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Carrot nutrition and irrigation

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Carrot production in Western Australia in 1989 was 31,000 tonnes, of which 17,500 tonnes were exported, mostly to south-eastern Asia. There, Western Australia has a reputation for supplying carrots of high quality.

The appearance of our carrots - straight and smooth skinned - is largely a result of crops being exclusively grown on sandy soils on the coastal plain between Bunbury and Guilderton. The Mediterranean climate with a maritime influence in this area makes carrot growing possible for 12 months of the year, allowing efficient use of machinery, land and water.

The sandy soils, while giving good root quality, present special problems in nutrition and irrigation management.

Soils

Soils for carrot production should be free draining, low in salts and have a pH range from 6.0 to 7.0.

Nutrition

Carrots were traditionally grown in rotation with other heavily fertilised crops such as cauliflower or potatoes. The crop residues left after growing these crops, when incorporated into the soil and decomposed, are often sufficient to grow a carrot crop without additional fertiliser.

Development of the export market to south-east Asia has led to the introduction of expensive mechanical aids to grow the crop. The cost of servicing borrowings on machinery and the export market's demand for consistent supply has led to more frequent cropping and even continuous cropping and also to greater fertiliser use to advance maturity.

The expected levels of some nutrients in plant tissues of healthy crops are shown in Table 1.

Poultry manure

Carrots, unlike most other vegetable crops, have not traditionally had animal manures, such as poultry manure, applied before planting or as a side dressing, for fear of root forking. Trials at Medina Vegetable Research Station have shown that yield increases and advanced maturity can be achieved by using poultry manure as a pre-planting treatment without increasing the percentage of root forming.

Despite these findings, the practice cannot be recommended because the use of poultry manure was associated with elevated levels of some heavy metals, which may be harmful to human health. Although the levels were below World Health Organisation standards, they could be higher under some growing conditions.

Table 1. Levels of nutrient elements found in tissues of healthy crops of summer-sown Western Red carrots

Element	Time from sowing (weeks)	Tissue levels, as %, found in		
		All leaves (average)	All petioles (average)	Whole tops
Nitrogen, N	8	3.75-4.5	1.30-1.6	2.9-3.2
	12	3.30-3.8	0.85-1.1	2.4
Phosphorus, P (lower levels are for a crop on a soil with the critical soil test level of 60 ppm P)	8	0.42-0.45	0.34-0.45	0.40
	12	0.32-0.33	0.27-0.35	0.36
Potassium, K (lower levels are for a crop on a soil with a level of 40 ppm K)	8	1.4-2.4	4.3-7.0	3.0
	12	1.4-2.2	4.3-6.7	3.1
Calcium, Ca (suggested levels)	8	3.4-3.9	1.4-1.9	3.1
	12	3.5-4.1	1.4-1.7	3.2
Magnesium, Mg (suggested levels)	8	0.37-0.52	0.19-0.26	0.35
	12	0.38-0.50	0.16-0.21	0.33

In addition, the nutrients in poultry manure are largely leached beyond the root zone of the crop when it is applied as a pre-planting treatment to a direct-sown crop like carrots. These nutrients have been implicated in surface and ground water pollution on the Swan Coastal Plain.

Mineral fertilisers

Nitrogen (N)

Nitrogen is the most important plant nutrient for high yields but is also the most difficult for growers to judge the best rate to apply. This is particularly so on sandy soils where it is readily leached. Rainfall and irrigation rate can make big differences in the nitrogen rate that will maximise yield.

Research in Western Australia has consistently shown that root yields of Western Red, grown on infrequently cropped sandy soils with good irrigation practice, are maximised by nitrogen fertiliser rates that provide between 215 and 280 kg elemental nitrogen/ha.

Increasing the rate of nitrogen applied increases yields of both roots and tops and shortens maturity time. Large tops can result in lodging in winter (tops fall over). Lodging makes harvesting impossible or causes tops to choke cutters on the harvesting, leaving a stub of stem on the carrot, which must be trimmed in the packing house.

Successful growing of varieties with large tops such as Western Red is a compromise between managing top size and achieving high yields. The compromise that most growers reach is to use nitrogen fertiliser rates that provide 100 to 150 kg elemental nitrogen/ha to control top size. Delayed maturity is the price paid for this practice, but harvesting is made easier and packing house labour is reduced.

Varieties with small tops such as Nanco, Tip Top and Nandor can be fertilised with less consideration for top control. Their naturally shorter maturity times can be shortened further by applying optimum nitrogen rates.

Deficiency symptoms: Nitrogen deficiency symptoms are common in carrot tops close to harvest. The symptoms are yellowing of old leaves with associated red tints in old and young leaves.

Phosphorus (P)

The rate and timing of phosphorus applications depend on crop history, irrigation and soil type. Phosphorus strategies vary according to the type of coastal sands on which carrots are grown.

Spearwood sands, red sands overlying limestone, are closest to the coast. They support tuart trees in their native state. Spearwood sands are normally reasonably high in native phosphorus and retain applied phosphorus well.

Soil tests on Spearwood sands can be useful in determining rates of phosphorus to apply. No increase in yield can be expected from applied phosphorus on these sands if soil test level (Colwell method) is above 60 ppm phosphorus.

Karrakatta sands are yellow-brown soils that lie further inland. They also support tuart trees in their native state. Like Spearwood sands, they retain phosphorus and in some cases, a soil test of 60 ppm may be adequate. In most cases it is wise to apply phosphorus fertiliser even at this soil test level.

Bassendean sands are grey sands that are further inland. They, and the associated **Gavin** and **Joel white sands**, support banksia and jarrah in their native state.

Bassendean sands are low in phosphorus in their native state and applied phosphorus is readily leached below the root zone of the crop. Ultimately, this fertiliser will find its way into water courses and the water table. They may require modification with soil improving agents to allow cropping without causing unacceptable levels of water pollution. Split applications of phosphorus throughout the life of the crop are the best compromise if a soil improving treatment has not been applied.

On Spearwood and Karrakatta sands, which retain phosphorus, pre-planting applications with a fertiliser such as superphosphate are acceptable.

Rates of phosphorus applied pre-planting have been shown to depend on irrigation practice. Rates as high as 140 kg elemental phosphorus/ha may be needed with twice daily irrigation on virgin soils. In trials, there was no loss in yield with rates as low as 100 kg phosphorus/ha if water was applied four times a day.

Deficiency symptoms: Phosphorus deficiency in carrots is not common in commercial practice but can be recognised by stunted top growth. Purple tints in the foliage appear with severe deficiency.

Purple tints are also related to low temperatures in winter and these should not be confused with phosphorus deficiency.

Potassium (K)

Potassium leaches from all three types of coastal sand almost as readily as nitrogen. Plants will compensate to a degree by storing potassium in times of good supply and mobilising the stored potassium and moving it around the plant when potassium levels in the soil are low. Despite this, it is accepted practice on sandy soils to apply potassium (potash) fertiliser regularly throughout the life of the crop.

Soil testing for potassium is only meaningful on Spearwood sands, where potassium has been shown to resist leaching in the 40 ppm K range. This level was adequate for one crop of carrots without yield loss. Applications of potassium to this soil were largely leached during the life of the crop.

Deficiency symptoms: Potassium deficiency is most common on Bassendean sands soon after germination, because soil levels are often low and applied potassium quickly leaches past the root zone. Marginal yellowing and scorching of cotyledons and older leaves are symptoms of severe deficiency.

Potassium deficiency can easily be confused with water stress of seedlings being established during hot periods in summer, and with damage by thrips in spring.

Calcium (Ca)

Calcium rarely needs to be applied separately if soil pH is maintained in the recommended range and superphosphate is used as a source of phosphorus. Superphosphate contains about 20 per cent calcium.

Magnesium (Mg)

Magnesium is one of the more common deficiencies in carrots, especially in acid Bassendean sands. In most cases, side dress magnesium up to four times during the life of the crop. The symptom of deficiency is bright yellow patches between the veins of the old leaves, especially close to harvest.

Manganese (Mn)

Manganese is sometimes deficient in crops grown on alkaline Spearwood sands where soil pH can be as high as 8.0 and limestone is present at depth.

Symptoms of manganese deficiency are a general yellowing of all leaves and poor growth. Close examination of affected leaves shows that yellowing is largely between the veins.

Crops show manganese deficiency when the tissue test levels for whole tops are below 30 ppm. Deficiencies can be corrected readily by foliar spraying with manganese sulphate.

Boron (Bo)

Boron deficiency is blamed for many problems in carrots but it is rare in commercial crops. Boron leaches readily in sandy soils, so that where boron is deficient, soil applications should be made before planting and while the crop is growing.

A symptom often attributed to boron is browning below the skin known as '5 o'clock shadow'. Oxidative browning of carrots resulting from bruising during the washing process is often confused with this symptom. Boron levels of 50 to 60 ppm have been recorded in healthy whole tops at 12 weeks.

Zinc (Zn)

Zinc deficiency is sometimes seen in carrots on alkaline soils where high rates of phosphorus have been applied.

New leaves are yellow, small and distorted, giving the tops a rosette-like appearance. Deficiency symptoms are seen most often in mid-summer. Tissue levels as low as 25 ppm have been recorded in healthy whole tops. Foliar sprays will correct a deficiency.

Fertiliser programs

Fertiliser programs suggested for carrots on new land, or where crop residues are poor, are shown in Table 2 for three cropping situations. The nutrients needed by a crop over its whole life are shown in Table 3.

Table 2. Suggested fertiliser programs for new land or where crop residues are poor (soil phosphorus test less than 5 ppm)

Time from sowing (days)	Application rate, kg/ha					Application method
Before sowing						
0-7 days	1200 superphosphate and 140 trace element mix (see Table 4)					broadcast
After sowing	**Ammonium nitrate†**	**Potassium nitrate**	**Complete fertiliser (NPK)††**	**Magnesium sulphate**	**Borax**	
14		25				sprinklers
21		50				sprinklers
28		50				sprinklers
35		50 or 100*		50	5	sprinklers
49	60†		120			broadcast
63	60†		120			broadcast
77	60†		120	50	5	sprinkler and broadcast
91**	60†		120			broadcast
105#	60†		120	50		sprinkler and broadcast
129##			120		5	broadcast
143##			120			broadcast

† Use ammonium nitrate only on small top varieties (Nanco, Tip Top, Nandor).
†† Use *one* of NPK red, NPK blue, Nitrophoska, or Komplete Blau.
* The higher rate to be applied on a summer grown crop only.
** Last application for summer program for Nanco, Tip Top, Nandor.
# Last application for summer Western Red, Majestic Red and Red Hot and winter Nanco, Nandor and Tip Top.
Extra applications for winter Western Red, Majestic Red and Red Hot.

Table 3. Approximate total nutrients needed over the whole life of crops (kg element/ha)

Crop type and nutrient	Variety	
	Western Red (large top)	**Nanco, Tip Top, Nandor (small top)**
Summer crop		
Nitrogen, N	101	168
Phosphorus, P	145	138
Potassium, K	182	162
Winter crop		
Nitrogen, N	130	197
Phosphorus, P	160	145
Potassium, K	220	163

Table 4. Trace element mix - 140 kg of mix consists of:	
Borax	11 kg
Copper sulphate	18 kg
Ferrous sulphate	18 kg
Magnesium sulphate	50 kg
Manganese sulphate	25 kg
Sodium molybdate	2 kg
Zinc sulphate	16 kg

How to use Table 2 - an example

Nandor is to be planted in March, for harvest in July; anticipated maturity 126 days.

Step 1 **Q:** Is ammonium nitrate recommended on Nandor?
A: Yes.

Step 2 **Q:** Summer or winter crop?
A: Winter.

Step 3 **Q:** How many days until side dressings are complete?
A: 105 days for winter Nandor (see footnote marked #).

The fertiliser program is thus:

Before sowing: 1200 kg/ha superphosphate
140 kg/ha trace element mix

After sowing: Kilogram per hectare of fertiliser

Days after sowing	Ammonium nitrate (Agran 34)	Potassium nitrate	NPK	Magnesium sulphate	Borax
14		25			
21		50			
28		50			
35		50		50	5
49	60		120		
63	60		120		
77	60		120	50	5
91	60		120		
105	60		120	50	
Total	300	175	600	150	10

The total main nutrient elements applied are 197 kg/ha of nitrogen, 145 of phosphorus and 163 of potassium.

Irrigation

All carrots are grown with overhead irrigation, either butterfly sprinklers at 6 m x 6 m spacing or impulse (knocker) sprinklers at 12 to 15 m x 12 to 15 m. All water is from underground aquifers.

Sandy soils have a low moisture holding capacity and irrigation is needed from one to four times daily in summer. The only practical method of scheduling irrigation on these soils is by evaporation replacement.

To schedule irrigation, growers should construct their own evaporimeter, or use evaporation data from Agriculture Western Australia research stations or local Bureau of Meteorology figures. Details of scheduling are given in Farmnote No. 23/90 'Irrigation scheduling - how and why' (Agdex 561).

Irrigate to replace daily evaporation plus 50 per cent for carrots on sandy soils. The following example illustrates how to schedule irrigation using evaporation data.

Example of irrigation scheduling

Pan evaporation (previous day) = 10 mm

Crop factor = 1.5

Sprinkler output rate = 0.12 mm/min

Total watering time = (Evaporation x crop factor) *divided by* (Sprinkler output rate)

= (010 x 1.5) *divided by* 0.12

= 125 minutes per day

To use this method, you must determine the output rate of your sprinklers. This can be done by measuring output with 5 to 10 rain gauges placed in the sprinkler bed for a 14 day period and recording times and rain gauge levels.

At the end of the period, take the average of times and rain gauge readings.

Output rate = (average rain gauge reading, in mm) *divided by* (average watering time, in minutes).

If unsure of rain gauge layout and method, contact your local Agriculture Western Australia Development Officer.

Irrigation rates during the germination and establishment phase can be higher and should be more frequent than those derived from the pan evaporation method.

For crops with three true leaves through to the half grown stage, irrigation, can be less than 150 per cent of evaporation replacement.

The effectiveness of fertiliser programs given in this Farmnote will depend on the irrigation rates applied. If irrigation scheduling is not adopted as described, the fertiliser programs given above may be inadequate.

Water quality

Carrots are sensitive to salty water. Germination and establishment can be badly affected if the total salt content of irrigation water is greater than 240 mS/m (millisiemens per metre). Carrots will grow best if total salts content is less than 80 mS/m.

Further reading

- Farmnote No. 89/86 'Diseases and pests of carrots' (Agdex 267/630) = AgFax Document No. 23606.
- Farmnote No. 93/90 'Planting and harvesting carrots' (Agdex 267/20).
- Farmnote No. 95/90 'Weed control in carrots' (Agdex 267/640).
- Bulletin 4175 'Nitrogen and phosphorus disorders of vegetable, crops' (Agdex 250/632).

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