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CGA CARNARVON GROWERS ASSOCIATION

Farmnote

Number 01

Fertilising tomatoes in Carnarvon

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Background information

Plant nutrients

Plants require 12 elements from the soil. The macro elements are required in large amounts and include nitrogen, phosphorus, potassium, calcium, magnesium, sulphur. The micro elements or trace elements are required in much smaller amounts and include manganese, zinc, iron, copper, molybdenum, boron. If the plant cannot access sufficient amounts of any of these nutrients then growth is affected.

Figure 1 shows an idealised yield response to a fertiliser nutrient. If the nutrient is deficient then the crop yield is reduced. There is a large range of nutrient application rates where maximum yield is achieved (adequate range), though to reduce fertiliser costs it is ideal to apply the minimum amount of fertiliser to reach the flat section of the graph. In some cases, very large nutrient applications can result in reduced crop yield or quality may suffer (adequate and excessive range).

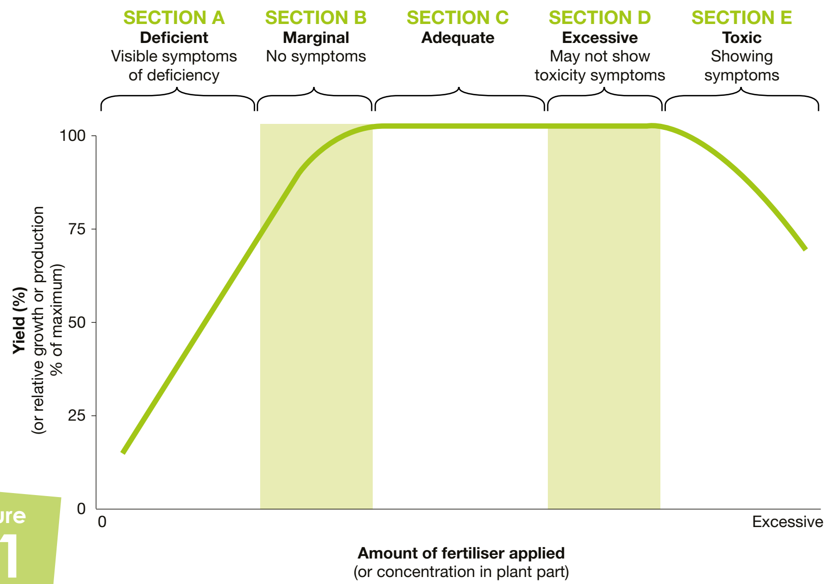
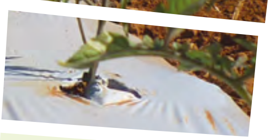


Figure 01

Idealised crop response curve to nutrient application



The alluvial soils at Carnarvon are well suited to tomato production and have a good natural fertility. The soil at Carnarvon is alkaline with a pH_{water} of around 7.5 to 8.0.

Different nutrients behave differently in the soil. Some are more mobile and can leach from the crops root zone while others are bound tightly to the soil and become less available to the plant. Table 1 outlines how nutrients behave in loamy, alluvial soils such as those at Carnarvon.

Table 1. Mobility of nutrients in the soil at Carnarvon

Nutrient	Mobility in the soil	Comments
Nitrogen	Mobile especially with excessive irrigation.	Apply at least every two or three weeks.
Phosphorus	Immobile. Can be tightly bound to the soil.	Can apply once per crop prior to planting or can apply more frequently if desired.
Potassium and magnesium	Held by clays and organic matter and released for plant growth.	Carnarvon soils contain naturally high levels of potassium.
Zinc, copper manganese, iron	Immobile on all soils. Less available to the plant in high pH soils.	Leaf analysis of crops grown in Carnarvon commonly shows marginal zinc levels.
Boron	Mobile.	Not required in Carnarvon as it is present in irrigation water.

How to determine how much fertiliser to apply

Growers should use some or all the following pieces of information to develop a fertiliser program:

- Look at plant growth and for visual deficiency symptoms
- Monitor yield and fruit quality
- Conduct leaf analysis
- Conduct soil analysis
- Analyse the nutrients in the irrigation water and make allowances for what is applied in the fertiliser program
- Compare your fertiliser rates with other growers and district recommendations

Fertiliser bench marking study

In 2016 the Carnarvon Growers Association (CGA) received funding to benchmark growers' practices. As part of this study leaf, soil and water samples were taken for analysis from ten tomato properties and the growers' fertiliser programs were recorded. The results provide a good insight into current fertiliser management of tomatoes at Carnarvon. Some of the results are summarised below.

Rates of nutrients applied by the growers

Table 2 shows the amount of nitrogen, phosphorus and potassium applied by growers involved in the tomato bench marking study. A wide range of rates of each element was applied. The ratio of nitrogen: phosphorus: potassium that was applied varied widely between the growers.

The crops were planted in May or June and had similar planting densities. The yields achieved by the growers were similar and those growers applying more fertiliser did not achieve a higher yield. The amount of each nutrient removed from the field in a 100 tonne per hectare crop is also shown in Table 2, as is a general recommendation for the how many kilograms of nitrogen, phosphorus and potassium to apply per hectare per crop. The cost of the fertiliser programs

Table 2. Rates of nitrogen, phosphorus and potassium applied by tomato growers in the benchmarking study

Grower	Nitrogen (kg/ha/crop)	Phosphorus (kg/ha/crop)	Potassium (kg/ha/crop)	Cost of fertiliser ($/ha)
1	186	40	425	2961
2	648	54	317	4535
3	190	44	693	5415
4	534	100	835	9203
5	688	56	1065	8617
6	376	78	875	6503
7	382	55	939	7595
8	178	25	576	3785
9	358	114	636	5818
10	688	56	1065	8617
Crop removal	**140**	**58**	**260**	
Recommendation	**350 to 400**	**75**	**300**	

also varied considerably across the ten growers.

Many of the growers involved in the study did not have a good understanding of basic plant nutrition, how different nutrients behave in the soil and the rates of each nutrient that they were applying.

Greater use of soil, leaf and water analysis and assistance from a qualified agronomist could result in many of the growers involved making considerable savings in their fertiliser programs.

Fertiliser rate trials either on farms or at Gascoyne Research Station could help demonstrate that reductions can be made without affecting quality or yield.

Leaf analysis results

Analysing the concentration of each of the essential plant nutrients in the leaves of a crop is a useful tool for determining if the crop has deficient, adequate or excessive amounts of that nutrient. Table 3 shows the leaf analysis results from the ten growers in the benchmarking study.

The leaf analysis results in Table 3 highlight a number of findings:

- All nitrogen levels are adequate despite a big range of nitrogen application rates. The growers who applied lower rates of nitrogen had sufficient levels of nitrogen in their leaves.
- Two of the growers crops had marginal leaf phosphorus levels.
- The potassium levels in the leaves were adequate in all samples. The CGA have never seen low potassium levels on any crop at Carnarvon (Annie van Blommestein pers. comm.).
- Magnesium levels were adequate in all samples despite some of the participants not applying any Epson Salts (magnesium sulphate).
- The high levels of copper are due to contamination of leaves by copper fungicide sprays.
- Zinc concentrations were low in two samples and marginal in one.

Soil analysis results

Table 4 shows the soil analysis results from the ten growers involved in the benchmarking study.

The soil analysis results in Table 4 highlight a number of findings:

- The pH $_{water}$ of the soils was generally between 7 and 8 which is typical for Carnarvon.
- The soil on two of the properties had a salinity (EC) above that recommended as suitable for growing tomatoes (the critical level of $EC_{1:5}$ for tomatoes is about 0.3 dS/m). However, the corresponding leaf samples from

Table 3. Leaf analysis results from the tomato growers benchmarking study

		Grower									
Nutrient	Units	1	2	3	4	5	6	7	8	9	10
Nitrogen	%	4.7	4.8	5.3	5.5	6.0	4.8	4.8	5.8	4.6	4.2
Phosphorus	%	0.41	0.47	0.54	0.68	0.97	0.37	0.44	0.34	0.47	0.44
Potassium	%	3.8	3.5	3.4	3.5	3.8	3.8	3.9	3.1	3.7	3.3
Magnesium	%	0.28	0.43	0.51	0.63	0.53	0.46	0.45	0.53	0.51	0.49
Copper	mg/kg	565	142	278	143	13.7	390	500	29	166	15.1
Zinc	mg/kg	35	116	81.8	30	133	69	64	15	13	13

Concentrations: Low Marginal Adequate High

Table 4. Soil analysis results from the ten properties

		Grower										
	Units	1	2	3	4	5	6	7	8	9	10	Virgin site
pH		7.8	7.6	7.4	7.5	6.8	8	7.6	6.8	7	6.9	7.6
EC $_{1:5}$ (salinity)	dS/m	0.09	0.10	0.16	0.16	0.12	0.20	0.66	0.80	0.14	0.14	0.04
Organic carbon	%	0.6	0.6	0.4	0.8	0.5	0.6	0.8	0.7	0.4	0.6	0.4
Phosphorus	mg/kg	67	96	51	40	105	41	67	67	85	118	24
Potassium	mg/kg	846	1069	874	415	785	796	1029	1029	602	732	657

Concentrations: Low Satisfactory High

tomatoes grown in this soil did not have elevated sodium or chloride levels.

- Seven of the growers soil samples showed low soil phosphorus levels (Colwell P).
- The potassium levels in the soil samples were very high (Colwell K). Samples taken from virgin soils adjacent to the horticultural area also showed very high levels of available potassium.

Water analysis results

Water analysis results from Gascoyne Water Cooperative bores show that the water contains significant amounts of some nutrients. The amount of these nutrients in the irrigation water should be taken into account when developing a fertiliser program. Table 5 shows approximately how much nutrient is supplied by applying 6000 KL/ha of irrigation water. For example, applying 6000 KL/ha supplies 90 kg magnesium per hectare which is most or all of a tomato crops annual requirement. Basin A water should be analysed for its nutrient content as the nutrient concentration of different bores varies considerably.

First prune of tomatoes

Fertiliser recommendations

Table 6 gives general recommendations for the amount of major nutrients that should be applied in a fertiliser program for tomatoes in Carnarvon. These recommendations should be modified based on past experience, crop yield and quality, and soil, leaf and water analysis. They take into account typical contributions from the irrigation water and soil reserves.

Fertiliser recommendations from other areas are often not appropriate for Carnarvon. The soils in Carnarvon are fertile and contain significant amounts of many nutrients and the irrigation water contains high concentrations of some nutrients.

Growers in Carnarvon use a range of fertilisers. The recommendations in Table 6 will need to be converted to kilograms of fertiliser per hectare based on the percentage of each nutrient in the fertiliser. There are many different fertiliser programs that achieve good results. Though as shown in Table 2 the cost of individual programs can vary greatly. A good fertiliser program needs to apply sufficient amounts of each element at the appropriate time.

Table 5. The approximate amount of nutrients supplied to a tomato crop when applying 6000 KL/ha of irrigation water

Nutrient	Typical concentration in the water (mg/L)	Irrigation applied (KL/ha/crop)	Supplied to crop from irrigation water (kg/ha/crop)
Potassium	15	6000	90
Magnesium	15	6000	90
Calcium	40	6000	240
Sodium	100	6000	600
Sulphur	25	6000	150

Table 6. General recommendations on the rate of fertiliser applied nutrient for tomatoes in Carnarvon

	Nitrogen (kg/ha/crop)	Phosphorus (kg/ha/crop)	Potassium (kg/ha/crop)	Magnesium (kg/ha/crop)
Recommendation	350–400	75	300	0–30

For newly developed land or virgin soils it is likely that higher rates, particularly of phosphorus and trace elements, will be required.

Leaf analysis

Leaf analysis should be conducted to determine if the crop is accessing sufficient nutrient. Table 7 shows the leaf analysis standards for tomatoes. The leaf sample should be taken from the youngest fully emerged leaf when the first mature fruit is present. The nutrient concentrations in the leaves vary thought the year and the standards for assessing the leaf analysis results are for this growth stage only. Separate samples are needed for different varieties, and for blocks that have had a different fertiliser history.

Nitrogen

The detrimental effects of applying excessive amounts of nitrogen on tomato quality are well documented. The shelf life, firmness and the sugar content of the fruit can be reduced. Excessive nitrogen may also result in poor flowering and excessively large fruit.

There was a wide range of nitrogen fertiliser application rates used by growers in the survey (178 kg N/ha to 688 kg N/ha). All leaf analysis results showed sufficient nitrogen levels. Growers applying more nitrogen did not report higher yields with all growers reporting that their crops yielded about 7 kg/plant. Growers in the survey were using a range of nitrogen sources such as potassium nitrate, calcium nitrate, urea and Polyfeed™.

It is likely that the growers using high rates of nitrogen can reduce the amount that they are applying without affecting yield.

Table 8 gives some general recommendations on how the total amount of nitrogen applied should be proportioned over the life of the crop.

Phosphorus

Phosphorus will not leach from the horticultural soils in Carnarvon and it is very likely that all past applications of phosphorus fertilisers will be retained in the top metre of soil. The Phosphorus Buffering Index (PBI) is moderate. This indicates that some of the past phosphorus applications will be bound by the soil and will not be readily available for plant growth, but a proportion will be available to subsequent crops.

On soils with a long history of phosphorus application and for crops where leaf analysis shows adequate phosphorus levels only a maintenance application of phosphorus is required (see rates in Table 6). Most of the growers were applying phosphorus as mono ammonium phosphate (MAP) or as Polyfeed™ throughout the crops life.

Table 7. Optimum leaf nutrient concentrations for tomatoes

Nutrient	Deficient	Low	Normal	High	Excess
Nitrogen (%)	< 3	3.0–3.5	4.0–5.5	> 6.0	
Phosphorus (%)	< 0.25	0.25–0.30	0.4–0.7	> 0.8	
Potassium (%)	< 2.0	2.0–2.9	3.0–5.0	> 6.0	
Calcium (%)			1.5–3.0		
Magnesium (%)	< 0.25	0.25–0.30	0.4–0.8	> 0.8	
Sulphur (%)			0.4–1.0		
Sodium (%)			0–0.4	0.5–0.6	> 0.6
Chloride (%)			0–1.6	1.7–1.8	> 2.0
Copper (ppm)		< 5	5–200		
Zinc (ppm)	< 18	18–19	20–200		
Manganese (ppm)		20–25	25–500	>700	
Iron (ppm)			100–300		
Boron (ppm)	<12	15–20	25–100	>200	

Source: Weir and Cresswell, 1993

Table 8. General recommendations on the time of nitrogen application over the tomato crops life

Days after transplanting	0–14	15–28	29–42	43–63	64–84	85–112	113–140
% of total application	5%	12%	20%	20%	17%	17%	9%

Two of the growers in the survey had crops that showed marginal phosphorus levels in their leaf samples. If leaf phosphorus levels are low or marginal apply higher rates of phosphorus to that crop and subsequent crops. Ideally the phosphorus should be banded along the planting line to reduce fixation by the soil. Higher rates should also be applied to crops that are to be established on land that has not previously been used for horticulture.

Excessive phosphorus applications can exacerbate zinc deficiency.

The soil test (Colwell bicarbonate extractable phosphorus) used in the bench marking study showed that six of the ten properties had low phosphorus levels. However, these low soil phosphorus levels did not reconcile well with the leaf test results where only two of the properties had marginal phosphorus levels. The Colwell soil test is the most common soil test used in Western Australia for measuring plant available soil phosphorus. However previous work on alkaline soils showed a poor correlation between Colwell soil phosphorus levels and leaf phosphorus levels (Allan McKay pers.com.). The usefulness of the Colwell soil phosphorus test on the alkaline soils at Carnarvon requires further investigation.

Potassium

All the horticultural soils in Carnarvon naturally contain large amounts of plant available potassium (Table 4). The irrigation water also contains potassium (Table 5). Typically tomatoes in Carnarvon are irrigated with about 6000 KL/ha/crop. This supplies 90 kg potassium per hectare which is equivalent to applying nine bags of potassium sulphate per hectare.

Fertiliser recommendations from other regions contain large quantities of potassium fertiliser. These rates of potassium are not required in Carnarvon because of the large amounts of potassium found naturally in the soil and irrigation water.

There was a wide range of potassium fertiliser rates used by growers in the survey (317 kg K/ha to 1065 kg K/ha). All leaf analysis results in the bench marking survey showed adequate potassium.

Potassium fertiliser trials on tomatoes conducted at Gascoyne Research Station in the 1970's showed that 300 kg of potassium per hectare was more than sufficient to obtain maximum yield.

Growers in the survey were using a range of potassium sources such as potassium nitrate, potassium sulphate, Polyfeed™ High K and Polyfeed™ Low K. When used by itself the nitrogen to potassium ratio of Polyfeed High K is not appropriate for most crops in Carnarvon as the percentage of potassium is too high.

Growers can reduce the level of potassium that is being applied in their fertiliser programs by:

1. Swapping some potassium nitrate for calcium nitrate. This would apply a similar amount of nitrogen and is a cheaper option if the potassium is not required.
2. Swapping some Polyfeed High K for Polyfeed Low K. This also would result in the application of more nitrogen and phosphorus.

Table 9 shows the nutrient concentration of potassium fertilisers that are commonly used in Carnarvon. Prices are also given (2016 prices).

Two of the growers in the survey believed that on cloudy days potassium uptake by the plant may be reduced and this leads to green shoulders on the fruit. Poor potassium uptake on crops can occur on such days in spite of high soil potassium levels so applying extra potassium to the soil may not alleviate the problem. Foliar applications of potassium may be beneficial in such cases.

Magnesium

No trials have been conducted to determine the magnesium requirements of tomatoes at Carnarvon. The irrigation water contains about 15 mg/L of magnesium, which when applied at 6000 KL/Ha supplies 90 kg magnesium per hectare. This would probably supply most or all of the crops magnesium requirements.

There was a wide range of magnesium fertiliser application rates used by growers in the survey (7 kg Mg/ha to 89 kg Mg/ha). Four of the ten growers applied no magnesium sulphate (Epsom salts). Polyfeed™ has a low magnesium content.

All leaf analysis results in the bench marking survey showed adequate magnesium levels.

If magnesium is required by tomato crops in Carnarvon it will be at low rates.

Table 9. Nutrient concentration of potassium fertilisers that are commonly used in Carnarvon

Fertiliser	% N	% P	% K	$/bag (25 kg)
Potassium nitrate	13.4		38	$50
Potassium sulphate			41.5	$40
Polyfeed High K	12	2.2	33.2	$63
Polyfeed Low K	19	8.4	15.8	$54
Calcium nitrate	15.5			$20

Blossom end rot.

Calcium

The irrigation water in Carnarvon contains calcium and a considerable amount is applied to the crop from this source. Typically, the water in Carnarvon contains around 40 mg/L of calcium. Applying 6000 kilolitres of water per hectare at this concentration will supply 240 kg/ha of calcium. Calcium is also supplied to the crop in fertilisers such as calcium nitrate. Calcium is more available to the plant in alkaline soils, such as those at Carnarvon, than in acid soils.

Gypsum contains 23% calcium and is a cheap calcium and sulphur fertiliser. Leaf analysis results from the tomato benchmarking study showed adequate or high calcium (and sulphur) levels despite some growers not applying gypsum. Given the calcium in the water and in other fertilisers it is unlikely that additional calcium in the form of gypsum is required for most crops in Carnarvon.

The exact cause of blossom end rot in tomatoes is often unclear, but it is usually associated with low calcium supply, high temperatures, high nitrogen fertilising, high crop loads and under watering. Calcium moves slowly through plants and there may a shortage at the blossom end of the fruit. Calcium deficiency in the plant can occur despite high soil calcium and leaf calcium levels. Muller (1993) found that the application of gypsum did not reduce the incidence of blossom end rot in tomatoes. Refer to the separate publication titled 'Gypsum recommendations for horticulture in Carnarvon'.

Trace elements

In the benchmarking study zinc was the only trace element that showed up as marginal or low in the leaf analysis (3 of 10 growers).

Zinc deficiency is common in crops in Carnarvon as the high soil pH makes zinc less available to the plant.

If leaf zinc levels are low consider applying foliar applications of zinc to the crop. In the following year apply:

- Zinc sulphate prior to planting, or
- Zinc sulphate or chelate (EDTA) via the irrigation ■

References

1. Muller, A.T. (1993). Effect of gypsum, deep ripping and irrigation on determinate tomatoes. *Australian Journal of Experimental Agriculture*, 33:803-6.
2. Weir, R.G. and Cresswell, G.C. (1993). Plant nutrient disorders 3. Vegetable crops. Inkata Press, Melbourne Sydney, Australia.

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For more information on this and other projects in the Carnarvon region:

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