Nutritional recommendations for

TOMATO

Haifa

Pioneering the Future

Nutritional recommendations for

TOMATO

in open-field, tunnels and greenhouse

Botanical name: *Lycopersicon esculentum Mill.*
Synonyms: tomate; pomodoro

Contents:

1. About the crop

1.1 Growth patterns

Tomato cultivars may be classified into three groups by their growth patterns, which are recognized by the arrangement and the frequency of leaves and the inflorescence on the stem.

a) **Indeterminate growth** – the main and side stems continue their growth in a continuous pattern. The number of leaves between inflorescence is more or less constant, starting from a specific flowering set (Fig. 1a). Cultivars of indeterminate growth are usually grown as greenhouse or staked tomatoes.

b) **Determinate growth** – the main and side stems stop growth after a specific number of inflorescences that varies with the specific cultivar (Fig. 1b). Processing tomatoes are often belong to determinate cultivars.

c) Semi-determinate growth - branches stop growth with an inflorescence, but this usually occurs at an advanced growth stage. Cultivars of this group are usually grown as out-door, non-staked tomatoes.

Table 1: Number of leaves between inflorescence in different growth patterns

	No. of leaves before inflorescence	
	Indeterminate	Determinate
1st inflorescence	6-14	4-6
2nd inflorescence	5-7	2-3
3rd and further inflorescences	3-5	0-1

Figure 1a: Indeterminate type of tomato growth

Figure 1b: Determinate type of tomato growth

1.2 Growth stages

Growth stages of plants, in very general terms, can be split into four periods:

- Establishment from planting or seeding during vegetative growth until first flower appears.
- From first flowering to first fruit set
- From fruit ripening to first harvest
- From first harvest to the end of last harvest.

These growth periods also represent different nutritional needs of the plant (see section 3.1). The duration of each stage may vary according to growing method, variety characteristics and climatic conditions (Table 2).

Table 2: A typical example of a growth cycle in central Israel by growth stages

Variety	VF121	
Growing method	Greenhouse	
Number days to first flowering	30	
Number days to first harvesting	65	
Growth stage	Stage duration (days)	Crop age (days)
Planting	1	1
Vegetative	14	15
First flowering	15	30
First fruit set	10	40
Fruit growth	20	60
Starting harvest - until end of last harvest	21-145	81-210

1.3 Fruit development

After fruit setting, fruit ripens over a period of 45 - 70 days, depending upon the cultivar, climate and growth conditions. The fruit continues growing until the stage of green ripeness.
Three fruit developmental stages are noted.
Ripening occurs as the fruit changes color from light green to off-white, pink, red, and finally dark red or orange. Depending on the distance and time to market, harvest may occur anytime between the pink to dark red stage, the later stages producing more flavorful fruit.

Table 3: Stages of fruit ripening

Stage	Description
Breaker	Red stains appear on fruit skin
Pink	Tomato turns pink, not yet ready for consumption
Red	The tomato is red and completely ripe for consumption

1.4 Crop uses

Tomatoes are consumed fresh, and are being processed to pickles, sauce, juice and concentrated pastes.

2. Growing conditions

2.1 Growing method

Soil or soilless, protected crop (greenhouse or high plastic tunnel) or open field.

2.2 Soil type

Tomatoes can be grown on soils with a wide range of textures, from light, sandy soils to heavy, clay soils. Sandy soils are preferable if early harvest is desired. Favorable pH level: 6.0-6.5. At higher or lower pH levels micronutrients become less available for plant uptake.

2.3 Climate

Temperature is the primary factor influencing all stages of development of the plant: vegetative growth, flowering, fruit setting and fruit ripening. Growth requires temperatures between 10°C and 30°C.

Table 4: Temperature requirements during different growth stages:

Growth stage	Temperature (°C)		
	Minimum	Maximum	Optimal
Germination	11	34	16-29
Vegetative growth	18	32	21-24
Fruit setting (night / day)	10 / 18	20 / 30	13-18 / 19-24
Formation of lycopene	10	30	21-24
Formation of carotene	10	40	21-32

Light intensity is one of the major factors affecting the amounts of sugars produced in leaves during the photosynthesis, and this, in turn, affects the number of fruits that the plant can support, and the total yield.

2.4 Irrigation

Tomato plants are fairly resistant to moderate drought. However, proper management is essential to assure high yield and quality.

The water requirement of outdoor grown tomatoes varies between 4000 - 6000 m^3/ha. In greenhouses up to 10,000 m^3/ha of water are required. 70% or more of the root system are in the upper 20 cm of the soil. Therefore, a drip system equipped with a fertigation device is advisable.

On light soils or when saline water is used, it is necessary to increase water quantities by 20% - 30%. Water requirements will differ at various growth stages. The requirement increases from germination until beginning of fruit setting, reaching a peak during fruit development and then decreasing during ripening.

Mild water stress during fruit development and ripening has a positive effect on fruit quality: firmness, taste and shelf-life quality, but may result in smaller fruit. Late irrigation, close to harvesting, may impair quality and induce rotting.

Water shortage will lead to reduced growth in general and reduced uptake of calcium in particular. Calcium deficiency causes Blossom End Rot (BER) (see page 15). On the other hand, excessive irrigation will create anaerobic soil conditions and consequently cause root death, delayed flowering and fruit disorders.

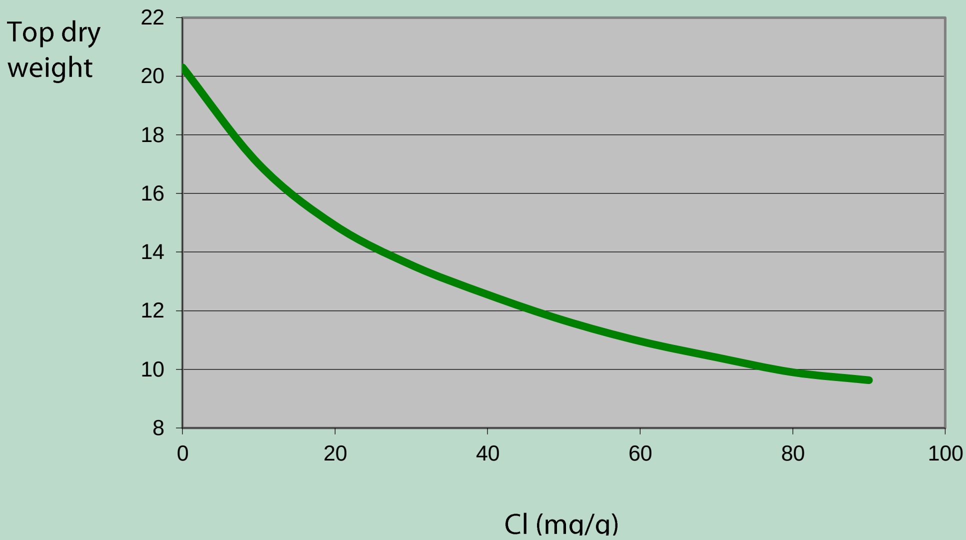
Water quality: Tomatoes tolerate brackish water up to conductivity of about 2-3 mmho/cm. Acidic (low pH) irrigation water is undesirable, as it might lead to the dissolution of toxic elements in the soil (e.g. Al^{3+}).

2.5 Specific sensitivities of the tomato plant

Sensitivity to soil-borne diseases
Tomatoes are prone to soil-borne diseases caused by fungi, viruses or bacteria. Therefore it is recommended to avoid growing tomatoes on plots that used for other sensitive crops (peppers, eggplants, Irish potatoes, sweet potatoes, cotton, soybeans and others) on recent years. A regime of 3-year rotation between small grains and tomatoes is recommended.

Sensitivity to salinity
Under saline conditions, sodium cations compete with the potassium cations for the roots uptake sites, and chloride competes for the uptake of nitrate-nitrogen and will impede plant development (Fig.2) and reduce yield.

Figure 2: Inverse relationship between top dry weight and concentration of plant tissue chloride – the higher the chloride in the plant composition, the lower its dry weight.

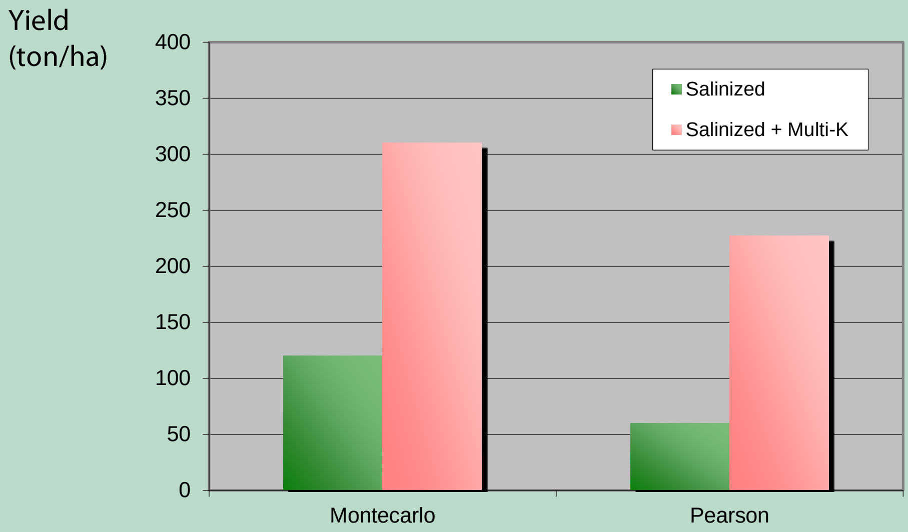


Salinity will result in a potassium deficiency in the tomato plants, leading to a low fruit number per plant. Corrective measures under such conditions must include the following steps:

- Abundant application of potassium, as this specific cation can successfully compete with the sodium, and considerably reduce its uptake and the resulting negative effects. (Fig. 3)
- Abundant application of nitrate, as this specific anion successfully competes with chloride, and markedly reduces its uptake and adverse effects.

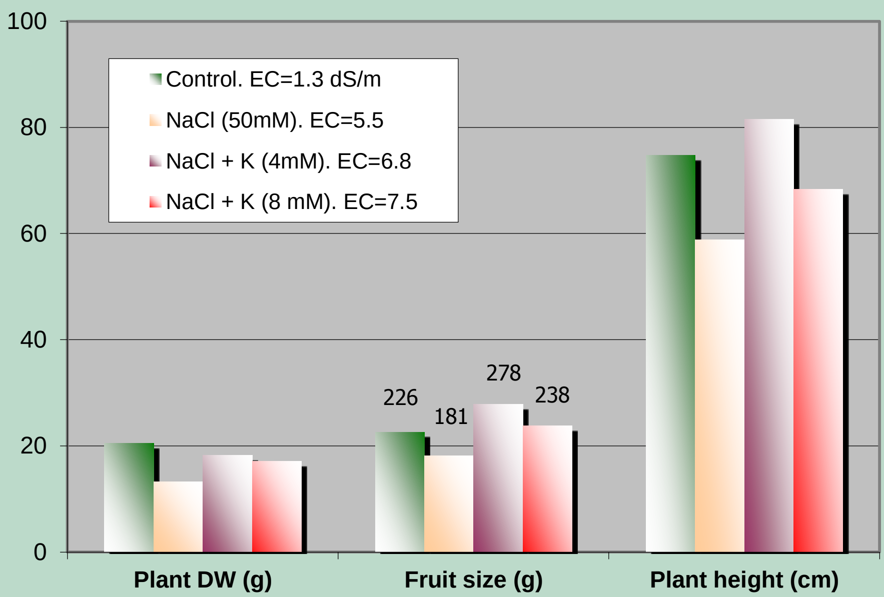
- Also, calcium helps suppressing the uptake of sodium. When sufficient calcium is available, the roots prefer uptake of potassium to sodium, and sodium uptake will be suppressed.

Figure 3: Multi-K® potassium nitrate reverses the adverse effects of salinity in greenhouse tomatoes (Source: Satti et Al. 1994)



Salination of the nutrient solution markedly decreased dry weight of the plant, fruit size and plant height. The addition of 4 or 8 mM Multi-K® potassium nitrate to the salinized nutrient solution markedly increased EC values of the nutrient solution but reversed the said adverse effects caused by the NaCl. Several parameters were improved even over the control as a direct result of the treatment with Multi-K®, i.e., fruit size and plant height (Fig. 4).

Figure 4: The effect of salinity and Multi-K® potassium nitrate on vegetative parameters and fruit size in 'Pusa ruby' greenhouse tomatoes.



Zinc improves tolerance to salt stress

Zinc nutrition in plants seems to play a major role in the resistance to salt in tomato and other species. Adequate zinc (Zn) nutritional status improves salt stress tolerance, possibly, by affecting the structural integrity and controlling the permeability of root cell membranes. Adequate Zn nutrition reduces excessive uptake of Na by roots in saline conditions.

Sensitivity to calcium deficiency

Tomatoes are highly sensitive to calcium deficiency, which is manifested in the Blossom-End Rot (BER) symptom on the fruits. Salinity conditions severely enhance BER intensity. Recently, it was found that manganese (Mn) serves as antioxidant in tomato fruit, hence its application to tomatoes grown under salinity can alleviate BER symptoms in the fruits. Special care must be taken to avoid growing conditions, which enhance BER phenomenon.

3. Plant nutrition

3.1 Dynamics of nutritional requirements

Nitrogen and potassium uptake is initially slow but rapidly increases during the flowering stages. Potassium is peaking during fruit development, and nitrogen uptake occurs mainly after the formation of the first fruit. (Figs. 5 and 6).
Phosphorus (P) and secondary nutrients, Ca and Mg, are required at a relatively constant rate, throughout the life cycle of the tomato plant.

Figure 5: The uptake dynamics of the macro- and the secondary nutrients by a tomato plant (Source: Huett, 1985)

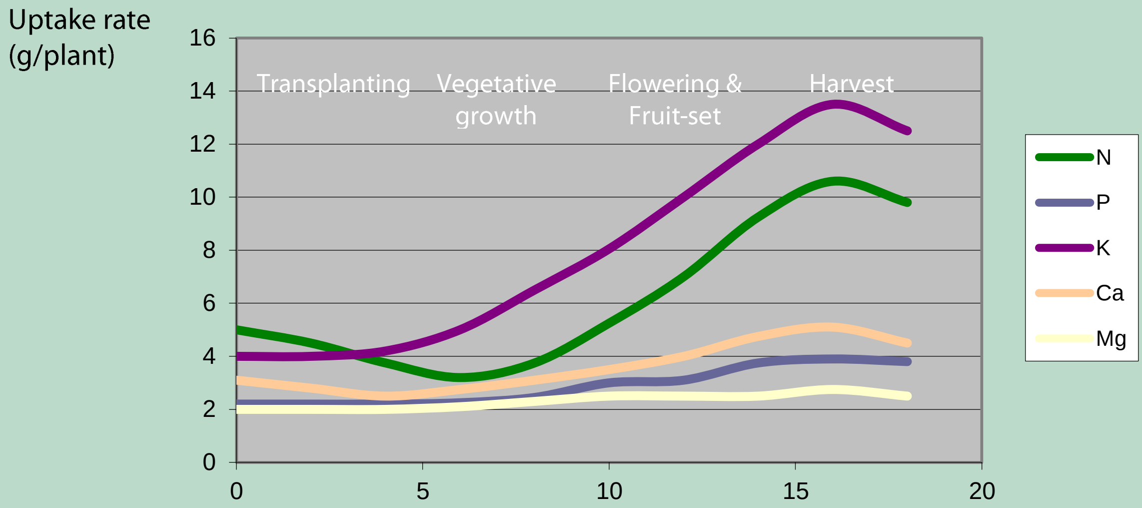
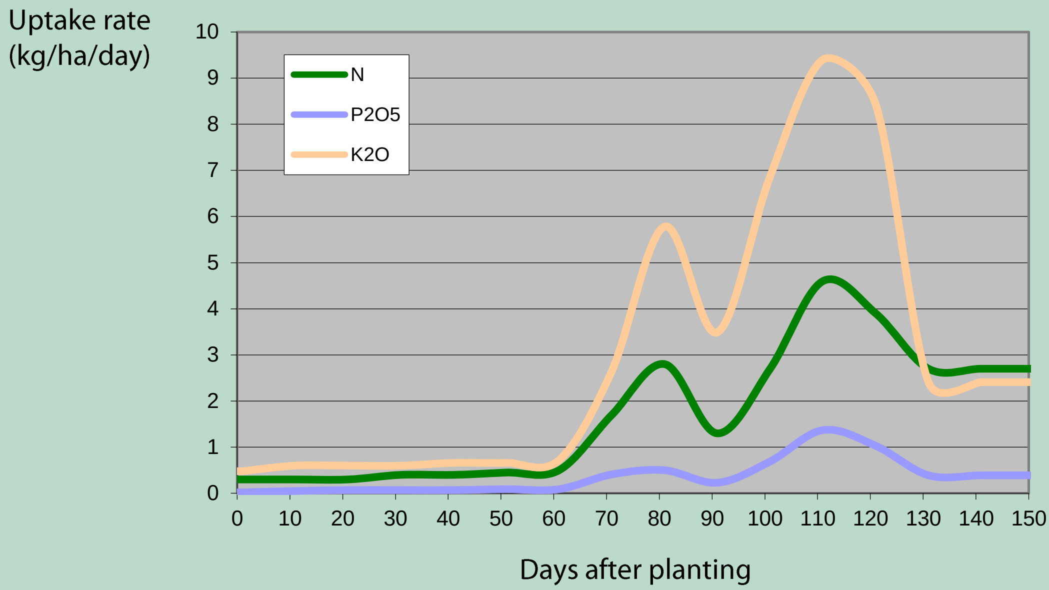


Figure 6: Daily uptake rates of plant nutrients by processing tomatoes yielding 127 T/ha (Source: B. Bar-Yosef) .



As can be seen in figures 5 and 6, the greatest absorption of nutrients occurs in the first 8 to 14 weeks of growth, and another peak takes place after the first fruit removal. Therefore, the plant requires high nitrogen application early in the growing season with supplemental applications after the fruit initiation stage. Improved N use efficiency and greater yields are achieved when N is applied under polyethylene mulches via a drip irrigation system. At least 50 % of the total N should be applied as nitrate-nitrogen (NO_3^-).

The most prevalent nutrient found in the developed tomato plant and fruit is potassium, followed by nitrogen (N) and calcium (Ca). (Figures 7 and 8)

Figure 7: Element composition of a tomato *plant* (Atherton and Rudich, 1986)

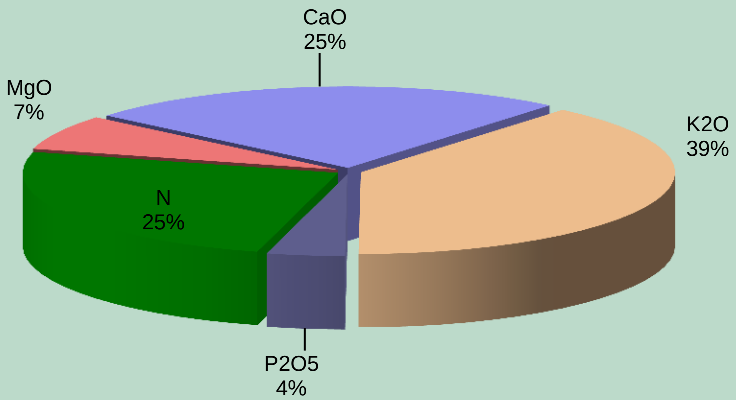
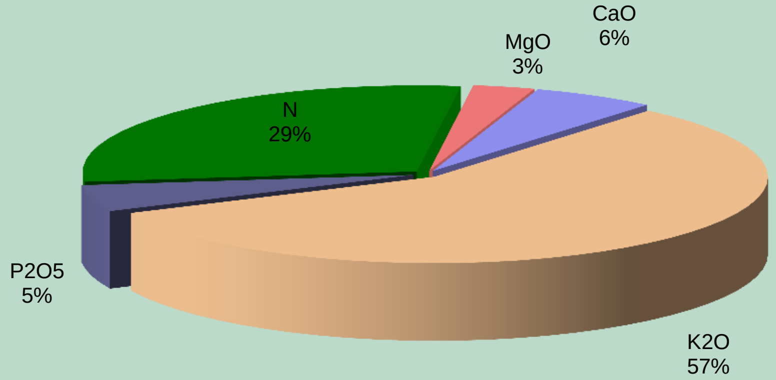


Figure 8: Element composition of a tomato *fruit* (Atherton and Rudich, 1986)



3.2 Main functions of plant nutrients

Table 5: Summary of main functions of plant nutrients:

Nutrient	Functions
Nitrogen (N)	Synthesis of proteins (growth and yield).
Phosphorus (P)	Cellular division and formation of energetic structures.
Potassium (K)	Transport of sugars, stomata control, cofactor of many enzymes, reduces susceptibility to plant diseases.
Calcium (Ca)	A major building block in cell walls, and reduces susceptibility to diseases.
Sulphur (S)	Synthesis of essential amino acids cystin and methionine.
Magnesium (Mg)	Central part of chlorophyll molecule.
Iron (Fe)	Chlorophyll synthesis.
Manganese (Mn)	Necessary in the photosynthesis process.
Boron (B)	Formation of cell wall. Germination and elongation of pollen tube. Participates in the metabolism and transport of sugars.
Zinc (Zn)	Auxins synthesis.
Copper (Cu)	Influences in the metabolism of nitrogen and carbohydrates.
Molybdenum (Mo)	Component of nitrate-reductase and nitrogenase enzymes.

Nitrogen (N)

The form in which N is supplied is of major importance in producing a successful tomato crop. The optimal ratio between ammonium and nitrate depends on growth stage and on the pH of the growing medium.

Plants grown in NH_4^+ -supplemented medium have a lower fresh weight and more stress signs than plants grown on NO_3^- only. By increasing the ammonium nitrate rates, the EC increases and consequently the yield decreases. However, when doubling the rate of Multi-K® potassium nitrate, the EC increases without adverse effect on the yield that increases as well (Table 6).

Table 6: The effect of nitrogen form (NO_3^- and NH_4^+) on tomato yield - showing the advantages of nitrate-nitrogen over ammoniacal nitrogen. (source: U. Kafkafi et al. 1971)

NO_3^- : NH_4^+ ratio	N g/plant		EC (mmho/cm)	Yield (kg/plant)
	Multi-K® potassium nitrate	Ammonium Nitrate		
100 : -	6.3	-	1.7	2.5
70 : 30	6.3	4.4	2.4	1.98
63 : 37	6.3	8.7	2.9	1.20
59 : 41	6.3	13.2	3.5	1.00
- : 100	12.6	-	3.1	3.43

Potassium (K)
Ample amounts of potassium must be supplied to the crop in order to ensure optimal K levels in all major organs, mainly due to the key role K plays in tomatoes:

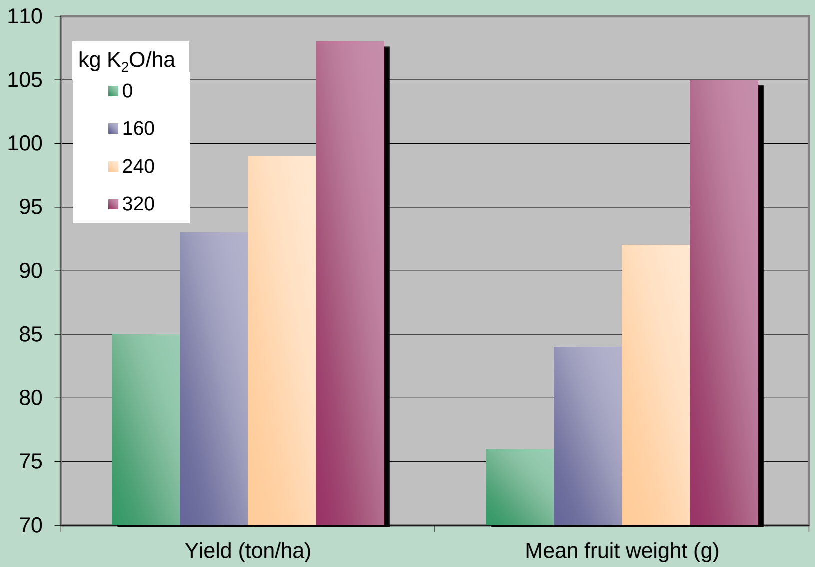
1. Balancing of negative electrical charges in the plant
As a cation, K^+ is THE dominant cation, balancing negative charges of organic and mineral anions. Therefore, high K concentration is required for this purpose in the cells.

2. Regulating metabolic processes in cells
Main function is in activating enzymes - synthesis of protein, sugar, starch etc. (more than 60 enzymes rely on K). Also, stabilizing the pH in the cell at 7 - 8, passage through membranes, balancing protons during the photosynthesis process.

3. Regulation of osmotic pressure
Regulating plant's turgor, notably on guard cells of the stomata.
In the phloem, K contributes to osmotic pressure and by that transporting metabolic substances from the "source" to "sink" (from leaves to fruit and to nurture the roots). This K contribution increases the dry matter and the sugar content in the fruit as well as increasing the turgor of the fruits and consequently prolonging fruits' shelf life.
Additionally, potassium has the following important physiological functions:

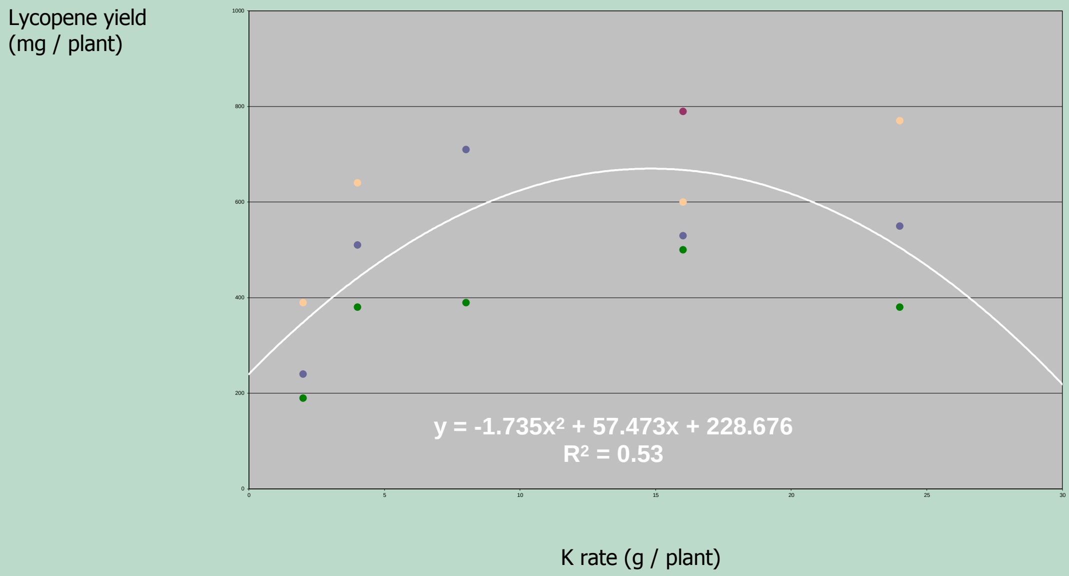
- Improves wilting resistance.(Bewley and White ,1926, Adams et al ,1978)
- Enhances resistance toward bacterial viral, nematodes and fungal pathogens. (Potassium and Plant Health, Perrenoud, 1990).
- Reduces the occurrence of coloration disorders and blossom-end rot. (Winsor and Long, 1968)
- Increases solids content in the fruit. (Shafik and Winsor,1964)
- Improves taste. (Davis and Winsor, 1967)

Figure 9: The effect of K rate on the yield and quality of processing tomatoes



Lycopene is an important constituent in tomatoes, as it enhances the resistance against cancer. Increasing Multi-K™ application rates increases lycopene content of the tomato. The function is described by an optimum curve (Fig. 10).

Figure 10: The effect of Multi-K™ rate on lycopene yield in processing tomatoes

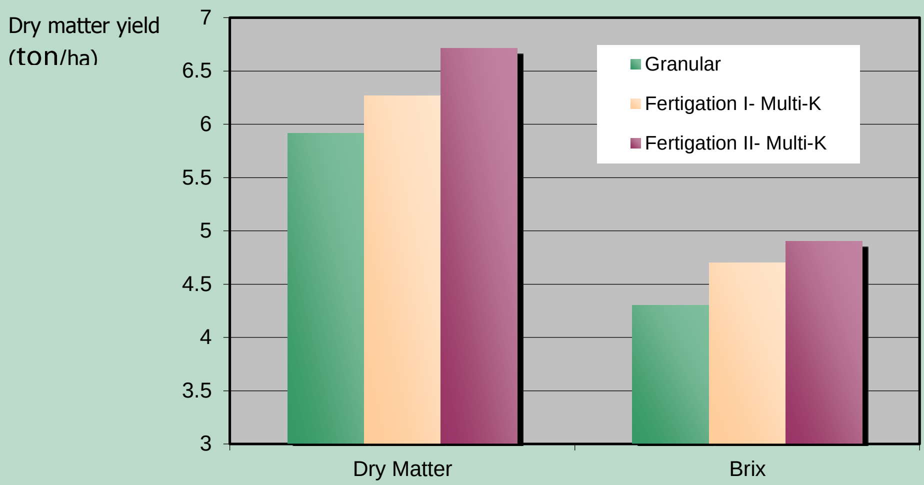


Multi-K™ was applied, as a source of potassium, either by itself or blended with other N and P fertilizers, to processing tomatoes. The different application methods, side-dressing dry fertilizers or combined with fertigation, were compared in a field trial (Table 7). Multi-K™ increased the yield (dry matter) and the brix level as can be seen in Figure 11.

Table 7: Layout of a field trial comparing different Multi-K™ application methods and rates, as a source of K, combined with other N and P fertilizers:

Method of application	N-P_2O_5-$K_2$0 kg/ha	
Base-dressing and side-dressing	120-140-260	1) 10 days prior to transplanting: 65% of N & K rates, and the entire P
		2) 26 days after transplanting (initial flowering): 10% of N & K rates
		3) 51 days after transplanting (initial fruit-set): 25% of N & K rates as **Multi-K™**
Base-dressing and Fertigation I	120-140-260	10 days prior to transplanting: 30% of N, P & K rates, 350 kg/ha of **Multi-K™** in a blend: 12-20-27.
		During the entire plant development stages, 70% of N-P-K as **Multi-K™** + Soluble NPK's + Multi-P (phos. acid), 12 weekly applications by fertigation
Base-dressing and Fertigation II	160-180-360 (34% higher rate)	10 days prior to transplanting: 30% of N, P & K rates as 400 kg/ha, a **Multi-K™** in a blend: 12-20-27.
		During the entire plant development stages, 70% of N-P-K as **Multi-K™** + Soluble NPK's + Multi-P (phos. acid), 12 weekly applications by fertigation

Figure 11: The effect of application method and rates of Multi-K™ potassium nitrate on the dry matter yield and brix level of processing tomatoes cv *Peto*.



Calcium (Ca)
Calcium is an essential ingredient of cell walls and plant structure. It is the key element responsible for the firmness of tomato fruits. It delays senescence in leaves, thereby prolonging leaf's productive life, and total amount of assimilates produced by the plans.
Temporary calcium deficiency is likely to occur in fruits and especially at periods of high growth rate, leading to the necrosis of the apical end of the fruits and a development of BER syndrome.

3.3 Nutrients deficiency symptoms

Tomatoes are rather sensitive to excess or deficiency of both macro- and micro- nutrients. Examples of common deficiencies, particularly in soilless culture, other than those of N and P, are: K deficiency, affecting fruit quality; Ca deficiency, causing blossom-end rot; Mg deficiency, in acid soils and in the presence of high levels of K; and deficiencies of B, Fe and Mn in calcareous soils.

Nitrogen
The chlorosis symptoms shown by the leaves on Figure 12 are the direct result of nitrogen deficiency. A light red cast can also be seen on the veins and petioles. Under nitrogen deficiency, the older mature leaves gradually change from their normal characteristic green appearance to a much paler green. As the deficiency progresses these older leaves become uniformly yellow (chlorotic). Leaves become yellowish-white under extreme deficiency. The young leaves at the top of the plant maintain a green but paler color and tend to become smaller in size. Branching is reduced in nitrogen deficient plants resulting in short, spindly plants. The yellowing in nitrogen deficiency is uniform over the entire leaf including the veins. As the deficiency progresses, the older leaves also show more of a tendency to wilt under mild water stress and senesce much earlier than usual. Recovery of deficient plants to applied nitrogen is immediate (days) and spectacular.

Figure 12: Characteristic nitrogen (N) deficiency symptom

Phosphorus

The necrotic spots on the leaves on Fig. 13 are a typical symptom of phosphorus (P) deficiency. As a rule, P deficiency symptoms are not very distinct and thus difficult to identify. A major visual symptom is that the plants are dwarfed or stunted. Phosphorus deficient plants develop very slowly in relation to other plants growing under similar environmental conditions but with ample phosphorus supply.
Phosphorus deficient plants are often mistaken for unstressed but much younger plants. Developing a distinct purpling of the stem, petiole and the lower sides of the leaves. Under severe deficiency conditions there is also a tendency for leaves to develop a blue-gray luster. In older leaves under very severe deficiency conditions a brown netted veining of the leaves may develop.

Figure 13: Characteristic phosphorus (P) deficiency symptom

Potassium

The leaves on the right-hand photo show marginal necrosis (tip burn). The leaves on the left-hand photo show more advanced deficiency status, with necrosis in the interveinal spaces between the main veins along with interveinal chlorosis. This group of symptoms is very characteristic of K deficiency symptoms.

Figure 14: Characteristic potassium (K) deficiency symptoms.

The onset of potassium deficiency is generally characterized by a marginal chlorosis, progressing into a dry leathery tan scorch on recently matured leaves. This is followed by increasing interveinal scorching and/or necrosis progressing from the leaf edge to the midrib as the stress increases. As the deficiency progresses, most of the interveinal area becomes necrotic, the veins remain green and the leaves tend to curl and crinkle. In contrast to nitrogen deficiency, chlorosis is irreversible in potassium deficiency. Because potassium is very mobile within the plant, symptoms only develop on young leaves in the case of extreme deficiency.

Typical potassium (K) deficiency of fruit is characterized by color development disorders, including greenback, blotch ripening and boxy fruit (Fig. 15).

Figure 15: Characteristic potassium (K) deficiency symptoms on the fruit

Calcium

These calcium-deficient leaves (Fig. 16) show necrosis around the base of the leaves. The very low mobility of calcium is a major factor determining the expression of calcium deficiency symptoms in plants. Classic symptoms of calcium deficiency include blossom-end rot (BER) burning of the end part of tomato fruits (Fig. 17). The blossom-end area darkens and flattens out, then appearing leathery and dark brown, and finally it collapses and secondary pathogens take over the fruit.

Figure 16: Characteristic calcium (Ca) deficiency symptoms on leaves

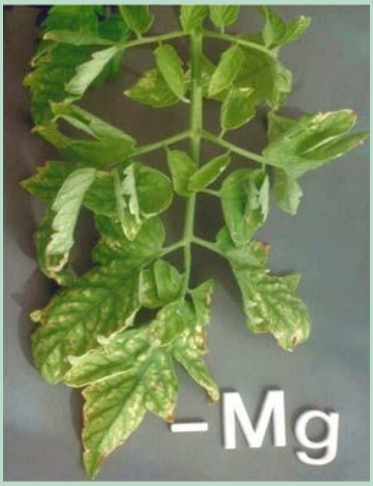
Figure 17: Characteristic calcium (Ca) deficiency symptoms on the fruit

All these symptoms show soft dead necrotic tissue at rapidly growing areas, which is generally related to poor translocation of calcium to the tissue rather than a low external supply of calcium. Plants under chronic calcium deficiency have a much greater tendency to wilt than non-stressed plants.

Magnesium

Magnesium-deficient tomato leaves (Fig. 18) show advanced interveinal chlorosis, with necrosis developing in the highly chlorotic tissue. In its advanced form, magnesium deficiency may superficially resemble potassium deficiency. In the case of magnesium deficiency the symptoms generally start with mottled chlorotic areas developing in the interveinal tissue. The interveinal laminae tissue tends to expand proportionately more than the other leaf tissues, producing a raised puckered surface, with the top of the puckers progressively going from chlorotic to necrotic tissue.

Figure 18: Characteristic magnesium (Mg) deficiency



Sulfur

This leaf (Fig. 19) shows a general overall chlorosis while still retaining some green color. The veins and petioles exhibit a very distinct reddish color. The visual symptoms of sulfur deficiency are very similar to the chlorosis found in nitrogen deficiency. However, in sulfur deficiency the yellowing is much more uniform over the entire plant including young leaves. The reddish color often found on the underside of the leaves and the petioles has a more pinkish tone and is much less vivid than that found in nitrogen deficiency. With advanced sulfur deficiency brown lesions and/or necrotic spots often develop along the petiole, and the leaves tend to become more erect and often twisted and brittle.

Figure 19: Characteristic sulfur (S) deficiency

Manganese

These leaves (Fig. 20) show a light interveinal chlorosis developed under a limited supply of Mn. The early stages of the chlorosis induced by manganese deficiency are somewhat similar to iron deficiency. They begin with a light chlorosis of the young leaves and netted veins of the mature leaves especially when they are viewed through transmitted light. As the stress increases, the leaves take on a gray metallic sheen and develop dark freckled and necrotic areas along the veins. A purplish luster may also develop on the upper surface of the leaves.

Figure 20: Characteristic manganese (Mn) deficiency

Molybdenum
These leaves (Fig. 21) show some mottled spotting along with some interveinal chlorosis. An early symptom for molybdenum deficiency is a general overall chlorosis, similar to the symptom for nitrogen deficiency but generally without the reddish coloration on the undersides of the leaves. This results from the requirement for molybdenum in the reduction of nitrate, which needs to be reduced prior to its assimilation by the plant. Thus, the initial symptoms of molybdenum deficiency are in fact those of nitrogen deficiency. However, molybdenum has also other metabolic functions within the plant, and hence there are deficiency symptoms even when reduced nitrogen is available. At high concentrations, molybdenum has a very distinctive toxicity symptom in that the leaves turn a very brilliant orange.

Figure 21: Characteristic molybdenum (Mo) deficiency

Zinc
This leaf (Fig. 22) shows an advanced case of interveinal necrosis. In the early stages of zinc deficiency the younger leaves become yellow and pitting develops in the interveinal upper surfaces of the mature leaves. As the deficiency progresses these symptoms develop into an intense interveinal necrosis but the main veins remain green, as in the symptoms of recovering iron deficiency.

Figure 22: Characteristic zinc (Zn) deficiency symptoms.

Boron
This boron-deficient leaf (Fig. 23) shows a light general chlorosis. Boron is an essential plant nutrient, however, when exceeding the required level, it may be toxic. Boron is poorly transported in the phloem. Boron deficiency symptoms generally appear in younger plants at the propagation stage. Slight interveinal chlorosis in older leaves followed by yellow to orange tinting in middle and older leaves. Leaves and stems are brittle and corky, split and swollen miss-shaped fruit (Fig. 24).

Figure 23: Characteristic boron (B) deficiency symptoms on leaves

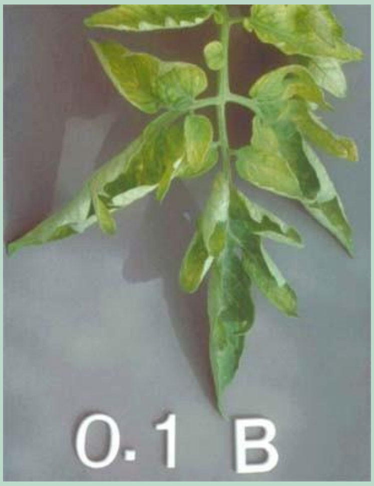


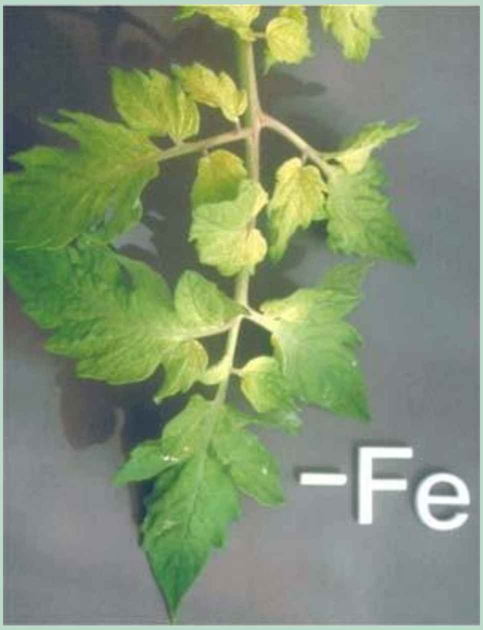
Figure 24: Characteristic boron (B) deficiency symptoms on fruits

Copper
These copper-deficient leaves (Fig. 25) are curled, and their petioles bend downward. Copper deficiency may be expressed as a light overall chlorosis along with the permanent loss of turgor in the young leaves. Recently matured leaves show netted, green veining with areas bleached to a whitish gray. Some leaves develop sunken necrotic spots and have a tendency to bend downward.

Figure 25: Characteristic copper (Cu) deficiency symptoms.

Iron.
These iron-deficient leaves (Fig. 26) show intense chlorosis at the base of the leaves with some green netting. The most common symptom for iron deficiency starts out as an interveinal chlorosis of the youngest leaves, evolves into an overall chlorosis, and ends as a totally bleached leaf. The bleached areas often develop necrotic spots. Up until the time the leaves become almost completely white they will recover upon application of iron. In the recovery phase the veins are the first to recover as indicated by their bright green color. This distinct venial re-greening observed during iron recovery is probably the most recognizable symptom in all of classical plant nutrition. Because iron has a low mobility, iron deficiency symptoms appear first on the youngest leaves. Iron deficiency is strongly associated with calcareous soils and anaerobic conditions, and it is often induced by an excess of heavy metals.

Figure 26: Characteristic iron (Fe) deficiency symptoms



3.4 Leaf analysis standards

In order to verify the correct mineral nutrition during crop development, leaf samples should be taken at regular intervals, beginning when the 3rd cluster flowers begin to set. Sample the whole leaf with petiole, choosing the newest fully expanded leaf below the last open flower cluster. Sufficiency leaf analysis ranges for newest fully-expanded, dried whole leaves are:

Table 8: Nutrients contents in tomato plant leaves

A. Macro and secondary nutrients

Nutrient	Conc. in leaves (%)	
	Before fruiting	During fruiting
N	4.0-5.0	3.5-4.0
P	0.5-0.8	0.4-0.6
K	3.5-4.5	2.8-4.0
Ca	0.9-1.8	1.0-2.0
Mg	0.5-0.8	0.4-1.0
S	0.4-0.8	0.4-0.8

B. Micronutrients

Nutrient	Conc. in leaves (ppm)	
	Before fruiting	During fruiting
Fe	50-200	50-200
Zn	25-60	25-60
Mn	50-125	50-125
Cu	8-20	8-20
B	35-60	35-60
Mo	1-5	1-5

Toxic levels for B, Mn, and Zn are reported as 150, 500, and 300 ppm, respectively.

3.5 Overall nutritional requirements

Table 9: Overall requirements of macro-nutrients under various growth conditions

	Yield (ton/ha)	N	P_2O_5	K_2O	CaO	MgO
Outdoor	80	241	62	416	234	67
	150	417	108	724	374	110
Processing	60	196	50	336	203	56
	100	303	78	522	295	84
Tunnels	100	294	76	508	279	80
	200	536	139	934	463	138
Greenhouse	120	328	85	570	289	86
	240	608	158	1065	491	152

4. Fertilization recommendations

The recommendations appearing in this document should be regarded as a general guide only. The exact fertilization program should be determined according to the specific crop needs, soil and water conditions, cultivar, and the grower's experience. For detailed recommendations, consult a local Haifa representative.

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4.1 Soil-grown tomatoes

4.1.1 Haifa NutriNet™ web software for Nutigation™ programs

Haifa fertilization recommendations are available online and can be accessed through Haifa's website, www.haifachem.com . Click on Haifa **Know-how** heading, or directly at: http://www.haifa-nutrinet.com and will enter into **NutriNet™**, a unique software program, that will assist you to workout the recommended fertilizer rates at different growth stages according to the expected yield under your growing conditions.

The following is an example of recommendations of open field grown tomatoes on sandy loam soil, as determined by NutriNet, with the assumption of split scheduled fertilization into:
a) Base-dressing (pre-plant) fertilizers followed by:
b) Nutrigation (fertigation) at different growth stages, on sandy-clay soil when the expected yield is 120 ton/Ha:

A. Base-dressing:

Base dressing - tomatoes

All nutrients in kg/ha

	N	P_2O_5	K_2O	CaO	MgO
Suggested base dressing	134	127	332	126	73
Actual base dressing					
% Surface covered	100%				
Ammonium nitrate (34%)	406				
Superphosphate (25%)	508				
Potassium sulfate (50%)	664				
Dolomite (26%)	485				
Magnesium sulfate (16%)	456				

B. Nutrigation (fertigation):

Total amount of fertigated fertilizers

Nutrigation - tomatoes

All nutrients in kg/ha

	N	P_2O_5	K_2O	CaO	MgO
Suggested nutrigation	311	85	497	31	18
Actual nutrigation	311	85	497	31	18
Ammonium nitrate (33%)	375				
Multi M.A.P (12-61-0)	139				
Multi-K (13-0-46)	1080				
Multi Cal (26%)	119				
Magnisal	112				

Table 10: The total contribution of plant nutrients from each fertilizer as calculated by NutriNet™:

Fertilizer	kg/ha	N	P_2O_5	K_2O	CaO	MgO
Ammonium nitrate 34-0-0	374.4	123.6				
Multi-MAP 12-61-0	139.3	16.7	85			
Multi-K™ 13-0-46	1080.4	140.5		497		
Calcium nitrate (26% CaO)	119.2	17.9			31	
Magnesium sulfate (16% MgO)	112.5					18
Total	1826	311	85	497	31	18

Table 11: Recommended nutrient rates per ha per day and per growth stage as calculated by NutriNet™:

Phase	Days from sowing / planting	kg/ha/day					kg/ha/phase				
		N	P_2O_5	K_2O	CaO	MgO	N	P_2O_5	K_2O	CaO	MgO
Planting	1	1	0	1	0	0	1	0	1	0	0
Vegetative	2-15	0.57	0.14	0.93	0.07	0	8	2	13	1	0
Flowering	16-30	0.6	0.13	0.93	0.07	0.07	9	2	14	1	1
Fruit set	31-40	0.6	0.2	0.9	0.1	0	6	2	9	1	0
Fruit growth	41-60	1.2	0.3	1.9	0.1	0.05	24	6	38	2	1
1st harvest	61-65	1.2	0.4	1.8	0.2	0	6	2	9	1	0
Harvest	66-120	2.36	0.65	3.78	0.24	0.15	130	36	208	13	8
Harvest	121-170	1.78	0.48	2.84	0.18	0.1	89	24	142	9	5
Last harvest	171-210	1.78	0.48	2.85	0.18	0.1	71	19	114	7	4
						Total	344	93	548	35	19

Table 12: Recommended fertilizers rates per growth stage

Phase	Days from sowing / planting	kg/ha/phase				
		Ammonium nitrate 34-0-0	Multi-MAP™* 12-61-0	Multi-K™ * 13-0-46	Mullti-Cal®* 15.5-0-0 +26CaO	Magnesium sulfate (16% MgO)
Planting	1	3	0	2	0	0
Vegetative	2-15	24	3	28	4	0
Flowering	16-30	26	3	30	4	6
Fruit set	31-40	18	3	20	4	0
Fruit growth	41-60	71	10	83	8	6
1st harvest	61-65	18	3	20	4	0
Harvest	66-120	382	59	452	50	50
Harvest	121-170	262	39	309	35	31
Last harvest	171-210	209	31	248	27	25
	Total	**374**	**139**	**1080**	**119**	**113**

*

Multi-K™ = Potassium nitrate

Multi-MAP™ = Mono-ammonium phosphate

Multi-Cal® = Calcium nitrate

Fertilization and fertigation rates may vary according to cultivar, growing method, climatic conditions, growth stages and expected yield. By using **Haifa NutriNet™** (http://www.haifa-nutrinet.com) program on-line, you may obtain **Haifa**'s recommendations most suitable to your growing conditions by selecting the expected yield, growing method and growth stages.

4.1.2 Poly-Feed® water-soluble NPK fertilizers

Table 13: Fertilization program for processing tomatoes. Expected yield: 50 ton/ha

Growth stage	Days	Poly-Feed® formula	Kg/ha/day
Planting to flowering	25	20-20-20	8
Flowering to fruit set	30	14-7-21+ 2MgO	15
Fruit set to harvest	40	14-7-28+ 2MgO	18

Foliar Feeding: To boost growth apply **Poly-Feed® Foliar Vegetative Booster** every 15 days. Volume: 200 L/ha. Concentration: 0.5% - 1%.

Table 14: Fertilization program for tomatoes in tunnels. Expected yield: 150 ton/ha

Growth stage	Days	Poly-Feed® formula	Kg/ha/day
Planting to flowering	25	20-20-20	8
Flowering to fruit set	20	14-7-21+ 2MgO	15
Fruit set to 1st harvest	35	14-7-28+ 2MgO	17
1st Harvest to Last harvest	100	14-7-28+ 2MgO	18

Table 15: Fertilization program for tomatoes in greenhouse. Expected yield: 160 ton/ha

Growth stage	Days	Poly-Feed® formula	Kg/ha/day	Total kg/ha
Planting to flowering	8	15-30-15	8	64
Flowering to Fruit set	25	19-19-19	13	325
Fruit set to 1st Harvest	30	18-9-27	17	510
1st Harvest to Last Harvest	110	16-8-32	17	1870

To cure and prevent magnesium deficiencies, apply **Magnisal®** by Nutrigation™ or foliar spray.
To cure and prevent calcium deficiencies, apply **Multi-Cal®** by Nutrigation™ or foliar spray.

4.1.3 Multicote® Agri Controlled Release Fertilizer

An N:P_2O:K_2O ratio of 2:1:3* is recommended, as pre-plant application. This application will take care of the nutritional requirement of the plot for the entire growth season.
Multicote® Agri granules should be incorporated into the soil, 10cm deep and 10cm away from the planting row.

Consult a local Haifa representative for detailed explanations and instructions.

Table 16: Multicote® Agri application recommendations tomato in greenhouse

kg/ha	Analysis*	Longevity
2,500 - 4,000	17-9-27	8 months

* The actual choice of formula should take into account soil type and addition of compost and any other factor that may affect the nutritional status of the soil.

4.1.4 Foliar nutrition

Foliar feeding is a fast and highly effective method of supplementing and enriching plant nutrients when needed. Foliar application of Haifa water soluble fertilizers provides needed plant nutrients for normal development of crops when absorption of nutrients from the soil is disturbed, precision-timed foliar sprays are also a fast-acting and effective method for treating nutrient deficiencies.

Foliar application of the correct nutrients in relatively low concentrations at critical stages in crop development contributes significantly to higher yields and improved quality.

Determine safe foliar applied rate:
To verify the safe rate under local conditions, it is advisable to spray recommended rate on a few plants. After 3-4 days check the tested plants for scorching symptoms.

Preparation of tank-mix:
Dissolve Haifa water-soluble fertilizes in about half of the tank volume, and add to the spray tank. When applying together with crop-protection agents, addition of wetting agents is not necessary. To ensure compatibility of tank-mix components, a small-scale test should be performed prior to actual application.

Table 17: Haifa water-soluble fertilizers for foliar application:

Fertilizer	Curing Treatment	Recommended concentration
Haifa Bonus™	Potassium deficiency	1 % - 2 %
Haifa MAP™	Phosphorus deficiency	0.5 % - 1 %
Haifa MKP™	Phosphorus and potassium deficiency	0.5 % - 1 %
Magnisal™	Magnesium deficiency	0.5 % - 0.75 %
Poly-Feed™	N-P-K and micronutrients deficiency	0.75 % - 1.5 %

4.2 Soilless-grown tomatoes

4.2.1 straight fertilizers

There are different growth media with different physical and chemical characteristics. The following are general fertilization recommendations for all soilless growth media.

Fertilizer stock solution: Once dissolved, not all fertilizers are inter-compatible with each other. Therefore, they have to be split into two fertilizer tanks: A and B, according to their compatibilities. Fertilizers containing phosphorus (P) or sulfur (S) should be dissolved in Tank A only, while fertilizers containing calcium (Ca) or magnesium (Mg) should be dissolved in Tank B. Chelated micronutrients should be dissolved in Tank B, as well.

The concentration of the fertilizers stock solution depends on:
1. The ambient temperature (higher ambient temperature enables higher concentration)
2. The injection rate - how many liters of the fertilizer solution will be injected into each cubic meter (1000 liters) of the irrigated water

Dividing the injection capacity by one cubic meter should be the concentration of the fertilizer solution. If, for example, the injector delivers 5 L into each cubic meter of the irrigated water, multiply the amount of fertilizer dissolved in the tank by 200 (1000 L / 5 L = 200).

Examples of Nutrigation™ regimes in soilless grown tomatoes:

The following example was prepared to fit **Dutch conditions** (low transpiration and low water EC). Considerable and proportional reduction in the concentration of the macronutrients should be required to offset for lower quality water prevailing in other conditions.

Table 18: Nutrition database for tomatoes. Growth medium: rockwool.

Parameter	Nutrient solution (ppm)
EC (mS/cm)	2.6
N- NH_4	16.6
N- NO_3	223.9
P	46.5
H_2PO_4	145.5
K	371.5
Ca	216.5
Mg	58.3
S, total	140.9
SO_4	422.8

Table 19: Recommended water-soluble fertilizers and their rates, to prepare the above recommended solution:

Fertilizers	g/m^3	Plant nutrients – g/m^3 solution						
		NO_3	NH_4	P*	K*	Ca*	Mg*	S*
Ammonium nitrate	**50**	8.5	8.5					
Multi-K™	**400**	52			152			
K_2SO_4	**400**				168			60
Haifa Cal™	**1150**	178.2				218.5		
$MgSO_4$	**600**						60	78
Haifa MKP™	**0**			45.4	56			
Total		**238.7**	**8.5**	**45.4**	**376**	**218.5**	**60**	**138**

An **Italian system** for fertigation management in close-loop soilless culture of tomato are:

NO_3	NH_4	P*	K*	Ca*	Mg*	S*
200	14	30	310	160	35	80

Table 20: Recommended water-soluble fertilizers and their rates to prepare a fertilizer solution for the above Italian system:

Fertilizers	g/m^3	Plant nutrients – g/m^3 solution						
		NO_3	NH_4	P*	K*	Ca*	Mg*	S*
Ammonium nitrate	**0**							
Multi-K™	**600**	78			228			
K_2SO_4	**200**				84			30
Haifa Cal™	**850**	131.7				161.5		
Magnisal™	**0**							
$MgSO_4$	**350**						35	45
Haifa MAP™	**100**		12	27				
Haifa MKP™	**0**							
Total		**209.7**	**12**	**27**	**312**	**161.5**	**35**	**75.5**

EC value should be maintained at ~ 2.07 mS/cm

* conversion factors: P x 2.29 = P_2O_5 ; K x 1.20 = K_2O ; Ca x 1.40 = CaO ; Mg x 1.66 = MgO ; S x 3.00 = SO_4

Table 21: Fertilizer recommendations for hydroponic (perlite, rockwool, and NFT) tomatoes in **Florida** (http://edis.ifas.ufl.edu/CV216):

Nutrient	Growth stage				
	1	2	3	4	5
	Transplant to 1st cluster	1st cluster to 2nd cluster	2nd cluster to 3rd cluster	3rd cluster to 5th cluster	5th cluster to termination
	Final delivered nutrient solution concentration (ppm)**				
N	70	80	100	120	150
P	50	50	50	50	50
K	120	120	150	150	200
Ca*	150	150	150	150	150
Mg*	40	40	40	50	50
S*	50	50	50	60	60

* Ca, Mg, and S concentrations may vary depending on Ca and Mg concentration in water and amount of sulfuric acid used for acidification.
** 1ppm = 1mg/liter

Table 22: Recommended water-soluble fertilizers and their rates to prepare a fertilizer solution from transplant to various growth stages as indicated in Table 21:

A. From transplant to 1st cluster

Fertilizers	g/m^3	NO_3	NH_4	P*	K*	Ca*	Mg*	S*
K_2SO_4	**150**				63			23
Haifa Cal™	**500**	77.5				95		
$MgSO_4$	**400**						40	52
Haifa MKP™	**200**			45.4	56			
Total		**77.5**	**0**	**45.4**	**119**	**95**	**40**	**75**

B. From 1st to 2nd cluster

Fertilizers	g/m^3	NO_3	NH_4	P*	K*	Ca*	Mg*	S*
K_2SO_4	**150**	19.5			57			
Haifa Cal™	**500**	77.5				95		
$MgSO_4$	**400**						40	52
Haifa MKP™	**250**			56.75	70			
Total		**97**	**0**	**56.75**	**127**	**95**	**40**	**52**

* conversion factors: P x 2.29 = P_2O_5 ; K x 1.20 = K_2O ; Ca x 1.40 = CaO ; Mg x 1.66 = MgO ; S x 3.00 = SO_4

C. From 2nd to 3rd cluster

Fertilizers	g/m³	NO_3	NH_4	P*	K*	Ca*	Mg*	S*
Multi-K™	**400**	52			152			
Haifa Cal™	**500**	77.5				95		
$MgSO_4$	**400**						40	52
Haifa MAP™	**180**		21.6	48.6				
Total		**129.5**	**21.6**	**48.6**	**152**	**95**	**40**	**52**

D. From 3rd to 5th cluster

Fertilizers	g/m³	NO_3	NH_4	P*	K*	Ca*	Mg*	S*
Multi-K™	**400**	52			152			
Haifa Cal™	**500**	77.5				95		
$MgSO_4$	**500**						50	65
Haifa MAP™	**180**		21.6	48.6				
Total		**129.5**	**21.6**	**48.6**	**152**	**95**	**50**	**65**

E. From 5th cluster to Termination

Fertilizers	g/m³	NO_3	NH_4	P*	K*	Ca*	Mg*	S*
Multi-K™	**530**	68.9			201.4			
Haifa Cal™	**500**	77.5				95		
$MgSO_4$	**500**						50	65
Haifa MAP™	**180**		21.6	48.6				
Total		**146.4**	**21.6**	**48.6**	**201.4**	**95**	**50**	**65**

Table 23: Recommendations for greenhouse soilless grown tomatoes, in **Israel**, according to the growing stages (NH_4/NO_3 ratio=0.1- 0.2):

Physiological stage	Concentration in the irrigation solution (dripper) (ppm)				
	N	P*	K*	Ca*	Mg*
Planting and establishment	120-150	40-50	180-220	100-120	40-50
Flowering	150-180	40-50	220-270	100-120	40-50
Ripening and harvest	180-200	40-50	270-300	100-120	50-80

* conversion factors: P x 2.29 = P_2O_5 ; K x 1.20 = K_2O ; Ca x 1.40 = CaO ; Mg x 1.66 = MgO ;
S x 3.00 = SO_4

Table 24: Recommended water-soluble fertilizers and their rates to prepare a fertilizer solution as indicated in Table 16 (above):

A. Planting and establishment

Fertilizers	g/m³	NO_3	NH_4	P*	K*	Ca*	Mg*
Multi-K™	**200-300**	26-39	0	0	76-114	0	0
K_2SO_4	**250**	0	0	0	105	0	0
Haifa Cal™	**520-600**	81-93	0	0	0	99-114	0
$MgSO_4$	**400-500**	0	0	0	0	0	40-50
Haifa MAP™	**150-180**	0	18-22	41-49	0	0	0
Total		**107-132**	**18-22**	**41-49**	**181-219**	**99-114**	**40-50**

B. Flowering

Fertilizers	g/m³	NO_3	NH_4	P*	K*	Ca*	Mg*
Multi-K™	**300-430**	39-56	0	0	114-163	0	0
K_2SO_4	**250**	0	0	0	105	0	0
Haifa Cal™	**520-600**	81-93	0	0	0	99-114	0
Magnisal™	**100**	11	0	0	0	0	9
$MgSO_4$	**300-350**	0	0	0	0	0	30-35
Haifa MAP™	**150-180**	0	18-22	41-49	0	0	0
Total		**131-160**	**18-22**	**41-49**	**219-268**	**99-114**	**39-44**

C. Ripening and harvest

Fertilizers	g/m³	NO_3	NH_4	P*	K*	Ca*	Mg*
Multi-K™	**440-500**	57-65	0	0	167-190	0	0
K_2SO_4	**250**	0	0	0	105	0	0
Haifa Cal™	**530-600**	82-93	0	0	0	101-114	0
Magnisal	**170**	19	0	0	0	0	15
$MgSO_4$	**350-650**	0	0	0	0	0	35-65
Haifa MAP™	**150-180**	0	18-22	41-49	0	0	0
Total		**158-177**	**18-22**	**41-49**	**272-295**	**101-114**	**50-80**

* conversion factors: P x 2.29 = P_2O_5 ; K x 1.20 = K_2O ; Ca x 1.40 = CaO ; Mg x 1.66 = MgO ; S x 3.00 = SO_4

4.2.2 Poly-Feed™ water soluble NPK fertilizers

Table 25: Recommended composition of nutritional solution for soilless-grown tomatoes

A. In temperate or cold climate with low sun radiation and soft water (e.g. North and North-East Europe, North France, UK, Japan, Korea)

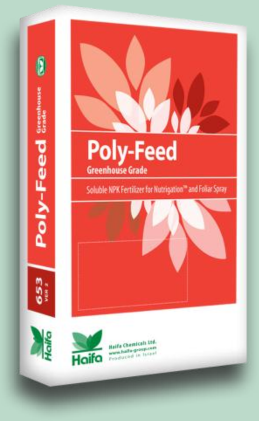
Concentration in irrigation water (ppm)					Recommended Poly-Feed® formula	Conc. (kg/m^3)
N	P	K	Ca	Mg		
190	50	310	150	45	14-10-34+ME	1.1

Some acid and Multi-Cal® calcium nitrate should be added to adjust the pH and to complete calcium requirements.

B. In hot climate with high sun radiation and hard water (e.g. Middle East, Mediterranean countries)

Concentration in irrigation water (ppm)					Recommended Poly-Feed® formula	Conc. (kg/m^3)
N	P	K	Ca	Mg		
170	45	225	105	40	17-10-27	1.0

Some acid and Multi-Cal® calcium nitrate should be added to adjust the pH and to complete calcium requirements.



Appendix I: Nutrigation™ (Fertigation)

Balanced irrigation & fertilization regime ensures optimal nutrition throughout the growth season.
Application of top-quality water-soluble fertilizers through the irrigation system is the optimal method for providing balanced plant nutrition throughout the growth season.
A balanced Nutrigation™ regime ensures that essential nutrients are placed precisely at the site of intensive root activity, and are available in exactly the right quantity when plants need them.

Evaporation considerations

The amount of water required per application can be determined by the coefficient of transpiration and the evaporation data from a class A pan. For example, average evaporation readings in the central part of Israel, expressed in mm/day, are given in table 26:

Table 26: Evaporation rates from Class A Pan in central Israel (mm/day)

Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
4.4	5.9	6.8	6.9	6.6	5.7	4.3	3.0

Plants, usually, are less influenced than an exposed pan to the prevailing climatic conditions, such as: sun, wind, humidity, etc., and will transpire less water. As an example, the percentage of transpiration by tomatoes, known as *transpiration coefficient*, is illustrated in Table 27. The coefficient increases according to the growth stage of the plant as the growing season evolves.

Table 27: Transpiration coefficients in tomatoes, according to the growth stages.

Growth stage	Planting –Blooming	Blooming – Fruit set	Fruit set - Harvesting
Transpiration coefficient	0.4	0.6	0.8

The following example of the amount of irrigation water, calculated from data collected on the losses of the evaporation A pan and multiplied by the transpiration coefficient is shown in Table 28.

Table 28: Example of water consumption of outdoor grown tomatoes, in Israel.

Growth stage	Month	Evaporation rates, (mm/day)	Transpiration coefficient	Water losses* (mm/day)	Required amount of irrigation water (m^3 /ha/day)
Blooming	May	5.9	0.4	2.36	23.6
Fruit set	June	6.8	0.6	4.08	40.8
Harvesting	July	6.9	0.8	5.52	55.2

* - via transpiration.

If the irrigation cycle is not daily, then the daily amount has to be multiplied by the number of days between irrigation cycles as shown in Table 29.

Table 29: Example of required amount of water for out-door grown tomatoes.

Growth stage	Month	Amount of required irrigation per day (m^3/ha)	Irrigation cycle (days)	Amount of water / irrigation per cycle (m^3/ha)
Blooming	May	23.6	3	71
Fruit set	June	40.8	5	204
Harvesting	July	55.2	4	222

Appendix II: Plant analysis guide

Nutrient Sufficiency Ranges

(source: A & L, Agronomy Handbook, Ankerman & Large, Eds.)

	N	P	K	Mg	Ca	S	Na	B	Zn	Mn	Fe	Cu	Al
	%							ppm					
From	3.00	0.30	2.50	0.50	2.00	0.50	0.01	40	35	100	100	8	20
To	6.00	0.80	5.00	1.00	6.00	0.90	0.01	60	50	200	200	20	200

Plant sampling

	Growth stage	Plant part to sample	No. of plants or leaves to sample
Open-field tomatoes	Prior to or during early bloom stage	3rd or 4th leaf from growing tip	20-25
Greenhouse tomatoes	Prior to or during fruit-set	Young plants: leaves adjacent to 2nd or 3rd cluster	20-25
		Older plants: leaves from 4th to 6th clusters	20-25

Appendix III: Haifa Specialty Fertilizers

Pioneering Solutions

Haifa develops and produces **Potassium Nitrate** products, **Soluble Fertilizers** for Nutrigation™ and foliar sprays, and **Controlled Release Fertilizers**. Haifa's Agriculture Solutions maximize yields from given inputs of land, water and plant nutrients for diverse farming practices. With innovative plant nutrition schemes and highly efficient application methods, Haifa's solutions provide balanced plant nutrition at precise dosing, composition and placing. This ultimately delivers maximum efficiency, optimal plant development and minimized losses to the environment.

Potassium Nitrate

Haifa's Potassium Nitrate products represent a unique source of potassium due to their nutritional value and contribution to plant's health and yields. Potassium Nitrate has distinctive chemical and physical properties that are beneficial to the environment. Haifa offers a wide range of potassium nitrate products for Nutrigation™, foliar sprays, side-dressing and controlled-release fertilization. Haifa's potassium nitrate products are marketed under the Multi-K™ brand.

Multi-K™ Products

Pure Multi-K™

Multi-K™ Classic	Crystalline potassium nitrate (13-0-46)
Multi-K™ Prills	Potassium nitrate prills (13-0-46)

Special Grades

Multi-K™ GG	Greenhouse-grade potassium nitrate (13.5-0-46.2)
Multi-K™ pHast	Low-pH potassium nitrate (13.5-0-46.2)
Multi-K™ Top	Hydroponics-grade potassium nitrate (13.8-0-46.5)

Enriched Products

Multi-npK®	Enriched with phosphate; crystalline or prills
Multi-K™ Mg	Enriched with magnesium; crystalline or prills
Multi-K™ Zn	Enriched with zinc; crystalline
Multi-K™ S	Enriched with sulfate; crystalline
Multi-K™ B	Enriched with boron; crystalline or prills
Multi-K™ ME	Enriched with magnesium and micronutrients; crystalline

Nutrigation™

Nutrigation™ (Fertigation) delivers pure plant nutrients through the irrigation system, supplying essential nutrients precisely to the area of most intensive root activity. Haifa's well-balanced Nutrigation™ program provides the plant with their exact needs accordingly with seasonal changes. Decades of experience in production and application of specialty fertilizers for Nutrigation™ have made Haifa a leading company in this field. Haifa keeps constantly up to date with contemporary scientific and agricultural research, in order to continuously broaden its product line to better meet the requirements of crops and cropping environments.

Haifa offers a wide range of water-soluble fertilizers for Nutrigation™. All products contain only pure plant nutrients and are free of sodium and chloride

Multi-K™ Comprehensive range of plain and enriched potassium nitrate products
Poly-Feed™ Soluble NPK fertilizers enriched with secondary and micro-nutrients
Haifa MAP™ Mono-ammonium phosphate
Haifa MKP™ Mono-potassium phosphate
Haifa Cal™ Calcium nitrate
Magnisal™ Our original magnesium nitrate fertilizer
Haifa Micro™ Chelated micronutrients
Haifa VitaPhos-K™ Precipitation-proof poly-phosphate for soilless Nutrigation™
Haifa ProteK™ Systemic PK fertilizer

Foliar Feeding

Foliar Feeding provides fast, on-the-spot supplementary nutrition to ensure high, top quality yields and is an ideal feeding method under certain growth conditions in which absorption of nutrients from the soil is inefficient, or for use on short–term crops. Precision-timed foliar sprays are also a fast-acting and effective method for treating nutrient deficiencies. Foliar application of the correct nutrients in relatively low concentrations at critical stages in crop development contributes significantly to higher yields and improved quality. Haifa offers a selection of premium fertilizers for foliar application. Haifa offers a selection of fertilizers for foliar application:

Haifa Bonus™ High-K foliar formulas enriched with special adjuvants for better absorption and prolonged action
Poly-Feed™ Foliar NPK formulas enriched with micronutrients specially designed to enhance the crop performance during specific growth stages

Magnisal™, **Haifa MAP™**, **Haifa MKP™**, **Haifa Cal™** and **Haifa Micro**™ are also suitable for foliar application.

Controlled Release Nutrition

Multicote™, Haifa's range of Controlled Release Fertilizers includes products for agriculture, horticulture, ornamentals and turf. Multicote™ products provide plants with balanced nutrition according to their growth needs throughout the growth cycle. Multicote® products enhance plant growth, improve nutrients use efficiency, save on labor and minimize environmental impact.

Single, pre-plant application controlled-release fertilizer can take care of the crop's nutritional requirements throughout the growth season. Controlled release fertilizers are designed to feed plants continuously, with maximal efficiency of nutrients uptake. Controlled release fertilizers save labor and application costs. Their application is independent of the irrigation system, and does not require sophisticated equipment.

Taking advantage of MulticoTech polymer coating technology, Haifa produces Multicote™ line of controlled release fertilizers.

Multicote™ Products

Multicote™ for nurseries and ornamentals; NPK formulae with release longevities of 4, 6, 8, 12 and 16 months
Multicote™ Agri / **Multigro™** for agriculture and horticulture
CoteN™ controlled-release urea for arable crops
Multicote™ Turf / **Multigreen™** for golf courses, sports fields, municipals and domestic lawns

Appendix IV: Conversion tables

From	To	Multiply by	From	To	Multiply by
P	P_2O_5	2.29	P_2O_5	P	0.44
P	PO_4	3.06	PO_4	P	0.32
H_3PO_4	H_2PO_4	0.98	H_2PO_4	H_3PO_4	1.38
K	K_2O	1.20	K_2O	K	0.83
Ca	CaO	1.40	CaO	Ca	0.71
Mg	MgO	1.66	MgO	Mg	0.60
S	SO_3	2.50	SO_3	S	0.40
S	SO_4	3.00	SO_4	S	0.33
N	NH_4	1.28	NH_4	N	0.82
N	NO_3	4.43	NO_3	N	0.22

1 meq	Correspondent element (mg)	1 mmol	Correspondent element (mg)	Weight of ion
NH_4^+	14 mg N	NH_4^+	14 mg N	18 mg NH_4^+
NO_3^-	14 mg N	NO_3^-	14 mg N	62 mg NO_3^-
$H_2PO_4^-$	31 mg P	$H_2PO_4^-$	31 mg P	71 mg P_2O_5
HPO_4^{2-}	31 mg P	HPO_4^{2-}	31 mg P	35,5 mg P_2O_5
HPO_4^{2-}	15.5 mg P	K^+	39 mg K	47 mg K_2O
K^+	39 mg K	Ca^{2+}	40 mg Ca	28 mg CaO
Ca^{2+}	20 mg Ca	Mg^{2+}	24 mg Mg	20 mg MgO
Mg^{2+}	12 mg Mg	SO_4^{2-}	32 mg S	48 mg SO_4
SO_4^{2-}	16 mg S	Na^+	23 mg Na	-
Na^+	23 mg Na	Cl^-	35.5 mg Cl	-

From	To	Multiply by	From	To	Multiply by
Acre	Hectare	0.405	Hectare	Acre	2.471
Kilogram	Lbs	2.205	Lbs	Kilogram	0.453
Gram	Ounces	0.035	Ounces	Gram	28.35
Short Ton	MT	0.907	MT	Short Ton	1.1
Gallon (US)	Liters	3.785	Liters	Gallon (US)	0.26
Kg/Ha	Lbs/acre	0.892	Lbs/acre	Kg/Ha	1.12
MT/Ha	Lbs/acre	892	Lbs/acre	MT/Ha	0.001