# Nutritional recommendations for

# ONION

Haifa

Pioneering the Future

# 1. Introduction

### 1.1 Overview

Onion *(Allium cepa* L. , member of the Liliaceae family) is a herbaceous bulbous plant that is cultivated for bulb production either as biannual or perennial (depending on the cultivation conditions). It is probably originated in the mountainous regions of Central Asia. Onions are among the most widely adapted vegetable crops, and they can be grown from the tropics to subarctic regions. World production is nearly 85 million tons of bulbs on some 4.4 million ha.
The onion crop thrives in mild climates, with no extreme temperatures and without excessive rainfall. The optimum mean daily temperature for growing onions varies between 15 and 20°C. Under normal conditions onion forms a bulb in the first season of growth and flowers in the second season. The production of the bulb is regulated by day length. The critical day length varies from 11 to 16 hours, depending on variety. For the initial growth period, cool weather and adequate water is advantageous for proper establishment, whereas during ripening, warm, dry weather promotes high yield of good quality.
Onions can be grown on many soils but medium textured soils are preferred. Optimum pH is in the range of 6 to 7. Fertilizer requirements are normally 60 to 100 kg/ha N, 25 to 45 kg/ha P and 45 to 80 kg/ha K.

### 1.2 Onion economy

Onion growing areas

| Country | ha | % from total | Country | ha | % from total | Country | ha | % from total |
|---|---|---|---|---|---|---|---|---|
| India | 1,203,570 | 22.7% | Myanmar | 77,200 | 1.5% | Mozambique | 39,700 | 0.7% |
| China | 1,034,841 | 19.5% | Egypt | 68,487 | 1.3% | Uzbekistan | 38,290 | 0.7% |
| Oman | 491,400 | 9.3% | Sudan | 60,000 | 1.1% | Romania | 30,290 | 0.6% |
| Nigeria | 487,000 | 9.2% | Brazil | 59,190 | 1.1% | Netherlands | 30,199 | 0.6% |
| Bangladesh | 150,915 | 2.8% | Ukraine | 58,800 | 1.1% | Morocco | 29,349 | 0.6% |
| Pakistan | 133,922 | 2.5% | Turkey | 58,315 | 1.1% | South Africa | 26,149 | 0.5% |
| Indonesia | 120,704 | 2.3% | Iran | 57,112 | 1.1% | Japan | 25,300 | 0.5% |
| Viet Nam | 94,051 | 1.8% | USA | 56,600 | 1.1% | Spain | 24,955 | 0.5% |
| Russian Federation | 85,993 | 1.6% | Algeria | 47,982 | 0.9% | Poland | 24,727 | 0.5% |
| Uganda | 77,716 | 1.5% | Mexico | 47,431 | 0.9% | Rest of the world | 559,870 | 10.6% |

**Onion trade (WTO 2014 data)**

| Exporters | | | | Importers | | |
|---|---|---|---|---|---|---|
| | tons | % share | | | tons | % share |
| World | 249579 | 100% | | World | 211371 | 100% |
| Pakistan | 81565 | 33% | | UAE | 39763 | 19% |
| India | 54306 | 22% | | Germany | 24164 | 11% |
| USA | 32203 | 13% | | UK | 12400 | 6% |
| China | 13119 | 5% | | Poland | 11285 | 5% |
| Egypt | 12152 | 5% | | Netherlands | 9312 | 4% |
| Poland | 8835 | 4% | | Russia | 6709 | 3% |

## 2. Growing onions

### 2.1 Varieties

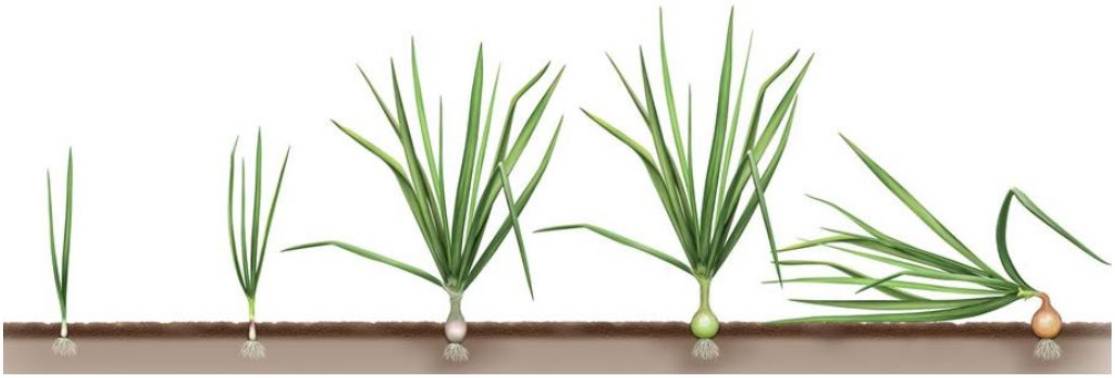
There is a wealth of types of edible onions that differs in size, shape and flavor. The bulb onion are the most prevalent members of the group, accounting for the largest growth areas and global yield.
Bulb onions are classified into three groups, according to their response to day length:

- Short-day bulb varieties with day lengths of 11-12 hours
- Intermediate bulb varieties with day lengths of 13-14 hours
- Long-day varieties with day lengths of 14-16 hours.

Onion varieties are also distinguished by their color, yellow/ brown, white or red. Usually cultivars with similar color will have typical features.



### 2.2 Onion growth stages



| Stage: | Establishment | Vegetative growth | Bulb initiation | Bulb development | Maturation |
|---|---|---|---|---|---|
| Stage duration: | 30 Days | 30 Days | 30 Days | 45 Days | 15 Days |
| Description: | 1 to 2 true leaves | From 4 to 7 true leaves. 'leek' stage, the fourth leaf appears and the neck of the plant starts to thicken | Bulb diameter is twice that of the neck, 8 to 12 true leaves. The second and third leaves fell. The plant reaches maximum height | Leaves continue to grow and elongate but the total leaf area and number of leaves stay about the same | Bulb enlargement near completion; more than 50 percent tops down. |

### 2.3 Crop growth needs

Onions have a shallow, sparsely branched root system with most roots in the top 30 cm of soil. Rooting density decreases with soil depth. Thus, it is important to maintain nutrient and soil moisture within the shallow rooting area . Soils need to be well structured and fertile to maximize growth and produce high

yields. Bulbs are harvested when the tops fall. For bulb production the plant should not flower, since flowering adversely affects yields. Flowering depends on day length, and requires low temperatures (lower than 14-16°C) and low humidity.

**Seed bed condition**
A fine, consolidated seed zone is required for maximum germination and good establishment. Clods and stones will hinder growth. Optimum soil temperature for germination is 15 to 25°C.

**pH**
Soil pH range of 6-7 is optimal for onion growth. When pH drops below 5.5, magnesium and molybdenum availability decline and when the pH exceeds 6.5 zinc, manganese and iron become deficient.

**Soil analysis guide for diagnosing available nutrient status**

| **Levels of available nutrient in the soil,ppm** | | | |
|---|---|---|---|
| **Soil status** | **Phosphorus** | **Potassium** | **Zinc** |
| **Very deficient** | 0-5 | <40 | <0.3 |
| **Deficient** | 5-9 | 40-80 | 0.3-0.5 |
| **Intermediate** | 10-15 | 80-120 | 0.5-0.8 |
| **Sufficient** | >15 | >120 | >0.8 |

Analytical methods:
Phosphorus – Olsen bicarbonate
Potassium – Ammonium acetate
(UC Davis 2016)

**Irrigation**
The onion crop requires 350 to 550 mm of water throughout the growth cycle. It is recommended to give frequent, light irrigations which are timed when about 25 percent of available water in the top 30 cm of soil is depleted. Irrigation intervals of 2-4 days are a common practice. Excessive irrigation sometimes gives rise to the occurrence of diseases such as mildew and white rot. Irrigation should be ceased 15 to 25 days before harvest. Late season irrigation might delay maturity and cause skin cracking.
The following table shows crop coefficient (kc) relating reference evapotranspiration (ETo) to water requirements (ETm) at different development stages.

| | Stages of development | | | | | Plant date | Region |
|---|---|---|---|---|---|---|---|
| stage | initial | Crop development | Mid-season | Late | Total | | |
| Length (days) | 15 | 25 | 70 | 40 | 150 | April | Mediterranean |
| | 20 | 35 | 110 | 45 | 210 | Oct./Jan | Arid region; California |
| Root depth, m | - | - | - | - | 0.6 | | |
| Crop coefficient, Kc. | 0.7 | >> | 1.05 | 0.75 | - | | |

(Source: FAO)

## 2.4 Stress factors

**Water stress**

Onions are very sensitive to water stress. Although onions can survive long periods of drought, water availability is critical for growth and high yields of quality bulbs. Onion responds to water-stress by reducing rates of transpiration, photosynthesis, and growth. During the stage of bulb growth, onions are more sensitive to water stress than most other crops. Water stress at this time reduces bulb yield and size. Under drought stress, onions are more likely to split or form double and multiple bulbs.

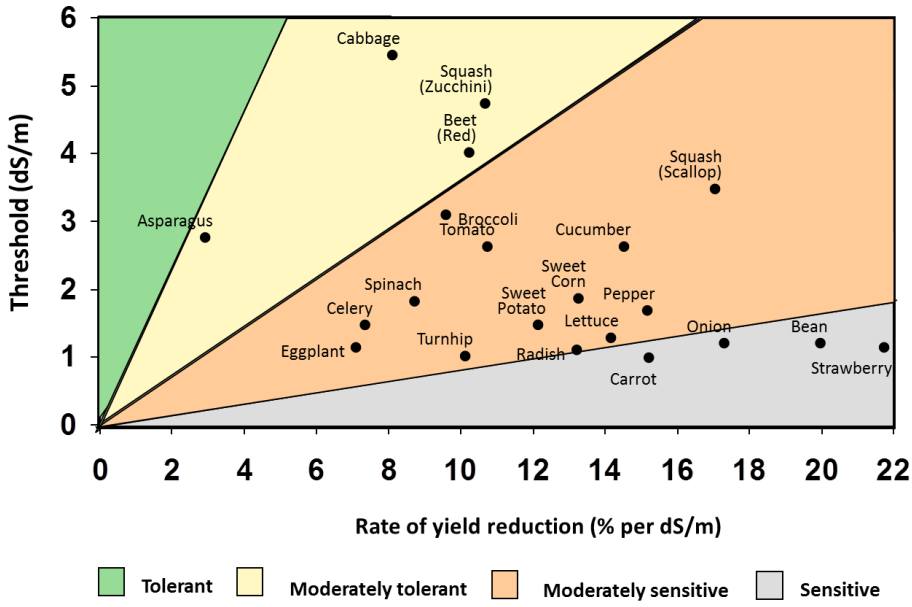
**Salinity**

The onion crop is sensitive to soil salinity, as the table below depicts.

| Conductivity (mmhos/cm) | 1.2 | 1.8 | 2.8 | 4.3 | 7.5 |
|---|---|---|---|---|---|
| Yield decrease | 0% | 10% | 25% | 50% | 100% |

Incorporation of fertilizers into planting beds before seeding increases level of soluble salts to a level that might harm seedlings as they emerge. After establishment, onions can tolerate higher salt levels. Salinity problems can also include specific toxicity of elements such as boron or sodium, usually are related to irrigation water quality.

Onions are more sensitive to salinity, sodium, and boron toxicity than are lettuce, cauliflower, broccoli, and cabbage.




Source: Shannon and Grieve (1999)

**Weed competition**

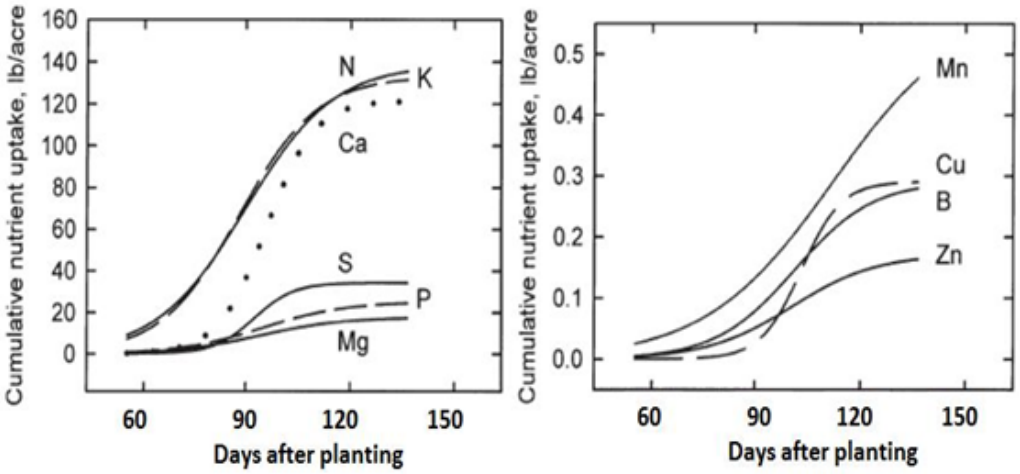
The onion is a naturally poor competitor. To avoid yield reduction, weed control is essential right from sowing.

## 3. Nutrition

**3.1. Nutrient uptake**- The sparse, shallow root system of the onion calls for careful management of water and nutrients, to ensure adequate availability. P, K and metal micronutrients, which are relatively immobile, are not easily reached by the roots, while mobile nutrients, such as nitrogen, tend to leach below the roots zone.

Various studies show that application near the onion's small root zone improves nutrients use efficiency. Thus, Nutrigation™ (fertigation), that supplies nutrition close to uptake sites, increases yields compared to broadcast application. (Thangasamy, 2016)

The following charts show the overall uptake dynamics throughout the season. The timing of nutrient application should take in consideration the nutrient uptake pattern during crop growth stages. As shown, most intensive uptake takes place from the start of the bulb initiation stage and during the bulb development.



Adapted from Oregon State University 2011

Improved nutrient management, by means of fertigation or controlled release fertilizers, will not only improve the onion yield, but also will enhance nutrient use efficiency that will give the grower a better return while minimizing environmental risks.

**Nitrogen (N)**

Dry bulb production, from transplanting, requires 140-170 kilograms nitrogen per hectare. Nitrogen application rates depend on soil type, rainfall, irrigation, plant population, and method and timing of application. Usually, it is advisable to incorporate 25-30% of the recommended nitrogen rate prior to planting.

Lack of available nitrogen will severely suppress growth. On the other hand, excessive nitrogen is believed to produce succulent plants that are more susceptible to frost injuries and disease, and tend to produce flower stalks. Heavy nitrogen fertilization also worsens storage properties of the bulbs. Finally, excess nitrogen late in the growing season is believed to delay maturity and causes double centers. It is recommended to cease N application at least 4 weeks before harvest.

**Phosphorus (P)**

Phosphorus is essential for root development and therefore required at the establishment stage. Phosphorus uptake rate is more or less constant throughout the growth cycle. Since phosphorus is immobile in the soil and can be translocated from the old leaves to the bulb during the bulb development and maturing stages, it is possible to apply most of the phosphorus before planting and up to the bulb development stage, to simplify the fertilization program.

Onions are highly dependent on arbuscular mycorrhizal fungi for uptake of phosphorus from soils with low to medium soil test P concentrations. Mycorrhizal fungi also improve the uptake of zinc and other micronutrients in some high-pH calcareous soils. Mycorrhizal fungi are usually abundant in agricultural soils, except when non-host crops (e.g. sugarbeet, canola) are grown, soil is fumigated, or high P is present.

**Potassium (K)** is an important factor in plant water relations, cell-wall formation, and energy reactions in the plant. It is recommended to split K applications by incorporating 30-50 percent of the recommended K before planting and split the remainder during the bulb development stage. Appling potassium during the bulb development stage increases the bulb size and quality. Low K level makes plants more susceptible to cold injury.

**Magnesium (Mg)** levels in the soil must be adequate for good onion growth. If Mg level is low, apply 30 kilograms per hectare of Mg in the preplant fertilizer.

**Sulfur (S)** Early application of sulfur is advisable in direct seeded and transplanted onions. Do not completely eliminate S from the fertility program. Apply elemental S half incorporated at transplanting or seeding and half applied before the bulb development stage. Application rates should not exceed 45 - 70 kg S /ha.

**Boron (B)** is required by direct-seeded or transplanted onions in the field. If the soil test detects a low B level, 1.0 kg B /ha, and incorporate prior to transplanting or seeding. Do not exceed the recommended amount since boron can be toxic to onions.

**Zinc (Zn)** levels determined to be low by soil testing can be corrected by applying 6 kg/ha of Zn. Excessive amounts of Zn can be toxic, so apply only if needed. Zinc is usually added in base fertilization.

**3.2. Nutritional disorders**

**Nitrogen:** Deficiencies result in stunted plants with pale green to yellow leaves that dieback from the tips. Also, the foliage tends to be erect and the bulbs are smaller than normal and mature earlier. Excess nitrogen causes rapid plant growth and delays maturity. The bulbs tend to be softer and more susceptible to storage rots.

**Phosphorus:** Deficiencies result in slow growth, delayed maturity and a high percentage of thick necked bulbs at harvest. Leaves become a dull green color and dieback from the tips without the yellowing associated with nitrogen and potassium deficiencies.

**Potassium:** Deficiencies result in the foliage initially becoming darker green and the tips of the older leaves begin to wilt, especially on the upper surface. Eventually the leaves droop and take on a satiny progressing to paper-like appearance and develop chlorosis similar to that caused by nitrogen deficiencies.

(picture source: IPI)

**Magnesium:** Deficiencies result in slow plant growth with the older leaves becoming uniformly yellow along their entire length.

**Zinc:** Deficiencies result in stunted plant growth with noticeable twisting and faint interveinal chlorosis of the leaves. Onions are very sensitive to zinc deficiencies.

**Molybdenum:** Deficiencies result in poor emergence and seedling death. As the plant grows, leaves will dieback from the tip with a noticeable soft transition zone between the healthy and necrotic tissue. Onions are very sensitive to molybdenum deficiencies

**Manganese:** Deficiencies result in slow growth, delayed maturity and a high percentage of thick necked bulbs at harvest. The older leaves develop interveinal chlorosis, which progresses to a tip-burn, and they may curl and eventually become necrotic. Onions are very sensitive to manganese deficiencies.

**Boron:** Deficiencies result in distorted and stunted plant growth. Leaves become brittle and may turn a gray-green to a blue-green color. Young foliage may be a mottled yellow green while older leaves

become chlorotic with tip dieback and sunken areas. Transverse yellow lines that develop into cracking can occur near the base of the leaves.

**Tissue analysis guide for diagnosing crop nutrient status**

Plant part to sample is the tallest leaf blade

| Sampling time and nutrient | Nutrient level | | |
|---|---|---|---|
| | Deficient | Intermediate | Sufficient |
| Early season (pre-bulbing) | | | |
| Total N, % | <3 | 3-4 | >4 |
| $PO_4$-P, ppm | <1000 | 1000-2000 | >2000 |
| Soluble K, % | <3 | 3-4 | >4 |
| Mid-season (bulbing) | | | |
| Total N, % | <2.5 | 2.5-3 | >3 |
| $PO_4$-P, ppm | <1000 | 1000-2000 | >2000 |
| Soluble K, % | <2.5 | 2.5-4 | >4 |
| Late seaon (post bulbing) | | | |
| Total N, % | <2 | 2-2.5 | >2.5 |
| $PO_4$-P, ppm | <1000 | 1000-2000 | >2000 |
| Soluble K, % | <2 | 2-3 | >3 |

(UC Davis, 2016)

4. **<u>Suggested fertilization programs for onion</u>**

The holistic approach of Haifa for plant nutrition offers the growers diverse options for enhancing the plant performance and fertilizer use efficiency.

In Haifa's plant nutrition approach, the fertilization program takes in consideration alternative fertilizer formulas and alternative application methods (fertigation only, fertigation + foliar, fertigation + controlled release fertilizer or controlled release fertilizer only) for each growth stage and for different environmental conditions to match the plant's nutrition special needs.

These fertilization programs take into consideration:

- The plant uptake curve for each elements (macro, secondary and micronutrients) for each plant growth stage.

- The best application method for each plant growth stage and for every environmental and climate conditions (the methods can be fertigation only, fertigation + foliar, fertigation + controlled release fertilizer, controlled release fertilizer only)

- Alternative fertilizer formulas or application methods for different conditions that may occur during the growth cycle such as unpredictable climate conditions (drought or extreme temperature) and plant diseases that will damage roots absorption or the leaf's activity.
  Special foliar fertilizers with prolonged and better action can be added to the fertilization programs to improve the root uptake and boost plant performance, as part of the overall nutritional program.

The main programs for onion are:

1. Base and side dressing - Simple and basic program where fertigation cannot be use.
2. Base application with controlled release fertilizer (Multicote) + side dressing - for better nutrient use efficiency, saving application costs and less soil compaction.
3. Fertigation using straight fertilizers + side dressing - for better nutrient use efficiency, saving application costs and soil compaction.
4. Base dressing with Haifa Turbo-K and fertigation using Poly-Feed (NPK soluble fertilizer) - precise nutrient formula application, better nutrient use efficiency, saving application costs and less soil compaction.
5. Base dressing with controlled release fertilizer (Multicote) and fertigation for precise nutrient application rate with precise nutrient formula (Poly-Feed).
6. Complementary foliar nutrition - To enhance plant performance during periods of special needs (nutrients disorders or abiotic stress)

**Basic assumptions for the following fertilization programs:**
Growing medium: Open field.
Soil type: Light to medium.
Expected yield: 65 MT/Ha (85% moisture).

**Kilograms of macro nutrients removed by 1 ton marketable product**

| N | $P_2O_5$ | $K_2O$ | CaO | MgO | S |
|---|---|---|---|---|---|
| 3.0-4.0 | 1.3-1.8 | 2.5-5 | 1.0 | 0.5 | 1.8-2.8 |

**Examples of 5 detailed Fertilization programs for onion:**

**Option 1. Base and side dressing - Simple and basic program where fertigation cannot be use.**

| Stage description | Pre-plant | Establishment | Vegetative growth | Bulb initiation | Bulb development | Maturation |
|---|---|---|---|---|---|---|
| duration | | 30 days | 30 days | 30 days | 30 days | 30 days |
| Fertilizers (kg/ha) | | | | | | |
| Haifa Turbo-K™ 15-15-15 | 400 | 300 | | | | |
| Haifa MAP™ 11-52-0 | 235 | | | | | |
| Haifa K-Mag 0-0- | 250 | | | | 250 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 22+18MgO +22 $SO_3$ | | | | | | |
| Dolomite 26% | 254 | | | | | |
| Urea 46-0-0 | | | | | 226 | |
| Total nutrients (kg/ha) | | | | | | |
| N | 862 | 45 | | | 104 | |
| $P_2O_5$ | 122 | | | | | |
| $K_2O$ | 60 | 45 | | | 55 | |
| MgO | 30 | | | | 30 | |
| CaO | 66 | | | | | |

Total nutrients (kg/ha)

| N | $P_2O_5$ | $K_2O$ | MgO | CaO |
|---|---|---|---|---|
| 235 | 122 | 215 | 60 | 66 |

* In soil with high phosphorus levels use Haifa Turbo-K™ 18-09-18

**Option 2. Base application with controlled release fertilizer (Multicote) + side dressing - for better nutrient use efficiency, saving application costs and less soil compaction.**

Due to the high nutrients use efficiency with Multicote™, application rates can be reduced to about 70% of the N and $K_2O$ compared to conventional fertilization.

| | Application rate - % of common practice | | | % coated nutrients | | |
|---|---|---|---|---|---|---|
| | N | $P_2O_5$ | $K_2O$ | N | $P_2O_5$ | $K_2O$ |
| Light soil | 60-70 | 100 | 70 | 70 | - | 30-50 |
| Heavy soil | 70-90 | 100 | 80 | 50 | - | 30-50 |

| Stage description | Pre-plant | Establishment | Vegetative growth | Bulb initiation | Bulb development | Maturation |
|---|---|---|---|---|---|---|
| duration | | 30 days | 30 days | 30 days | 30 days | 30 days |
| Fertilizers (kg/ha) | | | | | | |
| Multicote™ Agri 15-15-15 | 1000 | | | | | |
| Dolomite 26% | 250 | | | 250 | | |
| Multi-K™ 13-0-46 | | | | 100 | | |
| Total nutrients (kg/ha) | | | | | | |
| N | 150 | | | 13 | | |
| $P_2O_5$ | 150 | | | | | |
| $K_2O$ | 150 | | | 45 | | |
| MgO | 25 | | | 25 | | |
| CaO | 65 | | | 65 | | |

| Total nutrients (kg/ha) | N | $P_2O_5$ | $K_2O$ | MgO | CaO |
|---|---|---|---|---|---|
| | 163 | 150 | 195 | 50 | 130 |

**Option 3. Fertigation using straight fertilizers + side dressing - for better nutrient use efficiency, saving application costs and less soil compaction.**

| Stage description | Pre- | Establishment | Vegetative | Bulb | Bulb | Maturation |
|---|---|---|---|---|---|---|

| | plant | | growth | initiation | development | |
|---|---|---|---|---|---|---|
| duration | | 30 days | 30 days | 30 days | 30 days | 30 days |
| Fertilizers (kg/ha) | | | | | | |
| Multi-K™ 13-0-46 | | 100 | 140 | 140 | 170 | |
| Haifa MAP™ 11-52-0 | | 75 | 50 | 50 | 50 | |
| Magnisal™ 11-0-0+16MgO | | 34 | 68 | 68 | 90 | |
| Haifa Cal™ 11-0-0+26CaO | | 50 | 50 | 75 | 75 | |
| Ammonium Nitrate 34-0-0 | | 25 | 25 | 50 | 50 | |
| Total nutrients (kg/ha) | | | | | | |
| N | | 42 | 48 | 48 | 66 | |
| $P_2O_5$ | | 46 | 31 | 31 | 31 | |
| $K_2O$ | | 46 | 64 | 64 | 78 | |
| MgO | | 5 | 11 | 11 | 14 | |
| CaO | | 13 | 13 | 13 | 20 | |

Total nutrients (kg/ha)

| N | $P_2O_5$ | $K_2O$ | MgO | CaO |
|---|---|---|---|---|
| 204 | 139 | 252 | 41 | 59 |

**Option 4. Fertigation using Poly-Feed (NPK soluble fertilizer) - precise nutrient formula application, better nutrient use efficiency, saving application costs and less soil compaction.**

| Stage description | Pre-plant | Establishment | Vegetative growth | Bulb initiation | Bulb development | Maturation |
|---|---|---|---|---|---|---|
| duration | | 30 days | 30 days | 30 days | 30 days | 30 days |
| Fertilizers (kg/ha) | | | | | | |
| Poly-Feed™ 12-43-12 | | 45 | | | | |
| Poly-Feed™ 19-19-19 | | | 240 | | | |
| Poly-Feed™ 14-7-21 | | | | 300 | | |
| Poly-Feed™ 12-5-40 | | | | | 675 | |
| Magnisal™ 11-0-0+16MgO | | | 60 | 60 | 110 | |
| Haifa Cal™ 11-0-0+26CaO | | | 60 | 60 | 110 | |
| Total nutrients (kg/ha) | | | | | | |
| N | | 5 | 61 | 58 | 110 | |
| $P_2O_5$ | | 19 | 46 | 21 | 34 | |
| $K_2O$ | | 5 | 46 | 63 | 270 | |
| MgO | | | 10 | 10 | 18 | |
| CaO | | | 16 | 16 | 29 | |

Total nutrients (kg/ha)

| N | $P_2O_5$ | $K_2O$ | MgO | CaO |
|---|---|---|---|---|
| 234 | 120 | 384 | 38 | 61 |

**Option 5. Base dressing with controlled release fertilizer (Multicote) and fertigation for precise nutrient application rate with precise nutrient formula (Poly-Feed).**

Due to the high fertilizing efficiency of the Multicote™, the application rate will be only ~70% of the N and $K_2O$ common application practice:

| Stage description | Pre-plant | Establishment | Vegetative growth | Bulb initiation | Bulb development | Maturation |
|---|---|---|---|---|---|---|
| duration | | 30 days | 30 days | 30 days | 30 days | 30 days |
| Fertilizers (kg/ha) | | | | | | |
| Multicote™ Agri 15-15-15 | 300 | | | | | |
| Poly-Feed™ 19-19-19 | | 100 | | | | |
| Poly-Feed™ 14-7-21 | | | 100 | 150 | | |
| Poly-Feed™ 12-5-40 | | | | | 600 | |
| Magnisal™ 11-0-0+16MgO | | 60 | 60 | 60 | 90 | |
| Haifa Cal™ 11-0-0+26CaO | | 60 | 60 | 60 | 90 | |
| Total nutrients (kg/ha) | | | | | | |
| N | 45 | 35 | 30 | 37 | 95 | |
| $P_2O_5$ | 45 | 19 | 7 | 11 | 30 | |
| $K_2O$ | 45 | 19 | 21 | 32 | 240 | |
| MgO | | 10 | 10 | 10 | 14 | |
| CaO | | 16 | 10 | 16 | 24 | |

Total nutrients (kg/ha)

| N | $P_2O_5$ | $K_2O$ | MgO | CaO |
|---|---|---|---|---|
| 242 | 112 | 357 | 44 | 72 |

**Complementary foliar nutrition - To enhance plant performance during periods of special needs (nutrients disorders or abiotic stress)**

Foliar application of nutrients provides complementary fertilization with high added value, corrective nutrition when deficiencies are noticed and growth boosting during critical stages of the crop development. This foliar nutrition program can be added to all fertilization programs.

| Stage description | Pre-plant | Establishment | Vegetative growth | Bulb initiation | Bulb development | Maturation |
|---|---|---|---|---|---|---|
| duration | | 30 days | 30 days | 30 days | 30 days | 30 days |
| Fertilizers (kg/ha) | | | | | | |
| Poly-Feed™ 20-20-20 | | 1 kg/ha, conc. 0.5% | 1.5 kg/ha, conc. 0.5% | | | |
| Magnisal™ 11-0-0+16MgO | | | | 2 kg/ha, conc. 1% | 2 kg/ha, conc. 1% | |
| Haifa Bonus™ | | | | 5 kg/ha, conc. 2% | 5 kg/ha, conc. 2% | |

## Proven Results

1. **Multicote™ Agri trial in Israel** , 2016

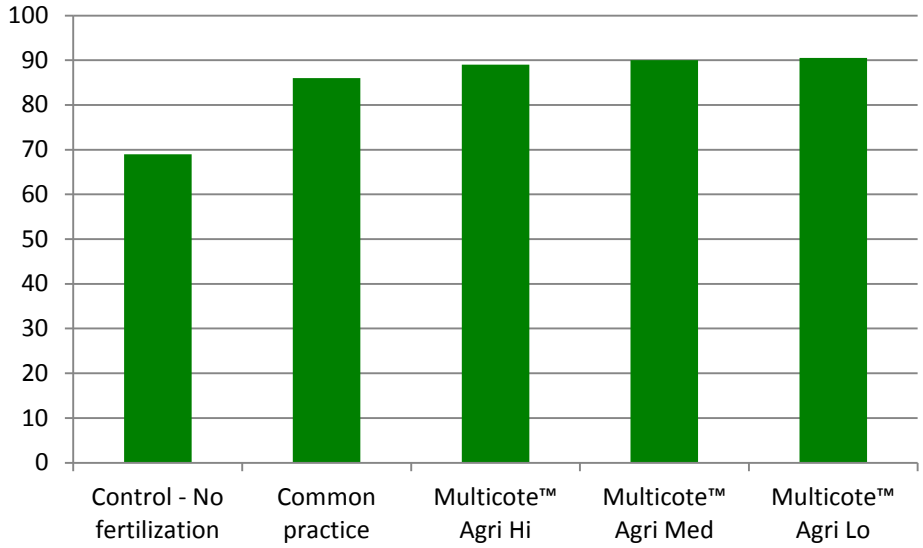
**Treatments**

| | Fertilizer | Rate (kg/ha) | N rate (kg/ha) | % N of common practice |
|---|---|---|---|---|
| Control - No fertilization | - | - | - | |
| Common practice | 46-0-0 | 652 | 300 | 100% |

| | | | | |
|---|---|---|---|---|
| Multicote™ Agri Hi | 42-0-0 | 714 | 300 | 100% |
| Multicote™ Agri Med | 42-0-0 | 536 | 225 | 75% |
| Multicote™ Agri Lo | 42-0-0 | 357 | 150 | 50% |

The common practice fertilization was applied by base dressing + 10 top dressings
Multicote™ Agri treatments were applied by single application

**Total yield (MT/ha)**




| | Fertilizer cost $/ha | Application cost $/ha | Total cost $/ha |
|---|---|---|---|
| Common practice | 378.3 | 417.7 | 793.0 |
| Multicote™ Agri Hi | 689.8 | 37.7 | 727.5 |
| Multicote™ Agri Med | 517.3 | 37.7 | 555.0 |
| Multicote™ Agri Lo | 344.9 | 37.7 | 382.6 |

- All Multicote Agri treatments resulted in higher yields compared to the farmers practice.
- The Multicote™Agri 50% N treatment was the most profitable treatment.

## 2. Multicote™ Agri trial in Mexico, 2007-2008

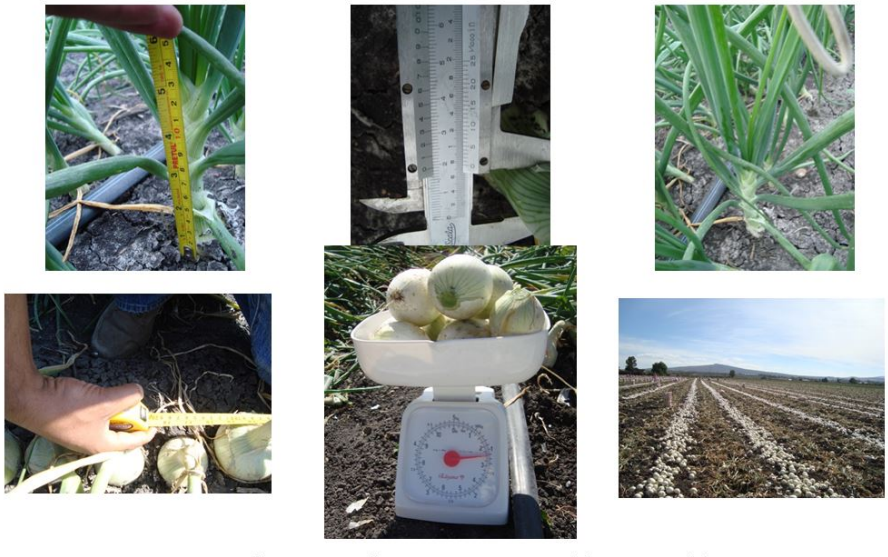
Location: INIFAD research center

Plot wat irrigated by flooding onion in

| Treatment no. | Rate (kg/ha) | | % CRF | | Yield (ton/ha) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | N | $K_2O$ | N | $K_2O$ | Total | Jumbo | Large | Medium | Small |
| T1 | 0 | 0 | 0 | 0 | $28.15^{d}$ | 8.64 | 56.66 | 29.03 | 5.72 |
| T2 | 100 | 100 | 50 | 30 | $52.69^{c}$ | 26.31 | 49.18 | 22.99 | 1.55 |
| T3 | 100 | 100 | 30 | 30 | $49.96^{c}$ | 19.96 | 52.93 | 25.44 | 1.66 |
| T4 | 140 | 140 | 50 | 30 | $57.71^{ab}$ | 24.91 | 49.70 | 23.70 | 1.68 |
| T5 | 140 | 140 | 30 | 30 | $61.78^{a}$ | 17.42 | 61.48 | 20.41 | 0.68 |
| T6 (conventional) | 200 | 200 | 0 | 0 | $53.33^{bc}$ | 20.44 | 52.61 | 24.47 | 2.48 |
| DSH (0.05) | | | | | 4.5 | | | | |
| CV (%) | | | | | 4.0 | | | | |

**Economic analysis ($/ha)**

| Treatment no. | Total income | Variable costs | Total costs | Net income | Benefit: cost ratio |
|---|---|---|---|---|---|
| T1 | 33503 | 0 | 30000 | 3503 | 0.12 |
| T2 | 67069 | 4325 | 34325 | 32744 | 0.95 |
| T3 | 62353 | 3824 | 33824 | 28711 | 0.85 |
| T4 | 73111 | 5787 | 35784 | 37324 | 1.04 |
| T5 | 78389 | 5085 | 35085 | 43304 | 1.23 |
| T6 (conventional) | 66674 | 3940 | 33940 | 32734 | 0.96 |



Evaluation of vegetative variables & Yield

**Conclusions:** This trial in flooded onion field proved the following:

The CRF treatment gave more yield, more dry matter and better absorption of N.P.K .

Net income obtained with CRF treatments was higher than conventional and control treatments.

**3. Multicote™ Agri trials in commercial farms, Mexico**

a. **Las Adelinas farm**

Location: Abasolo, Guanajuato state, Mexico.
Variety: Cirrus, area : 4.4 ha
Sowing: 17-18/8/2009, Harvest : 15/12/2009

Farmer's practice

| Fertilizer | Rate (kg/ha) | Total nutrients applied (kg/ha) | | | | |
|---|---|---|---|---|---|---|
| | | N | $P_2O_5$ | $K_2O$ | CaO | MgO |
| Base 13-18-20 | 500 | 67 | 92 | 100 | | |
| Fertigation | | 233 | 39 | 256 | 72 | 36 |
| Total | | 300 | 131 | 356 | 72 | 36 |

Haifa treatment

| Fertilizer | Rate (kg/ha) | Total nutrients applied (kg/ha) | | | | |
|---|---|---|---|---|---|---|
| | | N | $P_2O_5$ | $K_2O$ | CaO | MgO |
| Base: Multicote™ Agri (4) 21-17-17 | 553 | 117 | 92 | 94 | | |
| Fertigation | | 94 | 40 | 153 | 72 | 36 |
| Total | | 211 | 132 | 248 | 72 | 36 |

**Yield results (MT/ha)**

| Treatment | Total yield | Bulb size | | | | |
|---|---|---|---|---|---|---|
| | | rejected | small | medium | large | XL |
| Farmer's practice | 56.98 | 2.34 | 10.51 | 31.54 | 11.45 | 1.14 |
| Multicote™ Agri | 63.30 | 2.53 | 5.06 | 27.85 | 24.05 | 3.80 |

**b. El Palomar farm**

Location: Abasolo, Guanajuato, Mexico
Variety: Carta Blanca, area: 8 ha.
Sowing: August 2010, Harvest: January 2011.

Farmer's practice

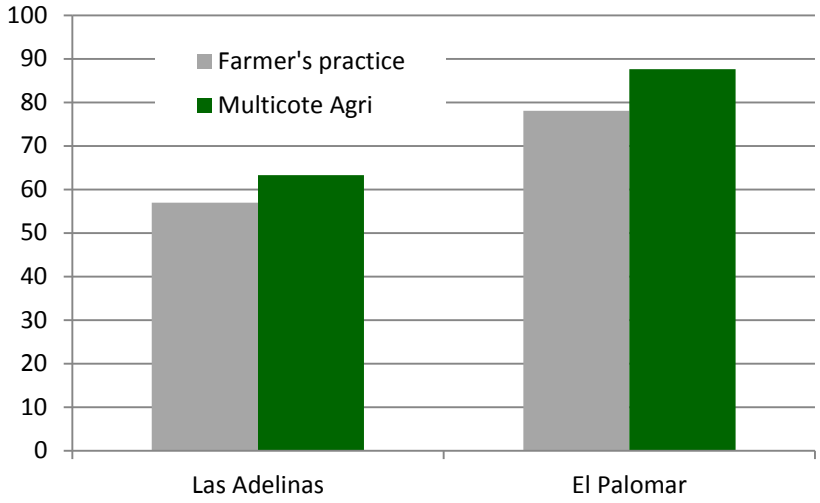
| Fertilizer | Rate (kg/ha) | Total nutrients applied (kg/ha) | | | | |
|---|---|---|---|---|---|---|
| | | N | $P_2O_5$ | $K_2O$ | CaO | MgO |
| Base 13-18-20 | 500 | 67 | 92 | 100 | | |
| Fertigation | | 233 | 28 | 250 | 60 | 15 |
| Total | | 300 | 120 | 350 | 60 | 15 |

Haifa treatment

| Fertilizer | Rate (kg/ha) | Total nutrients applied (kg/ha) | | | | |
|---|---|---|---|---|---|---|
| | | N | $P_2O_5$ | $K_2O$ | CaO | MgO |
| Base: Multicote™ Agri (4) 21-17-17 | 553 | 117 | 92 | 94 | | |
| Fertigation | | 94 | 40 | 153 | 72 | 36 |
| Total | | 211 | 132 | 248 | 72 | 36 |

**Yield results (MT/ha)**

| Treatment | Total yield | Bulb size | | | | |
|---|---|---|---|---|---|---|
| | | rejected | small | medium | large | XL |
| Farmer's practice | 78.11 | 11.26 | 2.73 | 17.40 | 33.09 | 13.64 |
| Multicote™ Agri | 87.61 | 8.60 | 4.30 | 23.86 | 39.50 | 11.34 |




**Conclusions**

The trial results proved that a single application of Multicote™ Agri gives a high yield and is cost-effective, compared with the farmer's practice. All Multicote™ Agri formulas in these trials have economic benefits over the farmer's practice.

## 4. Spring Onion trial in Australia

Grower's practice

| Fertilizer | No of applications | Kg/ha | | | | Cost of application |
|---|---|---|---|---|---|---|
| | | Total | N | $P_2O_5$ | $K_2O$ | |
| Granular 12-11.4-18 | 1 base | 800 | 96 | 91.2 | 144 | 11.7 |
| Granular 20-0-19 | 2 top | 800 | 160 | 0 | 152 | 23.4 |
| SOP | 1 top | 800 | 0 | 0 | 416 | |
| Total | 4 | 2400 | 256 | 91.2 | 712 | |

Haifa treatment

| Fertilizer | No of applications | Kg/ha | | | |
|---|---|---|---|---|---|
| | | Total | N | $P_2O_5$ | $K_2O$ |
| Multicote™ Agri (4) 13.5-4.5-36.5 | 1 base | 1140 | 153.9 | 51.3 | 416.1 |

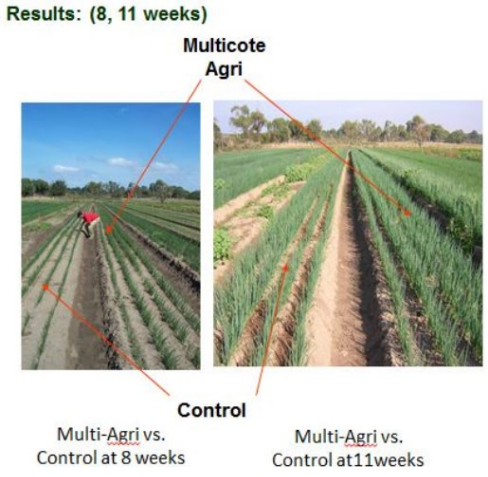
**Yields and profitability (after 14 weeks)**

| | Grower's practice | Multicote™ Agri | Difference |
|---|---|---|---|
| Yield(covers/plot) | 140 | 162 | 22 |
| Covers /ha | 17,724 | 20,509 | 2,785 |
| Profitability US$/ plot | 595.1 | 688.7 | 93.6 |
| US$/ha | 75,345 | 87,195 | 11,850 |

Cover = 10 bunches

Plots = 79 X1 m, 4 rows per plot

126.6 plots /ha. Cover estimated price: 4.251 us$





**Conclusions**: Multicote™ Agri treatment resulted in

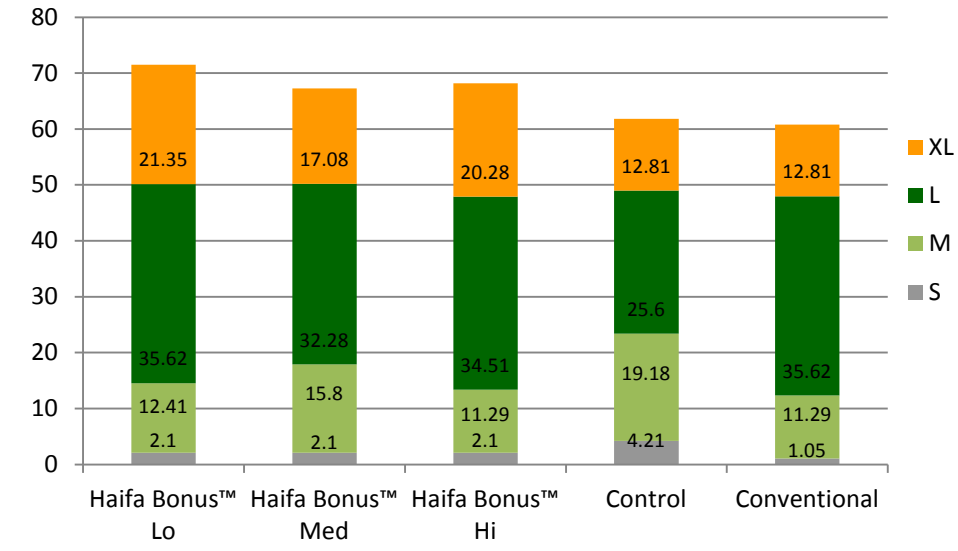
- Higher uniformity - plants with the same color
- Greater weight per bunch, higher total returns
- Labor saving
- Less harm caused by machinery

**5. Foliar nutrition trial, Mexico**

Location: Pénjamo, Guanajuato
Variety: Cal-214, area : 1.5 ha.
Sowing: 14/10/2009.

| # | Treatment | Spray concentration | No. of applications | Time interval between applications |
|---|---|---|---|---|
| 1 | Haifa Bonus™ Lo | 2% | 2 | 15 days |
| 2 | Haifa Bonus™ Med | 4% | 2 | 15 days |
| 3 | Haifa Bonus™ Hi | 6% | 1 | |
| 4 | Control | 0 | 0 | |
| 5 | Conventional | | | |

**Yield results (MT/ha)**




**6. Foliar nutrition trial, Peru**

Foliar Application of Poly-Feed™ and Haifa Bonus™ npK in red Onion Arequipeña type , Santa Rita zone - Arequipa – Fundo América - 2010:

| Size | Poly-Feed™ 1% | Poly-Feed™ 2% | Haifa Bonus™ 1% | Haifa Bonus™ 2% | Control |
|---|---|---|---|---|---|
| Paneton | 8.0 | 5.9 | 11.0 | 6.2 | 5.01 |
| Primera | 23.8 | 18.25 | 27.0 | 22.5 | 18.24 |
| Segunda | 3.0 | 3.85 | 3.65 | 2.98 | 4.98 |
| Floreada | 22.0 | 19.95 | 15.1 | 15.7 | 13.6 |
| Total | 56.8 | 47.95 | 56.75 | 47.38 | 41.83 |
| **Yield kg/ha** | **63,108** | **53,275** | **63,053** | **52,637** | **46,479** |

Poly-Feed™ 12-6-40+ME
Haifa Bonus™ 13-2-44

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