9. Passion-Fruit

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9.1. Introduction

The passion-fruit is extremely important in Brazil. Its fruits are rich in mineral salts and vitamins, especially A and C, and its juice has a wonderful aroma and flavor. It is widely accepted in different markets and there is a large potential for exports, not to mention its pharmacological properties.

In Brazil, the passion-fruit vine is cultivated predominantly in small orchards, on average 1.0 to 4.0 ha, and is an important source of income for small to medium producers.

Brazil is the world's foremost producer of passion-fruit, with about 90% of the production, followed by Peru, Venezuela, South Africa, Sri Lanka and Australia. Brazilian production is around 478,000 mt with a yield of about 13.8 mt/ha. The northern and north-eastern regions of the country are responsible for more than 80% of the national production.

In Brazil, the passion-fruit is used primarily for fresh consumption and the production of juice, which is also exported. For Brazilian exporters, the principal market is Europe, which imports more than 90% of the juice. However, there are very good prospects in the American, Canadian and Japanese markets.

9.2. Climate, soil and plant

9.2.1. Climate

Brazil, as a centre of passion-fruit production, provides excellent conditions for its cultivation. It develops well in tropical and subtropical regions, where the climate is hot and humid. Temperature, relative humidity, light intensity and precipitation have an important influence on the longevity and the yield of the plants, but also favor the incidence of pests and diseases.

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Biological processes, such as flowering, fertilization, fruit formation, maturation and fruit quality depend on elevated temperatures. The temperature range between 21 and 25ºC is considered as the most favorable for the growth of the plant, being best between 23 and 25ºC, but passion-fruit is being successfully cultivated in temperatures between 18ºC and 35ºC (São José, 1993). Lower temperatures slow the growth of the plant and reduce the uptake of nutrients and fruit production, while very high or very low temperatures affect fruit bearing (Manica, 1981). At intermediate temperatures of 23ºC to 28ºC, the fruit growth period for is 60.3 days, when the temperatures where lower (23ºC) and higher (33ºC) the period was 75 days (Utsunomiya, 1992). The germination period of the seeds is shorter in summer time than in the coldest months, when the period is longer (São José *et al*., 1991).

Growing passion-fruit at altitudes between 100 m and 1,000 m is recommended. Plantations at lower altitudes last for a shorter period of time than those with higher altitudes. In South Africa, at altitudes between 1,200 and 1,400 m, plantations may be productive for eight years, owing to the longer cycles, implicating a greater longevity (Teixeira, 1995).

Relative humidity has a great influence on vegetative development and the phytosanitary state of the passion-fruit. Air relative humidity of around 60% is the most favorable for the passion-fruit cultivar. Elevated temperature, associated with constant wind and low relative humidity, causes a drying out of the tissues by excessive transpiration and impedes the development of the passion-fruit. Relative humidity of greater than 60%, when associated with rains, favors the appearance of disease, like citrus scab, anthracnose (black spot) and bacteriose, in the aboveground parts of the vine (Lima and Borges, 2002).

The susceptibility of passion-fruit to strong winds is also an important factor for this crop. Besides direct damage to the plant, it has to adapt its conduction systems. Strong winds cause plants to fall and cold winds cause flowers and new fruits to fall, as well as delaying plant growth. In regions prone to high winds the use of windbreaks, like bamboo, grevillea, pine, hibiscus, eucalyptus and grass species is indispensable (Ruggiero *et al.,* 1996).

Light is also an important factor affecting growth due to its effects on photosynthesis. An increase in the hours of daylight results in greater photosynthetic activity, with an increase in the plants vigour and the size and quality of the fruit.

Inadequate light affects the formation of the flowers and fruit. Regions in which the day length is greater than 11 hours have the best conditions for flowering. In the winter months, the plants do not flower because the days are shorter. In the semi-arid regions of Brazil, with more than 11 hours of day light associated with high temperatures throughout the year, the passion flowers continuously and produces fruit throughout the year, as long as there is an adequate supply of water.

Light intensity greatly influences the phenological phenomenon of flower opening in the yellow passion-fruit (Gamarra Rojas and Medina, 1995). The flowers normally open at 12.00 hrs, immediately following the maximum incidence of photosynthetically active radiation (PAR), and close at 15.00 hrs; however when light intensity is lower, they close at 14.30 hrs.

Passion-fruit develops continuously and so needs a constant supply of water. The demand for water varies from 800 to 1,750 mm and must be well distributed throughout the year, preferably with 60 to 120 mm of water each month, by rain complemented when necessary with irrigation (São José, 1993).

Although the plant withstands droughts relatively well, prolonged drought damages its vegetative development, causing, in sever cases, leaf fall and the formation of smaller and lighter fruits. On the other hand, intense rains in the flowering period also damage production, because they inhibit pollination by diminishing the activity of pollinating insects and causing pollen grains to burst.

In regions where the rains occur in specific periods, resulting in shortage for a few months, for example north of Minas Gerais and in the semi-arid regions of the north-east, the use of irrigation is indispensable to guarantee good production and fruit quality (Lima and Borges, 2002).

9.2.2. Soil

The passion-fruit has a superficial root system (60% of the roots located within 30 cm of the surface). So it is important that there is no impedance to root growth in the top 60 cm. Passion-fruit can be grown on a range of soils, sands to clay loams. In general, it is recommended that the soil should be deep, relatively fertile and well drained. Poorly permeable soils with high clay content, subject to flooding, are not recommended. The best soils are sandy clay (Ramos, 1986, cited by Teixeira, 1995). For good growth, it is recommended that the soil have neither impermeable, rocky or hardened layers, nor a water table at less than 2 m to avoid the appearance of dry rot (Lima and Borges, 2002).

The availability of an adequate supply of oxygen is of fundamental importance for good root development of the plant. Oxygen deficiency results in roots losing their structure, and they may quickly rot. Poor soil aeration may be induced by soil compaction or flooding. Soils subject to flooding favor the occurrence of root diseases (Lima and Borges, 2002). Flat and smoothly undulated lands (gradients less than 8%) are most suitable because crop management, mechanization, harvest and soil cultivation and conservation are facilitated. On steeper slopes (in the range of 8 to 30%), besides erosion control measures (including levelling to create terraces, etc.), irrigation and/or fertigation are more difficult. In very steep areas, passion-fruit should be grown individually and the soil constantly replenished to maintain a natural soil covering (Lima and Borges, 2002).

9.2.3. Plant

The passion-fruit plant is a woody vine (climber) with very fast, vigorous, continuous and exuberant growth (Kliemann *et al.,* 1986). The growth rate is reduced at fruiting and at low temperatures. In the north and north-east of Brazil flowering is continuous due to very little variation in the photoperiod and high temperatures; in such way, the absorption of nutrients should be constant. In the south-east and east-central regions development and nutrient absorption are reduced in the winter because of a shorter photoperiod and/or lower temperatures.

In the south-east region, stem and leaf growth increases at around 250 days (8^{th} month), and decreases after about 340 days (11^{th} month). Branch growth is linear from 160 days (5^{th} month), reaching more than 8 m at 370 days (12^{th} month). Fruit formation starts at 280 days (9^{th} month), starting from the axillary flowers developed on new branches, with a fast accumulation of dry material within the first 60 days and then establishing itself during maturation (370 days, 12^{th} month). With the root system, there are three phases of growth: up to 220 days (7^{th} month) the growth is slow, with reduced production of dry matter; from 220 (7^{th} month) up to 310 days (10^{th} month) there is expansion; later growth stabilizes (Haag *et al.*, 1973).

There is little absorption of nutrients until 220 to 250 days (7^{th} to 8^{th} months), because of the small production of dry matter. After the appearance of the fruits (8^{th} and 9^{th} months), growth becomes exponential, increasing the uptake of N, K and Ca and also that of the micro-nutrients, especially Mn and Fe (Haag *et al.*, 1973).

9.3. Soil and crop management

Soil preparation aims to improve the soil conditions for root development, by way of increasing aeration and water infiltration and reducing soil resistance to root growth. Manual soil preparation starts with clearing existing vegetation and using it as mulch or burning it. Soil preparation is limited to the manual opening of the pits for planting the vines. Mechanical preparation is done by machine, taking care to not remove the superficial layer of soil, which is rich in organic material. This is followed by ploughing and then pit digging or creating of furrows for planting. Surface scarifying may substitute for ploughing for minimum soil preparation.

Weed control can be done manually in the rows and mechanically between the rows. During harvest weed control needs to be especially well done in the rows parallel to the planting lines because the fruits are usually collected from the ground. Mechanical weeding (close to the plant less than 1 meter) is not recommended in order to prevent damages to the roots, which are largely concentrated within 15 to 45 cm from the stem (Lima and Borges, 2002). Chemical weeding, using selective herbicides eliminates not only the weeds, but reduces operational costs and simplifies the work.

The best pre-emergence herbicides are "diuron" and "bromacil" (Durigan, 1987). Paraquat or glyphosate have been used in some plantations in the Triângulo Mineiro and in Sao Paulo at 1.5 to 2.0 L/ha, and applied between the rows, leaving the dead weeds as a form of mulch covering the soil surface (Silva and Rabelo, 1991). Lima *et al.* (1999), studying the selectivity of pre-emergence herbicides "diuron" (1.2, 2.4 and 4.8 kg/ha), "oxyfluorfen" (0.48, 0.96 and 1.92 kg/ha), "alachlor" (2.8, 5.6 and 11.2 kg/ha) and "atrazine" + "metolachlor" (3.0, 6.0 and 12.0 kg/ha), in yellow passion-fruit seedlings, observed that only "atrazine" + "metolachlor", in doses of 6.0 and 12.0 kg/ha, caused serious injury to the seedlings, while the others proved promisingly useful. Due to the fact that herbicide activity, in general, is limited to a specific plant or group of plants, it is recommended to use mixtures and planned combinations of herbicides pre-emergence and post-emergence, aiming to increase the period and active spectrum of the chemical control.

9.4. Mineral nutrition

9.4.1. Uptake and export of nutrients

For growth and production, passion-fruit requires an adequate nutritional state at all stages of growth and this requires a fertilization plan to permit the maintenance of an adequate nutritional state of the crop. From the start of fruit formation there is a great demand for energy by the plant and a strong translocation of nutrients from the leaves to the developing fruits and this reduces the vegetative growth of the plant.

The total quantities of nutrients taken up and exported by the entire plant, including the fruits, at 370 days, with 1,500 plants/ha, are shown in Table 9.1. The macro-nutrients N, K and Ca are taken up in the greatest quantities, followed by S, P and Mg. Of the micro-nutrients, Mn and Fe are absorbed in the greatest quantities, followed by Zn, B and Cu (Haag *et al.,* 1973).

Of the nutrients removed in the harvested fruits by far the largest quantity is K followed by N. Although only small quantities of Mg, S, Ca and P are removed, the amounts of P and Mg represent 40% and 29% of the total taken up, respectively (Table 9.1) (Haag *et al.,* 1973). Of the micro-nutrients, Mn is taken up most, but by percent Zn, followed by Cu, are the most exported. In spite of the large amount of Mn found in the fruits, it represents only 6.4% of the total taken up; however 34% of Zn, 32% of Cu, 13% of B and 11% of Fe are accumulated in the fruit and, thereby, removed at harvest (Table 9.2) (Haag *et al.,* 1973).

In this way for a crop yielding about 25 mt/ha, the export of macro-nutrients in the fresh fruits, in kg/mt, is 1.82 of N, 0.28 of P, 3.01 of K, 0.28 of Ca, 0.17 of Mg and 0.17 of S; while that for micro-nutrients, in g/t, is 1.54 of B, 2.61 of Cu, 3.59 of Fe, 7.35 of Mn and 4.41 of Zn.

Table 9.1. Quantities of nutrients absorbed by the whole plant (AB) and removed in the fruits (EX) of the yellow passion-fruit, at 370 days of age, with 1,500 plants/ha at yield level of 13 mt/ha.

Nutrient	Quantity	
	AB	EX
Macro-nutrient	------------- kg/ha	--------------
N	205	44.6
P	17	6.9
K	184	73.8
Ca	152	6.8
Mg	14	4.0
S	25	4.0
Micro-nutrient	-------------- g/ha	--------------
B	296	37.8
Fe	779	88.0
Mn	2,810	180.2
Zn	317	108.2
Cu	199	64.0

Source: Haag *et al.*, 1973.

9.4.2. Functions and importance of nutrients

Nitrogen (N): It is fundamental for the growth of all plant parts (Baumgartner, 1987; Kliemann *et al.*, 1986). It stimulates the development of floral and fruit buds, as well as increasing the amount of protein (Malavolta *et al.*, 1989). In its absence, growth is slow and the plant's size is reduced, with thinner and fewer branches (Marteleto, 1991). Data from the north-east region shows that there is a greater quantity of total soluble solids and lower acidity in yellow passion-fruit juice, as well as higher productivity, with the application of larger amounts of N to the soil (Marteleto, 1991).

Phosphorus (P): In its absence passion-fruit growth is reduced, affecting the quantity of dry matter, root growth and fruit production (Manica, 1981; Baumgartner, 1987).

Potassium (K): Its deficiency reduces the weight of the plant and the production of fruits, which fall prematurely or shrivel (Manica, 1981). In the north-east region increases in length and diameter of the fruit were observed with the application of larger amounts of K (Borges *et al*., 1998).

Calcium (Ca): Its deficiency results in deformed leaves due to the breakdown of leaf tissue structure (Cereda *et al*., 1991), because Ca affects cell elongation and the process of cell division (Ruggiero *et al*., 1996).

Magnesium (Mg): In nutrient culture experiments, the absence of Mg affected the nutrient state of the plant, resulting in a greater absorption of P, K and Ca, relative to plants grown using a complete solution (Fernandes *et al*., 1991).

Boron (B): Boron deficiency results in an increase in N, P and S in the tendrils and Mn in the stem and leaves of passion-fruit (Kliemann *et al*., 1986).

Visual diagnosis: Based on the fact that each nutrient has a specific role in the physiological functions of plants, then excesses or deficiencies, i.e. imbalances, often result in characteristic symptoms, which permit the identification of the cause of the disorder. To establish the cause of visual symptoms requires knowledge of the symptom and its cause determined in both controlled experiments, which simulate the nutritional disorders systematically, and from soil and plant analysis. In Table 9.2 symptoms of nutritional deficiencies are described.

However, it is not sufficient to just rely on visual symptoms, to confirm that an anomaly is due to a disorder provoked by a specific nutrient. Because many factors may act simultaneously, to rely on one diagnostic based only on visual symptoms is not prudent. Visual symptoms should be confirmed by leaf and soil analysis of samples taken from crops grown in the field. Once it has been confirmed that deficiency or excess of a specific nutrient is the cause of the problem appropriate corrections can be made.

Leaf diagnosis: This consists of the determination, via chemical analysis, of the nutrient composition of the leaf which is the organ that best reflects the nutritional state of the plant. To be successful appropriate leaves in relation to stage of growth and position on the plant must be taken for analysis.

Table 9.2. Visual symptoms of nutrient deficiency in passion-fruit leaves.

Nutrient	Leaf age	Leaf symptoms
N	Oldest	Light green and smaller area. Yellowing and premature falling. *Cause*: low composition of organic matter, acidity (lower mineralization), leaching, prolonged drought.
P	Old	Dark green, later yellowing from the edges to the centre. *Cause*: low composition of P in the soil, low pH (lower availability).
K	Old	Progressive chlorosis from the edges to the centre, necrosis and tissue “burn”. *Cause*: low composition of K in the soil, leaching and excessive liming.
Mg	Old	Yellowish spots between the veins, wizened lamina curling down. *Cause:* soils low in Mg, acidity and excessive potassium in fertilization.
Ca	Young	Death of apical sprout, interveinal chlorosis and necrosis. *Cause*: low Ca composition in the soil, excessive potassium in fertilization.
S	Young	Chlorotic, yellowish veins on the bottom side of the leaves. *Cause*: low soil S composition, low organic matter content.
Cu	Old	Large and wide leaves, dark green in color and partially shrivelled, thickening of the veins on the upper side, curved downwards. *Cause*: low soil Cu composition, excessive liming and high levels of organic matter.
Mo	Old	Interveinal chlorosis. *Cause*: acidity, excessive sulphate.
B	Young	Plants atrophied, necrosis of the terminal sprout. Smaller and shrivelled leaves with waves along the edges. *Cause*: low soil B composition, low organic matter content, excessive acidity, leaching.
Fe	Young	Interveinal chlorosis. *Cause*: Excessive liming, elevated organic matter content, low soil Fe composition and elevated moisture.
Mn	Young	Chlorotic spots between the veins. *Cause*: excessive liming, elevated organic matter content, low soil Mn composition.
Zn	Young	Small leaves, gaunt and pointed lobes, milky white spots with yellow edges *Cause*: low soil Zn composition, excessive liming and phosphatized fertilization.

Source: Borges and Lima, 1998.

For passion-fruit it is recommended to sample the 4th leaf from non-shaded and non-pruned branch apices, taking four leaves per plant, from both sides, including the leaf stem. In the first year, samples should be taken between the 8th and 9th months and, in the following years, during the flowering period. Adequate ranges of macro- and micro-nutrient compositions are given in Table 9.3.

Table 9.3. Adequate ranges of macro- and micro-nutrients in passion-fruit leaves.

Nutrient	Concentration
Macro-nutrient	---------- g/kg ----------
N	47.5-52.5
P	2.5-3.5
K	20.0-25.0
Ca	5.0-15.0
Mg	2.5-3.5
S	2.0-4.0
Micro-nutrient	---------- mg/kg --------
B	2.0-4.0
Cu	5.20
Fe	100-200
Mn	50-200
Zn	45-80

Source: IFA, 1992.

9.5. Fertilization

9.5.1. Inorganic fertilizer

Fertilization consists of supplying nutrients in quantities sufficient for the plant to be able to reach its production potential. Fertilization aims to increase both productivity and quality, without compromising the fertility of the soil, especially in irrigated areas, keeping in mind that fertilization can degrade soil. Any fertilization programme should take into account the fertilizer to be used, the quantity, the time of year and the location of application relative to the plant. Thus, there is no single formula that would be the best for all conditions. It is important that, for each plant, one takes into account soil fertility, evaluated by soil analysis, and the expected productivity (Table 9.4). Amounts of fertilizer used during early growth of the plant are, to a certain extent, comparable amongst the different regions of Brazil.

Fertilizer recommendations are related to soil analytical data and the potential productivity of the site and the phenological phase of the plant.

9.5.2. Organic manures

Using organic manures helps to maintain the soil's productivity, because it has beneficial effects on the physical, chemical and biological properties of the soil. The materials to be applied in the planting holes, especially in sandy soils and those of low fertility, depend on their availability. The quantities vary according to the nutrient composition of the materials available and may be corral manure (20 to 30 L), chicken manure (5 to 10 L), castor bean debris (2 to 4 L) and compost, amongst others. However, it is recommended to give preference to bovine manure, due to the greater amount that is available (Borges *et al.*, 2002).

9.5.3. Fertilization with micro-nutrients

In the absence of soil analytical data apply 50 g of F.T.E. BR-12 in the planting hole. Zinc and B are the micro-nutrients taken up in largest amounts by the plant, followed by Mn and Fe. With Zn deficiency, apply 20 g of zinc sulphate ($ZnSO_4.H_2O$) per plant, and of B, apply 6.5 g of boric acid (H_3BO_3) per plant. Boron and zinc recommendations for the yellow passion-fruit are given in Table 9.5.

9.5.4. Splitting fertilization applications

Deciding whether to split fertilizer application depends on the texture and the CEC of the soil, as well as the pattern of rainfall. In sandy soils and those with a low CEC, fertilizers should be applied weekly or biweekly. In more clayey soils, fertilizers can be applied monthly or bimonthly, especially when applied to the soil. With fertigation nutrients can be applied weekly or biweekly, depending on soil texture (Borges *et al.*, 2002).

9.5.5. Fertilization position

Passion-fruit has a shallow superficial root system, i.e. about 60% of the roots are found in the upper 30 cm of soil, and 87% between 0 and 45 cm from the base of the stem. In young orchards, fertilizers should be distributed in a 20 cm wide area around and 10 cm from the trunk, gradually increasing this distance with the age of the plants (Fig. 9.1 A and 9.1 B). In mature vines it is recommended to apply fertilizer in a band 2 m long and 1 m wide, on both sides of the plants and 20 to 30 cm from the trunk (Borges *et al.*, 2002).

Table 9.4. Fertilization recommendation in the plantation, formation and production phases of the irrigated yellow passion-fruit.

	N	P-resin (mg/dm^3)			K-soil ($cmol_c/dm^3$)				
		0-15	16-40	>40	0-0.07	0.08-0.15	0.16-0.30	0.31-0.50	>0.50
	kg/ha	---------------------- P_2O_5 (kg/ha) ----------------------			---------------------- K_2O (kg/ha) ----------------------				
At planting	150[1]	120	80	0	0	0	0	0	0
During growth									
Days after planting									
30	10	0	0	0	20	10	0	0	0
60	20	0	0	0	30	20	10	0	0
90	30	0	0	0	40	30	20	10	0
120-180	40	0	0	0	60	40	30	20	0
During fruit production									
Expected yield (mt/ha)									
<15	50	50	30	20	100	90	70	50	0
15-25	70	90	60	40	160	120	90	70	0
25-35	90	120	80	50	200	160	120	80	0
>35	120	150	100	60	250	200	150	100	0

[1] In the form of bovine manure.

Source: Borges *et al.*, 2002.

Table 9.5. Boron (B) and zinc (Zn) recommendation for the irrigated yellow passion-fruit.

Nutrient	Soil composition (mg/dm^3)	Classes of fertility	Nutrient dose (kg/ha)
	Hot water		
B	<0.2	Low	2
	0.21-0.6	Medium	1.0
	>0.6	High	0
	DTPA		
Zn	<0.5	Low	6
	0.6-1.2	Medium	3
	>1.2	High	0

Source: Borges *et al.*, 2002.

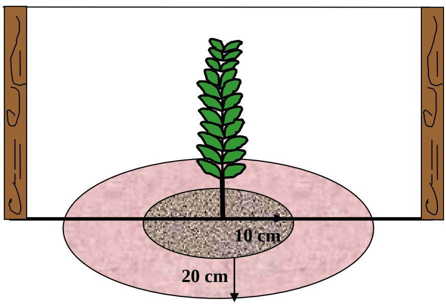

Fig. 9.1 A. Localization of fertilizers in young passion-fruit plants.

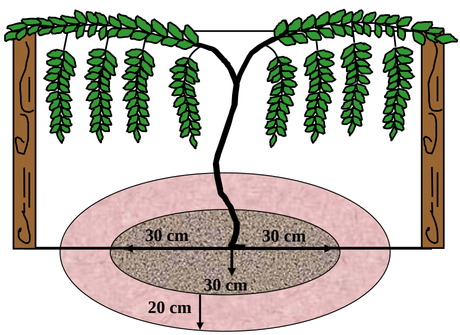

Fig. 9.1 B. Localization of fertilizers in adult passion-fruit plants.

Source: Borges, A.L., unpublished.

9.6. Irrigation

The soil water level influences passion-fruit flowering (Vasconcelos, 1994). A lack of moisture results in loss of leaves and fruits, especially at the start of their development, and this affects the production and quality of the fruits (Manica, 1981; Ruggiero *et al.,* 1996).

9.6.1. Irrigation method

The method most frequently used is localized irrigation, using drip and spray systems. Spraying promotes a greater wetted area of soil compared to dripping, thus permitting greater volume of root system expansion. The drip irrigation system has been more widely adopted by farmers because it provides moisture and aeration conditions that favor the development and productivity of the plants. Drip irrigation has the advantage of not contributing to the formation of a humid transitory microclimate within the culture orchard, thus helps to decreases the risk of diseases (Oliveira *et al.*, 2002).

9.6.2. Water requirements

Rainfall in the range of 800 to 1,750 mm, regularly distributed throughout the year, is ideal for passion-fruit. Productivity of around 40 mt/ha, has been obtained with a total water supply (rain + irrigation) of 1,300 to 1,470 mm, where 826 mm came from rain (Martins *et al.*, 1998, cited by Oliveira *et al.*, 2002). In areas where the rains are insufficient or poorly distributed, irrigation is essential, not only to increase productivity, but also to improve the quality of the fruit, via continuous and uniform production (Oliveira *et al.*, 2002).

9.6.3. Fertigation

The application of fertilizers via irrigation water results a more rational use of fertilizers in irrigated agriculture, because there is an increase in its efficiency, and a reduction in labour and energy costs. In addition, it allows flexibility in the time of nutrient application, which may be divided according to the needs of the crop in its various stages of development. Drip irrigation is the most appropriate for fertigation, because nutrients are applied directly to the zone of greatest concentration of active roots.

Nitrogen is the nutrient usually applied via irrigation, because it has a high mobility in the soil, especially in the form of nitrate (NO_3^-), but care must be taken not to favor loss by leaching. In fertigation, N is applied accordingly to the demand of the plant to reduce losses, especially in sandy soils. Because it is so mobile in soil, N should be applied frequently at three to seven day intervals, except in sandy soils when the interval should be around three days. The recommended quantity should be distributed throughout the period between the first four months of growths, corresponding to the formation phase of the plant and the beginning of the production phase (first year). Solid N fertilizers are available in four forms: ammoniacal (ammonium sulphate), nitric (calcium nitrate), ammoniacal-nitric (ammonium nitrate) and amide (urea), all being soluble in water and adequate for fertigation, including drip irrigation. In general, these N sources behave similarly and can be applied with other nutrients. Their different effect on the soil pH has to be considered (Borges and Sousa, 2002).

In general, P is not often applied with irrigation due to the low solubility of most P fertilizers and their facility of precipitate, causing blockage of the lines and emitters. Phosphoric acid, apart from a risk of corrosion in metallic lines and connections, does not cause problems of emitter blockage, and is applied via irrigation water to promote cleaning of the lines and emitters in fertigation systems. Apart from this, diammonium phosphate (DAP) and monoammonium phosphate (MAP) can be used in fertigation (Borges and Sousa, 2002).

Like N, the application of K via irrigation water is viable, because K fertilizers are soluble. When using split applications, it is important to consider its potential loss by leaching in very sandy soils and its adsorption by clay minerals in heavy soils. Potassium fertilizers normally used in fertigation are potassium chloride, potassium sulphate, potassium nitrate and potassium and magnesium sulphate. The application of K with irrigation may be done every six or seven days and it is recommended to continue the distribution throughout the growth of the plant. Starting from the second year, the recommended quantity of K_2O for the production period may be divided between the 5^{th} and the 12^{th} month after the seedlings have been transplanted (Borges and Sousa, 2002).

Drip irrigation emitters are usually placed at two emitters per plant at a distance of 60 cm between them and each one placed 30 cm from the stem (Borges *et al.*, 2002).

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