
TESSENDERLO
Kerley
PINEAPPLES

Pineapple fruit is one of the most popular tropical fruits in the world, consumed either as a tasty and juicy fresh fruit or processed into slices, concentrate, and juice. In any case, good fertilization management plays a key role in satisfying consumer demands. The plant grows reliably in a wide variety of soils (organic peat soils, volcanic ash and sandy soils), whereby a neutral to mildly acidic pH (4.5 to 6.5) is recommended with slight variations depending on the variety grown. The plant tolerates a high exchangeable aluminum and manganese content in the soil, a condition favoured in highly acidic soils. Pineapple should be grown in well-drained soils and areas of the landscape that do not flood.

For standard field production, fertilization is in the range of 500 – 800 kg/ha for nitrogen, 50 – 180 kg/ha for phosphorus and 600 – 900 kg/ha for potassium.

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PINEAPPLE CULTIVATION

Pineapple has a lower water requirement than the vast majority of cultivated plants. It has a series of morphological and physical characteristics typical of xerophile plants. It has the capacity to store water in the hypoderm of the leaves, to collect water efficiently, including dew, in its trough-shaped leaves, and to considerably reduce water loss (reduced transpiration) by several mechanisms.

Despite this crop being well adapted to dry conditions, the greatest yields and the best quality pineapples are obtained when the crop is well supplied with water. The ideal annual rainfall for the rain-fed growth of pineapple crop ranges from 1000 to 1500 mm well distributed throughout the year. The pineapple's demand for water varies from 1.3 to 5.0 mm/day, depending on its state of development and on soil moisture.

Complementary irrigation is required only for those locations where the annual rainfall does not reach that minimum value. Water with an EC of 1.28 dS/m reduces yield. Pineapple exhibits some tolerance to sodium, but is sensitive to chloride.

The optimum mean temperature lies between 20 to 30°C and more specifically at 23- 24 ° C. When ambient temperature drops between 10 to 16°C, fruit growth is constrained. Exposure to low temperatures, around 17-19 °C, for extended periods may promote flower induction (NF).

The yield varies on the cropping and production system used, it is typically 30-65 tons per ha, however with good management it can reach up to 90-110 tons per ha. High productivity depends on successfully managing controllable factors such as water and nutrient supply and pest and diseases. In well-irrigated areas pineapple can be planted at any time of the year.

Pineapples are usually produced in an intensive cropping system and balanced mineral nutrition is the basis for high quality production and marketable fruits. The nutritional requirements of pineapples are higher than those of many other crops, nevertheless only a small portion is retained in the fruits.

THE PINEAPPLE GROWTH CYCLE

The pineapple is a herbaceous perennial plant grown mainly in tropical areas worldwide. It requires three years from planting to replanting, during which time it produces two crops and requires larger amounts of nutrients. Pineapples can be grown once (a single cycle) or in one or more additional ratoon cycles. The cycles vary in duration, depending on the climatic conditions, the vigour of the plant material and the management of the cultivar. In commercial plantings, the plants are not allowed to produce more than 2 or 3 crops, due to a reduction in fruit size and uniformity.
When smaller fruit are desired for the fresh fruit market, the crop may be 'forced' earlier than when larger fruit is required for canning. The larger the plant at the time of forcing, the greater will be the size of its fruit.

Commercial plantations of 'Smooth Cayenne' and MD-2, the dominant pineapple cultivars grown commercially worldwide, are generally based on a two- or three-fruit crop cycle requiring approximately 32 or 46 months, respectively, for completion. Pineapples are planted all year round and forced 9–13 months after planting. Duration of the "plant" crop is usually 15–20 months from planting to harvest. In warmer, equatorial tropical climates, the crop may require only 11–14 months: 6–8 months for the vegetative phase and 5–6 months from forcing to harvest. After crop harvest, one or more suckers continue to grow to produce the ratoon crop average of about one fruit per plant with the high plant populations. Ratoon crops are forced five to seven months after the plant crop harvest. Fruit of ratoons is usually smaller, sweeter, less acidic, and more aromatic than fruit of plant crops. A second ratoon can be taken in a good field having adequate soil fertility and low nematode populations. Fruits are harvested year-round for the fresh market and canning operations.

Flower induction

Flower induction allows year-round production, ensures more uniform flowering and fruiting, and gives higher income especially during the off-season. It also stabilizes production, which assures the fresh market and processors of a continuous supply of fruits.
The time of induction is determined by plant size. In small farms, plants are induced when they have 55-60 functional leaves. In large farms, fruit quality, required for processing or exportation for fresh market,is achieved if induction is done when plants reaches 2.5 to 2.8 kg/plant and have at least 36 functional leaves.

Cultivars grown worldwide

Worldwide there are numerous pineapple varieties and unlike many crops where cultivars are bred to be better adapted to specific environments, only four pineapple cultivars are grown widely and only one, “MD-2”, is the result of a modern breeding programme.

Some of the many variants of these pineapples varieties are:

Smooth Cayenne
The most planted cultivar and the leading variety for canning, due to high yields

MD-2
Represents more than 80% of the fresh pineapples traded worldwide and has become the market standard for the fresh market. The main producer countries are Costa Rica, Philippines, Brazil, Mexico, Honduras, Colombia.

CO-2
Lower in acidity than MD-2 and suited for subtropical climates. This variety is grown for the fresh market in Australia, Malaysia, South Africa and Hawaii.

Singapore Canning
Cultivated in South Asia, particularly Malaysia.

Queen
Australia, China, Malaysia, Indonesia and Thailand.

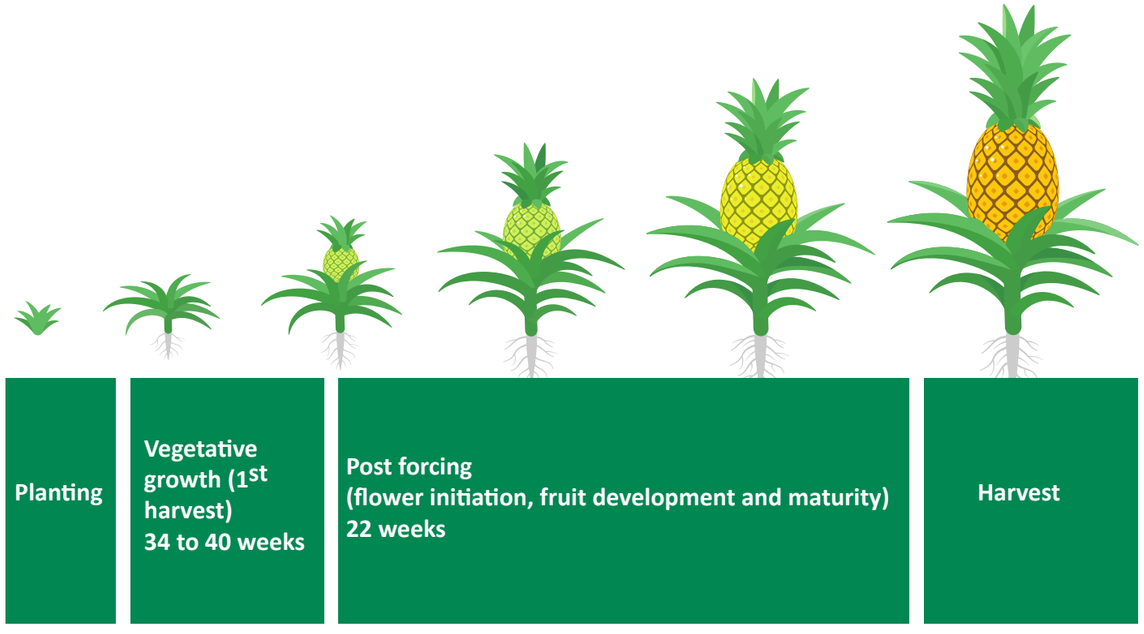
Española Roja
Venezuela, Caribbean and the Canary Islands.

Pérola
Main cultivar in the Brazilian market, with more than 85% of the commercial area.

Perolera
Andes of Colombia and Venezuela. Thailand too.

Manzana
Western Andes of Colombia (Valle del Cauca).

GROWTH STAGES OF PINEAPPLE



Note: After the 1st harvest the crops continues and is then called ratoon crop (RC) the growth stage lasts 22 weeks and the post-forcing phase lasts 22 weeks.

FERTILIZATION OBJECTIVES

Pineapple crops require maintenance of an adequate nutritional status in accordance with the quality demanded by the market, especially if the objective is to export. The growth dynamics of pineapple make the fertilization process complex: it is important to stablish fertilization guidelines allowing the supplying of an adequate quantity of nutrients, even without taking into account any environmental constraints.

The main nutritional demands of the pineapple crop concern potassium and nitrogen, since the yield depends primarily on these two elements. The need for phosphorus is low, as it is principally required during the flowering stage. However, the correct supply of calcium and microelements such as zinc and boron is important to increase pineapple quality and post-harvest life.

One of the key elements for the fertilization of pineapples is to take into account the differences that exist between different types of pineapple that are grown. The objectives will differ for each species although in all cases growers will be almost certainly aiming for good yields of fruits that have good size and color, high levels of sugar and that are sufficiently firm to resist storage and transport. The nutrient inputs are unique to each variety and will have to be adjusted according to the requirements of each variety and site. Therefore the nutrient inputs should be applied based on the results of soil analysis. This is also required in order to adapt fertilizer inputs to nutrients that are already present in the soil. Foliar analysis to demine the content of various nutrients in the leaves can also be a valuable tool to assist in defining the optimal fertilization program.

In many cases, the interaction between the nutrients in the pineapple and a balanced supply through fertilizer application is more important than the exact rates. For example, the development of fruit color is strongly affected by the balance between nitrogen and potassium. N and K levels for pineapple depend on factors such as the cultivar, age, soil characteristics, ground cover, and the irrigation method used. The optimum MgO:K_2O ratio is reported to be 1.0:2.5.

Potassium is usually applied to the soil before planting and later as side dressing. Other nutrients sometimes including K are applied as foliar sprays or through the drip irrigation system, or by both methods, during the growth cycle. Phosphorous and calcium can also be banded in the plant line during bed preparation. Pineapples respond better in both yield and quality to ammonium and urea N than to nitrate N, and to potassium sulphate (SOP) than to the chloride (MOP).

Therefore, the design of a good nutrient management strategy should include an understanding of soil chemical and physical properties, climatic conditions, as well water availability, pests, and diseases: all these factors influence plant growth and fruit appearance.
Commercial farms often adopt a different fertilization program where small doses of fertilizer are applied at biweekly or monthly intervals depending on the development stage of the crop. Large, highly mechanized farms apply most fertilizers using boom sprayers, and small farms use either backpack sprayers or a variety of motorized aids. It is recommended to start the fertilization program in the third or fourth week after planting, because in the first weeks the plants still do not have roots. The dosses of fertilizers increase over the weeks to reach the minimum amounts required for the floral induction (2.5 to 2.8 kg). Approximately 90% of the crop's fertilizer requirement are made in the vegetative phase, while in the reproductive phase calcium, potassium and boron are applied to improve the quality of the fruit.

Irrigation – Fertigation

Irrigation is desirable during dry seasons or in those places where long periods of inadequate rainfall are common, seriously affecting and compromising both plant growth and fruit development. The installation of an irrigation system is justified when the plantation is established in regions where there are three consecutive months with less than 15 mm of precipitation or four months with 40 mm or less precipitation.

There are a variety of irrigation systems used in regions where the rainfall does not meet the crop requirements. These include: drip irrigation, mini-sprinklers on poly-pipes, aluminum pipes with mini-sprinklers, single jet sprinkler gun on flexible hosting and mobile irrigators such as center pivots.
The choice of the irrigation systems will depend on the farm resources availability, slope of land, size of the plantation, level of management and water quality. Pineapples are sensitive to saline water.

Drip irrigation is more difficult to handle in the pineapple crop than sprinkler irrigation, in addition, the latter is cheaper and easier to operate. Another reason for more widespread use of sprinkler irrigation is the incredible absorption capacity of pineapple leaves, due to their size, composition and configuration.

NPK RECOMMENDATIONS FOR A PLANTATION UNDER IRRIGATION SYSTEM IN SEMI-ARID REGIONS, CONSIDERING SOIL NUTRIENT CONTENTS

	N	mg P/dm^3 in the soil (Mehlich)			mg K/dm^3 in the soil (Mehlich)			
		<5	6-10	11-15	<30	31-60	61-90	91-120
	Kg/ha	P_2O_5 kg/ha			K_2O kg/ha			
Month after planting								
1 to 2	60	120	80	40	90	75	60	45
4 to 5	80	-	-	-	120	100	80	60
6 to 7	90	-	-	-	135	110	90	75
8 to 9	9	-	-	-	135	115	90	60

Note. The doses above are for a density of 40 000 plants/ha in cultivar Pérola. For higher densities, around 50 000 plants/ha of cultivar Smooth Cayenne the doses must be increased by 25%.

NUTRITIONAL REQUIREMENTS OF PINEAPPLE

1. Nitrogen

Pineapple requires large amounts of nitrogen because of the very large amount of fresh biomass that accumulates during the vegetative growth, around 175 Mg/ha (up to 70 000 plants per hectare with an individual biomass of around 2.5 kg at forcing). Nitrogen mostly determines the productivity of the plant. The absence of N in either organic or mineral form, almost always results in compromised development and/or productivity of the plant, with the appearance of typical symptoms of N deficiency. N has a directly influence on fruit yield, size and mass, though it tends to reduce soluble solids and acidity. Despite this, an excessive nitrogen supply can have a negative impact on the quality of pineapples by reducing flesh firmness and sweetness, diminishing red color appearance and increasing susceptibility to disease and damage.

On the other hand, nitrogen deficiencies are characterized by greenish-yellow to yellow foliage, small and narrow leaves, a weak plant with slow growth and can lead to small fruits with poor flavor. Pineapples that are deficient in nitrogen tend to give a lower yield because of a shorter period of leaf maintenance, which leads to a shorter period for the accumulation of reserves during the post-harvest cycle. Symptoms are common on soils poor in organic matter, without fertilization and under hot and sunny conditions
A nitrogen application rate of 600 to 800 kg/ha/year is usually considered adequate for pineapples.

2. Phosphorus

Phosphorus is an essential nutrient both as a component of several key plant structures and as a catalyst in numerous key biochemical reactions in plants. Phosphorus is a vital component of adenosine triphosphate (ATP), the “energy unit” of plants. ATP forms during photosynthesis, has phosphorus in its structure, and is active from the beginning of seedling growth through to the formation of fruits and maturity.
It is important to maintain a K/Mg ratio of approximately 3/1 in the soil.

Phosphorus is important for the general health and vigor of all plants including pineapples. Some specific growth benefit that have been associated with phosphorus are: a stimulation of root development, improved flower formation and fruit production, improved crop quality, increased resistance to disease, and more vigorous development throughout the growth cycle.
Phosphorus deficiencies symptoms include dark, bluish-green foliage, which is more pronounced in the presence of excess N, and leaves that completely dry out at the tips, starting from the older ones. The old leaves have dry, brownish-red tips and brown transverse striations and the borders of these leaves turn yellow from the tips. Plants suffering from P deficiency also have more erect, long and narrow leaves and roots with longer, more colored and less ramified hairs; the fruit is small and reddish in color. P deficiency causes a reduction in the growth of all parts of the plant. Visual deficiency symptoms are often not seen and are not very specific, and hence could be mistaken for symptoms resulting from damage to the root system caused by water deficiency, nematodes or pests.

The addition of P fertilizer in the root zone will increase plant access to the nutrient and there must be adequate soil moisture for a good nutrient diffusion and root uptake. Therefore, foliar applications of phosphorus are more effective than simple dry basal applications.

3. Potassium (K)

Potassium is the nutrient most required and extracted by pineapple plants during the crop cycle, its concentration occurs mainly in the fruits but also in the leaves. K is taken up by and present in plants as the K+ cation, which plays an important role in regulating the osmotic potential of cells and in the activation of enzymes involved in respiration and photosynthesis.

Potassium is an extremely important nutrient for plant transpiration, chlorophyll uptake, and the transport and storage of carbohydrates in the fruits, helping to increase sugar content. It also helps to promote the storage of reserves in different parts of the plants.

The potassium increases the content of soluble solids and acidity, changes the color, increases fruit mass and diameter, produces higher firmness of the skin and pulp and reduces the browning of pineapple fruits.

During the early stages of K deficiency, leaves are dark-green and narrow, but if the deficiency is prolonged, leaves eventually become yellow.
In cases of potassium deficiency, pineapple productivity, quality and storage potential are negatively affected. Poor fruit color (either a lack of color or dirty looking fruit) is observed in pineapples suffering from potassium deficiency. Sugar content of fruits is also reduced. When potassium accumulation is excessive, total acidity decreases and fruit pH becomes unacceptably high, which may impact storage
quality.

To reach the plant’s requirement for high amounts of K, large quantities of K fertilizer are applied to the soil, or as a foliar spray, or both. The optimum soil K level at planting is 150 mg/kg (neutral ammonium acetate extraction), and deficiencies symptoms are observed when soil level is below than 60 mg/kg.

A large pre-planting application of K fertilizer can bring positive benefits, nevertheless previous soil analysis must be done to determine the doses and avoid nutrient imbalances.

4. Sulfur (S)

Sulfur demand for pineapples is relatively low in comparison with other nutrients and the incorporation of sulfur in a fertilization program in not common because sulfate is usually the accompanying ion when K, Mg and most micronutrients (except B) are sprayed as foliar fertilizers.

Sulfur deficiencies are rarely observed, though some symptoms associated with a deficiency of sulfur are: pale yellow to gold colored foliage; pinkish leaf borders, especially on older leaves; normal plant stature; very small fruit.

The pineapples crop is one of the few crops that can be profitable when grown in acid sulfate soils, probably because of its tolerance to soluble aluminium in the soil.

Fertilization programs with around 100 kg of S per hectare per year usually relate to yields greater than 85 tons per hectare in the first harvests.

5. Calcium (Ca)

Calcium requirement is low compared to other nutrients. The Ca requirement for the MD-2 variety appears to be higher than for Smooth Cayenne and the concentration in the plant depends on the availability of Ca in the soil. The level in soils for optimum growth should be > 100 mg/kg (neutral ammonium acetate extraction). Calcium deficiencies symptoms are observed when soil Ca is less than 25 mg/kg.

Calcium is quite important in the initial stages of crop establishment because cell division and differentiation are dependent on an adequate supply. Calcium is also very important after floral induction (forcing) due to is a period of rapid cell division and growth. Calcium may improve cell structure and reduce fruit translucence.

Calcium has an impact on the interior quality of pineapples, and fertilization may have positive or negative effect on the availability of calcium and its uptake from the soil. Fertilization in calcium deficient soils is a necessity, and this is very important in acidic soils.

6. Magnesium (Mg)

Magnesium is a component of the chlorophyll molecule that intervenes in carbohydrate synthesis, and a deficiency will reduce chlorophyll concentration, photosynthesis and growth. Deficiency symptoms can be most pronounced just prior to the floral differentiation and all leaves may be yellow during fruit development if the problem is not corrected. Such deficiencies are very common on soils low in Mg, especially when intensely fertilized with K under conditions of high solar irradiation

The optimum soil level of Mg should be > 100 mg/kg (neutral ammonium acetate extraction) at planting time. Deficiency symptoms are observed when soil Mg is below 10 mg/kg

7. Iron (Fe)

Iron deficiency symptoms starts in younger leaves, due to its low mobility in the plant. The first symptoms are development of interveinal chlorosis; the leaves are generally flaccid, wide, and yellow with a green mottling. The fruits on plants with severe Fe deficiencies will be small, hard and reddish in colour with a chlorotic crown. Symptoms can appear when large quantities of nitrate have been added.
Iron deficiency can occur under in soils with high pH, soils rich in manganese with lox pH compacted soils, areas of termite infestation and attack by pests both of which rapidly decrease root activity, and drought

8. Mangnese (Mn)

Manganese deficiency is rare too, but can occur in soil with high Ca and high pH. Deficiency symptoms are often not very characteristic: the plant can present marbled leaves with pale green areas, especially where the veins are located.
Mn deficiency occurs and visual symptoms become clearly visible when the Fe:Mn ratio in the leaf tissue is greater than 10.5.

9. Zinc (Zn)

Pineapples growing in soils with a pH of 6.0 or higher will often show signs of zinc deficiency. The symptoms are present in the center cluster of leaves, which become mildly to sharply curved. The surfaces in older leaves develop yellowish brown pinhead sized dashes coalescing to form elevated, blister-like spots.

Plants presenting Zn deficiency, like Ca deficient plants, tend to remain continuously vegetative. Zn deficiency is distinguished from Ca deficiency by the curved central leaves and the presence of blisters on the leaf surfaces.

10. Boron (B)

Boron requirement is quite low and can be meet with leaf sprays of 3 to 5 kg/ha.

Boron plays an important role in forming and strengthening cell walls, therefore a lack of boron in the plant will generate fruit cracking followed by corking at fruitlet margins. Other symptoms include death of the tips of the youngest leaves, with some serrations on the margins, while with severe deficiency the growing point will die.

There is a relationship between B and Ca as a consequence of deficiency of both these elements is the disruption of cell development

11. Copper (Cu)

Copper (Cu) deficiency symptoms show up as lighter green leaves than those of normal plants. The leaves in deficient plans are also narrow and the “U” shape in cross section is more distinct than for normal leaves.

Nutrient Requirement Table for Pineapple Plant Crop (PC) (90 to 130 T/ha, plant density 75 000 plant/ha, variety MD-2).

	Total	Vegetative Growth	Fruit set & filling until harvest
	kg/ha	%	%
N	600- 800	100	0
P_2O_5	150 – 300	100	0
K_2O	600- 1000	80- 75	20- 25
S	50 – 100	75	26
CaO	60 – 150	90	10
MgO	100 – 150	75	25
B	5	100	
Zn	5	100	
Fe	8	100	

FOLIAR NUTRIENT REFERENCE VALUES IN D-LEAF IN MD-2 PINEAPPLE		
Element	Unit	Adequate range
N	%	1.5- 2.0
P		0.1- 0.2
K		3.3- 3.8
Ca		0.4- 0.5
Mg		0.25- 0.4
S		0.1- 0.2
Fe	mg/kg	50- 150
Zn		20- 40
Cu		10- 50
Mn		60- 200
B		20- 25

ABSORPTION OF NUTRIENTS

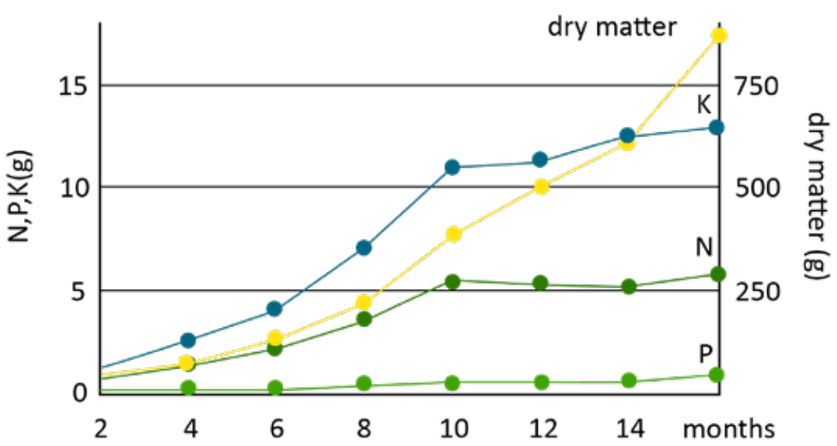
The nutritional demand of the pineapple plant is high in comparison to other crops and depends on the cultivar, weight of the fruit, and planting density, among other factors. Nutrient amounts required often exceed those which the majority of cultivated soils can supply. For this reason, fertilization is almost mandatory where the fruit is destined for sale.

Pineapple is a nutritionally demanding crop, with emphasis on nitrogen (N), potassium (K) and iron (Fe) nutrients, and relatively low requirements for phosphorus (P) and calcium (Ca) nutrients. These requirements are low until about 4 months after planting: requirements increase sharply afterward and peak at two to four months before flower induction.

Phosphorus uptake in not proportional to the supply available, but reflects the plant's requirement and this is also true for iron as long as soluble manganese levels do not interfere with iron upake.

A well-developed root system will facilitate the nutrient absorption as long as the nutrients are available in the soil. Pineapples are highly efficient in extracting K from the soil and, if readily available, more K is accumulated than is required from optimum growth.

During flowering and fruit filling, many nutrients are translocated, mainly from the leaves to the fruit and crown. The supply of Ca during the early stages of fruit development is quite important, since it improves the quality of the fruit and gives it greater tolerance to bacterial diseases; playing an important role in the post-harvest fertilization to ensure fruit firmness in the next season's crop. The doses of Ca and Mg will depend to a great extent on the acidity levels of the soil. Finally, the fertilization program must always be prepared based on the requirement of the crop and the nutritional status of the soil.



Element uptakes (left scale) and dry matter growth (right scale)

FERTILIZATION METHODS OR PRACTICES

The application of fertilizers sources in pineapple plantations can be made either with solids (granular or soluble) or with liquids fertilizers.

Granular solid fertilizers can be applied into the planting pits or furrows or as a side dressing. In addition, the fertilizer can be being directed to the bases of the oldest leaves, these practice is normally realize during the first months of the crop. The application of granular fertilizers is done by hand, using simple tools like scoops. Indistinctly of the application method used, fertilizers should not fall into the upper youngest leaves or into the center of the plant, because of the damage they may cause. Preplant fertilizers can be banded just below or adjacent to the plant line during bed formation to allow early root in interception.

Soluble and liquid fertilizers are applied to the leaves as foliar sprays. The architecture of the plant and the morphological and anatomical characteristics of its leaves favors foliar absorption of nutrients. This method of application is widely used to apply N, P, K, Ca, Mg and micronutrients. Foliar application is done using spray booms attached to backpacks or tractor mounted tanks. Generally, the concentration of fertilizers in the solution should not exceed 10%. The mature pineapples leaves tolerate high concentrations of fertilizer salts well, soil applications of excessive amounts can injure or kill roots by desiccation. Spray applications of fertilizers can cause plant damage if the concentration and volumes are both high. Most fertilizers sprays are applied in high volume, usually 2000 to 2 500 l/ha. The compatibility of the fertilizers source should keep in mind when applying several fertilizers.

Fertigation is commonly used with overhead spray irrigation or with high frequency localized irrigation. Nitrogen is most often applied with irrigation, followed by potassium. Calcium, magnesium, sulfur and micronutrients may also be applied by fertigation. Fertigation with phosphorus is not common; P fertilizers are usually applied only once as a solid before planting in the planting pits or furrows, or as a soil cover, within 30 to 60 days after planting.

PRODUCTS

TESSENDERLO KERLEY INT. FERTILIZERS

PRODUCTS	PRE-PLANTING	VEGETATIVE GROWTH	FLOWERING, FRUIT SET AND FILLING
Thio-Sul		Foliar / Fertigation	
P-Sure		Foliar / Fertigation	
SoluPotasse		Foliar / Fertigation	Foliar / Fertigation
KTS		Foliar / Fertigation	Foliar / Fertigation
CaTs	Soil application liquids	Foliar / Fertigation	Foliar / Fertigation
GranuPotasse	Soil application granules		

Legend:

Foliar application

Soil application granules

Fertigation

Soil application liquids

NUTRIENT CONVERSION FACTORS*		
TO CONVERT	TO	MULTIPLY BY
Ca	CaO	1.40
Mg	MgO	1.66
K	K_2O	1.20
P	P_2O_5	2.29
S	SO_3	2.50
S	SO_4	3.00

* To convert elemental units to oxide units multiply by the same factors

THIO-SUL

Characteristics and advantages

- Sulfur and nitrogen source without chloride.
- The addition of Thio-Sul transforms UAN into a stabilized nitrogen fertilizer.
- Sulfur in the unique thiosulfate form is a highly effective sulfur source, which is partly available immediately, and which is partly available over a period of several weeks.
- The leachability is significantly lower than with sulfur in the sulfate form.
- Promotes thiobacillus stimulation and especially the microbiological activity in the soil.
- Releases nutrients that are present in the soil.

Specifications

Ammonium thiosulfate	
- N (w/w) as ammoniacal nitrogen	12%
- S (w/w)	26%

Typical properties

- Appearance/color	Clear, colorless to light yellow
- pH range	6.5 - 8.5
- Density range (at 25°C)	1.32 kg/l - 1.35 kg/l
- Density (at 25°C)	1.33 kg/l
- Salt Out Temperature (SOT)	+ 4°C
- SO_3 (w/w)	64.9%
- N (w/v) as ammoniacal nitrogen	16%
- S (w/v)	34.6%
- SO_3 (w/v)	86.3%
- N (g/l) as ammoniacal nitrogen	160
- S (g/l)	346
- SO_3 (g/l)	863
- Chemical formula	$(NH_4)_2S_2O_3$

APPLICATION	DOSE PER APPLICATION	GROWTH STAGE	COMMENT
Thio-Sul (when combined with UAN)	5 to 10% Thio-Sul ratio	Vegetative growth	With each UAN application
Foliar (sprayboom)- Fertigation (sprinkler/pivot)	10 to 20 l/ha	Vegetative growth	Every 14 days

P-SURE

Characteristics and advantages

- P-Sure is 100% liquid.
- P-Sure has a high concentration of nutrients.
- P-Sure provides the essential nutrients phosphorous and nitrogen.
- P-Sure has 50% P in the orthophosphate form that is immediately available for plants.
- P-Sure has 50% P as a long chain polyphosphate available for plants over a period covering a few days to a few weeks.
- Combines effectively with KTS to give a highly efficient NPKS starter fertilizer.

Specifications

Ammonium polyphosphate	
- N (w/w) as ammoniacal nitrogen	11%
- P_2O_5 (w/w)	37%

Typical properties

- Appearance/color	Clear, green or colorless
- pH range	6 - 7
- Density range (at 25°C)	1.41 kg/l - 1.47 kg/l
- Density (at 25°C)	1.44 kg/l
- Salt Out Temperature (SOT)	- 20°C
- N (w/v) as ammoniacal nitrogen	15.8%
- P_2O_5 (w/v)	53.3%
- N (g/l) as ammoniacal nitrogen	158
- P_2O_5 (g/l)	533

APPLICATION	DOSE PER APPLICATION	GROWTH STAGE	COMMENT
Foliar (sprayboom)- Fertigation (sprinkler/pivot)	40 to 60 l/ha	Vegetative growth	Every 28 days

SOLUPOTASSE

Characteristics and advantages

- SoluPotasse is a cost-effective source of potassium and sulfur and is chloride and nitrate free.
- SoluPotasse provides a high concentration of these important crop nutrients.
- SoluPotasse dissolves rapidly and completely, leaving no residues.
- SoluPotasse has an extremely low salt index and is ideal for use in chloride sensitive crop or regions at risk from salinity.
- The acidification effect ensure optimal uptake of all nutrients and helps prevent clogging of the drippers.
- SoluPotasse is of a consistently high quality and is the market leading water soluble SOP for fertigation.
- Available in 25 kg bags and big bags (1000 kg or 1200 kg).

Specifications

Potassium sulfate	
- K_2O (w/w)	Min. 51%
- Cl (w/w)	Max. 1%
- S (w/w)	18.7%

Typical properties

- Appearance/color	Fine white powder
- Bulk density (struck/loose)	1.46 kg/l / 1.21 kg/l
- Angle of repose	40°
- pH (1% solution)	2.9
- Residues	0.03%
- Solubility at 25°C	120 g/l pure water
- Dissolved after 3 mins with stirring	90%
- K_2O (w/w)	51.5%
- Cl (w/w)	0.6%
- SO_3 (w/w)	47%
- H_2O (w/w)	0.02%
- Chemical formula	K_2SO_4

APPLICATION	DOSE PER APPLICATION	GROWTH STAGE (DAYS AFTER PLANTING)	COMMENT
Foliar (sprayboom)- Fertigation (sprinkler/pivot)	25 kg/ha 35 kg/ha 45 kg/ha 55 kg/ha 65 kg/ha 70 kg/ha	14, 28 42, 56 70, 84, 98, 112 126, 140, 154 168, 182, 196 210, 224, 238, 252	Every 14 days

KTS

Characteristics and advantages

- The concentrated liquid form is ideal for applications in low water volumes and for large areas.
- Active thiosulfate technology enhances the uptake of phosphorus and micronutrients present in the soil or from fertilization.
- The neutral pH level is ideally adapted to tank mixtures with acid or base sensitive materials.
- KTS contains the two key crop nutrients potassium and sulfur, and it is chloride and nitrate free.
- Available in bulk and in 1,000 l containers.
- Can also be applied to the soil as a starter fertilizer (with P-Sure®) and in overhead pivots and sprinklers.
- The thiosulfate form of potassium is taken up rapidly by the leaves.

Specifications

Potassium thiosulfate	
- K_2O (w/w)	25%
- S (w/w)	17%
- pH range	6.8 - 8.5
- Density range (at 25°C)	1.45 - 1.49

Typical properties

- Appearance/color	Clear and colorless
- Density (at 25°C)	1.47 kg/l
- Salt Out Temperature (SOT)	- 10°C
- SO_3 (w/w)	42.4%
- K_2O (w/v)	36.8%
- S (w/v)	25%
- SO_3 (w/v)	62.4%
- K_2O (g/l)	368
- S (g/l)	250
- SO_3 (g/l)	624
- Chemical formula	$K_2S_2O_3$

APPLICATION	DOSE PER APPLICATION	GROWTH STAGE	COMMENT
Foliar (sprayboom)- Fertigation (sprinkler/pivot)	20 to 40 l/ha	14, 28, 42, 56 and 70 days after floral induction	5 postforcing applications (after floral induction- fruit set and filling)

CATS

Characteristics and advantages

- CaTs is a neutral to basic, chloride and nitrate free, clear solution.
- CaTs may be applied by drip, sprinkler, or flood irrigation.
- It may be blended with other fertilizers or applied as a foliar treatment on selected crops.
- When used as a foliar fertilizer, CaTs should first be diluted with water before application.
- Blends of CaTs should not be acidified below a pH of 6.0.
- CaTs may be used as a fertilizer for the correction of calcium deficiency.
- CaTs is an effective water soluble source of calcium and thiosulfate sulfur which assists in the correction of these nutrient deficiencies in crops.
- CaTs may be used to improve water infiltration and assists in terms of leaching of harmful soil salts.
- CaTs is compatible with most fertilizer solutions.
- CaTs is not compatible with phosphate, sulfate and ammonium thiosulfate fertilizers.

Specifications

Calcium thiosulfate	
- Ca (w/w)	6%
- S (w/w)	10%
- pH range	6.5 - 8.8
- Density range (at 25°C)	1.22 - 1.26

Typical properties

- Appearance/color	Clear and colorless
- Density (at 25°C)	1.25 kg/l
- Salt Out Temperature (SOT)	0°C
- CaO (w/w)	8.4%
- SO_3 (w/w)	25%
- Ca (w/v)	7.5%
- S (w/v)	12.5%
- CaO (w/v)	10.5%
- SO_3 (w/v)	31.2%
- Ca (g/l)	75
- S (g/l)	125
- CaO (g/l)	105
- SO_3 (g/l)	312
- Chemical formula	CaS_2O_3

APPLICATION	RATE PER APPLICATION	GROWTH STAGE	COMMENT
Soil (drench)	100 – 150 l/ha	Pre-planting	To manage soil salinity problems
Foliar (sprayboom) Fertigation (sprinkler/pivot)	20 to 30 l/ha	Vegetative growth	Every 28 days
Foliar (sprayboom) Fertigation (sprinkler/pivot)	20 to 30 l/ha	14, 28 days after floral induction	2 postforcing applications (after floral induction-fruit set and filling)

GRANUPOTASSE

Characteristics and advantages

- GranuPotasse is a cost-effective source of potassium and sulfur, and it is chloride and nitrate free.
- GranuPotasse provides a high concentration of these important crop nutrients.
- GranuPotasse is virtually dust-free.
- GranuPotasse has a consistent granulometry that ensures uniform application, with a spreading range of up to 28 meters.
- GranuPotasse is suitable for both pre-emergence and post-emergence application during early stages of crop growth.
- GranuPotasse has excellent stability, which makes it ideal for producing a wide variety of NPK blends.
- Available in 25 kg bags or big bags (600 kg, 1,000 kg or 1,200 kg).

Specifications

Potassium sulfate	
- K_2O (w/w)	Min. 50%
- Cl (w/w)	Max. 2.5%
- S (w/w)	18%

Typical properties

- Appearance/color	Light grey to beige granules
- Bulk density (struck/loose)	1.40 kg/l / 1.27 kg/l
- Angle of repose	33°
- Sieve analysis	97% between 1.6 mm and 5 mm
- K_2O (w/w)	50.2%
- Cl (w/w)	2.3%
- SO_3 (w/w)	45%
- H_2O (w/w)	0.2%
- Chemical formula	K_2SO_4

APPLICATION	RATE PER APPLICATION	GROWTH STAGE	COMMENT
Soil application	200- 400 kg/ha	Prior to planting	Apply either soil incorporated prior to planting or apply annually as a basal dressing Dose will depend on what other forms of potash fertilization are used

FERTILIZATION RECOMMENDATIONS

TESSENDERLO KERLEY FERTILIZATION RECOMMENDATIONS

Pre-Planting		
TKI Fertilizer	Crop Stage	Pre-Planting
	Cycle	0
	DAP*	0
Liquids		
Thio-Sul (l/ha)**		
P-Sure (l/ha)		
KTS (l/h)		
CaTs (l/h)***		100- 150
Water Soluble		
SoluPotasse (kg/ha)		
Solids		
GranuPotasse (kg/ha)****		200- 400

*DAP: days after planting
** Thio-Sul can be blended with UAN solutions in a ratios of 5% to 10% Thio-Sul
*** To manage soil salinity problems
**** To improve soil imbalances due to excess Ca and Mg, recover soils with low contents of K or keep soil reserves.

Fertilization recommendations are for illustrative purposes. Many different products are available for use in fertilization and fertilizer choice will depend a many different factors. Always consult our qualified

Vegetative Growth

TKI Fertilizer	Crop stage	Vegetative Growth																	
	Cycle	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	DAP*	14	28	42	56	70	84	98	112	126	140	154	168	182	196	210	224	238	252
Liquids																			
Thio-Sul (l/ha)**		10-20	10-20	10-20	10-20	10-20	10-20	10-20	10-20	10-20	10-20	10-20	10-20	10-20	10-20	10-20	10-20	10-20	10-20
P-Sure (l/ha)		40-60		40-60		40-60		40-60		40-60		40-60		40-60		40-60		40-60	
KTS (l/ha)																			
CaTs (l/ha)***			20-30		20-30		20-30		20-30		20-30		20-30		20-30		20-30		20-30
Water Soluble																			
SoluPotasse (kg/ha)		25	25	35	35	45	45	45	45	55	55	55	65	65	65	70	70	70	70
Solids																			
Granupotasse (kg/ha)****																			

*DAP: days after planting
** Thio-Sul can be blended with UAN solutions in a ratios of 5% to 10% Thio-Sul
*** To manage soil salinity problems
**** To improve soil imbalances due to excess Ca and Mg, recover soils with low contents of K or keep soil reserves.

Fertilization recommendations are for illustrative purposes. Many different products are available for use in fertilization and fertilizer choice will depend a many different factors. Always consult our qualified

Fruit set & Filling until Harvest

TKI Fertilizer	Crop stage	Fruit set & Filling until Harvest				
	Cycle	1	2	3	4	5
	DAF*	14	28	42	56	70
Liquids						
Thio-Sul (l/ha)**						
P-Sure (l/ha)						
KTS (l/ha)		20-40	20-40	20-40	20-40	20-40
CaTs (l/ha)***		20-40	20-40			
Water Soluble						
SoluPotasse (kg/ha)						
Solids						
GranuPotasse (l/ha)****						

*DAF: days after forcing (floral induction)
** Thio-Sul can be blended with UAN solutions in a ratios of 5% to 10% Thio-Sul
*** To manage soil salinity problems
**** To improve soil imbalances due to excess Ca and Mg, recover soils with low contents of K or keep soil reserves.

Fertilization recommendations are for illustrative purposes. Many different products are available for use in fertilization and fertilizer choice will depend a many different factors. Always consult our qualified

GUIDELINES

General

- Do not apply products to crops which are sensitive to the effects of sulfur.
- Use the correct type of spray nozzles that are recommended for foliar applications.
- Contact a representative of Tessenderlo Kerley if you require any additional information.
- The purpose of this brochure is to provide information about fertilizer products and to make suggestions regarding their use in pineapples. The exact quantities of nutrients required by the crop will depend on local growing conditions including, but not limited to, soil type and nutrient content, climate conditions; crop variety, target yield, etc.
- Use of tissue and soil analysis to determine crop and soil nutrient status is recommended
- Tessenderlo Kerley recommends that you seek advice on your specific fertilization program from a qualified agronomist

Liquids

- Avoid applying products as a foliar spray when the temperature exceeds 30°C. Ensure you apply products (preferably) early in the morning or in the evening. When mixing with other products, it is recommended to conduct a small-scale trial in order to check the compatibility of the mixture before operating on a larger scale and applying.

Water solubles

- Continuous agitation or stirring will speed up dissolution.
- The time required to dissolve the product, however, will also depend on the quality and temperature of the spraying water. Poor quality water may affect solubility.
- To get the best results from the products:

1. Fill the tank with water to at least two-thirds of its capacity.
2. Add the product taking care not to exceed the maximum recommended concentration.
3. Maintain stirring or agitation throughout the entire operation.
4. Fill the remainder of the tank with water.
5. Check that the product has dissolved completely before using the solution.
6. The use of filters is recommended, as generally advised for most solid fertilizers when used in solution.

- Avoid applying products as a foliar spray when temperature exceeds 30° C- apply products preferably early in the morning or in the evening.
- Do not mix sulfates with materials containing calcium.
- When mixing with other products it is recommended to conduct a small-scale trial to check the compatibility of the mixture before operating on a larger scale.
- Store products in dry conditions, avoiding extreme heat or cold.

Always respect and comply with local legislation and regulation regarding the use of fertilizer products.

SUSTAINABLE CROP NUTRITION FOR AGRICULTURE

For over 100 years Tessenderlo Kerley International has demonstrated its commitment to nurturing crop life through innovation, research and the development of novel fertilizers for a more sustainable agriculture. Our diverse product portfolio addresses the challenges of modern agriculture by delivering essential nutrients in forms that protect soil health and optimize nutrient use efficiency.

We provide an extensive range of both liquid and solid/soluble fertilizers

HIGH-PERFORMANCE LIQUIDS

HIGH QUALITY SOLID/SOLUBLES

Our Crop Vitality experts are familiar with your region and crops. Their support includes:

- Agronomic advice
- Providing technical information
- Carrying out field studies that are specific to your issues
- Providing application and storage tips

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