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Minor bulbs: a review of dry bulb production with a view to their exploitation in the UK.

Undertaken for HDC.

ADAS

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AUTHENTICATION

I declare that this work was done under my supervision according to the procedures described herein and that this report represents a true and accurate record of the results obtained.

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MINOR BULBS: A REVIEW OF DRY BULB PRODUCTION WITH A VIEW TO THEIR EXPLOITATION IN THE UK

SUMMARY

The UK is the major producer of narcissus bulbs, but production of other flower-bulbs (especially tulip) has declined. Imports of bulbs from the Netherlands to the UK continue to rise, and, although dominated by tulip, comprise a wide range of the so-called minor bulbs or bijgoed. The production of a selection of minor bulb crops was reviewed, to determine whether some could be produced in the UK.

Five hundred hectares of Crocus are grown in the Netherlands, and over 100 million corms are exported to the UK annually. The area of Chrysanthus types has increased markedly in recent years, accompanied by falling prices. In common with other small-bulbed genera, techniques for growing the corms in nets need to be developed. There is scope for improving the health status and varietal purity of stocks.

Snowdrops (Galanthus spp.) are largely collected from the wild, mainly in Turkey, for export to the Netherlands, whence 50 million bulbs are exported annually (18 million to the UK). Many wild populations are threatened. There is scope for production in Western Europe if methods of commercialisation can be developed; these are likely to involve growing under shade and selling as potted bulbs, or, alternatively, using species from more arid environments.

Muscari spp. (grape hyacinths) are grown on over 70 ha in the Netherlands, the area having increased as large quantities are forced. Over 10 million bulbs are exported annually to the UK. The crop is dominated by M. armeniacum and its varieties, which are easy to grow, and could be used more widely for large-scale amenity planting, but there is scope for considerable expansion of choicer species and varieties.

Iris reticulata and related dwarf iris bulbs are grown on about 30 ha in the Netherlands, and can command a high price. Propagation and net-growing of hybrids and choice species need to be investigated for the UK.

Dwarf Narcissus species and hybrids are in demand for pot-plants and for garden use, being dominated by cultivar Tete-a-tete (nearly 140 ha in the Netherlands). This variety suffers from many fungal diseases, and, although improved stocks and replacement varieties are being sought, dwarf narcissus could be useful diversification for UK bulb growers. Some species are collected from the wild, and commercial propagation and growing should be encouraged.

In general, UK producers of minor (or special) bulbs would suffer only similar problems to their Dutch counterparts (lack of technical information, high labour demands, small overall market for individual species). With the exception of dwarf cyclamineus type narcissus, alternative bulb production might be more suitable for small, specialist growers. Such growers would need to develop appropriate growing skills, while expanding only gently the area grown.

1. INTRODUCTION AND SOME GENERAL CONSIDERATIONS

1.1 The UK and Dutch bulb industries

In common with the rest of UK agriculture, the flowerbulbs industry has seen great changes in the agritechnical-agribusiness revolution which has taken place since World War 2. From the labour-intensive production of a range of bulbous crops, this segment of horticulture has moved to large-scale, mechanisation-dependent production of narcissus bulbs.

For the past few years, the UK area of narcissus (Table 1.1) has remained steady at some 4000 ha. This acreage probably accounts for somewhat over half of world narcissus production: although the Dutch area is smaller (about 1700 ha, Table 1.4), Dutch production is predominantly on a one-year-down growing system, while UK production is on a two-year-down system, giving similar annual outputs for the two countries of about 35000 t each. The UK has a useful export trade in narcissus (Tables 1.2 and 1.3); much of the other bulb exports probably represents re-exports. The suitability of large-bulbed narcissus cultivars for the mechanised handling of high density plantings on large holdings, where the crop fits in well with potato and cereal growing, has helped its success. The Netherlands, on the other hand, with its history of small, labour-intensive family holdings, has continued to dominate in the production of other bulbs (Table 1.4).

As the narcissus crop has increased in the UK, so the tulip crop in particular has decreased: from 448 ha in 1981 to 190 ha in 1988 (Table 1.1). The remaining bulbs making up the rest of the 214 ha of field-grown flower bulbs in the UK in 1988 mainly comprise iris, anemone, lily and gladiolus.

Although UK production of bulbs other than narcissus has declined, the UK demand for flower bulbs and bulb flowers has increased. This is seen in the numbers of bulbs forced (Table 1.5), currently over 90 million narcissus and over 80 million tulip bulbs per annum. It is also seen in the rising levels of imports, which reached 728 million bulbs, value nearly £25 million, in 1988 (Tables 1.6 and 1.7). This consumer demand for ornamental horticultural produce, and the still low per capita consumption in the UK (Table 1.8), emphasise the continuing potential of the UK as a destination for Dutch exports. Table 1.9 shows how bulb sales have increased here, particularly in supermarket outlets, in recent years.

Table 1.1 Total areas (ha) of field-grown bulb and allied crops in England and Wales*

	1981	1982	1983	1984	1985	1986	1988**
Narcissus	3555	3675	3616	4013	3721	4042	4047
Tulip	448	360	282	269	235	193	190
Iris	58	56	36	36	31	28	26
Anemone	175	150	39	45	40	36	31
Others	147	109	125	155	153	157	157
Total	4383	4350	4098	4518	4180	4456	4451

* Source: MAFF (October censuses) (No figures available for 1987)
** Provisional

Table 1.2 UK bulb exports (millions of bulbs)*

	1985	1986	1987	1988**
Narcissus	76.8	99.2	86.9	62.9
Tulip	3.3	0.8	1.0	1.1
Iris	1.0	1.3	0.5	0.1
Hyacinth	<0.1	0.2	0.1	0.2
Gladiolus	<0.1	0	0.4	0.3
Other	43.1	35.2	33.6	13.8
Total	124.2	136.5	122.5	78.4

* Source: MAFF
** Provisional

Table 1.3 UK bulb exports (£ millions)*

	1985	1986	1987	1988**
Narcissus	2.5	4.1	4.4	3.7
Tulip	0.1	<0.1	0.1	<0.1
Iris	<0.1	<0.1	<0.1	<0.1
Hyacinth	<0.1	<0.1	<0.1	<0.1
Gladiolus	<0.1	0	<0.1	<0.1
Other	1.1	1.8	1.7	1.4
Total	3.7	6.0	6.2	4.9

* Source: MAFF
** Provisional

Table 1.4 Total areas (ha) of field-grown bulbs and allied crops in the Netherlands*

	1985/86	1986/87	1987/88	1988/89
Tulip	6981	7371	7372	7277
Narcissus	1620	1644	1676	1763
Hyacinth	1003	1024	1049	1014
Iris	962	959	926	916
Crocus	442	458	499	519
Muscari	63	65	75	73
Allium	52	65	62	58
Scilla	36	38	37	34
Chionodoxa	10	12	15	14
Puschkinia	4	4	4	5
Total of above	11171	11640	11715	11672

	1985	1986	1987	1988
Gladiolus**	1972	2188	2322	2114
Lily***	1686	1686	1868	2211
Dahlia****	376	389	N/A	N/A

* Source: PVS/BKD; latest year's figures provisional
** From 1988 onwards, gladiolus grown solely for flower-production are excluded
*** Lily figures include a small area grown under glass (19 ha in 1988)
**** Total including seed dahlias

Table 1.5 Number of flower bulbs (millions) forced under glass in England and Wales*

	1984/85	1985/86	1986/87	1987/88	1988/89**
Narcissus	83.4	80.7	81.9	99.6	92.6
Tulip	71.1	73.3	78.9	88.8	84.6
Others (winter season)	12.4	12.7	8.1	6.4	9.7
Total of above	166.9	166.7	168.9	194.8	186.9

	1984	1985	1986	1987	1988
Iris	12.5	12.2	13.6	13.0	13.4
Lily	13.6	16.7	21.9	22.6	20.4

* Source: MAFF (December censuses)
** Provisional

Table 1.6 Bulb imports to UK (millions of bulbs)*

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988**
Tulip	76	85	117	128	151	141	157	163	176	189	173
Hyacinth	26	26	27	27	27	27	29	30	27	28	28
Narcissus	14	19	36	28	45	53	41	37	32	40	33
Gladiolus	57	57	61	61	62	86	82	75	71	76	67
Iris	71	71	65	74	75	78	89	96	73	54	66
Others	165	184	189	221	273	275	326	350	373	336	361
Total	409	442	495	539	633	660	724	751	752	723	728

* Source: MAFF
** Provisional

Table 1.7 Bulb imports to UK (£ millions)*

	1985	1986	1987	1988**
Hyacinth	2.6	2.8	2.8	2.4
Narcissus	1.3	1.5	2.1	1.8
Tulip	4.8	6.5	6.7	5.8
Gladiolus	1.2	1.2	1.4	1.1
Iris	1.8	1.7	1.3	1.7
Other	9.1	12.2	13.3	12.1
Total	20.8	25.9	27.6	24.9

* Source: MAFF
** Provisional

Table 1.8 Per capita expenditure (£) on cut flowers (1983/84 figures)

The Netherlands	19.50
West Germany	17.25
Switzerland	15.75
Austria	11.25
USA	9.25
France	9.25
UK	4.50

Table 1.9 Dutch dry bulb exports to UK analysed by outlet type (figures are sales in Dfl million)*

	1978/79	1983/84	1984/85	1985/86	1986/87
Supermarket/department store	4.2	15.7	17.5	17.6	21.5
Mail order (direct & indirect)	5.0	10.6	12.5	11.3	12.0
Seedsman/garden shops (town centre)	5.0	8.4	9.4	11.4	10.7
Garden centres/garden shops (out of town)	4.4	12.1	16.8	14.0	10.8
Parks and ornamental gardens	1.6	2.8	2.1	2.3	2.5
Chemists, hardware stores, florists and greengrocers	0.7	3.1	3.0	2.6	2.2
Market traders	0.7	2.4	2.0	2.1	2.1
Landscape gardeners	-	0.5	0.7	0.4	0.6
Others	2.7	1.6	0	2.0	6.0
Total	24.3	57.2	64.0	63.7	68.4

* Source: PVS (1988b)
\- Not included in survey

1.2 Dutch bulb exports

It is useful to summarise recent trends in Dutch bulb exports (PVS, 1988a):

1. Tulips still account for some 30% of the volume of exports; exports to the US have declined while those to the UK, West Germany and France have increased.

2. Gladiolus corm exports are fluctuating. The main destination is Italy, while gladiolus is the main bulb import in Spain.

3. Iris exports, particularly to the biggest customer, the USA, have declined.

4. Lily exports have declined for the first time in years, although there is an interesting development of lily bulb exports to Japan.

5. Overall, the decline in bulb exports in weight is less than the decline in numbers and value in guilders, suggesting a shift to the larger, cheaper types.

6. There has been a marked decline in the guilder value of exports to West Germany, a marked general decline (quantities and value) in bulb exports to the USA, a drop in the average price of bulbs exported to France, a decline (mainly in numbers) in bulbs exported to the UK, while exports to Italy have remained constant.

7. Compared with 1983/84, in 1987/88 numbers exported increased by 13%, weight exported increased by 16%, and guilder value increased by 20%.

8. Over the same period the trend for numbers exported was particularly upwards for Canada (+42%), Denmark (+25%), Japan (+136%), Spain (+32%) and the USA (+31%).

World exports of bulbs from the Netherlands are given in Table 1.10, and exports to the UK in Table 1.11.

Table 1.10 Worldwide Dutch bulb exports (excluding Benelux); figures in main body of table are millions of bulbs*

	1983/84	1984/85	1985/86	1986/87	1987/88	% Change 86/87-87/88
Acidanthera	16.1	17.5	19.5	22.3	21.7	- 3
Allium	56.1	57.1	65.4	81.1	85.7	5
Amaryllis	10.0	9.7	10.9	10.4	10.6	2
Anemone	195.4	208.7	219.6	276.6	257.7	- 7
Arum	0.5	0.6	0.4	1.0	0.3	-70
Begonia	25.8	26.5	30.0	29.2	29.6	1
Broadiaea	9.8	9.9	12.0	13.5	13.8	2
Calla	0.8	1.1	1.1	1.0	1.1	10
Chionodoxa	9.9	12.1	18.7	21.0	19.5	-7
Colchicum	0.3	0.4	0.5	0.4	0.4	0
Crocosmia	0.4	0.4	1.0	2.8	1.3	-54
Crocus	357.6	399.5	428.3	387.9	374.1	-4
Cyclamen	2.0	2.4	1.6	1.4	0.9	-36
Dahlia	52.2	52.0	51.1	60.1	56.0	-7
Eranthis	11.3	11.0	11.2	11.8	11.7	-1
Erythronium	0.1	0.2	0.2	0.2	0.2	0
Eucharis	0.0	0.0	0.0	0.0	0.1	(+)
Eucomis	0.2	0.3	0.2	1.4	0.2	-86
Freesia	92.7	110.4	122.7	125.6	125.9	0
Fritillaria	5.6	7.2	8.2	7.8	8.1	4
Galanthus	43.5	48.3	48.4	49.6	48.9	-1
Galtonia	0.3	0.3	0.9	0.5	0.6	20
Gladiolus	1458.2	1492.7	1390.0	1485.1	1423.6	-4
Gloriosa	0.4	0.2	0.2	0.7	0.2	-71
Gloxinia	1.3	1.1	1.0	1.0	0.9	-10
Habranthus	0.2	0.2	0.3	0.2	0.1	-50
Haemanthus	0.0	0.0	0.0	0.0	0.1	(+)
Hyacinth	151.2	154.7	161.1	158.9	156.3	-2
Iris	414.4	488.0	482.9	470.6	429.3	-11
Ismene	0.2	0.3	0.3	0.4	0.4	0
Ixia	22.0	27.3	25.9	25.7	25.0	-3
Ixiolorion	2.0	2.6	2.7	3.8	3.1	-18
Lachenalia	0.0	0.0	0.0	0.0	0.0	0

Table 1.10 continued

	1983/84	1984/85	1985/86	1986/87	1987/88	% Change 86/87-87/88
Leucojum	5.0	6.2	6.8	6.9	7.4	7
Lily	172.1	213.3	271.5	302.8	300.6	-1
Montbretia	13.6	13.4	14.4	12.3	11.3	-8
Muscari	68.9	81.6	94.1	110.5	107.4	-3
Narcissus	219.3	256.8	249.9	263.2	265.0	1
Nerine	1.8	2.3	2.1	2.7	2.4	-11
Ornithogalum	11.4	9.1	10.1	10.5	10.8	3
Oxalis	37.0	48.2	47.9	61.9	74.6	21
Puschkinia	3.9	5.5	9.6	13.1	12.2	-7
Ranunculus	28.5	28.0	32.4	30.5	25.4	-15
Scilla	24.5	27.0	30.7	30.1	31.7	5
Sparaxis	20.4	23.8	26.3	31.8	32.7	3
Sprekelia	0.0	0.0	0.0	0.0	0.0	0
Sternbergia	0.1	0.2	0.4	0.6	0.3	-50
Tigridia	4.5	4.9	5.9	5.7	5.4	-5
Triteleia	2.8	2.5	3.3	3.4	2.4	-29
Tulip	1486.5	1606.4	1619.5	1651.8	1761.5	3
Vallota	0.0	0.0	0.0	0.0	0.0	0
Zephyranthes	1.5	1.8	2.0	2.3	2.2	-4
Unknown	8.7	22.3	16.2	9.4	4.0	-57
Total (million bulbs)	5051.0	5496.0	5559.4	5801.4	5696.0	-2
Narcissus ('000 t)	4.9	5.1	4.7	3.9	4.6	18
Total ('000 kg)	135,154	146,809	152,968	158,315	156,707**	-1.0
Total (Dfl '000)	800,646	904,385	954,132	982,699	965,524	-1.7

* Source: PVS (1988a)
** Provisional

Table 1.11 Dutch bulb exports to UK (including Channel Islands); figures in main body of table are thousands of bulbs*

	1983/84	1984/85	1985/86	1986/87	1987/88	% Change 86/87-87/88
Acidanthera	2,009	2,588	4,156	2,805	3,080	10
Allium	9,260	11,913	14,809	14,335	14,784	3
Amaryllis	1,826	1,955	1,600	1,737	1,463	-16
Anemone	27,164	29,776	33,950	47,394	36,566	-23
Arum	107	115	81	104	72	-31
Begonia	5,550	4,082	5,943	5,539	5,257	- 5
Brodiaea	1,544	2,005	3,009	3,431	3,277	- 5
Calla	30	41	60	52	45	-13
Chionodoxa	1,836	3,820	5,185	6,454	6,164	- 4
Colchicum	80	109	137	126	130	3
Crocosmia	71	69	111	340	327	- 4
Crocus	101,366	117,839	120,376	113,908	105,425	- 7
Cyclamen	305	607	492	417	500	20
Dahlia	6,317	5,926	5,591	5,690	5,617	- 1
Eranthis	2,170	2,492	2,611	3,303	2,759	-16
Erythronium	16	65	66	53	57	8
Eucharis	0	0	1	1	1	0
Eucomis	21	43	35	18	13	-28
Freesia	12,908	17,225	18,152	18,800	20,045	7
Fritillaria	1,296	1,781	2,322	2,275	2,420	6
Galanthus	11,875	15,560	15,871	17,543	18,044	3
Galtonia	93	65	75	99	94	- 5
Gladiolus	89,934	77,647	81,781	87,072	71,757	-18
Gloriosa	17	16	23	20	61	(205)
Gloxinia	447	345	316	284	256	-10
Habranthus	1	6	1	-	-	-
Haemanthus	3	3	4	1	2	(100)
Hyacinth	27,540	28,470	29,158	27,939	28,851	3
Iris	88,441	106,487	103,968	88,383	77,625	-12
Ismene	54	84	48	51	49	- 4
Ixia	3,898	4,895	5,680	5,473	4,478	-18
Ixiolirion	226	347	499	599	458	-24
Lachenalia	2	3	7	4	2	-50
Leucojum	228	317	442	688	506	-26
Lily	27,565	31,678	33,155	33,807	32,472	- 4
Montbretia	1,497	1,541	1,863	1,577	1,367	-13

Table 1.11 Continued

	1983/84	1984/85	1985/86	1986/87	1987/88	% Change 86/87-87/88
Muscari	10,797	14,841	13,778	20,009	13,063	-35
Narcissus	15,168	19,278	24,812	25,724	26,971	5
Nerine	282	302	279	317	449	42
Ornithogalum	3,290	1,366	1,828	2,932	2,841	- 3
Oxalis	1,046	1,173	1,858	2,499	1,883	-25
Puschkinia	1,111	1,843	3,584	4,901	4,444	-10
Ranunculus	1,642	1,570	2,614	1,371	1,525	11
Scilla	5,918	6,794	7,344	7,492	8,343	11
Sparaxis	4,202	6,106	6,434	6,249	5,913	- 5
Sprekelia	2	2	3	2	2	0
Sternbergia	8	11	62	72	83	15
Tigridia	728	768	1,075	1,227	966	-21
Triteleia	593	955	1,641	1,197	906	-24
Tulip	135,877	156,705	153,431	175,590	186,333	6
Vallota	1	1	10	2	2	0
Zephyranthes	847	823	800	596	708	19
Unknown	8	1,343	1,001	833	7,658	(819)
Total ('000 bulbs)	608,217	683,796	712,132	741,335	706,118	- 5
Narcissus ('000 kg)	725	1,174	687	348	1,053	(203)
Total ('000 kg)	13,952	15,664	15,395	15,704	15,805**	1
Total (Dfl '000)	77,719	85,166	88,897	91,838	90,259	- 2

* Source: PVS (1988a)
** Provisional

1.3 A place for "bijgoed" in UK bulb growing?

Bulk imports to the UK from the Netherlands continue to be dominated by tulips, and also include some narcissus (possibly mainly miniature types), hyacinth, lily and iris, but also an excellent range of the so-called bijgoed (miscellaneous or minor bulbs), both spring- and summer-flowering (Table 1.11). It is the quantity and range of these imports which has led to the production of this report, for there are good reasons to pose the question, can some of these alternative bulbous crops be produced in the UK?

From Acidanthera to Zephyranthes, these minor bulbs encompass a wide range of colours, sizes, habits and flowering seasons: indeed, the appellation bijgoed (applied in The Netherlands to all bulbous crops except narcissus, hyacinth and tulip), with the connotation of subsidiary, secondary or minor, is inappropriate. In the Netherlands in 1987/88, in the case of the three main bijgoed (Crocus, Muscari and Scilla), 1000 million bulbs (or plants) were sold, the same number as roses produced each year. Among the others, the sale was 300 million bulbs (or plants). The term bijgoed has been viewed as a positive discouragement to their appreciation and sales, and the term "Speciale Bolgewassen" (special bulbous crops) was proposed (Dwarswaard, 1989). It is suggested that any UK enterprise diversifying into "minor bulb" production, should seek to gain identity for the product by adopting a distinctive generic label (such as "England's Choice Bulbs" or "Bulbs of Distinction"). Dutch efforts to expand the range of species available, along with information for exporters, merchants and consumers, look set to increase (for recent Dutch views, see Zandbergen 1988a, b, c).

UK narcissus production looks assured of a reasonable short- to middle-term future, but only if investment is continued to funding R & D into producing superior, purpose-bred cultivars, on biological (or at least environment-friendly) pest and disease control, and on cost-effective bulb handling and storage procedures, as well as on promotion to establish large-scale sales outlets at home and abroad. The UK narcissus industry may contract somewhat: if so, perhaps the production of other bulbs could fill the gap?

The advantages to the UK, and its bulbs industry, of home production of "choice" bulbs include the following:

1. Alternatives to dependence by bulb growers on narcissus.

2. Opportunities for small or specialised growers.

3. Diversification possibilities for growers of "food mountain crops".

4. Creating and satisfying a niche for high-quality home-grown bulbs.

5. Import substitution.

6. Further export potential.

7. Reduced pressure to collect wild bulbs.

It is only fair, however, to point out possible problems in minor bulb production. As perceived in The Netherlands and enumerated recently (Dwarswaard, 1989), these include the following, some of which may apply in the UK:

1. Changes related to 1992 (such as the transfer of phytosanitary inspections from the place of final destination to the external frontiers of the EEC, which could lower the quality of products moving internally).

2. The lack of price (fixing) agreements (which would increase profitability) in the bulbs sector.

3. The difficulties of matching the quality and price of some imports.

4. The danger of a too rapid expansion in output of products with limited sales.

5. A decline in product quality with increased production.

6. Lack of product innovation despite the range available.

7. Wider issues such as protectionism, a stagnation in levels of disposable income, and various environmental issues.

What particular features are limiting or preventing the growing of other bulbs in the UK? Three contributing factors could be: tradition, with an unwillingness to diversity; the acknowledged excellence of Dutch bulb production and marketing; and a lack of easily accessed UK advisory information. In respect of this last point, it is the purpose of this report to set out the relevant information, which could then be converted to simple "fact sheets" or advisory leaflets; more easily available information could help to reverse the other factors holding back the production of choice bulbs in the UK.

1.4 The scope of the present report

Only a few alternative bulbous subjects could be covered in this report, and five were chosen, each for different reasons:

1. The genus Crocus (including autumn-flowering types), which is notable for the large quantity of bulbs imported from the Netherlands to the UK (105 million corms in 1987/88).

2. The genus Galanthus (snowdrops), for which demand is high, yet the genus is hardly commercialised, most of the bulbs in the trade resulting from wild collections.

3. Grape hyacinths and their allies, the genus Muscari (including Pseudomuscari, Leopoldia and Muscarimia), which are easy to grow, imported in quantity (13 million bulbs in 1987/88), yet have scope for wide-scale amenity use and for varietal diversification.

4. Iris reticulata and its allies including I.danfordiae, ie, the Section Reticulata of Iris (or Iridodictyum), which are imported in small quantities but command a high price.

5. Species and wild forms of Narcissus (ie, Division 10 narcissus). Because of a paucity of horticultural information on narcissi of this Division, and the interest in "dwarf" narcissi generally, the review was extended to cover dwarf and small-bulbed types. Narcissus are well-suited for growing in the UK, and dwarf types are in high demand for garden use.

The scope of the present review[1] includes statistics, uses, all aspects of crop husbandry and handling, and R & D needs for the five subjects. It is hoped that other bulbous types could be reviewed later in a further report.

1.5 General considerations: minor bulb growing in the Netherlands

In the Netherlands most minor bulbs are grown on calcareous and sandy loams around Hillegom in the West, and around Breezand in the North. These soils, coupled with the water table controlled at about 500 mm, make for good growth and early harvesting of small bulbs. Many holdings are only 1-3 ha in extent, perhaps up to 20 ha in the North, with heavy reliance on family labour, plus students and children in peak periods. In West Holland, a major problem is the cost of good sandy bulb soil; some bulb production has moved to heavier soils further North. On farms growing only bulbs, the following rotation is used: tulip, hyacinth, narcissus, other bulbs, but non-bulb crops are introduced if possible.

On sandy soils, most bulbs are grown in beds, separated by semi-permanent wheelings spaced at 1.5 m, often using a four- or five-row planter which feeds from a common hopper, while on silt soils standard ridge bulb planters are used, following potato growing practice on 0.75 m ridges. The ridge system gives a four percent reduction in yield due to non-ideal plant distribution, but the system works well on loam soils (up to 18 percent <0.002 mm), but is not workable on heavier clay soils. Growing in nets is of particular interest for growers of small bulbs (see Section 1.6).

The harvesting of minor bulbs on sandy soils uses lifting machines which remove the top 80 mm of soil, lift the bulbs and vibrate off the fine soil, the bulbs being harvested directly into 0.5 t bulk bins which are tilted hydraulically to minimise damage to the bulbs. Three to four workers can harvest around one ha per day in this way. Harvesting bulbs from ridges on the silty soils is similar to procedures used in England.

Most small bulbs are handled in bulk bins, except on the smallest units, although hyacinths are always handled in trays. Bulbs are dried on a letterbox system for three to five days, with air at 5°C above ambient. Bulbs from silt soils may be washed before drying. After drying, bulbs are partly cleaned by machine ("pre-cleaning") to remove stalks, loose scales and roots, with further cleaning by hand.

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[1] The literature search was concluded in mid-1989. Liberal use, without reference, is made of the general articles, text book and MAFF/ADAS material cited in the General Bibliography; other publications cited are listed under References for each crop. Crocus, Galanthus, and Muscari are fully reviewed; for dwarf Iris and Narcissus, only specific topics relevant to these types are dealt with, and reference should be made to standard sources for further information on the general culture of narcissus and iris. A preliminary report has already been published (Hanks, 1989).

In the Netherlands, all bulb crops are inspected. Amongst the miscellaneous bulb and corm crops, only crocus is covered by special quality rules ("Landbouwkwaliteitsbesluit"), whereas the others are covered only by disease control regulations ("Reglement voor de Ziektebestrijding").

Specialist bulb merchants handle most of the minor bulbs. Bulb merchants also import large quantities of minor bulbs, for example, from Turkey, Morocco, France and Portugal. As well as selling large quantities of common minor bulbs to general bulb merchants and to marketing organisations for pre-packing, the specialist merchants also handle small quantities of valuable rare bulbs.

1.6 General considerations: bulb growing in nets

Work on bulb growing in nets has been carried out in the Netherlands in the context of allowing bulb planting and harvesting in areas of heavier soils, such as those of the IJsselmeer polders, where clod separation is a major problem. In the Dutch system (Perdok, 1980; Ruyter, 1982) there is a 400 mm wide net (3 x 10 mm mesh) fed by power rollers through the planting machine and into the furrow bottom, 15 cm deep. Bulbs are scattered within a 250 mm wide band as usual, and a second net is applied over the bulbs ahead of the disc coverers. The nets are not sealed. The planting machine was developed by Wolfs and IMAG. At harvesting, a modified lifter separates the nets from the elevator, and brushes out the bulbs before rewinding the nets. The nets can be re-used, although they tend to become narrower with use: 500 mm wide netting is now recommended.

Trials of this system in the Netherlands with tulips have shown a reduction in yield of 3-5 percent in some (but not all) cases, perhaps because netting adversely affects rooting. With iris, the system is proving successful.

The growing of small bulbs in nets has also been investigated in England, at Rosewarne Experimental Horticulture Station (EHS) (Tompsett, 1985). In contrast to the system described above, a single net is used. The net, 500 mm wide (3 x 10 mm mesh) is laid into the open furrows, the bulbs scattered on, and the net folded over the top of the bulbs before covering. In manual trials of this system, good results were obtained with iris bulbs: these were lifted clean, quickly and with minimal damage, while all offsets were retrieved and virtually no ground-keepers remained. In these trial conditions, a 5 percent loss of yield was general as a result of growing in nets; however, in conventional bulb growing, a loss of 5 percent of the bulbs as ground-keepers could be assumed, and would involve additional costs due to further herbicides or cultivations needed to remove them. With bulbs other than iris, varied weight increases were obtained when growing in nets (Table 1.12): Muscari, tulip, Chionodoxa, crocus and Iris reticulata performed satisfactorily, whereas Scilla and Galanthus performed poorly. The indifferent yields could be a reflection of poor cultural conditions generally (rather than effects of netting), particularly with Scilla and Galanthus (for the latter especially, different growing techniques may be needed). Certain corm crops such as Gladiolus nanus were unsuitable because the new cormlets became enmeshed.

In later trials at Rosewarne and Isles of Scilly EHSs (ADAS, 1989) weight increases of some of the above bulbs were compared over five growing seasons either planted in the net system or loose (Table 1.12). Net planting reduced yields, by up to 48 percent in crocus Large Yellow but by much smaller amounts in the other bulbs tested. Furthermore, attempts to mechanise net planting using an adapted Nobells planting machine showed that it was difficult to achieve a satisfactory throughput, and the project was suspended (ADAS, 1987).

Table 1.12 Performance of bulbs grown in netting in trials at Rosewarne and Isles of Scilly EHSs

Crop	% weight increase grown in netting		
	Trial 1 (Rosewarne)*	Trial 2 (Rosewarne)**	Trial 2 (IoS)**
Muscari armeniacum	200	139 (9)	149 (2)
Tulip cv Apeldoorn	152	144 (5)	86 (10)
Chionodoxa gigantea	151	-	-
Tulipa praestans	146	-	-
Dutch iris cv Ideal	132	102 (15)	92 (12)
Iris reticulata cv Joyce	104	-	-
Crocus chrysanthus	93	77 (29)	61 (-13)
Crocus cv Large Yellow	92	23 (48)	54 (19)
Pushkinia libanotica	66	-	-
Galanthus elwesii	8	-	-
Scilla cv Spring Beauty	5	-	-

* Source: Tompsett (1985)
** Source: ADAS (1989), means of five seasons' results; figures in parentheses are % reduction in increase compared with planting loose
\- Not tested

1.7 Introductory references cited

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2. CROCUS (INCLUDING AUTUMN-FLOWERING TYPES)

2.1 Area grown

Some 500 ha are presently grown in the Netherlands (Table 2.1). Of this area, 74% is comprised of large-flowered Dutch hybrids (of which 38% are blue/purple, 24% yellow, 21% white and 16% multicoloured) and 20% are chrysanthus types (dominated by three cultivars, Dorothy, Cream Beauty and Fuscotinctus); the remainder is made up of other spring- and autumn-flowering species and hybrids (1988/89 figures).

The Dutch area has increased steadily in recent years, mainly due to increased growing of chrysanthus types. Examination of typical wholesale prices, however, show a marked fall in the price of the corms in the last few years.

Some crocus corms are grown in NE Scotland.

Crocus cancellatus, C. pulchellus and C. speciosus are listed among the twenty most important bulb exports of Turkey; C. ancyrensis, C. biflorus, C. flavus, C. fleischeri, C. kotschyanus, C. pallasi and C. sativus are also exported (S. Oldfield, pers. comm.).

2.2 Types

There are some 90 species and many hybrids, although few achieve substantial commercial areas (Table 2.1).

Autumn-flowering species include Crocus laevigatus Fontenayi, C. medius, C. ochroleucus, C. sativus (the Saffron Crocus), C. speciosus and their garden varieties.

Among the late-winter and spring-flowering types are C. chrysanthus (and its many cultivars including Blue Pearl, Cream Beauty, Dorothy, Fuscotinctus, Saturnus and White Triumphator), C. sieberi, C. susianus, C. tomasinianus (the well-known silvery lavender crocus much used for naturalizing), C. flavus (syn. aureus) and C. ancyrensis (the Golden Bunch crocus).

The many large-flowered Dutch hybrids, derived principally from C. vernus, include Flower Record (violet-blue), Grand Maitre (silvery lavender-violet), Remembrance (silvery violet-blue), Pickwick (grey-white striped violet), and Jeanne d'Arc (white). Yellow is represented by Large Yellow (Yellow Giant, Golden Yellow), a sterile triploid hybrid maintained solely by vegetative propagation.

2.3 Applications and opportunities

With the flowering period extending from September to March, and being hardy in all parts of the UK, crocus are in demand for bedding and naturalizing for amateur and amenity use, and are often grown in bowls for winter decoration.

Crocus can be produced as pot-plants, forcing programmes allowing a succession from December to March; a novel approach is to force mixed bulbs, including crocus, in containers as "spring gardens". Full details are given in standard texts (Buschman & Roozen, 1980; De Hertogh, 1985). There is, in the Netherlands, increasing interest in using species crocus as pot-plants. Crocus can be forced successfully under low levels of artificial light, down to four days at 200 lx (Jerzy & Krause, 1981). It may be possible to retard crocus in a similar way to ice-tulips, although trials are not yet very advanced (Krinkels, 1987). The forcing period can be shortened by applying gibberellin prior to cold storage (Tonecki, 1984).

At current Dutch levels of production, all the supply is absorbed. In the early 1970s there was some over-production, when the area increased to 650 ha (Zandbergen, 1987). The chief opportunities would, therefore, seem to be range diversification and the production of high quality container-grown plants.

In 1988, inspections of crocus (Anon., 1989) resulted in the following classifications:

Hybrids (soort-krokussen): 26 percent of total acreage class I or II.

Species (species-krokussen): 80 percent of total acreage general class; and
14 percent of total acreage standard class.

The quality inspection considered not only plant health but also varietal purity. On the question of plant health, the 1988 inspections revealed an increase in virus infestation, indicating a strong need to rogue for virus. The number of lots rejected due to nematode also increased, indicating the need for proper hot-water treatment. Mildly infested lots of marketable corms may be released for sale, following the removal of infested specimens and re-inspection by BKD (except that there is a nil tolerance for corms to the USA or Canada). Varietal purity is a major problem in crocus, especially in the species. Evidently, this was a neglected aspect of growing in the past. The only remedy would be to plant out large sized corms, carry out careful inspections, and build up an improved stock.

Autumn-flowering types have striking styles and divided stigmas, typified by the Saffron Crocus, C. sativus. Saffron, the only product of economic importance obtained from the genus, consisting of the dried stigmas, is one of the most costly plant products. The UK industry fell into decline in the nineteenth century: the name Saffron Walden is a reminder. Although now produced mainly in Spain, in principle saffron could be grown in the UK. The uses and cultivation of Saffron Crocus have been reviewed by Basker & Negbi (1983) and Rees (1988), and cultural and other details summarised by Gorini (1982). It should be possible to devise treatments to increase the yield of saffron: there are several reports that the application of growth regulators, such as gibberellin and kinetin, stimulate plant growth and increase saffron yield (Chrungoo & Farooq, 1984; Azizbekova et al., 1978), while controlled storage conditions are being developed to encourage flowering prior to leaf appearance, thereby raising the possibility of mechanical harvesting without leaf damage (Plessner et al., 1989); the effects of planting depth on development have also been studied (Negbi et al., 1989).

Table 2.1 Dutch crocus areas (ha)*

	1984/85	1985/86	1986/87	1987/88	1988/89**
BLUE					
Early Perfection	0.39	-	-	-	-
Enchantress	6.38	6.38	6.06	6.63	6.33
Flower Record	47.21	46.09	47.29	44.14	41.58
Grand Maitre	41.93	36.81	36.61	37.69	37.01
Jubilee	0.31	0.27	0.25	0.19	0.11
Little Dorrit	0.70	0.64	0.72	0.77	0.73
Negro Boy	0.40	0.62	0.67	0.68	0.71
Paulus Potter	1.42	1.87	1.98	2.31	2.24
Purpureus Grandiflorus	5.70	4.74	4.29	3.05	1.79
Queen of the Blues	2.30	2.27	2.38	2.57	2.95
Remembrance	56.45	49.45	45.75	48.85	46.78
Sky Blue	2.58	2.31	2.38	2.21	2.10
The Sultan	1.23	1.38	1.15	0.80	0.77
Vanguard	1.92	1.42	1.52	1.68	1.49
Victor Hugo	4.82	2.98	1.83	1.88	1.82
Others***	2.47	1.32	1.02	1.09	1.14
SUB TOTAL	176.65	158.55	153.90	154.54	147.55
MULTICOLOURED					
King of the Striped	10.02	10.14	11.53	13.79	13.76
Pickwick	54.62	49.14	49.01	51.22	48.39
Striped Beauty	0.67	0.36	0.25	0.74	0.84
Others	0.06	-	-	-	-
SUB TOTAL	65.37	59.64	60.79	65.75	62.99
WHITE					
Jeanne d'Arc	62.23	64.29	67.58	76.72	79.55
Peter Pan	2.14	1.15	1.44	1.31	1.07
Others	-	0.01	0.02	0.03	0.07
SUB TOTAL	64.37	65.45	69.04	78.06	80.69
YELLOW					
Geel	83.41	72.41	73.05	83.37	93.55
SUB TOTAL	83.41	72.41	73.05	83.37	93.55

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Little Dorrit	0.70	0.64	0.72	0.77	0.73
Negro Boy	0.40	0.62	0.67	0.68	0.71
Paulus Potter	1.42	1.87	1.98	2.31	2.24
Purpureus Grandiflorus	5.70	4.74	4.29	3.05	1.79
Queen of the Blues	2.30	2.27	2.38	2.57	2.95
Remembrance	56.45	49.45	45.75	48.85	46.78
Sky Blue	2.58	2.31	2.38	2.21	2.10
The Sultan	1.23	1.38	1.15	0.80	0.77
Vanguard	1.92	1.42	1.52	1.68	1.49
Victor Hugo	4.82	2.98	1.83	1.88	1.82
Others***	2.47	1.32	1.02	1.09	1.14
SUB TOTAL	176.65	158.55	153.90	154.54	147.55
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SUB TOTAL	64.37	65.45	69.04	78.06	80.69
YELLOW					
Geel	83.41	72.41	73.05	83.37	93.55
SUB TOTAL	83.41	72.41	73.05	83.37	93.55

Table 2.1 Continued

	1984/85	1985/86	1986/87	1987/88	1988/89**
CHRYSANTHUS					
Advance	0.46	0.28	0.48	0.40	0.48
Ard Schenk	0.47	0.65	1.07	1.31	1.82
Blue Bird	0.96	1.07	1.31	1.46	1.45
Blue Pearl	7.34	6.77	7.30	7.62	7.66
Chrysanthus	0.82	0.78	0.94	0.88	0.83
Cream Beauty	11.05	13.58	16.02	17.79	19.28
Dorothy	1.68	1.61	1.66	20.72	25.74
E P Bowles	2.67	2.58	1.85	0.95	1.30
Eye-catcher	0.28	0.38	0.40	0.57	0.72
Fuscotinctus	14.26	16.64	22.82	9.58	13.65
Gipsy Girl	0.59	0.63	0.45	0.38	0.55
Goldilocks	1.98	2.19	2.55	2.55	3.21
Ladykiller	0.14	0.16	0.20	0.21	0.23
Moonlight	1.21	0.91	1.00	1.26	1.56
Prins Claus	-	0.42	0.75	0.94	1.10
Prinses Beatrix	0.35	0.36	0.37	0.42	0.48
Romance	-	0.20	0.27	0.23	0.33
Ruby Gown	0.39	0.30	0.22	0.17	0.05
Saturnus	3.62	4.84	6.86	8.27	8.81
Skyline	-	-	-	0.04	0.17
Snowbunting	1.17	0.98	0.80	0.97	1.23
Warley White	0.32	0.39	0.40	0.28	0.37
White Triumphator	3.47	3.38	5.08	5.53	6.51
Zwanenburg Bronze	2.11	1.98	2.17	2.64	3.30
Others	1.94	0.76	0.51	0.62	0.75
SUB TOTAL	57.28	61.84	75.48	85.79	101.58
AUTUMN FLOWERING					
Autumn flowering crocuses	0.52	0.70	1.31	0.80	0.92
Conqueror	-	0.17	0.17	0.17	0.18
C. goulimyi	0.16	-	-	0.01	0.03
C. sativus	0.08	0.61	0.38	0.48	0.48
C. ochroleucus	0.15	0.07	-	-	-
Others	0.15	0.10	0.08	0.12	0.19
SUB TOTAL	1.06	1.58	1.94	1.58	1.80

Table 2.1 Continued

	1984/85	1985/86	1986/87	1987/88	1988/89**
SPECIES					
C. ancyrensis (Golden Bunch)	4.37	4.78	5.21	5.99	7.08
Fire Fly	1.08	1.01	1.35	1.72	1.31
Miss Vain	0.91	1.12	1.29	1.26	1.38
Ruby Giant	5.30	5.55	6.11	6.35	6.22
C. tomasinianus	0.15	0.40	0.68	1.84	2.09
Tom Bar's Purple	1.37	1.25	1.25	2.04	1.33
Violet Queen	2.38	3.42	2.75	0.90	1.28
Whitewell Purple	3.08	3.11	3.55	6.35	5.68
C. zonatus	0.43	0.45	0.62	0.62	0.80
Others	0.05	0.05	0.05	0.14	0.20
SUB TOTAL	19.12	21.14	22.86	27.21	27.37
OTHERS					
Mixed	4.86	3.19	2.74	2.55	2.74
Other species	0.38	0.46	0.34	0.37	0.32
Seedlings and sundries	0.82	0.99	1.28	3.00	3.19
TOTAL	468.08	441.60	458.34	499.30	518.72

* Source: PVS/BKD
** Provisional
*** Throughout these tables "others" include cultivars grown by only one grower

2.4 Yields

A doubling of corm weight is to be expected with one season's growth. In herbicide trials at Kirton, the percentage weight increase for loose-planted corms averaged 27% for small mixed crocus and 131% for Large Yellow (Wallis, 1975). At Rosewarne EHS, C. chrysanthus and crocus Large Yellow gave percentage weight increases of 93 and 92 when grown in netting, but other trials indicated that growing in net reduced yields in Large Yellow by up to 48% compared with growing loose, while C. chrysanthus performed better (Table 1.12) (ADAS, 1989; Tompsett, 1985).

Using cultivar Remembrance, 5-6 cm grade, planting densities of 120 to 280 corms/m^2 were investigated by LBO (1977b); over this range, the yield (kg/m^2) increased from 1.34 to 2.21 and the number of 7+ cm grade bulbs harvested (per m^2) from 118 to 241.

2.5 Soil and fertility

A wide range of deep, preferably stone-free, well-drained sandy loams is suitable for crocus production. In trials in Poland, yields were reduced by

up to 40 percent in heavy alluvial soils compared with a light soil (Szlachetka, 1976/77). The soil should be reasonably moisture retentive during the growing season, and could be improved by ploughing in FYM for the previous crop. On coarse, sandy loams yields may be poor in dry seasons, and irrigation of 25 mm at 25 mm deficit is valuable; however, under very wet conditions the bulbs have a tendency to split up. Adequate liming is needed. There is little information available on manuring, but growers usually apply a compound fertiliser to give 60 kg N, 60 kg P_2O_5 and 200 kg K_2O/ha. Soil analysis should be carried out to check for deficiencies. It is important to avoid a close rotation with gladiolus (see section 2.12).

C. sativus is not free-flowering in gardens in the UK, and it seems, from historical accounts of the former saffron industry, to need a very rich, well manured ground, as well as division and replanting into fresh ground each year.

Trials at Zwaagdijk and Breezand Experimental Stations with varieties Remembrance, Blue Pearl and Large Yellow (Hof & Slangen, 1988) showed that nitrogen applied immediately after planting gave good results on light loamy and sandy soils, in years when there was less than 100 mm of rain during the first two months after application. There was no benefit on heavy loamy soils (where nitrogen supply was greater - say, over 100 kg/ha - and leaching less). Crocuses take up nitrogen from the soil only from emergence onwards (March-April), so nitrogen must be available in the root zone shortly beforehand: it should be applied well in advance (say, January), to allow adequate downwards movement. On lighter soils, insufficient nitrogen is released during the growing season. The highest corm yields were obtained, in years with dry winters, following the application of 75 kg N/ha as a base application and a further 75 kg N/ha applied in two doses. In higher rainfall years, the additional nitrogen should be applied at 150 kg/ha in two doses. On heavier soils, additional fertiliser had no measurable effects. Crocus corms take up much nitrogen (in examples, 120-212 kg/ha) without showing improved yields. With more nitrogen applied, the likelihood of Fusarium attack was greater.

Summarising the recommended N fertiliser practice for bulb crops from Dutch trials work, van Berkum (1989) suggested a rate of 175 kg/ha for yellow crocus and 125 kg/ha for other crocuses, in each case minus the mineral N level of the soil as determined by analysis. Nitrogen should be available from March onwards, and, on light soils especially, applications should be split. In a survey of fertiliser usage in the northern sand region of The Netherlands, crocus growers applied between 60 and 280 kg N/ha, the most usual rates being 40-60 kg/ha in winter and 75-125 kg/ha in spring. The most usual rates of P, K and Mg were 100, 240 and 40-60 kg/ha, respectively, but a very wide range of K applications were employed (80-380 kg/ha) (van Berkum, 1987).

Alex et al. (1984) reported the result of a three-year fertilisation study on crocus Large Yellow conducted on sandy loam soil at Zullsdorf, GDR. Prior to autumn ploughing, 40 kg P/ha and 160 kg K/ha were applied, and nitrogen (0-240 kg/ha) was given in stages, in early December (as ammonium sulphate) and in early March and early April (as calcium ammonium nitrate). The best yields after three years were achieved with the highest rate used. After three years, each 6 cm corm had produced an average of 13 corms (four of which were over 7 cm grade). The harvested corms under this regime contained 2.25% N, exceeding levels in the non-fertilised crops by 0.6%.

2.6 Climatic factors

Very small planting stock (see section 2.7) is left down for two or three years, and in the Netherlands it is necessary to cover the crop with straw in severe winters, as damage is likely below -3°C. Larger corms are, however, relatively resistant to frost injury, compared with other bulbs (van der Valk, 1971). Relatively low rates of straw covering (7 to 10.5 t/ha) are recommended, and this may be left in place with advantage, rather than being removed (Meijers, 1979). In trials of the freezing tolerance of a range of bulbs, Sakai & Yoshie (1984) found that bulbs of C. chrysanthus cultivars, rooted and with 2 cm long shoots, survived and subsequently flowered when frozen at temperatures down to -7°C. Lundquist & Pellett (1976) found that planted corms of C. speciosus, acclimatised at 5°C, were moderately cold resistant, severe injury occurring when temperatures dropped to -9°C, and the shoots being somewhat more sensitive than the rest of the stem tissue.

2.7 Planting

Planting dates in the Netherlands are August to October, with reportedly greater foliage and corm production from August or September plantings.

Formerly, the corms were planted in beds in 150 mm rows, 25-40 mm within the row, 60 mm deep. Planting is now carried out with standard bulb planting machinery, in ridges at 655-750 mm centres. Planting rates range from 800,000 corms/ha (6-8 cm grade) to 2 million corms/ha (3-4 and 4-5 cm grades). Ideal planting depth in the ridge is 8 cm of loose soil covering (Ruyter, 1987).

2.8 Herbicides and other growing season husbandry

After planting, paraquat should be applied or the ground lightly harrowed to clear the surface.

In autumn, a pre-emergence residual herbicide should be applied. The currently approved material is chlorpropham. Other possibilities might be chlorpropham with fenuron, chlorbufam with chloridazon, and metamitron. Chlorpropham (alone or with fenuron) has also been used at similar rates post-emergence.

Herbicide trials on mixed crocus and crocus Large Yellow were conducted on light silt and sandy loam soils in Lincolnshire, using chlorpropham, chlorpropham + diuron, chlorpropham + linuron, pyrazone + chlorbufam, lenacil + linuron and methazole, either pre-emergence in December or post-emergence in early-February (5-7.5 cm shoots) (Wallis, 1975). There were no visual symptoms of damage on any treatment, although yields were generally lower following post-emergence treatments in the case of the small crocus.

Trials with yellow crocus at Lisse showed that simazine or metamitron appeared suitable for use at emergence, and phenmedipham post-emergence; alloxydim-sodium was damaging (de Winter and van Leeuwen, 1982, 1983). Fluazifop-butyl (plus wetter) was found to be safe for the control of volunteer cereals (Koster, 1983; de Rooij & Koster, 1984). Bing (1985) reported that in trials with several pre-emergence herbicides, napropamide, alachlor, oryzalin, chlorthal-dimethyl and trifluralin were safe to apply to crocus at the low, recommended rates; oxadiazon and oxyfluorfen were not. Waagmeester (1973) reported that, for crocus on all soil types, chlorpropham was suitable pre-emergence, adding paraquat when weeds were present; the same

rate of chlorpropham could be used around emergence, as well as post-emergence on a crop which was well hardened off. Smith & Treaster (1984) evaluated several herbicides for pre-emergence use on mixed crocus. At the rates used, oxadiazon caused severe injury; a low rate of trifluralin, and both rates of napropamide and oryzalin used, were acceptable. In trials on sandy soil in the FRG, lenacil, chloroxuron and propachlor were found suitable for use with crocus (BBLF, 1972).

2.9 Harvesting

The crop is easier to harvest and clean once the foliage has completely died down, in late June to early July. Bed plantings are ploughed out and picked by hand. Ridge plantings are lifted with an elevator-type digger, either onto the ground and then hand picked into trays, or directly into bulk bins. Smaller, more specialised elevator-type diggers may be available from firms specialising in bulb machinery; using a potato harvester too many corms may be lost through the webbing.

2.10 Corm treatment and storage

The corms should be dried thoroughly under cover, preferably with forced air ducts or in a well ventilated store with heat exchangers and fans. Recommendations for drying temperatures include 20-24°C, 5°C above ambient, or 20-17°C, drying the corms in about a week. In one trial with several varieties, corms stored at 19-23°C sprouted and flowered earlier than those stored at higher temperatures (23-27°C) or left in the ground (Kol'tsova, 1974).

Cleaning must be carried out carefully to avoid damage to the base plate. The bulbs are graded on standard bulb grading machinery (round riddles): typical saleable grades are 9-10 cm or 10-11 cm, according to variety and species. Minimum corm size for flowering purposes are 5 cm (C. candidus, C. chrysanthus, C. sieberi, C. speciosus and C. susianus), 8 cm (C. sativus), 4 cm (C. tomasinianus) and 7 cm (others). In C. sativus, corm survival increased from 39 to 86 per cent, and the number of shoot per corm increased from 0.9 to 6.7, as planting grade was increased from 1.5 to 11 cm circumference (Pandey et al., 1974).

In order to control problems such as Fusarium (corm rot), Penicillium and Pythium (root rot), the planting stock should be disinfected using a 15 minute dip just before planting in captan or zineb/maneb. If Penicillium is a problem, captan is preferred.

If nematodes are a problem, hot-water treatment (HWT) must be given within 7-14 days of harvesting: corms are stored for one week at 25-30°C, pre-soaked for 24 hours in plain water, and given a 4 hour HWT at 43.5°C in plain water. After HWT, the corms are drained for 30 minutes, then dipped for 30 minutes in captan or zineb/maneb plus 0.5% commercial formalin plus anti-dust preparation.

Trials indicated that there may be varietal differences in sensitivity to fungicides (LBO, 1978).

When topping up the dips, all chemicals (including formalin) are added at the original concentrations. After dipping, the corms are drained for a few hours, and dried at about 3°C above outside ambient temperatures.

In crocus, floral initiation occurs after the corms have been harvested in warm summer temperatures, so that at planting in the autumn all floral parts have been formed (as in the case of tulip, hyacinth and Iris reticulata). In the Netherlands, trials were carried out with a view to improving the subsequent flowering of outside crops of C. sativus (de Winter et al., 1986; van Leeuwen and van der Lans, 1988): storage of corms at 20-25°C improved flowering to some extent, but the results were still poor.

2.11 Propagation

Propagation is from seed, which germinates freely, the seedlings reaching flowering size in three or four years, and by separating the daughter cormlets.

Tissue culture is being investigated, eg for C. sativus which is a sterile triploid (Plessner et al., in press).

2.12 Fungal diseases

Serious losses due to fungal diseases are rare, and affected corms must be discarded. Close rotation with gladiolus must be avoided.

Copper web (Helicobasidium purpureum stat. myc. Rhizoctonia crocorum), in earlier centuries a major disease of saffron, results in patches of poor growth with corms rotting to black powdery masses. Corms are infected from mycelium and sclerotia in the soil, and violet mycelial threads and large, fleshy sclerotia are found in soil and on corms surrounding the centre of attack, causing further infection. The corms become a yellowish pulpy mass.

The fungus also attacks lily, iris, Muscari and narcissus. No information is available on its control, and no resistant cultivars known; infected land should be avoided, affected corms dug up and destroyed, and affected areas sterilised chemically.

Fusarium rot (Fusarium oxysporum f. sp. gladioli) shows in the field as prematurely yellowing and dying foliage, and may also attack in store. Infection is through the roots or corm base, the tissues becoming brown and rotten. Cutting affected corms shows decay as brown-black strands spreading from the base. Rings of blackish, slightly sunken spots with white centres may be seen on the upper parts of the corm. Olive-green covering scales are a good external indication of the disease. Rotten corms become soft and brown, covered with mycelium, often infested with Rhizoglyphus mites and exhibiting a characteristic smell, or very hard ("stone disease"), like tulip bulbs affected with the condition known as "chalking". During storage, spores are widely spread, affecting other stocks. The disease mainly affects the heavier corms.

There are no resistant cultivars. Other hosts, including gladiolus, iris and freesia, should be avoided in the rotation. Affected land and corms should be treated as above, but a corm dip after lifting and before planting in a benzimidazole fungicide (eg, carbendazim) will give some control.

In C. sativus, Fusarium rot was successfully controlled by a pre-planting dip in captafol, carbendazim or benomyl; captan was less effective.

Pseudo-rust (Fusarium oxysporum) has corm symptoms resembling those caused by rust. Large dark brown spots develop on the base or sides of the corms, with a sharp delineation between diseased and healthy tissues. No fungus forms on the outside of the corms, and no mites are present, and the corms may remain fleshy for a long time. Weak plants emerge, with prematurely yellowing leaves. Pseudo-rust occurs mainly on the larger corms. The disease is caused by a strain of F. oxysporum, but not that which causes Fusarium corm rot. Control is by removing infested corms, dipping stocks, planting late and not on over-fertilised land, and using a long (6 year) rotation.

Smut (Urocystis gladiolicola) shows as grey spots in the tunic at harvest, which burst to release a dark spore mass after drying. Heavily infested corms die, whereas less severely affected ones produce more or less normal plants, the leaves of which develop spots as above and die prematurely. The disease also affects gladiolus, and can survive in the soil in infected debris for some time.

Rust (Uromyces croci) gives rise to dark streaks on the leaves underground and leaf sheaths, parallel to the veins, in which orange-brown spores are formed. The corms are also affected, but not the above-ground leaf parts. The spores are persistent in the soil, and spread during storage is also important. Removal of affected material, proper rotation, dipping corms and using HWT ($2\frac{1}{2}$ hours at $43.5^{\circ}C$) are the control measures.

Root rot (Pythium ultimum and other Pythium spp.) results in early spring in roots with small dark spots, the roots breaking easily at these points and later becoming glassy. The leaves turn yellow or grey, and patches die prematurely. The disease can be spread between crocus and iris.

Metalaxyl and furalaxyl were found to give good control of the fungus, propamocarb being much less effective (de Winter and van Leeuwen, 1980, 1981, 1982). Crocus from plots contaminated with Pythium senesced early, with poor corm yields; treatment with captafol gave improved growth (de Winter and van Leeuwen, 1984). Soil incorporation of prothiocarb reduced the effects of P. ultimum, resulting in greater yields of larger corms (Bastiaansen et al., 1974). A similar result was reported by LBO (1977a) using a severely infected site, irrespective of whether organic manure was applied or not; on the other hand soil injection of metham-sodium or of chlorbromopropene were less effective, and yields were reduced when these materials were used in combination with FYM.

Damage to crocus caused by root rot has been troublesome in the Netherlands on sandy soil, and the fungus has become tolerant of the fungicides used (Tubosan, Ridomil, Fongarid or Previcur N). (LBO, 1988). Risks should be minimised by cleaning corms (removing roots properly), disinfecting planting material, and using land on which these chemicals have been little used.

In the Netherlands crocus corms which have received HWT, are drained, then dipped in captan or zineb/maneb, plus 0.5% commercial formalin plus anti-dust preparation. In the case of corms which have not received HWT, a captan or zineb/maneb dip is used immediately before planting; in this case, formalin should also be used, but, as it is not safe immediately before planting, formalin (0.5% commercial formalin for 30 minutes) should be used alone earlier (eg, on dormant corms in August). Planting early increases the likelihood of root rot attack (although planting late can damage shoots and reduce yields). Planting in firm soil results in less root rot - the land could be cultivated as early as possible, and rolled (LBO, 1988).

Storage rot (Penicillium corymbiferum or P. verrucosum var. corymbiferum) results in light brown rotted areas developing after harvest. Heavily attacked corms form poor sprouts and petrify; other corms continue to rot in the ground, a blue-green fungal mass developing, and leaf tips becoming necrotic. The pathogen attacks at wound sites, and, as is usual, it is those corms which are damaged late in storage which are the more vulnerable. Yellow and species crocus with a thin skin are susceptible. Daughter corms are not attacked.

Corms should be stored in dry, well ventilated conditions, and should be treated with care, especially susceptible cultivars. Corms with well developed shoots should be picked for pot culture.

P. corymbiferum has been shown to be responsible for dry brown lesions developing in storage on the flesh beneath the outer tunic, which have disfigured corms grown in Kincardineshire for many years. In trials in Scotland (Sutton and Wale, 1985, 1986), heavy infestations with P. corymbiferum at planting reduced corm yield by up to 20%, compared with corms only slightly infested at planting. Dipping corms in benomyl, captafol, mancozeb or thiram after harvesting did not control the disease in store; the dry, outer tunic renders penetration of dip chemicals to the flesh of the corm difficult, even when a wetter is added. The severity of the disease in store was increased by pre-storage damage (eg, vigorous riddling) and reduced by delayed harvesting (to late July or August), but was unaffected by pre-harvest defoliation or by storage at 30^{o}C after lifting (which reduces infestation of gladiolus corms by P. gladioli). A good proportion of the fungal isolates were tolerant of benomyl, so that continued use of this material, coupled with damage on harvesting, exacerbates the problem.

Botrytis disease (Botrytis croci; B. gladiolorum and B. cinerea are also found in affected corms) results in heavily infested corms in dark brown tunics with small sclerotia on the surface of the corm itself. In severe cases the shoot goes black and rots before it emerges above ground, otherwise the leaf sheaths turn brown, the flower bud rots, and only the leaves emerge. Leaf spots (fire) develop, especially in humid conditions, and mould develops on the withered flowers; sclerotia develop on the dead leaves. The disease is spread by infected corms and spores, while the sclerotia are not thought to play an important part.

Obviously affected corms should be discarded. A fungicide dip should be used, and during humid periods (especially when frost or storms are likely to cause damage) a fungicide spray should be used. A three year crop rotation should be used, and gladiolus, freesia and montbretia should not be grown in the intervening years.

Dry rot (Stromatinia gladioli) results in leaves turning yellow from the tip, and the root system rots away; small sclerotia may appear on the lower leaf sheaths and on roots. The sclerotia remain viable in the soil for a long time. Yellow crocuses are particularly susceptible. Control is by using clean or disinfected soil and by disinfecting corms.

Grey bulb rot (Rhizoctonia tuliparum (Sclerotium tulipae)) can show as patches of slowly emerging plants with brown, distorted sheaths below ground, but in a light attack the only symptoms may be light sunken spots on the leaves (at the same height on one plant), and the plants may recover if the temperature rises. The corms are not attacked. Planting stocks and soils should be disinfected.

Other fungal diseases reported on crocus include hard rot (Septoria gladioli), black slime (Sclerotinia bulborum), storage rot (Penicillium gladioli), Verticillium croci, and grey mould (Botrytis cinerea).

2.13 Bacterial diseases

Scab caused by Pseudomonas marginata (or P. gladioli) and various corm rots (including Erwinia carotovora var. carotovora) have been reported.

2.14 Virus diseases

As usual, control consists of roguing infected plants, avoiding infested stocks and controlling vectors.

Iris severe mosaic virus causes chlorotic striping and flecking of the leaves and flowers. It is aphid transmitted.

Tobacco rattle virus causes stunting and necrotic flecks, streaks and rings on leaves and flowers; nematode transmitted.

Cucumber mosaic virus has been reported in Germany and Sweden to cause leaf distortion and chlorosis, flower streaking and stunting.

Tobacco ringspot virus occurs without symptoms in the USA.

"Fan variegation" (possibly Arabis mosaic virus) causes abnormally coloured sectors in the perianth and colour breaking in blue and purple cultivars. There are no leaf abnormalities and the vectors are not known.

2.15 Pests

Potato tuber nematode (Ditylenchus destructor) results in stunted growth, leaf distortion and corm rotting.

Leaf or crocus nematode (Aphelenchoides subtenuis) produces crinkled and blistered bulbs; infected leaves yellow and die prematurely, without spickels forming. Generally less important than the potato tuber nematode.

These two nematodes are rarely found in the UK but can be troublesome in The Netherlands. They are often found together, and are best avoided by good rotations: they may attack other bulbs (narcissus, iris, tulip and Allium) and have many weed hosts also.

All species and cultivars can be affected, and spread is mainly by corm material during the growing season. Symptoms in the corms only become visible later in the storage season, say, from mid-September, with poor root-ridge development and brown-pink discolouration of the corm tissues, first seen in the root-tips. In the field, affected plants are late, and may have dead leaf tips. Control is usually by HWT (de Winter, 1980).

After lifting, the corms are stored at 25°C, and HWT (four hours at 43.5°C) given two weeks after lifting. The corms do not need to be cleaned in advance (cleaning may reduce yields), and they may receive a pre-soak before HWT. Early lifting before HWT is not necessary, and may result in yield loss. Applying HWT immediately after lifting, even at a lower temperature or for a shorter time, reduces yields. Because of these dangers, HWT is not used as a preventive, but only when an infestation is observed (de Winter, 1979, 1980). Storing bulbs at a higher temperature (30°C) before HWT

increased corm tolerance to the treatment, and there was no evidence for increased splitting-up of corms as a result (de Winter and van Leeuwen, 1981). HWT will control nematodes before damage is done in the growing season.

As an alternative to HWT, chemical control has been investigated. The best control is obtained by apply aldicarb when the plant is well developed, at or just after flowering (late-March). No better pesticide was found in trials, but results varied from year to year. However, in some trials a spray of oxamyl (in addition to aldicarb treatment) reduced spread of nematodes; a single spray in early-May was effective, with no advantage of split applications (Windrich, 1976; de Winter, 1979, 1980; de Winter & van Leeuwen, 1980, 1981, 1982, 1983, 1984, 1985).

Root nematode (Pratylenchus penetrans) causes brown spots on the roots, resulting in wilting and yellowing in patches. Fungal and bacterial infection follows. Soil disinfection and crop isolation should be used.

Tulip bulb aphid (Dysaphis tulipae) can attack in store or in the growing season: treat as for tulip.

Bulb mites (Rhizoglyphus spp.). attack corms damaged by fungi or nematodes, but not healthy bulbs.

Gladiolus thrips (Thrips simplex) may damage corms in store but usually die out when the corms are planted. Gladiolus flowers or corms should not be handled in the same store.

Rats, voles, mice, hares and rabbits sometimes dig out and eat the corms.

Birds are well known to cause damage to flowers of crocus. Sparrows eat the flowers, particularly in gardens, while crows and pheasants, especially, pull out the plants.

2.16 Physiological and other disorders

Gummosis, a gum exudation as found on tulip bulbs associated with poor storage conditions (ethylene), occurs in crocus corms.

Bud-blasting (or flower withering) is similar to that which occurs in other bulbous types, the floral parts becoming desiccated and the leaves making strong growth. Similarly, it is more common in forced crops, and there can be several causes (warm storage, insufficient cold, high growing temperature, poor rooting, dry soil, too early forcing).

Mechanical damage can result in storage rot (Penicillium corymbiferum, see 2.12).

Shoot damage can develop in forcing or in the field in the form of brown spots, which decompose so that holes with rough brown edges develop, on the leaf sheaths. It is always accompanied by root rot due to Pythium ultimum, although it is not known whether this is the cause of the disorder. Penicillium is also present in the lesions.

Refinement ("Verfijning") occurs in cultivar Remembrance and others, and the cause is unknown. The stigma remains stuck at the base of the perianth, flowers are smaller and fewer, with more but smaller shoots (and hence corms). Late HWT also results in smaller corms but this, unlike verfijning, lasts only one season.

Calcification and petrification - corms drying out and becoming abnormally hard - results from damage to the tunics during handling. Cultivars with thin skins (eg, Jeanne d'Arc and Peter Pan) are vulnerable, although in other crocuses with thicker skins these may break off during cleaning (eg, yellow crocuses and C. chrysantha). Penicillium may enter via the wounded areas.

Frost damage. Severe early frosts, spongy corms and roots and glassy shoots can result. Severe late frosts cause brown discolouration of the leaves and roots; internal cavities may develop in the corms. Severe damage may occur after a few weeks at $-2^{\circ}C$.

Zig-zag leaf describes a disorder which occurs in forced and pot-grown crocuses but not in the field. The cause is unknown, but it does not persist to the daughter corm. Yellow crocuses, Remembrance and Peter Pan are among the susceptible ones.

Sun scorch. Crocus corms are less susceptible than narcissus and hyacinth to sun damage, but it may occur, taking the form of grey to brown areas on the corm surface or the development of a faint striped pattern.

2.17 R & D needs

1. In common with many small bulbed species, there is a need to develop techniques and machinery for growing in re-usable netting. Reasons for differences between types in response to growing in nets need to be investigated.

2. A range of promising varieties needs to be evaluated in bulb production trials in appropriate sites under UK conditions.

3. Production of high quality container-grown crocus, of a good range of varieties and species, needs to be developed for sales for garden planting.

4. Trials to assess the suitability of varieties and species for large-scale amenity use are needed.

5. There is a need to develop techniques to reduce predation by birds.

6. Extension of the forcing season should be investigated for container-grown hybrids and species, including mixed plantings.

7. There is a need to investigate fungicides for the control of Pythium, Fusarium, Penicillium and other pathogens, and of HWT for nematode control, under UK conditions.

8. There is a need to develop virus-tested stocks of high varietal purity.

9. Agronomy and storage of saffron crocus could be investigated for improved flowering under UK conditions.

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3. SNOWDROP (Galanthus)

3.1 Production

Many snowdrops were lifted from semi-naturalised stocks on old orchards and parklands, and are now imported from wild populations in Greece, Turkey and France. Some are cultivated in orchards in Holland, but no figures occur in the Dutch statistics of bulb areas. Apart from limited schemes in Turkey to grow on bulbs which are below size, there is no large scale propagation for the international market (Lear, 1988).

Bulbs dug from the wild in Turkey are an important source of foreign exchange for that country. Snowdrops lead this list of exports consistently and by a large margin: in 1984, 40 million snowdrop bulbs were exported, following a rising trend (Table 3.1; Gokceoglu & Sukatar, 1986). Two-thirds of the bulbs exported from Turkey are traded in the Netherlands, but this proportion has fallen as the exporters deal direct with countries such as the UK, USA and FRG; of those traded through Holland, over half go to the same three destinations (Read, 1989).

Table 3.1 Number (millions) of bulbs exported from Turkey, with foreign exchange earnings*

Genus	1980	1981	1982	1983	1984
Galanthus	20.7	25.2	27.5	36.8**	40.0**
Eranthis	10.0	12.1	13.5	12.4	12.1
Anemone	8.8	9.3	10.2	5.1	9.7
Leucojum	4.8	4.8	5.3	6.0	3.2
Cyclamen	2.3	1.3	2.4	3.6	4.3
Others	1.2	2.6	3.9	1.5	0.5
Total (number)	47.8	55.3	62.3	65.4	69.7
Total value (millions)	$1.3	$1.2	Dfl 3.4	Dfl 4.4	Dfl 4.9

* Source: Turkish Ministry of Agriculture, Forestry and Rural Affairs, quoted by Gokceoglu & Sukatar (1986). Read (1989) quotes similar figures for total numbers and the following figures for 1985-1987: 60.8, 70.9 and 59.0 millions.

** Turkish Ministry quotas for snowdrop bulb exports for 1983 and 1984 were reported by Altan (1984) as 36.9 and 82.8 million, respectively.

Wild stocks are becoming scarce due to over-collecting, and awareness of conservation needs is increasing in the consumer countries, so there is scope for commercialization of snowdrops. There is also "green" concern that the true origins of such bulbs are not disclosed, and that the wild plants may introduce pests and diseases. Then issues are discussed by Read (1989). Snowdrops on sale in the UK now come mainly from the Black Sea area, whence G.elwesii have been collected for 10-15 years. Although this species is common and unlikely to be rendered extinct, its populations have been severely damaged in the Mediterranean area, and its distribution is already becoming more restricted in the Black Sea area. It may be substituted by G. ikariae, or mixed by collectors, deliberately or accidentally, with rarer species (such as G. gracilis, G. nivalis and G. fosteri (S. Oldfield, pers. comm.). Local pressure to collect snowdrop bulbs results in collection earlier in the year, before seed has been set or the bulb has bulked-up, and tonnes of undersized bulbs are dumped. Collection of bulbous plants in Turkey was monitored in detail by Ekim et al. (1984); see also Gokceoglu & Sukatar (1986), Oldfield (1984) and Lear (1988). Ekim et al. (1984) recommended closer controls on the methods of collecting snowdrop bulbs, and that the quota figures for 1985 should not exceed 8 million snowdrop bulbs (excluding "breeding material"). Among wild bulbous types, only cyclamen is at present protected under the Convention on International Trade in Endangered Species (CITES).

The harvesting of snowdrop bulbs is also practiced in European countries, notably France, where, in 1983, collections amounted to 10 million bulbs (by count) plus 13.2 t (by weight) (Table 3.2; Ekim et al., 1984). Wild populations of G. nivalis are "farmed" in the Loire Valley.

Table 3.2 Turkish and French snowdrop harvests*

Country	1980	1981	1982	1983
Turkey				
millions of bulbs	14.9	20.1	21.1	28.8
France				
millions of bulbs	18.0	19.5	12.9	10.0
plus				
tonnes of bulbs	4.3	-	8.9	13.2

* Source: Ekim et al. (1984); note that there appear to be some discrepancies between these figures and those given in Table 3.1.

Levels of Dutch (re-)exports of snowdrops are shown in Table 3.3. Currently, some 49 million snowdrop bulbs are exported from Holland worldwide, including some 18 million to the UK; the total level of snowdrops traded is about stable, while the proportion exported to the UK is rising slowly (27% of total in 1983/84, 37% in 1987/88). The quantity of snowdrops exported from Holland to the USA remains small (4 million in 1987/88; Table 3.3). Dutch imports of (all) bulbs from Turkey reached 62 million in 1987 (Lear, 1988).

Table 3.3 Dutch exports of snowdrop bulbs (millions of bulbs)*

Destination	1983/84	1984/85	1985/86	1986/87	1987/88
Total**	43.5	48.3	48.4	49.6	48.9
UK***	11.9	15.6	15.9	17.5	18.0
USA	2.0	2.2	3.2	4.2	3.8

* Source: PVS

** excluding other Benelux countries

*** including Channel Islands

Examination of typical wholesale catalogues shows that the price of G. nivalis has increased by nearly 50% compared with about 5 years ago, but is now steady.

3.2 Types

Galanthus is a uniform genus, with perhaps 10-20 species but many hybids, forms and selections. Although associated with shady places, some species are natives of the dry parts of the Mediterranean area.

The main snowdrops in commerce are G. nivalis (single and double forms), which has large flowered, scented hybrids such as S. Arnott, and G. elwesii.

3.3 Application and opportunities

With a flowering period from January to March, and hardiness in all areas of the UK, the bulbs are in demand for naturalising in gardens and growing in containers indoors and outdoors. There is consumer interest in delicate ornamentals: "The fashion for wild gardens and subtle colour schemes has greatly increased the demand for bulbs which are more natural in appearance" (Lear, 1988).

Snowdrops would have appeal if developed as a pot-plant for garden planting. It is widely held that snowdrops should be transplanted while in leaf, and any dry storage adversely affects flowering (see section 3.10). Sale as pot plants would avoid this problem. G. nivalis begins to initiate flower buds in March, in low soil temperatures, and initiation is completed in late May in the year before anthesis (Luyten & van Waveren, 1952). Trials in Holland (de Winter, 1979; de Winter and van Leeuwen, 1985) confirmed that flowering from previously stored bulbs is poor, although good vegetative growth was obtained in pot plants in a heated glasshouse. Using large (5-6 cm grade) bulbs, of which 95% had initiated a flower, 50% was the best proportion of flowering achieved. Shrivelling of the flower bud is encouraged during the storage period, especially at low (9°C) temperatures.

Attempts have been made to retard snowdrops in a similar way to ice-tulips (Krinkels, 1987).

There are many attractive large flowered cultivars which could be used to extend the range of snowdrops in commerce.

3.4 Yields

G. elwesii and Turkish G. nivalis do not do well in the Netherlands, but some French G. nivalis is grown (S. Oldfield, pers. comm.).

Snowdrops to not do well under conventional bulb cultivation. In herbicide trials at Kirton with G. nivalis, the percentage weight increase averaged only 18% (Wallis, 1975); G. elwesii grown in netting at Rosewarne EHS gave very little weight increase (Tompsett, 1985).

3.5 Soils and fertility

Snowdrops are difficult to grow commercially, although known to prefer damp, heavy soil and to benefit from generous autumn top dressing.

3.6 Climatic factors

Snowdrops are still grown in orchards in The Netherlands, and used to be grown on the shady sides of hedges in Kennemerland (until the hedges were removed). Shade can, however, be provided by interplanting snowdrops with narcissus, or by stretching netting over the beds; transplanting while in flower and growing for two years was recommended (Zandbergen, 1985).

Although associated with semi-shade, many snowdrops come from dry Mediterranean areas and do best in full sun or drier shade; these include G. graceus and the forms of G. nivalis known as G. corcyrensis and G. reginae-olgae.

In trials assessing the freezing tolelrance of bulbous crops, Sakai & Yoshie (1984) reported that bulbs of G. elwesii (with 4 cm leaf growth) survived freezing down to -7°C, but only to -5°C if subsequently to flower. Lundquist & Pellett (1976) found that planted bulbs of G. nivalis, acclimatised at 5°C, were moderately cold resistant, severe injury occurring when temperatures dropped to -9°C; the roots and basal plate were most, and the shoot least, sensitive to cold.

3.7 Planting

Bulbs can be planted shallowly in drills made up into beds in late summer or autumn, but there would be advantage to minimal dry storage beforehand.

Trials in Turkey with 4-5 cm grade bulbs of G. elwesii (Altan, 1985) showed that disturbance due to lifting a proportion of the bulbs reduced the number of bulbs produced, but did not decrease the size of these bulbs. When commercially undersized (3-4 cm) bulbs were collected from the wild and replanted in either irrigated or non-irrigated manured plots, 73-75% had reached commercial, exportable size (up to 6-7 cm) in one year (Gokceoglu & Sukatar, 1986).

In the Netherlands, Galanthus have been grown interplanted with narcissus (for shelter and shade), or shaded with nylon netting (Zandbergen, 1985).

Small offsets grow well once separated from the mother bulb.

Twin-scaling is reported to be possible with snowdrops (Alkema & van Leeuwen, 1977a, b), although the small bulbs have only a few scales, making dissection difficult. Bulbs of double G. nivalis, 4-5 cm grade, produced bulbils successfully when chipped to 8 segments using the methods applied to narcissus (Hanks, 1987). It is reported that chipping is being used to propagate G. elwesii in Holland, using incubation temperatures of 13-15°C.

As with many other bulbs, micropropagation is successful. In trials with G. elwesii, for example, Girman & Zimmer (1988) found that bulb segments were the best material for the regeneration of new bulblets, despite high rates of contamination.

3.12 Fungal diseases

Grey mould (Botrytis galanthina) is the only snowdrop disease of significance. In Britain, the disease has been noted at various times, wihout serious effect; sclerotia of the fungus have been observed on the outer papery scales of imported bulbs as isolated but conspicuous black dots. On the continent the disease is seasonal but appears to cause more damage, and has been described from Germany, Holland, Denmark, Sweden and Austria. In the field the disease is seen in patches when the shoots are emerging, affected plants having shoots completely enveloped in a fungal mass. The bulb is completely rotted. Sclerotia remaining in the ground are the most likely source of infestation. Grey mould is troublesome in mild seasons or when wet periods alternate with frosty weather, and especially when snow melts rapidly in situations with a good covering of decayed leaves. G. nivalis is most often attacked, and the susceptibility of other species varies.

Diseased bulbs should not be planted, but where sclerotia are present on the outer papery scales it may be sufficient to remove these. Any affected plants, and surrounding soil, should be removed and burnt, and infested sites avoided for a few years. Where the disease is prevalent, old leaves should be raked away, and more resistant species and varieties planted. In Holland the bulbs used to be given HWT for one hour at 42°C with added mercurial fungicide.

Stagonospora curtisii can infect snowdrops and cause heavy losses. Dark red areas appear at the top of the outermost scale, and spread. Trials (van Leeuwen & van der Lans, 1988) showed that heat treatment stimulated crop growth and suppressed the fungus, although fungicide dip treatments also gave good results.

Macrophomina phaseolina (Sclerotium bataticola) may occur in imported stocks of G. elwesii and G. nivalis, but does not spread in storage and does not survive under Western European conditions. Infested bulbs are grey or black, and the outermost fleshy scale has many very small sclerotia, or the whole bulb may be attacked and become mummified. The infestation occurs on some other bulbs, such as Tulipa hageri, Sternbergia spp. and Leucojum aestivum.

Smuts. No smuts have been recorded on snowdrops in Britain, but Urocystis galanthi and U. colchici have been reported on G. nivalis in Germany.

Rusts. Puccinia galanthi and Melampsora galanthi-fragilis have been recorded on G. nivalis but not in Britain.

Other fungal diseases. Stromatinia gladioli, Ascochyta sp., Septocylindrium septatum, Monosporium galanthi and Fusoma galanthi have been reported on snowdrops.

3.13 Bacterial diseases

These do not appear to be a significant feature of snowdrops.

3.14 Virus diseases

Virus diseases do not appear to be a problem in snowdrops.

3.15 Pests

Stem nematode (Ditylenchus dipsaci). Both the tulip and narcissus races attack Galanthus, infested plants developing leaf swellings (spickels) and becoming distorted and stunted. Cut across, infested bulbs reveal brown rings, as seen in narcissus bulbs. There are no recommendations for HWT, so destruction of infested stock might be advisable. However, trials (de Winter et al., 1986) showed that, for G. nivalis, there was no evidence for damage or reduced yield following HWT at 43.5°C for 4 hours; 10 days at 25°C before HWT gave a higher yield.

Tulip bulb aphid (Dysaphis tulipae) can infest many bulbs in store, including snowdrops. This species feeds and breeds beneath the dry outer bulb scales in suitable conditions, and seriously attacks the young shoots on planting. Control is by store hygiene, regular store fumigation, and roguing of infested plants in the field.

Large narcissus fly (Merodon equestris). Maggots have been found in snowdrop bulbs. In narcissus, prevention formerly consisted of treatment of bulbs and soil with aldrin, and control is by HWT (dipping bulbs in gamma-HCH has also been used). Control in the growing crop is not generally practical, but in a small stock of valuable bulbs surface cultivation could discourage egg laying.

Bulb mite (Rhizoglyphus spp.) may occur, as in narcissus.

3.16 Physiological and other disorders

These do not appear to be of significance in snowdrop growing.

3.17 R & D needs

1. There is a need to investigate growing systems for snowdrops, in order that their culture may be commercialised and pressure to collect from the wild reduced. Different systems may be needed for temperate, woodland types (like G. nivalis) and dry arid Mediterranean types (like G. elwesii). Key requirements would include freedom from disturbance (suggesting growing for two or more years down) and (for types like G. nivalis) appropriate cool soil conditions, which could involve mulching, growing under grass or netting, or interplanting.

2. Offsets, seedlings and bulbils from chips are vigorous, and offer alternative scenarios for investigating propagation for commerce or conservation. These methods of propagation, along with (in the initial stages) micropropagation, should be investigated with a range of choice types with species and varietal diversification in view.

3. Floral bud blasting during dry storage of bulbs is a major limitation to pot-plant production. The application of gibberellins to some other bulbous crops increases the sink strength of the floral as against the vegetative parts during conditions of stress, and should be investigated with dry-stored snowdrop bulbs. This problem is relevant also to the horticulturally inconvenient techniques of transplanting snowdrops "in the green".

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4. GRAPE HYACINTH AND ALLIES (Muscari)

4.1 Area grown

In the last ten years the area of grape hyacinths grown in the Netherlands has about doubled. This area now seems to be stabilizing, at about 70 ha (Table 4.1). Muscari armeniacum and its varieties account for over 86% of this area. There have been some notable increases recently in the small amounts of some other members of the group, such as M. comosum plumosum, M. alba and M. latifolium.

Prices in wholesale catalogues of common Muscari appear to have been fairly steady over the past 5 years.

Muscarimia (see section 4.2) is exported from Turkey (S. Oldfield, pers. comm.).

4.2 Types

Some species are sometimes placed in the related genera Leopoldia, Muscarimia and Pseudomuscari. M. armeniacum is the major representative, with its varieties Album, Blue Spike, Cantab and Early Giant. Other species include M. azureum (Pseudomuscari azureum), M. botryoides album, M. tubergenianum and the feathered hyacinth, M. comosum plumosum (Leopoldia comosa plumosa).

4.3 Applications and opportunities

The common types are popular in gardens, flowering March to May, but there is a wide range which could be used to extend this market. The bulbs are cheap and vigorous for large-scale amenity use, naturalising well, and hardy in all areas of the UK. The value of several species has been described by Mussel (1972). The market appears able to absorb the current supply, because large quantities are forced (Zandbergen, 1987a). Muscari are useful as long-lasting cut-flowers and as pot-plants.

M. armeniacum can be forced into bloom over the period mid-December to March, either as a high-density cut-flower crop, or in pots; large bulbs produce more than one inflorescence in a season (Buschman & Roozen, 1980; De Hertogh 1985). With its dwarf habit and colourful, scented inflorescences, it also makes an excellent subject for pot-plants. For fast-flowering and good quality in M. armeniacum, a 15-week storage period at 9°C (planting seven weeks into the cold period) was suitable; cooling at lower temperatures (2 or 5°C) gave longer scapes, while a shorter cold period led to a slower flowering but more flowers per bulb (Hoogeterp, 1967; de Winter & van Leeuwen, 1981, 1982, 1983a,b,c; Hanks & Jones, 1987). Storage of bulbs for six weeks at 20 or 25°C between lifting and cooling (rather than shorter periods or storage at 17°C) led to 100% flowering, but with slower progress to flowering and longer leaves (de Winter & van Leeuwen, 1983c, 1985). Some other Muscari could make interesting pot-plants. The responses of M. botryoides album and M. azureum were similar to the above, while inflorescence production in M. tubergenium, a good pot-plant, was less affected by storage treatments; M. comosum plumosum, however, flowered satisfactorily, even after a short cold period, although the glasshouse period was prolonged (Hanks & Jones, 1987). Gibberellin treatments would be useful in speeding flowering (Saniewski, 1977, Saniewski et al., 1978; Tymoszuk et al., 1979).

Muscari and related genera contain several attractive species which could broaden the range used for forcing, including white flowered types (such as M. botryoides album), hybrids like Saffire with large racemes, unusual species like the dark blue M. paradoxum and M. neglectum (Zandbergen, 1987b), and the highly decorative featherred hyacinth M. comosum plumosum.

M. comosum, the tassel hyacinth, is in demand as a cooked vegetable, for pickling and in oil in Italy; some is grown in Southern Italy, but it has been over-harvested and is largely imported from Greece and North Africa (Gorini, 1982; Orsi & Tallarico, 1986).

Table 4.1 Dutch Muscari areas (ha)*

	1984/85	1985/86	1986/87	1987/88	1988/89**
M. alba	0.28	0.49	0.59	0.72	1.16
M. ambrosiacum	-	0.19	0.25	0.14	0.16
M. armeniacum	52.22	51.44	51.45	59.98	56.20
M. armeniacum Album	0.59	0.65	0.37	0.46	0.76
M. armeniacum Blue Spike	3.92	3.56	4.68	4.93	3.62
M. armeniacum Cantab	-	0.01	0.01	0.02	0.02
M. armeniacum Early Giant	2.15	1.59	1.51	1.78	2.12
M. azureum	0.17	-	-	-	-
M. botryoides album	2.75	2.63	2.33	2.55	2.76
M. comosum	0.09	0.19	0.34	0.30	0.07
M. comosum plumosum	1.37	1.90	2.59	3.46	4.57
M. latifolium	0.03	0.04	0.15	0.32	0.53
M. neglectum	-	-	0.01	0.01	0.01
M. paradoxum	-	0.02	0.05	0.03	0.10
Saffier	-	0.03	0.07	0.10	0.24
M. tubergenianum	0.04	0.04	0.08	0.03	0.04
Others	0.33	0.35	0.31	0.59	0.56
TOTAL	63.94	63.13	64.79	75.42	72.92

* Source: PVS/BKD

** Provisional

4.4 Yields

The percentage weight increase of Muscari grown in herbicide trials at Kirton averaged 72% (Wallis, 1975). M. armeniacum Blue Spike and M. botryoides album planted in nets and grown in ridges at Kirton EHS at 0.5 million bulbs/ha (3 and 1 t/ha respectively), showed weight increases of 242 and 166%; in each case, over 80% of the harvested weight was in the larger, saleable grades (ADAS, unpublished data). In net growing trials at Rosewarne EHS (Tompsett, 1985; ADAS, 1989) M. armeniacum showed a 136-200 percent weight increase, and a 9 percent reduction in yield compared with growing loose (Table 1.12).

For M. comosum, grown at a low planting rate (70, 1-2 cm grade bulbs/m^2) with low N fertilisation, Orsi & Tallarico (1986) reported yields equivalent to 10.4 t bulbs/ha. These authors reported that planting densities of up to 250 plants/m^2 are used commercially in southern Italy for the production of small bulbs.

4.5 Soil and fertility

There is the general need for a well-drained, friable, sandy, stone-free soil.

In container-grown trials in Italy with M. comosum, it was concluded that only modest fertility was needed; however, there was a yield increase (up to 4 g per bulb) when 50-150 kg K/ha was added; an N, P, K ratio of about 3:1:3 was suggested (Orsi & Tallarico, 1986).

4.6 Climatic factors

In trials assessing the freezing tolerance of bulbs and corms, Sakai & Yoshie (1984) found rooted bulbs of M. armeniacum and M. armeniacum Blue Spike, with 1 cm long shoots, survived freezing to -10 and -13°C, respectively, and rooted (but non-shooting) bulbs of M. botryoides to -13°C, subsequently flowering. Lower temperatures (-13 to -15°C) were survived with loss of flowers. Lundquist & Pellett (1976) found that planted bulbs of M. armeniacum Blue Spike, acclimatised at 5°C, were moderately cold resistant, severe injury occurring when the temperature dropped to -9°C; the roots and basal plates were most, and the shoot least, sensitive to cold.

4.7 Planting

Bulbs are planted in autumn, 7-8 cm bulbs at rates up to 1 million/ha, and 5-6 cm bulbs at up to 1.8 million/ha.

Some Muscari species produce contractile roots which can lower the bulb in the soil, or horizontal stolons which can disperse the offsets (Galil, 1980).

4.8 Herbicides and other growing season husbandry

Muscari have no cold requirement for leaf growth, hence care needs to be exercised in applying herbicides early in the season.

Paraquat should be used well before crop emergence, and pre-emergence application of chlorpropham, chlorbufam + chloridazon and metamitron have been used. Trials in Holland (de Winter & van Leeuwen, 1982, 1983c) showed that linuron, metamitron or simazine applied before or at emergence had no adverse effects; phenmedipham (post-emergence) and metoxuron caused damage, and alloxydim-sodium was a possibility.

In trials on sandy soil in the FRG, lenacil, chloroxuron and propachlor were found suitable for use with M. armeniacum (BBLF, 1972).

Herbicide trials with Muscari and other minor bulbs were conducted on light silt and sandy loam soils in Lincolnshire, using chlorpropham, chlorpropham + diuron, chlorpropham + linuron, pyrazone + chlorbufam, lenacil + linuron and methazole, either pre-emergence in December or post-emergence in early-February (Wallis, 1975). There were no visual symptoms of damage in any treatment, and yields in treated plots were higher than in untreated plots.

Muscari can become established as weeds. M. racemosum is a weed of vineyards and orchards, spreading as seeds or bulblets which reach flowering size in two years; herbicides have limited use, and soil cultivation is needed for its control (Anon., 1987).

4.9 Harvesting

Bulbs are lifted mechanically when the leaves are dead, in August.

4.10 Bulb treatment and storage

The bulbs are ripened either naturally or with slight warmth and ventilation in a building. Drying is done at 5°C above ambient and subsequent storage at 20°C. Storage at 23-25°C has also been recommended, with a greater chance of mould growth at lower temperatures.

Saleable bulbs are grade 6-8 cm, according to variety; 5 cm would be considered the minimum grade for flowering purposes.

In the Netherlands, Muscari planting stock is given HWT in plain water to control nematodes, and, after draining for 30 minutes, this is followed by dipping for 30 minutes in captan. If the stock is to be dried, rather than planted immediately, anti-dust preparation is added to the dip. If no HWT is necessary, the above dip treatment can be given for 15 minutes prior to planting. If the stock is suffering from fungal infections, then the following dip is used: captan plus benomyl or carbendazim or thiophanate-methyl.

4.11 Propagation

The bulbs are easily increased by offsets which bulk up rapidly (Krause, 1986). It is reported that ITAL selections of M. armeniacum had very low levels of cormlet production compared with commercial material (de Winter & van Leeuwen, 1983c). Propagation trials in Holland demonstrated scooping, cross-cutting and single- and twin-scaling in Muscari, twin- and single-scales performing well (Alkema, 1971 a,b, 1972; Alkema & van Leeuwen, 1977). When 7-8 cm grade bulbs of M. armeniacum were chipped into 16 segments and incubated at 20°C for 12 weeks, almost all segments produced a bulbil (Hanks, 1987).

It has been shown that benzyladenine applications (in lanolin paste to the base of intact bulbs) can induce bulblet formation in M. comosum, M. armeniacum and M. botryoides (Saniewski, 1979; Saniewski & Puchalski, 1982), which may be useful in varieties in which few offsets are produced. Applying benzyladenime in combination with cycloheximide further increased bulblet production in M. armeniacum, M. comosum and M. botryoides, although the bulblets produced were smaller and mis-shapen (Saniewski & Puchalski, 1983).

During seed propagation, chipping the seed coat may be beneficial in some Muscari species (Newman, 1980).

4.12 Fungal diseases

Black slime (Sclerotinia bulborum) has a wide host range, being important in hyacinth. It is not common, but has been recorded on Muscari in Jersey. Previously healthy leaves turn yellow and die, their subterranean parts becoming soft and off-white or grey, and the bulb scales turn grey-black and rot. Affected parts are covered with a white mould, within which sclerotia develop. The disease may occur during glasshouse forcing, but is more usual in the field.

Storage rot (Penicillium spp.). Damaged patches on bulbs become soft and brown, covered with an easily spread light green spore mass. Although the interior of affected bulbs remains viable (unlike similar infestations in Iris, etc), bulbs are unsaleable. Control is by avoiding bulb damage during handling, drying bulbs in windrows for several days followed by thorough drying at 25°C or higher, and packing the bulbs with dry wood shavings or similar material.

Grey bulb rot (Rhizoctonia tuliparum) occurs, as in hyacinth. Leaves of emerging plants are severely damaged, but the roots and bulbs (except for small cracks in the top of the bulb) are not affected.

Rhizoctonia disease (Rhizoctonia solani). After flowering, leaves yellow prematurely, their subterranean parts developing brown streaks, patches of rot, and possibly wet rot. Unlike black slime disease, the bulbs generally remain healthy. The disease appears in late-May onwards. Soil disinfection is needed to control its spread.

Anther smut (Ustilago vaillantii) has been found on various species in Europe and in Britain on M. botryoides.

Rusts. Uromyces muscari causes typical rust symptoms with well-marked concentric rings of sori and local mycelium. U. christensenii has been recorded on M. parviflorum in Israel.

Other fungal diseases recorded are Botrytis hyacinthi, various Septoria species (isolated from the foliage in Europe), and Physoderma muscari on leaves of M. comosum in France.

4.13 Bacterial diseases

Corynebacterium fascians causes gall formation, with many white shoot outgrowths on the base plate. It often occurs with shallow planting or with planting in loose soil, and does not necessarily occur in subsequent harvests. A wide rotation and the above cultural factors should be considered.

4.14 Virus diseases

Mosaic virus results in various symptoms: light green leaf spots in M. armeniacum, dark streaks in M. latifolium, and mottling of the flower stem in M. paradoxum. It is related to other mosaic viruses (eg hyacinth) and is aphid-transmitted. Infected plants must be eliminated. Virus-free bulbs can be grown from seed.

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4.15 Pests

Stem nematode (Ditylenchus dipsaci). The hyacinth race of this pest also attacks Muscari bulbs, causing similar bulb and leaf symptoms - foliage distorted, with yellowish or light green streaks, and swellings (spickels), often on only one side of the leaf, and dark rings seen when the bulbs are cut across. It is reported that HWT at 45°C for four hours, following four weeks 25°C storage and pre-soaking in water for 24 hours, has been successful in M. ambrosiacum, M. armeniacum, M. botryoides, M. comosum and M. moscatum. Rees (1972) noted that HWT at 45°C was successful if the bulbs were stored for four days at 34°C immediately after lifting and before HWT, and it has also been reported that good control is obtained in M. ambrosiacum if bulbs are stored at 34°C for one to three weeks after lifting. Soil disinfection may be used.

Potato tuber nematode (Ditylenchus destructor) results in curved, twisted leaves, brown streaks on the subterranean leaf bases, and poorly developing flower clusters; an orange-brown patch spreads outwards on the outside scale from the base plate, with affected tissue being dry. The nematode survives with difficulty in infested bulbs, and in the soil cannot survive for more than about two years in the absence of host plants. HWT (as for stem nematode, see above) is needed, along with a long rotation or soil disinfection.

4.16 Physiological and other disorders

Bulb rot has been observed in M. comosum plumosum as a dark brown rot from the bulb base. Fusarium has been isolated from infected bulbs, but has not been proved to be the cause.

Nose-rot (van Leeuwen & van der Lans, 1988) has been described in M. armeniacum in which the scale tips become soft and dark-brown, the rot spreading but usually confined to the top half of the scales. Flowering is unaffected. Mites may colonise affected tissue. It is usually seen when plants are lifted green and stored at 30°C. Head-rot may be related. This condition, producing black, rotted scales, may be a problem in Holland when bulbs are harvested with the leaves green. The disease may be bacterial in origin. Trials with M. armeniacum in Holland (de Winter & van Leeuwen, 1985) showed that less head-rot occurred in bulbs from the latest lifting date (15 August); storage of bulbs at higher temperatures (30°C) or in sealed conditions (unperforated plastic rather than perforated plastic or gauze) increased the incidence of head-rot.

Gummosis, a gum exudation as found on tulip bulbs associated with poor storage conditions, has been recorded on Muscari.

Leaf damage. The leaves may appear in late autumn and become damaged in severe winters, but this is not serious (although care would be needed with pre-emergence herbicides).

Degeneration ("verwildering") is the production of many long slender leaves with no (or abnormal) flowers and many bulblets. It often occurs in M. armeniacum and sometimes in others such as M. comosum and M. comosum plumosum.

4.17 R & D needs

1. As for other small bulbed species, there is a need to develop techniques for growing in netting.

2. A range of promising varieties should be demonstrated and their propagation and commercialisation should be attempted.

3. Possibilities for producing M. comosum as a vegetable crop need investigating.

4. Varietal suitability for forcing, bulb sales in pots, and large-scale amenity planting should be assessed.

5. Head- and nose-rots need to be investigated further.

6. For pot work, earlier and faster flowering selections are required which do not require dwarfing.

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5. IRIS RETICULATA AND ALLIES

5.1 Area grown

The area grown in the Netherlands has increased, to 29 ha in 1988/89. Iris danfordiae makes up 38% of this area, the old cultivated form of I. reticulata 43%, and cultivars of I. reticulata (especially Harmony) the remainder (Table 5.1). In the early 1980s, I. reticulata was under-supplied and the Dutch Growers' Association took action to regulate prices (Anon., 1982). Wholesale prices of I. reticulata are similar to those of five years ago.

I. reticulata and many other Iris species are exported from Turkey (S. Oldfield, pers. comm.).

5.2 Types

The Section Reticulata or Iris includes many attractive dwarf species such as I. bakerana, I. danfordiae, I. histrio, I. histrioides, I. hyrcana, I. kolpakowskyana, I. pamphylica, I. reticulata, I. vartanii and I. winogradowii. In commerce in Holland, the most widely grown dwarf iris are I. reticulata itself, its hybrids Harmony, Cantab, Joyce, J S Dijt and Violet Beauty, and I. danfordiae.

5.3 Applications and opportunities

Dwarf iris species are in demand for garden planting in containers, rockeries and borders and for naturalising. They flower from February to March, and are hardy in all areas of the UK, standing adverse weather conditions well.

I. danfordiae and I. reticulata and hybrids are also produced as pot plants, and may be forced over the period December to March. There is potential to use other species: in trials, I. histriodes cultivar George produce good pot plants in early January, following two to four weeks 17°C storage and 13-15 weeks at 9°C (de Winter et al., 1986). Dwarf iris can also be found as components of mixed bulb plantings in "Spring Gardens"; full details are given in Buschman and Roozen (1980) and De Hertogh (1985). It may prove possible to retard I. reticulata in a similar way to ice tulips (Krinkels, 1987).

5.4 Yields

I. reticulata Joyce achieved a 104 percent weight increase in net-growing trials at Rosewarne EHS (Tompsett, 1985). However, trial plots of I. reticulata and I. danfordiae grown in nets at Kirton EHS, planted at 35 bulbs/metre run (equivalent to 0.8 and 1.7 t/ha, respectively), achieved weight increases of only 48 and 20 percent; of the lifted weight, 93 and 80 percent, respectively, was in saleable grades.

5.5 Soils and fertility

The general requirements for iris bulb production are a light to medium sandy loam soil free of stones and not prone to forming clods, freely drained, moisture retentive, with a reasonable lime content and a minimum pH of 6.3. Ideally, iris could follow a grass ley, provided sufficient time is given to allow the soil to be thoroughly worked down and fertilisers applied before planting. A compound fertiliser which will supply 75 kg N, 90 kg P_2O_5 and

125 kg K/ha is suggested for the base, followed by a further 55 kg N/ha top-dressed in the early growing season to ensure maximum growth. Fertiliser recommendations for narcissus may be used for iris. These recommendations do not apply specifically to iris species.

Table 5.1 Dutch dwarf iris areas (ha)*

	1984/85	1985/86	1986/87	1987/88	1988/89**
Cantab	0.28	0.30	0.29	0.44	0.42
I. danfordiae	6.75	7.19	6.90	9.43	11.06
Gordon	-	-	-	-	0.16
Harmony	2.48	3.84	2.61	3.38	3.26
Joyce	0.44	0.41	0.61	0.50	0.50
J S Dijt	0.39	0.34	0.30	0.32	0.42
Pauline	0.02	0.02	0.04	0.07	0.28
Purple Gem	-	-	0.02	0.07	0.16
I. reticulata	8.37	7.22	10.90	11.52	12.46
Violet Beauty	0.14	-	-	-	-
Others	-	0.25	0.31	0.38	0.48
Total	18.87	19.57	21.98	26.11	29.20

* Source: PVS/BKD
** Provisional

5.6 Climatic factors

In the Netherlands, a straw covering of 14 to 17.5 t/ha is used to protect Dutch iris, as these may become frozen within a few days if the soil temperature falls to -2 to -3°C (Meijers, 1979). Such quantities of straw are too great to be left in place, and must be subsequently removed to allow normal growth and cultivation.

5.7 Planting

Small iris bulbs are treated in a similar way to crocus corms, with planting rates up to 6 million/ha. Iris are normally planted from August until October, early planting having the advantage of producing greater growth as the bulbs become established before the onset of cold weather.

5.8 Herbicides and other growing season husbandry

Paraquat can be applied to iris crops not later than four to five weeks after planting, to avoid subsequent damage to emerging foliage. Residual herbicides approved for pre-emergence use on Dutch iris are: chlorpropham and chlorpropham + diuron; other materials which have been used are chlorpropham + fenuron, diphenamid and diphenamid + chlorthal-dimethyl. Chlorpropham can be used post-emergence. If the crop foliage has died off completely by lifting time, paraquat may be used again at this stage. No specific recommendations are available for dwarf iris.

5.9 Harvesting

The bulbs should be lifted once the foliage is completely dead, preferably under dry conditions which facilitate cleaning.

Early lifting reduces problems with ink spot disease (see below); in trials in the Netherlands (LBO, 1978), yield increased when lifting was delayed from early to mid-June, but there was no further benefit by delaying lifting until July.

5.10 Bulb treatment and storage

The bulbs should be cleaned and graded immediately after lifting and, provided that lifting has taken place under dry conditions, the clusters separate easily, minimising any damage. Iris bulbs are sometimes washed then dried in trays, using warm air. In the Netherlands, it is recommended that bulbs of I. reticulata and I. danfordiae are stored at 23-25°C.

Unlike Dutch iris (which forms flowers at low temperatures after planting), bulbs of this group initiate flowers during the storage period, like tulip. Hartsema (1961) reported that 13°C was the ideal temperature for floral initiation, but flowers were formed at all temperatures from 2-31°C, although proceeding very slowly at the extreme temperatures. Flowering could be accelerated by planting at 9°C, then, when floral initiation was about complete, a temperature of 13 or 17°C was optimal.

In the Netherlands, iris planting stock (not specifically dwarf iris species) is treated during storage by a 15 minute dip in 1% commercial formalin to control Fusarium (basal rot) and Pythium (root rot). In the case of nematode infestation, HWT is used as follows: a one to four week storage period at 20-23°C, followed by HWT for two hours at 45°C with added 1% commercial formalin. After disinfecting or HWT, the bulbs are dried and stored. Just before planting, the planting stock is dipped (15 minutes) in captan. If necessary, and if the bulb is still sufficiently dormant prior to planting (undeveloped root crown), formalin treatment can be given with the captan at that stage. When topping-up dips, use commercial formalin at 1½ times the original concentration and other materials at the original concentration. On the other hand, saleable sizes of iris bulbs intended for flower production (not dry bulb sales) are dipped to control Fusarium and Penicillium. A few days before starting cool storage, bulbs are immersed for 15 minutes in benomyl or carbendazim or thiophenate-methyl plus captan plus anti-dust preparation. The dip treatment should be repeated just before planting; if the bulbs are to be planted wet, the anti-dust preparation is omitted. The dip baths should be topped-up as necessary with all chemicals at the initial concentration.

5.11 Propagation

Chipping is worthwhile with Dutch iris, although it is important that the first cut is made in the correct position, adequate fungicide treatment is applied, and bulbs are stored at 30°C until November prior to chipping (Vreeburg, 1983; Hanks, 1987; Jones and Hanks, 1988). Although early trials of chipping I. reticulata and I. danfordiae were disappointing, due to widespread rotting of the chips, it is likely that these results could be improved by investigating other fungicides for dipping and by delaying the date of chipping as above (Hanks, 1987).

5.12 Fungal diseases

Iris leaf spot (Mycosphaerella macrospora) and ink disease (Drechslera iridis) are major leaf diseases on Dutch iris in the south-west of England. Elsewhere they could be expected to be less of a problem except under adverse weather conditions. Regular fungicide sprays will be needed (of a dithiocarbamate for leaf spot, of chlorothalonil (or, formerly, of captafol) for ink disease). These diseases are more of a problem in long-term crops. In Dutch iris, the black lesions of ink disease affect foliage, stem and spathe, but in I. reticulata, black streaks appear on the bulbs also, which originally gave the disease its name. Ink disease has been widely recorded on I. reticulata and has been reported on other species such as I. bakerana and I. histrioides; I. danfordiae and the cultivated varieties of I. reticulata are less susceptible.

In trials in Scotland (NOSCA, 1973), corms of I. reticulata cultivars Hercules and J S Dijt infested with ink disease, were either dusted with thiram or dipped in aqueous ethoxyethylmercuric chloride; both treatments reduced losses due to rotting. In trials in the Netherlands (LBO, 1978; de Winter & van Leeuwen, 1982, 1984) the control of ink disease in infested bulbs of I. reticulata has proved difficult. Dips of captafol (alone), zineb/maneb (alone), or zineb/maneb plus benomyl, pimaricin or vinclozolin (the zineb/maneb was included to control Pythium) were tested; these treatments failed adequately to control ink disease.

Root rot (Pythium irregulare) can be a serious problem of iris under glass. It could be controlled by soil sterilisation or compost incorporation or drenching with furalaxyl or propamocarb hydrochloride, or, preferably, metalaxyl; maneb/zineb dips are also used to control Pythium (LBO, 1978; de Winter & van Leeuwen, 1980, 1981).

Bulb rot (Penicillium corymbiferum), basal rot (Fusarium oxysporum f. sp. gladioli), and stem and bulb rot due to Botrytis cinerea can affect iris bulbs. Benzimidazole fungicide used to control the former two may now be ineffective against Penicillium because of the development of resistance. Carbendazim or chlorothalonil may be used as sprays to control Botrytis.

Alternaria alternata on I. reticulata could be controlled by dipping in imazalil, and triflorine and triadimefon also had some effect (de Winter & van Leeuwen, 1982, 1983).

5.13 Bacterial diseases

Bacterial diseases are not generally associated with bulbous iris.

5.14 Virus diseases

Several aphid- and nematode-borne viruses affect iris, in particular Iris Mild Mosaic (IMMV) and Iris Severe Mosaic Viruses, and roguing must be carried out, especially for the latter. IMMV is important in I. reticulata and I. danfordiae.

The superior characteristics of virus-tested bulbs of I. reticulata have been described (van Leeuwen & van der Lans, 1988).

5.15 Pests

On Dutch iris, the following are the main insect pests, and appropriate controls are needed: potato tuber nematode (Ditylenchus destructor), aphids (including the tulip bulb aphid, Dysaphis tulipae), iris sawfly and small narcissus fly, along with slugs, cutworms and swift moth. Caterpillars of the storage moth Plodia interpunctella feed on the bulbs of I. reticulata, I. histrioides and other iris species. Damaged or diseased bulbs are attacked mainly, and the development of the pest, which lives in many kinds of stored plant products, is stimulated by high temperature.

5.16 Physiological and other disorders

Failure of floral initiation and bud blasting occur in Dutch iris, but have not apparently been reported for dwarf iris.

5.17 R & D needs

1. Trials are needed on production systems for bulb growing in the UK, including growing in nets; the reasons for poor yields in some UK trials should be investigated.

2. Development work to evaluate the performance of hybrids (for bulb production and forcing in pots) is required.

3. Bulb storage and disinfection needs to be investigated specifically for dwarf species.

4. Propagation (chipping) should be further developed in relation to exploiting a wider range of cultivars and species.

5. For pot-plant work, longer-lasting, multiflowered selections are needed.

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6. DWARF NARCISSUS

6.1 Area grown

Some 234 ha of "dwarf narcissi" are grown in the Netherlands (1988/89 figures, Table 6.1). This total was made up to 190 ha cyclamineus types (Division 6), 22 ha triandrus types (Division 5), 18 ha jonquilla types (Division 7) and 3 ha of the species, wild forms and hybrids of Division 10.

The wholesale price of varieties like Tete-a-tete and February Gold are somewhat lower now than five years ago, having peaked in the intervening time.

Narcissus species are imported by the Netherland from, eg, Spain, Portugal, Belgium, Malta and Austria. In 1986/87, over one million wild daffodils were imported from Portugal, including N. cyclamineus, N. jonquilla, N. triandrus and Angel's Tears (N. triandrus triandrus, syn. N. triandrus albus). In Spain, N. moschatus has been collected to extinction, and an hotel was built over the last site of N. wilkommii in 1988 (Read, 1989).

6.2 Types

Of the Divisions covered by this review, Divisions 5-7 comprise those of garden origin showing clearly the characteristics of N. triandrus, N. cyclamineus and N. jonquilla, respectively, while Division 10 includes all species and wild (or reportedly wild) forms and hybrids. This assemblage is diverse, but includes most dwarf and (or) small-bulbed types.

Of the triandrus types, the cultivars Hawera and Thalia make up the bulk (82%) of the current area (Table 6.1). Cyclamineus types are dominated by Tete-a-tete, currently 73 per cent of the Dutch area, having trebled in area over the past five seasons; the only other cultivars with significant areas are February Gold and Jack Snipe (12 and 4% of area), respectively), which have remained relatively stable. Division 7 is represented mainly by cultivars Baby Moon, Suzy and Trevithian, which together make up 58 per cent of this area.

Among the Division 10 narcissus, only N. canaliculatus achieves a reasonable area (1 ha) (the statistics show a great drop after 1984/85, Table 6.1). Other species are represented by very small quantities only. The main species grown in Holland are N. bulbocodium, N. campernelli (N. odorus, single and double), N. gracilis, N. jonquilla, N. nanus, N. obvallaris, N. pumilus and N. recurvus. Others incude N. calcicola, N. cyclamineus, N. elegans, N. juncifolius, N. minimus, N. minor, N. pseudonarcissus, N. odorus, N. rupicola, N. scaberulus, N. serotinus, N. tazetta, N. triandrus, N. viridiflorus and N. watieri.

Flowering characteristics of some dwarf narcissus, extracted from ADAS (1963, 1967) where further information can be found, are given in Table 6.2.

6.3 Applications and opportunities

There has been a large increase in the production of small narcissus in Holland recently (Tables 6.3 & 6.4). This seems linked with a demand for compact plants for container growing and for rockery and small garden use. UK growers would be well-placed to take advantage of this trend; growing small narcissus bulbs would have the advantage of diversification, without major changes in husbandry, while avoiding complications associated with flower picking. Expertise in bulb chipping could assist UK growers in these respects.

Table 6.1 Dutch dwarf narcissus areas (ha)*

	1984/85	1985/86	1986/87	1987/88	1988/89**
TRIANDRUS (DIVISION 5)					
Hawera	11.99	11.80	13.53	12.02	13.43
Ice Wings	-	-	0.07	0.85	0.71
Liberty Bells	1.08	1.16	0.76	0.66	0.47
Petrel	-	-	0.03	0.32	0.53
Rippling Waters	0.50	0.27	0.27	0.27	0.30
Shot Silk	0.72	0.66	0.75	0.52	0.51
Thalia	7.18	5.86	5.33	5.81	4.86
Tresamble	1.05	0.96	0.99	0.94	1.16
Others	0.29	0.10	0.07	0.17	0.37
Sub-total	22.81	20.81	21.80	21.56	22.34
CYCLAMINEUS (DIVISION 6)					
Andalusia	0.01	0.03	0.25	0.30	0.42
Baby Doll	0.56	0.43	0.63	0.52	0.68
Bartley	2.32	1.51	0.71	0.52	0.22
Beryl	0.15	0.17	0.12	0.13	0.10
Charity May	1.87	1.51	1.00	0.65	0.82
Dove Wings	0.37	0.26	0.15	0.11	0.10
February Gold	28.61	29.52	27.79	24.28	23.71
February Silver	0.49	0.66	0.67	0.62	0.68
Foundling	-	-	-	0.02	0.06
Garden Princess	0.86	0.79	0.77	0.92	0.94
Jack Snipe	7.62	7.84	7.60	7.02	7.86
Jenny	1.78	1.42	1.23	1.56	1.73
Jet Fire	-	-	0.03	0.27	0.60
Jumblie	4.42	4.73	5.77	7.00	7.45
Lark Whistle	-	-	0.11	0.13	0.18
Little Witch	1.40	1.88	2.01	1.77	1.59
March Sunshine	0.27	0.26	0.22	0.07	0.07
Peeping Tom	2.59	2.45	2.22	2.07	2.06
Quince	-	-	0.02	0.54	0.74
Satellite	-	-	-	0.01	0.01
Tete-a-Tete	45.19	62.23	82.05	114.49	139.18
Winged Victory	-	-	0.12	0.18	0.29
Others	0.22	0.13	0.24	0.21	0.27
Sub-total	98.73	115.82	133.71	163.39	189.76

Table 6.1 (continued)

	1984/85	1985/86	1986/87	1987/88	1988/89**
JONQUILLA (DIVISION 7)					
Baby Moon	2.53	2.14	2.53	2.31	2.38
Bobbysoxer	0.02	-	-	-	-
Dicksissel	-	-	-	0.11	0.31
Golden Perfection	1.02	0.55	0.50	0.38	0.26
Hillstar	-	-	-	-	0.02
Lintie	0.83	0.67	0.53	0.63	0.48
Philomath	-	-	-	0.03	0.12
Pipit	-	0.06	0.18	0.48	0.81
Quail	-	-	-	0.65	1.54
Sugarbush	1.56	0.94	0.76	0.47	0.42
Sundial	0.82	0.78	0.78	0.85	0.99
Sun Disc	0.18	0.30	0.30	0.48	0.37
Suzy	5.28	4.98	4.46	3.42	4.94
Sweetness	0.86	0.78	0.89	0.93	1.11
Tittle-Tattle	0.54	0.29	0.40	0.43	0.46
Trevithian	2.61	2.99	3.30	2.94	3.13
Verdin	-	-	-	0.03	0.02
Waterperry	0.45	0.52	0.45	0.50	0.49
Others	0.53	0.39	0.49	0.55	0.31
Sub-total	17.23	15.39	15.57	15.19	18.16
SPECIES ETC (DIVISION 10)					
N. asturiensis	-	-	-	-	0.01
N. bulbocodium conspicuus	0.16	0.02	0.13	0.15	0.20
N. canaliculatus	5.01	1.54	1.05	1.27	1.02
N. gracilis	0.01	-	-	-	-
N. jonquilla	0.21	0.30	0.57	0.26	0.13
N. nanus	0.04	-	-	-	-
N. lobularis	-	0.05	0.05	-	0.18
N. obvallaris	0.47	0.54	0.65	0.98	0.93
N. pumilus	0.17	0.17	0.12	0.12	0.16
N. recurvus	0.51	0.34	0.49	0.59	0.70
Others	0.08	0.04	0.02	0.11	0.07
Sub-total	6.66	3.00	3.08	3.48	3.40
Total of above	145.43	155.02	195.96	203.62	233.66

* Source: PVS/BKD ** Provisional

Table 6.2 Flowering and bulb yield data of some dwarf narcissus cultivars and species*

Cultivar etc	Emergence date	First flower date	Flowers/bulb		Flowers/ stem	Scape length (cm)	Perianth diam (cm)	% Bulb wt. inc.	
			2 years	3 years				2 years	3 years
TRIANDRUS (DIVISION 5)									
April Tears	19 Jan	13 Apr	2.9	-	1-4	27	5	288	-
Dawn	28 Dec	25 Mar	2.2	-	2-3	33	8	192	-
Harvest Moon	30 Dec	18 Mar	-	-	-	27	9	-	-
Moonshine	5 Jan	7 Apr	-	1-2	1-2	24	7	-	345
Niveth	13 Dec	23 Mar	2.3	2-3	1-2	28	7	243	480
Rippling Waters	2 Jan	27 Mar	2.7	3-4	2-3	34	9	205	259
Shot Silk	15 Dec	22 Mar	2.2	3-4	1-2	38	9	212	379
Silver Chimes	7 Oct	24 Mar	-	1-2	6-9	28	6	-	196
Snowbird	6 Dec	24 Mar	2.3	2-3	1-2	34	9	179	375
Thalia	7 Dec	20 Mar	2.3	3-4	1-2	33	9	205	388
Tresamble	18 Nov	29 Mar	2.3	4-5	1-2	42	10	246	405
Treskewes	8 Dec	15 Mar	-	-	1	29	10	-	-
CYCLAMINEUS (DIVISION 6)									
Baby Doll	15 Jan	15 Mar	4.1	4-5	1	26	9	172	243
Beryl	24 Dec	7 Mar	4.2	5-6	1	27	8	270	465
Charity May	4 Jan	7 Mar	3.8	-	1	25	9	184	-

Table 6.2 (Cont'd)

Cultivar etc	Emergence date	First flower date	Flowers/bulb		Flowers/ stem	Scape length (cm)	Perianth diam (cm)	% Bulb wt inc	
			2 years	3 years				2 years	3 years
CYCLAMINEUS (DIVISION 6) (Cont')									
February Gold	13 Dec	15 Feb	2.5	3-4	1	25	8	208	314
Garden Princess	7 Dec	3 Mar	-	5-6	1	35	10	-	545
Golden Lacquer	27 Dec	2 Mar	2.5	4-5	1	36	10	199	298
Jack Snipe	27 Dec	6 Mar	4.1	5-6	1	29	8	276	728
Larkelly	29 Dec	21 Mar	3.8	3-4	1	30	9	293	364
Le Beau	27 Dec	14 Mar	-	2-3	1	28	9	-	320
Little Witch	13 Jan	3 Mar	2.6	-	1	25	9	274	-
March Sunshine	5 Dec	25 Feb	2.8	4-5	1	26	10	265	242
Orange Glory	14 Dec	4 Mar	-	5-6	1	36	8	-	561
Peeping Tom	23 Dec	24 Feb	3.9	4-5	1	34	10	219	337
Trewirgie	21 Dec	19 Mar	-	2-3	1	34	9	-	325
Woodcock	29 Nov	2 Mar	-	-	1	32	11	-	-
JONQUILLA (DIVISION 7)									
Aurelia	25 Nov	31 Mar	0.8	2-3	1	38	8	189	422
Baby Moon	17 Nov	18 Apr	-	-	3-6	25	4	-	-
Bolton	25 Nov	23 Mar	2.6	4-5	1-2	48	8	300	385
Buttercup	23 Nov	30 Mar	-	4-5	1	47	9	-	553
Cherie	1 Dec	28 Mar	2.6	4-5	1-2	47	8	235	439
Cutty Sark	28 Nov	17 Mar	2.1	1-2	1-3	44	8	192	365

Table 6.2 (Cont'd)

Cultivar etc	Emergence date	First flower date	Flowers/bulb		Flowers/ stem	Scape length (cm)	Perianth diam (cm)	% Bulb wt inc	
			2 years	3 years				2 years	3 years
JONQUILLA (DIVISION 7) (Cont'd)									
Golden Goblet	19 Nov	16 Mar	-	1-2	1	38	11	-	204
Golden Perfection	22 Nov	23 Mar	2.6	3-4	1-2	50	11	301	340
Golden Sceptre	16 Oct	14 Mar	-	5	1	44	8	-	468
Goldilocks	3 Dec	21 Mar	1.0	2.7	1-2	47	8	209	319
Hesla	10 Nov	16 Mar	-	5	1	51	8	-	343
La Belle	1 Jan	23 Apr	-	3	1-2	26	6	-	403
Lanarth	18 Oct	1 Mar	4.5	3-4	1-2	46	8	337	343
Lintie	28 Jan	7 Apr	3.2	-	2-4	33	7	310	-
Nirvana	23 Nov	21 Mar	-	3-4	1-3	40	6	-	708
Orange Queen	16 Oct	4 Mar	-	4-5	1-3	30	6	-	381
Parcpat	13 Nov	16 Mar	-	9-10	1-2	44	8	-	533
Penpol	22 Oct	5 Mar	3.4	4-5	1-3	46	8	247	458
Polnesk	19 Nov	18 Mar	3.1	5-6	1-3	50	8	249	386
Shah	25 Nov	3 Mar	2.9	3-4	1	42	10	186	472
Sweetness	2 Nov	8 Mar	4.5	7-8	1	48	8	415	936
Trevithian	30 Oct	9 Mar	2.8	3-4	1-3	51	7	241	532
Waterperry	28 Nov	7 Mar	-	-	1-2	29	8	-	-
Zanita	12 Nov	29 Mar	-	-	1-3	44	8	-	-

Table 6.2 (Cont'd)

Cultivar etc	Emergence date	First flower date	Flowers/bulb		Flowers/ stem	Scape length (cm)	Perianth diam (cm)	% Bulb wt inc	
			2 years	3 years				2 years	3 years
Compressus	8 Nov	18 Mar	1.9	4-5	8-11	34	4	158	317
jonquilla	11 Sept	24 Mar	-	11-12	1-6	38	4	-	1105
poeticus Ornatus	10 Jan	25 Mar	2.3	-	1	34	7	244	-
poeticus Flore Pleno	27 Dec	11 May	-	4-5	1	56	8	-	598
poeticus radiiforus poetarum	29 Dec	7 Apr	3.1	4-5	1	48	8	228	748
poeticus poeticus recurvus	19 Jan	2 May	1.7	3-4	1	58	7	325	369
pseudo-narcissus gayi	13 Jan	1 Mar	1.9	-	1	26	11	332	-
pseudo-narcissus major	10 Nov	29 Feb	-	4	1	46	10	-	599

Table 6.2 (Cont'd)

Cultivar etc	Emergence date	First flower date	Flowers/bulb 2 years	Flowers/bulb 3 years	Flowers/ stem	Scape length (cm)	Perianth diam (cm)	% Bulb wt inc 2 years	% Bulb wt inc 3 years
SPECIES ETC (DIVISION 10) (Cont'd)									
pseudo-narcissus obvallaris	12 Dec	17 Feb	2.7	5-6	1	31	7	373	876
tazetta lacticolor canaliculatus	30 Nov	2 Mar	-	3-4	2-4	18	3	-	737

* Data from Rosewarne EHS for two-year-down growing (ADAS, 1967) and (or) three-year-down growing (ADAS, 1963); where a cultivar was tested in both systems, means for the two are given except for flowers/bulb and bulb weight increase. Note that numbers of flowers are given as means or ranges

-, not determined or not recorded

Table 6.3 Analysis of narcissus production in the Netherlands in recent years

Division/Type	% of area grown 1982/83	1985/86	Change
1. Yellow Trumpet	33	26	Decrease
Bicolour Trumpet	1	1	None
White Trumpet	1	1	None
2. Long Cup	44	48	Increase
3. Short Cup	4	3	Decrease
4. Double	7	7	None
5. Triandrus	1	1	None
6. Cyclamineus	4	7	Large increase
7. Jonquilla	1	1	None
8. Tazetta	2	3	Increase
9. Poeticus	1	1	None
10. Species	1	1	None
11. Split Cup	1	1	None
Total Area (ha)	1518	1582	Small increase

Table 6.4 Expansion of dwarf narcissus production in the Netherlands

Division	Cultivar	Area grown (ha) 1982/83	1985/86	% change
5	Hawera	7	12	71
	Thalia	5	6	20
6	February Gold	20	30	50
	Jack Snipe	4	8	100
	Jumblie	2	5	150
	Tete a tete	26	62	138
7	Suzy	6	6	0

There is demand in Holland for new varieties, and especially for a replacement for Tete-a-tete; Jet Fire is a variety of interest. Varieties with pink paracorollas are increasing in popularity. Most new varieties come from Northern Ireland or England. The qualities needed are dual purpose (pot and garden use), bright lasting colour, good yield and disease tolerance.

There is increasing demand in Holland for dwarf narcissus in pots; usually, three bulbs are planted in a 7 cm pot. Pot-grown Tete-a-tete are dwarfer and more acceptable as pot-plants when lower temperatures (2 or 5°C) are used, instead of 9°C, for cooling; time to anthesis was extended, but this was not necessarily a disadvantage for the pot-plant. This technique was more acceptable than using the growth retardant ethephon or shortening the cold period (de Greef, 1986).

An indication of the price range of some dwarf varieties is given in Table 6.5.

Table 6.5 Some dwarf narcissus wholesale prices*

Cultivar	Division	Price (£ per 1000)
Baby Moon	7	52
N. bulbocodium conspicuus	10	92
N. canaliculatus	10	63
Charity May	6	72
N. campernelli, double	10	104
February Gold	6	44-63
Jack Snipe	6	45-100
Jenny	6	144
N. jonquilla	10	52
Jumblie	6	36-40
Suzy	7	115
Trevithian	7	81
Libery Bells	5	130
Lintie	7	130
Little Gem	1	144
N. lobularis	10	58
N. obvallaris	10	115
Peeping Tom	6	87-115
Pencrebar	4	173
Rip van Winkle (N. minor pumilus)	4	259
Tete-a-tete	6	49-81
N. triandrus albus (Angel's Tears)	10	86
Hawera	5	27-41
Thalia	5	115

* List compiled by A A Tompsett; approximate prices in 1988

6.4 Yields

Yield data for six cyclamineus cultivars grown two-years-down at Rosewarne EHS are given in Table 6.6. With the planting rates used (5-11 t/ha), the percentage weight increase averaged a very respectable 225% across all cultivars. In further trials at Rosewarne (ADAS, 1988), the percentage weight increases after one season for Tete-a-tete grown at 9.5 t/ha ranged from 161 to 182 in different treatments. The responses of such cultivars at the current standard planting density of 15 t/ha is not known. Weight increases of further dwarf cultivars are given in Table 6.2.

Table 6.6 Yield of cyclamineus cultivars grown two-years-down*

Cultivar	Planting rate (t/ha)	% weight increase	Disposable surplus (t/ha)
February Gold	6.3	208	13.1
Beryl	6.5	270	17.5
Jack Snipe	4.6	266	12.3
Larkelly	9.5	293	27.7
March Sunshine	6.3	265	16.7
Peeping Tom	10.8	219	23.7

* Data extracted by A A Tompsett from ADAS (1967)

6.5 Soils and fertility

It is to be assumed that the general requirements for narcissus would apply, with the usual provisos for small-bulbed species.

6.6 Climatic factors

The bulbs are grown on a one-year-down system. In Holland, before December the land is covered with straw to protect from frost, water and blown-sand injury; the straw is removed in February, either mechanically or by burning in situ. Up to 20t straw/ha may be used, although Meijers (1979) recommended 7 to 10.5 t/ha, a quantity which can be left in situ rather than removed. A further recommendation given was to incorporate into the soil surface 1.5 t straw/ha, followed by sowing rye at 250 kg/ha prior to 15 September, this being killed by spraying in December. Other covering materials have been tried: Meijers (1979) quoted examples of frost penetration to a depth of 32cm in non-covered plots, compared with 10cm under straw, 16.5cm under rye, 1-5cm under reeds and less than 1cm under bubble or other plastic foil. It is not yet determined whether the use of a cover would be advantageous in UK conditions.

Narcissus are less sensitive to frost injury, compared with some other bulbs such as iris. Sakai & Yoshie (1984) tested the freezing tolerance of various bulbs. Among the narcissus tested, rooted bulbs (usually with a short emergent shoot) survived freezing and subsequently flowered, down to -5°C (Tete-a-tete, Geranium and an unnamed trumpet cultivar), to -7°C (Actaea) and -10°C (N.poeticus). In experiments with N.lobularis, root growth ceased when soil temperatures dropped to 3°C (Wilson & Peterson, 1982).

6.7 Planting

The narcissus species have small bulbs (2-3 cm), while bulbs of cyclamineus types may be 10-12 cm, so it is impossible to generalise on planting rates across the range of dwarf narcissus. In Holland, the bulbs are planted September-October at around 10 t/ha, around half the rate for larger narcissus, and are grown on a one-year-down system as normal.

In trials with cultivar Tete-a-tete at Rosewarne EHS (ADAS, 1988), planting 7-9 cm grade bulbs at 9.5 t/ha in netting did not reduce yield after one season compared with planting loose.

As with all bulbs, correct planting depth is important. In a study of the wild daffodil, N.pseudonarcissus, Barkham (1980) showed that shallow planted bulbs (2.5 or 5 cm deep) produced more daughter bulbs, fewer and more rapidly senescing leaves, and a lower bulb yield than bulbs planted deeper (10 or 15 cm).

6.8 Herbicides and other growing season husbandry

Weeds are controlled using chlorpropham, chlorbufam + chloridazon, or, especially, metamitron. Routine fungicide sprays are applied, usually four times, at flowering and then at 10 day intervals, using benomyl, vinclozolin, maneb or appropriate mixtures.

The dwarf cultivars Tete-a-tete and Peeping Tom in some cases showed yield reductions when bentazone was used; fluazifop-butyl, metamitron, chlorbufam + chloridazon and chlorpropham are generally safe. Glyphosate and glufosinate-ammonium could be used with Tete-a-tete, pre-emergence in December, as a substitute for paraquat, with no yield loss (Vreeburg & Korsuize, 1986, 1987).

In trials on sandy soil in the FRG, lenacil, chloroxuron and propachlor were found suitable for use with N. pseudonarcissus and N. poeticus (BBLF, 1972). Smith & Treaster (1982) evaluated several herbicides for pre-emergence use on N. campernelli Flore Pleno. At the rates used, chlorthal-dimethyl and dichlobenil caused only minor visual injury; oryzalin, pronamide, napropamide and simazine caused moderate, and oxadiazon and oxyfluorfen severe, damage.

Some dwarf cultivars (Tete-a-tete and Hawera) appeared in trials to be more sensitive to yield loss when mineral oils were applied, compared with standard varieties (Vreeburg & Korsuize, 1985, 1986, 1987).

6.9 Harvesting

The bulbs are harvested mid-July to early-August. Bulbs may be windrowed, but only for a short time and only in favourable weather conditions (sun scorch may occur, and wet weather leads to infection by Botrytis and Penicillium).

6.10 Bulb treatment and storage

Narcissus planting stocks are routinely given HWT to control nematodes, narcissus fly and bulb scale mite, with fungicide added to prevent the spread of fungal diseases. In the UK, the standard HWT is for 3 hours at 44.4°C, with or without pre-warming (7 days at 30°C) and (or) pre-soaking (3 hours or overnight at ambient temperatures), formalin and wetter being added to the tanks. In trials with cultivar Tete-a-tete at Rosewarne EHS (ADAS, 1988), pre-warming, pre-soaking and HWT at 46°C increased bulb yields and reduced HWT damage compared with HWT at 44.4°C following ambient storage.

In The Netherlands, standard narcissus planting stocks are treated as follows. To control nematodes specifically, 1 week at 30°C is followed by HWT for 4 hours at 47°C, within 3 weeks of lifting. To control narcissus fly and (or) bulb scale mite, the routine is a 2 hour HWT at 43.5°C. The following are added: 1% commercial formalin and zineb/maneb or captan or benomyl or carbendazim or thiophanate-methyl.

On the other hand, miniature narcissus planting stocks are sensitive to formalin, so the following additives are used: zineb/maneb or captan plus benomyl or carbendazim or thiophanate-methyl. If, however, there is heavy contamination with basal rot, 0.5% (maximum concentration) commercial formalin is added in any case. If Penicillium is a problem, captan must be used instead of zineb/maneb. To obtain better skin quality, the concentration of benomyl, carbendazim and thiophanate-methyl may be doubled. Batches suffering with poor skin quality are better treated with captan plus prochloraz; with this combination, HWT must be applied before mid-September, to bulbs with closed noses. Chemicals in HWT tanks must be replenished as necessary, using commercial formalin at 1½ x the original strength and other materials at the original strength. If the bulbs are to be dried after HWT (rather than being planted immediately), anti-dust preparation is added to HWT, usually at a high rate in the case of miniature narcissus. If HWT is not given (this is not recommended), then the above chemicals are used as a 15 minute bulb dip, with added anti-dust preparation if planting is to be delayed.

With miniature narcissus, removal of offsets should take place at least 7 days before HWT. Fungal infection can easily occur at the sites of damage. All handling procedures should be adjusted to minimise damage (van der Weijden, 1989).

HWT must take place at the appropriate time. Poeticus narcissus are usually treated earliest, followed by, in order, short-cupped, long-cupped and, finally, trumpet narcissus. Dwarf types form fine and early roots. In trials in the Netherlands (Vreeburg, 1978, 1979), Trevithian (Division 7) and February Gold, Jack Snipe and Tete-a-tete (Division 6) received HWT with pimaricin, or combinations of formalin, thiram and benomyl. Late HWT (7 October) gave a considerable yield loss compared with HWT on 3 September. Pimaricin gave lower yields and poorer skin finish than thiram + formalin or thiram + benomyl (although some growers reported that thiram + formalin was less satisfactory). With February Gold, formalin (0.5 or 1% commercial product) plus benomyl gave good results.

In the case of saleable-size bulbs of miniature narcissus intended for flower production (not dry sales), fungicide dips are confined to cultivars susceptible to Botrytis or Stagonospora. Narcissus bulbs for pot-plant production are usually dipped. Dipping is carried out, prior to planting, in benomyl or carbendazim or thiophanate-methyl plus vinclozolin. If Penicillium is present, captan is added to the above materials; in the case of miniature narcissus for pot cultivation, captan should always be added. Dips for 15 minutes are sufficient, and topping-up should be carried out with all chemicals at the original concentrations.

Miniature pot narcissus receiving a pre-cooling period are dipped twice, once before pre-cooling (adding anti-dust preparation), and the second time just before planting.

The foregoing Dutch recommendations for fungicide dips for dwarf cultivars were derived from series of trials which showed that these combinations of chemicals were most effective, giving the best yields and skin finish, and preventing bulb scale mite infestation, in cultivars Tete-a-tete and Jack Snipe; using these chemicals separately, or using some others (vinclozolin, prochloraz) was less effective or reduced yields (Vreeburg & Korsuize, 1982, 1983, 1984, 1985). Further trials looked at the problems of Botrytis, Penicillium, Fusarium and Rhizopus in Tete-a-tete grown in pots (Vreeburg and Korsuize, 1986, 1987, 1988; van der Weijden, 1989; van der Weijden & Vreeburg, 1988); these tend to rot when cooled even if the bulbs do not when planted in the field. Thorough drying of bulbs following lifting (preferably not in windrows), not beginning cold storage too soon, and dipping in appropriate fungicides preferably before pre-cooling and before planting, were the most important factors. In more recent recommendations, all cold is given to planted bulbs (14 weeks 5^{o}C) (van der Weijden, 1989). The chemicals were benomyl and vinclozolin plus captan, using an anti-dust chemical when dipping for the first time, or, alternatively, carbendazim or thiophanate-methyl instead of benomyl. Captafol also used to give some control. Good results were also obtained by dipping bulbs soon after lifting and planting in a potting compost with a high percentage of black peat; placing bulbs on the compost and covering with sand helps prevent the spread of moulds.

Careful bulb handling is required, drying between stages. Storage of bulbs at 75% relative humidity in airy conditions is important: when drying bulbs in trays, it was recommended that air was blown through the produce at 100 m^{3}/hour per 100 litres bulbs, with external air warmed by about 3^{o}C; after thorough drying, perhaps 2 months after lifting, the above rate could be reduced to 50 m^{3}. For this stage, recent recommendations are for 6 weeks after-drying, at 20^{o}C for flowering until the end of January and at 25^{o}C for later flowering; thereafter at 17-20^{o}C until planting. Miniature narcissus must not be stored in bulk. If the bulbs are dried only for 4 weeks before cooling, the waste is higher than if longer drying is used.

6.11 Propagation

The chipping methods works satisfactorily with Tete-a-tete. In Holland, bulbs are generally cut into 12, rather than 16, segments, because of their small size and annual growing system. In trials, 14-71% of bulbs flowered in their second year after chipping, depending on initial bulb size. The optimum incubation for chips of this cultivar was 13 weeks at 23^{o}C (Vreeburg & Korsuize, 1984,1985). Direct-planting is also being used, planting by late-July at the latest.

There are reports of species (such as N. pseudonarcissus and N. scaberulus) being propagated by chipping or twin-scaling (S. Oldfield, pers. comm.)

A range of miniature and species narcissus has been evaluated using the chipping technique at Kirton EHS (Hanks, 1987). 10-12 cm bulb of Tete-a-tete and Thalia, cut to 16 segments, produced 1.7 and 1.4 bulbils per chip, respectively, with a mean bulb length over 10 mm. Among the species tested, bulbil production varied considerably. N.canaliculatus and N.triandrus albus (Angel's Tears) performed least well, but, even so, 70 to 80% of their chips produced a bulbil. N.cyclamineus, N.jonquilla and N.minimus chips performed better, while chips of N.bulbocodium conspicuus and N.lobularis (N.minor conspicuus) gave two or three good-sized bulbils each. The smaller-bulbed species were usually cut to eight segments each. Although exacting, chipping species narcissus is worthwhile: even 4-6 cm bulbs of N.lobularis cut to 16 chips each yielded well. In these trials, all chips were incubated at 20°C for 12 weeks.

Recent estimates (1987) of the extent of narcissus chipping in Holland are that 10-15 growers chip narcissus for themselves or on contract, involving 300-400 t bulbs annually and 200-300 ha on about 50 farms. While much of this enterprise is directed to producing uniform round bulbs for pre-packs, it seems likely that some production is directed towards multiplying miniature narcissus because of the demand for these.

Some wild species form few offsets, and are therefore propagated by seed, which can be small and difficult to handle (S. Oldfield, pers. comm.). Propagation from seed is important in breeding programmes, but there is a long juvenile period before flowering, from four to six year in different varieties, and during this time leaf number and size are very restricted, resulting in slow bulking. In wild N. pseudonarcissus, pollination is by bumble bees, and little pollination occurs in the absence of the insects: pollination is often poor, because of infrequent insect visits in the cool conditions of early spring (Caldwell & Wallace, 1955). This probably applies generally to other species and cultivars.

Rees (1972) states that seeds of narcissus have a cold requirement, possibly of many weeks, for germination, hence they germinate in spring when days are lengthening. In practice, seeds are sown and kept outdoors or in cold frames, germination occurring rather unevenly. However, in a study of the germination of N. bulbocodium, Thompson (1977) found that conditioning imbibed seeds at 26°C for 7 weeks resulted in rapid and uniform germination at temperatures between 5 and 16°C; conditioning at lower temperatures (6 or 16°C) was not effective. Hence there was no evidence that cool treatments broke dormancy in this species. An effective treatment would be to sow seeds soon after harvest in a warm glasshouse, moving to cooler conditions after about two months. These findings explain the practical horticutural observation that, sown outside after collection, N. bulbocodium germinates fairly soon, in summer, whereas N. pseudonarcissus germinates last, the following spring (Wells, 1989). Seeds of N. pseudonarcissus are not apparently light-sensitive (Caldwell & Wallace, 1955).

6.12 Fungal diseases

The range of standard narcissus pathogens should be considered, but dwarf narcissus can suffer serious wastage from Sclerotinia, Botrytis and Penicillium, which cause poor skin quality, and also Fusarium and Rhizopus. Tete-a-Tete is particularly susceptible.

Sclerotinia (Botrytis) narcissicola (smoulder) and Botrytis cinerea (grey mould). Leaf tips of bulbs may appear brownish-black in colour, with a grey-brown mould; there is usually a broad, yellow band separating infected tissue from the rest of the leaf, and infected leaf tips may stick together. The shoot may be very stunted, or the bulbs themselves may be affected, with a pale brown basal plate and bulb scales.

Penicillium. Infection occurs after lifting, with the infected tissue at damaged points going brown and beginning to rot. The rot is initially confined to the damaged scale, and subsequently spreads to the base plate or to other scales. Greenish to grey mould may be seen externally, although this may be concealed by the tunic; a "puffer" is a completely rotted bulb beneath an intact tunic, which can be easily crushed to release a cloud of spores. Damage likely to result in infestation could be a damaged outer scale or wound where an offset has been removed.

Both Botrytis and Penicillium occur in miniature narcissus, Tete-a-tete being specially susceptible. The two diseases are not easy to distinguish or to spot during storage, but may become evident when the bulbs are brought from cold storage. Control measures are given above under bulb handling; however, it appears that the problem has not yet been fully solved, and a decline in the area of Tete-a-tete may be expected.

Rhizopus sp. (soft rot) causes a very rapid rot of bulbs under conditions of high temperature (30°C or above) and high humidity. Bulbs are particularly vulnerable when given a high temperature treatment following a dip; formalin and benzimidazole fungicides do not control Rhizopus.

Penicillium and Rhizopus may be troublesome during bulb propagation by chipping, and appropriate dips should be used.

Fusarium oxysporum f. sp. narcissi (basal rot). Most large trumpet narcissus cultivars in commerce are susceptible to basal rot, whereas those of the triandrus, jonquilla, tazetta and poeticus divisions are resistant to the disease. Linfield (1986) examined the susceptibilty of several narcissus species to basal rot applied as soil infestations. The following species were resistant to basal rot: N. bulbocodium, N.canaliculatus, N.henriquesii and N.odorus rugulosus, and the following were partially resistant: N.nanus, N.minor pumilus, N.jonquilla and N.poeticus flore pleno; N.asturiensis, N.juncifolius, N.pseudonarcissus, N.scaberulus and N.triandrus concolor were susceptible.

The control measures given for standard cultivars should be followed.

Ramularia vallisumbrosae (white mould), Stagonospora curtisii (leaf scorch) and Sclerotinia polyblastis (fire) attack narcissus in general, and normal recommendations would apply.

Sclerotinia bulborum (black slime disease) may occur on narcissus. Bulbs of Tete-a-tete have been treated with 0.1% procymidon in HWT to control the disease, with no loss of yield (Vreeburg & Korsuize, 1988).

6.13 Bacterial diseases

Bacterial diseases are not apparently a problem in narcissus.

6.14 Virus diseases

Many viruses, both aphid- and nematode-borne, attack narcissus. Virus, especially tobacco rattle virus, is a major problem of many dwarf narcissus. Stock selection, roguing and control of vectors are all needed. Virus-tested bulbs of Tete-a-tete have been produced at LBO Lisse and IHR Littlehampton. N. pseudonarcissus appears relatively immune from disease, including virus (Caldwell & Wallace, 1955).

6.15 Physiological and other disorders

Those affecting narcissus include grassiness and various flowering failures, along with disorders such as neck rot and chocolate spot and physical effects such as cold injury (to leaves) and HWT damage.

There appears to be no specific reference to dwarf narcissus in these cases.

6.16 Pests

The control of Ditylenchus dipsaci (stem nematode) in dwarf narcissus by HWT has been described above. Although no information specific to dwarf cultivars is available, it is to be expected that control for other pests - other nematodes, large and small narcissus flies, bulb scale mites and bulb mites, along with aphids and slugs - would follow that for standard varieties. In Tete-a-tete, narcissus fly has been reported to enter down the neck of the bulb.

6.17 R & D needs

1. Development of improved disease control in dwarf cultivars like Tete-a-tete is urgently needed.

2. Agronomy of Tete-a-Tete (density, HWT, covering) needs to be investigated in the UK.

3. Replacement cultivars for Tete-a-tete are urgently needed; varietal assessments are required and breeding programmes should be encouraged.

4. There is a demand for species narcissus which is unlikely to be met from wild collections; trials on propagation and growing systems need urgently to be instigated.

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7. DISCUSSION

7.1 Discussion

Rees (1972) heads his chapter on bulb morphology and development by quoting from Chouard (1931): "Sous un mode de vie apparement uniforme, les plantes bulbeuses cachent une grande diversite". It is this hidden diversity among bulb plants which led to the commissioning of the present report. While a certain few bulbous ornamentals - tulip, narcissus, hyacinth - have captured the imagination of commercial horticulturists and horticultural scientists for four centuries, such that their production has been developed successfully and to a high degree of technical excellence, most other bulbous genera remain, despite their obvious attractions, poorly understood and underexploited. Perhaps the forebears of today's tulips, narcissi and hyacinths were in the right place at the right time - and had the right physiology for Western European conditions - to become the subjects of the bulb growing pioneers. Equally, perhaps the time is now appropriate more fully to exploit the range of so-called minor bulbs, for today's consumer society wants choice, something new - something special - and all produced to the highest standards. There is a growing awareness also of the value of wild bulbous species, often a delicate foil to the big bright bulb crops with which we have become familiar. The Dutch bulbs industry, ably assisted by flower-bulb research workers, have certainly responded to these trends, with the development of innovations (recent examples include developments in the use of Scadoxus, Tulbaghia, Oxalis and Fritillaria) as well as a continued search for new exploitable species. On the other hand, UK bulbs interests may be perceived as staid (Economist Intelligence Unit, 1989). As the statistics in Section 1 indicate, however, a wide variety of Dutch bulbs are avidly purchased by UK customers, and in considerable quantities.

What, then, are the prospects for growing a wider range of bulb crops in the UK? They seem at first sight to be poor, and the decline in UK tulip growing is usually cited as back-up for this view. But the production, marketing and general resources available to Dutch tulip growing are in no way relevant to such considerations: the tulip is the premier flower bulb in the Netherlands (with over 7000 ha in the field). In contrast, it is clear from the bulb press that Dutch producers of minor (or special) bulbs have had to come to terms with problems entirely similar to those which would face a specialist bulbs producer elsewhere - lack of information (for growers, merchants and consumers), indifferent quality and choice of stocks, the limited market (with worries about pricing and over-production), and the high labour requirements (with labour becoming scarcer).

Small or specialist UK growers would, then, share problems to those of their Dutch counterparts. They would enjoy some advantage in terms of climate, while suitable land could be sought out (the areas involved would be small); judging from the results of UK trials on the irrigation of bulb crops, where responses to irrigation have been poor in most years (ADAS, 1986, 1987, 1989), the lack of a controlled water-table may not be too great a disadvantage. UK growers should not lose out in terms of transportation or technical abilities or resources, and they are near to markets which continue to have a high level of demand for bulbs or which are expanding; they may, however, suffer to some extent because of the lack of well integrated research, marketing and publicity infrastructures.

If these problems of UK growers can be found, the choice of what bulbs to grow is then critical. The author's view is that to grow bulbs which, although relatively easy to produce, are already produced in quantity in the Netherlands - such as Large Yellow Crocus, Muscari Blue Spike or Iris reticulata - would only be worthwhile if a specific market (perhaps large-scale amenity planting or a pot-grown bulb enterprise) were available. With such genera, a better approach might be to use micropropagation and chipping to bulk superior varieties presently in short supply. There is, for example, a demand for healthy stocks of dwarf narcissus varieties as alternatives for Tete-a-tete; the culture of dwarf narcissus could be a relatively simple diversification exercise for UK growers, and one which would suit the large-scale bulb producer as well as the small specialist grower. In the case of Muscari, Crocus and dwarf Iris, good cultivars should be made more widely available. The remaining bulb considered in this report, the snowdrop, is a special case: commercial methods of culture, handling and marketing need to be developed, but there seems to be no reason why this could not be done. With Galanthus, Narcissus species and some others, there is the added interest relating to conservation aspects.

Growing minor bulbs involves technical, as well as economic, choices. For the more exotic bijgoed, there is a severe lack of specialist information, but, if this could be provided, there could be the possibility of creating appropriate market niches. Success with this category of bulbs in the Netherlands seems to come for growers prepared to develop specialist knowledge in a range of uncommon bulbs, which can command good prices to repay the effort involved. The diversity of bulbs, already referred to, shows in the conditions they need for successful culture, and innovative thinking or special conditions may be need to achieve this. Erythronium, for example, will grow well when interplanted with narcissus, which acts as a windbreak and shade. Galanthus can also be grown in this way, or shaded with netting. The delicate bulbs of Fritillaria meleagris can be protected from desiccation by using a coating wax; other bulbs with delicate skins, eg bluebell, simply need careful handling. Ismene (or Hymenocallis) festalis Zwanenburg is a spectacular flower, but may need glasshouse culture to ensure the production of large bulbs of flowering size. In some cases more suitable varieties need to be bred: there have been some successes among the minor bulbs, such as the hardier Erythronium hybrid Pagoda, large-flowered Scilla and the very large headed Allium Globe Master.

The specialist grower - not necessarily with a bulb-growing background - who is considering producing special bulb crops, will need to look carefully at the statistics of bulb growing, looking for useful trends; to study the available technical information, including the Dutch press (Bloembollencultuur or Hobaho and Vakblad voor de Bloemisterij) and the excellent textbooks on minor bulbs which are available; and to study the live material in shows, botanical gardens and the national collections. He will need commitment to do the job right, including seeing it is not undervalued by the consumer - with bulbous products, the customer is buying a product which, like any perennial, should increase and give years of satisfaction. Sensible areas of crops need to be grown, with gentle expansion, preferably not relying on a single species. Some opportunism and entrepreneurial skills will be called for; but, above all, the potential grower of special bulb crops will need to do his homework, and then decide whether he can take the risks involved.

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8. RECOMMENDATIONS

1. There is a general requirement for minor bulb crops to investigate techniques for bulb production in netting under UK conditions, including the general agronomy of the netted crop and the reasons for loss of yield in some crops when net-grown.

2. A further general need is for the production of high health status stocks of good varietal purity.

3. Other R & D needs are summarised under individual crops (sections 2.17 etc).

4. While many problems face the grower of minor bulb crops (such as lack of information, high labour requirements, and the dangers of over-production), these apply to Dutch producers as well as others. With careful consideration, there is scope for specialised growers to produce a distinctive range of high-quality alternative bulb crops in the UK.

5. In the case of dwarf narcissus, there is high demand, and diversification to these could be attempted by larger UK bulb growers, and not necessarily be restricted to small specialist growers.

6. For small bulbs such as dwarf iris, crocus and Muscari, which are produced in quantity in the Netherlands, the chief opportunities appear to be in widening the range of choice species and varieties available; these would need to be carefully promoted, perhaps by developing a high-quality pot-grown product sold in bud or flower for transplanting to the garden. Justification for growing the more usual types would be if large-scale amenity sales could be promoted.

7. For snowdrops, consumer appeal and conservation aspects suggest an urgent need to investigate propagation (seed, chipping, micropropagation) and growing systems for a range of species from different habitats. These would be a prime subject for sale in pots, although bulb storage should nevertheless be investigated for larger-scale commercial practice.

8. For species narcissus (in contrast to dwarf cyclamineus types) propagation and growing systems also need to be investigated urgently, because of consumer demand and concerns over collection from the wild.

9. The production of specialised products, such as saffron and cipollacio o muscaro, could be investigated.

10. Besides the five groups examined in this report, many choice bulbous crops could potentially be exploited by the Bulbs Industry, benefiting the industry, consumers and the environment. Technical and even basic botanical information is usually lacking in these cases. A modest commitment to both far- and near-market research would ensure a dynamic bulbs industry well into the next century.

9. ACKNOWLEDGEMENTS

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I thank Mrs L J Withers for her efforts in setting up a bulb bibliographic database at Kirton EHS, Mr A A Tompsett (formerly Deputy Director, Rosewarne EHS) for providing information from trials at Rosewarne, and Miss S Oldfield (International Union for Conservation of Nature and Natural Resources, Cambridge) for information on bulbs collected from the wild.

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APPENDIX I COPY OF CONTRACT

Contract between ADAS (hereinafter called the Contractor) and the Horticultural Development Council (hereinafter called the Council) for a research/development project).

PROPOSAL

1. TITLE OF PROJECT BOF/13/88

Minor bulbs: a review of dry bulb production with a view to their exploitation in the UK.

2. BACKGROUND

UK dry bulb production is dominated by narcissus, which has a stable crop area (4042 hectares in the field, 1986 figures) and increasing values of exports (£4.1m in 1986). The production of tulip bulbs, on the other hand, has declined dramatically in the UK (from 368 hectares in the field in 1982, to 193 hectares in 1986). The field-grown area of all other bulbs, predominantly lily, gladiolus, iris and anemone, is also relatively stable as a whole (198 hectares in 1982, 221 hectares in 1986), although undoubtedly lily is increasing in importance. Given that the decline in tulip acreage is unlikely to be reversed with our present state of knowledge, and that the other bulb crops mentioned above are relatively stable, what opportunity is there to introduce other species to the UK bulb industry?

UK bulb imports rose from 495m bulbs in 1980, to 752m bulbs (£25.9m) in 1986. What bulbous subjects made up this increase? Figures for imports from Holland to the UK reveal the following facts (1985 values). Numerically, these imports are dominated by tulip (151m bulbs) and crocus (120m). Other important bulbs are iris (39m), hyacinths (29m), anemone (21m), Galanthus (16m), Muscari (14m), ornamental Allium (12m) and lily (11m). In addition, narcissus imports comprise 25m bulbs sold by number, of which dwarf narcissi probably form a large percentage, plus 682 tonnes re-planting stock, which will include some dwarf bulbs. The remaining species may be small in number, but some are high value bulbs and others show dramatic increases in numbers imported. For example, numbers of the following bulbs imported to the UK increased between two and six-fold over the period 1980 to 1985: Pushkinia, Fritillaria, Leucojum, Oxalis, Allium, Brodiaea, Lilium, Narcissus (sold by numbers), Chionodoxa, Crocus, Muscari and Tritelia.

Few of these minor bulbs are produced in the UK, and information on suitable production methods is sparse.

3. OBJECTIVE

The project aims to provide a review covering dry bulb production methods for a selection of these minor bulbs, along with associated information on statistics and potential uses, and an indication of any R & D work needed.

4. POTENTIAL BENEFIT TO THE INDUSTRY

Increased UK production of some of these minor bulbs would confer several advantages to our bulb industry:

1. Diversification from narcissus production;

2. Satisfying the needs of UK consumers for high value bulbs;

3. Import substitution;

4. Further export potential.

5. CLOSELY RELATED WORK IN PROGRESS OR RECENTLY COMPLETED

There have been very small inputs on chipping minor bulbs at Kirton EHS and on the production of minor and alternative bulb crops at Rosewarne EHS over the past few years.

6. DESCRIPTION OF THE WORK

A detailed review of the bulbs listed leading to a comprehensive report indicating potential for the UK industry:

1. Species narcissi;

2. Galanthus;

3. Iris reticulata and hybrids;

5. Muscari species and hybrids.

There will be a heavy component of translations from Dutch work, which will increase the time required for the project to be completed.

7. STARTING DATE AND DURATION

June 1988 for 1 year.

8. STAFF RESPONSIBILITIES

HDC Co-ordinator: J D Taylor
HDC Project Leader 9ADAS0: G R Hanks

9. LOCATION

Kirton Experimental Horticulture Station.

10. COSTS

£1,500.

11. PAYMENT

On each quarter-day the Council will pay the contractor in accordance with the following schedule:

Project Year	1	2	3
	£1.5K		
Quarter/Year	1988		1989
1			375
2			375
3	375		
4	375		

TERMS AND CONDITIONS

12. The Council's standard terms and conditions of contract shall apply.

Signed for the Contractor(s) Signature .....

Position .....

Date .....

Signed for the Contractor(s) Signature .....

Position .....

Date .....

Signed for the Council Signature .....

Position .....

Date .....