Agronomic Principles

The aim of any producer is a high yielding, high quality crop that satisfies the end user. There are a large number of agronomic factors which can influence this, many are within the control of the grower, under given growing systems, climatic and soil conditions.

Soil and Water Requirements

Apples trees can grow in a wide range of soils from medium textured clays to gravelly sands. However, poor soils will produce poor results and the best crops are found on fertile sandy soils and loams.

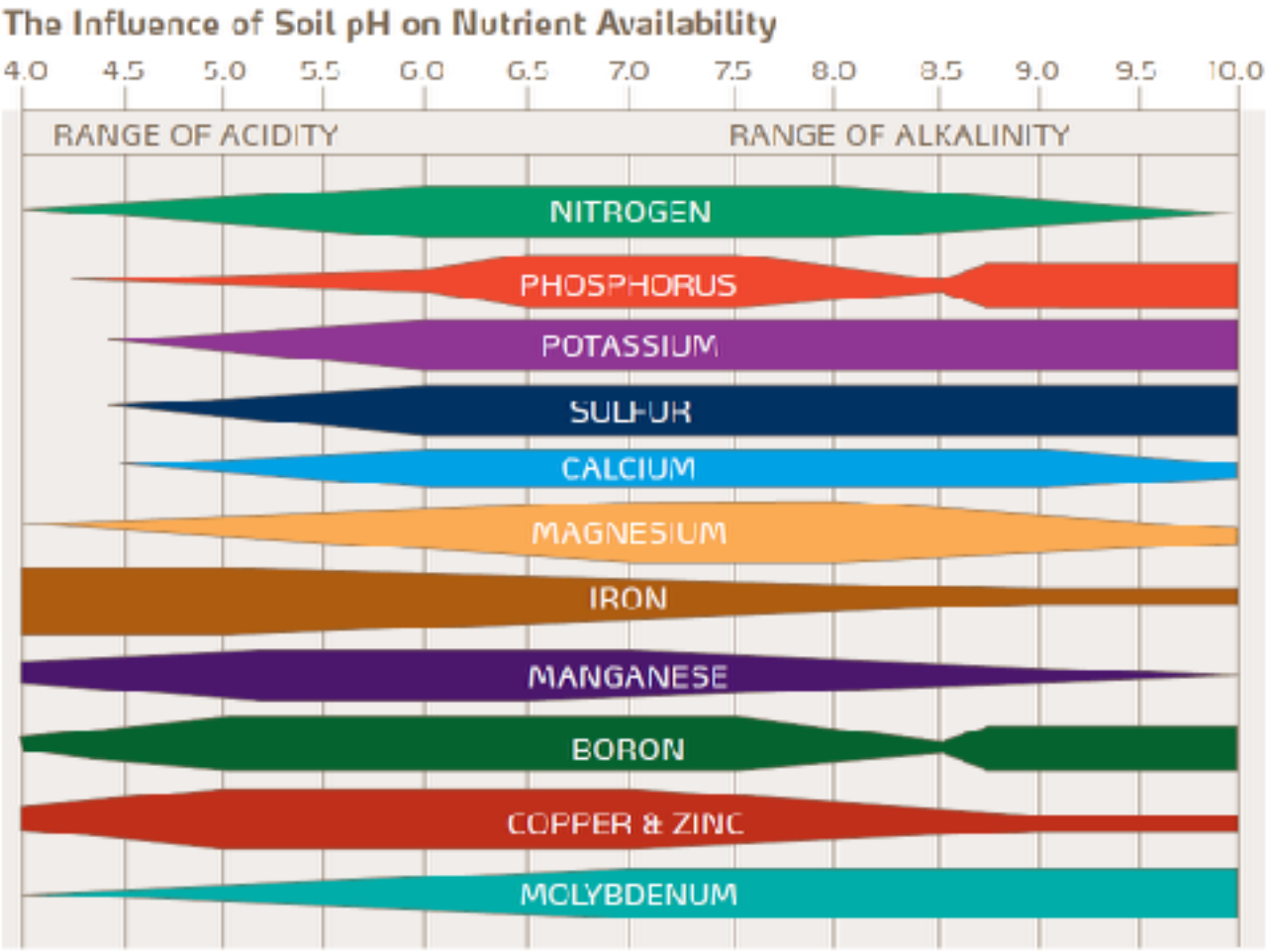
Soils should be well drained. Wet soils lead to poor aeration and increased incidence of crown rot in apples (Phytophthora cactorum). Generally, rooting tends to be shallow, and wet soils will restrict development, resulting in poor anchorage of the tree and a reduced area of soil from which nutrients can be extracted.

Soils with high organic matter contents are normally better structured and allow good rooting.

Irrigation is necessary on dry soils, particularly when establishing and growing young orchards. Trickle irrigation and fertigation are increasingly used. In young orchards fertigation helps increase early tree growth and brings trees into bearing earlier. Sprinkler irrigation can be used to protect the tree buds and fruitlets against frost damage.

Sowing of a grass mulch between the tree rows is common practice, which together with any clippings, helps to increase water holding capacity, infiltration rate, soil aggregation and recycling of nutrients.

Apples prefer a slightly acidic to neutral soil (pH between 5.8 and 7.0). Extreme soil pH values result in nutrient tie-up or toxicity and poor tree and fruit development. It is important to amend the pH in acidic soils by incorporating lime before planting.



Rootstock

Optimum planting density depends upon cultivar, rootstock and likely pruning strategy. Choice of rootstock governs tree size and the efficiency of nutrient uptake.

There are four general categories; vigorous, semi-vigorous, semi-dwarf and dwarf.

Choice of rootstock should suit the soil (pH, structure, humidity) and other local conditions (frost hardiness, pest and disease resistance, etc).

For apples, the dominant rootstocks used are the Malling types (M. and MM. series).

Orchard Systems

A wide range of planting systems are used for apples. All aim to produce high, early yielding, top quality crops. Ease of harvesting and management are also key factors taken into account.

Modern systems use higher densities than older established orchards. Today, normal densities range from 400-2,500 trees/ac,

whereas 50 years ago, 28-41 tress/ac would have been more commonplace. In higher yielding, fertile soils and sites, growers can plant up to 4,000 trees/ac and expect 26t/ac yields.

This increased density has been made possible following the introduction of dwarf rootstocks which produce higher yields in the first 10 years of production than were previously possible.

Tree canopies are manipulated to produce four basic shapes of tree – spherical canopies, conical canopies, flat fan shapes, or Y, A or V shapes.

Spherical shapes were most commonly used in traditional European and North American orchards and largely allow the natural shape of the tree to develop.

Conical shapes are now more common. They allow good light penetration by limiting the width of the top of the tree. They require minimal branch and leader manipulation.

Flat fan systems are increasingly common in high density orchards to bring forward bearing, increase yield and make harvesting easier.

V-shaped, or angled canopies on the Tatura or other types of trellis, again allow good light penetration by most effective alignment of the tree. They produce very high yields at maturity and allow the producer to more effectively crop alleyways.

Low density system

High density system

"Y" Shape

"A" Frame

Tree Manipulation

Newly planted trees invariably need to be pruned. The exact pruning depends on the desired shape of the tree.

During full production, all trees need pruning and thinning of fruits to ensure an optimum leaf to flower/fruit ratio and to allow for air circulation through the tree and light penetration to improve fruit quality and size.

Pruning also helps to ensure that water and nutrients are available to an optimum number of well-positioned fruits.

Major pruning is normally carried out while the trees are still dormant in late winter. Pruning in summer is done to remove weak-bearing water sprouts and to allow light into thick canopies.

Pruning in late summer is not recommended as it can delay dormancy and predispose trees to more winter injury.

As a general rule it is better to prune little and often rather than to severely cut back the tree in one pruning session. Such severe pruning generates vigorous vegetative growth acting as a strong sink for nutrients and water, and thereby affecting fruit quality and bud differentiation.

It is desirable in many years to reduce the crop load that results from a heavy bloom and a good “fruit set”. Allowing too many fruits

to remain on the tree will reduce fruit size and tree vigor and can cause the tree to bear biennially (every other year).
Five to six flowers bloom on each bud of an apple tree. If all of these were allowed to mature, fruit size would be very small and the tree would become under-nourished and not flower the next year. The crop is thus thinned, leaving about one fruit for each 3 to 5 buds.

Fruit thinning encourages larger, even sized fruit.

Heavy fruit loads encourage biennial bearing.

Crop Protection

Top quality fruit production requires good disease, pest and weed control.

Many disease-causing pathogens (fungi, bacteria, viruses, and nematodes) attack apple trees.

Diseases may damage the fruit directly, making it unattractive or inedible, but they can also weaken the tree by injuring or invading the leaves, trunk and branches.

Damage to the tree reduces productivity and increases susceptibility to winter injury or attack by additional pests.

Over 50 types of insects attack apple trees, foliage, or fruit. The most serious are those insect pests that directly damage the fruit. These include apple maggot (railroad worm), various types of caterpillars such as leafrollers, fruitworms, and codling moth, plum curculio, and rosy apple aphid.

Insects and mites, e.g. aphids, caterpillars, scale insects, spider mites, and leafminers feed on foliage or branches, weakening trees and restricting growth, and bloom and fruit set.

Grass or other vegetation, which competes for nutrients and moisture, should not be allowed to grow within at least 15-20in of the trunk of the tree.

Where there is a risk of hail, netting is used to protect the developing fruit.

Codling moth damage

Netting protects fruit from hail damage

Harvesting

Fruit should be harvested before it is fully ripe, but after it has had time to mature. This varies according to cultivar and different fruit varieties will often ripen at different times over a three-month period. As the fruit mature, the starch changes to sugar and the aroma and flavor develops. Sugars are the major soluble solid in fruit juice and therefore soluble solids are often used as an estimate of sugar content (referred to as °Brix).

Immature fruit has a starchy taste, an undeveloped aroma and is very hard and crisp when cut. Mature fruits are firm but not hard. Since there are variations in a wide number of quality parameters each year, considerable practical experience is needed when determining best harvest date.

Storage

Storage conditions are vital to long-term quality and shelf life. Fruit needs to be harvested with minimal bruising, cooled quickly and kept in controlled atmosphere conditions, so as to avoid any further physiological changes to the fruit.

High relative humidities (90-95%) should be maintained in order to minimize moisture loss from fruit. Controlled atmosphere conditions

with lower oxygen and higher carbon dioxide levels decrease metabolism and fruit breakdown.
Practices that leave the picked fruit in high temperatures for long periods will result in a rapid deterioration in quality.
Apples that are earlier maturing (summer and autumn apples), produce higher levels of ethylene in storage and are more prone to breakdown than later maturing cultivars (winter apples). They thus have reduced storage potential.

Crop Nutrition Program

Role of Nutrients in Apple Production

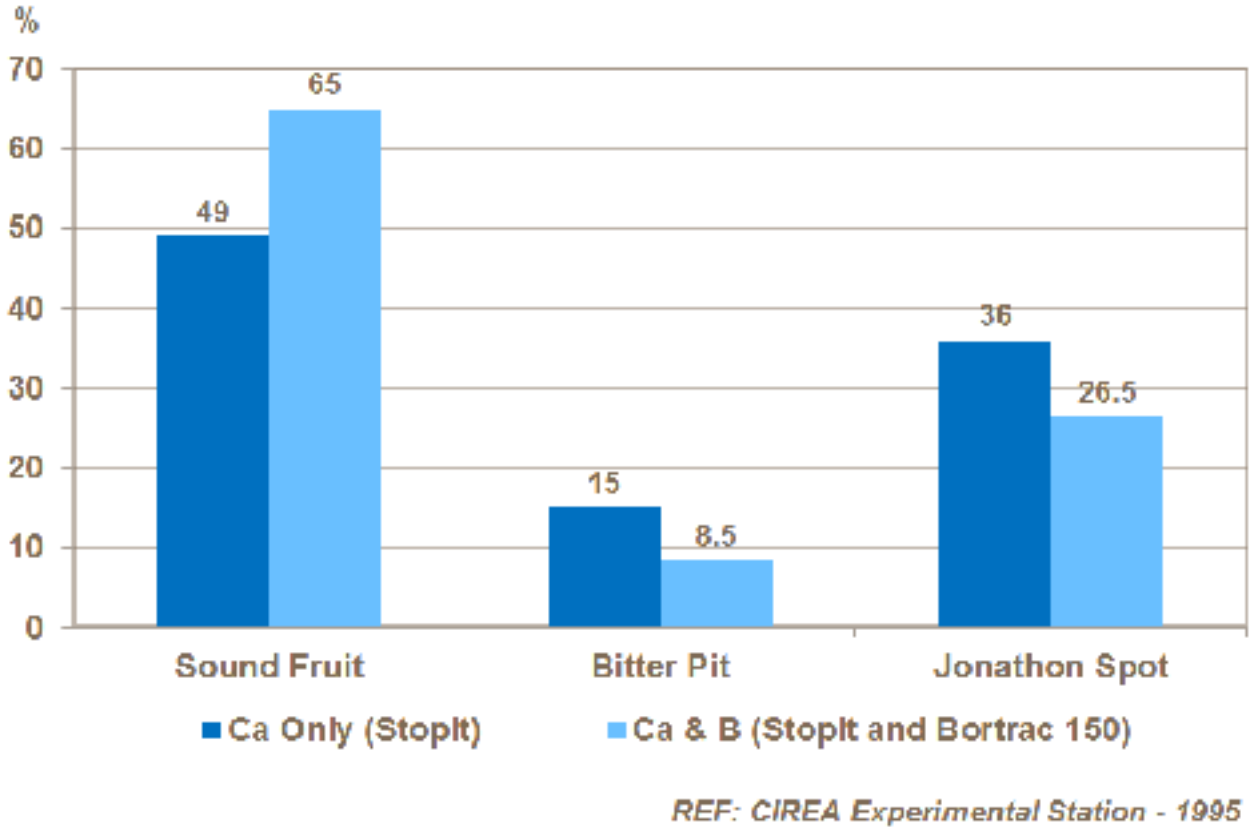
Table1: suitable plant needs products for apple cultivation

Apple cultivation	Product	Dose	benefits
new planting	PLANC and or Bio Fume	500kg/ha	control Nematodes and many other soil pest and disease , adds plant nutrients
Plants with stablished orchard	PLANC - spread and Incorporate in to the soil profile. ALOE neem- Fertigate @rate of 5 litre /ha ,2 times with in the interval of 3 weeks well before flowering . PLANO- Fertigate @ the rate of 3 litre /ha ,total 15 litres 5 times during bud initiation flowering and fruit formation , starting ist week of November in Victoria Australia ,till 2nd week of January .	5 litre/ha = total 10litre 3litre/ha =total 15litre .	Helps in fertilising the soil and improves plant health as Aloe-vera with neem will help the plants to regenerate by unlocking available nutrients during the peak growing season. Plano will help in controlling pest and disease and also it will take part in overall improving plant health by creating oxidation surrounding root zone .
Apple crop	SPRAY NEED'- is the best and safe emulsifier /surfactant or wetting agent . from Plant needs . Use 500ml -700ml of Spray Need in each 1000 litre water .	100 ml in each litre of herbicides, insecticides or fungicides , will increase the dilution and effective spray coverage,	Easy dilution , broader coverage and good penetration of all products in to the crops .

Role of Boron in Apple Production;

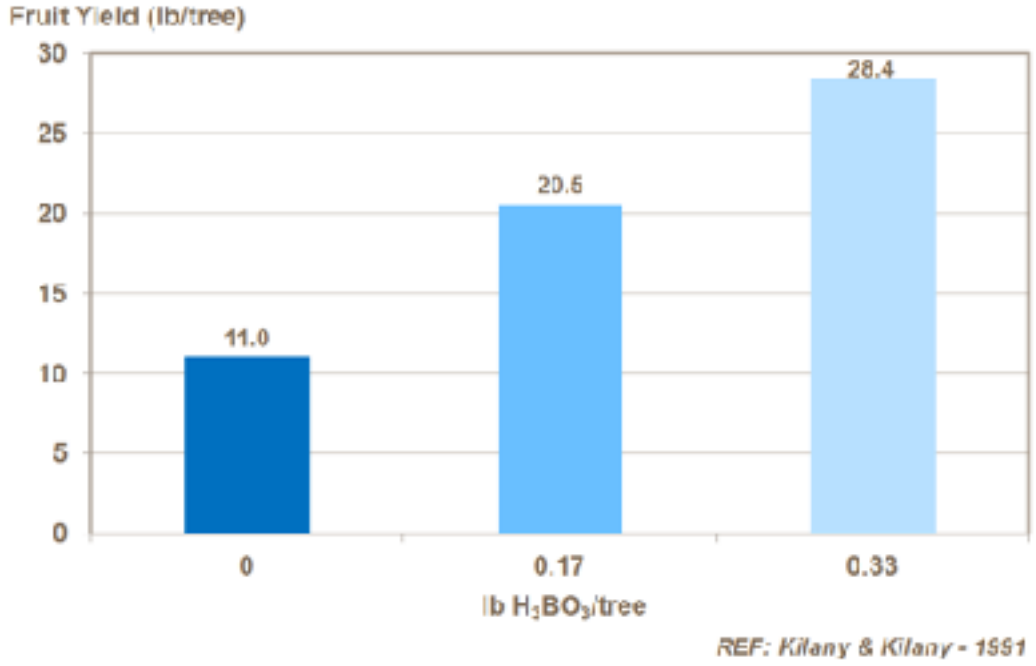
Boron is involved in cell wall formation, stabilization and lignification, and xylem differentiation. It is needed to ensure normal development of new tissues from roots to flowers and fruit. Boron is responsible for pollen germination and pollen tube formation and activation. Thus, poor boron supply results in poor flower and fruit formation. In severe cases it causes ‘blossom blast’ where flowers dry out and are shrivelled at bloom.

Boron and calcium efficiency



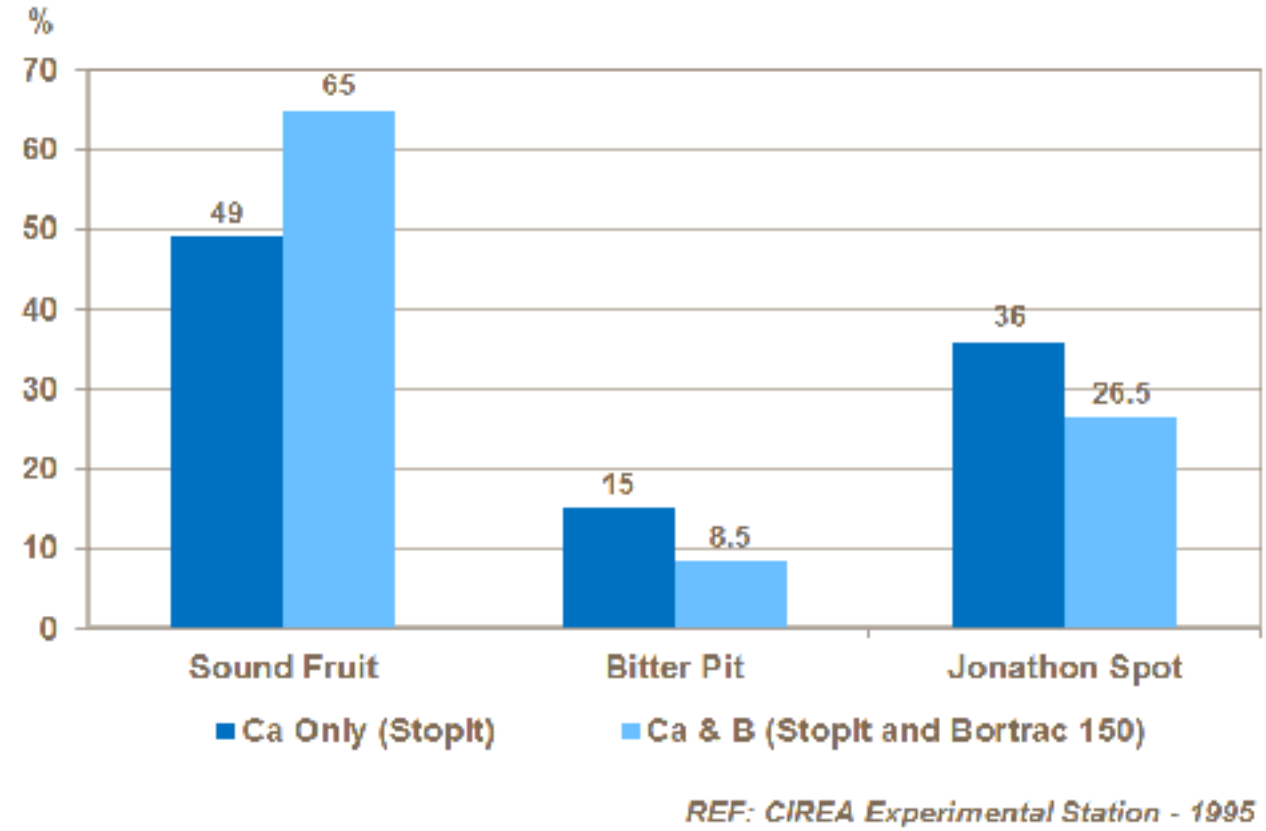
Boron and calcium efficiency
Spray programs support calcium uptake, minimising bitter pit and Jonathon spot in apples, as shown in studies in France.

Boron and yield



Boron and yield;
Soil applications should be used to meet tree needs, thereby maintaining yield. See figure above (trials in Egypt).

Boron and calcium efficiency;



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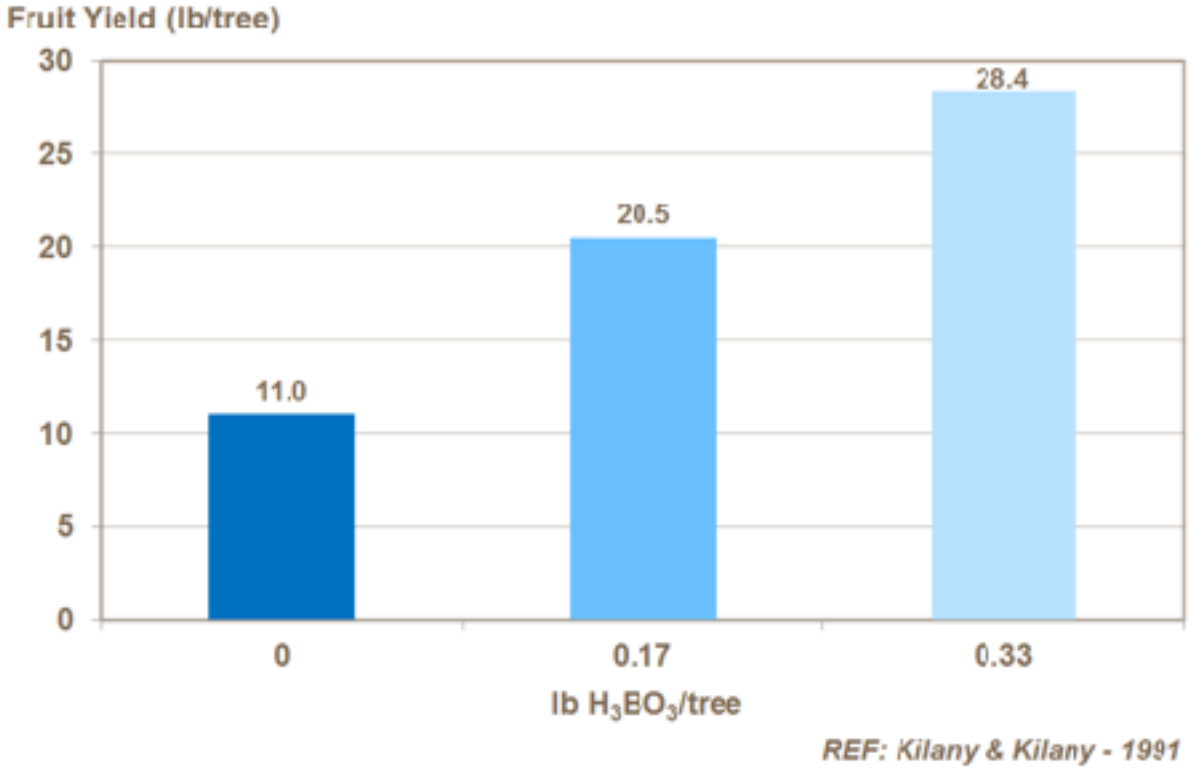

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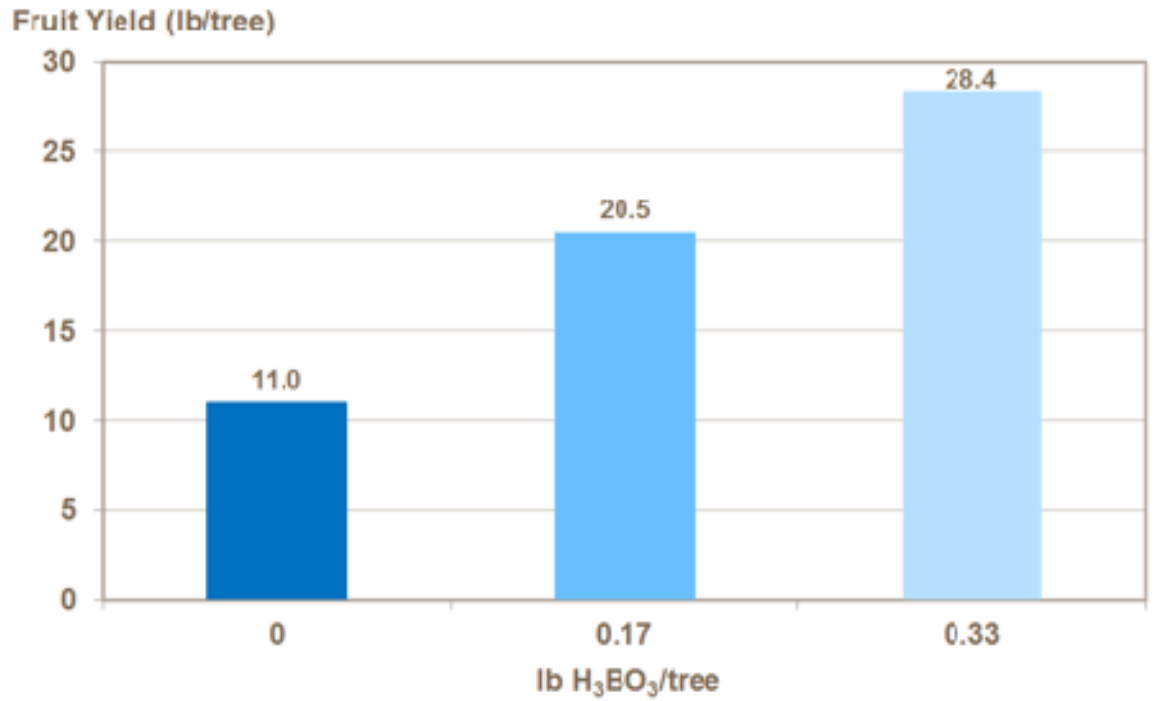
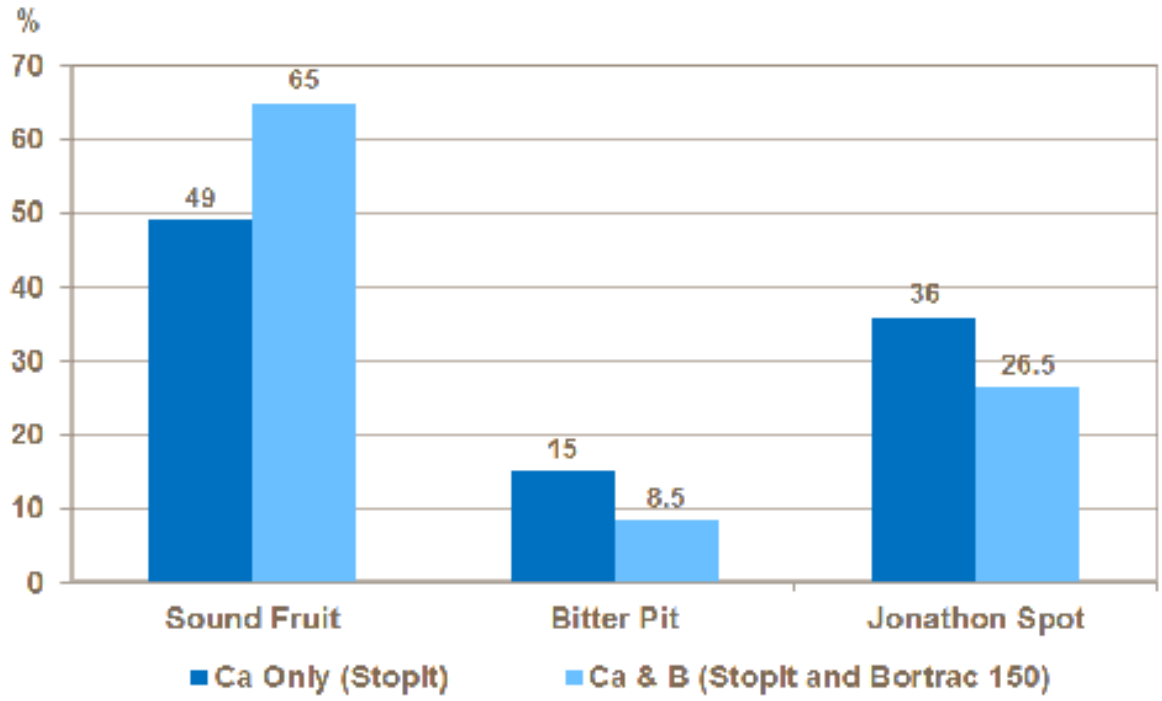


REF: Kilany & Kilany - 1991



REF: CIREA Experimental Station - 1995

Boron effect at growth stages

Stage

Boron effect

Bud Burst - Start of Flowering

Maximise pollination and strong flower development

Fruit Set to Fruitlet at 30mm
Improve fruit set
Post Harvest
Replenish reserves and strengthen new buds

General guidelines for Boron application;

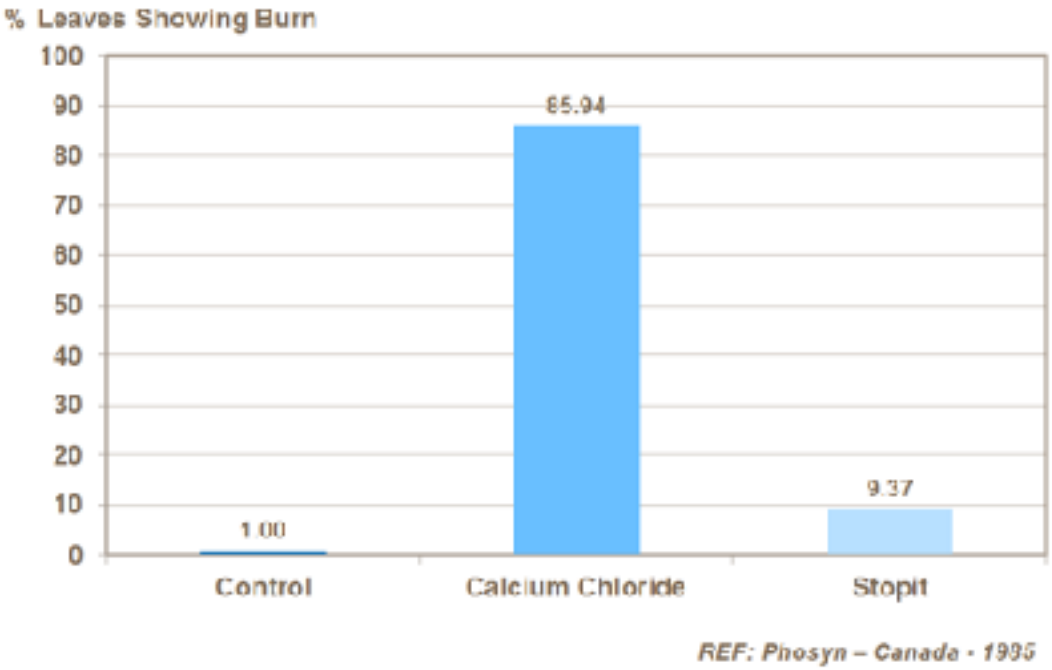
Of the micronutrients, boron is needed in greatest amounts both in the fruit and leaf, but there is a relatively narrow margin between deficiency and toxicity.
Where soil analysis identifies a need, soil applications should be used to meet tree needs. But, because boron is not readily translocated within the tree, it is most critically used as foliar applications targeted at key periods of flower and fruit formation so as to maintain flower set and fruit quality.

Boron deficiencies in apples;

Symptoms are frequently found in the fruit with little sign of deficiency in the leaves unless the deficiency is severe.
The most common symptom in apples is small, clear, water-soaked areas in the flesh of the fruit. These may dry out, turn brown and leave spongy lesions in the fruit.
In some cases, deep cracks in the skin may occur. The skin is rough and heavily russeted.
When boron deficiency occurs in combination with a lack of calcium, the fruit is of poor storage quality and bitter pit is more common.
In severe cases, dead areas appear on the bark of young branches (apple measles).
Boron toxicity results in chlorosis of leaf margins and tips, followed by necrosis. In fruit, high levels lead to a reduction in storage quality – fruit softening.

Role of Calcium in Apple Production;

Calcium activates enzymes and is essential for cell division, elongation, and fruit growth. It stabilizes and ensures permeability of the cell wall, protecting it from degradation by enzymes.
As a result, fruits with high levels of calcium are firmer and the skin and flesh is less liable to breakdown disorders with reduced leakage through cell wall membranes. Thus, good calcium supply delays ripening and increases storability of fruits.



Foilar calcium source;

The type of calcium spray is important. Calcium chloride can result in leaf scorch, reducing tree health and productivity, as can be seen in Canadian trials.

Calcium and yield

Soil application of calcium nitrate in the spring shows better results increases crop yield than ammonium nitrate, as you can see the figure above (US trials with Golden Delicious apples).

Soil applied calcium and bitter pit

Soil applied calcium and bitter pit
Lack of calcium nutrition increases the incidence of bitter pit and internal breakdown. Soil supply is important to keep fruit from these disorders.

Studies with Golden Delicious apples in US show that calcium nitrate can reduce the incidence of bitter pit.

Calcium sprays and bitter pit

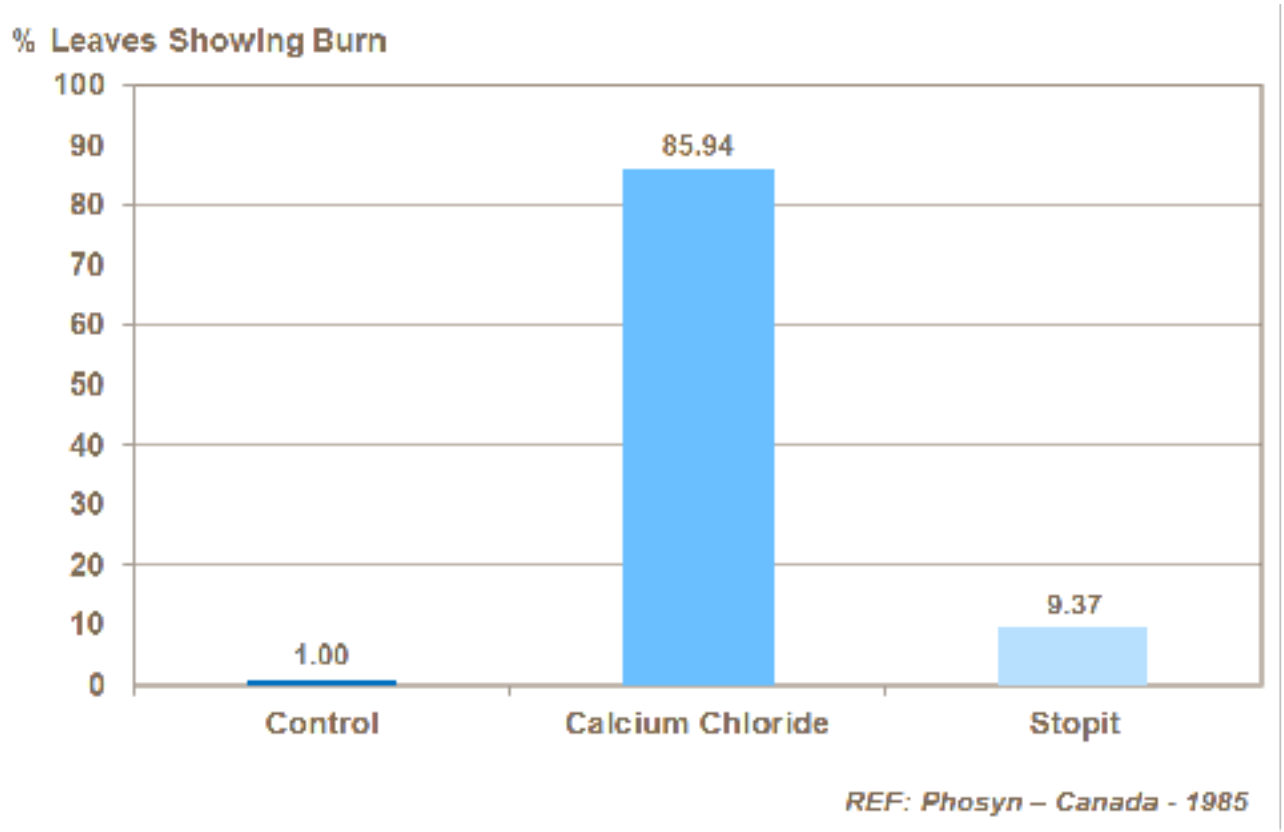
Soil supply of calcium should be backed by fruit applied sprays targeted to get more of the nutrient into the fruit. The greater the number of sprays the better the fruit quality and it is important to continue spraying right though to harvest, as shown in trials in Poland.

Calcium and fruit firmness;

Soil applied calcium nitrate is effective in improving fruit firmness. When using foliar applications, the more sprays the better, provided that products such as calcium nitrate don’t deliver too much nitrogen, which can create nutrient imbalances and loss in quality. See figure above (studies in Spain).

Calcium and sun scald

Calcium also has an effect on sun-scald damage, as studies in North America show. By improving calcium content in the skin and pulp, cells are less liable to damage and subsequent breakdown.



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Calcium effect at growth stages

Stage
Calcium effect
Bud Burst – Start of Flowering
Boost root and leaf growth and high yields
Fruit Set to Fruitlet at 30mm
Maintain good fruit quality and minimise fruit disorders
Fruit Fill – Maturity
Maintain good fruit firmness and storage quality
Post Harvest
Maintain high levels in the tree

General guidelines for Calcium application

Calcium is taken up by root tips and transported to the leaves and developing fruitlets through the transpiration stream, via the xylem. At this stage, uptake is quite rapid and soil supplies are important. By the time fruit reaches the fruitlet stage, over 50% of the final total amount of calcium will already be in the fruit. Thus it is critical that soil applied calcium has been applied before this stage.
However, at later stages, as the fruit rapidly expands, most Ca is transported to the leaves where it cannot be redistributed and so amounts in the fruit become diluted. At this stage, fruit sprays should be used to supplement calcium levels.

Calcium deficiencies in apples;

Calcium is immobile in the phloem and can't be remobilised from older tree tissues, so youngest leaves are the first to show symptoms, becoming chlorotic. New growth becomes stunted and fruit yield may be reduced.
Crop quality also deteriorates with reduced firmness and increased incidence of physiological disorders such as cork spot, sun-scald and bitter pit.

Role of Copper in Apple Production;

Copper is required for chlorophyll synthesis and is a constituent of enzymes responsible for the reduction of molecular oxygen.

General guidelines for Copper application;

Deficiency is rare in apples as soil supplies are normally sufficient. However, if seen, foliar applications quickly correct the supply problem.
Generally, the best approach is to spray up to 1/4 green leaf, or after harvest. Copper sprays can russet apples if applied post-bloom, or cause injury if applied under freezing conditions.

Copper deficiencies in apples

Terminal leaves develop brown necrotic areas, curl upwards and become distorted. This disorder is known as ‘wither tip’ or ‘summer die-back.’

Severe deficiency results in cracking of the bark and profuse sucker development from the tree base.

Role of Iron in Apple Production;

Iron is required as a precursor to chlorophyll formation and in a number of important plant enzymes. Poor supply restricts photosynthesis and, as a result, reduces leaf growth and resultant fruit yield and quality.

General guidelines for Iron application;

Deficiencies are rare and because soil or tissue analysis is relatively unreliable, common practice is to base treatment on historical knowledge of the site or when symptoms are seen.

Soil applications with chelates are used early season in calcareous soils, or alternatively in season foliar programs targeting the growing shoots are used to meet iron needs. Care has to be taken with foliar applications to minimise phytotoxicity risks.

Iron deficiencies in apples;

Deficiency leads to characteristic chlorotic yellowing, and sometimes bleaching, of new leaf growth. In severe cases, leaves become scorched in summer months.

Problems are more common on high pH calcareous soils and often due to transient adverse weather, temporary water logging, or high copper levels in the soil.

Role of Magnesium in Apple Production;

Magnesium is a key constituent of the chlorophyll molecule; usually 15-20% of the tree’s Mg total is found in the chloroplast. It is also

involved in various biochemical functions including activating enzymes involving phosphorylation, and protein synthesis.

General guidelines for Magnesium application;

Regular soil application of magnesium ensures good leaf uptake and productive growth. This ensure a marked reduction on fruit drop. The optimum range of magnesium in apples is around 5mg/100g at harvest or 15mg/100g in a 30g fruitlet. Where deficiencies are seen, foliar applications are needed to check any growth effect or fruit loss. Soil applications also ensure regular long-term supplies are available within the tree.

Magnesium deficiencies in apples;

Inter-veinal chlorosis and bright yellowing develops first on older leaf margins and tip and spreads back to the main vein. The leaves often have a characteristic herringbone pattern of chlorosis on new year's growth. Symptoms are normally most obvious later in the season during fruit fill.
In severe instances, leaves curl up, die and drop prematurely, leaving a few tufted leaves at the tip of the branches.

Role of Manganese in Apple Production;

Manganese is involved in a wide range of enzyme processes including hormone synthesis. It also plays a key role in photosynthesis. It is particularly important in maintaining leaf quality and tree health in apples.

General guidelines for Manganese application;

Foliar manganese, applied at least twice in the spring, can improve leaf colour and minimise leaf drop and blotchiness. Sprays in the autumn are less effective because manganese is relatively immobile and won't move from reserves to the leaf.

Manganese deficiencies in apples;

Manganese deficiency is first seen as light green spots on leaf margins and as an inter veinal mottling. Usually the recently matured leaves in early summer growth are the first to show symptoms.
Inter-veinal areas then become yellow, with prominent green veins. When severe, leaves and shoots become stunted although generally there is little change from normal leaf size and shape. Excessive amounts of available manganese uptake – associated with low pH soils and poor drainage – results in necrosis of trunk and branch bark (measles).

Role of Nitrogen in Apple Production

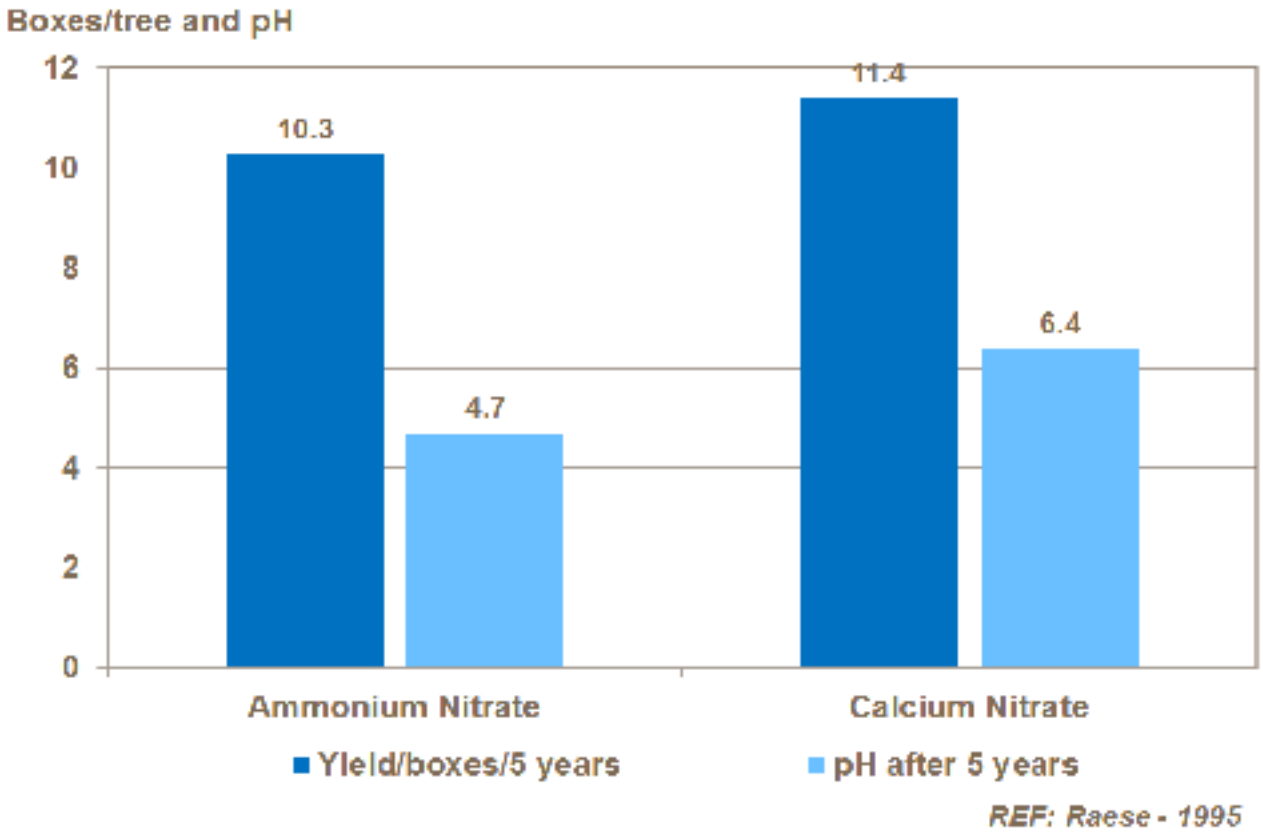
Nitrogen has a major effect on yield and quality. It is a component of the chlorophyll molecule and involved in nucleic acid synthesis and hence important for cell division and the growth of young tissues (e.g. buds, flowers, leaves).
Nitrogen is involved in amino acid synthesis and protein production.

Nitrogen and soluble solids
Trials in North America and Italy show that nitrogen has a positive effect on the soluble solids content of fruit.

Nitrogen and yield;

Researchers have recorded considerable variation in the level of nitrogen in trees. Fertiliser response depends upon the fertility status of the soil, the level of nitrogen in the tree reserves and the orchard system. The figure above shows the effect on yield on orchards of moderate density in US.

Nitrogen form - yield and soil pH



Nitrogen form - yield and soil pH
Nitrogen form is critical to supply. Calcium nitrate forms are readily available and can produce higher yields, as shown in trials with Delicious apples in USA. Compared to ammonium nitrate, this form of fertiliser also has an effect on maintaining soil pH, improving tree growth and ensuring other nutrients are more available.

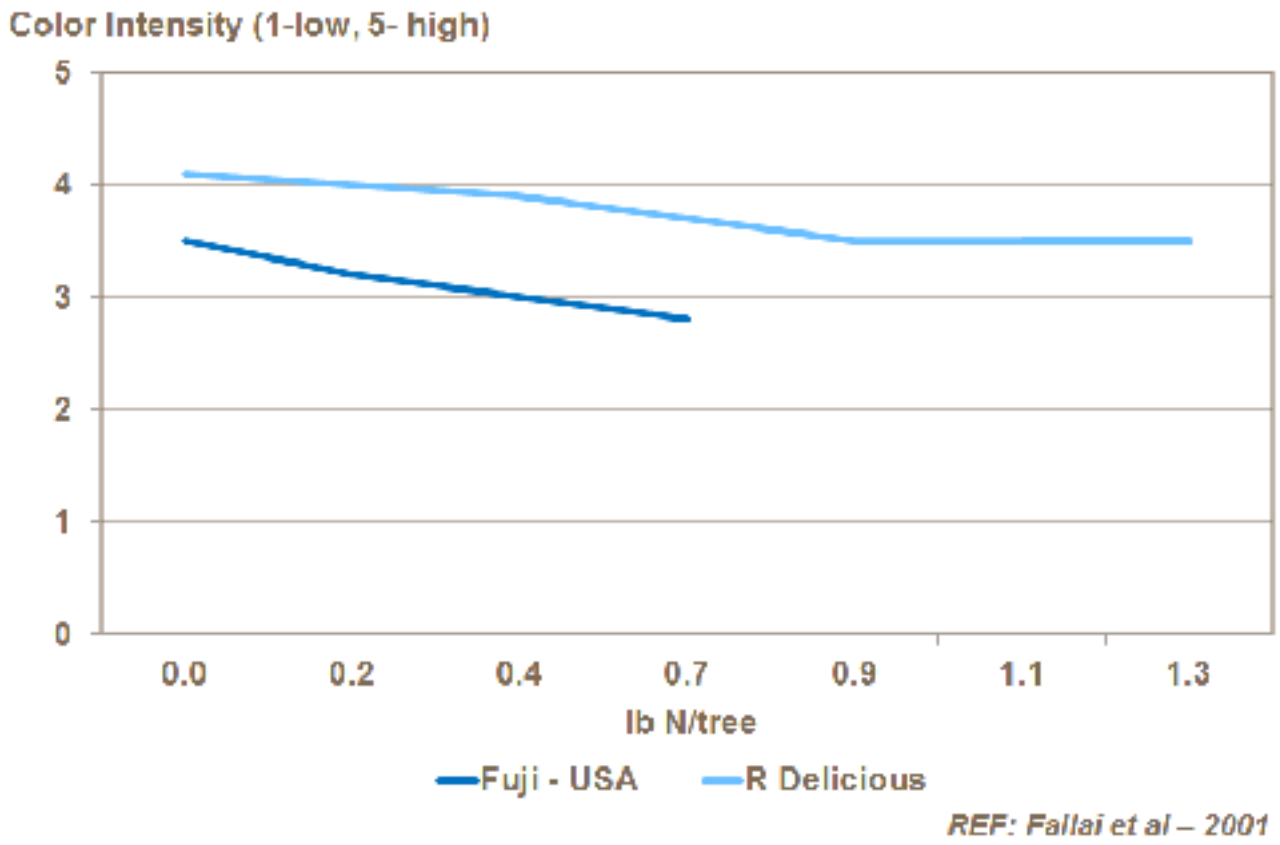
Nitrogen form and calcium uptake;

Studies with York Imperial apples in US show that nitrogen form also affects calcium uptake, with calcium nitrate forms encouraging better uptake of calcium than ammonium nitrate. Without enough calcium, fruit quality deteriorates.

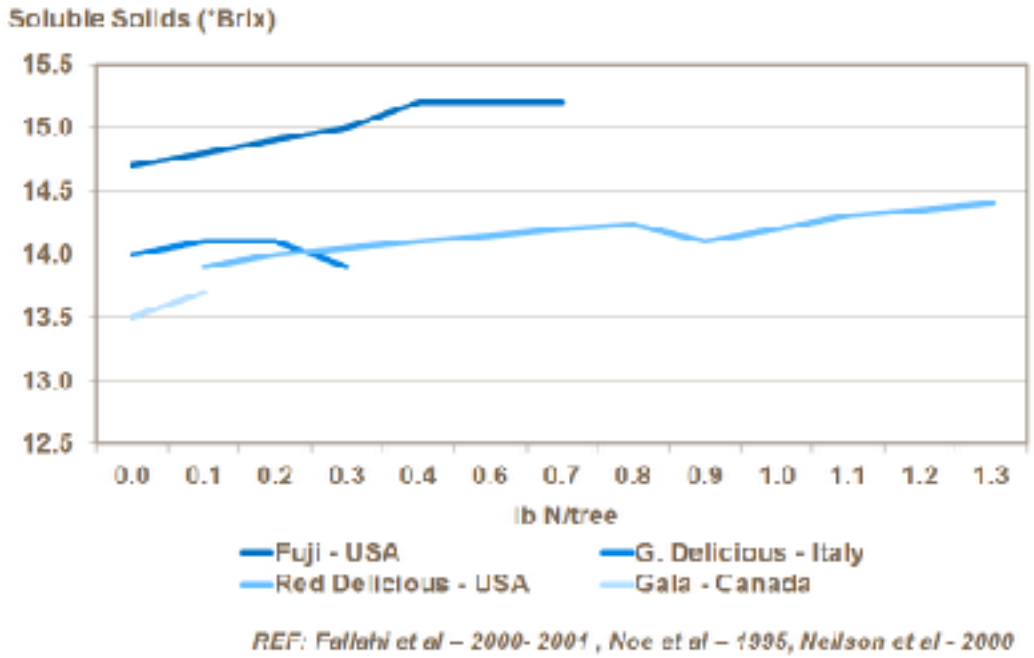
Nitrogen and fruit firmness

Over-use of nitrogen reduces apple firmness, potentially resulting in more damage in transit and storage, and a reduced shelf life, as studies in North America show.

Nitrogen and red apple colour



Over-use of nitrogen can also reduce the red coloration of red apples, as study in US shows. However, this can be advantageous in green apples improving greenness and minimising red colours.



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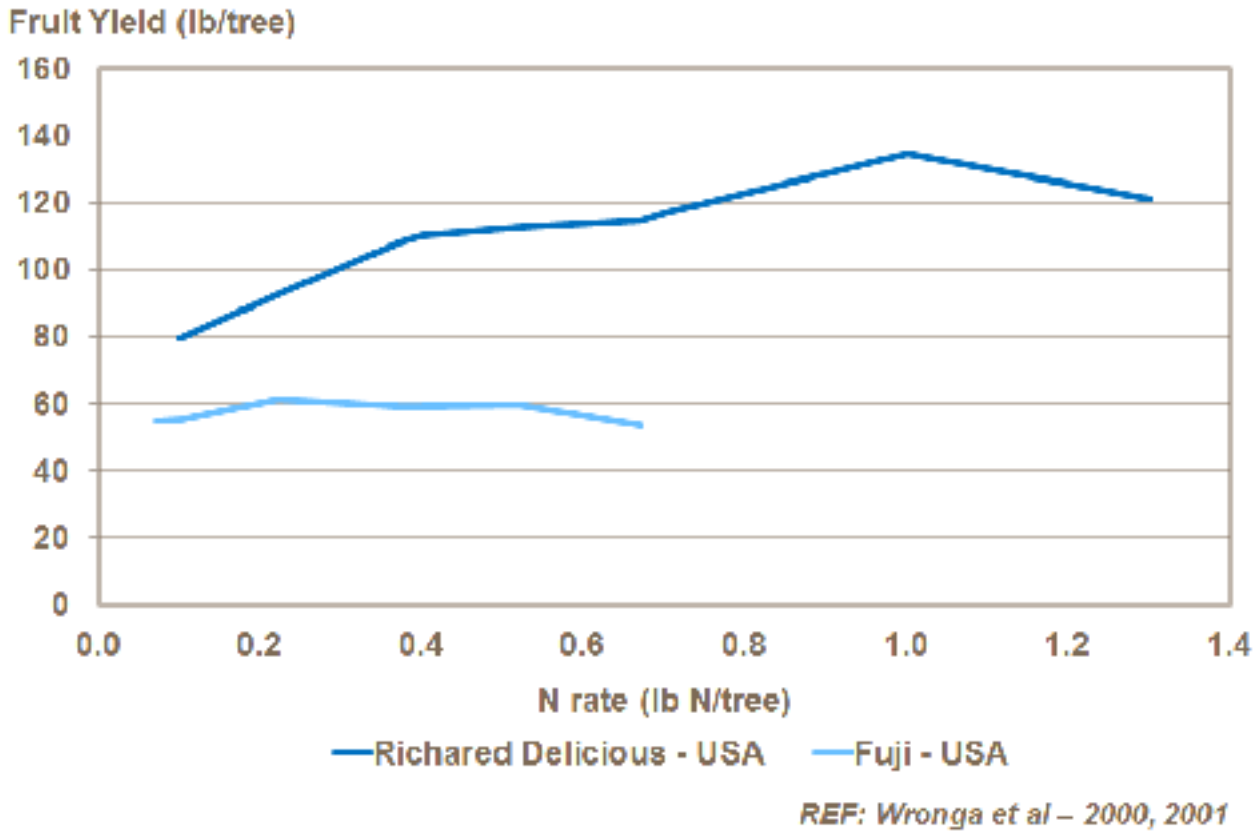

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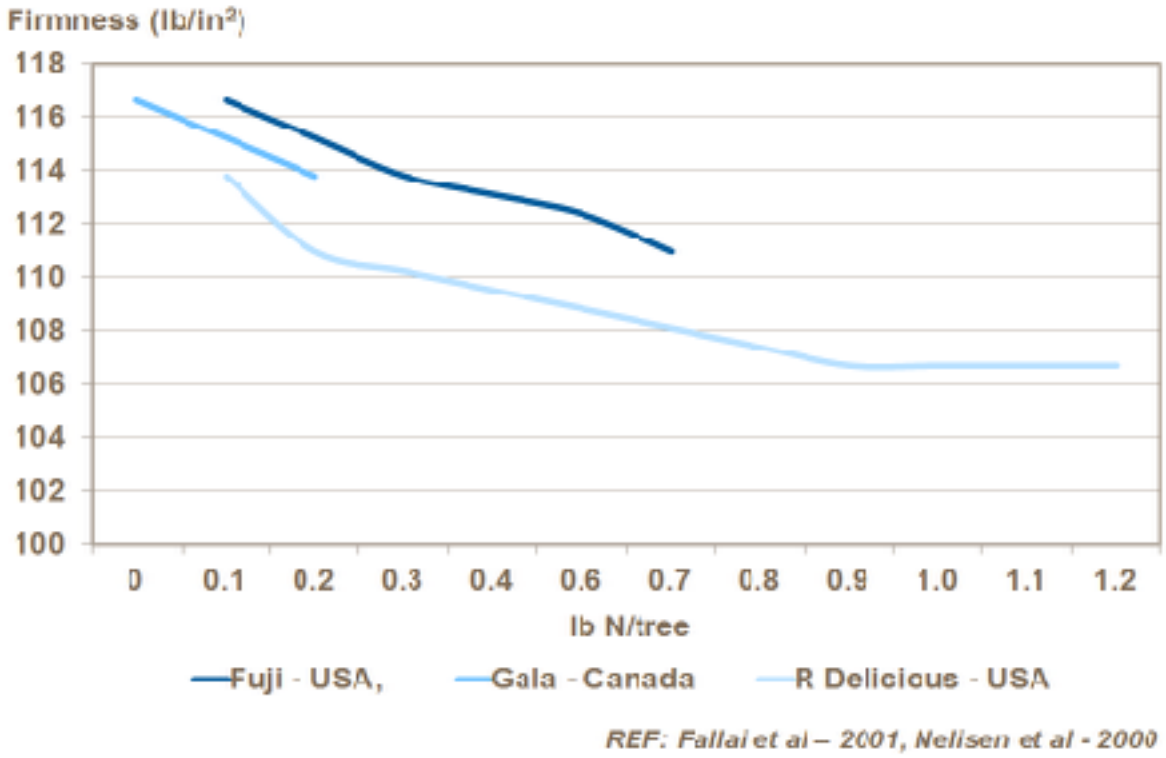
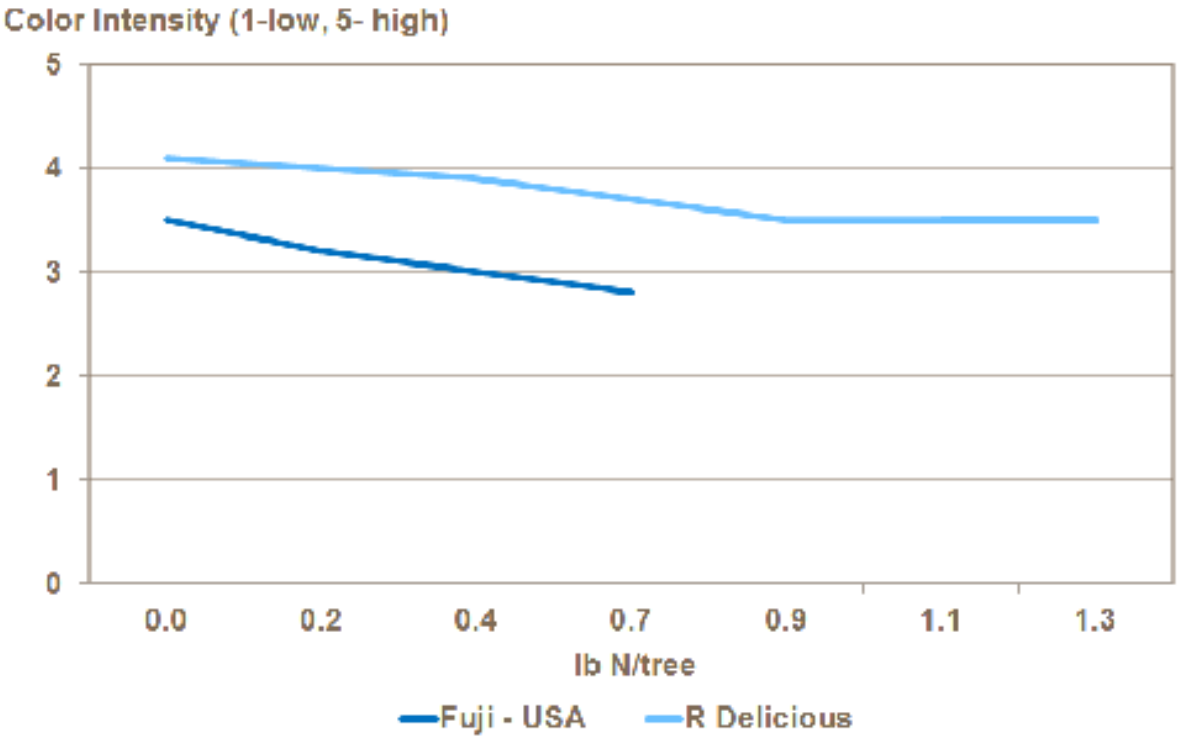


REF: Fallai et al – 2001, Nelisen et al - 2000



REF: Fallai et al – 2001

Nitrogen effect at growth stages;

Bud Burst – Start of Flowering
Promote strong early growth of new plant tissues and maximum tree productivity

Fruit Set to Fruitlet at 30mm
In reduced amounts to maintain fruit fill
Fruit Fill – Maturity
In reduced amounts to maintain fruit fill and high sugars – excess can lead to rots and quality deterioration
Post Harvest
Boost reserves for next season's early growth

General guidelines for Nitrogen application:

Optimum N-response varies according to a host of site and production factors. Rates and practices are best adjusted according to local trials. Generally, fertiliser response depends upon the fertility status of the soil, the level of nitrogen in the tree reserves and the orchard system.
Over-use of nitrogen results in excess, luxuriant leaf growth at the expense of fruit development. Trees subjected to excess nitrogen applications can be more susceptible to disease attack (e.g. fire blight), and at risk of premature fruit fall. Fruit size is reduced and quality can deteriorate.

Nitrogen deficiencies in apples;

Deficient leaves are small, narrow and pale green. The older leaves turn a yellowish orange to purplish colour and drop prematurely. New growth is stunted.
Because few buds are formed, blossom is sparse and so fruit set is restricted. As a consequence, yield is reduced. Fruit may colour prematurely.

Role of Phosphorus in Apple Production;

Phosphorus is involved in energy transfer, the maintenance of cell membranes and as a bridging element for genetic information. It has a direct effect on yield and tree health, but it is also important in determining fruit size, firmness, colour and storage potential.

General guidelines for Phosphorus application;

High phosphorus demand occurs during periods of root, shoot and flower emergence and growth, so it is important that supplies are not limiting at this time, or growth will slow.
While phosphorus is sometimes perceived as unimportant in soils with high natural phosphate levels, it is often locked-up in the soil and unavailable. Thus, fertiliser supplies – including foliar applications - are important and produce yield and fruit quality improvements.
Because phosphorus is critical for rooting, common practice is to use phosphate around the roots when planting new orchards. Foliar applications complement soil reserves and ensure immediate tree growth or fruit quality needs are met.
Foliar phosphate is also used after flowering and again at early ripening where there is a need to improve fruit colour.

Phosphorus deficiencies in apples;

Visual leaf symptoms are rarely observed. In the autumn, leaves may turn dark green with bronze-like or purple tints. Generally, foliage is small and sparse.
More common is reduced meristematic activity, including retarded bud burst and reduced flowering, leaf size and shoot growth. Fruit is smaller sized, often has a hard flesh and is low in sugars and lacking in taste.
Apples low in phosphorus will not store well, breaking down under low storage temperatures.

Role of Potassium in Apple Production;

Potassium promotes strong, vigorous tree growth, boosts fruit size and cell strength. It also encourages good tolerance to pests and diseases.

General guidelines for Potassium application;

Apples remove over double the level of potassium than nitrogen. Insufficient K-levels cause nutrient imbalance problems. Optimum levels are between 100 and 120mg/100g of fruit fresh weight. Over-use of potassium, can, however, adversely affect fruit quality. This is largely as a result of competing with, and restricting, calcium uptake.

Potassium deficiencies in apples;

Severe deficiency results in marginal leaf browning on older leaves. Symptoms normally occur later on in the season as the fruit draws upon potassium from the leaf and fruit bearing spurs. The leaves will stay on the tree, even though they are dead.
Spur leaves can develop an irregular chlorotic appearance leading to inter veinal browning and then scorch at harvest.
Fruit is small, dull in colour and often has a thickened skin. The flesh is low in sugars and insipid to taste.
When K is deficient, uptake of calcium and magnesium is usually increased.

Role of Sulfur in Apple Production;

Sulphur is a key component of amino acids, proteins and coenzymes. Thus, lack of sulphur will inhibit protein synthesis and reduce tree growth.

General guidelines for Sulphur application;

Apples require sulphur at similar levels to that of phosphate and most soils contain sufficient to support good growth.
Problems with sulphur are rare. Inadequate supplies are only likely in orchards on leached soils with low organic matter.

Sulphur deficiencies in apples;

Deficient trees exhibit chlorosis in younger leaves at the top of the plant. Leaves get progressively paler yellow.

Role of Zinc in Apple Production;

Zinc functions in many enzyme systems and biochemical functions including acting as a precursor of indoleacetic acid which is involved in shoot elongation. The micronutrient thus plays a major part in bud development and flowering. Poor zinc supply restricts leaf and bud growth and development, leading to bare bark or rosettes of spindly leaves.

Soil applications need to be applied or banded around the root zone, but uptake is limited and doesn't occur until 4/5 leaves are unfolded in the spring.
C are is needed in choosing the right form of foliar-applied zinc so as to minimise damage to young leaves and the fruit.

Zinc deficiencies in apples;

Symptoms occur in the spring and include chlorosis of the youngest shoot leaves, which are stunted and narrower than normal – 'little leaf'.
Yellowing occurs between leaf veins and is less symmetrical than, for example manganese deficiency. The leaves may show a wavy margin. Blind bud and rosetting can also occur. Leaf symptoms are not strong in apples compared to other fruit trees.
Extreme deficiency results in shoot defoliation and the production of misshapen and poorly coloured apples.