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Broccoli / cauliflower nutrition guide

About this guide

- The Soil Wealth ICP team has developed a series of crop nutrition guides to help growers, advisors and other vegetable industry service providers to manage crop-specific nutrition. The guides explore key considerations to ensure crop growth and nutrient needs are met, including:
- Growth stages of the crop and the nutritional focus for each stage
- Determining and calculating nutrient removal
- Factors affecting nutrient availability and uptake in the crop
- Approaches to crop monitoring, and
- Other helpful resources and information on nutrient functions.

Other nutrition guides in this series include:

- Lettuce
- Carrot
- Cucurbit
- Onion.

CONTENTS

Hort Innovation

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1. Broccoli and cauliflower growth and nutrient needs

When determining crop nutritional needs, it is important to be familiar with the site and local soil and climatic conditions as well as the cropping system. The following aspects should be considered:

- Crop, variety and growing days
- Growing season (weather impacts)
- Soil type and texture (approximate clay, silt, sand proportions)
- Soil condition/ physical properties in the rootzone and beyond (e.g. compaction layers, other subsoil restrictions, salinity or sodicity, water holding capacity, drainage water and logging risks.
- Soil uniformity (across paddock, in the soil profile) – variable soil conditions may need targeted testing of management zones and variable application rates for best results.
- Site history (crop rotations over the past 4-5 years, previous fertiliser applications, organic amendments such as composts, as well as pest, disease and weed history)
- Cultivation practices/tillage
- Irrigation system and practices
- Water quality
- Available and or preferred nutrition products and soil amendments
- Application equipment
- Ability to adjust nutrition program during the season.

Having analytical data from comprehensive soil tests (including nutrient levels, CEC, pH, EC, organic carbon, total carbon and nitrogen) is a prerequisite to making decisions about applications of fertilisers or soil amendments. For more information refer to the Fertcare soil sampling guide and SWICP Soil test interpretation guide (please refer to *Other helpful resources* on pg 14).

The information and trends from soil tests taken over several previous years should be considered when making decisions about nutrient needs for a specific crop within the farming system.

- Soil tests are used to ensure that a base fertiliser application balances out deficiencies and imbalances in the soil as much as possible. For intensive crops like broccoli/cauliflowers, annual soil testing is recommended.
- Knowing the expected yield and the crop growth stages (for topdressing and foliar applications) is critical to ensure the crop is getting the nutrients it needs at each phenological growth stage.

- Growth stages can be determined using the BBCH growth scale[1]. The following are ten stages of plant growth in the BBCH scale[2]:

1. Germination/ early crop establishment;
2. Leaf development;
3. Formation of side shoots;
4. Stem elongation;
5. Development of harvestable vegetative plant parts
6. Inflorescence emergence;
7. Flowering;
8. Development of fruit;
9. Ripening of fruit and seed;
10. Senescence

- Nutrient removal rates based on the expected yield are used to ensure that the crop receives the amounts of nutrients it is expected to remove from the soil during its growth. The base fertiliser will provide some, or sometimes all the nutrients that the crop will remove for fast growing crops. For broccoli and cauliflower, a nutrient budget has to be developed that includes top dressing at key growth stages and monitoring approach e.g. sap or dry tissue testing to ensure the program is working well.
- Nutrients that will not be easily lost and may be fixed by the soil, e.g. phosphorus, may be applied as a base dressing to cover the entire season. In P fixing soils, top dressing may still be required. P input to P fixing soils have to be above the P removal rate. Local guidance from an experienced agronomist should be sought.
- Fast growing crops like baby leaf types, will usually not be top-dressed. They may receive a foliar application or fertigation if required to deal with imbalances.
- Slow growing crops like most head broccoli/ cauliflower crops will require top-dressing at key growth stages. This is especially important for nutrients that can be easily lost from the rootzone such as nitrogen, sulphur, boron or potassium in sandy soils. Nutrients like potassium and nitrogen are needed in relatively large quantities and therefore spreading the nutrition program over the growing season to match nutrient uptake requirements at each growth stage is vital.

1 https://www.politicheagricole.it/flex/AppData/WebLive/Agrometeo/MIEPFY800/BBCHengl2001.pdf

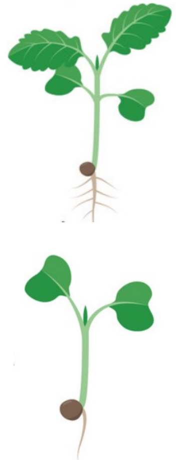
2 https://eos.com/blog/stages-of-plant-growth/

1.1 Broccoli and cauliflower growth stages and nutritional focus

Table 1 provides an overview of the nutritional aspects to consider for head broccoli/cauliflowers (e.g. cauliflower and broccoli) at key crop growth stages.

Table 1: Broccoli growth stages and nutritional focus

Crop stage	Image (photos or drawings)	Description	Comments	Focus
Pre plant		Evaluate all site and local conditions and data mentioned in section 1 above this table. Determine total nutrient requirements based on soil tests and removal rates whether the crop is grown from seed or transplanted to develop the crop nutrient budget. If an adviser, consider the operational aspects of the site in discussion with the grower.	Evaluate all site and local conditions and data mentioned in section 1 above this table. Determine total nutrient requirements based on soil tests and removal rates whether the crop is grown from seed or transplanted to develop the crop nutrient budget. If an adviser, consider the operational aspects of the site in discussion with the grower.	Site conditions and suitability for crop. Prepare the soil to ensure the physical properties are adequate for nutrient availability with good rooting depth and no compaction. Ensure that fertiliser is applied for optimal nutrient use efficiency. For example, phosphorus (P) should be applied as a broadcast or banded as close to planting as possible in P-fixing soils. Using nitrogen fertilisers with denitrification inhibitors is one way of reducing nitrogen top dressing needs. Brassica crops required good soil levels of sulphur and boron..

Crop stage	Image (photos or drawings)	Description	Comments	Focus
At planting and through to germination (direct seeded crop), early crop establishment (BBCH stage 1)	 	The nutrient application The nutrient application should be designed to last until the first planned topdressing. Ensure there is a small surplus amount of nutrients needs to ensure that the crop is not deficient in nutrient over the course of the growth cycle.	Saline (high EC/chloride) and sodic soils may require higher levels of calcium and potassium than soils without these problems. The same applies if irrigation water is saline. Crops grown in poorly structured soil will have a restricted root zone. Therefore, they may require feeding more frequently with smaller amount of nutrients than crops grown in well-structured soil. Sandy soils and those with low organic matter levels may also need fertilising more often with smaller amounts of nutrients than soil with good organic matter levels and or heavier soils.	Compound fertilisers as a banded or broadcast application are a good option to ensure even distribution of essential elements especially calcium and trace elements. Mixed fertilisers easily separate in the spreader and especially trace element application will be uneven. Foliar applications may be a good option, if compound fertilisers are not used

Crop stage	Image (photos or drawings)	Description	Comments	Focus
Leaf development and vegetative growth (BBCH stages 2-5)	 	Plant nutrient tests should be performed from early growth stages and throughout vegetative growth to allow time for nutrient imbalances to be corrected. Once head development is well under way, testing may be used for diagnostic purposes, but correcting nutrient deficiencies will become more difficult the older the plant is..	The youngest fully expanded leaf should be sampled for dry matter testing. For sap testing the leaf petioles of these leaves are good indicators of the plant's most recent nutrient uptake. If planning for 1-2 tests only, focus on the earlier stages; then imbalances are easier to correct.	Nitrogen is important for early development when plants are growing rapidly, but must be in balance with other nutrients, especially calcium. Calcium is critical for early head development, strong structure, and shelf life. It is best applied in good time to be available when the head starts to form. Foliar applications are possible.
Head Development (BBCH stage 6) Early to mid head development	 	If calcium is not applied prior to this stage, foliar applications should be considered. Plant sap analysis can still be used at early head formation to amend any nutrient requirements.	Calcium nitrate and boron can be used to help maintain a good rootzone environment for optimal nutrient uptake and to combat adverse saline (high soil sodium chloride) or sodic (high sodium) conditions.	Nitrogen should best be applied in the plant available form as nitrate if immediate plant uptake is important. Trace elements are now best applied with foliar applications. Foliar fertilisers may also help to correct low plant levels of potassium and calcium.

Crop stage	Image (photos or drawings)	Description	Comments	Focus
Head Development (BBCH stage 7-8) Mid- head development to harvest	 	Potassium demand is at its highest during head development. In most plants potassium is removed at a faster rate than nitrogen. Monitor nutrient levels with sap tests, if required for diagnostic purposes.	Potassium can be applied as a liquid thiosulphate or as potassium sulphate or potassium nitrate, if nitrogen is needed. Potassium may be limiting in soils, even if it is at satisfactory levels because its rate of release from the soil cannot keep up with the demand of the crop during a rapid phase of growth.	Apply potassium before the period of rapid growth at (mid head development). Ensure adequate uptake of calcium and potassium whilst maintaining magnesium and trace elements.
Harvest (BBCH 9)	 	It is too late to make any nutrient amendments.	To ensure the site is restored for the next crop consider soil nutrient testing and the nutrients that will be returned to the soil with crop residues to ensure that nutrient levels are replenished to the desirable crop requirement but not oversupplied. For instance, residues from a broccoli or cauliflower crop can return > 170 kg/N per hectare to the soil.	Plan soil nutrient testing ahead of the next crop for the site.

SOME KEY CONSIDERATIONS

- Experience and knowledge of soil conditions and weather
- Yield potential and crop removal figures
- Growth stages and expected rooting depth and distribution
- Nutrient uptake efficiency and limiting factors
- Soil management, mulching, green crops may have a greater impact on nutrient uptake than fertiliser applications
- Growing conditions and irrigation management may have a greater impact on nutrient uptake than fertiliser applications
- Stress, including from pests and diseases will influence nutrient uptake significantly
- Good decisions are based on good data such as soil, plant and water test results.

2. Crop Monitoring

While a soil analysis provides information about soil reserves, deficiencies and imbalances in the soil and potential nutrient availability, a plant analysis provides information about actual nutrient uptake and use.

Plant analyses are required to gain information about the nutritional status of a crop before problems are visible. If symptoms appear, plant analysis can be used to diagnose nutrition problems (deficiencies, imbalances, toxicity) as early as possible. Planned, repeated monitoring within a crop cycle helps to assess nutrient availability within the soil and removal of key nutrients by a crop. Plant analysis data can be used to replace nutrient in the soil after harvest.

Procedures for plant analysis include:

- Plant sap testing - A quick way to check the nutritional status of your crop. Sap testing offers early detection and correction of nutritional problems in the crop.
- Plant dry matter (or tissue) analysis – As a measure of nutrient accumulation in the tissue, the analysis can provide information for checking the effectiveness of nutrient budgeting, calculation of crop nutrient removal (if the harvested plant part is analysed) or total nutrient uptake of biomass samples

WHICH ANALYSIS TO CHOOSE

- Determining which test to do is based on the how the data is to be used.
- For nutrient budgeting based on removal post-harvest, a dry matter (tissue) test of the harvested plant parts is required.
- For monitoring nutrient uptake during the growth cycle, a plant sap test is more suitable.
- To correct nutrient deficiencies, samples should be taken during early growth, well before symptoms appear.

If nutrition trends over time are monitored, it is recommended to take a sap test at a consistent time of day when transpiration rates are low and comparable. Never sample stressed plants for any type of analysis.

Sampling

- Plant dry matter
  - sample the entire youngest fully expanded leaf (monitoring)
  - sample the entire heads at harvest (nutrient removal)
- Plant sap
  - sample the petiole in the youngest fully expanded leaf.

WHAT TO CONSIDER FOR A FERTILISER PROGRAM

- Nutrient removal rates at the expected yield level
- Crop requirements at different growth stages
- Rooting depths, root distribution
- Crop and variety specific needs
- Expected weather conditions
- Water quality and irrigation system
- Available/preferred application methods and fertilisers
- Monitoring plan - actual nutrient uptake during early growth
- Ability to adjust nutrition program during the season.

For more information on crop monitoring please refer to the Soil Wealth Integrated Pest Management Plant Analysis Guide: soilwealth.com.au/resources/articles-and-publications/plant-analysis-for-vegetable-crops-a-practical-guide-to-sampling-analysis-and-interpretation/

For sampling procedures please refer to the Fertcare soil sampling guide: fertilizer.org.au/Portals/0/Documents/Fertcare/Fertcare%20Soil%20Sampling%20Guide.pdf?ver=2019-06-17-095413-863

For information on soil test interpretation please refer to the SWICP Soil Testing and Interpretation for Vegetable Crops guide: soilwealth.com.au/2020/02/plant-analysis-for-vegetable-crops-a-practical-guide-to-sampling-analysis-and-interpretation/

WHEN INTERPRETING SOIL TEST RESULTS, CONSIDER

- Mobility/ movement of different nutrients, nutrient interactions e.g. cations, P & Zn, trace metals, and EC and pH
- Specific nutrient needs of the crop
- Soil related constraints such as salinity or sodicty, rootzone restrictions (e.g. compaction, sudden changes in texture) that limit root growth.

2.1 Determining nutrient removal

During harvest, nutrients are removed from the system. If the soil is in balance, only what is removed with harvest needs to be replaced via mineral or organic fertilisers. Thus, crop removal figures can be used as a starting point for nutrient budgeting. Various nutrient budgeting tools are available (see Resources).

1. Use a soil test to determine nutrient deficiencies and imbalances in the soil (best over the main rootzone depth). Calculate the amount of nutrients required to balance the soil, so that all nutrients are within a satisfactory range in the soil.
2. To convert mg/kg to kg/ha, multiply the soil test value in each sampling layer by the depth of the soil sample (millimetres), then multiply by the bulk density (g/cm3) and divide by 100, then add up the values for each layer to arrive at nutrient content in kg/ha to the total soil depth sampled.

   Explanation and example for converting mg/kg (=ppm) of a nutrient in a soil test to kg/ha of that nutrient for a sampled soil depth:

   Calculation: kg/ha of selected nutrient = Soil test value (mg/kg) × Bulk density (g/cm) × Soil depth (m)×10.

Step-by-Step Explanation

- mg/kg (ppm) from soil test – this is the concentration of the nutrient in the soil.
  - Bulk density (g/cm³) – Typical values:
  - Sandy soil: ~1.4 g/cm³
  - Loamy soil: ~1.3 g/cm³
  - Clay soil: ~1.2 g/cm³
  - Soil Depth (cm) – e.g., 20 cm (= 0.2 m).
  - Factor (10) – to convert g/m² to kg/ha.

Example Calculation

Soil test value	**50**	**mg/kg**
Bulk density	**1.3**	**g/cm3**
Sampling depth	**0.2**	**m**
Factor	**10**	
Result	**130**	**kg/ha**

If a soil test shows 50 mg/kg (ppm) of a nutrient in a loamy soil (bulk density = 1.3 g/cm³) sampled to 0.2 m depth:

kg/ha = 50 × 1.3 × 0.2 × 10 = 130 kg/ha of nutrient to 20 cm soil depth.

2.2 Calculating nutrient removal

Nutrient removal is the amount of all nutrients removed at harvest (total yield taken off without trimming) in kilograms per tonne (kg/t) of dry matter removed.

For a nutrient budget, the anticipated total yield in tonnes per hectare (t/ha) is used to estimate nutrient removal by the crop. This helps to determine how much of each nutrient is required to grow the crop (kg/ha), if the soil is in balance i.e. has no deficiencies. The principle is to provide the nutrients that will be removed over the growing season.

Example of calculating nitrogen removal rates:

60,000	heads/ha planted
0.6	kg/head harvested, not trimmed
36,000	kg total removed from the paddock
10	% dry matter (DM)
3,600	kg DM/ha removed
4.50%	N in head dry matter (based on a dry tissue analysis)
162.00	kg N removed with harvest

Figure 1 provides an example of nutrient removal rates for broccoli and cauliflower in kg/tonne. The examples show that broccoli removes more nitrogen than cauliflower. The nutrients in the crop residue will be returned to the soil and become available to the following crop or cover crop as the biomass breaks down. This should be considered in the nutrient budget for the following crops.

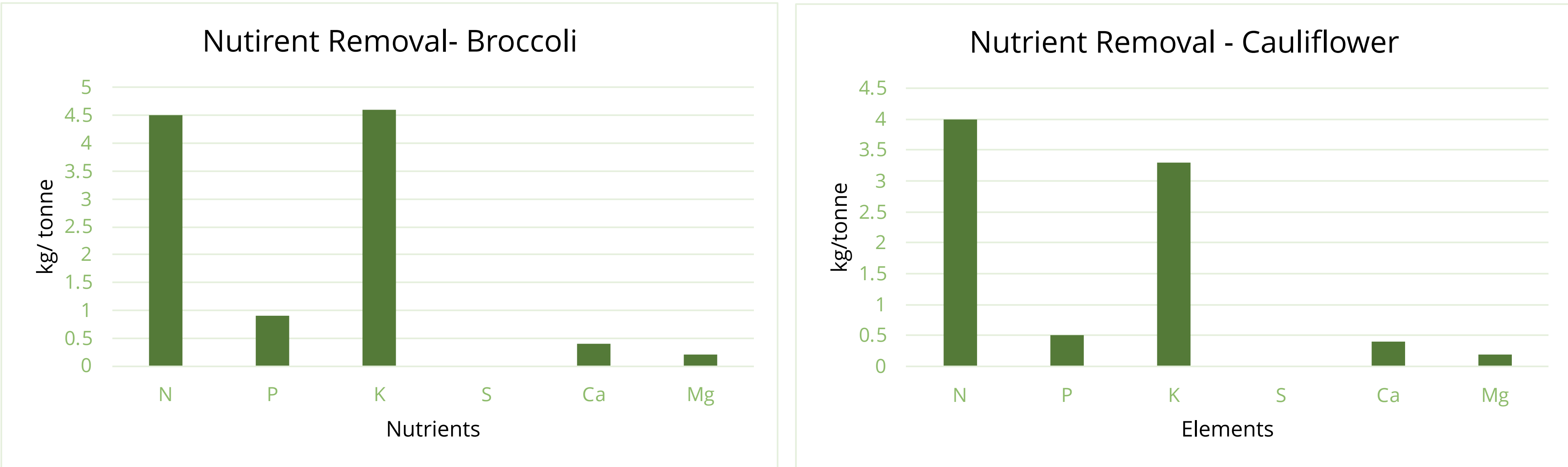


Figure 1: Example of nutrient removal rates for cauliflower and broccoli. Major elements are shown in kg/tonne harvested crop.

Replenishment of nutrients based on removal rates:

N	Match removal rates, reduce for high organic matter soils, potentially increase for depleted soils, or very light soils	3–4 split applications according to growth stages and plant testing results, broccoli needs little N early in its growth; excess N applied early is likely to be lost from the rootzone
P	2–3 x removal rate, potentially more on P fixing soils	P can be pre-spread; P top dressing or foliar applications may be required on P fixing soils based on plant testing results
K	Match removal	Split applications are recommended for light textured soils, topdressing should occur before major growth phases (high biomass production, head development); potassium is commonly required at similar rates as nitrogen
Ca	Up to 2 x removal rate, reduce in high Ca soils	
Mg	Match removal, reduce in high Mg soils	
S	Match removal, increase for depleted soils	Consider sulphur proportion in Mg and K fertilsers

The above approach is based on adding nutrients that correspond with removal rates to a balanced soil with nutrients within the desirable range or 'topped up' to the desirable range as part of a preplant application.

Calculating fertiliser application rates

kg/ha nutrient required ÷ % nutrient in fertiliser x 100 = amount of fertiliser kg/ha to apply.

3. Nutrition strategies and factors affecting nutrient availability and uptake for broccoli and cauliflowers

Refer to the SWICP nutrition products guide and the soil test interpretation guide for more information about nutrients in fertilisers and soil amendment as well as nutrient interactions and their movement in soils and plants. Crop nutrition should consider the following factors that affect the availability of nutrients to plants.

3.1 Factors affecting nutrient availability and uptake

- **Physiological disorders** – Many nutritional disorders are initiated as early as during seed germination. Therefore, it is important to have a relationship with the supplier of seedlings to ensure they are of the required quality and nutrient level/balance.
- **Soil salinity and sodicity** influence the quantity of cations (K, Mg, Ca) that can be taken up by the plant due to cation competition with sodium (Na). High Na levels in the soil have a negative effect on soil structure and therefore affect root health and nutrient movement.
- **Soil structure** – Compaction leads to poor root penetration, water infiltration and drainage which reduces nutrient uptake.
- **Organic matter** affects nutrient availability and uptake positively as it increases porosity (air spaces and water infiltration, storage and drainage); it provides food for soil biology, a high cation exchange capacity and source of nutrients via mineralistaion.
- **Soil biology/microbial composition** – It is important for improving nutrient cycling and plant nutrient uptake
- **Soil acidity or alkalinity (pH)** – Soils can become more acidic or alkaline depending on the type of fertiliser used, which affects nutrient uptake. Nitrogen is the main nutrient affecting pH. Ammonium- based products and urea have the greatest potential to acidify soil. Lime or dolomite can be applied to correct soil pH; dolomite should be used when magnesium is low and lime if calcium is low in the soil. Gypsum can be applied to supply calcium and sulphur to the soil but it does not affect the soil pH.

Other helpful resources

Soil wealth ICP Phase 2 outputs

1. Getting the soil pH right – Lime quality and application rates Fact sheet, January 2019
soilwealth.com.au/resources/fact-sheets/soil-nutrition-and-compost/getting-soil-ph-right-lime-quality-and-application-rates/
2. Managing salinity in vegetable crops Fact sheet, August 2019
soilwealth.com.au/resources/fact-sheets/soil-nutrition-and-compost/managing-salinity-in-vegetable-crops/
3. Soil phosphorus – The basics Fact sheet, September 2019
soilwealth.com.au/resources/fact-sheets/soil-nutrition-and-compost/soil-phosphorus-the-basics/
4. Nitrate field test Fact sheet, January 2020
soilwealth.com.au/resources/fact-sheets/soil-nutrition-and-compost/nitrate-field-test/
5. Taking soil samples fact sheet, January 2020
soilwealth.com.au/resources/fact-sheets/taking-soil-samples/
6. Plant analysis for vegetable crops: A practical guide to sampling, analysis and interpretation, Doris Blaesing, RMCG Version 2 February 2020
soilwealth.com.au/resources/articles-and-publications/plant-analysis-for-vegetable-crops-a-practical-guide-to-sampling-analysis-and-interpretation/
7. Managing sodicity in vegetable crops Fact sheet, may 2020
soilwealth.com.au/resources/fact-sheets/soil-nutrition-and-compost/managing-sodicity-in-vegetable-crops/
8. Soil phosphorus – The basics Fact sheet , September 2019
soilwealth.com.au/resources/fact-sheets/soil-nutrition-and-compost/soil-phosphorus-the-basics/
9. Nutrition management support Fact sheet, June 2020
soilwealth.com.au/resources/fact-sheets/soil-nutrition-and-compost/nutrition-management-resources/
10. Soil Testing and Interpretation for Vegetable Crops, Doris Blaesing, RMCG
soilwealth.com.au/resources/fact-sheets/soil-nutrition-and-compost/soil-testing-and-interpretation-for-vegetable-crops-a-guide/
11. Crop nutrition products – A guide to product types, properties and uses, RMCG, March 2022

Tools/calculators for nutritional needs

1. Nutrient removal Calculator
ipni.net/article/IPNI-3346 or fertilizer.org
2. Fertcare Soil Sampling Guide
fertilizer.org.au/Portals/0/Documents/Fertcare/Fertcare%20Soil%20Sampling%20Guide.pdf?ver=2019-06-17-095413-863
3. Department of Primary Industries and Regional Development Fertiliser Calculator
agric.wa.gov.au/fertiliser-calculator

References

1. IFA – International Fertiliser Association
fertilizer.org
2. AgVita Analytical
agvita.com.au
3. Campbells Fertilisers Australia
campbellsfert.com.au

Appendix

Salinity case study

Many Australian soils are affected by salinity. Werribee South located 32 km south-west of Melbourne is a large vegetable growing region covering an area of 3,000 hectares which consists of a high proportion of lettuce and broccoli/cauliflower production. The Werribee South growing region is part of the Werribee Irrigation District Recycled Water Scheme which provides irrigation water to a large proportion of vegetable farms. The irrigation water is relatively high in salt concentration, containing particularly high levels of sodium and chloride. This high salt level in the water results in high electrical conductivity which fluctuates between 800 mg/L and more than 1000 mg/L, an equivalent EV of 1.4 dS/m to 1.8dS/m. The low rainfall of 542 mm means that the salt is not washed away from the rootzone.

A demonstration trial was conducted at Fresh Select, a vegetable business in Werribee South, to examine the effects of different soil ameliorants including compost, gypsum and calcium thiosulphate on soil and plant sodium levels. The plant sap tests showed that the plants that received the calcium thiosulphate treatment had lower sodium levels in combination with compost compared to the control bay which had only received gypsum. Calcium thiosulphate displaces the sodium from the soil exchange sites. The thiosulphate ion slowly oxidises releasing additional calcium for greater sodium removal compared with gypsum which contains sulphur and has low solubility and an inconsistent release of calcium.

Nutrient functions

Macro nutrients (major elements)

Nitrogen

Nitrogen (N) is an essential component of amino acids for building proteins, nucleic acids and chlorophyll for photosynthesis. Nitrogen is available to the plant in the form of nitrate which in combination with ammonia should not exceed 50kg/ha in the root zone. NUE (Nitrogen Use efficiency %= N removed/ N applied x 100) is calculated after harvest and shows how much N has been used by the lettuce crop.

The key growth stages for nitrogen requirement are during intensive leaf production. Nitrogen requirements will vary between broccoli/cauliflower types and range between 1.6kg/t – 4.7 kg/t.

Phosphorus

Readily available Phosphorus (P) is important for early growth stages to promote root development and to boost establishment in broccoli/cauliflower crops through the vegetative growth stages. Australian soils are low in P which is non- labile (not available for plant uptake). Given the nature of phosphorus availability from soils, P replacement rates need to be higher (2-3 times) more than removal rates especially in heavier P fixing soils which that are high in aluminium and iron (low pH) and high in calcium (high pH). The most common phosphorus sources are superphosphate-based fertilisers (e.g. single super phosphate, SSP 7-9% P or triple superphosphate, TSP 44-46% P). The key difference between single superphosphate and triple superphosphate is that single superphosphate is produced from phosphate rock and sulfuric acid, whereas triple superphosphate is produced from phosphate rock and phosphoric acid. Humic acids, Monopotassium phosphate (MKP) or liquid P fertiliser formulations can help acidify the rootzone to make P more readily available. Nitrogen and Phosphorus can provide a synergistic effect when banded together, N providing an increased amount of P uptake. Good soil structure and organic matter will support microbial activity and mycorrhiza association with the roots which will improve P availability and uptake. Broccoli/cauliflowers utilize around 0.33 -0.67 kg P/t of total fresh matter.

Potassium

Potassium (K) is required for plant water relations by regulating stomatal functions and water use efficiency in plant transpiration. In broccoli/cauliflower crops potassium is in high demand during the mid to late heading stages. Potassium provides strength to plant cell walls enhancing crop vigour, helps form and remove starches, sugars and oils and decreases susceptibility to diseases and insects. According to some agronomic trialling, potassium can increase the flavour profile enhancing the sugar levels in lettuce. K can be applied in the forms of muriate of potash (potassium chloride) and sulphate of potash (potassium sulphate) are the common sources of K and K fertilisers include potassium nitrate and potassium thiosulphate, and mono ammonium phosphate (MAP). Depending on the broccoli/cauliflower type, between 2.7-5.1 kg/t of potassium is required with significant proportions removed in cabbage crops.

Calcium

Calcium (Ca) is essential for root health, growth of new roots and root hairs, and the development of leaves as well as building strong cell walls. Adequate calcium levels in the plant are important for good storage performance.

Calcium uptake is driven by transpiration, i.e., the loss of water through leaves (passive transport). This means that calcium only moves upwards with water, not from leaves to roots (no active transport). Calcium also protects the plant against diseases (fungi and bacteria), regulates stomata aiding with transpiration and contributes to crop quality. The soil pH influences calcium availability, generally more alkaline soil increases the availability of calcium, hence calcareous soils in the Mallee region. Calcium competes with other cations (positively charged ions). Saline soils can impact the uptake of calcium as sodium (Na+) displaces calcium.

Ca is generally in short supply in acid soils. Lime, gypsum, dolomite and superphosphate (a mixture of calcium phosphate and calcium sulphate) all supply calcium to the soil but do not provide readily available Ca to the soil solution. Lime and dolomite raise the pH, gypsum improves soil structure in clay soils but does not change the pH. Peak calcium requirements is at the beginning of head formation. Most calcium is utilised for leaf growth with proportionally lower levels found in the harvested heads. Higher calcium tissue levels improve crop quality and storage.

Lime is often seen as the cheapest option for increasing soil Ca levels, and it is important for increasing the pH of acid soils (via its carbonate component), improving soil structure and microbial activity (as part of the pH and structure effect). However, soluble Ca should be provided especially early in the season, e.g., via liquid fertilisers or calcium nitrate. When using calcium nitrate, care must be taken to not oversupply nitrate N to young crops when uptake is low. Calcium nitrate may be a good topdressing fertiliser.

Magnesium

Magnesium (Mg) is a key component of the green pigment chlorophyll. It is vital for photosynthesis (the conversion of the sun's energy to energy for the plant). Magnesium is required at lower levels in broccoli/cauliflowers than in other crops and removals are between 0.1-0.3kg/t depending on the broccoli/cauliflower crop. Deficiencies occur mainly on sandy, acid soils in high rainfall areas, especially if used for intensive horticulture or dairying. Heavy applications of potassium in fertilisers can also produce magnesium deficiency due to cation competition.

Magnesium deficiency in soils can be overcome with dolomite (magnesium-calcium carbonate, slow availability), magnesite (magnesium oxide) or Epsom salts (magnesium sulphate).

Micronutrients (trace elements)

Boron

Boron (B), together with calcium, helps with the formation of cell walls in rapidly growing tissue. Deficiency reduces the uptake of calcium and inhibits the plant's ability to use it. Boron is one of the most prevalent micronutrient deficiencies in Australian soils used for horticulture.

Boron can be reasonably easily applied to the soil via borax or calcium nitrate plus B. Do not exceed the recommended amount since boron can be toxic. Applications need to be based on soil testing results. Foliar applications work as well, and rates must not exceed label recommendations because B will be phytotoxic if oversupplied. Plant testing can provide information on how much to apply.

Boron uptake is driven by transpiration, i.e., the loss of water through leaves (passive transport). This means that boron only moves upwards with water, not from leaves to roots (no active transport).

However, soil plant testing should be used to confirm the need for B fertilisers to avoid phytotoxicity.

Zinc

Zinc (Zn) helps in the production of a plant growth regulators responsible for stem elongation and leaf expansion. It is readily available in acid soils but is easily outcompeted for uptake by iron in volcanic soils. If zinc levels determined by soil testing are low addition of zinc sulphate can be used to increase soil levels. Zinc is usually added in the preplant fertiliser. Crops can be sprayed with foliar zinc fertilisers if required based on plant testing. Chelated products will be most efficient.

Excessive amounts of Zn can be toxic, so apply only if needed. Zn can compete with other trace metals (e.g., copper, manganese) for uptake.

Copper

Copper (Cu) is an essential constituent of enzymes in plants and can be readily available in some soils, although it can be deficient, especially in red soils. Copper can be applied as copper chelate EDTA, copper sulphate pentahydrate or copper sulphate monohydrate. Overuse of another trace element, e.g., molybdenum, can cause copper deficiency in animals. Overuse can cause toxicity and reduce uptake of other trace metals (e.g., Mn).

Iron

Iron (Fe) is a constituent of many plant compounds that regulate and promote growth. It usually is readily available in naturally acid soils. Deficiencies can be addressed via foliar applications.

These are commonly applied as a complete trace element mix.

Manganese

Manganese (Mn) helps with photosynthesis. It is freely available in naturally acid soils, often in toxic amounts in very acid soils, but can be deficient in sandy soils. Toxicity is remedied with lime.

Molybdenum

Molybdenum (Mo) helps bacteria and soil organisms convert nitrogen from the air to soluble nitrogen compounds in the soil, so is particularly needed by legumes. It is also essential in the formation of proteins from soluble nitrogen compounds taken up from the soil or leaves.

Molybdenum deficiency is prevalent in many acid soils but can be remedied easily with applications of Mo super, molybdenum trioxide (applied during inoculation and lime pelleting of legume seed), or sodium molybdate (sprayed on emerging and young plants).

For analysis of nutrients in soil testing refer to the Soil Testing and Interpretation for Vegetable Crops guide published as part of the Soil Wealth Integrated Crop Protection Project for the Australian Vegetable Industry