fertigation. The quantity of fertilizers to be dissolved for injection into the system is calculated taking into consideration the discharge rate of the emitters and the duration of irrigation. However, it must be remembered that the solubility of the fertilizer determines the maximum quantity that may be dissolved in a given volume of water. To achieve uniform application, fertigation should only be started after the irrigation system has been pressurized. Nutrient additions may be monitored by collecting solution samples at the nozzle.

**Table 5.5.** Solubility and salinity index values of some fertilizers used in fertigation.

| Fertilizer | Solubility 20°C | Salinity index |
|---|---|---|
| | g/100 ml | |
| Urea | 78 | 75.4 |
| Ammonium sulphate | 71 | 69.0 |
| Ammonium nitrate | 118 | 104.7 |
| Calcium nitrate | 102 | 52.5 |
| Sodium nitrate | 73 | 100.0 |
| Monoammonium phosphate | 23 | 29.9 |
| Phosphoric acid | 45.7 | no value |
| Potassium nitrate | 32 | 73.6 |
| Potassium chloride | 34 | 116.3 |
| Potassium sulphate | 11 | 46.1 |

*Source*: Villas Bôas, *et al.*, 1999

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