Incitec Pivot Fertilisers

AGRITOPIC

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BORON

1. INTRODUCTION

Boron (B), along with chlorine, copper, zinc, iron, manganese and molybdenum, is classified as a micronutrient. Micronutrients are required in smaller amounts than the macronutrients (i.e. nitrogen, phosphorus, potassium, calcium, magnesium and sulfur) but a deficiency of any one of these micronutrients (or trace elements) can have just as deleterious an effect on yield and quality as a deficiency of a macronutrient. Consequently, boron is commonly recommended in routine fertiliser programs for high return crops with an established requirement for boron.

2. BORON IN THE SOIL

The soil organic matter is the major reserve of boron in most agricultural soils. In this respect boron behaves in a similar fashion to nitrogen in the soil and its availability fluctuates according to soil microbial activity and mineralisation potentials. It becomes available as the soil organic matter decomposes.

In the soil solution, boron is present in a non-ionic form [$B(OH)_3$], i.e. it does not dissociate to form positive and negative charged ions. Consequently, it is not attracted to soil colloids. Once in solution, boron is among the most mobile and leachable nutrients in the soil, i.e. similar to nitrate nitrogen.

Once boron is released from soil minerals and organic matter, it can be leached from the soil fairly rapidly. Light textured soils in high rainfall areas are often deficient in boron. Conversely, boron can accumulate in the sub-soil in semi-arid regions, particularly on heavier textured clay soils, and may reach toxic concentrations, e.g. light clays in the Victorian Mallee.

3. BORON IN THE PLANT

3.1 Uptake and Function in Plants

Boron is thought to be taken up by plants as undissociated boric acid [H_3BO_3 or $B(OH)_3$]. Within plants, boron is relatively immobile. It is not readily relocated from old to young plant tissue. Plants are therefore dependent on continuous uptake of boron during the growing season. Boron plays a role in cell wall development, and is important in pollination, fruit development and the translocation of sugars. An adequate supply of boron is important at flowering, and in seed set, e.g. in legumes. Fruit quality is affected in many crops if boron is deficient.

The range between deficient and toxic levels of boron is very narrow. This situation may create an increased liability risk for advisers, if inappropriately managed. Different species and varieties show considerable variation in their requirement of boron and tolerance of excess boron. In general, the monocotyledons (grass species such as wheat, oats, sorghum, maize and sugarcane) have a lower requirement than the dicotyledons, i.e. soybeans, crucifers and pasture legumes.

Boron deficiency occurs more commonly in dry weather. Microbial activity in the soil is reduced, and the movement of boron in the soil solution to plant roots is restricted.

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3.2 Deficiency Symptoms

Root crops, vegetables and many fruit trees are more susceptible to boron deficiency than grain legumes. Deficiency also occurs in timber and forestry species, e.g. *Pinus radiata.*

The most frequently occurring symptoms of boron deficiency are:

- Chlorosis (yellowing) and death of the growing points. Because boron is relatively immobile in plants, deficiency begins at the growing points. In this respect, its behaviour in plants is very similar to calcium (both are immobile) and deficiency symptoms can be confused.
- Distortion, thickening and cracking of stems. The stems may be hollow or brittle.
- The formation of rosettes, growth of auxiliary buds (side shooting), bushy growth and multiple branching.
- The discolouration to yellow or red and the necrosis (death) of leaves in the region of growth.

Other symptoms of deficiency which may develop in the leaves are leaf distortion without necrosis (i.e. twisting); leaf distortion as a result of necrosis (i.e. crinkling); non-uniform venation and the bursting of leaf veins (cracking) a decrease in leaf size and formation of irregular shaped leaves; and leaf fall.

- The thickening, twisting and failure of roots to spread out or develop properly. In some cases the roots may show excessive branching. Root crops often fail to develop edible portions, or the quality is severely affected by the presence of dark coloured corky areas. Cuttings may fail to take root.
- The dropping of buds or blossom. Fruits and seed may also be affected. Brown sunken areas may develop in fruit.

Specific symptoms of boron deficiency in some major agricultural and horticultural crops are:

Lucerne - Yellowing and reddening of the upper leaves. The upper part of the stem may be stunted and bear numerous short side branches, giving the plant an umbrella-like appearance. Deficiency is closely associated with moisture stress, and frequently mistaken for drought damage - but with boron deficiency, the yellowing is confined to the upper leaves. Reduced flowering may delay cutting, and result in poorer quality hay and reduced yields.

Cotton - Excessive shedding of squares and young bolls, dark internal discolouration at the base of bolls, delaying boll opening and half-opened bolls.

Maize - Deficiency is not easily detected and crop losses may be large before visual symptoms appear. Deficiency shows up with a general reduction in growth with barren or half-filled cobs and the irregular distribution of kernels.

Apple - Dieback of growing points, with a rosetting of thickened leaves at the base of the shoots. Dead areas appear on the bark of young wood, and external and internal lesions are found (apple measles); the bark may be rough and split. Premature fruit drop occurs and fruit quality is usually impaired by cork formation. The development of cracks in the fruit, which is often attributed to drought may be caused by boron deficiency. The storage life of fruit is often reduced.

Grape - Severe deficiency may result in the death of the growing points, leaf fall, and the development of secondary buds and shoots. The young shoots tend to be brittle and internodes near the dead growing point are often abnormally short. The leaves may show an interveinal chlorosis that spreads inward from the margins. There is considerable reduction in fruit set with bunches of small seedless berries of varying sizes, a condition known as 'hen and chickens'. In severe cases, no normal fruit develops.

Citrus - Foliar symptoms of boron deficiency on citrus are not very characteristic, and a deficiency suspected on the basis of leaf symptoms should be confirmed by the fruit symptoms. The first signs appear on the younger leaves as water-soaked spots that become translucent, the veins tend to be thick, cracked and somewhat corky. The young leaves wilt and curl and have a dull brownish-green colour without any lustre, and dieback of leaf tips is common. A gummy exudate may appear on the twigs and fruit pedicels. The fruit, which are small, shrivel and become hard. The rind is thick and the fruit has a low juice content. Grapefruit may be lop-sided, with gummy areas in the rind. Excessive dropping of young fruit occurs, resulting in poor yields.

Papaw - First noticeable symptoms are slight yellowing and downward curling of leaf tips with slight deadening of tips and leaf margins. These leaves are claw-like, harsh and brittle in appearance. Younger leaves show first symptoms. A latex exudate from the underside of the main leaf veins occurs and, as the leaves age, corky splits or cankers develop along the main veins, again on the underside. In the fruit, the most noticeable symptom is "bumpy" fruit but reduction in yield and flavour can occur even where "bumpy" fruit are not present.

Avocado - Leaf symptoms have not been identified in avocados. During flowering and fruit development a deficiency can induce embryo abortion or produce small misshapen fruit. Boron deficient fruit show an indentation on one side giving a dumpy, hooked shape. In severely affected fruit a lesion similar to the base of a navel orange develops in the indented side. This lesion penetrates through the flesh to the seed that often shows necrotic areas of the tissue developing on the cotyledons (seed parts). Affected fruit is downgraded or rejected. The Sharwil variety is particularly sensitive to boron deficiency and the first to show fruit symptoms. Boron deficient Sharwil trees are stunted and grow along the ground. It is a good indicator tree to include in the orchard to detect boron deficiency.

Vegetables - Boron deficiency is very common in vegetables. Some deficiency symptoms are:

- Beetroot- stunting, surface cracking, with patches of internal breakdown in the roots.
- Broccoli - brown dry areas in heads.
- Cabbage - internal breakdown of stem.
- Carrots - death of leaf and stem growing tip, yellow leaf margin.
- Cauliflower - deformed foliage and brown curd.
- Celery - cracked stem, mottling of bud leaves.
- Lettuce - death of terminal bud, brittle cup-shaped leaves.

- Turnips - internal browning of root.

3.3 Toxicity Symptoms

Boron toxicity occurs in arid and semi-arid regions where there are high levels of boron in the soil. In some parts of the world, it is also associated with the use of high boron irrigation water. However, one of the most common causes is over-fertilisation with boron fertiliser.

In the early stages, the symptoms of boron toxicity are normally expressed as marginal and tip chlorosis of the older leaves. Moderate to severe toxicity produces progressive leaf necrosis beginning at the tip or margins and gradually covering the whole leaf, resulting in premature leaf drop. Monocotyledons (grasses and cereal) usually show a tip and not a marginal chlorosis. Where boron is over-applied as a fertiliser or is present at toxic concentrations in the sub-soil, root growth into the affected area may be restricted.

Strawberry, peach, grape, bean, pea, and cucumber are sensitive to boron toxicity. Boron tolerant crops include turnip, sugarbeet and cotton.

4. CRITICAL LEVELS OF BORON

4.1 Soil Analysis

The total boron content of most soils varies from 20 to 200 mg/kg B. However, the total amount of boron in the soil is poorly correlated with that available for plant uptake, as typically only a small fraction (about 5%) occurs in an available form. The level of plant available boron in the soil can be determined by various methods. The two most commonly used methods in Australia are the hot water method and the boiling calcium chloride method.

4.2 Tissue Analysis

Plant tissue analysis is useful to help confirm a deficiency or toxicity where initially indicated by soil analysis. It is also useful as a monitoring tool in horticultural crops to better predict boron fertiliser requirements. The optimum ranges across all crops are extremely variable, some being quite wide, e.g. citrus 30 - 100 mg/kg B, some being narrow, e.g. lettuce 25 - 45 mg/kg B.

Cereal crops are deficient when the boron level is less than 4 - 5 mg/kg B, oilseeds less than 10 mg/kg B, fruit trees less than 10 - 25 mg/kg B and vegetables less than 10 - 15 mg/kg B. Boron can be toxic to many crops, e.g. cereals and pastures when it is greater than 30 mg/kg B in the leaf, but the levels are quite variable for fruit and vegetable crops, ranging from greater than 50 to 800 mg/kg B.

5 BORON FERTILISERS

Various boron fertilisers are available to apply to the soil or foliage. Most of these fertilisers contain sodium borate, which is soluble in water, and readily available for plant uptake, or leaf absorption if applied in foliar sprays, though the products do vary in their solubility. Being water soluble, sodium borate fertilisers allow quick responses to be obtained in the field. They can also harm seedlings and plant roots if placed in close proximity or applied at too high a rate. Calcium borate (Colemanite) is not water soluble and is used in slow release products.

Borax

Borax is disodium tetraborate decahydrate ($Na_2B_4O_7.10H_2O$). It contains 11.3 % B. Borax is a fine crystalline product that can be either applied dry to the soil, or in solution (dissolved in water) to the soil or foliage. Little use is made of Borax nowadays. Granular boron fertilisers that are more suited to mechanical application and use in blends with other granular fertilisers are used if boron is to be applied dry to the soil; and more soluble boron compounds with a finer particle size if boron is to be applied in solution.

Solubor

Solubor is one of the more commonly used product names for disodium octaborate tetrahydrate ($Na_2B_8O_{13}.4H_2O$). It contains 20.5 % B. The product has a fine particle size and is more soluble than Borax, especially in cold water, making it the recommended choice for application in solution. It is used in soil and foliar sprays, and in fertigation programs.

Solubility in water at 20^0 C.

Product	Analysis (% B)	Solubility (kg/100L)
Borax	11.3	4.9
Solubor	20.5	9.5

Boric Acid

Though not commonly used, Boric Acid (H_3BO_3), a white crystalline solid containing 16.5 – 17.5% B, is also used in the preparation of boron solutions. Boric acid is not suitable for foliar applications.

Granular Boron Fertilisers

Granular boron fertilisers are recommended where boron is to be applied dry to the soil. Two commonly used formulations are:

- Disodium tetraborate pentahydrate or $Na_2B_4O_7.5H_2O$, containing 14.3 % B. This product is sold as **Granubor**.
- A mixture containing 15% B, that consists mostly of disodium tetraborate pentahydrate ($Na_2B_4O_7.5H_2O$), and a smaller amount of disodium octaborate tetrahydrate ($Na_2B_8O_{13}.4H_2O$), the form in which boron is present in **Solubor**.

These products can be applied dry on their own to the soil or used in blends.

Ulexite

Ulexite is sodium calcium borate ($Na_2O.2CaO.5B_2O_3.16H_2O$) It is slightly soluble in water. The analyses of commercial products vary, but are typically around 12% B. The main use of Ulexite in Australia is as a slow-release boron fertiliser in forestry in which fertilisers are applied on an infrequent basis. Ulexite is less subject to leaching on light-textured (sandy) soils than sodium borate fertilisers. The calcium borate component is likely to be less effective or even ineffective on alkaline (high pH) soils.

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Incitec Pivot Fertilisers stocks **Granubo**r (14.3% B) for use as a straight and in blends. **Ulexite 12** is also stocked at some distribution centres in southern Australia for use in blends for forestry. Disodium octaborate tetrahydrate was sold as **Liquifert Boron** or **Solubor** (20.5% B), for application in solution.

6. PREVENTION OF BORON DEFICIENCY

Seek local district and crop advice on boron use. In the absence of more detailed information, the following advice may be used. The rates given are for **Granubor** (14.3% B) for soil application, and **Solubor** (20.5% B) for foliar application and in fertigation programs. Application rates will need to be adjusted if other products are used.

6.1 Soil Application

Whereas some trace elements, e.g. copper, zinc and molybdenum, can be applied as infrequently as once every five years, this is not possible with boron given its mobility in the soil, the likelihood of toxicity, and its susceptibility to leaching. Annual or more frequent applications are usually required. Frequent applications at low rates minimises leaching losses and the risk of toxicity.

While all plants need boron, the amount in which it is required differs. What may be adequate for one crop may result in either deficiency or toxicity in others. Specific advice should be obtained on the crop to be fertilised, as application rates are extremely variable. Boron may be rarely required in some crops, and almost always essential in others.

The best time to apply boron to the soil will depend upon the crop being grown, soil type and the local rainfall pattern. Boron can be applied dry to the soil, e.g. as **Granubor**, or in solution, e.g. as **Solubor**, either through a boom as a soil spray, or in the irrigation water (fertigation).

Foliar sprays are recommended in crops that are sensitive to boron toxicity and in which boron is applied at low rates. At low rates, it becomes more difficult to apply boron uniformly to the soil, particularly if the fertiliser is applied dry. This increases the risk of toxicity, while other plants in the field may be left deficient in boron.

<u>Annual crops</u>

Boron can be applied pre-plant, or if the position of the intended crop row is known in advance in vegetable crops, boron can be applied in the basal fertiliser if it is applied in a broad band along the position of the row, and it is then incorporated into the soil before planting.

Boron should not be applied in the planting fertiliser if it is applied in narrow bands adjacent to the seed, transplants or setts during the planting operation. Applying the crop's complete boron requirements at this time and in this way is likely to result in root burn and toxicity.

If side-dressed, apply boron fertiliser to the inter-row space in as broad a band as possible early in the growing season, e.g. drop on the soil surface and water in. If applied into the soil, do not apply too close to the row to avoid root pruning and toxicity.

Suggested **Granubor** application rates per crop are shown in the following table.

Suggested Application Rates for Granubor in Annual Crops

Crop	Granubor (kg/ha)
French Bean, Strawberry	2
Maize	2 – 4
Cucurbits	3
Potato	4
Cotton, Sunflower, Tomato	4 – 8
Carrot, Celery, Lettuce, Onion	8
Canola, Lucerne, Cabbage, Cauliflower, Beetroot	8 – 12

Lower application rates may be considered where there is less evidence that boron is required, e.g. as insurance against a minor deficiency in susceptible crops. Suggested maximum broadcast application rates, which should not be exceeded on loam soil for various field crops, are shown in the following table. Too high an application rate of boron may result in toxicity.

Maximum Annual Application Rates for Granubor

Crop	Granubor (kg/ha)
Cowpea, Cucumber, French Bean, Pea, Strawberry, Cereals	4
Celery, Citrus, Melon, Potato, Squash	15
Cabbage, Carrot, Chilli, Radish, Spinach, Sweet Potato	25
Cauliflower, Mustard, Tomato, Turnip, Beetroot	40

Consideration also needs to be given to the next crop to be grown in the rotation. If it is sensitive to or intolerant of boron, it may be advisable to err on the low side when choosing the rate at which boron is to be applied, or use foliar sprays. In particular French Bean, Pea and Cucumber are subject to boron toxicity.

Perennial (Tree, Vine and Plantation) Crops

In perennial crops, it is usually recommended that boron be applied annually at the start of the main growing season, e.g. at the end of winter or early spring. To minimise leaching on light textured soils, it is advisable not to apply boron during the wet season, unless this coincides with the period of maximum uptake, in which case a number of split applications during the growing season may be best.

In tree crops, the boron should be spread or sprayed over the root zone, i.e. under the whole canopy and just beyond the area of the tree canopy, but no closer than 30 cm to the trunk. Toxicity may occur if it is applied unevenly, i.e. it is concentrated in small areas. Young non-bearing trees require less boron than mature trees.

In the absence of more specific local advice, the rates detailed in the following table can be used as a guide to **Granubor** application rates.

Suggested Application Rates for Granubor in Perennial Horticultural Crops (Note: 1 g/m^2 = 10 kg/ha)

Crop	Rate
Bearing Pome and Stonefruit	Apply Granubor at 8 – 25 g/tree in the late winter/spring. This equates to 5 – 15 kg/ha of Granubor at 6 x 3 metre row spacings (555 trees/ha). Higher rates may be required where severe deficiency occurs. Boron is not recommended on trees less than three years of age.
Avocado	Application rates, frequency and timing are variable depending on the soil type, degree of deficiency as measured by soil and leaf analysis, rootstock and disease. Seek professional or Departmental advice before use.
Banana	Apply Granubor at 7 g/plant on two occasions each year. At 2 000 plants per hectare, this equates to 15 kg/ha of Granubor per application, and an annual rate 30 kg/ha of Granubor.
Grape	Apply Granubor at 8 g per mature vine in August. At 1,500 vines/ha, this equates to 12 kg/ha of Granubor. On very sandy soils, split this into two applications, at least four months apart.
Lychee	Apply Granubor at 3 g/m^2 of canopy cover.
Macadamia	Apply Granubor at 1.5 g/m^2 of canopy cover in April, up to a maximum of 40 g/tree for large trees. At 250 trees/ha, this amounts to a maximum of 10 kg/ha of Granubor.
Mango	Apply Granubor at 35 g evenly under the canopy of trees with radius > 2.5

	m after harvest and again at flowering. At densities of 100 – 200 trees/ha, this amounts to 7 – 15 kg/ha/annum of Granubor. For trees smaller than 2.5 m radius, apply evenly to the canopy area twice per year at 1.75 g/m^2 of canopy area. On very sandy soils, split this into four applications per year at 0.9 g/m^2
Papaw	Apply Granubor at 20 kg/ha pre–plant. Once established, apply 2 g/m^2 of canopy cover in spring and again in autumn on red volcanic soils. On sandy soils, boron will need to be applied more regularly at lower rates. Apply a maximum of 1.5 g/m^2 of canopy cover/application four times per year.
Passionfruit	15 kg/ha of Granubor (or 1.5 g/m^2 of canopy cover) annually.

6.2 Foliar Application

Foliar sprays can be used in place of or to supplement soil applications of boron. Boron is immobile in plants, i.e. it is not readily relocated from old to new growth, so several sprays will usually need to be made during the growing season. The "little and often" approach also reduces the risk of foliar burn or boron toxicity.

Foliar sprays should be applied from early in the growing season, e.g. to new growth in tree crops or as part of the routine insecticide and fungicide spray program in vegetables. Do not apply boron foliars during flowering, as open flowers are susceptible to burn/damage. It is best not to allow boron deficiency to develop before spraying. If this occurs, yield potential will already have been lost. If boron deficiency does occur during the growing season, apply a boron spray as soon as practical.

Where used as the sole means of applying boron, typical foliar application rates for disodium octaborate tetrahydrate (**Solubor**) are in the range of 0.5 – 2.5 kg/ha per application, the higher rates being used in the more tolerant crops and those with a high boron demand. In total, seasonal application rates are in the range of 1 – 7.5 kg/ha of **Solubor**, depending on the crop.

Where used as the sole means of applying boron, cumulative annual foliar application rates may approach those recommended for soil application, though, given that utilization of foliar applied nutrients should be better, they will usually be lower. Lower rates than those described above are required if boron is also applied to the soil, and foliar sprays are used as a supplement rather than as the primary way in which boron is applied.

<u>Spray Volumes</u>

Spray volumes, unless detailed otherwise, are typically around:

- 500 L/ha in vegetables, and
- 1 000 L/ha or more in tree crops.

Spray volumes in vegetables increase as the crop matures and there is more foliage to spray, e.g. from 250 L/ha up to 1 000 L/ha. Trace elements sprays are usually applied in the early growth stages, often at 400 – 500 L/ha.

Spray Concentrations

Typical foliar spray concentrations for **Solubor** are in the range of:

- 200 - 500 g/100 L (0.2 - 0.5% w/v) in vegetables, and
- 100 - 250 g/100 L (0.1 - 0.25% w/v) in tree and vine crops.

Lower spray concentrations are used in some crops, including sensitive crops such as strawberry (50 g/100 L). Spray concentrations may need to be adjusted if using spray equipment that delivers higher or lower spray volumes than the norm, so as to apply the desired rate of boron. Spray concentrations will also need to be reduced if applying boron sprays on a more regular basis than is the norm, or if boron fertiliser has also been applied to the soil.

Spray Programs

Seek local and industry advice on appropriate spray programs for the crops to be grown. In the absence of specific crop advice, the programs shown in the following table may be used as a guide to how much boron to apply where a deficiency is expected without corrective action being taken.

Suggested Foliar Spray Programs for Disodium Octaborate Tetrahydrate (Solubor).

Crop	**Solubor Concentration/Timing**
Bearing Pome and Stonefruit	275 g/100 L, 2 weeks after petal fall. If deficiency is severe in apples and pears, apply 3 sprays at 2 - 3 week intervals at 200 g/100 L from bud break to early fruit development.
Cherry	250 g/100 L, 3 sprays from petal fall at 2 week intervals.
Grape	125 – 250 g/100 L, either 3 weeks before or after flowering.
Citrus	150 g/100L, in spring.
Papaw	275 g/100 L, apply to new growth at 6 week intervals for a total of 5 – 6 sprays per year.
Custard Apple	150 g/100 L, to mature spring flush leaves and again on summer growth.
Macadamia	100 g/100 L, 4 sprays directed at the nuts from September to December.
Broccoli, Brussel Aprout, Cabbage, Cauliflower	250 g/100 L, 2 sprays in seedbed, 2 – 3 sprays after planting.
Beetroot, Carrot, Celery, Lettuce	200 – 250 g/100 L, apply 3 – 4 sprays.

Cucurbits	250 g/100 L at the 4 - 5 leaf stage. A repeat spray may be required where deficiency is severe, or persists.
Potato	250 g/100 L, 3 weeks after emergence. A repeat spray may be required where deficiency is severe, or persists.
Capsicum, Tomato	200 g/100 L, 1 – 3 sprays after planting out (in seedling stage).
Strawberry	50 g/100 L, 5 sprays at monthly intervals. Test spray small area first as strawberries are sensitive to excess boron.
French Bean, Pea	500 g/100 L at 2 leaf stage at 250 L/ha; or 250 g/100L at 2 leaf stage and again 2 weeks later.
Cotton	450 g/100 L, 4 – 5 sprays at 20 – 25 L/ha if deficiency occurs.

Some of the above programs call for the use of boron sprays after flowering in tree crops, or their direction at the fruit. Some authorities now believe it is better to apply boron pre-flowering to the developing bloom. This ensures boron is available in the critical cell division stage, which lasts 4 – 6 weeks after pollination. In addition, uptake of boron by young leaves is better than that of old leaves which have developed thick waxy coverings.

Add Urea (1 kg/100 L in field crops, 500 g/100 L in vegetables, 100 g/100 L in tree crops) to the spray mixture, plus a non-ionic wetting agent at label-recommended rates.

Note. The above spray programs and concentrations are representative of those reported in the literature. Even so, foliar burn may occur under adverse environmental conditions. Some authorities recommend lower rates.

6.3 Fertigation

Boron can be applied with the irrigation water where overhead sprinkler and flood irrigation systems are used, and in other situations where or at least 50% of the soil is wetted. There is a risk of toxicity if the boron is applied to too small a volume of soil. Do not fertigate with boron in:

- crops that are sensitive to boron toxicity,
- tree or vine crops with dripper irrigation systems,
- tree crops with poor water distribution from under-tree sprinklers,
- tree crops with sprinklers situated close to the butts of the trees.

Solubor should be applied in small doses (typically less than 0.5 kg/ha/application) on a regular basis through the growing season.

Total crop requirements for annual crops or annual application rates for tree crops will be similar to those detailed for dry soil application (Section 6.1).

Solubor (20.5% B), being more concentrated than **Granubor** (14.3% B), needs to be applied at 70% of the **Granubor** rate.

If fertigation allows fertiliser use efficiency to be improved, it may be possible to reduce the cumulative boron rate to some extent.

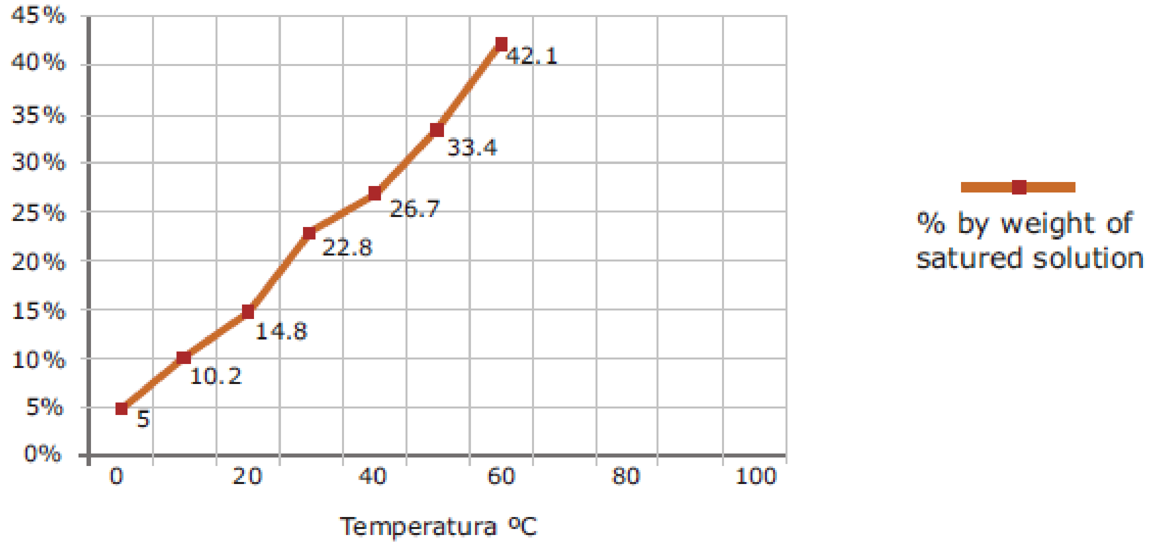
7. BORON SOLUTIONS

7.1 Solubility

At usual temperatures, around 10 kg of **Solubor** can be dissolved in 100 L of water. In practice it is suggested that about one-half to two-thirds of this amount be dissolved in water, as **Solubor** becomes increasingly more difficult to dissolve as the concentration increases.

These concentrations are not reached in the preparation of foliar sprays, but may be in the preparation of concentrated solutions for use in soil sprays or fertigation programs.

The solubility of disodium octaborate tetrahydrate (**Solubor**) increases with temperature, as depicted in the following graph.



Source: Minera Santa Rita, Aquabor® Product Profile Nº MSR-DOT-05/2005

7.2 Mixing

When preparing fertiliser solutions, fill the tank with water to near capacity, leaving space for the added fertiliser, which should then be added slowly while agitating. Do not pre-mix. Fertiliser solutions should be prepared just prior to use, and not allowed to stand for an extended period, to minimise sediment formation and settling in tanks.

Disodium octaborate tetrahydrate (**Solubor**) may be applied with routine insecticide and fungicide sprays, provided no compatibility problems exist. Check the labels of all crop protectants to be used in the spray tank before use. Boron is not compatible with oil-based solutions.

7.3 Compatibility in Solution with other Fertilisers

Soluble sodium borate fertilisers are compatible in solution with urea, ammonium nitrate, soluble phosphorus fertilisers, e.g. monoammonium phosphate (MAP) and monopotassium phosphate (MKP), and potassium fertilisers (Muriate of Potash, Sulfate of Potash and Potassium Nitrate). Do not mix with calcium or magnesium fertilisers, e.g. calcium nitrate or magnesium sulfate, or metallic sulfates, e.g. zinc sulfate, as insoluble boron compounds will be precipitated.

8. CORRECTION OF BORON TOXICITY

Boron toxicity is much more difficult to correct than boron deficiency. Moderate liming to raise the soil pH is often beneficial, and heavy rainfall or irrigation will help leach boron from the root zone. The cause of the toxicity should be found and if possible steps taken to prevent its recurrence.

If the toxicity is the result of boron being over-applied in fertiliser programs, leaching is often the only possible assisting remedy. If boron fertiliser has been applied in bands at excessive rates, thorough cultivation, e.g. with a rotary hoe, will help mix the boron through the soil. If irrigation water is high in boron, the supply of water will need to be changed or a more tolerant crop grown. If excess boron is present in the sub-soil in rain-grown cropping areas as commonly occurs in many parts of north-west Victoria and South Australia, there is not a lot that can be done. Boron tolerant cereal varieties should be chosen.

FURTHER READING

Incitec Pivot Fertilisers Agritopics are also available on “Fertigation” and "Foliar Fertilisers" if either of these application methods is to be used when applying boron.

WARNING

This information is for use as a guide only. The use of fertilisers is not the only factor involved in producing a high yielding crop. Local soil, climatic and other conditions should also be taken into account, as these could affect crop or pasture response to applied fertiliser.

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