Factsheet 14/13

Field Vegetables

Asparagus nutrient management

Daniel Drost, Utah State University

This factsheet summarises a wide range of literature to provide best practice for nutrient management in asparagus. Climatic conditions in the UK are such that production of asparagus is not as prolific as it is in more favourable climates. In order to be successful, attention to detail in every aspect of growing asparagus must be addressed. Asparagus nutrition is one important topic that growers need to manage to achieve the best potential.

Action points

- Soil test and correct for pH, phosphorus, potassium and any trace nutrient in the year prior to establishing a new asparagus field.
- Apply sufficient nitrogen fertiliser during the establishing years to grow healthy fern.
- Once established, supplement nutrients to meet replacement needs of nutrients removed during harvest.
- Nutrient applications before or during harvest have little impact on present years productivity as spear growth is dependent on prior years nutrient storage.
- Nutrient deficiency symptoms are not common and careful fern and root testing are needed to identify if they exist.

Summary

Asparagus is a herbaceous perennial vegetable grown for its immature shoots generally called “spears”. The growth of spears depends on energy and nutrients stored in the roots which were produced or stored during the previous growth period. While harvested spears remove very little nutrients from the field, large quantities of nutrients are found in the storage roots, crown and fern. Nutrient needs are quite high during the early growth years as the plant develops its large root system. Once a field is fully mature, asparagus efficiently recycles nutrients, thus fertiliser additions should match spear productivity levels.

Asparagus growth

The asparagus plant consists of an underground rhizome or crown with multiple growing points commonly called bud clusters. Within each bud cluster are numerous buds which grow into spears or fern. Growing off the rhizome are large adventitious fleshy roots which store carbohydrates and nutrients. Fine lateral roots (feeder roots) grow from the fleshy roots. Feeder roots are primarily responsible for water and nutrient uptake (Figure 1).

1. **Asparagus crown consisting of rhizome, bud clusters, buds, fleshy storage roots and fine feeder roots**

Each spring, buds elongate to produce the spears. Spears are allowed to grow to specific lengths and then harvested. Within a bud cluster there is a hierarchical order to bud growth. Generally the largest or oldest buds grow first and after that bud (spear) reaches a marketable height, it is harvested. Once harvested, the next bud in the bud cluster begins growing. The spears growing from buds vary in size due to the environmental and plant cultural conditions experienced during the previous growing season.

Spears that are not cut during the harvesting period rapidly develop into foliage called fern. Fern can grow to a height of 1-2 m. The development of healthy fern supports root and rhizome growth and influences bud number and size. Bud size has been correlated with spear size and weight, so careful attention to fern growth is necessary each year. Fern senesces and dies in the autumn with the onset of frosts.

Due to the perennial growth habit of asparagus, over time, more weight is partitioned to the rhizome and roots. By the time the plant is fully established, approximately two thirds of the plants total biomass is partitioned to the roots and rhizome. Therefore, high yields in asparagus are positively correlated with large root systems.

Long-term asparagus productivity is primarily influenced by seasonal harvest pressure, plant nutrient management and other cultural practices. Harvest pressure needs to consider field age and harvest duration since both directly influence crop yield. Young establishing fields do not have the large root systems necessary to support long harvest durations. While older fields can be harvested for longer periods, harvest duration will vary depending on length of the whole growing season, the amount of energy stored in the roots during the prior year's growth, and any stresses the plant may have experienced. Therefore, crop management after harvest needs to take into account these parameters.

In addition, successful asparagus production depends on proper soil and site selection, careful soil preparation, and a long-term nutrient management strategy that ensures plant growth is maximised.

Soil and site selection and preparation

To grow asparagus successfully, growers need to identify appropriate sites and properly prepare fields prior to planting. Once planted, site improvements are difficult. Asparagus can be grown in most soil types however, deep loam and sandy loam soils perform best. Since high production is associated with the development of large root systems, deep soils with no underlying obstructions ensure roots have plenty of room to grow. Asparagus roots can grow 2-3 m deep, however, the bulk of the root system is found in the upper 1 m of soil. Soils which have good drainage, are not prone to water logging or have shallow water tables are preferred. Avoid soils with high salt content and very low pH. The ideal pH for asparagus is between 6.5 and 7.5 and regular lime applications may be needed to raise soil pH levels if soil testing indicates low pH.

It is difficult to improve the soil after planting asparagus, so add manures, fertilisers, and control problem weeds the year before crowns (or transplants) are planted. Asparagus productivity improves when soils are supplied with additional organic matter. Animal manure, compost or green manures should be applied and incorporated in the spring of the year prior to planting asparagus. However, few recommendations are available on how much manure or compost to apply. Nutrient analysis of the manure or compost can provide valuable information so that later nutrient additions are tailored to the crops needs. Specific fertiliser requirements are then determined by soil analysis in the late autumn or early spring of the planting year.

Soil sampling technique

Sampling in a 'W' pattern is adequate to give a representative sample. Approximately 20 sites within the pattern should be sampled at four depths 0-15 cm, 15-30 cm, 30-45 cm and 45-60 cm. The soil from each sampling point is bulked for each depth and approximately 1 kg of soil needs to be collected in total from each depth. Analysis will give a guide to the nutrient levels at each depth and alert growers to any problems, especially at the lower depths and give an opportunity to make the necessary corrections before planting. The samples need to be analysed for pH, phosphorus (P), potassium (K) and magnesium (Mg).

Nutrient needs of new asparagus plantings

Fertilisation before planting

Having determined the specific nutrient needs by soil analysis, fertiliser is applied and then ploughed down in the spring before setting the crowns. Soil type, soil nutrient levels, prior cropping history and climate conditions will influence nutrient needs. Table 1 provides some recommendations for P and K fertiliser application amounts based on soil test values in the USA and Canada. In the UK, fertiliser recommendations for asparagus production are detailed in the Defra publication RB209. Soil test results should be consulted to establish the soil index value (Table 2). The quantity of fertiliser needed can then be established using the index system (Table 3).

Amounts applied should be adjusted according to local conditions and are illustrative only. Soils that fix P will require higher amounts and future additions should be designed to maintain baseline soil P and K levels. Additional nitrogen is recommended at planting in line with RB209. Ploughing down the fertiliser puts it at the proper depth for the asparagus crowns (transplants).

In addition to the fertiliser recommended by the soil analysis, additional phosphorus fertiliser can be applied in the planting furrow before setting the crowns (transplants). Apply 50 to 75 kg P/ha from either superphosphate (0-20-0) or concentrated superphosphate (0-46-0). Do not apply phosphorus sources that contain nitrogen (11-52-0) or fertiliser damage may occur to the crown and new roots. If soil tests indicate very high levels of phosphorus (>30 mg P/kg), omit the broadcast P and only apply the amount recommended for the furrow. It is also necessary to top dress asparagus in the planting year with

an additional 30-50 kg N/ha before the second cultivation. This helps ensure vigorous fern growth during the first year. If the soil test identifies any trace mineral deficiencies, correct these before planting.

Table 1. Asparagus phosphorus and potassium recommendations based on soil test values for different asparagus production regions in North America

Phosphorus (mg/kg)*	Broadcast application amount (kg P/ha)			
	California	Michigan	Washington	Canada
0-5	200	125	130	115
6-10		100	85	105
11-15	100	75	65	95
16-20		50	25	85
21-25	0	25	0	75
26-30		0		60
31+				45

Potassium (mg/kg)*	Broadcast application amount (kg K/ha)			
0-50	200	150-100	200	350-300
51-75		99-50	150	270-230
76-100	100	49-25	115	210-190
101-150		0	75	170-150
151-200	0		0	130-100
200-250				80-40

* 1 mg/kg soil = 1 mg/l soil = 1 ppm

Table 2. Classification of soil phosphorus and potassium analysis results into indices (Defra, RB209)

Index	Phosphorous (mg/l)	Potassium (mg/l)
0	0-9	0-60
1	10-15	61-120
2	16-25	121-240
3	26-45	241-400
4	46-70	401-600
5	71-100	601-900
6	101-140	901-1500

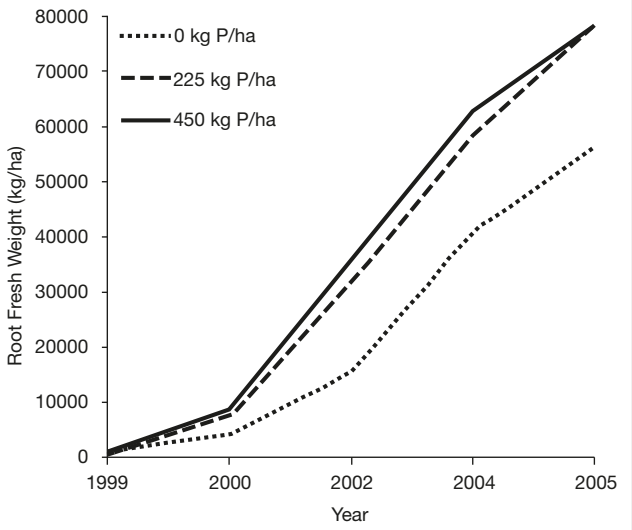
Table 3. Recommendations for phosphate and potash applications before planting based on soil index number (Defra, RB209)

Index	Phosphate (kg/ha)	Potash (kg/ha)
0	175	250
1	150	225
2	125	200
3	100	150
4	75	125
5 or higher	0	0

Fertilisation during establishing years

The primary objectives during the first four or five years after planting (the establishing years) are to grow sufficient fern to build a large root system. Studies in Germany and the USA show that asparagus crown weight increases by 600-800% in the first year (planting year), by 400% in the second year, and by 100-200% in the third and fourth year. By year five, asparagus is considered fully grown and the change in root weight from year to year (root loss = root gain) is relatively stable.

Figure 2 illustrates the change in root biomass during the first five years of a phosphorus nutrition study carried out in Utah. Root fresh weight increased by 4-5 times the initial planting weight of the crown in year 1. Between the second and sixth years, fresh weight increased dramatically when supplied with additional phosphorus. By year 6 when the crop is fully established, root turnover (dead or dying roots) was about equal to root replacement (new root growth). Structural root mass is relatively stable in well-established asparagus fields but poor cultural practices can negatively influence root growth. Therefore, ensuring that new asparagus plantings are properly cared for during the early establishment years is critical for high future productivity. Anything during the establishing years that slows up growth (fern or root diseases, over-harvesting, flooding, drought, nutrient deficiencies, or other stresses) will have a detrimental effect on future yield and may shorten the lifespan of the crop as it affects root and crown development.



2. Fleshy root biomass accumulation during asparagus establishment when fertilised with 0, 225, or 450 kg P/ha at planting in a soil known to be P deficient (Drost, unpublished)

Fertiliser application rates during the establishing years vary greatly and depend partially on yield expectations, length of growing season, soil type, and prior fertility applications but also on how much root biomass is established. Fertiliser applications should be based on regular soil tests and should be designed to maintain soil P and K values in the range of 15-20 mg P/kg and 100-150 mg K/kg, respectively. Fertiliser and asparagus fern residue should be incorporated carefully so as not to damage the crown or storage roots. Nitrogen should be applied each year at 75-100 kg N/ha either in the early spring or after harvest is finished. This amount is sufficient to ensure good fern growth. Trace mineral needs should be based on soil and tissue tests and are added only if needed. It is important to remember that fertiliser is only one element of proper plant management. If asparagus is stressed due to pests and diseases, weeds, drought or flooding, or excessive harvest, a “complete or unique fertiliser programme” cannot improve plant performance.

Nutrient needs of established asparagus plantings

Asparagus does not require a lot of fertiliser once established if it has been properly managed during the establishing years. In general, N, P and K application rates are low because asparagus has the capacity to store large amounts of all nutrients in its large root system (Figure 3). The primary objective is to maintain plant vigour by supplying sufficient nutrients to grow healthy fern. It is widely accepted that fleshy asparagus roots store approximately 300-500 kg N/ha, 30-50 kg P/ha, and 225-375 kg K/ha in a mature asparagus field. Since asparagus stores so many nutrients, the response to nutrient additions is quite low. Knowing the quantity of asparagus roots can be very helpful in assessing future nutrient needs. While intensive sampling is required to obtain accurate root biomass values (Figure 2), average producing fields generally have 60-70,000 kg of fresh root mass per hectare and high yielding fields have in excess of 100,000 kg fresh root mass per hectare.

Calculating asparagus nutrient storage content

- Estimate or determine storage root fresh weight (FW)/ha.
- Convert fresh weight to dry weight (DW).
- Multiply root dry weight by root nutrient content (see Table 4 or use tissue testing results).

Example: A vigorous high yielding asparagus field has 100,000 kg root FW/ha. Fleshy asparagus roots are about 25% dry matter. On average, roots contain 1.75-2.0% nitrogen. Therefore, roots contain 440-500 kg N/ha (100,000 x 0.25 x 0.02 = 500). Similar calculations can be done for the other elements.

Yearly applications of N, P and K therefore depend on how well the crop has been fertilised during the establishing years and the level of crop productivity. If 5000 kg/ha of spears are harvested from a well-established planting, only 25-30 kg N/ha, 5-10 kg P/ha, and 20-30 kg K/ha would be removed each year. These values are calculated in the same way that you would determine root nutrient storage capacity. Assume spears are 10% dry matter and use the spear nutrient values listed in Table 4. Since asparagus harvest (spears) removes very small amounts of nutrients, excessive amounts of fertiliser do not increase plant performance or improve productivity.

3. Extensive asparagus root system

Table 4: Fern, spear and root tissue nutrient contents from a variety of sources

Nutrient	Summer Fern	Autumn Fern	Fern	Fern	Spears	Spears	Roots
	Nutrient Content (% dry weight)						
N	4.50-5.50	2.40-4.00	2.50-4.00	2.10-2.75	6.00-6.60	5.30	1.00-2.25
P	0.35-0.50	0.20-0.50	0.20-0.40	0.18-0.25	0.85-0.91	0.78	0.17-0.22
K	3.50-4.50	1.50-2.80	1.70-3.50	2.48-2.74	4.00-4.35	3.28	1.05-1.50
Ca	0.60-1.20	0.40-1.00	0.60-1.50	0.65-0.72	0.27-0.30	0.21	0.10-0.13
Mg	0.20-0.50	0.15-0.30	0.14-0.35	0.22	0.20-0.21	0.20	0.07-0.08
S	-	-	0.30-0.45	-	-	0.61	-
	Nutrient Content (mg/kg)						
B	25-100	25-100	30-150	36-47	26-28	-	-
Cu	5-25	5-25	5-15	7-14	22-27	18	-
Fe	60-300	40-250	50-150	128-144	130-160	100	-
Mn	20-200	10-200	30-160	44-51	30-35	21	-
Mo	-	-	0.08-0.40	-	-	-	-
Zn	25-100	20-100	20-60	-	-	77	-

The fern also uses some of the stored nutrients as they grow. However since fern is commonly chopped and returned to the soil, its mineral content is made available to the plants as the fern decomposes. Most of the N in fern is remobilised back to the crown and roots as the fern senesces (turns yellow) in the autumn and the residual nutrients are returned when the fern is chopped and incorporated. Late season tissue testing can help estimate nutrient returns provided the nutrients are not fixed in the soil or lost through leaching or erosion.

Vigorous asparagus fields produce 10-15 ferns per plant with a fresh mass of 2.0-2.5 kg/plant. At standard plant populations (22,000/ha), there would be about 50,000 kg fern/ha. Fresh ferns are about 10% dry matter and would contain 30-40 kg P/ha and 100-150 kg K/ha which is recycled each year.

Similar calculations can be done for the trace minerals in the roots and fern if nutrient levels are monitored through tissue testing. In general, unless the plant is deficient (as determined by soil and tissue testing) in a specific element, the addition of excessive amounts of fertiliser do not significantly alter asparagus productivity.

The timing of fertiliser application depends on grower preference. It is generally recommended that the N should be applied toward the end of the harvest period. Since N use for spear growth comes from root reserves, pre-harvest (spring) N applications do not influence N content in the spears or impact spear number, diameter or weight. In UK trials, soil mineral nitrogen samples were analysed at several depths. The results showed that if soil mineral N is higher than 160 kg/ha N and more than 120 kg/ha N is in the top 0-30 cm layer, it is not necessary to apply any N fertiliser. If the level of soil mineral N is less than 160 kg/ha, apply enough mineral fertiliser at the end of February/early March to bring the level of soil mineral N in the surface 0-30 cm to 120 kg/ha. Apply the balance by April. This strategy should deliver satisfactory amounts of nitrogen to support fern growth which is important for the production of spears. It should reduce excess nitrogen being released into the environment by leaching into water courses.

The P and K can be applied any time of the year. Fertiliser is often added when fields are lightly cultivated to incorporate the mowed fern in the autumn or before harvest when beds are formed or after harvest when tillage is used for weed management. Care should be taken to minimise root damage if P and K fertilisers are incorporated into the soil or if substantial bed shaping occurs each year. Studies have shown that tillage can negatively impact asparagus productivity mostly by reducing crown/root size.

In temperate growing regions like the eastern US, Canada, northern Europe, and New Zealand, yearly fertiliser application rates range from 50-150 kg N/ha, 25-50 kg P/ha, and 20-80 kg K/ha. As soil P and K levels increase over time or if naturally high levels are present as determined from soil testing, yearly applications may not be necessary. In asparagus growing locations that are more arid, have long growing seasons and are extensively irrigated like Arizona, California and Washington in the US, Peru, or southern Europe, higher N levels (200-300 kg/ha) are often applied as irrigation may leach out some of the nitrogen.

Secondary nutrient needs and asparagus tissue testing

Asparagus response to application of secondary and micronutrients varies greatly. Local conditions, soil type, and soil testing will dictate if they are needed. In areas where soils have low pH (<6.0), additional calcium (Ca) and Mg may be required. The use of dolomitic lime prior to planting and periodic re-applications during future years will help increase soil Ca and Mg levels.

Sulphur (S) may be limiting on very sandy soils with low organic matter content. If S is determined to be deficient, apply 50-100 kg S/ha or use a sulphur containing N source. Zinc (Zn) deficiencies have been reported in high pH soils, on low pH sandy soils, when asparagus is grown in high organic soils or if fields have excessive P levels. Where soil tests for Zn are less than 1.0 mg/kg or if tissue tests indicate a deficiency, apply 20-30 kg Zn/ha.

Asparagus rarely responds to boron (B) if soil test levels indicate B levels are in excess of 0.5 mg B/kg. Soils with high pH (>7.5) may fix B while in very acidic soils, B may be leached. The application of 5-10 kg B/ha may be warranted if these conditions exist.

In general, asparagus response to micronutrients is low. There have been very few studies that have shown a positive link between the addition of micronutrients and asparagus yield. Table 4 lists some of the established nutrient ranges from healthy mature asparagus ferns, spears or roots. If a nutrient deficiency is suspected, it should be confirmed with soil tests and/or tissue analysis.

Tissue sampling technique

When collecting fern for tissue analysis, select the most recently mature fern from a plant, harvest the top 30 cm of growth, then discard the top 10 cm before analysing the tissue. Be sure to gather sufficient random samples from throughout the field or area of concern. If sampling spears, be sure to collect a representative sample from throughout the area of concern.

If roots are sampled for tissue analysis, collect 20 samples from each production field or area of concern. Sampling should be random, similar to soil sampling. Using a spade, make a deep vertical cut 15-20 cm from the plant. Make a second cut at a 45-degree angle to the first cut and pry out the wedge of soil. Collect 5-10 of the large storage roots making sure roots are firm and alive. Root pieces should be 10-15 cm long. After 20 samples have been collected, carefully wash the roots so that most of the soil is cleaned off and store in plastic bags. Keep the fern, spear or root samples cool until analysed.

Asparagus nutrient deficiencies

Visual nutrient deficiencies are hard to identify in asparagus as plants rarely show strong symptoms. It has been noted that asparagus grown under nutrient deficient conditions initially appeared normal (early fern growth) but as the duration of exposure increased, noticeable variations in growth occured. Fern growth variations included chlorosis, tissue dieback, stunting, and necrosis.

The following key may help determine if a nutrient deficiency occurs in asparagus. The location of the primary deficiency symptoms are located on the plant helps narrow down the potential deficiency. Additional tissue testing is required to confirm a possible deficiency. Also, use the photographs of common nutrient deficiency symptoms to help make preliminary evaluations of possible nutrient shortages (Figures 4-16). Deficiency symptoms may look different in mature plants so additional soil and plant analysis will be required.

Fern with “normal” expansion growth - nutritional deficiency

- Needles or shoots fully expanded – No detectable/visible deficiency
- Needles light yellow green along entire length – Potassium
- Needles bunches light yellow in sporadic areas on terminal portions of fern – Sulphur

- Needles chlorosis in discrete areas near terminal of fern – Manganese
- Terminal of fern shows extreme chlorosis (white tips) particularly at tips – Iron

Fern showing "dieback" symptoms - nutritional deficiency

- Complete dieback of fern tips particularly on new ferns – Calcium
- Scattered regions of dieback on old and new fern – Molybdenum
- Sporadic dieback of primary stems. Plants produce additional (secondary) branching off primary stems which also dieback – Copper
- Needles show increasing yellowing from mid-fern area to terminal branches which then dieback. Entire portions of fern may be chlorotic – Magnesium

Fern show little growth and/or needle development - nutritional deficiency

- Needles light green with open airy appearance – Nitrogen
- Needles have yellow discoloration on tips – Phosphorus
- Fern very stunted and compact. Needles tightly clustered and may have yellow tips – Zinc
- Fern have few needles which are chlorotic over entire length. Terminal dieback noted in stems – Boron

Nutrient deficiency symptoms

4. Complete nutrients, no visible deficiency

5. Potassium

6. Sulphur

7. Manganese

8. Iron

9. Calcium

10. Molybdenum

11. Copper

12. Magnesium

13. Nitrogen

14. Phosphorus

15. Zinc

16. Boron

Image credit

Photographs of deficiency symptoms were kindly supplied by Dr. Brian Benson.

Acknowledgements

Thanks are due to Wilson Dyer, Independent Consultant, for comments on the draft.

Further Information

Aegerter B, Cahn M, Koike S, Smith R, Hartz T, and Suslow T (2011). *Asparagus Production in California.* Univ. of California: Vegetable Research and Information Center. Publication 7234. http://anrcatalog.ucdavis.edu/pdf/7234.pdf

Anon (1982). *Fertiliser Guide: Irrigated Asparagus.* Cooperative Extension Washington State University. FG0012.

CRAAQ (2010). *Guide de Référence en Fertilisation, 2e édition.* Centre de reference en agriculture et agroalimentaire du Quebec. Quebec, Canada. http://www.craaq.qc.ca/Publications-du-CRAAQ/guide-de-reference-en-fertilisation-2e-edition/p/PSOL0101

Dean BB, Boydston R , Cone W , Ley T, Mink G , Parker R , Stevens R , Sorensen E, Van Denburgh R , and Johnson DA (1994). *Washington Asparagus Production Guide*. Cooperative Extension Washington State University EB997.

Defra (2010) Fertiliser Manual RB209 8th edition.

Douglas JA and Ledgard SF (1990). *The Fertiliser Requirements of Asparagus (Chap 4)*. In: Franklin, S.J. (ed). The New Zealand Asparagus Manual. Manurewa, NZ.

Drost, DT (1997). *Asparagus.* In: Physiology of Vegetables. CAB International. pg 621-649.

Dyer, WJ and Rahn C (1996). HDC Project FV152. *Comparison of rates and timings of nitrogen applications on asparagus crop performance.*

Dyer, WJ (1996). HDC Project FV153. *Comparison of rates of phosphate and potash on asparagus crop performance.*

Lespinasses P and Baillet M (2010). *Fertilisation de L'asperge.* Le CEHM, France. http://www.cehm.net/IMG/pdf/FERTILISATION_DE_L_ASPERGE.pdf

OMAFRA (2010). *Fertiliser Recommendation Tables.* Ontario Ministry of Agriculture, Food and Rural Affairs. www.omafra.gov.on.ca/english/crops/facts/fert-rec-tables-toc.htm

Rahn C (2012). HDC Factsheet 09/12 (Project FV 345a). *Soil nitrogen supply for field vegetables.*

Sandsted RF, Wilcox DA, Zitter TA, and Muka AA (1995). *Asparagus Information Bulletin.* Cornell Cooperative Extension Bulletin 202. http://vegetablemdonline.ppath.cornell.edu/factsheets/AsparagusInfo.htm

Wilson DR, Sinton SM, Butler RC, Drost DT, Paschold PJ, Van Kruistum G, Poll JTK, Garcin C, Pertierra R, Vidal I, and Green KR (2008). *Carbohydrates and yield physiology of asparagus – A global perspective.* Acta Horticulturae 776:413-427.

£8.75
where sold

HDC is a division of the Agriculture and Horticulture Development Board (AHDB).

AHDB Agriculture & Horticulture DEVELOPMENT BOARD

HDC **Horticultural Development Company**

Stoneleigh Park
Kenilworth
Warwickshire
CV8 2TL

T: 024 7669 2051
E: hdc@hdc.org.uk
Twitter: @HDCtweets

www.hdc.org.uk