Nutritional recommendations for

POTATOES

Botanical name: *Solanum tuberosum L.*
Synonyms: Spuds; Pomme de terre; Patata; Kartoffel

Contents:

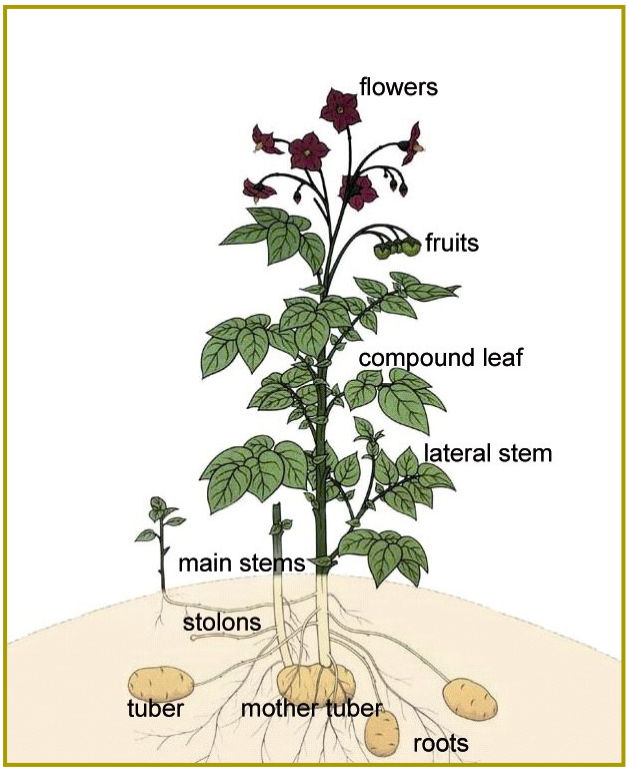
1. General Growing Conditions

1.1 The plant

The potato (*Solanum tuberosum*) is an herbaceous annual that grows up to 100 cm (40 inches) tall and produces tubers, which are botanically thickened stems that are so rich in starch that they rank as the world's fourth most important food crop, after maize, wheat and rice.

The potato belongs to the Solanaceae, and shares the genus *Solanum* with at least 1,000 other species, including tomato and eggplant. *S. tuberosum* is divided into two, only slightly different, subspecies: *andigena*, which is adapted to short day conditions and is mainly grown in the Andes, and *tuberosum*, the potato now cultivated around the world, which is believed to descend from a small introduction to Europe of *andigena* potatoes that later adapted to longer day conditions.

Figure 1: A scheme of he potato plant



1.2 Soil type and pH

Potatoes will grow on most soils, organic as well as mineral ones. But, light and medium texture soils are recommended where mechanical harvesting is practiced, to avoid difficulties in harvesting when weather conditions are adverse at harvest time. Lowest possible soil pH is 5.5. Soil pH below 4.8 generally results in impaired growth.
Too alkaline conditions can adversely affect skin quality and can induce micronutrients deficiencies.

1.3 Special sensitivities of the potato plant

1.3.1 Chloride

Potatoes are sensitive to the chloride anion. Chloride damage is manifested by scorching of the leaf tips and margins, and leaves yellowing and distortion. Fertilization with chloride-free fertilizers will, therefore, contribute to increased yields and to the improvement of their quality.

1.3.2 Boron deficiency

“Hollow Heart”, by comparison, is characterized by formation of a cavity near the tuber centre, without any external indication of this syndrome. It is the result of soil boron deficiency. Rapid growth of the tuber, sometimes due to too low plant density, may cause this syndrome, too.

1.3.3 Storage condition

“Black heart” symptom of potatoes is caused by a limited supply of oxygen to the tubers during their storage, and cannot be alleviated by improved growth conditions.

1.4 Irrigation

During the early growth phase, until tuber formation, it is essential to keep the soil constantly and uniformly wet to a depth of at least 10-15cm. The frequency of irrigation cycles during this period should be determined according to the specific soil type and climate conditions.
During the second growth phase, during tuber development, irrigation will be less frequent and applied once every 3-5 days. This allows efficient root respiration and intensifying growth rate.
Potatoes can be irrigated almost until harvest.
Irrigation at tuber initiation can affect the skin quality of daughter tubers by influencing phytopathogens, either favorably or adversely, according to conditions**,** and moisture rate present.
A monitored drip system equipped with a Nutrigation™ (fertigation) device is the preferable method of irrigation (Fig. 2)

Figure 2: Drip-irrigated potato field in southern Israel

1.5 Crop uses

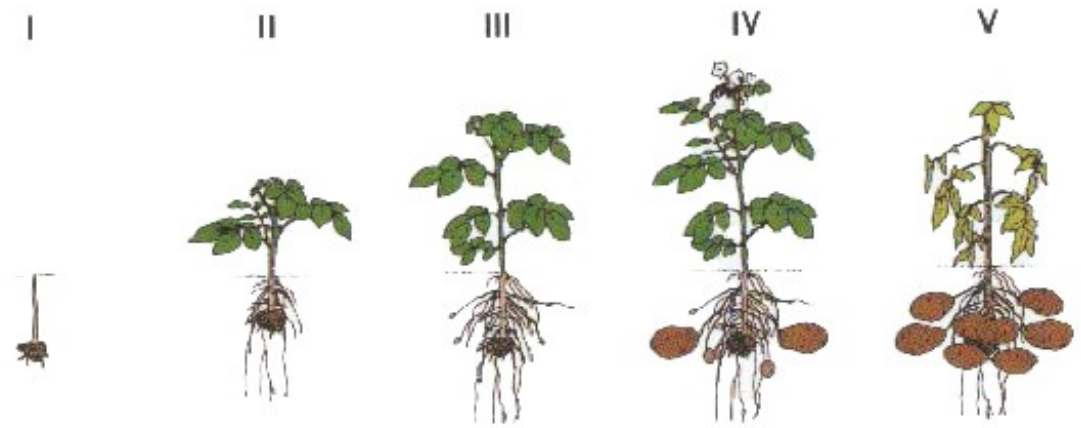
Potatoes are consumed fresh, and are being processed to chips and crisps. Potatoes are also used for the production of starch. Selected plots are grown for seed production.

Potatoes grown for processing are valued for yield, size, shape, and mainly for dry matter content (measured by specific gravity). As the specific gravity increases, the water content of the potato decreases, improving the frying properties and flavor. Management factors, including plant nutrition treatments, will influence potato yield, quality, and storage properties.

1.6 Crop growth stages

Potato growth is classified into five distinct growth phases (Fig. 3). The exact timing of these growth phases depends on many environmental and management factors that vary between locations and cultivars. However, these distinct stages of growth need to be considered when managing the crop.

Figure 3: Main stages of growth and development of potatoes. The nutritional requirements of the developing potato change during the growing season.



Stage I Sprout development
Sprout develops from eyes on seed tubers and grows upward to emerge from the soil. Roots begin to develop at the base of emerging sprouts.

Stage II Vegetative growth
Leaves and brunch stems develop from aboveground nodes along emerged sprouts. Roots and stolons develop at below-ground nodes.
Photosynthesis begins

Stage III Tuber initiation
Tubers form at stolon tips but are not yet appreciably enlarging. In most cultivars the end of this stage coincides with early flowering.

Stage IV Tuber bulking
Tuber cells expand with the accumulation of water, nutrients, and carbohydrates. Tubers become the dominant site for deposition of carbohydrates and mobile inorganic nutrients.

Stage V Maturation
Vines turn yellow and lose leaves, photo-synthesis decreases, tuber growth slows, and vines eventually die. Tuber dry matter content reaches a maximum and tuber skins set.

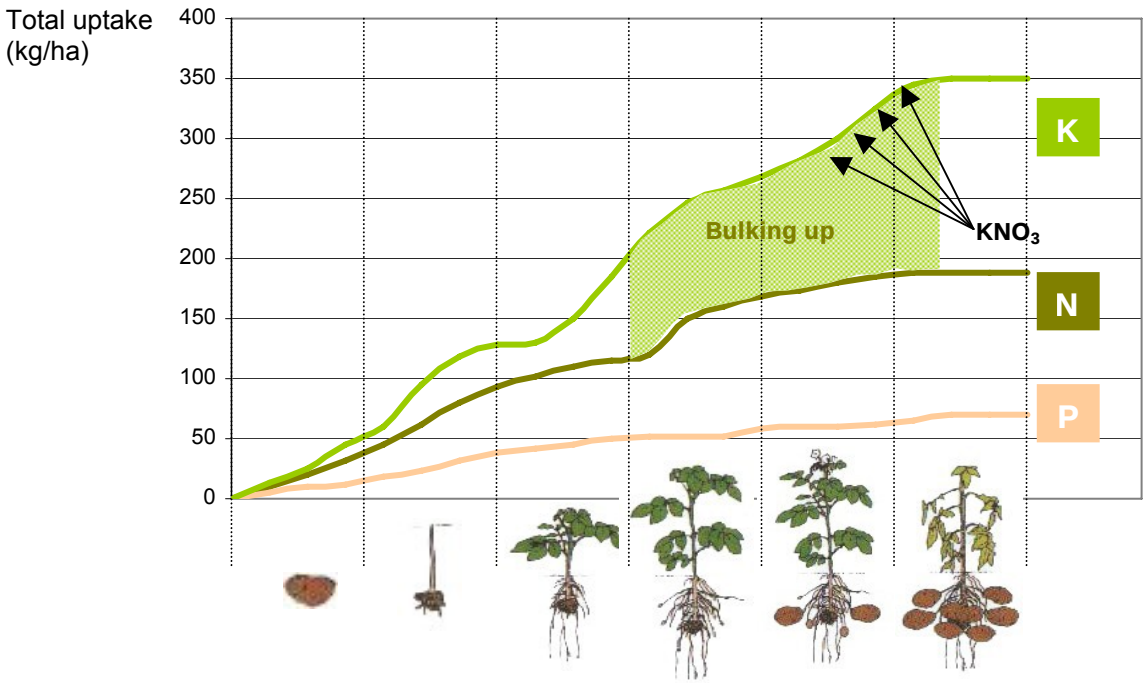
2. Nutritional requirements

2.1 Nutrient uptake curves

Nutrients uptake is at its greatest during tuber bulking up (intensive volume increase process). The amount of nutrients removed by a potato crop is closely related to yield. Usually, twice the yield will result twice the removal of nutrients. Nutrients need to be applied as accurately as possible to the zone of uptake, slightly before, or at the time that the crop needs them. Failure to ensure that each plant gets the right balance of nutrients can spoil crop quality and reduce yield.

The highest requirement for potassium, as shown on Figure 4, is during the bulking up stage of the tubers. The flowering of potato plants is an indication when this morphological stage starts. Consequently, the ideal side-dressing period with Multi-K would be during the tuber bulking stage.

Figure 4: Uptake of macronutrient uptake by a whole potato plant
Source: Harris (1978)



The daily requirements of potato tubers during the critical bulking stage are 4.5 kg/ha N, 0.3 kg/ha P and 6.0 kg/ha K. Potassium requirements of potato tubers during the bulking stage are very high as they are considered to be luxury consumers of potassium. Daily yield increase during the critical tuber bulking stage can reach 1000 - 1500 kg/ha/day. Therefore, it is important to supply the required plant nutrients during the tuber bulking stage in right N-P-K ratio and in ample quantities.

Figure 5: Uptake of macro and secondary nutrients by vines and tubers of potato plants yielding 55 ton/ha. Source: Reiz, 1991

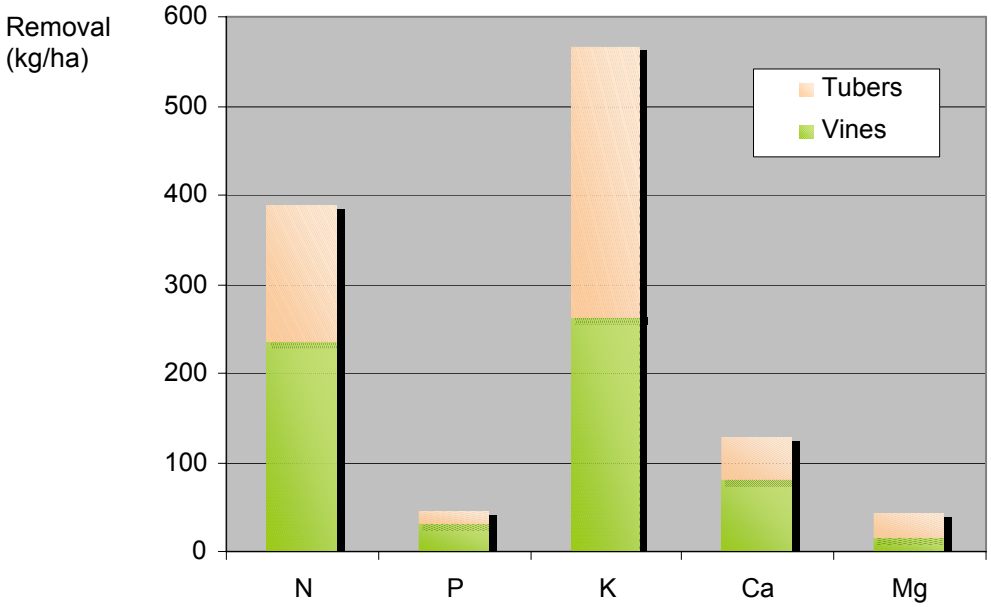
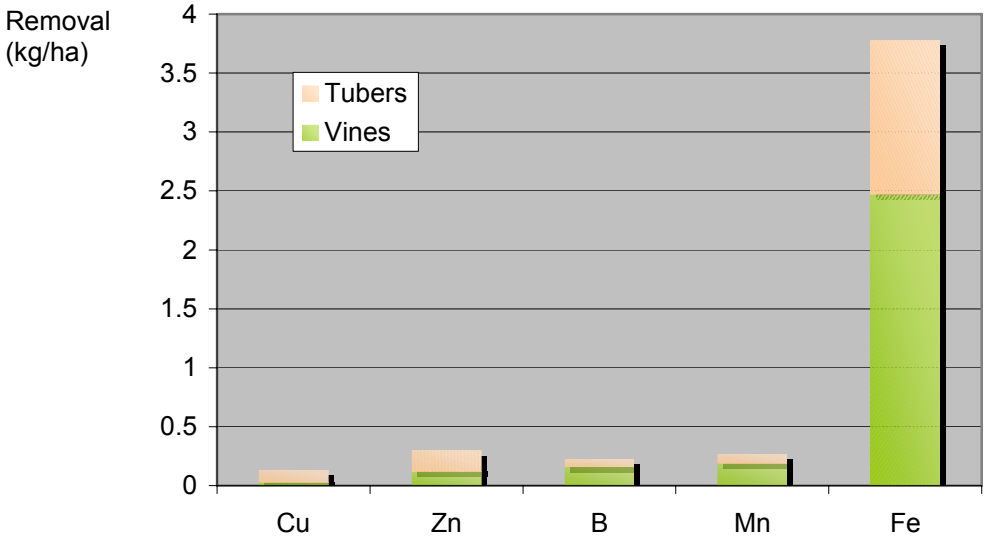


Figure 6: Uptake of micro-nutrients by vines and tubers of potato plants yielding 55 ton/ha.
Source: Reiz, 1991



2.2 Main functions of plant nutrients

Table 1: 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.
Sulfur (S)	Synthesis of essential amino acids cystine 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.

Table 2: Effects of the nutrients and the potassium source on the yield quality.

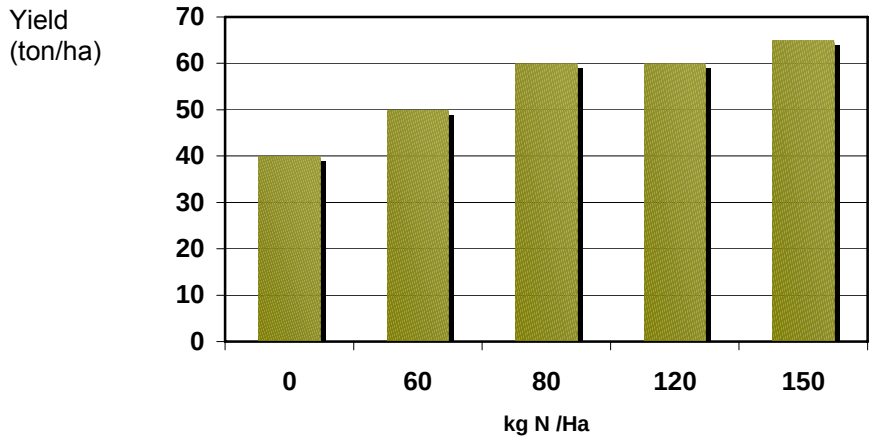
Parameter	Increase in dosage of			Application of KCl in comparison to chloride-free K (-Cl)
	Nitrogen	Phosphorus	Potassium	
Tuber size	↑	No effect	↑	Chloride-free K helps increasing size
Sensitivity to mechanical damage	↑	↓	↓	No information
Tuber blackening [1]	↑	No effect	No effect	KCl is more effective than (-Cl)
% dry matter [2]	↓	↑ Slight effect	↓	Chloride-free K yields better results
% starch [3]	↓	↑	↓	Chloride-free K yields better results
% protein	↑	↓	Conflicting results	Chloride-free K helps increasing content
% reducing sugars	Inconsistent	↑	↓	No difference
Taste	↓	↑	No effect	Chloride-free K is better
Blackening after cooking	↑	No effect		

[1] Blackening is caused by oxidation of phenol compounds when skin is exposed.
[2] A high percentage of dry matter is required in potatoes for industry.
[3] High concentrations are desirable. The characteristic is correlated to the specific gravity.

Nitrogen (N)

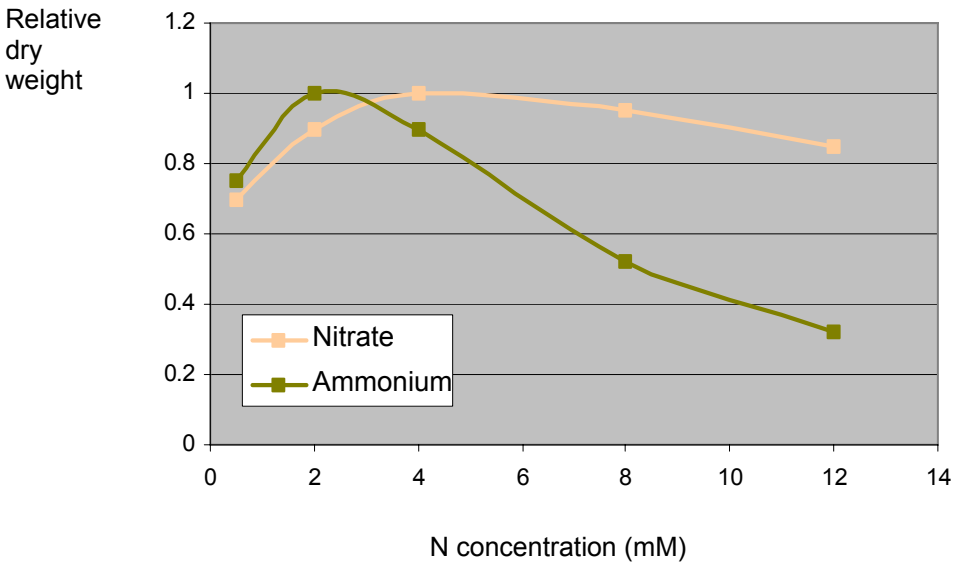
Adequate N management is one of the most important factors required to obtain high yields (Fig. 7) of excellent quality potatoes. An adequate early season N supply is important to support vegetative growth.

Figure 7: The effect of nitrogen (N) on potato yields



Excessive soil N, applied late in the season delays maturity of the tubers and result in poor skin set, which harms the tuber quality and storage properties. Potatoes are a shallow-rooted crop, generally growing on sandy, well-drained soils. These soil conditions frequently make water and N management difficult since nitrate is susceptible to leaching losses. On these sandy soils, it is recommended that potatoes receive split applications of N during the growing season. This involves applying some of the total N requirement prior to planting and applying the remainder during the season with side-dress applications or through the irrigation system by Nutrigation™ (fertigation). The period of highest N demand varies by potato variety and is related to cultivar characteristics, such as root density and time to maturity. Petiole analysis during the growing season is a useful tool, allowing growers to determine the N status of the crop and respond in a timely manner with appropriate nutrients.
A balanced ammonium / nitrate ratio is very important at planting time. Too much ammonium-nitrogen is a disadvantage as it reduces root-zone pH and thereby promotes Rhizoctonia disease. Nitrate-nitrogen enhances the uptake of cations such as calcium, potassium and magnesium, required for elevated specific gravity values.

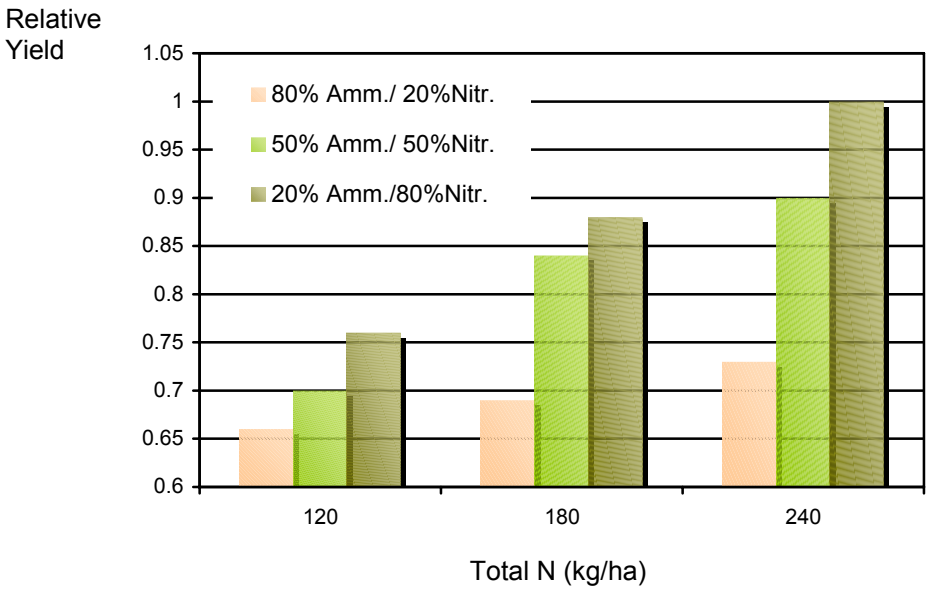
Figure 8: Relative response of potato growth to the nitrate-ammonium concentrations in the nutrient solution



At 12 mM of N, plants exhibited interveinal ammonium toxicity with NH_4^+ nutrition, but healthy growth with NO_3^- nutrition. Thus, a careful control of NH_4^+ concentrations is necessary to minimize ammonium toxicity to potato plants.

Figure 9: Effect of Nitrate/Ammonium ratio and N rate on total yield of U.T.D. tubers

Source: Vegetables & Fruits, Feb./March, 2000. South Africa



Nitrogen Assessment

Soil testing to a depth of 60 cm. in the spring is critical to planning an effective and efficient N management program. Post harvest soil samples may help growers to select succeeding crops, which will make maximum use of the residual N after the potato crop.

The nitrogen demand by the crop during tuber bulking may be 2.2 to 3.0 kg/ha/day. Petiole nitrate sampling allows for in-season monitoring of the crop's nutrient status. Collecting the 4th petiole from 30 – 50 randomly selected plants throughout the field (Fig. 10) is recommended. Tissue samples are often collected weekly to track changes in nitrate levels, and to plan supplemental fertilizer applications, should levels drop below optimum.

Critical petiole nitrate-levels decline as the potato crop develops and matures. Generally, petiole nitrate-N levels at tuber bulking are <10,000 ppm = low, 10,000-15,000 ppm = medium, >15,000 ppm = sufficient. (Fig. 11)

Figure 10: The structure of the 4th leaf on a potato plant

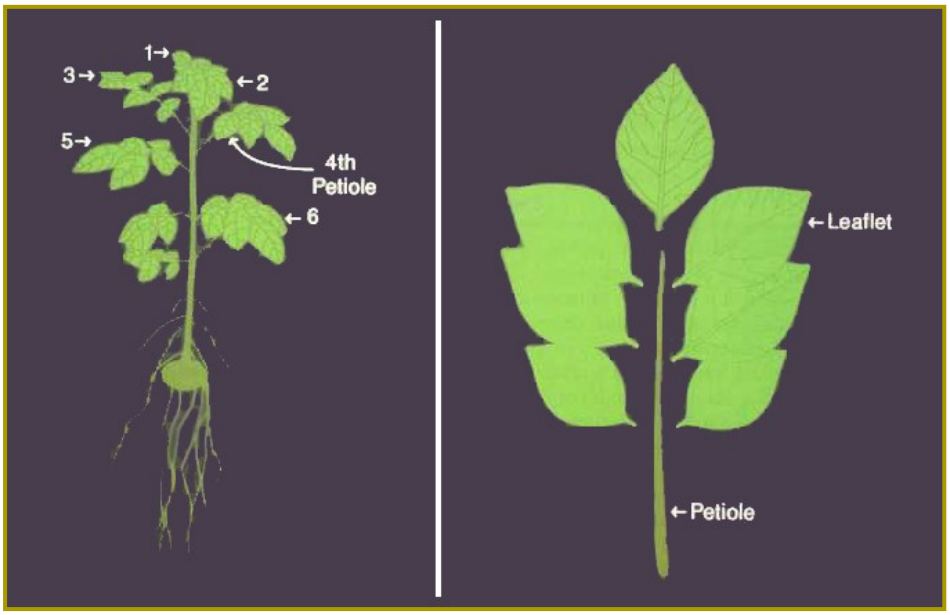
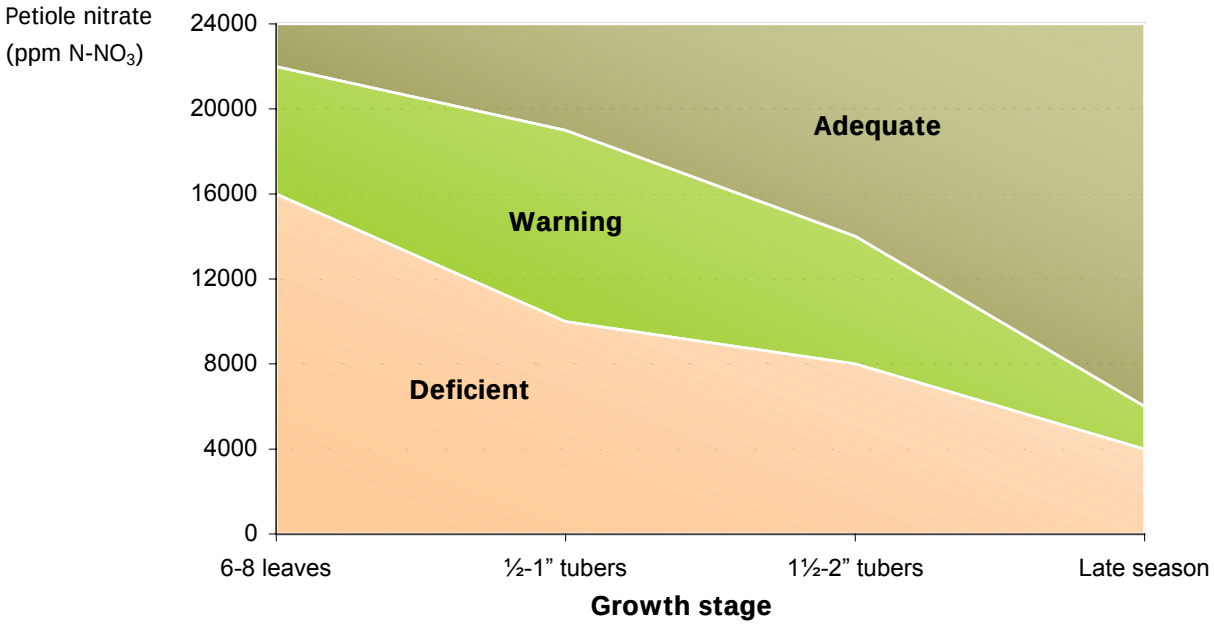


Figure 11: Interpretation of N-NO_3 levels in potato petioles at different stages of growth



Phosphorus (P).

Phosphorus is important for early root and shoot development, providing energy for plant processes such as ion uptake and transport. Roots absorb phosphate ions only when they are dissolved in the soil water. Phosphorus deficiencies can occur even in soils with abundant available P, if drought, low temperatures, or disease interfere with P diffusion to the root, through the soil solution. These deficiencies will result in stunt root development and inadequate function.

At the tuber initiation stage, an adequate supply of phosphorus ensures that optimum number of tubers is formed. Following the tuber initiation, phosphorus is an essential component for starch synthesis, transport and storage.

Recent research suggests that modifications to P fertilizer, such as polymer additives, humic substances, and coatings may be beneficial in improving P uptake and potato production.

Potassium (K).

Potato plants take up large quantities of potassium throughout the growing season. Potassium has an important role in the control of the plant water status and internal ionic concentration of the plant tissues, with a special focus on the stomatal functioning.

Potassium plays a major positive role in the process of nitrate reduction within the plant.

Where large amounts (e.g. >400 kg/ha K_2O) are to be applied, in temperate conditions it is advisable to split the dressings 6-8 weeks apart.

Potatoes require large amounts of soil K, since this nutrient is crucial to metabolic functions such as the movement of sugars from the leaves to the tubers and the transformation of sugar into potato starch. Potassium deficiencies reduce the yield, size, and quality of the potato crop. A lack of adequate soil K is also associated with low specific gravity in potatoes.

Potassium deficiencies impair the crop's resistance to diseases and its ability to tolerate stresses such as drought and frost. Applying K fertilizer with a broadcast application prior to planting is most commonly recommended. If the K is band-applied, the rates should be kept below 45 kg K_2O/ha to avoid any salt injury to the developing sprouts.

Selection of the best K fertilizer

The source of potassium plays an important role on the quality and the yield of potato tubers. By comparing different sources of K, Multi-K® potassium nitrate was found to increase the dry matter ontent and the yield significantly higher than other sources of K (Fig. 12 & 13). This study was done on different cultivars and all of them responded with higher tuber yield to Multi-K® treatment (Fig 14).

Figure 12: The effect of different potassic fertilizers on the potato tuber yield

Source: Reiz, 1991

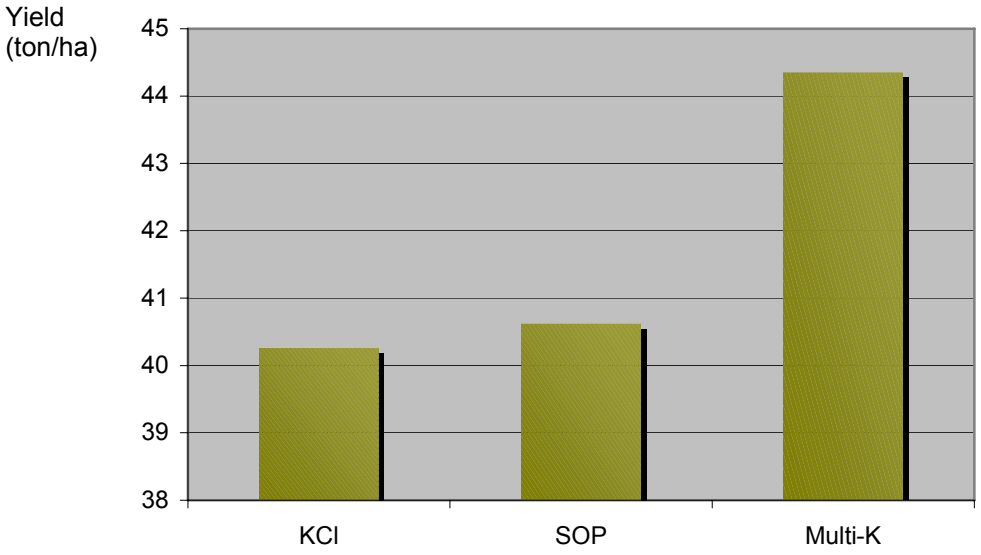


Figure 13: The effect of different potassic fertilizers on the dry matter content in potato tubers
Source: Reiz, 1991

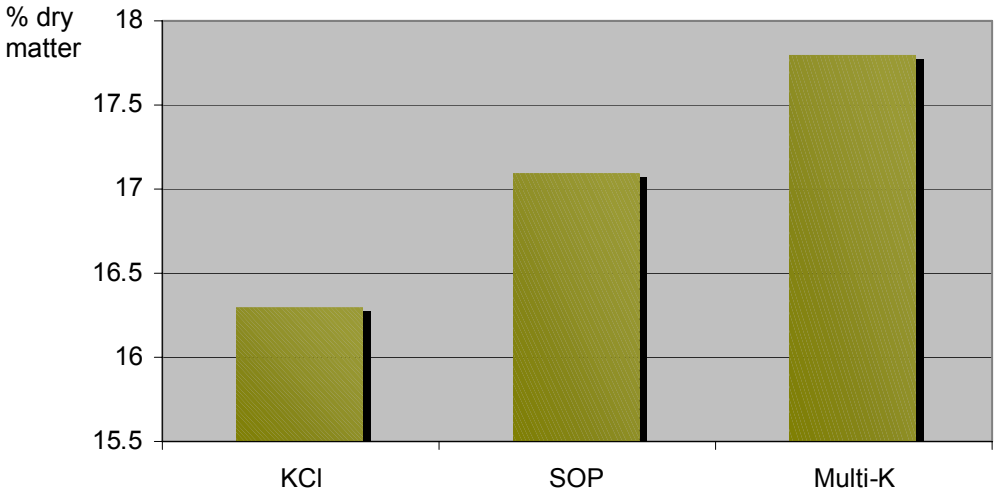
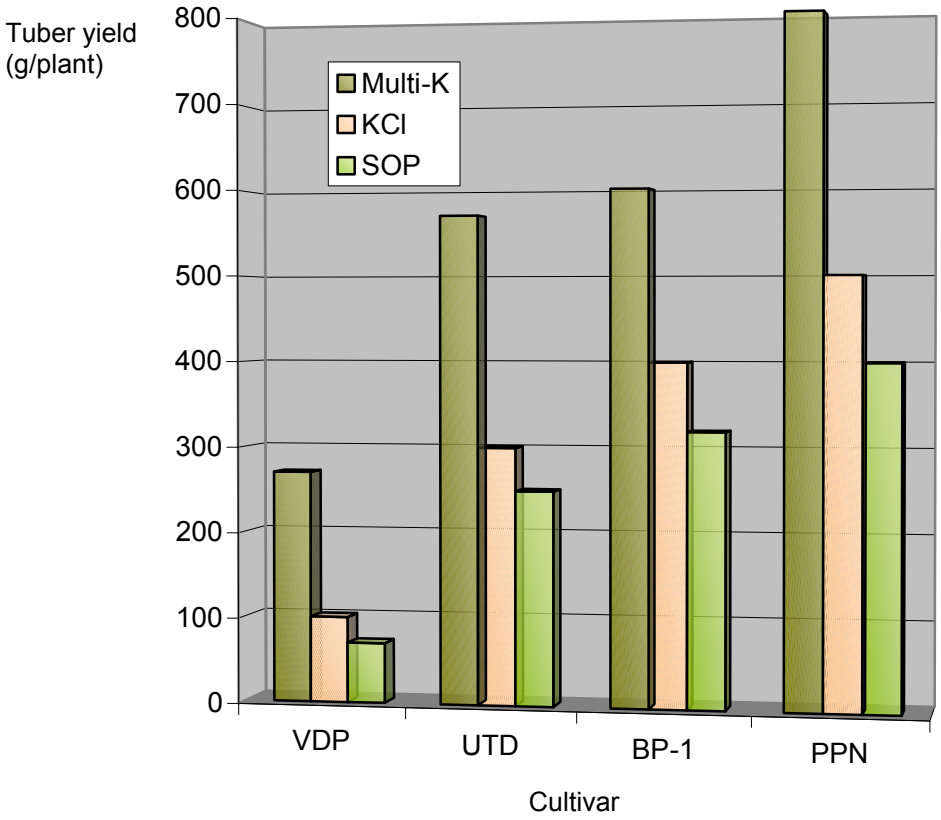


Figure 14: The effect of different potassic fertilizers on potato yield of various cultivars
Source: Bester, 1986



The potato's specific gravity and the chips color are important parameters for the processing potatoes industry. Both of these parameters are responding favourably to Multi-K® potassium nitrate treatments as compared to other sources of K fertilizers (Fig. 15, 16).

Figure 15: The effect of different potassic fertilizers on chips color rating
Source: Reiz, 1991

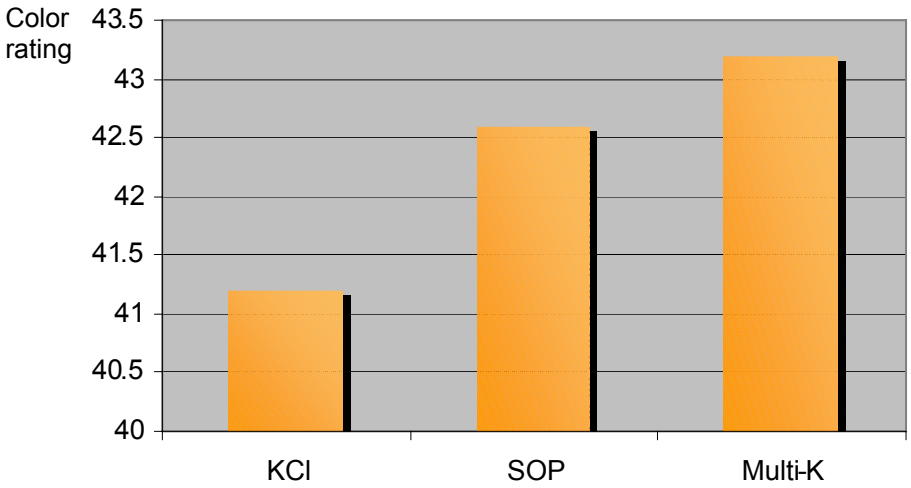
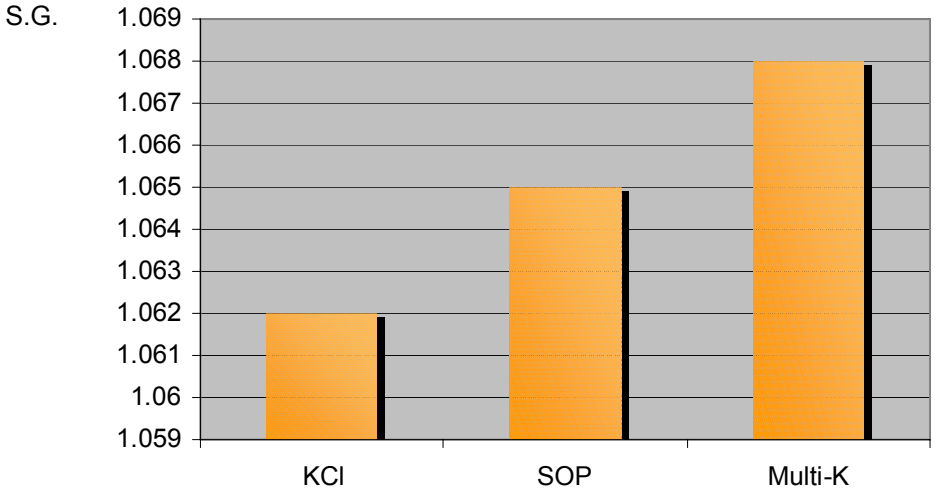
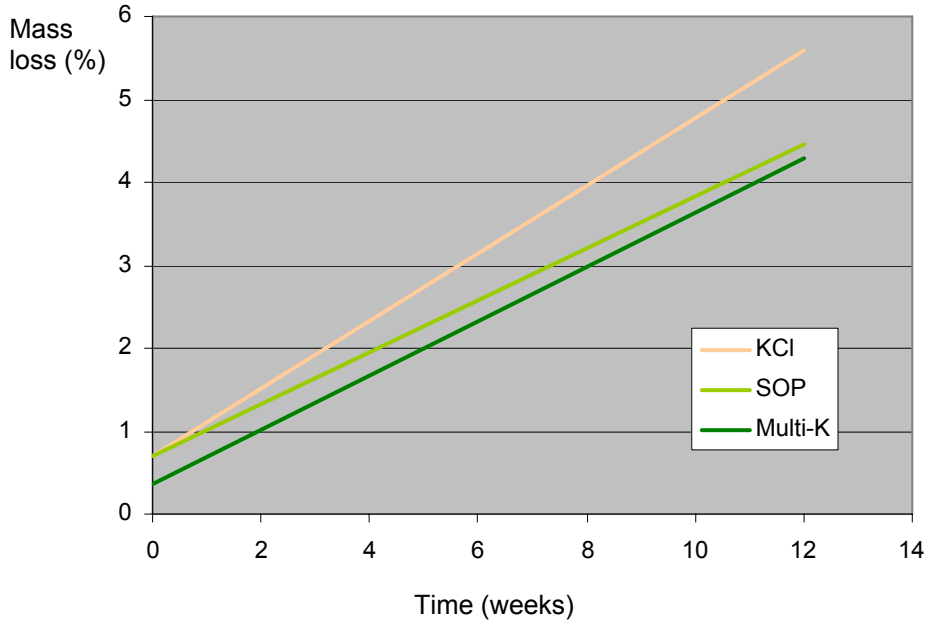


Figure 16: The effect of different potassic fertilizers on specific gravity of potato tubers
Source: Reiz, 1991



Beside the favourable effect of Multi-K® on the quality and yield of potato tubers, it also improves the shelf life of the tubers in storage (Fig. 17).

Figure 17: The effect of different K fertilizers loss of mass over time (@ 20°C, RH 66%)
Source: Bester (1986)



Calcium (Ca)
Calcium is a key component of cell walls, helping to build a strong structure and ensuring cell stability. Calcium-enriched cell walls are more resistant to bacterial or fungal attack. Calcium also helps the plant adapt to stress by influencing the signal chain reaction when stress occurs. It also has a key role in regulating the active transport of potassium for stomatal opening.

Magnesium (Mg)
Magnesium has a central role in photosynthesis, as its atom is present in the centre of each chlorophyll molecule. It is also involved in various key steps of sugar and protein production as well as the transport of sugars in the form of sucrose from the leaves to the tubers.
Yield increases of up to 10% were obtained in trials in which regular application of magnesium fertilizers has been practiced .

Sulphur (S)
Sulphur reduces the level of common and powdery scab. This effect is related to a reduction in the soil pH where sulphur is applied in its elemental form.

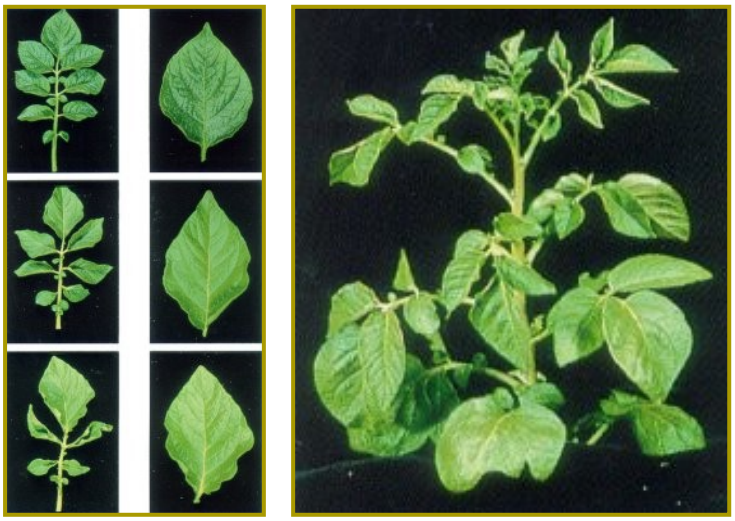
2.3 Nutritional disorders in potatoes

Nitrogen

Nitrogen deficiency is manifested by reduced growth pale leaves, and results in reduced tuber yield (size and number). The deficiency is made worse by extrenme soil pH (low or high), low organic matter, drought conditions or heavy irrigation (Fig. 18).

Nitrogen excess causes delayed maturity, excessive top growth, hollow heart & growth cracks, increased susceptibility to biotic diseases, reduced tuber specific gravity and difficulty in vine 'burning' before harvest.

Figure 18: Characteristic nitrogen (N) deficiency symptoms



Phosphorus

Typical symptoms and syndroms related with phosphorus deficiency are: fewer tubers, smaller tubers, stunted plants, yellowing of older leaves, small dark green younger leaves (Fig. 19). P deficiency leads to reduced early vigor, delayed maturity and reduced yields.

Excessive phosphorus, when present, ties up other elements such as calcium and zinc, inducing thereby their deficiencies

Figure 19: Characteristic phosphorus (P) deficiency symptoms

Potassium

Potassium deficiency retards nitrogen uptake, slows down plant growth and leads to reduced yields, inferior quality, and poor disease resistance. Typical symptoms of K deficiency are necrosis of leaf margins, premature leaf senescence (Fig. 20)

Excessive potassium causes reduced tuber specific gravity and reduced calcium and/or magnesium uptake. It also degrades soil structure.

Figure 20: Characteristic potassium (K) deficiency symptoms

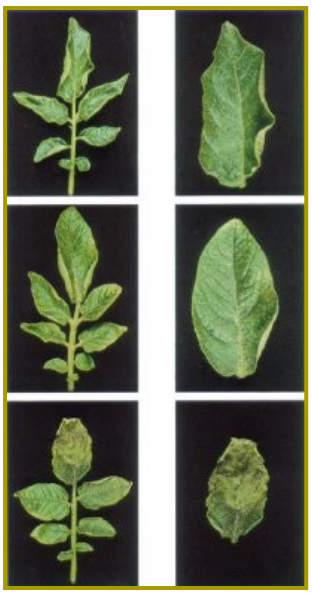
Calcium

Calcium deficiency interferes with root growth, causes deformation of foliage growth tips, and may result in reduced yields and poor quality. Calcium-deficient potato tubers have reduced storage capability. Low calcium levels in the soil result in poorer soil structure.

Typical symptoms of calcium deficiency are yellow curled leaves on upper leaves, tip burns, and small chlorotic new leaves. (Fig. 21)

Excessive calcium results in reduced magnesium uptake, with the symptoms related to magnesium deficiency.

Figure 21: Characteristic calcium (Ca) deficiency symptoms



Magnesium

As magnesium is a key element in photosynthesis, its rate slows down under conditions of magnesium deficiency, resulting in Reduced tuber formation and lower yields. Severe magnesium deficiency can reduce yields by up to 15%. Magnesium-deficient tubers are more easily damaged during lifting and storage.

Typical deficiency symptoms: Leaves get yellow and brown; The leaves wilt and die; Stunted plants, early crop maturation; Poor skin finish of the tubers. (Fig. 22)

Excessive magnesium results in reduced calcium uptake, with the symptoms related to calcium deficiency.

Figure 22: Characteristic magnesium (Mg) deficiency symptoms

Sulfur

Sulfur (S) deficiency causes reduced growth, and leaves become pale green or yellow. Number of leaves is reduced. (Fig. 23)

Figure 23: Characteristic sulfur (S) deficiency symptoms

Iron

Under Iron (Fe) deficiency, the interveinal areas get chlorotic while the veins remain green. In cases of severe deficiency, the entire leaf is chlorotic. (Fig. 24). Iron deficiency symptoms firstly appear on the youngest leaves.

Figure 24: Characteristic Iron (Fe) deficiency symptoms

Boron

Boron (B) regulates transport of sugars through membranes, and also plays a key role in cell division, cell development and auxin metabolism.

Under condition of boron deficiency growing buds die, and plants appear bushy, having shorter internodes. Leaves thicken and roll upward; leaf tissue darkens and collapses. Brown necrotic patches appear on tubers, and internal rust spot are formed. (Fig. 25)

Figure 25: Characteristic Boron (B) deficiency symptoms

Copper

Under copper (Cu) deficiency young leaves become flaccid and wilted, terminal buds drop at flower bud development, and leaf tips become necrotic (Fig. 26).

Figure 26: Characteristic Boron (B) deficiency symptoms

Zinc

Zinc deficiency symptoms: Young leaves become chlorotic (light green or yellow), narrow, upwardly-cupped and develop tip-burn. Other leaf symptoms are green veins, spotting with dead tissue, blotching, and erect appearance. (Fig. 27)

Figure 27: Characteristic Zinc (Zn) deficiency symptoms

Manganese

Manganese (Mn) deficiency symptoms: black or brown spots on younger leaves; leaves yellowing; poor skin finish of the tubers (Fig. 28). Tubers are more easily damaged during lifting and storage.

Figure 28: Characteristic manganese (Mn) deficiency symptoms

2.4 Leaf analysis standards

Table 8: Reference levels for each nutrient at foliar level:

Nutrient (%)	Deficient	Low	Normal	High	Excessive
Nitrogen (N)	< 4.2	4.2-4.9	5.0-6.5	>6.5	
Phosphorus (P)	<0.23	0.23-0.29	0.3-0.55	>0.6	
Potassium (K)	<3.3	3.3-3.9	4.0-6.5	6.5-7.0	>7.0
Calcium (Ca)	<0.6	0.6-0.8	0.8-2	>2.0	
Magnesium (Mg)	<0.22	0.22-0.24	0.25-0.5	>0.5	
Sulfur (S)			0.30-0.50		

Nutrient (ppm)	Deficient	Low	Normal	High	Excessive
Copper (Cu)	<3	3.0 -5.0	5.0 -20	30-100	
Zinc (Zn)	<15	15-19	20-50		
Manganese (Mn)	<20	20-30	50-300	700-800	>800
Iron (Fe)			50-150		
Boron (B)	<15	18-24	30-60		
Sodium (Na)			0-0.4	>0.4	
Chloride (Cl)			0-3.0	3.0-3.5	>3.5

2.5 Plant Nutrient Requirements

Table 9: Nutritional requirements of potatoes:

Expected yield (ton/ha)	Removal by yield (kg/ha)					Uptake by whole plant (kg/ha)				
	N	P_2O_5	K_2O	CaO	MgO	N	P_2O_5	K_2O	CaO	MgO
20	38	18	102	2	2	105	28	146	29	19
40	76	36	204	4	4	171	50	266	42	28
60	114	54	306	6	6	237	72	386	55	37
80	152	72	408	8	8	303	95	506	68	46
100	190	90	510	10	10	369	117	626	82	55
110	209	99	561	11	11	402	128	686	88	59

3. 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, and the grower's experience. For detailed recommendations, consult a local Haifa representative.

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3.1 General recommendations

3.1.1 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 you will enter into **NutriNet™**, a unique expert software program, that will assist you working out the recommended fertilizer rates at different growth stages according to the expected yield under your growing conditions.

The following is an example of recommendations, found on the NutriNet, in accordance with the above-mentioned guideline to split the scheduled fertilization into:
a) Base-dressing (pre-plant) fertilizers, followed by:
b) Nutrigation (fertigation) at different growth stages, on sandy-loam soil, when the expected yield is 80 ton/ha:

a) Base dressing

Base dressing - potatoes

All nutrients in kg/ha

	N	P_2O_5	K_2O	CaO	MgO
Suggested base dressing	109	132	263	27	37
Actual base dressing					

% Surface covered: 100%

Ammonium nitrate (34%)	330
Superphosphate (25%)	528
Potassium sulfate (50%)	526
Dolomite (26%)	104
Magnesium sulfate (16%)	231

b) Nutrigation™

Total amount of fertilizers applied by Nutrigation™

Nutrigation - potatoes

All nutrients in kg/ha

	N	P_2O_5	K_2O	CaO	MgO
Suggested nutrigation	255	88	395	7	9
Actual nutrigation					
Ammonium nitrate (33%)	351				
Multi M.A.P (12-61-0)	144				
Multi-K (13-0-46)	859				
Multi Cal (26%)	27				

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

	kg	N	P_2O_5	K_2O	CaO	MgO
Ammonium nitrate (34%)	351	116				
Multi-MAP (12-61-0)	144	17	88			
Multi-K® (13-0-46)	859	112		395		
Multi-Cal® (26% CaO)	27	4			7	
Magnesium sulphate (16% MgO)	58					9
Total	**1437**	**255**	**88**	**395**	**7**	**9**

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 growth	2-40	1.56	0.54	2.44	0.05	0.05	61	21	95	2	2
Tuber initiation & bulking	41-80	3.15	1.08	4.85	0.08	0.1	126	43	194	3	4
Maturation	81-130	2.36	0.82	3.64	0.06	0.08	118	41	182	3	4
						Total	306	105	472	8	10

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®* (26% CaO)	Magnesium sulfate (16% MgO)
Planting	1	2	0	2	0	0
Vegetative growth	2-40	172	34	207	8	13
Tuber initiation & bulking	41-80	150	70	422	12	25
Maturation	81-130	72	67	396	12	25
	Total	**396**	**144**	**859**	**27**	**56**

*

Multi-K® = Potassium nitrate

Multi-MAP™ = Mono-ammonium phosphate

Multi-Cal® = Calcium nitrate

3.1.2 Side dressing with Multi-K®

It is recommended to apply Multi-K® by side dressing in prilled form. It can be done by any surface fertilizer applicator. However, when the soil is too wet, especially in early spring, aerial application is recommended.

Table 12: Soil applied fertilization

Type of potatoes	When to apply	Rate kg/ha
Ware potatoes	5 - 8 weeks after planting	250 - 300 kg Multi-K® /ha
Early potatoes	After removing plastic cover	200 - 250 kg Multi-K® /ha
Comments	Split into 2 - 4 applications. First application 20-30 days after emergence	Fewer applications in heavier soils, more in light texture soils. 15 - 20 days interval.

3.1.3 Poly-Feed® water-soluble NPK fertilizers

Table 13: fertilization recommendations for potatoes. Expected yield: 60 ton/ha

Growth stage	Days	Poly-Feed formula	kg/ha/day	Total kg/ha
Planting & Establishment	30	20-20-20	6	180
Tuber initiation	25	14-7-21+2MgO	18	450
Tuber growth	55	14-7-21+2MgO	18	990

3.1.4 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 14: Multicote® Agri application recommendations for potatoes*

	Application rate % of local practice*			% coated nutrients		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Light soil	60-70	100	70	70	-	Up to 50
Heavy soil	70-90	100	80	50-60	-	Up to 50

* These recommendations refer to areas where nitrogen application rates are not restricted by regulations. If nitrogen application is restricted, calculation of Multicote Agri application rates should be based on the full optimum rates that would have been given with no restrictions.

3.1.5 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 15: Haifa water-soluble fertilizers for foliar application

Fertilizer	Curing Treatment	Recommended concentration
Haifa-Bonus™	Potassium deficiency	1% - 3%
Multi-MAP™	Phosphorus deficiency	1% - 3%
Multi-MKP™	Phosphorus and potassium deficiency	1% - 3%
Magnisal®	Magnesium deficiency	1% - 2%
Poly-Feed®	N-P-K and micronutrients deficiency	See table below
Multi-Micro®	Micronutrients deficiencies	Consult Haifa agronomist

Table 16: Recommended foliar feeding with Poly-Feed products for boosting crop performances

Stage	Poly-Feed Foliar analysis	Concentration	Spray volume
Vegetative growth	"Vegetative Booster" 21-21-21	2% - 5%	50 – 80 L/ha
Tuber growth	"Poly-Potato" 12-5-40	Two applications at 2% - 4%	50 – 80 L/ha

3.2 Examples of potato fertilization with Multi-K® in various countries

3.2.1. South Africa

A. Cape region

Application Schedule	Product (N- P_2O_5-K_2O)		kg/ha	N	P	P_2O_5	K	K_2O
Before plant	Gypsum		2000					
Bended at planting	Granular 8-29-20		1130	55	110	252	95	114
Fertigation (Via Central Pivot)								
Weeks		Applications per week	Rate per application					
1 to 4	13-10-27*	2	75 kg/ha	80	27	61	133	160
	Calcium Nitrate	1	50 kg/ha	28	0	0	0	0
5 to 7	Multi-K®	2	60 kg/ha	55.2	0	0	110	132
	Calcium Nitrate	1	50 kg/ha	21	0	0	0	0
8 to 10	Multi-K®	3	60 kg/ha	54	0	0	158	189
Sub-total Nutrigation				238	27	61	401	482
Total				293	137	313	496	596

* Water-soluble fertilizer made of Multi-K® MKP and AS

B. Free State

Fertilizers	Magnisal®	Multi-Cal®	UAN	4-3-4 (18)	Multi-K®	KCl
S. G.	1.3	1.48	1.3	1.3	0.2	0.2
Week	kg/ha					
0 (Jan-10)						
1 - 5						
6	100	100	150	100		
7	100	100	150	100		
8	100	100	100	100		
9	7		90	100		
10				95	50	
11					50	
12					50	25
13					10	25
14						25
15						
Total	307	300	490	495	160	75

3.2.2. Australia

Soil type: Light (with low phosphorus and potassium)

Note: Nutrients supplied by a base dressing with strategic applications through the centre pivot irrigators.

Recommended rates of nutrients

N	P	P_2O_5	K	K_2O
150-250 kg/ha	60-110 kg/ha	135-250 kg/ha	150-200 kg/ha	180-240 kg/ha

a) Base-dressing

On silt soils (medium soils) up to 50% of the N and K should be applied as pre-plant and up to 100 % of P applied as pre-plant dry fertilizer *.

N	P	P_2O_5	K	K_2O
50-80 kg/ha	60-110 kg/ha	135-250 kg/ha	50-60 kg/ha	60-70kg/ha

* On light (sandy) soils, up to 30% of the N and K should be applied as pre-plant and up to 100 % of the P applied as pre-plant dry fertilizer.

b) Nutrigation

50%** of N and K are applied through the irrigation system (centre pivot)

Time of application (weeks after emergence)	kg/ha/application					
	N	P	K	K_2O	Multi-K®	Ammonium Nitrate
1-5						
6	23	52	19	23	50	50
8	23	52	19	23	50	50
10	23	52	19	23	50	50
12	23	52	19	23	50	50
14	23	52	19	23	50	50

** When 70% of N and K are applied, increase Multi-K® rate to 55 - 60 kg/application an ammonium nitrate to 90 kg/application.

Nutrient applied kg/ha	N	P	P_2O_5	K	K_2O
(Approx)	195	70	160	185	225

Note: Nutrigation begins 6 weeks after emergence. If practical, applications can be split and applied on a weekly basis.

3.2.3. Poland

Soil type: Light /sandy
Plant density : 40,000-75,000 / ha
Expected yield: 35-45 T/ha, depending on variety

Average recommended rates of nutrients (kg/ha):

N	P_2O_5	K_2O	CaO	MgO
200-250	150	350-450	60-80	60-80

a) Base-dressing

Nutrient Requirements				Recommended Fertilizers			
N	P_2O_5	K_2O	MgO	AN	TSP	K_2SO_4	$MgSO_4$
30	100	130	53	90	220	260	160

AN - Ammonium nitrate (34%)
TSP - Triple Super phosphate (46% P_2O_5)
K_2SO_4 - Potassium sulfate (50% K_2O)

b). Nutrigation
Based on a weekly irrigation.

Growth stage	Weeks after emergence	Nutrition requirement (kg/ha/week)					Recommended fertilizer (kg/ha/week)			
		N	P_2O_5	K_2O	CaO	MgO	Multi-K Mg	Multi-MAP	AN	CN
Vegetative growth	1-5	6	6					10	18	
Tuber initiation	6-7	5	5					8	15	
Tuber bulking	8-10	28		32	60	3.0	78		58	230*
Maturation	11-13	15		32		3.0	78		58	
	14-16			10		0.8	22			
Total		169	40	222	180	20	480	66	170	230

If fertilizers are applied by side-dressing, the entire weekly rate should be applied at once. Fertilizers should be placed besides the row.

Multi-K Mg = Potassium nitrate enriched with magnesium (11-0-40+4MgO)
Multi-MAP= Mono-Ammonium Phosphate (12-61-0)
AN = Ammonium nitrate
CN = Calcium nitrate

3.2.4. Israel

Soil application:

Growth stage	N rate	Multi-K*	P_2O_5 rate
From planting till tuber initiation	70-105 kg/ha	---	According to soil test or 150-200 kg /ha
At tuber initiation	-	300-500 kg/ha	
10 - 15 days later	-	300-500 kg/ha	

* Optional Multi-K Mg

Foliar feeding

Treatment	Fertilizer	Spray timing	Conc.	Spray volume	No. of applications
Improving growth	Poly-Feed 20-20-20	One week after emergence	2% - 3%	Full coverage	2 - 3
Correcting K deficiency	Bonus-npK 12-2-44	Two weeks after emergence	5% - 8%		
Higher yield	Bonus-npK 12-2-44	From full canopy	5% - 8%		

Aerial application:
When there is a need for top-dressing and the soil is either too wet or the field is too large for timely ground application, an aerial application of prilled Multi-K is a practical solution. this is especially effective when the soil temperature is still cold, (usually in early spring), so a nitrate application will enable the plant to take up nitrogen at this stage for quick response.

Appendix I: Haifa Specialty Fertilizers

Teaspoon-Feeding™

Innovative Technology for Optimal Plant Nutrition and Maximum Yields

Modern agriculture is continuously striving for maximum yields at minimum production costs — while eliminating environmental impact.

Teaspoon-Feeding™ is a revolutionary concept of fertilization that provides plants with balanced nutrition throughout the growth season. Nutrients are provided in measured portions, that exactly or match plant requirements. Teaspoon-Feeding™ is designed to address plants' changing needs during each stage of the growth cycle, ensuring optimal plant development and maximum, high quality yields.

HAIFA fertilizers for Teaspoon-Feeding™ combined with innovative application techniques of Nutrigation, Controlled-Release Nutrition and Foliar Feeding enable precision-controlled composition, quantity, and timing of the nutrient supply that is tailored to the crop and the specific growing conditions.
HAIFA is a pioneering company in the development and marketing of innovative fertilization products and techniques that meet the demands of modern agricultural practice, while taking strictest environmental concerns into consideration.

Nutrigation™ (Fertigation)

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*.

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
Multi-MAP™	Mono-ammonium phosphate
Multi-MKP™	Mono-potassium phosphate
Multi-Cal®	Calcium nitrate
Magnisal®	Our original magnesium nitrate fertilizer
Multi-Micro®	Chelated micronutrients
VitaPhos-K™	Precipitation-proof poly-phosphate for soilless Nutrigation™
Multi-ProteK™	Systemic PK fertilizer
Multi-Pepton™	Amino-acid nutritional supplement

Use Haifa NutriNet™ and Haifast™ software to create your optimal Nutrigation™ regime. See details on HAIFA website.

Foliar Feeding

Foliar Teaspoon-Feeding™ is a fast, highly effective method of providing nutrients when used as a supplement to administering fertilizers through the soil. It 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 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
Poly-Amin™ Growth promoting foliar amino-acid preparation
Magnisal®, **Multi-MAP™**, **Multi-MKP™**, **Multi-Cal®** and **Multi-Micro®** are also suitable for foliar application.

HAIFA's innovative Teaspoon-Feeding™ fertilizer products and modern application methods provide the ideal solution for the nutritional needs of any crop under all growth conditions.

Controlled Release Nutrition

Multicote® innovative fertilizers for Teaspoon-Feeding™ release plant nutrients gradually and steadily according to plants' needs throughout the growing season.
HAIFA's Multicote polymer-coated fertilizers slowly release plant nutrients into the soil solution at a pre-determined rate. Moisture in the soil is absorbed by the fertilizer granules - dissolving the nutrients inside and releasing them into the root zone.
The release rate is determined by the soil temperature, which is also a major factor affecting plant growth rate. Soil type, humidity, PH, and microbial activity do not affect the release rate.
A single application of Multicote fertilizers is sufficient to provide balanced nutrition for the duration of the growing season – significantly saving labor and costs.
Multicote fertilizers ensure maximal uptake by the root system - leaving no excess fertilizer to contaminate the soil or groundwater.

HAIFA offers a selection of smart controlled-release fertilizers to suit all crops and growing conditions:
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 turf

Multi-K®

Potassium nitrate products

Multi-K®, Haifa's potassium nitrate, is a unique source of potassium in by its nutritional value, fertilization efficiency and application considerations, and environmental impact.

Multi-K® contains 100% plant macronutrients – potassium (K) and nitrate-nitrogen ($N\text{-}NO_3$). It is free of chloride, sodium and any other plant-detrimental elements.

Plants absorb the potassium and the nitrate from Multi-K® rapidly, in a balanced manner. This improves the movement of both ions in the plant, enhancing its performance.

Crystalline Multi-K products

Crystalline Multi-K® products are fast dissolving and easily integrated in the soil solution. The crystalline form is ideally suited for Nutrigation™ (fertigation) and foliar application.

Nutrigation™ with Multi-K® improves the uptake of potassium and nitrate by the plant roots, and minimizes leaching of nutrients below the root zone. Millions of cultivated acres worldwide have shown the superiority of Multi-K® for Nutrigation™ of high added-value protected crops such as tomatoes, cucumbers, bell-pepper, roses, chrysanthemum, etc. Multi-K® products can be mixed with phosphate, magnesium and calcium fertilizers to prepare nutrient solutions with no risk of clogging of the irrigation system.

Foliar feeding of fruit crops with Multi-K® products results in higher yields and better yield quality. Multi-K® retains atmospheric water when sprayed on leaves, thereby extending the absorption period by the leaves. It is free of harmful elements and highly compatible with other plant nutrients and agrochemicals. Combining Multi-K with other agents results in remarkable savings in labor, time and machinery.

*for high-K foliar nutrition, Bonus-npK® is recommended

Multi-K Classic	13-0-46	Pure potassium nitrate

Special grades

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

Enriched products

Multi-npK	13-5-42	Potassium nitrate enriched with phosphorus
	13-3-43	
	13-2-44	
Multi-K Mg	12-0-43+2MgO	Potassium nitrate enriched with Magnesium
	11-0-40+4MgO	
	12-2-43+1MgO	
	12-2-42+2MgO+0.5Mn	
	12-0-42+2MgO+0.2B	
Multi-K Zn	11-0-40+4Zn	Potassium nitrate enriched with Zinc
	12-0-43+2Zn	
Multi-K S	12-0-46+4.5 SO_3	Potassium nitrate enriched with Sulfate
Multi-K B	12-0-44+0.5 B	Potassium Nitrate enriched with Boron
Multi-K ME	12-0-43+Mg+ME	Potassium nitrate enriched with magnesium and micronutrients

Multi-K® prills

For direct soil application (side-dressing)

Multi-K Prills	13-0-46	Potassium nitrate prills
Multi-npK Prills	13-3-43	Potassium nitrate enriched with Phosphorus
	13-2-44	
Multi-K Mg Prills	12-0-42+2MgO	Potassium nitrate enriched Magnesium
	11-0-39+4MgO	

Poly-Feed®

Water-soluble NPK fertilizers

Poly-Feed is a range of fully water-soluble NPK fertilizers, designed to provide complete plant nutrition throughout the growth season. The wide choice of formulae and compositions meets the needs of vegetable crops, fruits and flowers at all types of cropping systems.

The benefits of Poly-Feed® products:

- Fully water soluble, safe for use with all irrigation and spraying systems
- Consists of pure plant nutrients exclusively
- Free of chloride, sodium, and other detrimental elements
- Made of high quality ingredients
- Enriched with high levels of micronutrients
- Good handling and storage properties, due to the Granular Matrix Technology

Poly-Feed® GG (Greenhouse Grade)

Soluble NPK fertilizers for Nutrigation™ and foliar feeding of greenhouse-grown crops

Poly-Feed® GG products are suitable for use with water of varied quality. All the formulae are enriched with high concentrations of micronutrients. Special formulae for soilless culture are based on ammonium nitrate and have K_2O/N ratio and nitrate/ammonium ratio adapted to the conditions prevailing in soilless media.

Poly-Feed® GG products are easily identified by the red color of both the bag and the crystals.

Poly-Feed® Drip

Soluble NPK fertilizers for in Nutrigation™ (fertigation) of fruit-trees vegetables, and all types of crops grown in open field

Poly-Feed® Drip formulae are enriched with magnesium and micronutrients. The Granular Matrix Technology (GMT) grants Poly-Feed® Drip products with improved handling and storage properties. Poly-Feed® Drip products are easily identified by the light-blue color of both the bag and the crystals.

Poly-Feed® Foliar

NPK fertilizers for foliar feeding of open-field crops, protected crops and fruit-trees

Poly-Feed® Foliar nourishes crops with their exact needs during critical growth phases, for maximal yields and top quality.

Poly-Feed® Foliar formulae are based on low-biuret urea and contain remarkably high concentrations of micronutrients in the form of EDTA chelates. The Granular Matrix Technology (GMT) grants Poly-Feed® Foliar products with improved handling and storage properties. Poly-Feed® Foliar products are easily identified by the green color of both the bag and the crystals.

Poly-Feed® MAR

NPK fertilizers enhanced with seaweed extracts

Poly-Feed® NPK fertilizers provide crops with all the nutritional elements needed for healthy development. Enrichment with seaweed extracts stimulates plant growth and improves plant nutrition, resulting in better performance of the fertilizer – and the plant.

The seaweed extracts contain a wide range of nutrients, growth bio-stimulants and conditioners that act together to improve both plant development and soil properties.

A variety of Poly-Feed® formulae are now available, enriched with 0.5% seaweed extracts.

Haifa-Bonus™

High K formula for foliar feeding of fruit-trees and field-crops

Haifa-Bonus™ is an innovate foliar preparation, designed to allow for concentrated spray applications. Haifa-Bonus™ is based on Multi-K® potassium nitrate. Phosphorus (P) enrichment enhances the nutritional value of the product, and reduces its pH for optimal absorption.
Haifa-Bonus™ contains special adjuvants for better adhesion to the leaf surface, improved absorption and prolonged action.

The benefits of Haifa-Bonus™

- Enables highly concentrated sprays, thus less applications are required
- Compatible with a large variety of pesticides, enabling tank mixing them with Haifa-Bonus™, thus saving on spray operations
- Consists of pure, fully soluble nutrients only
- Free of sodium and chloride

Multi-MAP™

Mono-ammonium phosphate (12-61-0)

Multi-MAP™ is a fully water-soluble mono-ammonium phosphate (12-61-0) fertilizer, a highly efficient source of phosphorus and nitrogen for plants. Multi-MAP™ is recommended for use at the beginning of the growth season, when phosphorus availability is crucial for the establishment of root system. Multi-MAP™ can be tank-mixed with other fertilizers* to meet crop nutritional needs throughout the growth cycle.

Multi-MKP™

Mono-potassium phosphate (0-52-34)

Multi-MKP™ is a fully water-soluble mono-potassium phosphate (0-52-34) fertilizer a highly efficient source of phosphorus and potassium for plants. Due to its high concentration of plant available phosphorous and potassium, it is a widely used fertilizer, consisting of 100% plant nutrients.
Multi-MKP™ is recommended for use at the beginning of the growth season, when phosphorus availability is crucial for the establishment of root system. Multi-MKP™ can be tank-mixed with other fertilizers* to meet crop nutritional needs throughout the growth cycle.

Multi-Cal®

Calcium Nitrate

Multi-Cal® is a highly efficient source of available calcium and nitrogen for plants. Calcium is a “quality nutrient” that enhances yield quality and prolongs shelf life of the yields. As calcium is not mobile in the plant, it has to be supplied throughout the growth season to keep adequate levels in the plant tissues and to ensure proper development. The nitrate-nitrogen in Multi-Cal® is readily consumed by the plant and improves the efficiency of calcium uptake.

Three grades of Multi-Cal® are available

- **Greenhouse Grade** (15.5-0-0+26.5 CaO) – For Nutrigation™ of greenhouse crops. Suitable for preparation of fertilizer blends and liquid fertilizers.
- **Nutrigation Grade** (15.5-0-0+26.5 CaO) For Nutrigation™ of field-crops and fruit-trees. Suitable for preparation of fertilizer blends and liquid fertilizers.
- **Agri Grade** (15.5-0-0+27CaO) - Granular fertilizer for base- and side-dressing of field crops

Magnisal®

Magnesium nitrate (11-0-0+16 MgO)

Magnisal® is a fully water-soluble magnesium nitrate (11-0-0+16 MgO) fertilizer. Magnesium deficiency retards the development of plants, resulting in decrease of yields.
Magnisal provides plants with the magnesium together with nitrate-nitrogen, which is readily absorbed by the plant. The nitrate in Magnisal® facilitates and accelerates magnesium uptake by the plant. Magnisal® is the most recommended fertilizer to cure and prevent magnesium deficiencies. Magnisal® is supplied in the form of flakes for convenient handling and dissolution.

Multi-Micro®

Chelated micronutrients

Multi-Micro® is a line of water-soluble chelated micronutrients for Nutrigation™ and foliar application of all crops. The chelated form ensures stability and plant-availability of the micronutrients, even in alkaline soils. Multi-Micro products dissolve rapidly and completely in water, with no risk of clogging of spray nozzles or narrow water passages.

Available products:

Multi-Micro® Fe	Iron-EDTA 13%
	Iron-EDDHA 6%
Multi-Micro® Mn	Manganese-EDTA 13%
Multi-Micro® Zn	Zinc-EDTA 14%
Multi-Micro® Cu	Copper-EDTA 14%
Multi-Micro® Comb	7.1% Fe, 3.48% Mn, 1.02% Zn, 0.76% Cu, All as EDTA chelates 0.485% Mo as ammonium molybdate
Multi-Micro® Soilless combination	6.5% F3-DTPA, 3.48 Mn-EDTA, 1.02% Zn-EDTA, 0.76% Cu-EDTA 0.485% Mo as ammonium molybdate

VitaPhos-K®

Precipitation-proof phosphate for soilless Nutrigation™

VitaPhos-K® provides plant-available phosphate in the form of soluble polyphosphate, which prevents formation of insoluble precipitates.
In the root zone, the polyphosphate undergoes slow hydrolysis, providing plant-available phosphate over time. The composition of VitaPhos-K® ensures that the hydrolysis occurs at the right time and the right location – by the surface of the root.
VitaPhos-K® helps keeping water passages clean of precipitates and free for water flow, as it dismantles precipitates by bonding cations, which are then released again for plant uptake.

Haifa-ProteK™

Systemic PK fertilizer

Haifa-ProteK™ is an innovative systemic fertilizer, suitable for Nutrigation™ and for foliar application.
Haifa-ProteK™ combines phosphate and phosphite to improve phosphorus uptake by the plant, thus eliminating the occurrence of P deficiencies. It enhances vegetative growth and root development, and increases fruit size and total yields. It also improves the resistance of the plant towards various diseases.
Haifa-ProteK™ is environmentally safe and practically non-toxic.
When applied by foliar spray, Haifa-ProteK™ leaves neither spots nor toxic residues.

Two analyses are available

- **Standard** 0-26-37+30% HPO_3^{2-}
- **Total** 0-0-39+60% HPO_3^{2-}

Multi-Pepton™

Amino-acid nutritional supplement for Nutrigation™

Multi-Pepton™ is a natural bio-stimulant. It contains Amino acids, low molecular weight peptides and humic acids that act together to support the metabolism of the plant and catalyze growth processes, even under adverse environmental conditions.
All the components of Multi-Pepton™ are 100% natural, so they easily integrate with the plant's metabolism.

Poly-Amin™

Growth promoting foliar amino-acid preparation

Poly-Amin™ is a natural bio-stimulant, specially designed for foliar application. It contains amino acids and low molecular weight peptides that act synergistically to catalyze growth processes and to support the metabolism of the plant. Poly-Amin™ helps the plant to overcome adverse environmental conditions.
Poly-Amin™ is absorbed by the leaves quickly and efficiently without scorching. All the components of Poly-Amin™ are 100% natural, so they easily integrate with the plant's metabolism.

Multicote®

Controlled Release Fertilizers

Multicote polymer-coated controlled release fertilizers release plant nutrients slowly and continuously throughout the growth cycle. A single application of Multicote® will take care of optimal plant nutrition over months. Multicote® is available at a wide range of formulae, and with release longevities of 4 to 16 months (at soil temperature of 21°C). Most formulae are enriched with micronutrients.

The advantages of Multicote

- Plant nutritional needs are met by single application per season
- Reliable release profile, which is unaffected by soil type, soil pH, moisture or microbial activity.
- Broad selection of products for an extensive variety of applications
- High concentration of nutrients
- Homogenously distributed in the soil or potting mix

Multicote release longevity

Multicote release rate increases with temperature, and the longevity is decreased accordingly.

	15°C (60°F)	21°C (70°F)	30°C (86°F)
Multicote 4	6 months	4 months	2 months
Multicote 6	7-8 months	6 months	3-4 months
Multicote 8	9-10 months	8 months	5-6 months
Multicote 12	15-16 months	12 months	7-8 months
Multicote 16	20-22 months	16-18 months	9-10 months

Recommended applications

Longevity	Recommended for
4 months	Bedding plants, pot plants and hanging baskets
6 months	Bedding plants, pot plants, garden trees and shrubs
8 months	Container-grown nursery stock, garden trees and shrubs
12 months	Container-grown nursery stock
16 months	Container-grown nursery stock, specially recommended for use in tropical and sub-tropical regions

Multicote® Agri

Controlled Release Fertilizers for Agriculture & Horticulture

Taking advantage of MulticoTech™ polymer coating technology, HAIFA has developed Multicote® AGRI - a family of controlled-release fertilizer products for agriculture and horticulture. Multicote® AGRI products contain polymer-coated sources of nitrogen, phosphorus and potassium, with release longevity of 2-8 months.

Multicote® AGRI products are recommended for cash crops in open field, protected crops and fruit-trees. For arable crops, CoteN™ polymer-coated urea, and CoteN™ Mix polymer-coated urea with readily available nutrient, products are recommended.

Recommended applications

Multicote® AGRI products are highly recommended in the following cases:

- On light soils, where conventional fertilizers are easily leached
- In rainy areas, when rainfall accelerates nutrient leaching
- Wherever nitrogen application is limited e.g., by environmental regulations
- For crops with a shallow root system
- For crops with high nutritional requirements
- In cases where mid-season application is not feasible (e.g. when the crop covers the soil surface, in mulched crops and in muddy fields)

Multicote® Turf

Controlled Release Fertilizers for Turf

Proper nutrition is an essential condition for healthy, vigorous, good-looking turf. Multicote® TURF product line fully addresses all growth factors. It offers optimized fertilization programs for every combination of turf species, climate conditions and maintenance level. Multicote® TURF year-round nutritional programs are composed of formulae with different N:K ratios, addressing the changing nutritional needs of the turf plant and supporting seasonal growth processes.

Product	N:K* ratio	Action
Booster	2:1	Dormancy breaker; Initiates intensive leaf growth
Feeder	1:1	Balanced fertilizer, regulates root and shoot growth. Helps maintaining turf quality and strength during seasons of intensive use.
Keeper	1:2 or 1:3	High-potassium fertilizer supports last leaf growth and builds carbohydrate storage.
Multi-K® Turf	1:3	Quickly available potassium fertilizer; “Quick action for tough periods”.

For close-cut turf, the Multicote® TURF **MINI range** of fine prilled products is recommended.

Appendix II: 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	0.9898	H_2PO_4	H_3PO_4	1.01
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

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

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	-