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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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PRACTICAL SECTION

Objectives and background

There is a demand in the trade for bulbs of attractive and delicate wild species, such as *Narcissus cyclamineus*. In the past, many bulbous species were collected from the wild, a practice which yielded bulbs of poor quality and which was environmentally unacceptable. Sales could probably be increased if commercial methods of sustainable production were available for such species.

The objectives of the project were:

- to review the status of *Narcissus* species in the wild and in the trade, and their commercial potential
- to determine the conditions required for optimum seed germination
- to describe efficient growing systems for producing saleable bulbs from seed
- to investigate the production and maintenance of sustainable crops for seed production

Three species were used in the experimental work: *Narcissus bulbocodium* var. *citrinus*, *N. cyclamineus* and *N. pseudonarcissus*.

Summary of results

Survey of species

Classification of the genus *Narcissus* is contentious, because of the ease with which hybridisation occurs and the difficulty of defining what constitutes a species. As a starting point to the survey of the availability and commercial potential of *Narcissus* species, a practical classification of the genus was developed. The species were grouped into autumn- or winter/spring-flowering types and into ten Sections, and the defining characteristics of each group were listed. The recognised species – 68 in the present classification – were listed in these Sections, and for each species the following information was given: (a) a brief description (not so much as an aid to identification, but to point out horticulturally useful characters), (b) their availability in the trade, based on retail surveys, with retail prices where applicable, and (c) comments on their likely potential in horticulture.

The following were noted as of particular potential: *N. assoanus*, *N. fernandesii*, *N. cordubensis* and *N. henriquesii* (dwarf jonquils), *N. calcicola*, *N. rupicola* and *N. scaberulus* (*Apodanthi* group, similar to jonquils), *N. poeticus* and its varieties (poet's or pheasant's eye narcissus), *N. triandrus* and its varieties (angel's tears daffodils), *N. bulbocodium* and its varieties (hoop petticoat daffodils), *N. asturiensis*, *N. cyclamineus* and *N. minor* (dwarf trumpet narcissus), *N. alpestris*, *N. longispathus*, *N. nevadensis*, *N. nobilis*, *N. obvallaris*, *N. pallidiflorus* and *N. pseudonarcissus* and its subspecies *eugeniae* (small trumpet types). Many other species listed would have potential for high value sales to specialists. Several of the listed species, whilst not regarded as having potential in themselves, are important for breeding and selection, such as *N. cavanillesii* (autumn-flowering) and *N. tazetta*. Most of these are difficult to obtain at present.

More detailed notes, including notes on their conservation status, are given for a selection of these species, namely *N. cyclamineus*, *N. pseudonarcissus*, *N. pallidiflorus*, *N. alpestris*, *N. asturiensis*, *N. triandrus*, *N. assoanus*, *N. rupicola*, *N. willkommii* and *N. bulbocodium*.

Germination studies

The main part of the germination studies involved defining responses to temperature. In all three species investigated, a conditioning treatment, in which the imbibed seed was held for 8 or 12 weeks at 25 or 30°C, resulted in rapid germination when the seed was transferred to 15°C. Seed of *N. bulbocodium* var. *citrinus* and *N. pseudonarcissus* germinated well at a constant temperature of 10 or 12.5°C, and much less so at 7.5 or 15°C. Seed of *N. cyclamineus* did not germinate well at these low temperatures. Somewhat better germination was obtained with seed stored for a few months than with fresh seed; in some cases seed was stored for up to 4 years without subsequent germination being greatly affected. In general, percentage germination was highest in *N. bulbocodium* var. *citrinus* and lowest in *N. cyclamineus*. Germination was poorer when planted in compost and grown in a glasshouse or tunnel, than when sown in Petri dishes in controlled temperatures, probably partly due to moulds, which were generally more severe on *N. cyclamineus* seed and particularly so in one seed batch. A warm-water treatment (for 24 hours at 30°C) reduced mould growth to some extent, without adversely affecting percentage germination, but tests with various disinfectants, fungicides and an antibiotic were generally not successful in controlling mould growth and in some cases appeared to be counter-productive. Scarifying seed did not improve germination. Germination was usually carried out in the dark; germination in *N. pseudonarcissus* (but not the two other species) was low when tests were carried out in continuous light.

Growing systems and sustainable crops

The ability to obtain rapid germination through cold treatment (10°C) or conditioning (at 30°C) enabled a variety of systems to be tested for the most efficient production of young bulbs. Germination was high using temperature-treated seed sown in cellular trays and grown on in a frost-free tunnel or glasshouse, although the small size of cells limited growth. Growing in pots, ordinary trays or in seed beds increased the individual weight of bulbils produced, but the less easily controlled conditions resulted in relatively low numbers of bulbs being produced and recovered.

The following results were taken from a three year trial, excluding results for seed raised in seed beds (outdoors or in a frost-free tunnel) or outdoors in pots or trays, where results were generally poor. In *N. pseudonarcissus*, mean bulb weight and diameter three years after sowing ranged from 1.5 to 2.8 g and 10 to 15 mm, respectively, in the various treatments. In the third year, bulbs did not reach flowering size. In *N. bulbocodium* var. *citrinus*, the corresponding figures were 2.8 to 8.6 g and 18 to 25 mm, and, on average, 55 per cent of bulbs flowered in their third year. In *N. cyclamineus* bulbs grew slowly. The best results, after three years, were obtained when plants were raised in module trays and transferred to pots in the second year, but mean bulb weights in different treatments were only 1.1 to 1.5 g, with diameters of only 10 to 11 mm. In this species a small proportion of the plants flowered in their third year. In *N. cyclamineus*, recovery rates (bulbs produced as a percentage of seed sown) were poorer than for the other species.

The initial bulb size for flower initiation was 3 to 5 cm circumference in *N. bulbocodium* var. *citrinus* and *N. cyclamineus*, and was reached after 2 to 3 years. In *N. pseudonarcissus*, the critical size for flowering was >5 cm (circumference), reached after 3 to 4 years. Stock beds of *N. bulbocodium* var. *citrinus* gave a prolific seed yield in their third year from sowing.

Action points for growers

Although there is much further development work which could be carried out on this subject, it is clear from the results obtained so far that production from seed could be highly effective. Growers interested in the possibility of producing bulbs of *Narcissus* species from seed would first need to consider:

- source of initial seed supplies
- most promising species
- markets (high value species for specialist market, or larger quantities for general sales)
- production systems
- mode of sale (dry bulbs, growing potted plants)

Whilst the current project cannot offer financial advice, it is suggested that there are good prospects for producing bulbs of species such as *N. bulbocodium* and *N. cyclamineus*, which take three to four years from sowing to reach flowering (saleable) size; other species (exemplified by *N. pseudonarcissus* in the current project) take four to five years. While simply sowing seed into beds would work as a 'low tech' method, the experimental work carried out suggests that specialist nurserymen could obtain more efficient production through sowing into cellular trays in autumn, giving a warm or cool treatment of two to three months, followed by growing under frost-free conditions and, after one or two years, transplanting modules to the pots in which the plants could be offered for sale 'in the green' in garden centres.

INTRODUCTION

Interest in dwarf types of flower-bulbs has increased in recent years, related to the changing tastes of consumers and expanding sales of a great variety of pre-packed bulbs in garden centres. In contrast to the spectacular array of standard cultivars of tulips, daffodils, etc., bulbs of dwarf varieties are in relatively short supply, and the number of available wild species - perhaps representing the ultimate in delicate appeal - is very low. Previously, the demand for bulbs of wild species has been met by the collection of bulbs from the wild, a practice now regarded as unacceptable. Quite apart from the conservation aspect, bulbs derived from the wild are often of poor quality with high wastage rates: the bulbs are usually not harvested at the ideal time, are often stored in sub-standard conditions, and may change hands several times before their final destination, resulting in physical damage and desiccation. To meet current needs, and eventually to expand this market, alternative, sustainable sources of these bulbs are needed.

There are many aesthetically pleasing bulbous species which could be made available from commercially propagated stock, if suitably efficient systems of production could be devised. This would increase the range of subjects available to the gardening public, while preserving dwindling wild populations. The objective of this project is to establish the most effective protocols for producing saleable bulbs, growing plants and sustainable commercial stocks, using species of *Narcissus* raised from seeds. The principles could be applied later, with adaptations, to a much wider range of bulbous plants.

Several *Narcissus* species are very suitable for more natural garden plantings, but are difficult to source for the reasons mentioned. *N. cyclamineus* is one which is in demand, but the source of wild-collected material has dried up, through over-collection and habitat loss through urban development (Blanchard, 1990). There is little know-how on commercial production, and, for such species, propagation methods like twin-scaling and chipping are labour-intensive and unlikely to be economically viable (Hanks, 1987), while micro-propagation is relatively costly and has been insufficiently studied. On the other hand, seed-based systems could be developed for producing sustainable, high-quality stocks. Production from seed carries additional benefits: some degree of genetic diversity is retained, and transmission of many common viruses is avoided.

Narcissus species have been chosen for this project because of the dominance of daffodil growing in the UK bulb industry and because discussions with commercial bulb growers have indicated a keen demand for species such as *N. cyclamineus*. The project was carried out with this species and with *N. pseudonarcissus* and *N. bulbocodium* var. *citrinus*, seed of which was kindly made available for the project. Experiences of growing these species at the Royal Horticultural Society's garden at Rosemoor have recently been described elsewhere (Bailes, 1996).

There have been few scientific studies of narcissus production from seed, although this method is of course used by breeders and enthusiasts (e.g., see Wells, 1989). The structure and development of the seed and seedling plant was described by Chan (1952). The biology and ecology of *N. pseudonarcissus*, including flower and seed production, has been described (Caldwell and Wallace, 1955). Seeds of hybrids (Linfield and Price, 1986) and species (Rees, 1972) have a cold requirement for germination. In perhaps the only scientific report on seed germination studies in the genus, Thompson (1977) demonstrated in *N. bulbocodium* var. *conspicuus* that a conditioning treatment at 26°C resulted in rapid germination when seeds were

transferred to lower temperatures. Literature searches conducted on CABI and BIDS-ISI databases up to October 1998 failed to reveal further scientific publications on the subject.

The development of efficient, sustainable production systems for *Narcissus* and other bulbous species would offer the UK bulbs industry and customers a novel type of bulb product with a natural, 'green' image. They could be produced as dry bulbs, pot-grown bulbs or as plugs for transplanting, initially to the specialist market but also, as stocks and expertise are built-up, in developing wider markets (garden centre sales and landscape use). These species bulbs are of relatively high value. For example, a random survey of 1997 wholesale catalogues showed that bulbs of *N. bulbocodium* var. *conspicuus* and *N. obvallaris*, the most readily available species narcissus, were priced at £110 to £150 and £79 to £155 per thousand, respectively. Wholesale prices of about £220 per thousand bulbs were noted for *N. poeticus* var. *recurvus* and *N. triandrus* 'Albus' 'Angels Tears'. Supplies of species such as *N. cyclamineus* are very limited, with retail prices of around £3 per bulb quoted in specialist catalogues. Only a small percentage of demand can be satisfied at present, and the potential for further sales is undeveloped. With a small bulb size and a high planting density, only a small amount of land would be involved for production initially, but high prices and the potential to expand markets at home and abroad (including that for landscape use) might make a financially useful operation.

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The classification and nomenclature of the genus *Narcissus* is highly contentious, and anyone working with the genus is bound to encounter difficulties in naming them. For this reason, the review section of the project begins with a classification of the genus and, within its subdivisions, a listing of acceptable names of species and other taxa. Brief descriptions of the species are given, highlighting their main characteristics, and this is followed by comments on the availability of bulbs and the potential of each type for greater commercial utilisation. Several of the better known species were considered in greater detail.

The project started in 1995, although some preliminary investigations had taken place in preparation for the work, and these were written up as part of the project. Interim reports were produced in 1996 and 1997, and a summary was published in HDC Project News (Hanks and Mathew, 1997). This final report is a compilation of the earlier reports, with the addition of a further year's experimental data, an expansion of the section on *Narcissus* species and their availability and commercial potential, and an updated discussion and summary.

A REVIEW OF *NARCISSUS* SPECIES AND THEIR POTENTIAL FOR COMMERCIAL EXPLOITATION

Classification of *Narcissus*

The number of wild species quoted for the genus *Narcissus* varies wildly from about 16 to 150, this remarkable discrepancy caused by a lack of agreement for the last 100 years among botanists as to what constitutes a species. For example, *Flora Europaea* (Tutin *et al.*, 1980) regarded *N. pseudonarcissus* as a widespread species embracing seven localised subspecies, whereas Pugsley (1933) and Fernandes (1967) had recognised these as separate species; the latter course has been followed more recently by Blanchard (1990). Botanists continue to study the genus in the wild with the result that new species, subspecies, etc., and natural hybrids, are still being discovered.

Whilst botanists may search for 'the truth' about the taxonomy of *Narcissus*, for the purposes of horticulture and conservation it is most convenient to take a narrow view of each 'species'. It is easy to lose sight of potentially important local variants if they are included under the umbrella of very widespread species, but it may be that that these local variants have significant horticultural potential, either in their own right as ornamentals or as breeding stock for the introduction of new characters, disease resistance, etc. From the conservation viewpoint, interesting local variants, with their more restricted distributions, may well be under threat for some reason (building, dam construction, agriculture, etc.) but, if 'sunk' into a common and widespread species, their conservation status may well be overlooked. However, even if a species is considered plentiful and under no great threat in the wild, there is no case for collecting commercial quantities. Wild collections should only ever be viewed as a means by which new and interesting variants can be introduced into horticulture, for subsequent commercial propagation.

There have been numerous attempts at classifying the many species of *Narcissus* into a system which appears to have some sort of logic and is of practical value. In fact, most of these systems are similar in their overall groupings, and it does not take a trained botanist to arrive at roughly the same conclusions. Most people, if given a range of *Narcissus* species in flower and asked to arrange them in groups, would be likely to place the trumpet daffodils in one group, the tazettas in another, the pheasant's eye daffodils in another, the hoop petticoats in another, the jonquils in another, and so on - and that would sum up the major groups as they have appeared to most botanists. Some botanists have been more 'splitty', and have recognised a larger number of groups, while others, the 'lumpers', have recognised less. These various groups within the genus have traditionally been called Sections, and these were sometimes split into 'sub-groups' referred to as Subsections.

Since this project deals essentially with the propagation of *Narcissus* species rather than the myriad of hybrid cultivars, it was thought that, as a point of reference, it would be useful to provide a framework showing the various Sections and Subsections, and the species which are attributed to them. This should not be viewed as the 'definitive word' in *Narcissus* classification. It is intended only as a practical guide, although it is a guide based on the cumulative studies of several botanists over the past century, together with some informed judgement of our own.

The following table is a summary of the classification showing the 10 Sections, with short descriptions picking out some of their more obvious characteristics. The Sections are placed in

two groups, autumn-flowering and winter/spring-flowering, since this is of great interest to horticulturists.

SUMMARY OF CLASSIFICATION OF *NARCISSUS*

Section/Subsection	Description of Section/Subsection
1. Section *Serotini* (1 species)	Autumn-flowering. Leaves very narrow, almost thread-like. Flowers white with a very small orange or yellow cup (up to 2 mm deep).
2. Section *Aurelia* (1 species)	Autumn-flowering. Leaves wide, flat. Flowers white, cup represented by only a tiny rim.
3. Section *Tapeinanthus* (1 species)	Autumn-flowering. Leaves very narrow, thread-like. Flower yellow, cup absent, represented instead by six small scales.
4. Section *Tazettae*	
a) Subsection *Angustifolii* (1 species)	Autumn-flowering. Leaves narrow, flat, grey-green. Flowers up to 7 in an umbel, white with shallow green or greenish-brown cup which has an incurved margin.
b) Subsection *Tazettae* (16 species)	Usually spring-flowering. Leaves broad and flat, usually grey-green. Flowers up to 20 in an umbel, very fragrant, with a small cup and long slender tube.
5. Section *Jonquillae*	
a) Subsection *Chloranthi* (1 species)	Autumn-flowering. Flower green throughout, with a small cup and long slender tube. Leaves narrow, cylindrical.
b) Subsection *Jonquillae* (9 species)	Spring-flowering. Leaves very narrow, usually dark green, subcylindrical (rush-like). Flowers in umbels of up to 8, sometimes solitary, very fragrant, with a small cup and long slender tube.
6. Section *Apodanthi* (5 species)	Spring-flowering. Leaves narrow, grey-green, 4-angled or with 2 keels underneath. Flowers in umbels of up to 5, sometimes solitary, very fragrant, with a small cup and long slender tube.
7. Section *Narcissus* (2 species)	Spring-flowering. Leaves flat, wide. Flowers always solitary, very fragrant, flattish, white with a shallow saucer-shaped corona which is usually yellow with a red rim; flower tube long and slender.
8. Section *Ganymedes* (1 species)	Spring-flowering. Leaves narrow, flat or subcylindrical. Flowers in umbels of up to 6, nodding with petals sharply reflexed; corona bell-shaped; flower tube long and narrowly funnel shaped.
9. Section *Bulbocodium* (5 species)	Winter or spring-flowering. Leaves very narrow, cylindrical. Flowers solitary, with a widely funnel-shaped tube; corona widely funnel-shaped, petals very narrow. Stamens with long, curved filaments.
10.Section *Pseudonarcissus* (25 species)	Spring-flowering. Leaves flat, wide. Flowers usually solitary, with a widely funnel-shaped tube and large trumpet, cylindrical except at the mouth which may be flared outwards.

Details of species with notes on their availability and commercial potential

This section consists of brief descriptive notes about these species, arranged according the foregoing classification. The descriptions are intended not so much as an aid to identification, but to highlight a few of the salient features of each species. The abbreviation AGM indicates plants which have been awarded the RHS Award of Garden Merit. In addition, there are observations giving details of any interesting variations, cultivation notes, soil preference, garden or commercial potential, etc., which may be helpful in considering which species should be investigated with a view to developing sustainable propagation for commercial exploitation. It should be noted that, although some species may be regarded here as of low commercial interest, all *Narcissus* species, even the most esoteric, are of some specialist interest to bulb enthusiasts, and could command high individual prices if made available in limited quantities.

Also given for each species is an availability rating, showing the number of retail outlets from which each is available. This was compiled, in autumn 1998, from a catalogue survey and using the RHS Plant Finder 1998-99 (Philip and Lord, 1998). Where available, examples of retail prices (per bulb, unless otherwise stated) are also given.

For ten selected species, more detailed information was given in the 1996 annual report, and, for convenience, this section has been included as Appendix A to the present report. These species are indicated by * in the following pages. This section includes notes on the conservation status of these species, which was assessed from published literature and from questionnaires sent to botanists and enthusiasts familiar with wild populations of *Narcissus* species in Europe and North Africa.

A. AUTUMN-FLOWERING SPECIES

1. Section Serotini [One species only in Section]

N. serotinus - Flowers fragrant, 1-3 in an umbel, up to 3.5 cm in diameter, white with a small (up to 2 mm deep) orange or yellow saucer-shaped corona and a long, slender tube. Leaves absent at flowering time, thread-like, green.
Availability: 2
Retail price example: £2.00
Comments: Although an interesting and attractive miniature species, this is not a striking plant unless seen in hundreds, and it is shy-flowering in Britain, probably due to lack of consistent warmth in summer. Requires cultivation under glass. Little commercial value, but it is, however, of specialist interest, being autumn-flowering and very fragrant.

2. Section Aurelia [One species only in Section]

N. broussonetii - Flowers fragrant, up to 12 in an umbel, about 3 cm in diameter, white; corona represented by only a tiny rim. Leaves visible at flowering time, broad, flat, grey-green.
Availability: 3
Retail price example: £3.00-£7.00
Comments: An attractive and interesting autumnal species but tender in Britain, requiring frost-free cultivation under glass, so mainly of specialist interest and of little commercial value. It resembles the paperwhite narcissus to which it is related. A larger-flowered (about 3.5 cm diameter) tetraploid form is known as forma *grandiflorus*.

3. Section Tapeinanthus [One species only in Section]

N. cavanillesii (= *Tapeinanthus humilis*) - Flower yellow, usually 1 per stem, only 2-2.5 cm in diameter and facing upwards; corona absent, consisting only of six small scales. Leaves thread-like, green, present at flowering time or sometimes appearing slightly later.
Availability: 1 (and var. *mauretanicus* 1)
Retail price example: 50p (var. *mauretanicus* £3.00)
Comments: A fascinating autumn-flowering plant with tiny yellow flowers, but really of specialist interest and of little commercial value. However, larger-flowered forms have been found in the Atlas Mountains of North Africa. It is shy flowering in Britain and requires cold glasshouse cultivation.

4a. Section Tazettae, Subsection **Angustifolii** [One species only in Subsection]

N. elegans - Flowers fragrant, up to 7 in an umbel, 2.5-3.5 cm in diameter, white with a green or greenish-brown shallowly cupped corona which has an incurved margin. Leaves narrow, flat, grey-green, visible at flowering time.
Availability: 1
Retail price example: £3.50-£4.00
Comments: Although very attractive in its wild state, with several quite large fragrant white flowers in autumn, this species is difficult to cultivate and shy to flower. It is, therefore, a challenge for the specialist grower, and not likely to be of much commercial value. It varies considerably, and some of these variations have been named:

forma *auranticoronatus* has an orange cup
var. *fallax* has greenish-white petals
var. *flavescens* has creamy petals
var. *intermedius* has broader petals than usual

Note: some wild forms of *N. tazetta* (see below in 4b, Subsection Tazettae), although predominantly winter/spring-flowering, sometimes flower in autumn in the wild, but they do not appear to do so consistently when introduced into cultivation.

5a. Section Jonquillae, Subsection **Chloranthi** [One species only in Subsection]

N. viridiflorus - Flower very fragrant, 1-5 in an umbel, about 2-2.5 cm in diameter, deep green throughout; corona a shallow cup only 1-5 mm deep, petals reflexed. Leaves very narrow, dark green, not present at flowering time.
Availability: 1
Retail price example: £3.00-£4.00
Comments: As an autumn-flowering narcissus with wholly green flowers, this is fascinating and unique, and therefore has great interest value, but it is not easy to induce it to flower reliably. In Britain it is tender and requires cultivation under frost-free glass with a hot summer dormant period. Very limited commercial potential, for the specialist bulb market.

B. WINTER- OR SPRING FLOWERING SPECIES

4b. Section Tazettae, Subsection **Tazettae** [Up to 16 species in Subsection]

This Section, consisting of the very fragrant, cluster-headed tazetta and paperwhite *Narcissus* species and their relatives, has been classified in very different ways. Some authors have regarded all those listed below as separate species, others have grouped them as subspecies or varieties of either *N. tazetta* (those with yellow or bicoloured flowers) or *N. papyraceus* (those with wholly white flowers), while others have 'sunk' some of the names altogether, without any recognition whatsoever. Here, in order that interesting variations may not be overlooked, they have been retained with their specific names, but grouped with the two 'umbrella' species.

a. Tazetta Group (the tazettas) - Flowers wholly yellow or bicoloured white and yellow, very fragrant, up to 15 in an umbel; corona cup-shaped, usually about 3-5 mm deep. Leaves broad and flat.

N. tazetta - Petals white, cup deep yellow or orange. Flower stem flattened in cross-section. Leaves grey-green.
Availability: 1 (as 'Chinese sacred lily')
Retail price example: £2.00-£3.00
Comments: This is the 'typical' tazetta narcissus, with white petals and a deep yellow to orange cup. A well-known and common Mediterranean species, much used (or its selections and hybrids) as a cut flower for the winter/early spring months. Unfortunately it is not very frost hardy and in the cooler parts of Britain, outside the South-west, it does not thrive outdoors, and this comment applies to the other 'species' listed. However, they are of considerable ornamental value should not be written off because of lack of hardiness. Propagation techniques have largely concentrated on vegetative increase but if new stocks were raised from seed it is possible that hardier, freer-flowering selections could be made. There is a subspecies *lacticolor* (see below).

N. tazetta subsp. *lacticolor* (*N. canaliculatus*) – Petals white, cup yellow. Leaves grey-green.
Availability: 2
Retail price example: 5 for £1.50
Comments: A miniature tazetta with small bicoloured flowers, attractive and well worth growing but often not very free-flowering; requires hot sunny places, as do most tazettas. Has been widely available (as *N. canaliculatus*) in the past, less so at present.

N. aureus - Petals bright yellow, cup darker yellow-orange. Leaves green.
Availability: 1
Comments: An all-yellow tazetta narcissus, similar to the often-cultivated cv Soleil d'Or which may be a selection of it. Attractive and very fragrant, but commercially offers no advantages over Soleil d'Or, except to purist specialists.

N. bertolonii - Petals pale to bright yellow, cup bright yellow to orange. Leaves slightly greyish-green.
Availability: 1
Retail price example: £4.00
Comments: Very similar to the above, and to Soleil d'Or, so the same comments apply.

N. cupularis - Petals and cup pale to bright yellow. Leaves strongly blue-grey-green.
Availability: 0
Comments: Another yellow tazetta, with blue-grey-green foliage. Again, it is attractive but has little extra to add to the commercial scene.

N. cypri - Petals white, cup pale yellow, expanded at mouth. Flowers large (4-5 cm diameter).
Availability: 2
Comments: A bicoloured tazetta, with large flowers, white with a yellow cup. Mainly of specialist interest.

N. italicus - Petals pale creamy-yellow, cup yellow. Flowers large (4-5 cm diameter). Leaves green.
Availability: 0
Comments: This large-flowered, bicoloured (cream with a yellow cup) Italian tazetta is reputedly hardier than most, but still mainly of specialist interest.

N. ochroleucus - Petals white, cup pale lemon yellow. Leaves green. Flowers 2.5-3.5 cm diameter.
Availability: 0
Comments: Similar to *N. italicus* but with smaller flowers, so the same comments apply.

N. patulus - Petals a little reflexed, white, cup deep yellow. Flowers 1.8-2.5 cm diameter. Leaves grey-green.
Availability: 1
Comments: A rather small-flowered, bicoloured tazetta but has attractively reflexed petals, white with a deep yellow cup. Blanchard (1990) rates it for garden use as being 'desirable'. Mainly of interest to specialist growers.

b. Papyraceus Group (the paperwhites) - Petals and corona wholly white, very fragrant, up to 20 in an umbel; corona cup-shaped, usually 2-4 mm deep. Leaves broad and flat.

N. papyraceus - Flowers 2.5-4 cm diameter. Flower stem flattened. Leaves very grey-green.
Availability: 9 (and widely in garden centres)
Comments: This cluster-headed white, fragrant narcissus is very popular for forcing either as a cut flower or a pot plant, and this is where the main value lies commercially. However, the wild forms make very good garden plants for a sunny position against a wall or fence and appear to be hardier and freer-flowering than the tazettas. The other 'species' listed are variations on the same theme.

N. barlae - Flowers 2-2.5 cm diameter. Leaves very grey-green.
Availability: 0
Comments: Possibly the same as *N. panizzianus*.

N. canariensis - Flowers small (said to be at most 1.5 cm diameter) with pointed petals. Leaves greyish-green.
Availability: 0
Comments: A small-flowered version with pointed petals. Of little commercial interest.

N. dubius - Flowers 1.5-2 cm diameter, the cup half as long as petals. Leaves dark green, slightly glaucous.
Availability: 1
Comments: A small plant with a much deeper cup to the white flowers than in the 'paperwhites', so a rather different-looking species. It is undoubtedly an interesting and attractive plant and may find a small specialist market.

N. pachybolbos - Flowers 1.5-2 cm diameter, cup less than a third as long as petals. Leaves pale grey-green.
Availability: 0
Comments: A north African variation on the *N. papyraceus* theme, probably of no commercial interest.

N. panizzianus - Flowers 2-2.5 cm diameter, petals pointed. Leaves grey-green.
Availability: 1
Comments: Although smaller-flowered than the common paperwhite, this is a worthwhile variant of *N. papyraceus*, described by Blanchard (1990) as an 'attractive and satisfactory garden plant'. It is perhaps better than *N. papyraceus* for planting in the garden, flowering later and apparently slightly hardier. Possibly of interest for the connoisseur bulb market.

N. polyanthos - Flowers 2.5-4 cm diameter. Flower stem rounded in cross-section. Leaves green.
Availability: 0
Comments: Another variation of *N. papyraceus*, not sufficiently different to be of any great commercial interest.

N. tortifolius - Flowers about 1.5 cm diameter. Leaves grey-green, twisted lengthways.
Availability: 0
Comments: A newcomer, discovered in Spain quite recently (1976). It has up to 16 small white flowers and takes its name from the characteristically twisted grey leaves. Undoubtedly it has novelty value in the specialist bulb market but its garden value is as yet unknown.

5b. Section Jonquillae, Subsection **Jonquillae** [Up to 9 species in the Subsection]

The jonquils have deep yellow highly fragrant flowers which are individually quite small at 1-3.5 cm in diameter, but there are up to 8 in an umbel. They are flattish with a long slender tube and a cup-shaped corona about 3-7 mm deep. The leaves are dark green and sub-cylindrical, rather rush-like. *N. jonquilla* has been cultivated in Britain for over 300 years, but some of the smaller species are less well-known in gardens and yet have considerable horticultural value. *N. assoanus* is cultivated to a certain extent, although not commonly; it may be seen under one of its synonyms, *N. juncifolius* or *N. requienii.*

Botanically, the jonquils are very confusing, with much natural variation, and botanists have for long disagreed as to how many species there are in the group. Listed below are the various 'species' which have been described; although some of them may be considered just minor variations of others, from the horticultural point-of-view in some cases they are significantly different in appearance or in behaviour in cultivation, so for the purposes of this project are included in our survey.

N. jonquilla (AGM) - Flowers up to 5 per umbel, 3-3.5 cm diameter; corona 2-4 mm deep, 7-10 mm wide; tube curved.
Availability: 13
Retail price example: 10 for £1.80
Comments: The common jonquil, the most robust and well-known of this group, loved for its intensely fragrant deep yellow flowers in a cluster. It is readily obtainable and an easily-grown garden plant. Some of its smaller relatives are, however, little-known in gardens in spite of being just as satisfactory and very attractive. With several flowers per stem, most of them produce a lot of seed.

*N. assoanus** (*N. juncifolius*, *N. requienii*) - Flowers 1-2 per umbel, 1.5-2.2 cm diameter; corona 3-5mm deep, 9-11 mm wide; tube straight.
Availability: 9
Retail price example: £3.00
Comments: A charming miniature jonquil, very fragrant and easy to cultivate but still mainly grown by specialists. Although already obtainable by mail order as dry bulbs in autumn, there should be great potential if container-grown for the rock garden when in flower.

N. baeticus (*N. assoanus* var. *praelongus*) - A variation of *N. assoanus* with a longer, narrower tube.
Availability: 1
Retail price example: £2.00
Comments: A variation of *N. assoanus*, so the same remarks apply.

N. cerrolazae - Flowers 1-4, 2.5-4 cm diameter; corona 5-7 mm deep, 11-16 mm wide; tube straight or curved.
Availability: 0
Comments: A fairly recently described species which appears to differ very little from *N. cordubensis*.

N. cordubensis - Flowers up to 3, about 3 cm diameter; corona 5 mm deep, 15 mm wide; tube slightly curved.
Availability: 1
Retail price example: £2.00-£3.00
Comments: An attractive small jonquil, but is very similar to *N. fernandesii* (below), so much the same remarks apply to its commercial potential.

N. fernandesii - Flowers up to 4 per umbel, 2.5-3.3 cm diameter; corona 6 mm deep, 8 mm wide; tube curved.
Availability: 3
Retail price example: £2.50
Comments: A smaller plant than the common jonquil, but with good-sized, nicely fragrant flowers, so this is a worthwhile variation on the theme. This, and the other similar species such as *N. cordubensis*, could be commercial propositions if offered in flower.

N. gaditanus - Flowers up to 8 per umbel, 1-2 cm diameter; corona 2.5-7 mm deep, 4.5-8 mm wide; tube curved.
Availability: 2
Retail price example: £1.00-£1.80
Comments: One of the tiniest of the jonquils, with several very small fragrant yellow flowers in each umbel. It is a charming plant, but does not grow very satisfactorily in the open ground so it is mainly a plant for specialists. Even smaller plants from Portugal have been called *N. minutiflorus* (Availability: 1), which perhaps has some curiosity value: its flowers are only 1 cm across.

N. henriquesii (*N. jonquilla* var. *henriquesii*) - Flowers 1-2 per umbel, 3.5-4cm diameter; corona 6 mm deep, 10 mm wide; tube straight.
Availability: 3
Retail price example: £2.00-£3.00
Comments: This small version of the jonquil does very well in cultivation, hardy and free-flowering, but is still mainly confined to the specialist bulb market. Although offered by a few nurseries, this is traded only as dry bulbs; there must be considerably greater potential if marketed in flower.

N. marianicus - Probably a variation of *N. fernandesii*.
Availability: 0
Comments: See above for *N. fernandesii*.

*N. willkommii** - Flowers up to 3 per umbel, 1.5-2 cm diameter; corona 4-5 mm deep, 7-11 mm wide; tube straight.
Availability: 1
Retail price example: £1.75
Comments: Another variation on the jonquil theme, like a small, more delicate version of *N. jonquilla*; of interest mainly to the specialist since it is not sufficiently different from *N. fernandesii* and *N. henriquesii* to make it more widely popular.

6. Section Apodanthi [Up to 5 species in Section]

Although very similar to the jonquils in flower shape, with long-tubed fragrant flowers with small or shallow cup-like coronas, they are generally smaller plants, not more than 20 cm tall and the flowers are only 1.2-4 cm in diameter. There may be up to 5 flowers in an umbel in some cases, but several have solitary flowers. The leaves are rather different, usually grey-green and squarish in cross-section or with two obvious keels on the underside, not green and rush-like as in the jonquils.

A group of delightful miniature daffodils of great interest and ornamental value to bulb and rock garden enthusiasts. Some of the species (e.g. *N. rupicola*) will grow well outdoors but their diminutive charm also makes them ideal for pot cultivation under unheated glass (alpine house, cool conservatory or bulb frame). They mostly occur on acid formations in the wild, so are suited particularly to gardens with acidic to neutral soils, although *N. rupicola* subsp. *marvieri* is usually found on limestone and may be more tolerant of alkaline soils. In pots, standard commercial composts, providing they are freely drained, seem to be satisfactory without particular adjustment to pH levels.

N. atlanticus - Flowers solitary, creamy-white, c. 3.5 cm diameter; corona cup-shaped, 6 mm deep, 11 mm wide.
Availability: 1
Comments: Like a small jonquil but with solitary, creamy-white flowers. This is attractive, but purely a plant for the specialist grower in a cold glasshouse (alpine house).

N. calcicola - Flowers up to 5, yellow, 1.7-2.5 cm diameter; corona cup-shaped, 4-8 mm deep, 6-9 mm wide.
Availability: 1
Comments: There are several of these small, yellow, cluster-headed jonquil-type narcissus, all of which are similar to, and have the same horticultural appeal as, *N. scaberulus* (see below).

N. cuatrecasasii - Flowers 1-2, yellow, 2.2-3 cm diameter; corona cup-shaped, 3-6 mm deep, 8-10 mm wide.
Availability: 1
Comments: Similar to *N. scaberulus* (see below) and as appealing, but not distinct enough to warrant commercial interest in both. The variety *segimonensis* (Availability: 1) is a minor variation, perhaps with some specialist interest.

*N. rupicola** - Flowers solitary, yellow, 2-4 cm diameter; corona a wide funnel, 2-6 mm deep, 7-10 mm wide.
Availability: 8
Retail price example: £2.00-£3.00
Comments: One of the best of this whole group, with flattish, solitary yellow flowers, a perfect miniature only about 15 cm tall. It is not difficult to grow on well-drained acid soils and is also a beautiful plant for pot cultivation in an alpine house. It is usually traded as dry bulbs in autumn, but there must be great potential as a container-grown plant in flower in spring.

The variant subspecies *marvieri* (Availability: 2) is very similar but appears to favour alkaline soils, so there may be a case for offering both. Flowers solitary, yellow, c. 3.5 cm diameter; corona a wide funnel, c. 10 mm deep, 1.5 mm wide.

N. scaberulus - Flowers up to 4, yellow, 1.2-1.7 cm diameter; corona cup-shaped, 2-5 mm deep, 5-7 mm wide.
Availability: 2
Comments: A delightful small-growing species with up to four yellow, fragrant 'jonquil-like' flowers with reflexed petals. It grows in acid soils and makes an attractive plant for the rock garden or alpine house. There are various similar plants such as *N. calcicola* and *N. cuatrecasasii* which are botanically important, and are of undoubted interest to the specialist enthusiast, but there would probably be insufficient demand to merit the propagation of more than one on a larger commercial scale. As with other small *Narcissus* species, the current demand is largely met through the trade in dry bulbs in autumn, but container grown plants in flower for the rock garden would attract a wider interest.

N. watieri (*N. rupicola* ssp. *watieri*) - Flowers solitary, white, c. 3.5 cm diameter; corona a wide funnel, 2-6 mm deep, 7-10 mm wide.
Availability: 8
Retail price example: £3.00-£4.00
Comments: Closely related to *N. rupicola* but with solitary pure white flowers, perhaps even more attractive than the better known yellow-flowered plant, but it does not do well in the open garden. However, it can be very successful under cold glasshouse conditions (alpine house) and there is undoubtedly a specialist market for this lovely plant.

7. Section Narcissus [2 species in Section]

Flowers one per stem, large (4.5-7 cm diameter), very fragrant, with white petals and a very shallow corona which is yellow, edged with red or orange, either flattish like a disk or more like a shallow cup; tube long and slender. Leaves wide, grey-green, flat or channelled. There have been great differences of opinion over the classification of the poet's or pheasant's eye narcissus. At one extreme all the variations are considered to belong to one species, *N. poeticus*, while at the other extreme about 10 separate species are recognised. The current view, which appears to have gained more support, is that there are two species, *N. poeticus* and *N. radiiflorus*, with several named variants of each.

N. poeticus is an old favourite in gardens, although its wild forms are seldom cultivated and are at present difficult to obtain through the nursery trade. The two species and their various forms are very attractive, flowering later than most of the *Narcissus* species and are therefore excellent for extending the daffodil season into late April and May. Being plants of mountain meadows in the wild, they require situations where they will not become too dry in summer and are particularly suitable for growing in grass. The true species is surprisingly seldom offered in catalogues in spite of being very easy to cultivate in damp positions.

N. poeticus - Petals broad and overlapping at the base, giving a substantial 'rounded' flower; stamens unequal.
Availability: unspecified variety: 2; var. *hellenicus*: 1
Retail price example: 5 for £1.75 to £2.00 each (var. *hellenicus* £10)
Several varieties have been named:

var. *poeticus* - corona flattish and disk-like; petals at right angles to corona; flowers up to 7 cm diameter

var. *hellenicus* - corona shallow cup-shaped; petals reflexed; flowers small, about 4.5 cm diameter

var. *majalis* - corona shallow cup-shaped, with a white zone below the red edge; flowers up to 7 cm diameter

var. *recurvus* (AGM) - corona shallow cup-shaped, green-yellow edged red; petals reflexed; flowers up to 7 cm diameter

var. *verbanensis* - corona shallow cup-shaped; petals very pointed at apex; flowers small, about 3.5-5 cm diameter

N. radiiflorus - Petals not overlapping at the base, the flower more 'starry' in appearance; stamens nearly equal.
Availability: 0
Comments: This is closely related to the poet's narcissus but has flowers which are more 'starry' in appearance, the petals not overlapping. At present it is not offered in the trade, nor are any of its varieties, but it is mainly only of specialist interest. There is a number of varieties:

var. *radiiflorus* - corona shallow cup-shaped, less than 1 cm across
var. *stellaris* - corona shallow cup-shaped and about 1 cm across
var. *exertus* - corona flattish and disk-like, yellow or yellowish-green with a red or orange edge
var. *poetarum* - corona flattish, wholly red

8. Section Ganymedes [1 species in Section]

These, the angel's tears daffodils are among the most attractive of all *Narcissus* species, having elegant pendent flowers with swept back petals. They are small plants, at most 30 cm tall with 1-6 drooping flowers in an umbel. The corona is deeply bell-shaped and is very conspicuous because of the sharply reflexed petals. The narrow leaves are deep green or slightly glaucous and are flat or subcylindrical in cross-section.

Charming plants, of great interest to rock gardeners and bulb enthusiasts. In the wild they occur in semi-shade or on mountain slopes in acid conditions, except for one locality in the Isles de Glenán, western France where they grow in sand near the sea. The variants of *N. triandrus* are very hardy and in cultivation appear to thrive best in cool growing conditions in light, acid soils.

All the variants are uncommon in cultivation but the most frequently seen and offered by nurseries is known as 'N. triandrus albus', a creamy-coloured form; the yellow var. *concolor* is rarely seen, although very attractive.

*N. triandrus** (AGM)

var. *triandrus* - Flowers white or with a yellowish tinge on petals; leaves 4-5 mm wide.
var. *cernuus* - Flowers creamy-white or very pale yellow; leaves very narrow, about 2 mm wide
var. *concolor* - Flowers bright yellow
var. *loiseleurii* - Similar to var. *triandrus* with white flowers but growing in sand by the sea (W. France)

Availability: 5 (unspecified varieties)
Retail price example: 10 for £4
Comments: The angel's tears daffodil always attracts public attention when on display and undoubtedly having great commercial potential if container grown and offered in flower. It is very hardy and is easily cultivated in acid sandy soils which do not get too hot and dry in summer. The commonest form has white flowers, sometimes with a yellowish tint; *N. triandrus* 'Albus' is a form of this, normally offered as dry bulbs in autumn.

It is probably unnecessary to consider var. *cernuus* and var. *loiseleurii* since they are very like var. *triandrus*, but var. *concolor* (Availability: 2), with its similarly-shaped but bright yellow flowers, is definitely worthy of consideration.

9. Section Bulbocodium [5 species in Section]

The hoop petticoats are the most distinctive of all the *Narcissus* species. Unlike all others, where the petals corona (cup or trumpet) are a very conspicuous part of the whole flower, here, the wide funnel-shaped corona (hence the name) provides the most obvious feature, surrounded by six very narrow and rather insignificant petals. They are all small plants, bearing one flower per stem, and have narrow, often almost thread-like, dark green leaves. They are a highly confusing group, mainly distributed in the Iberian Peninsula and North Africa, often with much variation in their characteristics, even within one population. Needless to say there has been much disagreement over their classification and the following list will give a hint as to the complexity of the group. Although many of the species below have characters which overlap those of others, and may therefore be viewed as unsatisfactory, it would be equally unsatisfactory, probably even more so, to lump all of them together under one species, *N. bulbocodium*!

These are all delightful dwarf daffodils, of extreme interest to bulb enthusiasts. They flower over a long period from early to late winter and on into spring, starting with the forms of the white *N. cantabricus* and ending with the later forms of *N. bulbocodium* such as var. *citrinus*. They all make excellent subjects for growing in pots in an unheated glasshouse or cool conservatory, especially those which flower in mid-winter since their delicate blooms are protected and can be appreciated in comfort, but they are surprisingly hardy plants and they can be grown successfully outdoors. Especially successful are the later ones (e.g. var. *citrinus*) since they flower at a time when the weather has improved and the flowers are less likely to be damaged. *N. hedraeanthus* and most forms of *N. bulbocodium* occur naturally on acid soils and do well in light sandy, acid soils, but *N. romieuxii* and *N. cantabricus* often occur on limestone formations as well as in low pH areas, so it may be possible to select forms to suit differing soil conditions in gardens; *N. bulbocodium* var. *obesus*, for instance, is native to limestone areas.

A form which is in cultivation and being distributed by specialist nurseries as *N. romieuxii* var. *mesatlanticus* is probably just a slight variant of var. *romieuxii* but is an excellent vigorous, free-flowering form, showing how successful some of these are as garden plants.

*N. bulbocodium** (AGM) - Flowers in varying shades of yellow, winter to spring flowering.
Availability: 12 (of unspecified variety)
Retail price example: 5 for £2.00
Comments: The hoop petticoat daffodil is one of the most delightful of all the small *Narcissus* species. Although quite readily obtainable as dry bulbs in autumn, it is seldom offered as growing plants in flower in spring, which is probably where the potential for the greatest sales lies. It is a hardy plant, easily cultivated in pots under cold glasshouse (alpine house) conditions. Outdoors it can be grown on the rock garden and will naturalise in turf if given the right conditions which appear to be a damp acid soil, drying out a little in summer. There are many different 'forms' in varying shades of yellow, and flowering from winter through to spring, so it is worth propagating more than one form. Some of the more distinct are:

var. *bulbocodium* - flowers usually rich yellow

var. *citrinus* (Availability: 4; Retail price example: £2.00) - robust forms with large (up to 5 cm long) pale lemon yellow flowers, later spring than most forms

var. *conspicuus* (Availability: 20; Retail price example: 5 for £1.80) - robust forms with erect leaves; flowers bright yellow, 3-3.5 cm long; corona c. 2 cm diameter

var. *obesus* (Availability: 6) - flowers large, usually deep yellow; corona with incurved margin; leaves prostrate; better for alkaline soils

Other variants which would be of interest to a more specialist audience include:

var. *ectandrum* (Availability: 0) - Dwarf plants with prostrate leaves; flowers yellow with a very wide 'petunioid' corona

var. *graellsii* (Availability: 2) - Dwarf plants with primrose coloured flowers with protruding stamens

var. *nivalis* (Availability: 0) - Dwarf plants with small flowers (up to 3 cm long); petals nearly as long as corona

var. *pallidus* (Availability: 0) - Robust, with primrose yellow flowers; corona a wide, wavy-margined funnel c. 3.5 cm across

var. *praecox* (Availability: 1) - Flowers primrose yellow; corona widely funnel-shaped, to 3.7 cm diam. Winter-flowering

var. *serotinus* (Availability: 0) - Robust with large golden yellow flowers (to 5 cm long); leaves wide (to 4 mm)

var. *tenuifolius* (Availability: 6) – Similar to var. *conspicuus* but usually with slender prostrate leaves.

subsp. *genuinus* (Availability: 1) – Robust form with golden flowers, similar to var. *conspicuus*

subsp. *mairei* (Availability: 1) – A little-known North African form, very similar to var. *conspicuus*

subsp. *viriditubus* (Availability 2; Retail price example: £2.00) – Clear yellow with a green perianth tube

N. cantabricus - Flower pure white, milky-white or greenish-white, usually produced in early to mid winter.

Availability: 3

Comments: This is like a white version of the hoop petticoat daffodil, often earlier flowering, in early to mid-winter and therefore more delicate. It is thus best grown in pots under cold glass and really cannot be recommended for outdoor planting. For this reason it has to be regarded as a subject for the specialist enthusiast, but as such commanding a reasonably high individual price. This is especially true of the very beautiful var. *petunioides* which has the corona very widely flared and crinkly; it is always in demand and in short supply.

Like *N. bulbocodium*, *N. cantabricus* is very variable and several of these are as desirable as the species itself. Variants include:

var. *cantabricus* (Availability: 4; Retail price example: £1.50-£2.00) - Flowers pure white; leaves usually 2 per bulb, spreading or prostrate

var. *eualbidus* (Availability: 1; Retail price example: £1.50) - Flowers creamy-white, probably a variant of the above

var. *foliosus* (AGM) (Availability: 5; Retail price example: £1.50-£2.50) - Flowers milky-white, born on a distinct stalk; corona 2-3 cm diameter; leaves 3-8 per bulb, erect

var. *monophyllus* (Availability: 2; Retail price example: £1.50-£2.50) - Flowers pure white; corona 1-2 cm long, 2-3.5 cm diameter; usually 1 prostrate leaf per bulb

var. *kesticus* (Availability: 0) - Flowers milky- or greenish-white; corona 2.5-3 cm diameter; leaves usually 2-4 per bulb

var. *petunioides* (Availability: 2) - Flowers white; corona up to 4 cm diameter, very widely flared and crinkly; leaves 1-3 per bulb

N. hedraeanthus - Dwarf, with small straw yellow flowers tending to face upwards; petals wide (c. 5 mm).
Availability: 1
Retail price example: £3.50
Comments: A very dwarf hoop petticoat, with small, upward-facing straw-coloured flowers. Although apparently hardy, this is so small that it is better grown under cold glass than outdoors. Its distinctiveness and diminutive size are points which make this quite sought-after among specialists, but it must have limited commercial value.

N. romieuxii (AGM) - Flowers pale sulphur yellow to near white, often produced in mid winter to very early spring.
Availability: 18 (unspecified as to variety)
Retail price example: £1.50
Comments: This version of the hoop petticoat daffodil usually has flowers in the pale sulphur yellow range, and they normally flower rather early in mid winter to very early spring. Although perhaps slightly less susceptible to winter weather than *N. cantabricus,* they are still best cultivated under the protection of cold glass. This too is a specialist subject for alpine and bulb enthusiasts. As with the other species, there is much variation and several of the variants have received names:

var. *romieuxii* (Availability: 1) - Flowers large, usually 3.5-4 cm long, pale sulphur yellow; petals almost as long as corona

var. *albidus* (Availability: 3; Retail price example: £4.50) - Flowers whitish, nearly erect, small, petals longer than corona

var *mesatlanticus* (Availability: 3; Retail price example: £2.00) – Flowers large, pale yellow. Although probably only a variant of var. *romieuxii*, the plant cultivated under this name is vigorous and free-flowering.

var. *rifanus* (Availability: 1; Retail price example: £2.25) - Flowers small, pale yellow, near horizontal, usually 2.5-3.5 cm long, petals longer than corona

var. *zaianicus* (Availability: 5) - Flowers near horizontal, pale yellowish to near-white, petals about as long as corona

N. tananicus - Flowers with off-white corona and pale yellow petals; corona narrowly conical, 2-2.5 cm diameter.
Availability: 1
Retail price example: £2.50
Comments: Another variation on the hoop petticoat theme, with a rather narrow 'hoop', otherwise similar to some forms of *N. romieuxii*. Although interesting botanically, it probably has little commercial potential.

10. Section Pseudonarcissus [Up to 25 species in Section]

These are the true daffodils in which the corona is in the form of a long more or less cylindrical trumpet rather than a cup, saucer or funnel shape. Their flowers are usually solitary, although two of the species may have more than one flower per stem, and their leaves are generally rather wide, strap-like and grey green but, even here, there are exceptions. There is also a tendency for them to flower in mid spring, after the early hoop petticoats and angel's tears but before the *N. poeticus* forms. Their flowers may be wholly white, wholly yellow or bicoloured with white or cream petals and a darker yellow trumpet; the reverse, a pale trumpet with darker petals, is not thought to occur in nature, although it has been achieved in cultivation by hybridisation and

selection. Many species have been described and most are listed below, grouped initially into two, the very small ones like *N. asturiensis* and *N. nanus* and the larger-flowered including *N. pseudonarcissus* and its relatives.

As the wild originators of the ever-popular trumpet daffodil cultivars, are, on the whole, much easier to cultivate in the open garden than the species of most of the other sections. Although they all have the same basic set of characteristics, there is great variation within the section giving a range of interesting possibilities as garden plants. For example, there are miniatures for the rock garden or alpine house (*N. asturiensis* and relatives), taller more robust plants for growing in the border or for naturalising in grass (*N. obvallaris*, *N. nanus* and the *N. pseudonarcissus* forms) and rare or particularly distinctive species for the enthusiast (the white *N. alpestris* and novelties like the recently discovered *N. pseudonarcissus* subsp. *eugeniae*). Most of them are very hardy plants not requiring any specialist cultivation skills and they flower over a long period from late winter in the case of *N. asturiensis* to late spring with *N. abscissus*. The most distinctive species, *N. cyclamineus*, which is a very rare plant in the wild and not very common in cultivation either, is excellent for growing in a cool position where it will not become too hot and dry in summer. In some places, on acid sandy soils which are very moist in spring, it has become naturalised in grass - for example at the RHS Garden at Wisley and at the Savill Gardens, Windsor where there are large colonies.

a) Plants dwarf (usually less than 15 cm) and (or) with small flowers (to 3.5 cm diameter).

*N. asturiensis** (AGM) - Dwarf, to 10 cm; flowers very early, yellow, to 3.5 cm diameter; corona constricted in middle.
Availability: 6
Comments: This is by far the smallest of the trumpet daffodils but is hardy and very easily cultivated, particularly suited to acid conditions. Although not difficult to obtain as dry bulbs in autumn, it must also have considerable commercial potential if offered container-grown in flower.

*N. cyclamineus** (AGM) - Flowers with sharply reflexed petals; leaves bright green, not at all glaucous
Availability: 11
Retail price example: £3.00-£3.50
Comments: Instantly recognisable, with its sharply reflexed petals, this is perhaps the most desirable of all the trumpet narcissus species. It is very easy to grow in a moist position and is a very hardy species. In spite of being apparently quite readily available, it is seldom seen in gardens and is a much sought-after plant. In the wild it is now nearly extinct due to over-collection in the past and habitat destruction. The commercial propagation of this unique species is thus of great importance.

N. jacetanus
Availability: 1
Retail price example: £2.50
var. *jacetanus* - Very similar to *N. asturiensis* but grows on limestone formations.
var. *vasconicus* - Ditto, a very small-flowered form with corona only 1.5 cm long.
Comments: This is very similar to *N. asturiensis*, so from that point of view has little commercial potential, but it grows on limestone formations in the wild (*N. asturiensis* inhabits acid areas) so

this may be a useful characteristic. The variant var. *vasconicus* is even smaller than *N. asturiensis.*

N. lagoi - Up to 50 cm tall but with small flowers like *N. asturiensis.*
Availability: 0
Comments: A very little-known species, probably not in cultivation and possibly extinct in the wild.

N. minor (AGM) - A larger version of *N. asturiensis*, to 15 cm; yellow flowers, corona not constricted in middle.
Availability: 6
Retail price example: 5 for £1.70
Comments: A name given to a small yellow trumpet daffodil which is like a slightly larger version of *N. asturiensis.* It is an excellent garden plant, very hardy and sturdy enough to be grown satisfactorily in grass. Probably great potential if offered container-grown in spring in flower. *N. nanus* is another small, early-flowering trumpet daffodil, a little larger than *N. minor* and bicoloured. Like the latter it is a good, vigorous garden plant and has similar potential. The same comments might also be made about *N. provincialis, N. pumilus (minor* var. *pumilus), N. parviflorus* and *N. portensis*, although it is doubtful if they represent distinct species; they are probably not distinct enough from those already mentioned to make them anything more than collector's items.

b) Plants taller (usually 15-60 cm or more) and (or) with larger flowers (usually 5-12 cm diameter).

N. abscissus - Flowers bicoloured with cream petals and yellow parallel-sided corona not expanded at mouth.
Availability: 0
Comments: This probably has great commercial potential. It is very hardy, late-flowering compared with other small trumpet *Narcissus* species and has distinctive characteristics - notably the bicolored flowers with a straight-sided trumpet, crinkled at the mouth as if trimmed with pinking scissors. It is easily cultivated, but is currently unobtainable through the trade.

N. bicolor is similar to *N. abscissus* but has pale yellow petals and a deep yellow corona, slightly expanded at mouth - probably insufficiently different from the latter to attract much interest.

N. albescens - Flowers creamy-white, held horizontally and the corona much-expanded at the mouth.
Availability: 0
Comments: A rare plant, but probably not distinct enough to be of any horticultural importance; it is similar to *N. moschatus* with creamy-white flowers, but held more horizontally.

*N. alpestris** - Flowers wholly white, pendent; petals drooping alongside corona.
Availability: 0
Comments: Of considerable commercial potential and 'different', with its charming wholly white, pendent flowers. It is very hardy and not difficult to cultivate in a cool position but is rare in cultivation and unobtainable through the trade at present.

N. confusus - A tall, robust plant with green leaves and wholly yellow flowers facing obliquely upwards.
Availability: 0
Comments: A little-known plant, probably of no commercial importance.

N. gayi - Slight variation of *N. pseudonarcissus*.
Availability: 1
Comments: Probably just a slight variation of *N. pseudonarcissus* and not sufficiently distinct from it to be of much commercial interest.

N. hispanicus - Tall, with flowers to 10 cm diameter, yellow; leaves bluish, twisted; corona very flared at mouth.
Availability: 0 (but widespread in cultivation)
Comments: An ancient garden *Narcissus*, a tall plant with wholly yellow flowers and twisted bluish leaves, but unknown in the wild. It probably does not lend itself to commerce since it is frequent in cultivation as an old garden plant.

The Spanish *N. bujei* is similar and probably not distinct enough to make it suitable for commercial production. It has wholly yellow flowers to 6.5 cm across; corona mouth not very crinkly; otherwise like *N. hispanicus*.

N. longispathus - Tall with up to 4 wholly yellow flowers per umbel; spathes very conspicuous, to 10 cm long.
Availability: 2
Comments: Although difficult to obtain commercially, this must have considerable potential since it is an easily-cultivated and very hardy plant for damper situations, and is unusual in having up to 4 yellow flowers on each stem.

N. moschatus - Up to 30 cm tall; flowers creamy-white, pendent with petals drooping alongside corona.
Availability: 1
Retail price example: £4.95
Comments: This has a similar aspect to *N. alpestris*, but has creamy-white flowers and is not so easy to cultivate, so is rather more of specialist interest. Nevertheless it is well worth considering since it has historic interest, having been cultivated for over 300 years, and is currently not easy to obtain.

The same applies to the similar *N. tortuosus* which is an old garden plant but now very rare. Flowers sulphur-white with twisted petals, similar to *N. moschatus* but stronger-growing.

N. nevadensis - Flowers up to 4 in an umbel, bicoloured with pale yellow petals and corona slightly deeper.
Availability: 2
Retail price example: £2.50
Comments: This is very unusual among the trumpet daffodils in having up to 4 bicoloured flowers in an umbel, so is of considerable interest but almost unknown outside specialist enthusiast circles. It is not difficult to grow.

N. nobilis - Only 15-30 cm tall but flowers 8-12 cm diameter, bicoloured; petals white, corona deep yellow.
Availability: 1
Comments: A distinctive daffodil, quite dwarf but with large bicoloured flowers. It has potential for naturalising in grass since it is a mountain-meadow plant in the wild. It is very hardy and easily-cultivated but not readily obtainable.

N. obvallaris (AGM) - The Tenby Daffodil. To 30 cm but smallish flowers (4 cm diameter), wholly yellow.
Availability: 7
Retail price example: 5 for £1.70 to 5 for £2.50
Comments: The Tenby daffodil grows extremely well in grass and provides a more naturalappearance than the large-flowered trumpet cultivars. It also has the 'British native' connection, which might provide added commercial interest.

*N. pallidiflorus** - Flowers very pale cream/yellow, to 7.5 cm diameter; petals twisted, corona mouth much-toothed.
Availability: 0
Comments: A beautiful plant with sulphur-coloured flowers, so this is of very considerable horticultural potential but is currently difficult to obtain. It is easily cultivated and hardy, requiring no special treatment.

N. macrolobus is similar to *N. pallidiflorus*, so the same comments apply, although the latter is the preferable option. It is up to 25 cm tall; pale yellow with corona slightly deeper yellow; similar to *N. pallidiflorus*.

*N. pseudonarcissus**
Availability: 12 (unspecified to subspecies or variety).
Retail price example: 10 for £2.10
N. pseudonarcissus ssp. *pseudonarcissus* - To 30 cm; bicoloured white/yellow flowers; corona not widely expanded and frilled.
Comments: A small, bicoloured trumpet daffodil which has for centuries been naturalised in parts of Britain. Although fairly readily obtainable by mail order as dry bulbs, this should be of considerable commercial interest for selling in pots in flower. It is very hardy and easily cultivated and is suitable for naturalising in grass.
N. pseudonarcissus ssp. *eugeniae* - Small plant to 10 cm but flowers to 7.5 cm diameter; petals not overlapping; leaves short and wide.
Availability: 0
Comments: A fairly recently described species, so having novelty value. It is an attractive plant, probably with good potential for popularity, being very compact, only 10 cm tall, but with large yellow flowers and neat blue-grey foliage.

N. radinganorum - Related to *N. hispanicus* with wholly yellow flowers, but a smaller plant, 25-40 cm tall.
Availability: 1
Comments: A small yellow trumpet daffodil with wholly yellow flowers, only recently described and introduced so with some novelty value. It seems to be establishing well and may prove a useful introduction.

EXPERIMENTAL SECTION

Materials and Methods

Seed supplies

Seeds of *Narcissus bulbocodium* var. *citrinus*, *N. cyclamineus* and *N. pseudonarcissus* were collected in 1991, 1992, 1993 and 1995 from near-pure stands growing in the Valley Gardens, Windsor Great Park. They were collected once ripe and prior to capsule dehiscence, and were despatched to HRI-Kirton (usually in July). Seed set in *N. cyclamineus* was relatively poor, and seed for experiments was therefore in short supply. Surface-drying was completed in trays at ambient temperatures, and the seeds were stored, with silica gel desiccant, in paper bags in an incubator at 15°C. Typical 100-seed weights of 'dried' seeds were *ca.* 0.1 g for *N. bulbocodium* var. *citrinus*, 0.3 g for *N. cyclamineus* and 0.4 g for *N. pseudonarcissus*. Seeds were generally pre-counted and sorted from chaff and debris before use in germination experiments. Later in the project, seed was also collected from bulbs growing at Kirton, and where this stock was used it is specified in the text.

Germination studies

General methods Experiments were generally carried out in Petri dishes (9 cm diameter) with 25 seeds per dish. Three replicate dishes were used per treatment, and experiments were carried out with all three species unless otherwise stated. In the first two runs of the experiment only, seeds were placed on a layer of 1.5% agar (Oxoid No. 1, *ca.* 30 ml per dish); in subsequent runs seeds were placed on two filter papers (Whatman No. 1, 9 cm diameter) moistened with *ca.* 5 ml water, and the dishes were checked weekly and water added as appropriate to maintain a uniform moist surface. Dishes were placed in containers (usually seed trays with propagator lids) with moistened paper tissue to slow drying out, and were placed in un-lit incubators or controlled-temperature stores at the required temperature (usually with limits of ±1°C).

The dishes were inspected weekly (less frequently towards the end of experiments) and germinating seeds (with radicles emerging) were counted and removed. Observations were continued until germination ceased, often for about a year. Moulds were a problem in some batches of seed, especially the 1993 batch, and generally with *N. cyclamineus*. *Penicillium* sp. occurred in lower temperature treatments and *Mucor* and *Rhizopus* spp. were identified at the higher temperatures.

(1) Effect of temperature: basic experiment Dishes of seeds were incubated at 5, 10, 20, 25 or 30°C for 4, 8 or 12 weeks before being transferred to 15°C, further dishes being kept at 15°C throughout. This experiment was repeated with seed from each batch and either soon after collection or after various durations of storage. The schedule of experiments is shown in the following table:

Collection year	Storage period (months)	Start of experiment	Notes
1991	0	3 July 1991	-
	6	25 February 1992	Also included 16 week temperature treatment
	12	30 July 1992	5, 15 and 25°C treatments only
	24	26 July 1993	5, 15 and 25°C treatments only
	50	18 September 1995	5, 15 and 25°C treatments only
1992	0	30 July 1992	-
	6	10 February 1993	-
	12	26 July 1993	-
	38	18 September 1995	5, 15 and 25°C treatments only. Excluding *N. cyclamineus*
1993*	26	18 September 1995	5, 15 and 25°C treatments only
1995	2	18 September 1995	Also tested seed of *N. bulbocodium* var. *citrinus* collected from stocks at Kirton

*Seed of all three species from the 1993 batch were badly affected by mould (see above), perhaps due to damp conditions around the time of collection. Germination was very sporadic and the test was discontinued.

(2) Effect of temperature: cold treatments To define optimum cold treatments more closely for *N. bulbocodium* var. *citrinus* and *N. pseudonarcissus*, seed (1995 stock) was placed in Petri dishes on 14 March 1996 and incubated at 5, 7.5, 10 or 12.5°C either continuously or for 2, 4, 6, 8, 10 or 12 weeks before transferring to 15°C; control dishes were placed at 15°C throughout.

(3) Effect of temperature: pot-grown seeds As a further test of the effect of temperature on germination, another experiment was carried out with seeds in pots of compost rather than Petri dishes. Fifty seeds (1991 batch) were sown in a plastic flower pot (14 cm diameter) of peat-grit compost (75:25 v/v, with the following additions per 1000 litres compost: 0.40 kg potassium nitrate, 0.75 kg single superphosphate and either 1.0 kg ground limestone for *N. bulbocodium* var. *citrinus* or 3.0 kg ground limestone for *N. cyclamineus* and *N. pseudonarcissus*). They were incubated at 5 to 30°C for 4 to 12 weeks. Treatments were set up so that all ended together on 18 November 1992, following which all pots were grown on in a frost-free polythene tunnel for two years before yield was recorded.

(4) Effect of temperature: cold treatment after warm treatment To evaluate the effect of cold treatment *after* warm treatment, seed (1991 batch) was incubated from 18 May 1992 in dishes for 8 weeks at 25°C before transfer either to 15°C immediately, or to 5, 10 or 20°C for 4, 8 or 12 weeks before transfer to 15°C.

(5) Effect of light Seed (1995 batch) was placed in dishes on 13 March 1996 at 15°C, either in an un-lit store (as used for routine germination experiments) or under continuous light (from four 36W warm white tubular fluorescent lamps 0.6 m above the dishes).

In a second experiment, seed (of *N. bulbocodium* var. *citrinus* and *N. pseudonarcissus* only, from the same batch as before) was sown in light or dark conditions on 12 December 1997. Conditions were otherwise as before.

(6) Effect of scarification Seed of *N. pseudonarcissus* (1991 batch) was treated on 4 March 1992. Small lots of seed were treated in a scarifier (Jones *et al.*, 1986) for 30 seconds, 1 minute or 2 minutes, then incubated in dishes for 8 weeks at 30°C before transferring to 15°C.

(7) Effect of treatments to control mould growth: surface sterilisation Seed of *N. pseudonarcissus* (1991 batch) were treated on 5 March 1992 by immersion for 1 minute in either industrial methylated spirit (IMS) or a bleach solution (20% aqueous Domestos), controls being treated in plain water. Seed was then placed in Petri dishes as usual and incubated at 30°C for 8 weeks before transfer to 15°C.

(8) Effect of treatments to control mould growth: hot-water treatment Seed of *N. pseudonarcissus* (1991 batch) was treated as follows beginning on 11 March 1992. Small seed lots were immersed in either water or aqueous thiram (as 2.5 g Thiram (80% a.i.) per litre), each with non-ionic wetter added (0.6 ml per litre) for 15, 60 or 120 minutes at 45, 50 or 55°C, or for 24 hours at 30°C. After allowing drainage, seed were placed in Petri dishes and incubated at 30°C for 8 weeks followed by transfer to 15°C.

(9) Effect of treatments to control mould growth: fungicides Seed (1992 batch) was placed in dishes moistened with water or fungicides (0.05, 0.2 or 0.6% a.i. captan, thiram or benomyl) on 11 September 1992 and incubated at 10°C. The fungicide solutions were made up by using 0.6, 2.4 or 7.2 g Captan 83%/litre, 0.625, 2.5 or 7.5 g Thiram 80%/litre, or 1.0, 4.0 or 12.0 g Benlate 50%/litre.

(10) Effect of treatments to control moulds: antibiotics Seed (1991 batch) was placed in dishes moistened with plain water or aqueous chloramphenicol (Sigma Chemical Co.) (1, 10 or 100 mg/litre) on 16 July 1996, and incubated at 10°C. Germination was recorded as usual and at the conclusion of the test the extent of mould growth in the dishes was scored on a scale from 1 (no mould) to 5 (much of surface covered).

(11) Effect of treatments to control moulds: further disinfectant and fungicide treatments Seed of *N. bulbocodium* var. *citrinus* (1995 Kirton batch) was immersed in 'Jet 5' disinfectant or fungicides prior to placing in Petri dishes as usual. Treatments consisted of 30 minute soaks in peroxyacetic acid (as Jet 5, either 1 ml or 5 ml per litre) or thiabendazole (as 5 ml Storite Clear Liquid per litre), or an 8 hour soak in iprodione (as 1 g Rovral WP per litre), and control lots were soaked in plain water for 30 minutes or 8 hours or were sown without prior soaking. The test was set up on 27 May 1997 and all dishes were incubated at 15°C. In the case of peroxyacetic acid treatments only, dishes were topped up with diluted Jet 5 (1 ml per litre) rather than plain water.

(12) Effects of treatments to control moulds: peroxyacetic acid soaks and hot-water treatments On 2 December 1996 seed *N. cyclamineus* (1995 batch) was treated in plain water or peroxyacetic acid (as 1 ml Jet 5 per litre) either (a) at room temperature for 30 minutes or (b) at 30°C for 24 hours. After draining the seed it was placed in Petri dishes as usual (moistened with plain water) which were kept at 25°C for 8 weeks and then moved to 15°C. There were four replicates of each treatment. Mould growth in the dishes was recorded at intervals.

The experiment was repeated with the same seed batch, starting 17 December 1997.

Growing systems

General cultural methods For experiments, seeds were sown in cellular trays, pots, trays or into small beds. Cellular trays (modular trays) were single- or double-seeded, either 'Hassy 308' trays (15 ml cell volume), 'Hassy 104' trays (45 ml cell volume) or 'Quickpot 150' trays (deep cells with a volume of 30 ml). The compost for cellular trays consisted of 20:1 (v/v) fine peat: silver sand, with the following additions per 1000 litres peat: 0.40 kg potassium nitrate, 0.75 kg single superphosphate, 0.40 kg frit and either 2.00 kg ground limestone (for *N. bulbocodium* and *N. cyclamineus*, pH *ca.* 5.0) or 5.00 kg ground limestone (for *N. pseudonarcissus*, pH *ca.* 6.5). Pots (7.5 x 7.5 cm square) were single-seeded, and were grouped as 48 pots in a 0.60 x 0.45 m tray. Trays (simply referred to in the text as 'trays', to distinguish them from cellular trays), *ca.* 0.60 x 0.45 x 0.11 m, were each broadcast with 48 seeds. The compost for pots and trays consisted of 2:1:1 (v/v/v) medium peat : perlite : grit, with the following additions per 1000 litres peat: 0.80 kg potassium nitrate, 1.50 kg single superphosphate, 0.80 kg frit and either 2.00 or 5.00 kg ground limestone for acid or neutral composts (as before). Plots in outdoor beds or in beds in polytunnels were each 0.60 x 0.45 m and were also broadcast with 48 seeds each. The soil of the seedbed plots was a fine silty marine alluvium previously ameliorated by the addition of peat and gravel, fertilised according to soil analysis and MAFF recommendations for narcissus, and limed where necessary to give the approximate pH values previously mentioned. All seed were lightly covered after sowing. The outdoor beds were located in a reasonably sheltered site, and the polythene tunnels or glasshouses used for frost-free growing were heated to 3°C and ventilated at 10°C. In all growing regimes plants were watered individually according to need.

Thiram (as 400 g of 80% a.i. product/10 litres, using *ca.* 200 ml/m^2) was used occasionally to control mosses and liverworts. Weed control in seed beds was by using paraquat + diquat in the dormant season and chlorpropham + linuron pre-crop-emergence, according to the manufacturers' recommendations, and weed control in containers was by hand. As leaves died down in summer, water was withheld and the trays, etc, were moved to a controlled temperature store at 17°C; in mid-September, they were moved back to the normal growing environment, the compost surface being scarified and top-dressed with appropriate compost if necessary. During the growing season in the second year onwards, a weekly liquid feed was applied ('Sangral 1-1-1' at a dilution of 1:200, giving 95 ppm each of N, P_2O_5 and K_2O, plus trace elements).

Preliminary observations (1) In a preliminary investigation of different growing systems, seed (1991 batch) was sown in August 1992 in 'Hassy 308' cellular trays (double-seeding each cell) or in trays (0.6 x 0.45 m) (broadcasting 150 seeds per tray) in appropriate compost and grown-on in a frost-free glasshouse. There were six trays of each type for each species. After one year's growth, half the modules of the cellular trays were transplanted singly to flower pots (7.5 cm diameter), the remainder being left in the original cellular trays. After a second year's growth, pots and trays were sampled to determine the yields and sizes of bulbils.

Preliminary observations (2) Bulbs from earlier sowings in 1992 and 1993 were bulked in autumn 1995. Samples of graded bulbs of each species were dissected or grown-on for further observations, and the remainder were used as stocks. 10 bulb samples of small, medium and large grades (see Table 4) of each species were dissected (October 1995) to determine the number

with flower initials. Three trays of bulbs of each grade and species were planted, using 48 bulbs per tray and conditions as otherwise described below, and grown-on in a frost-free polythene tunnel. Records taken included initial bulb weight, leaf and flower numbers and bulb yield.

Main experiment (1) Seed of all three species (1995 batch) were sown and grown under the regimes ticked in the following list, the trial being set up 24-26 October 1995:

	Outdoors	Frost-free polytunnel	Temp. treatments then frost-free-glasshouse
Seedbed	✓	✓	-
Trays	✓	✓	✓
Pots	✓	✓	✓
'104' Module trays	-	✓	✓
'308' Module trays	-	✓	✓

There were six trays for each species for each regime. Modules were single-seeded. The temperature treatments consisted of 16 weeks at 9°C for *N. bulbocodium* var. *citrinus* and *N. pseudonarcissus* and 16 weeks at 30°C for *N. cyclamineus*.

For *N. bulbocodium* var. *citrinus* and *N. pseudonarcissus* only, additional sowings of '104' and '308' cellular trays were made on 18 January 1996, held at 9°C for 12 weeks and then transferred to a frost-free glasshouse (as above). For each species and tray type, 6 trays were sown with one seed per cell and 6 with two seeds per cell.

In the second year of the experiment, on 20 March 1997, plants in module trays were potted-on to flower pots (7.5 x 7.5 cm square). Only cells with emerged leaves were used, two cells were transferred to each pot, and a maximum of 42 pots per plot was set up. The total number of cells with emerged leaves was also recorded.

The number of seeds germinating or plants emerging was recorded each year in early-summer. One plot of each type was sampled at random in summer in 1996 and 1997, recording the number and weight of the bulbs recovered and noting typical bulb grades. The remaining four plots of each treatment were harvested and recorded in 1998.

Main experiment (2) The previous experiment was repeated in 1996, using seed of *N. bulbocodium* and *N. pseudonarcissus* only (1995 batch). Outdoor seedbeds were excluded, but a cellular tray with a deeper module ('Quickpot 150') was also used, the full range of treatment combinations being as shown in the table below:

	Outdoors	Frost-free polytunnel	Temp. treatments then frost-free-glasshouse
Seedbed	-	✓	-
Trays	✓	✓	✓
Pots	✓	✓	✓
'104' Module trays	-	✓	✓
'308' Module trays	-	✓	✓
'150' Module trays	-	✓	✓

Modules were all single-seeded. The trial was sown on 31 September-1 October 1996. There were four replicates for each treatment combination. The experiment was recorded as described above.

Main experiment (3) - liquid feeding Additional sowings of all three species were made on 2 December 1996, using the 1991 seed batch. Ten '104' module trays were single-seeded for each species, and they were placed for 12 weeks at 9°C (*N. bulbocodium* var. *citrinus* and *N. pseudonarcissus*) or 25°C (*N. cyclamineus*) before transfer to a heated glasshouse (minimum maintained temperature 15°C, automatic ventilation at 18°C). Five trays of each species received a weekly liquid feed (as described under General cultural methods, see above), while the others were untreated. Other experimental details were as described for the previous experiment, and bulb yields were determined at the end of one year's growth.

Establishment of stocks

Seed of *N. bulbocodium* var. *citrinus* and *N. pseudonarcissus* (1991 batch), surplus to the requirements of germination experiments, was planted in sheltered outside beds in October 1992. There was 123 g seed of *N. bulbocodium* var. *citrinus* and 194 g seed of *N. pseudonarcissus*, each species being broadcast over an area of 13.5 m² (*ca.* 9000 and 3500 seeds per m², respectively). These beds were lifted in 1996. Surplus bulbs and seeds were replanted into outside beds in 1996 and 1997.

Results

Seed germination

(1) Effect of temperature: basic experiment The full results of seed germination tests were presented graphically in the earlier reports, and examples for the three species are shown in Figure 1 in the present report.

N. bulbocodium var. *citrinus*. Seed from the 1991 batch was tested on receipt or after storage for 6, 12, 24 or 50 months. Seed germinated throughout the range of storage duration and temperature treatments tested, although at varying rates. There was a general trend for faster germination and higher final percentage germination in stored than in non-stored seed. This

effect was well illustrated by the results for seed kept at 15°C throughout, which reached a final percentage of about 20 per cent in fresh seed but of 40 to 60 per cent in stored seed. However, this storage effect was seen at all temperatures tested, the greatest change occurring between 0 and 6 months of storage.

Germination occurred relatively slowly using an initial treatment at 5°C, but rapidly at 10°C, even before transfer to 15°C. Initial treatment at 20, 25 or 30°C progressively increased the speed of germination once seed was transferred to 15°C: in all cases germination occurred rapidly once transferred to 15°C. In seed which had been stored for 4 years there was little change in germination characteristics compared with seed stored for 2 years.

Seed from the 1992 batch was tested on receipt or after storage for 6, 12 or 38 months, and results confirmed those for the 1991 seed batch. There was relatively slow germination following 5°C treatment, rapid germination at 10°C, and rapid germination at 15°C after transfer from 20, 25 or 30°C treatments. Improved germination of stored seed, compared with fresh, was less clear than in the 1991 seed batch. Germination characteristics was similar in seed stored for 12 or 38 months. Seed from the 1995 batch (both from Windsor and Kirton) was tested 2 months after collection, and confirmed the results from earlier seed batches.

N. pseudonarcissus. Seed from the 1991 batch was tested as fresh seed or after storage for 6, 12, 24 or 50 months. The results were very similar to those described above for *N. bulbocodium*: germination was generally better for stored than fresh seed, was slow at 5 or 15°C, occurred in 10°C (for stored seed only) and occurred rapidly on transfer to 15°C from 20, 25 or 30°C. Generally, germination was somewhat poor than in the case of *N. bulbocodium*. When stored for 50 months, germination was poorer than when stored for 24 months, with 25°C treatments being less effective in giving rapid germination.

Seed from the 1992 batch was tested as fresh seed and seed stored for 6, 12 or 38 months. The responses were similar to those described for the first batch. As for the results with *N. bulbocodium* var. *citrinus* the better germination of stored against fresh seed was less pronounced with the 1992 seed batch than with the 1991 batch. Germination responses of the 1995 batch of seed, tested 2 months after collection, were similar to those of previous batches tested soon after collection.

N. cyclamineus. Seed from the 1991 batch were tested as fresh seed and after storage for 6, 12, 24 or 50 months. Germination was very slow and poor in 5, 10 and 15°C treatments, although slightly better in stored than fresh seed. With treatment at 20, 25 or 30°C, germination occurred quickly on transfer to 15°C, as found for the previous two species. Overall percentage germination was lower for *N. cyclamineus* than for the other two species. Germination was similar in seed stored for 24 or 50 months. The responses of later seed batches were similar.

(2) Effect of temperature: cold treatments In this experiment seed was held at 5 to 12.5°C for various periods before transfer to 15°C, or was held at constant temperatures between 5 and 15°C. At a constant temperature, germination of *N. bulbocodium* var. *citrinus* was quickest and highest at 10 and 12.5°C, markedly less so at 7.5 or 15°C, and poor at 5°C (Figure 2). Longer pre-treatments at lower temperatures, or early transfer to 15°C from a lower temperature, slowed germination and also reduced final percentage germination (Figure 3).

In *N. pseudonarcissus*, as for the previous species, germination in a constant temperature was better at 10 or 12.5°C, but lower and higher temperatures were inimical to germination. Periods at lower and higher (15°C) temperatures reduced germination as for the previous species. (For full data, see 1997 report.)

(3) Effect of temperature: pot-grown seeds Figure 4 shows the number of bulbils recovered after two years, when seeds were sown in pots and given temperature treatments in controlled temperatures prior to placing in a frost-free polytunnel. Bulb yields were highest following treatments at 10°C in the case of *N. bulbocodium* var. *citrinus* and *N. pseudonarcissus*, and following 20°C in *N. cyclamineus*.

(4) Effect of temperature: cold treatment after warm treatment The effect of storage for up to 12 weeks at 5, 10 or 20°C, after a standard 25°C treatment for 8 weeks, on subsequent germination at 15°C is shown in Figure 5(a)–(c) for the three species. The responses of all three species were similar, although *N. bulbocodium* var. *citrinus* had the greatest germination percentages and *N. cyclamineus* the lowest. In the 'controls', moved to 15°C immediately after the 25°C treatment, germination was almost nil in *N. cyclamineus*, slight (finally about 20%) in *N. pseudonarcissus*, and greatest (reaching a maximum of about 60%) in *N. bulbocodium* var. *citrinus*. In the 5°C treatment, germination started soon after transfer from 25°C: germination was low in *N. cyclamineus*, poor in *N. pseudonarcissus* (especially when retained in 5°C for more than 4 weeks) and high and rapid in *N. bulbocodium* var. *citrinus*. In 10°C, there was rapid germination soon after transfer to 10°C in all three species. In the 20°C treatment, there was rapid germination soon after moving from 20°C to 15°C.

(5) Effect of light In the first experiment, for *N. bulbocodium* var. *citrinus* and *N. cyclamineus* the rate and final percentage of germination were similar in seeds in dark and continuous light. The percentage germination figures were 52 and 48 per cent for dark and light, respectively, for the former species, and 12 and 8 per cent for the latter. In *N. pseudonarcissus* 32 per cent of seed germinated in the dark, and none in continuous light.

This experiment was repeated to check the results. In *N. bulbocodium* var. *citrinus* the final percentage germination was 49 per cent in the dark and 32 per cent in the light. For *N. pseudonarcissus*, 21 per cent of seed germinated in the dark, but only 5 per cent in the light. There was good agreement between replicate dishes.

(6) Effect of scarification All scarification treatments adversely affected germination in a trial with *N. pseudonarcissus*. Seed from the 1 and 2 minute treatments rotted during the 30°C incubation period, and was discarded. Seed from the short (30 second) treatment achieved a final percentage germination of only 15 per cent, with the whole filter paper surface covered by moulds. Untreated seed achieved 91 per cent germination with only 15 per cent of the surface affected by moulds.

(7) Effect of treatments to control mould growth: surface sterilisation Seed of *N. pseudonarcissus* was treated with IMS, bleach solution or plain water, before incubation at 30°C for 8 weeks and transfer to 15°C. Seed from all three treatments achieved similar final percentage germination: 88 per cent for IMS, 83 per cent for bleach solution, and 80 per cent for the control. The amount of the dish surface covered by moulds, by the end of the recording period, was 30 per cent for IMS, 23 per cent with bleach solution, and only 17 per cent in the controls.

(8) Hot-water treatment Seed of *N. pseudonarcissus* was treated in plain water or aqueous thiram for 15 minutes to 2 hours at 45 to 55°C, or for 24 hours at 30°C, placed at 30°C for 8 weeks and then transferred to 15°C. Final percentage germination and the amount of mould growth are shown in Table 1. Untreated control seed had a final germination of 91 per cent, and germination rates were similar in the 30°C treatment; however, increasing the temperature and duration of HWT (particularly to 2 hours at 50°C or to 1 hour at 55°C) reduced germination. Control dishes developed a mould cover of 15 per cent: a 30°C treatment appeared to reduce mould growth substantially, whereas increasing the duration and temperature of HWT greatly increased it. There were no clear differences between HWT in plain water or thiram.

(9) Fungicides The effects on germination of all three *Narcissus* species of using fungicides in the Petri dishes is shown in Table 2. None of the fungicide treatments appeared to adversely affect the germination of *N. bulbocodium* or *N. pseudonarcissus*, but the highest rate used of benomyl and thiram reduced germination percentage in *N. cyclamineus*.

(10) Antibiotics In *N. bulbocodium* var. *citrinus* and *N. pseudonarcissus*, the rate and extent of seed germination were similar in all treatments (0, 1, 10 and 100 mg chloramphenicol per litre). However, in *N. cyclamineus*, the final germination was 43 per cent in the controls, but fell progressively with increasing concentrations of antibiotic, to only 17 per cent at the highest concentration. Across all dishes, the mean mould score at the end of the test was 2.1 for controls but higher where chloramphenicol had been used (mean scores of 3.1, 3.2 and 3.5 for 1, 10 and 100 mg/litre, respectively).

(11) Further disinfectant and fungicide treatments The mean final percentage germination in the four disinfectant or fungicide treatments (two rates of peroxyacetic acid, thiabendazole or iprodione) varied between 45 and 47 per cent. This was consistently lower than germination in the controls (plain water soaks or non-treated) which was 56 to 59 per cent. The mould score for dishes at the end of the test was similar in all treatments, varying from 2.0 to 2.7.

(12) Jet 5 soaks and hot-water treatment The mould score near the end of the 25°C period was lowest (1.5) in the dishes where seed had been treated with peroxyacetic acid as a hot-water treatment, and varied between 2.0 and 2.8 in the other treatments; however, by the end of the test, the mould score varied between 3.0 and 4.0 in all treatments, so no clear effects due to peroxyacetic acid or hot-water treatment were clearly evident. Mean percentage seed germination was only 47 per cent when seed had been treated in plain water at ambient temperatures, but was 56 to 61 per cent in the other three treatments, suggesting a possible beneficial effect of peroxyacetic acid or 30°C treatment.

To check these possibly useful results, the experiment was later repeated with the same seed batch. Mould growth was again extensive, and similar in all four treatments. Seed germination was much poorer than in the earlier experiment, presumably due to the deterioration of the seed stock. However, it was lower when treated with peroxyacetic acid (6 per cent with room temperature treatment, 8 per cent with 30°C treatment), than when treated with plain water (14 per cent with room temperature treatment, 16 per cent with 30°C treatment), indicating a possibly adverse effect of the disinfectant. Results were consistent between replicates.

Growing systems

Preliminary observations (1) Bulbil yields after two years of growth in trays or '308' cellular trays, and after growing in cellular trays before transplanting to small pots for a further year, are summarised in Table 3. When grown for the whole period in cellular trays, almost all cells contained at least one bulbil (cells were double-seeded), but mean weight of bulbils per cell was only 0.1 g (averaged across the three species). When transferred from cellular trays to small pots after the first year, 82 per cent of pots yielded at least one bulbil, with a much greater mean weight of bulbils per pot: 0.25 g for *N. cyclamineus*, 0.36 g for *N. pseudonarcissus*, and 0.62 g for *N. bulbocodium* var. *citrinus*. When grown in ordinary trays, only 42 per cent of the seeds sown produced a bulbil, although the weight of these was much greater than from cellular trays: about 0.6 g (a 5 mm diameter bulb) for *N. cyclamineus* and *N. pseudonarcissus* and 1.6 g (a 10 mm diameter bulb) for *N. bulbocodium* var. *citrinus*.

Preliminary observations (2) Information of the performance of bulbs of different sizes is summarised in Table 4. In *N. bulbocodium* var. *citrinus*, three grades of bulbs were examined in autumn, from 5-10 mm grade (diameter) to 16-25 mm, weighing on average 0.4 to 3.4 g. Only 20 per cent of the smallest bulbs had initiated flowers, whereas 90 per cent of the medium grade and 100 per cent of the largest grade had. For bulbs of roughly similar grade, *N. cyclamineus* produced similar figures for percentage floral initiation, 80 per cent, for 11-15 mm grade bulbs (the largest available), although these were much smaller than *N. bulbocodium* var. *citrinus* bulbs of a similar grade (1.1 g against 1.8 g). For *N. pseudonarcissus*, no floral initiation had occurred even in bulbs of the largest grade available, 12-16 mm, although of a similar weight (1.8 g) to *N. bulbocodium* var. *citrinus* bulbs of similar grade. Flower counts the following spring confirmed the results of dissection in October. The percentage of bulbs sprouting varied from 78 to 100 per cent in samples of *N. bulbocodium* var. *citrinus* and *N. pseudonarcissus*, while for *N. cyclamineus* it was poorer, from 48 per cent for small (4-8 mm) bulbs to 82 per cent for the largest (11-15 mm). Bulbs of *N. bulbocodium* var. *citrinus* produced about twice as many leaves as bulbs of about the same grade of the other species, and up to 7 for the largest bulbs. Translated to the more usual cm circumference grades, *N. bulbocodium* var. *citrinus* and *N. cyclamineus* had a critical bulb size for flowering of 3-5 cm, while critical size was >5 cm for *N. pseudonarcissus*.

Bulb yields and grades after recovery are also given in Table 4. *N. bulbocodium* var. *citrinus* was the most vigorous, with 70 to 80 per cent recovery of bulbs, and mean bulb weights of 4 to 12 g for the three planting grades. Samples of bulbs of grade 10-15, 15-20 and 20-25 mm (diameter) were examined, and all were found to contain flower buds. *N. pseudonarcissus* had poor recovery of smaller grades, but 90 per cent recovery from the largest planting, with mean bulb weight of 4 g. In this species, all bulbs of grade 15-20 mm (diameter) contained flower buds, but only 10 per cent of bulbs of grade 10-15 mm, and none of grade 5-10 mm, were floral. Recovery of *N. cyclamineus* was poor (19-25%), with the bulbs produced weighing only about 1 g on average. In this case, bulbs of grade 15-20 mm (diameter) were all floral; smaller grades (5-10 and 10-20 mm) had 70 to 80 per cent of bulbs with flower buds.

Main experiment (1) Seeds of *N. bulbocodium* var. *citrinus* and *N. pseudonarcissus* started to germinate during the 9°C vernalization period (Table 5). In the various modules, germination at this stage varied from 16 to 44 per cent for *N. bulbocodium* var. *citrinus* and from 8 to 30 per cent for *N. pseudonarcissus*. *N. cyclamineus* seeds did not start to germinate during the 30°C conditioning period.

Results for the three years of the experiment are given in Tables 6 and 7. In the first year of the experiment, the highest percentage germination of *N. bulbocodium* var. *citrinus* and *N. cyclamineus* was seen where vernalised or conditioned seed had been used (whether sown in trays, cellular trays or pots), generally of the order 50 to 70 per cent. Germination of these species was poorer where non-treated seed had been used. In the case of *N. pseudonarcissus*, germination was relatively high (40-80%) in all growing systems (except seed beds) grown in the frost-free polythene tunnel. Germination in seed beds (outdoors or in tunnel), and in containers outdoors, was poor for all three species. These results were generally reflected in the bulb yields from samples taken after the first year: in the best treatments (vernalised or heat-treated seed grown in containers in the frost-free tunnel), 60 to 70 per cent of sown seeds produced a bulb, typical bulb weights being 0.2 to 0.3 g (with a diameter of 5 to 6 mm) in *N. pseudonarcissus*, and 0.1 to 0.2 g (4 to 5 mm diameter) in the other two species. Double-seeding cellular trays did not appear to be helpful.

During the second growing year, cells from 104 and 308 module trays were transplanted to flower pots. At this stage, between 40 and 94 per cent of cells, in the different systems and species, contained growing seedlings. For the two species where modular trays were sown on two occasions (*N. bulbocodium* var. *citrinus* and *N. pseudonarcissus*), the later sowings performed better. The best results were obtained with late-sown *N. pseudonarcissus*, where 80 per cent of single-seeded cells, and 90-94 per cent of double-seeded cells, resulted in a usable cell for transplanting.

In *N. pseudonarcissus*, the most vigorous of the three species, records taken after the second year of growth showed that the highest recovery rates (bulbils obtained as a percentage of seeds sown) were from pot-sown seeds raised under frost-free conditions, where the recovery was 85-92 per cent. Recovery was somewhat lower (65-79%) in trays and late-sown modular trays grown under frost-free conditions, and was poor from seeds raised in seed beds, in pots or trays outdoors, and in the early sowing of modular trays (29-53%). The largest bulbs produced, in tray- or pot-raised plants from frost-free conditions, exceeded 0.7 g each in average weight, with a diameter of 8-10 mm. Plants raised in module trays and transplanted to pots in the second year were typically around 0.4 g in weight with a diameter of 6-8 mm. After a third year, however, with the exception of seed raised in seed beds, or in pots or trays outdoors, all treatments gave an average bulb weight in the range 1.5 to 2.8 g, with bulb diameters of 10 to 15 mm. No flowering took place in *N. pseudonarcissus* bulbs in their third year.

For *N. bulbocodium* var. *citrinus* the best recovery rates (70-80%) occurred with vernalised seed sown in trays, pots and module trays and grown in frost-free conditions. Generally, there seemed to be poorer growth using smaller cells (308 trays) and employing double-seeding. Amongst the better treatments, mean bulb weight was about 2.4 g and bulb diameter 14-18 mm with plants raised in trays or pots, and up to about 1.7 g and 11-15 cm diameter raised in module trays and transplanted to pots in the second year. After a third year, as was the case for *N. pseudonarcissus*, bulb weights were poor for those sown in seed beds or raised in pots or trays outdoors. Among the remaining treatments, mean bulb weights varied from 2.8 to 8.6 g and diameters from 18 to 25 mm. In several of these treatments over 50 per cent of the bulbs of *N. bulbocodium* var. *citrinus* flowered in the third year.

In *N. cyclamineus*, raising plants in pots, trays or module trays under frost-free conditions gave the best recovery rates, generally 50 to 65 per cent. The bulb size achieved after two years'

growth was small: even in the best treatment mean bulb weight failed to reach 0.2 g, with a bulb diameter of 5 to 6 mm. In the case of this species, benefits of sowing in cellular trays and transplanting to pots were clearly seen after three years' growth, where these treatments gave the largest (albeit still small) bulbs, 1.1 to 1.5 g in weight and 10 to 11 mm in diameter; several bulbs in these treatments flowered in the third year.

Main experiment (2) The results for the two years of the experiment are given in Table 8.

In *N. bulbocodium* var. *citrinus*, germination rates were highest when sown in pots and module trays and raised under frost-free conditions, where they varied from 58 to 78 per cent. A vernalisation treatment generally improved germination by a few per cent over non-vernalised seed. Results were poor when raised outdoors in pots or trays or in a seed bed in frost-free conditions.

After one year's growth, the largest bulbils of *N. bulbocodium* var. *citrinus* weighed about 0.25 g each with a diameter of 5-7 mm, these being obtained from tray- or pot-raised plants under frost-free conditions. Raised in module trays, mean weights were 0.05 to 0.19 g. However, bulbil recovery rates (as a percentage of seed sown) were higher from module- or pot-raised seeds (frost-free), where between 56 and 89 per cent were recovered, than in tray-raised plants. After a second year, there was a clear advantage of frost-free, tray- or pot-raised plants, which produced bulbs with mean weights of 2.4 to 2.7 g, 12 to 15 mm in diameter. Those raised in module trays (and transferred to pots) were 0.4 to 0.7 g in mean weight, with diameters of 8 to 10 mm.

N. pseudonarcissus germinated best when sown in pots under frost-free conditions (81%), with progressively poorer results in '104' or '150' module trays (50-67%), in '308' module trays or plain trays under frost-free conditions (23-48%), and outdoors in pots or trays or in a seedbed in frost-free conditions, where germination was very low and sporadic. After one year's growth, bulb size in *N. pseudonarcissus* was small, weights varying from 0.03 g to 0.11 g, and diameters from 3 to 5 mm, in different treatments. After a second year's growth, the largest bulbs were obtained from seed sown in pots or trays and raised under frost-free conditions, where the mean bulb weight was 0.9 g (diameters of 8 to 9 mm). When raised in module trays, mean bulb weights in the different treatments were 0.2 to 0.4 g, with diameters of 6 to 8 mm.

Main experiment (3) - liquid feeding Results after one year of growth are given in Table 9. Initial germination was lower than in the preceding experiment, probably as an older seed stock was used. No clear benefits of using a liquid feed were evident in bulb size or weight.

Establishment of stocks

Grown in outside seed beds *N. pseudonarcissus* plants showed a typical spring growing period, whereas *N. bulbocodium* var. *citrinus* remained in leaf for much of the year. Some flowers of *N. bulbocodium* var. *citrinus* were produced in 1994 and flowering was prolific in subsequent springs; in 1995, 200 g seed was collected, and in 1996, 320 g. In contrast, flowering in *N. pseudonarcissus* did not start until 1996, and only a small amount of seed (3 g) was collected.

Discussion

Complementing the experimental part of the current project, *Narcissus* species were reviewed, presenting a classification, and detailing their characteristics, availability and commercial potential. This review drew attention to a number of species which were considered to have potential for significant commercial sales, if blueprints for their efficient and sustainable production from seed could be developed. These species included *N. assoanus*, *N. fernandesii*, *N. cordubensis* and *N. henriquesii* (dwarf jonquils), *N. calcicola*, *N. rupicola* and *N. scaberulus* (*Apodanthi* group, similar to jonquils), *N. poeticus* and its varieties (poet's or pheasant's eye narcissus), *N. triandrus* and its varieties (angel's tears daffodils), *N. bulbocodium* and its varieties (hoop petticoat daffodils), *N. asturiensis*, *N. cyclamineus* and *N. minor* (dwarf trumpet narcissus), *N. alpestris*, *N. longispathus*, *N. nevadensis*, *N. nobilis*, *N. obvallaris*, *N. pallidiflorus* and *N. pseudonarcissus* and its subspecies *eugeniae* (small trumpet types). These would all have great appeal sold at garden centres as pot-plants in flower for transplanting to the garden. Many other *Narcissus* species, while not having the same mass appeal (because of their similarity to other more vigorous species, or because they are less hardy in the UK), should command good prices from specialists. The experimental part of the project clearly demonstrated the value of seed-based production systems for these plants, as a practical alternative to conventional bulb growing or propagation by 'chipping' or tissue culture.

Although *Narcissus* species could be raised commercially by simply scattering seed in beds and relying on natural temperatures to bring about germination, it would be sensible to establish optimum conditions for seed germination, if efficient growing systems are to be established. Strong responses to temperature treatments were demonstrated in the present study, for all three species. The most striking response was the effect of a conditioning treatment (for 8 or 12 weeks at 25 or 30°C) applied to the imbibed seeds: when transferred to 15°C after such a treatment, germination followed almost immediately. This finding confirmed and extended the report of Thompson (1977) for *N. bulbocodium* var. *conspicuus*, who found that conditioning imbibed seed at 26°C for 8 weeks resulted in rapid and near-complete germination when transferred to temperatures between 5 and 16°C. Thompson (1977) regarded his *N. bulbocodium* seed as initially dormant: when dried immediately after harvest and sown, one week after harvest, at a range of temperatures, no germination occurred within 2 weeks. In the present study, seed was not used in germination tests as quickly as in this earlier study, nor was it rapidly dried in warm air. Nevertheless, stored seed of all three species showed generally higher germination than that of 'fresh' seed. Under our conditions, seed could be safely stored for up to 4 years. In the present study it was found that germination was greatly reduced under continuous light in *N. pseudonarcissus*, but not in the other species examined.

In *N. bulbocodium* var. *citrinus* and *N. pseudonarcissus*, but not in *N. cyclamineus*, good germination occurred at 10°C, although not synchronously as occurred following a warm conditioning treatment. Despite the lack of germination of *N. cyclamineus* at 15°C following a 10°C treatment, a further experiment (in which seed were conditioned at 25°C and then moved to 10°C) showed that germination of this species will occur at 10°C following conditioning. The use of temperature treatments (at 10, 25 or 30°C) resulted in rapid germination at high rates, which would enable the development of optimal commercial growing systems. These would involve sowing seed in modules, conditioning at low or warm temperatures, and moving to optimum growing temperatures, a regime probably more efficient than relying on protracted 'natural season' growing. Shortening the conditioning/growing period might also allow the use of

small-celled module trays, in which seedlings would otherwise become too vulnerable to limiting factors.

While good germination was achieved under controlled conditions, a number of factors appeared to be responsible for the somewhat poorer results observed when seedlings were grown-on under practical conditions for bulb production. In Petri dishes in controlled temperatures, the maximum germination obtained with *N. bulbocodium* var. *citrinus* and *N. pseudonarcissus* was about 90 per cent, and, with *N. cyclamineus*, about 80 per cent (although it was often much less in some seed lots of this species). When temperature treatments were carried out in pots of compost, and results assessed by the recovery of bulbils after two years' growth in a polythene tunnel, the highest success rates (percentage of seeds yielding a bulb after two years) were only 30 to 40 per cent. Reasons for poor results might include using sub-optimal growing temperatures (not examined in this project, where most growing was in a frost-free tunnel) or losses due to moulds or other disease. The seeds, particularly of *N. cyclamineus*, were often obviously affected by fungi, *Penicillium*, *Mucor* and *Rhizopus* being identified. Various means were investigated to control these moulds. The use of surface disinfectants, fungicides, an antibiotic (chloramphenicol, often used in laboratory experiments to control seed-borne moulds) and hot-water treatment were ineffective, and a 24 hour warm-water (30°C) treatment failed to give consistent benefits in reducing mould growth without affecting germination. Mould control is an important topic for further investigation. Further losses of bulbils occurred in *N. cyclamineus* and *N. pseudonarcissus* due to bulb rots; these species are susceptible to basal rot, whereas *N. bulbocodium* is resistant (C.A. Linfield, personal communication).

Several systems were tested to determine the most suitable growing systems for producing saleable bulbs of *Narcissus* species from seed. Preliminary studies indicated that sowing in small-module cellular trays ('Hassy 308') for two years gave high bulbil recovery rates, but that the bulbils produced were small (about 0.1 g). Transferring the modules to pots, after one year, improved bulbil size after two years, to 0.25 g for *N. cyclamineus* and to 0.62 g for *N. pseudonarcissus*, but with about 20 per cent of modules failing to produce bulbs. However, sowing seed in ordinary trays produced larger bulbs (from 0.6 g for *N. cyclamineus* to 1.6 g for *N. bulbocodium* var. *citrinus*) but with a poorer recovery rate (42%). Using small cells offers the advantage of providing closely controlled, uniform conditions, but limits growth. However, there is scope for testing cellular trays with larger modules and for enhancing growing conditions by using liquid feeding, capillary matting, etc., which have not yet been fully tested. In the first, main growing system experiment, the value of sowing in modular trays, cold treating (10°C) or conditioning (30°C) seed, and growing in a frost-free environment, was confirmed, giving the best rates of germination and recovery after one year in all three species. Under these conditions, 60 to 70 per cent of modules produced a bulbil which, after one year, weighed 0.1 to 0.2 g each in *N. bulbocodium* var. *citrinus* and *N. cyclamineus*, and 0.2 to 0.3 g each in *N. pseudonarcissus*. *N. pseudonarcissus* also grew well as non-vernalised seed, in seed beds, and under outside conditions, whereas the other two species performed much less well.

The project enabled different growing systems to be tested for up to three years. The three species used developed at different rates, sometimes responding differently to particular growing systems. In *N. pseudonarcissus* and *N. bulbocodium* var. *citrinus*, it was clear after three years' growth that the mean bulb sizes obtained were relatively small in plants raised in seed beds or in pots or trays outside. For seed raised under frost-free conditions, whether in pots, trays or module trays (the last transferred to pots in their second year), bulb size was satisfactory, with typical bulb diameters up to 15 mm for *N. pseudonarcissus* and 25 mm for *N. bulbocodium* var. *citrinus*.

In the case of *N. cyclamineus* the best results were obtained from plants raised in module trays and transferred to pots in their second year, although in this slow-growing species the best treatment resulted in mean bulb weights of only 1.5 g, with typical diameters of 11 mm.

As stated above, *N. bulbocodium* var. *citrinus* seed could produce flowering size bulbs in two to three years. The critical grade for flowering was 3 to 5 cm circumference, with a bulb weight of about 3 g. Outside seed beds began producing useful quantities of seed in their third year, making sustainable stocks possible for this species. The critical bulb size for flowering in *N. cyclamineus* was similar, but the bulbs were much slower to bulk up. In *N. pseudonarcissus* the critical grade was >5 cm circumference, and only a few bulbs flowered in their fourth year from sowing in an outside seed bed. Management of beds of *N. cyclamineus* and *N. pseudonarcissus* is likely to be straightforward, but *N. bulbocodium* var. *citrinus*, under these conditions, had a very prolonged growing period, which could make the use of herbicides difficult. In the time-scale of the current project (3½ years) it was not possible to develop fully studies into seed production, as *N. pseudonarcissus* requires four to five years from sowing to reach flowering size, while poor germination and growth hindered progress with *N. cyclamineus*. Developing sustainable production of these and other *Narcissus* species would depend on seed availability. The authors do not know of any published references to the fertility of *Narcissus* species, but experience of them in cultivation is that true wild species normally set fertile seeds quite readily and in quantity.

In conclusion, seed-based systems were shown to be of considerable potential for the development of commercial, sustainable production of *Narcissus* species. A number of species were listed as suitable for commercialisation. Optimum conditions for seed germination have been established. Tests on growing systems showed that flowering size bulbs could be produced by sowing seed in medium- to large-celled modular trays, treating the seed for two to three months at appropriate temperatures, growing in a frost-free glasshouse, and, after two years, potting on modules into pots in which the plants could be sold 'in the green' once at flowering size. Sold as dry bulbs, the small bulbs are liable to become desiccated. The procedures described would, of course, need to be tested for their applicability to as yet untested *Narcissus* species. In all respects, *N. bulbocodium* var. *citrinus* was found to be an excellent subject for this work: the species flowered on a small bulb size, is very appealing visually, produces a good yield of seed, and is not susceptible to basal rot.

To develop seed-based production systems for *Narcissus* species further, a number of topics need to be investigated. These include:

- mould control in *N. cyclamineus*
- optimising growing conditions in the tunnel or glasshouse
- optimising husbandry in seed beds (including herbicide use, pH and feeding)
- improving seed set (e.g. by the use of pollinators)
- evaluation of other promising *Narcissus* species

Because of the threats to wild populations of some *Narcissus* species, including those of potentially useful or attractive subspecies or other variants (which might be lost if subsumed into the overall species), the establishment of a genetic bank for the genus is considered important. Wild *Narcissus* include many interesting attributes, such as disease resistance and autumn flowering, which should not be lost to future breeding programmes.

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Table 1. The effect of hot-water treatment for different durations and temperatures, in plain water or aqueous thiram, on final percentage seed germination and mould growth in *N. pseudonarcissus*. Controls had a percentage germination of 91% and 15% mould cover on the dishes

Temperature (°C)	Duration (hours)	% germination		% mould	
		Water	Thiram	Water	Thiram
30	24	95	92	3	3
45	¼	89	85	14	22
	1	83	96	30	5
	2	88	91	22	17
50	¼	88	90	7	7
	1	88	87	15	18
	2	69	43	43	42
55	¼	85	88	37	20
	1	67	51	38	75
	2	1	0*	87	100

*all rotted

Table 2. The effect of incubation on fungicide solutions on final percentage germination in *Narcissus* species

Fungicide and rate (% a.i.)		*N. bulbocodium*	*N. cyclamineus*	*N. pseudonarcissus*
Control		92	15	84
Benomyl	(0.05%)	93	25	89
Benomyl	(0.2%)	91	19	92
Benomyl	(0.6%)	89	8	89
Captan	(0.05%)	84	21	83
Captan	(0.2%)	95	16*	87
Captan	(0.6%)	91	13*	79
Thiram	(0.05%)	89	21	81
Thiram	(0.2%)	92	13	84
Thiram	(0.6%)	92	9	80

*high level of mould present

Table 3. Bulbil yield and weights of *Narcissus* after growing in cellular trays, pots or ordinary trays for two years

(a) Modules (results based on 10-15 module random samples for each of six original cellular trays)

Species and module type	% modules with bulbs	Bulbs per module*	Bulb weight (g) per module*	Bulb grade (mm diam.)
N. bulbocodium				
Cellular tray	100	1.10	0.11	4
Cellular tray/pot (transferred after 1 year)	87	1.13	0.62	8
N. cyclamineus				
Cellular tray	100	1.30	0.10	4
Cellular tray/pot (transferred after 1 year)	80	1.33	0.25	4
N. pseudonarcissus				
Cellular tray	100	1.50	0.13	4
Cellular tray/pot (transferred after 1 year)	80	1.42	0.36	5

*excludes modules with no surviving bulbs

(b) Tray raised (results are means of 6 trays)

Species	Bulb yield (no./tray)**	Mean bulb weight (g)	Bulb grade (mm diam.)
N. bulbocodium	64	1.59	10
N. cyclamineus	64	0.62	5
N. pseudonarcissus	58	0.58	5

**based on sowing 150 seed per tray

Table 4. Observations on flower, leaf and bulb production from bulbs of *Narcissus* species of different sizes

Species	Bulb grade etc at start			Data at April 1996			Bulb yields 1996		
	Grade (mm diam.)	Weight (g)	% floral	% bulbs emerged	Leaves per bulb*	Flowers per bulb*	% bulbs recovered	Weight per bulb (g)*	Grade** (mm diam.)
N. bulbocodium	5-10	0.36	20	94	3.0	0.1	83	4.10	12-26
	11-15	1.78	90	85	4.6	1.1	76	9.36	10-30
	16-25	3.39	100	78	6.6	1.9	67	11.98	11-33
N. cyclamineus	4-8	0.20	0	48	1.5	0	21	0.90	7-13
	8-10	0.44	30	67	2.0	0.1	19	1.17	6-14
	11-15	1.05	80	82	2.2	0.7	25	1.66	12-22
N. pseudonarcissus	4-6	0.21	0	78	1.5	0	53	1.28	7-13
	7-11	0.71	0	92	2.1	0	81	2.50	9-18
	12-16	1.82	0	100	3.3	<0.1	90	3.78	9-23

*expressed in terms of numbers of emerged or recovered bulbs not number planted

**range of sizes in sample

Table 5. Percentage germination of seeds of *Narcissus* species by the end of a 9°C vernalisation treatment

	N. bulbocodium	*N. pseudonarcissus*
Main trial		
Tray-grown	22	18
Pot-grown	20	21
'104' trays	33	28
'308' trays	44	30
Additional sowing		
'104' trays, single seeded	16	12
'104' trays, double seeded	17	8
'308' trays, single seeded	29	16
'308' trays, double seeded	36	23

Table 6. Crop performance in growing systems experiment (1): percentage germination, emergence and flowering (means of six replicates initially).

(i) *N. bulbocodium* var. *citrinus*

System[a]	Year 1	Year 2	Year 3	
	% seed germinated[b]	% modules emerged[c]	% plant emergence[b]	% flowering[b]
Seed bed/outdoor	3	-	-	-
Seed bed/FF	13	-	17	<1
Tray/outdoor	21	-	21	2
Tray/FF	31	-	35	28
Tray/FF (treated)	56	-	38	61
Pots/outdoor	13	-	18	1
Pots/FF	32	-	35	45
Pots/FF (treated)	61	-	56	86
104 trays/FF → pots	32	51	49	34
104 trays/FF (treated) → pots	61	62	57	71
308 trays/FF → pots	34	51	46	43
308 trays/FF (treated) → pots	65	68	66	86
Additional sowings				
104 trays/FF (treated) → pots	61	58	55	57
ditto, double-seeded → pots	39	75	32	24
308 trays/FF (treated) → pots	58	57	56	41
ditto, double-seeded → pots	41	77	48	24

[a] 'FF'means grown in frost-free tunnel; 'treated' means vernalised (9°C) for *N. bulbocodium* and *N. pseudonarcissus* or conditioned (30°C) for *N. cyclamineus*. Treatments marked '→ pots' had cells potted on in second year

[b] % of seed originally sown (48, 104, 208, 308 or 616/plot)

[c] % of cells with viable seedlings

Table 6 (continued).

(ii) *N. pseudonarcissus*

System[a]	Year 1	Year 2	Year 3	
	% seed germinated[b]	% modules emerged[c]	% plant emergence[b]	% flowering[b]
Seed bed/outdoor	10	-	-	-
Seed bed/FF	31	-	39	0
Tray/outdoor	6	-	20	0
Tray/FF	42	-	57	0
Tray/FF (treated)	60	-	67	0
Pots/outdoor	4	-	16	0
Pots/FF	78	-	65	0
Pots/FF (treated)	67	-	67	0
104 trays/FF → pots	63	40	35	0
104 trays/FF (treated) → pots	57	48	40	0
308 trays/FF → pots	67	50	47	0
308 trays/FF (treated) → pots	45	56	50	0
Additional sowings				
104 trays/FF (treated) → pots	52	80	60	0
ditto, double-seeded → pots	38	94	38	0
308 trays/FF (treated) → pots	52	80	61	0
ditto, double-seeded → pots	38	90	61	0

For footnotes, see Table 6(i)

Table 6 (continued).

(iii) *N. cyclamineus*

System[a]	Year 1	Year 2	Year 3	
	% seed germinated[b]	% modules emerged[c]	% plant emergence[b]	% flowering[b]
Seed bed/outdoor	2	-	-	-
Seed bed/FF	13	-	20	1
Tray/outdoor	2	-	10	0
Tray/FF	13	-	11	0
Tray/FF (treated)	56	-	21	2
Pots/outdoor	0	-	9	0
Pots/FF	11	-	20	0
Pots/FF (treated)	66	-	15	0
104 trays/FF → pots	23	69	32	7
104 trays/FF (treated) → pots	68	57	49	4
308 trays/FF → pots	21	68	35	4
308 trays/FF (treated) → pots	66	52	44	3

For footnotes, see Table 6(i)

Table 7. Crop performance in growing systems experiment 1: bulb numbers, weights and grades (values based on one plot per treatment recovered in years 1 and 2, means of four plots in year 3).

(i) *N. bulbocodium* var. *citrinus*

System[a]	Year 1			Year 2			Year 3		
	% recovery[b]	mean bulb weight (g)[c]	bulb grade (mm diam.)	% recovery[b]	mean bulb weight (g)[c]	bulb grade (mm diam.)	% recovery[b]	mean bulb weight (g)[c]	bulb grade (mm diam.)
Seed bed/outdoor	4	0.17	4	-	-	-	-	-	-
Seed bed/FF	8	0.06	4	13	0.07	4	10	0.57	9
Tray/outdoor	23	0.11	5	17	0.31	8	20	2.27	14
Tray/FF	38	0.21	5	27	1.65	14	30	6.17	25
Tray/FF (treated)	67	0.20	6	73	2.35	18	35	8.65	25
Pots/outdoor	23	0.07	3	25	0.12	5	18	1.37	13
Pots/FF	27	0.15	4	29	1.06	13	37	3.79	19
Pots/FF (treated)	56	0.23	5	77	2.37	14	63	5.89	21
104 trays/FF → pots	36	0.17	5	72	0.92	10	42	3.00	19
104 trays/FF (treated) → pots	75	0.18	4	75	1.75	15	70	3.80	21
308 trays/FF → pots	20	0.13	3	51	1.22	14	30	3.80	21
308 trays/FF (treated) → pots	66	0.18	6	71	1.68	11	35	4.10	21
Additional sowings									
104 trays/FF (treated) → pots	57	0.12	5	79	1.49	13	54	3.60	18
ditto, double-seeded → pots	61	0.08	4	53	1.67	12	28	2.80	19
308 trays/FF (treated) → pots	65	0.09	4	54	1.34	13	31	3.90	20
ditto, double-seeded → pots	65	0.09	3	46	1.18	14	17	3.20	18

[a] See legend to Figure 6(i) [b] % of seed originally sown (48, 104, 208, 308 or 616/plot) [c] Mean individual bulb weight based on number recovered (not number of seeds sown)

Table 7 (continued)

(ii) *N.pseudonarcissus*

System[a]	Year 1			Year 2			Year 3		
	% recovery[b]	mean bulb weight (g)[c]	bulb grade (mm diam.)	% recovery[b]	mean bulb weight (g)[c]	bulb grade (mm diam.)	% recovery[b]	mean bulb weight (g)[c]	bulb grade (mm diam.)
Seed bed/outdoor	10	0.25	6	-	-	-	-	-	-
Seed bed/FF	15	0.19	5	29	0.36	7	41	1.60	13
Tray/outdoor	2	0.11	5	38	0.12	4	9	0.68	8
Tray/FF	52	0.17	4	65	0.74	8	56	1.87	12
Tray/FF (treated)	35	0.22	5	67	0.72	10	64	2.64	14
Pots/outdoor	0	-	-	42	0.04	4	13	0.24	6
Pots/FF	73	0.23	5	85	0.51	6	64	1.68	12
Pots/FF (treated)	67	0.20	5	92	0.75	8	66	2.19	15
104 trays/FF → pots	78	0.23	5	34	0.27	6	35	2.80	13
104 trays/FF (treated) → pots	68	0.31	6	43	0.43	7	39	2.30	12
308 trays/FF → pots	76	0.15	4	43	0.42	8	28	1.80	12
308 trays/FF (treated) → pots	62	0.22	6	53	0.53	6	25	2.00	13
Additional sowings									
104 trays/FF (treated) → pots	54	0.15	6	79	0.35	5	58	2.20	12
ditto, double-seeded → pots	51	0.14	6	73	0.40	7	32	2.10	13
308 trays/FF (treated) → pots	49	0.16	5	75	0.35	8	21	2.10	11
ditto, double-seeded → pots	49	0.15	6	68	0.26	4	19	1.50	10

For footnotes, see Table 7(i)

Table 7 (continued)

(iii) *N. cyclamineus*

System[a]	Year 1			Year 2			Year 3		
	% recovery[b]	mean bulb weight (g)[c]	bulb grade (mm diam.)	% recovery[b]	mean bulb weight (g)[c]	bulb grade (mm diam.)	% recovery[b]	mean bulb weight (g)[c]	bulb grade (mm diam.)
Seed bed/outdoor	4	0.12	4	-	-	-	-	-	-
Seed bed/FF	8	0.13	5	33	0.11	5	14	0.72	11
Tray/outdoor	4	0.08	4	8	0.05	3	5	0.27	6
Tray/FF	8	0.16	5	50	0.05	4	8	0.53	9
Tray/FF (treated)	65	0.09	4	35	0.19	5	13	0.58	8
Pots/outdoor	0	-	-	19	0.02	3	3	0.28	6
Pots/FF	6	0.16	5	54	0.07	4	10	0.63	8
Pots/FF (treated)	58	0.07	4	52	0.16	5	5	0.37	7
104 trays/FF → pots	25	0.16	5	60	0.15	6	30	1.30	10
104 trays/FF (treated) → pots	69	0.08	4	52	0.19	5	42	1.20	10
308 trays/FF → pots	21	0.12	5	65	0.14	8	14	1.10	11
308 trays/FF (treated) → pots	63	0.08	4	42	0.19	6	21	1.50	11

For footnotes, see Table 7(i)

Table 8. Crop performance in growing system experiment 2. Percentage germination, emergence and flowering are means (of four replicates initially). Bulb numbers, weights and grades are based on one plot of each treatment in year 1 and are means of three plots each in year 2.
(i) *N. bulbocodium* var. *citrinus*

System[a]		One year			Two years				
	% seed germinated[b]	% recovery[b]	Mean bulb weight (g)[c]	Bulb grade (mm diam.)	% plant emergence[b]	% flowering[b]	% recovery[b]	Mean bulb weight (g)[c]	Bulb grade (mm diam.)
Seed bed/FF	-	21	0.03	3	-	0	15	0.10	4
Tray/outdoor	-	21	0.08	4	19	0	10	1.00	9
Tray/FF	30	27	0.25	5	35	2	35	2.70	15
Tray/FF (vernalised)	54	40	0.25	7	57	1	61	2.40	14
Pots/outdoor	-	13	0.05	3	14	0	13	0.60	12
Pots/FF	60	69	0.20	7	59	0	63	2.50	12
Pots/FF (vernalised)	58	56	0.25	6	61	0	67	2.40	15
104 trays/FF → pots	67	89	0.08	4	66	0	70	0.50	12
104 trays/FF → pots (vernalised)	78	88	0.15	5	77	0	80	0.60	10
308 trays/FF → pots	62	69	0.05	4	56	0	58	0.40	8
308 trays/FF → pots (vernalised)	67	85	0.11	6	65	0	66	0.40	8
150 trays/FF → pots	60	81	0.11	6	61	0	69	0.70	9
150 trays/FF → pots (vernalised)	68	86	0.19	6	62	0	65	0.50	9

[a]For details, see footnote to Table 6 [b]% of seed originally sown (48, 104, 150 or 308/plot) [c]Mean individual bulb weight based on number recovered (not number of seeds sown) [d]% of cells with viable seedlings -Low, sporadic germination

Table 8 (continued).

(ii) *N. pseudonarcissus*

System[a]	One year				Two years				
	% seed germinated[b]	% recovery[b]	Mean bulb weight (g)[c]	Bulb grade (mm diam.)	% plant emergence[b]	% flowering[b]	% recovery[b]	Mean bulb weight (g)[c]	Bulb grade (mm diam.)
Seed bed/FF	-	40	0.06	5	-	0	20	0.30	6
Tray/outdoor	0	0	-	-	34	0	16	0.10	4
Tray/FF	23	38	0.11	4	35	0	25	0.90	9
Tray/FF (vernalised)	48	44	0.10	4	53	0	52	0.90	8
Pots/outdoor	-	13	0.03	4	5	0	4	0.20	6
Pots/FF	81	81	0.09	5	59	0	58	0.90	9
Pots/FF (vernalised)	81	75	0.09	5	53	0	53	0.90	9
104 trays/FF → pots	62	93	0.07	4	24	0	21	0.30	7
104 trays/FF → pots (vernalised)	50	80	0.10	3	49	0	44	0.40	8
308 trays/FF → pots	39	81	0.05	3	16	0	10	0.20	6
308 trays/FF → pots (vernalised)	30	74	0.08	4	37	0	32	0.30	6
150 trays/FF → pots	67	95	0.07	4	35	0	59	0.35	7
150 trays/FF → pots (vernalised)	51	88	0.11	4	63	0	33	0.40	6

For footnotes, see Table 8(i)

Table 9 Percentage germination (means of ten trays) in growing system experiment (3), along with bulb numbers, weights and grades (means of five trays) after one year

Species and treatment	% germination	% recovery	Mean bulb weight (g)	Bulb grade (mm diam)
N. bulbocodium var. citrinus				
+ feed	)	27	0.21	4
no feed	)29	31	0.19	4
N. cyclamineus				
+ feed	)17	11	0.04	3
no feed	)	8	0.04	4
N. pseudonarcissus				
+ feed	)23	18	0.10	5
no feed	)	12	0.10	6

Fig. 1(a) Germination of *N. bulbocodium* var. *citrinus*, 1992 seed batch, seed stored for 6 months. Seed were treated for 4, 8 or 12 weeks at the temperatures shown, then moved to 15C

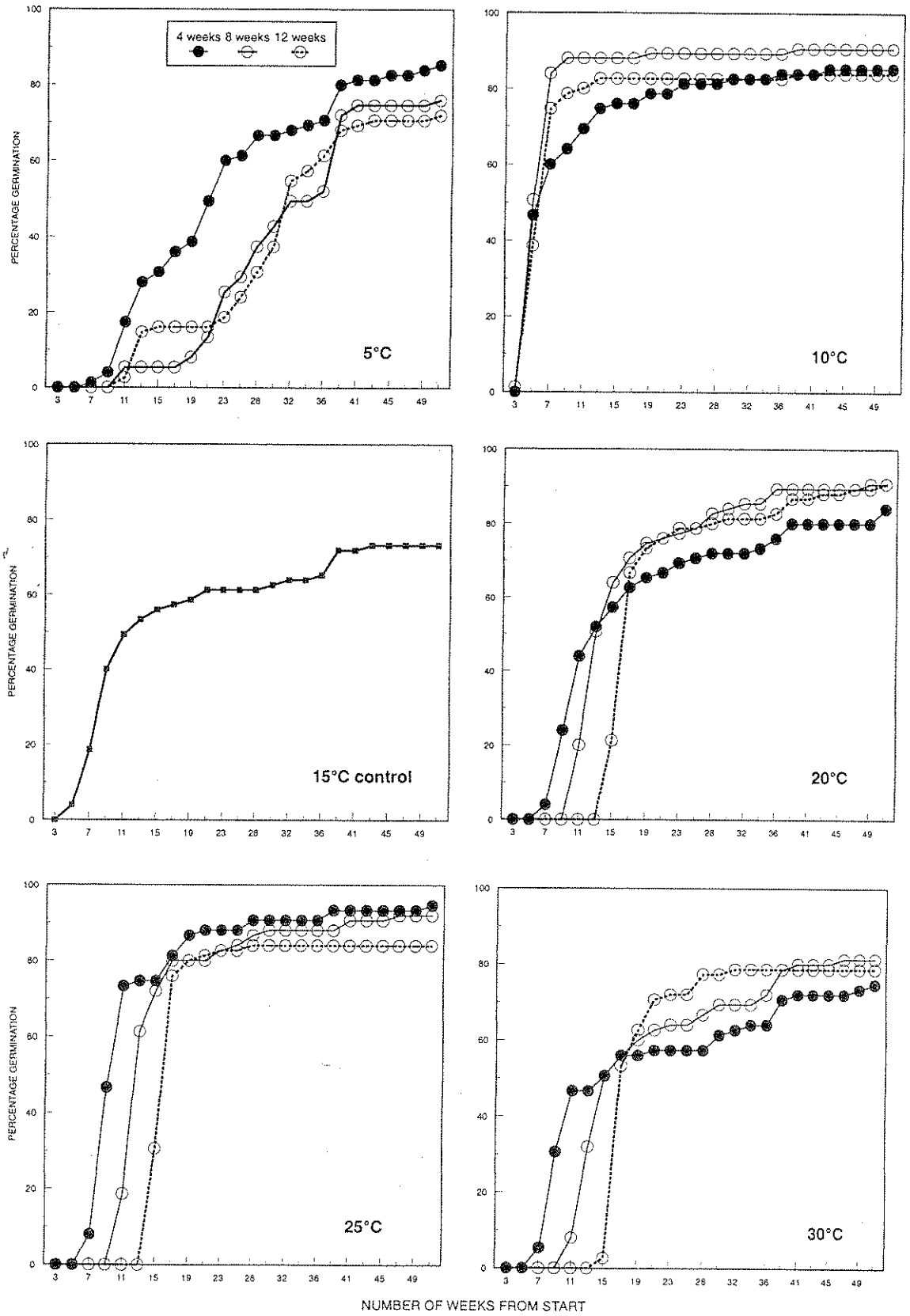


Fig. 1(b) Germination of *N. pseudonarcissus*, 1992 seed batch, seed stored for 6 months. Seed were treated for 4, 8 or 12 weeks at the temperatures shown, then moved to 15C

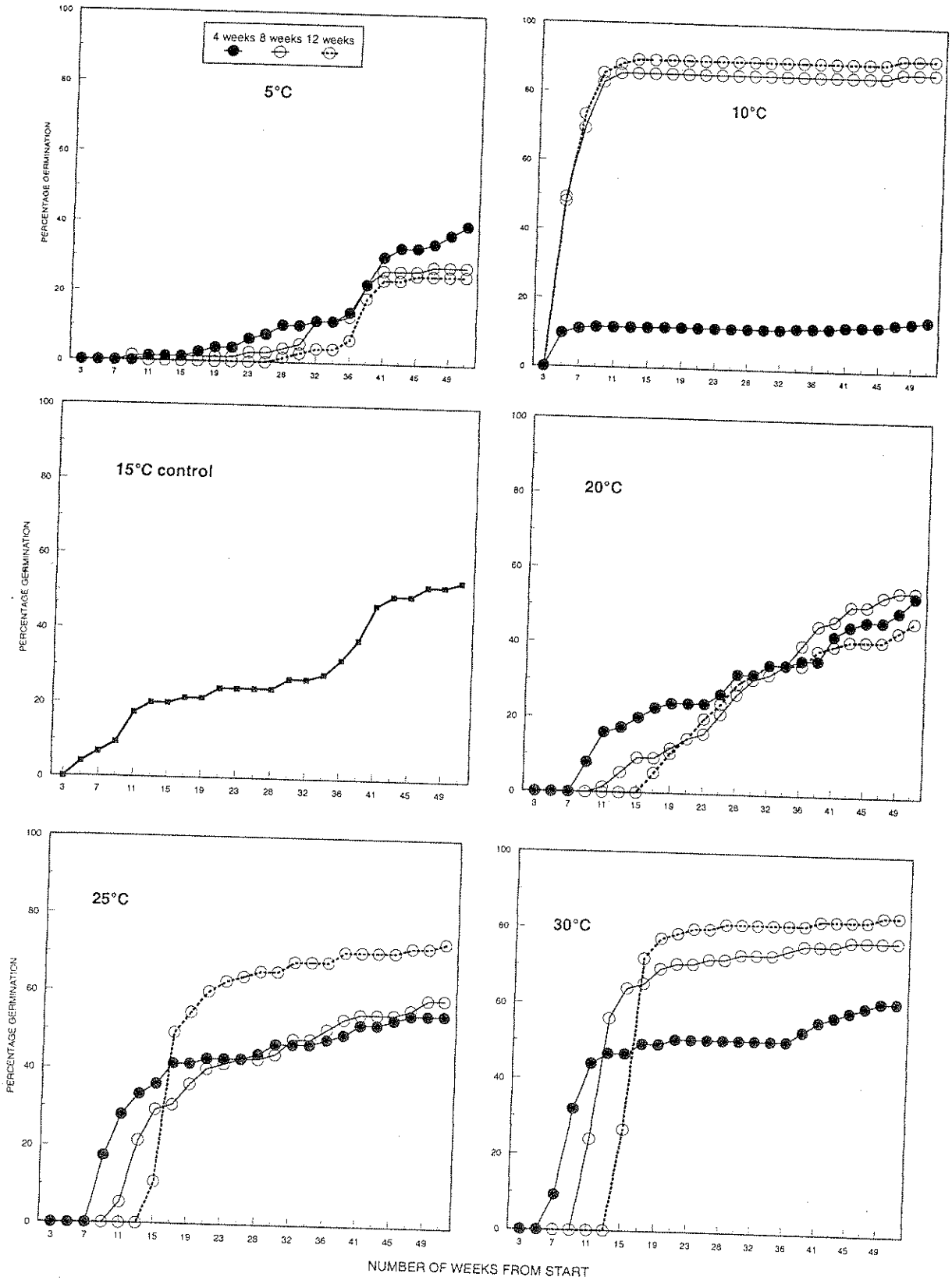


Fig. 1(c) Germination of *N. cyclamineus*, 1992 seed batch, seed stored for 6 months. Seed were treated for 4, 8 or 12 weeks at the temperatures shown, then moved to 15C

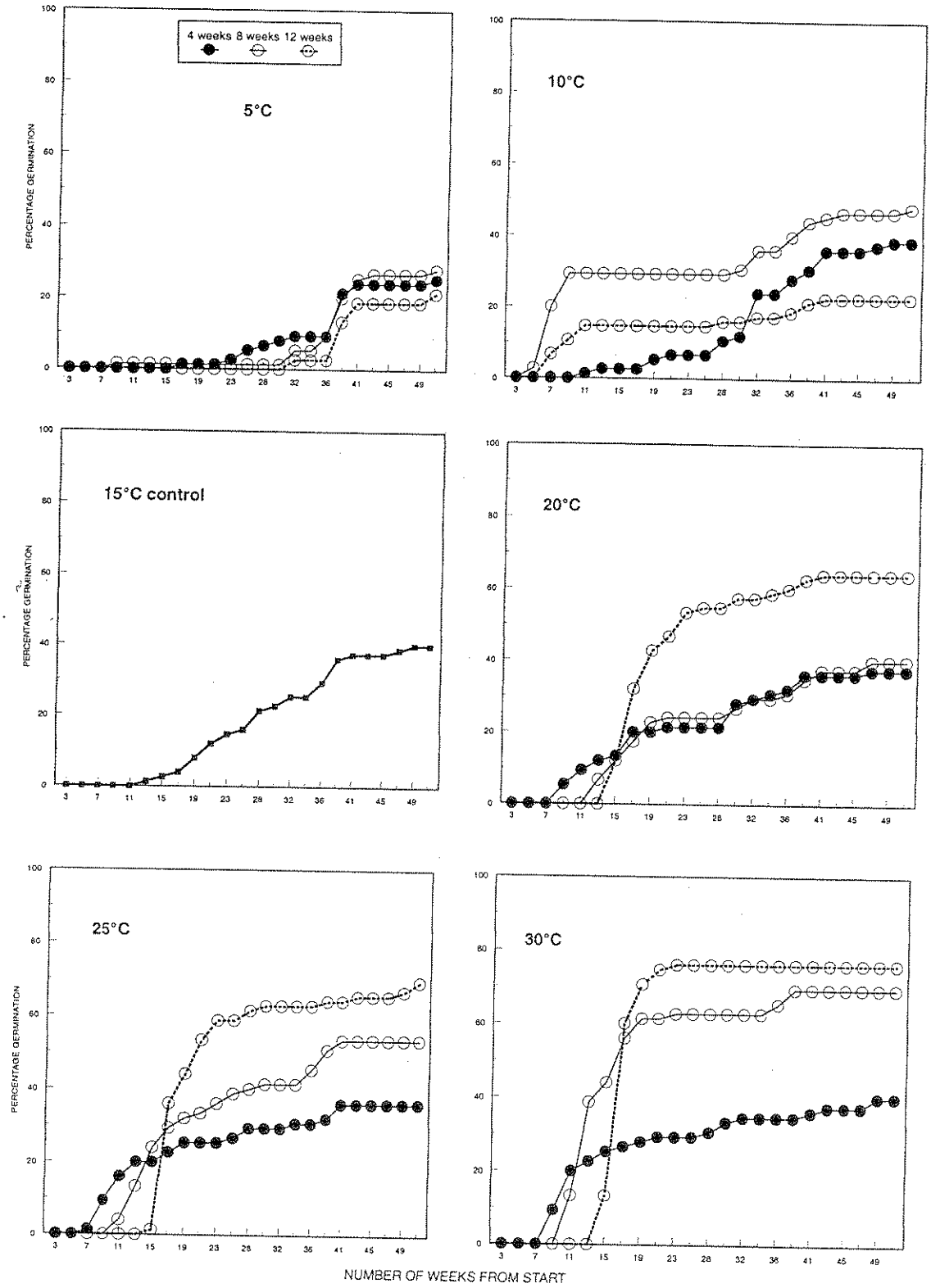


Fig. 2 Germination of *Narcissus bulbocodium* var. *citrinus* (cold treatment experiment): germination of control batches kept at constant temperatures

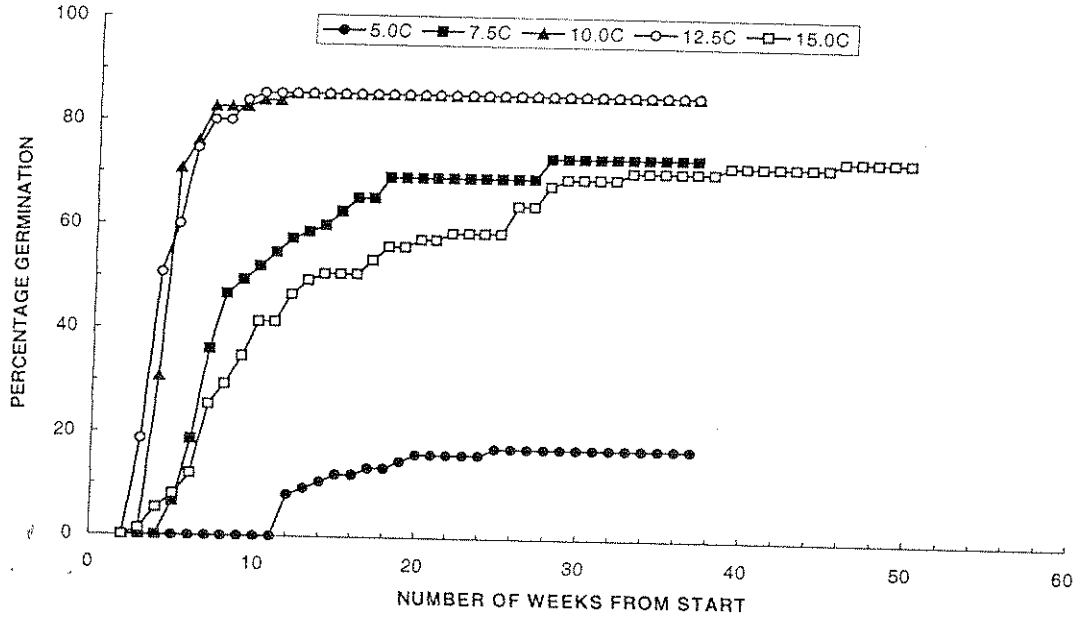


Fig. 3 Germination of *Narcissus bulbocodium* var. *citrinus* (cold treatment experiment). Seed were treated for 2 to 12 weeks at the temperatures shown, then moved to 15C

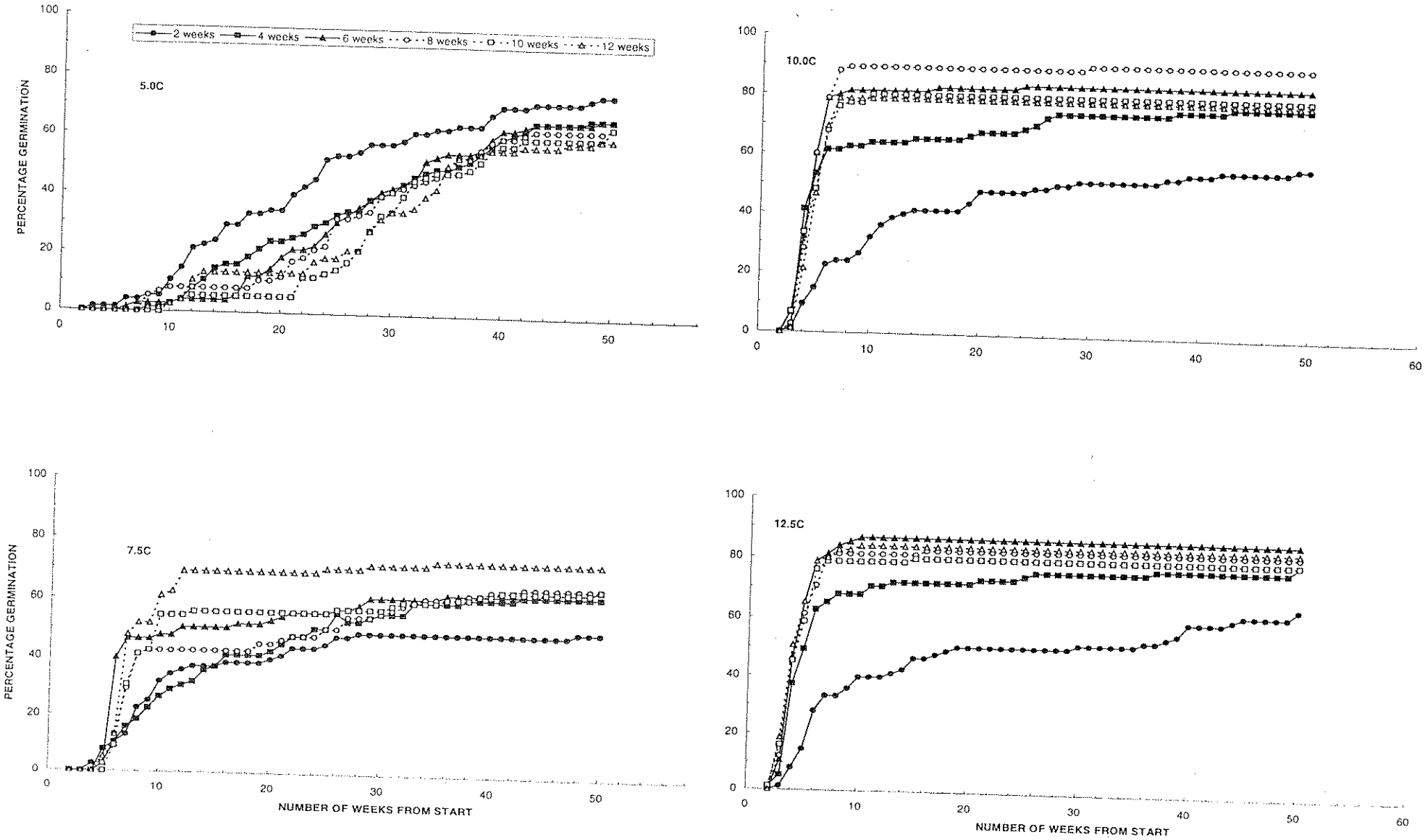


Fig. 4 Bulb yields from the pot-grown seed experiment. 50 seed were sown per pot, given the temperature treatments for the times and temperatures shown, and bulb yields were recorded after two years

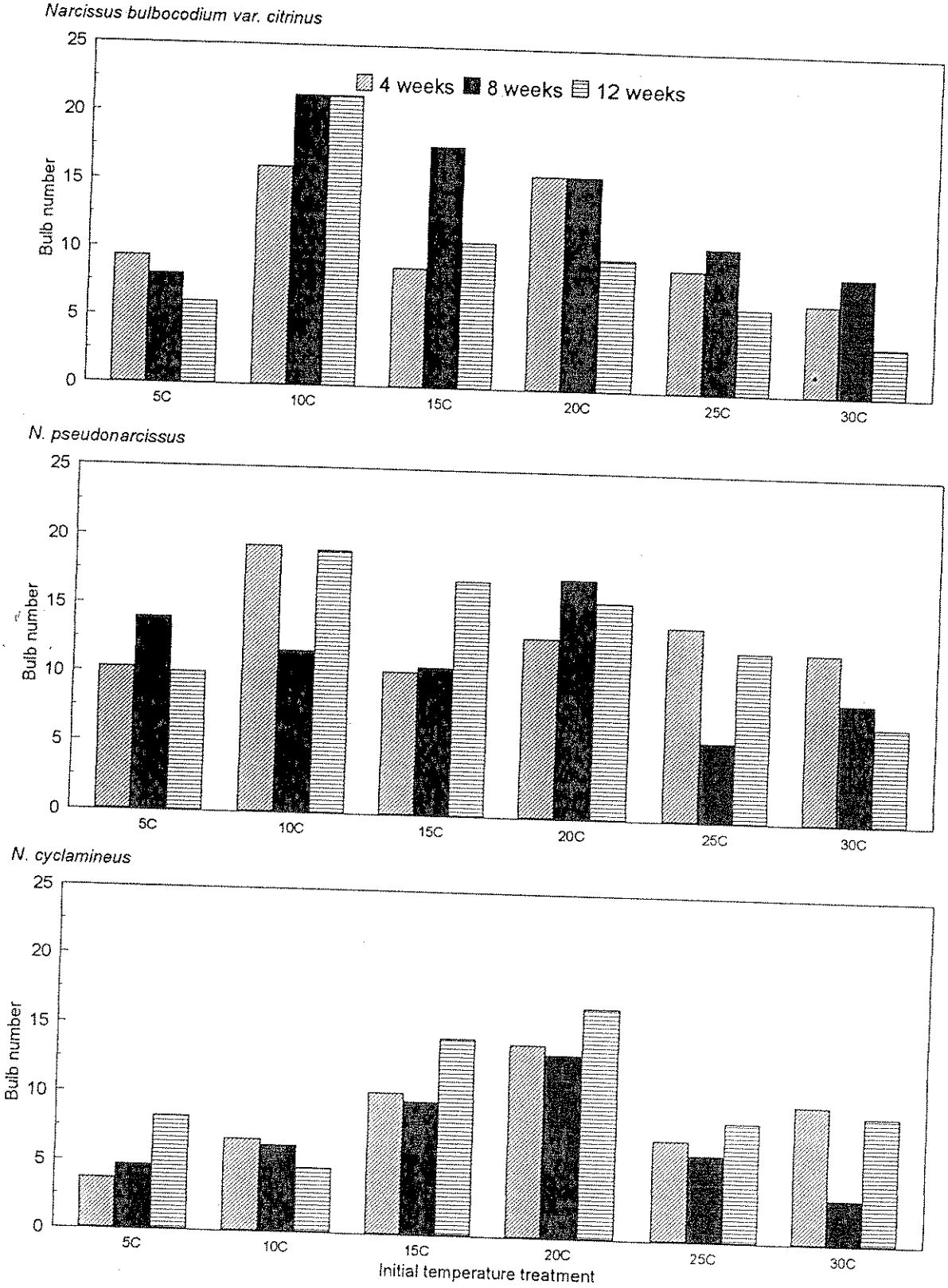


Fig. 5(a) Germination of *N. bulbocodium* var. *citrinus*. Seed were treated at 25C and moved to 15C, either immediately (control) or after the temperature treatments shown

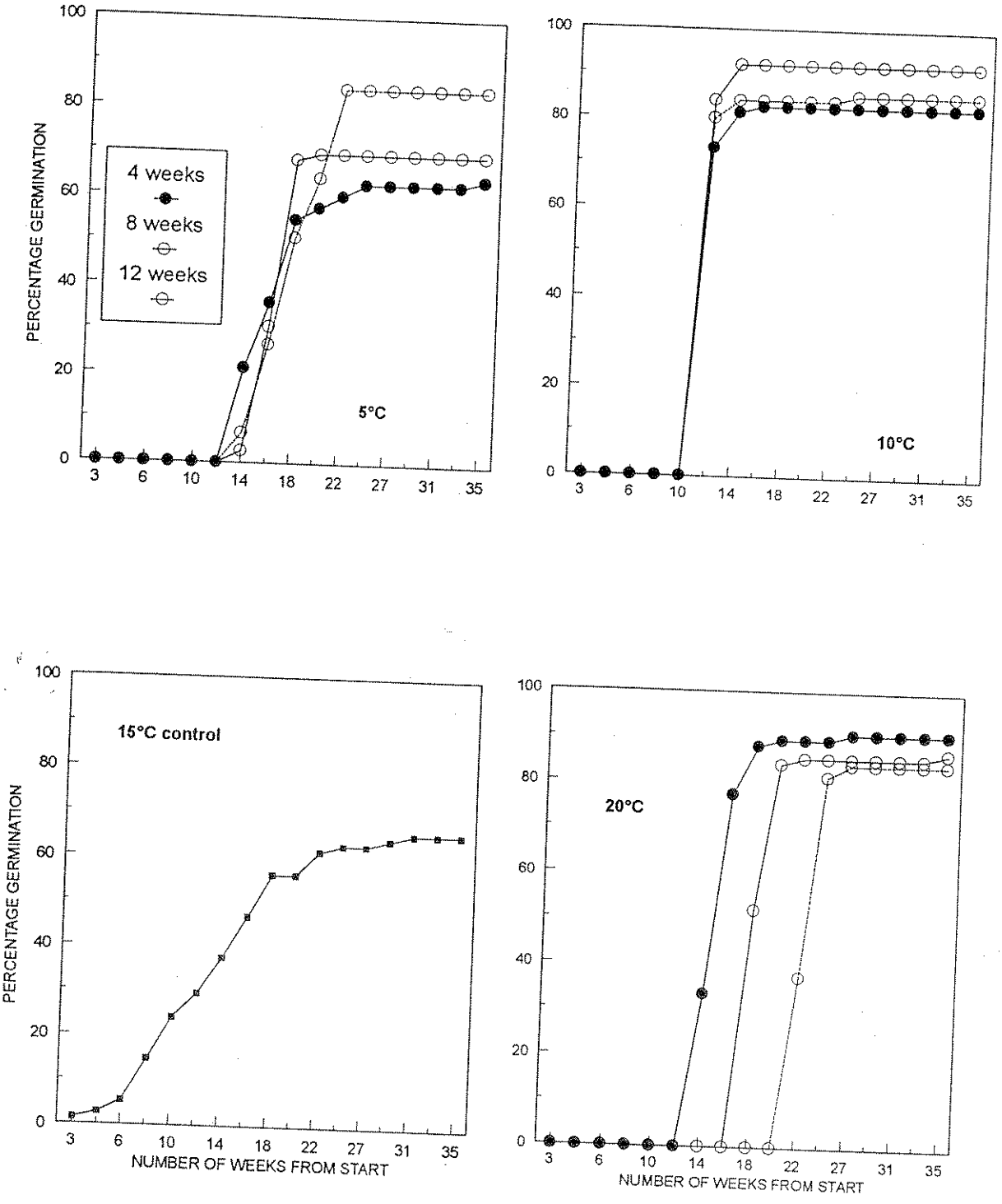


Fig. 5(b)Germination of *N. pseudonarcissus*. Seed were treated at 25C and moved to 15C, either immediately (control) or after the temperature treatments shown

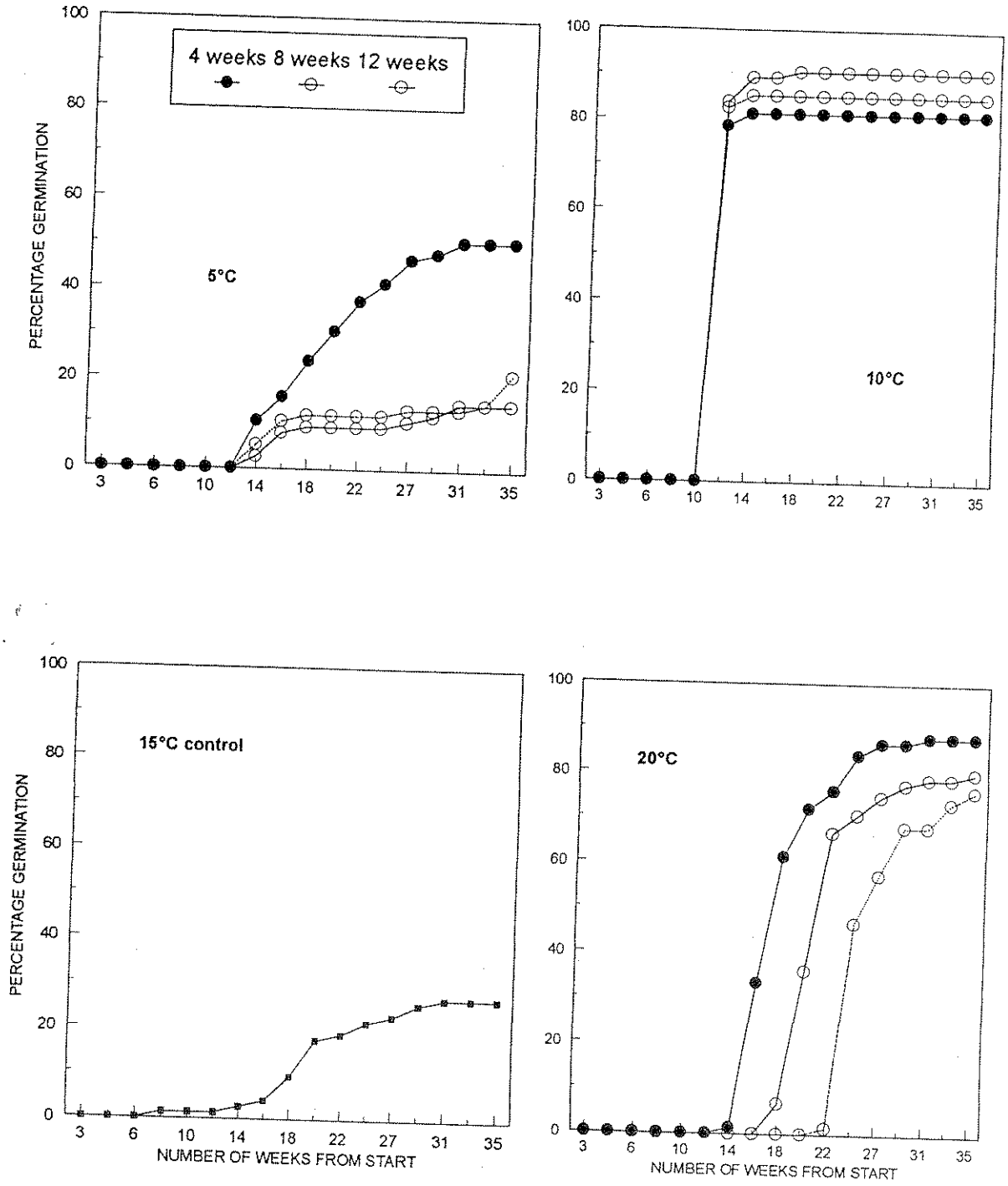
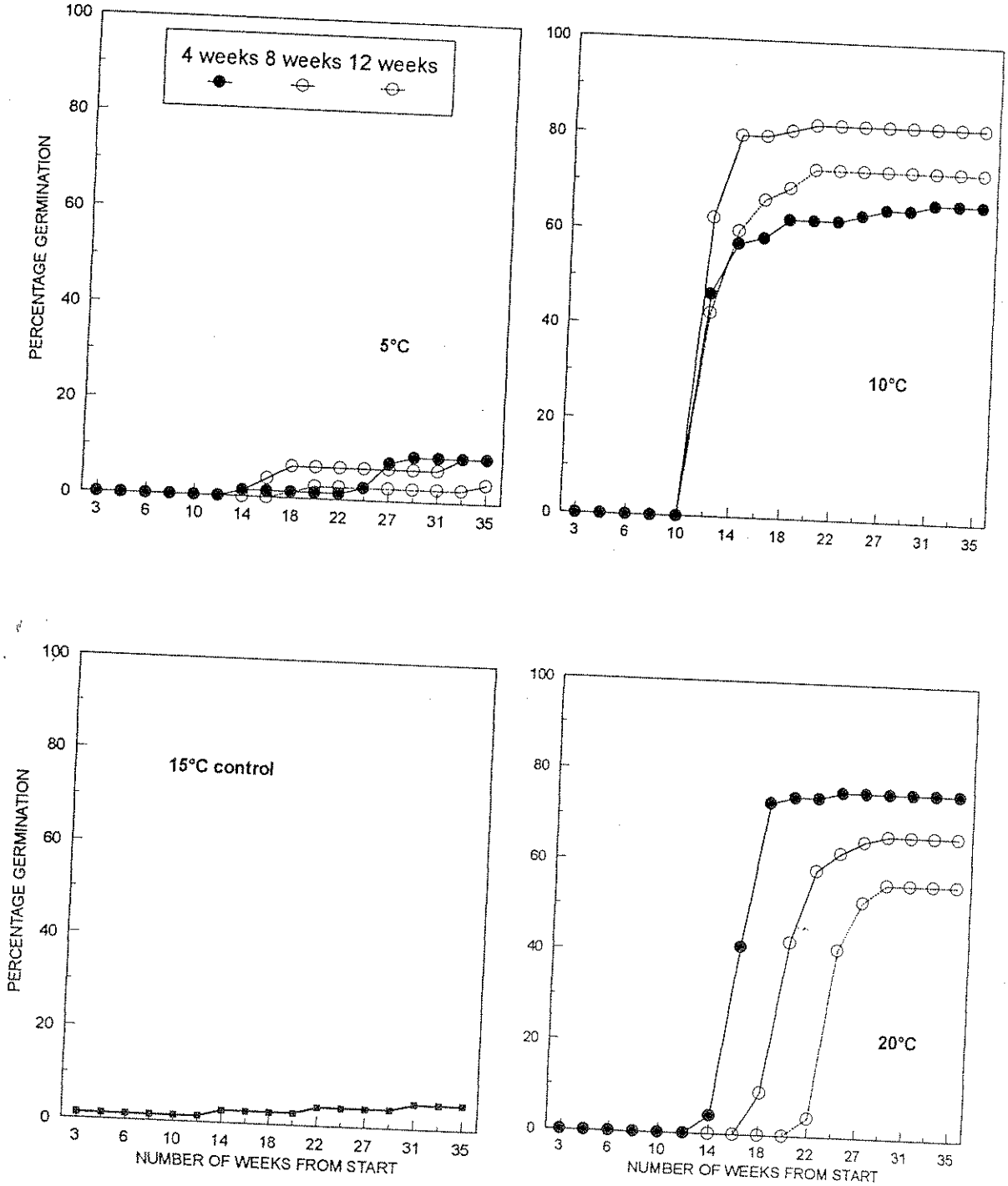


Fig. 5(c) Germination of *N. cyclamineus*. Seed were treated at 25C and moved to 15C, either immediately (control) or after the temperature treatments shown



APPENDIX A

FURTHER DETAILS OF SELECTED *NARCISSUS* SPECIES

In these notes the terms used to denote the degree of threat are taken from the IUCN Red Data Book (Lucas and Synge, 1978), as follows: endangered (habitats reduced and plant numbers reduced to the extent that survival is unlikely if the causal factors continue operating); vulnerable (populations decreasing because of adverse factors, likely to move into the endangered category if this trend continues); and rare (species with small world populations, either very localised or thinly scattered over a wider area, so potentially at risk).

1. *NARCISSUS CYCLAMINEUS* De Candolle

Description: Bulb 1-2 cm diameter. Leaves bright green, 15-30 cm long, 4-6 mm wide. Flower stem 15-20 cm tall, one-flowered. Flower uniform deep yellow, pendent; trumpet (corona) about 2 cm long with a crenate mouth; perianth segments (corolla) sharply reflexed, about 2 cm long.

Flowering period: February-March

Distribution: Northern Portugal, northern Spain.

Conservation Status: Apparently nearing extinction in the wild.

1)'has become scarcer in the wild.....one of these [sites] was around Vigo where it seems almost certain that it has been lost as a result of urban development' (Blanchard,1990)

2)'Endangered in Portugal' (Eckersley *et al.*, 1992)

3)'One small colony with a handful of plants' (Salmon, unpublished data, 1996)

Cultivation: *N. cyclamineus* is a very frost-hardy species and is easily cultivated, providing that its relatively simple requirements are met. It needs moist conditions, especially during its spring growing season, and must not become too hot and dry during its summer dormancy. It also prefers acid conditions and all the really successful plantings in gardens are to be found on acidic soils.

Comments: Perhaps the most beautiful and distinctive of the dwarf species of *Narcissus*. It has great garden value in its true wild form and has been much-used in hybridisation, giving rise to the popular 'Cyclamineus Daffodils' (Division 6 in the Royal Horticultural Society's classification). The wild form has never been common in cultivation and is quite rare in gardens, except in a few notable locations where conditions have proved favourable, e.g. Savill Gardens, Windsor, and the RHS Gardens, Wisley. Although formerly it was offered frequently by bulb nurseries, much of the stock is thought to have been wild-collected in Portugal; for example, the average export of this species from Portugal to The Netherlands in 1992 was 2,500 bulbs (Blok, 1992). This source has now ceased, presumably due to its rarity which would make it uneconomic to collect. Currently it is offered by a few nurseries (Philip and Lord, 1998) but is comparatively expensive, stocks are small and it must be regarded as a specialist subject. However, if larger stocks were made available it is likely that *N. cyclamineus* would prove to be widely popular, particularly if offered in spring, pot-grown and in flower.

2. *NARCISSUS PSEUDONARCISSUS* Linnaeus

Description: Bulb 2-4 cm diameter. Leaves grey-green, 12-35 cm long, 6-12 mm wide. Flower stem 12-30 cm tall, one-flowered. Flower nearly horizontal or slightly pendent, bicoloured, the yellow trumpet darker than the whitish or pale yellow perianth; trumpet (corona) 3-4 cm long with a crenate mouth; perianth segments (corolla) 2-3.5 cm long, often somewhat twisted, standing out at right angles to the trumpet.

Flowering period: March (January-June in the wild)

Distribution: France, northern Spain (and naturalised elsewhere).

Conservation Status: Widespread and no cause for concern, although local populations may be destroyed by farming, building etc.

Cultivation: *N. pseudonarcissus* is a very hardy and easily-cultivated species, much-loved as the small wild daffodil of the Lake District, and parts of Gloucestershire and Yorkshire, although it is probably naturalised in Britain from ancient introductions from France or Spain. It is an excellent subject for planting in quantity in grass or light woodland for a natural effect.

Comments: With the current interest in natural gardening and cottage gardens, this could be of interest to gardeners if available relatively cheaply and in quantity. There are several other wild daffodils which are treated by some botanists as subspecies of *N. pseudonarcissus*. Some of these are distinct enough to be of interest to the gardening public, not just specialist enthusiasts, but they are not widely available. For example *N. pallidiflorus* and *N. alpestris* (see below).

3. *NARCISSUS PALLIDIFLORUS* Pugsley

Description: Similar in general details to *N. pseudonarcissus* (see above) but flowers with a creamy-coloured perianth and pale sulphur-yellow trumpet.

Flowering period: February-March

Distribution: Pyrenees, northern Spain.

Conservation Status: Not apparently under threat but 'very localised in N. Spain' (Norman, unpublished data, 1996).

Cultivation: Not difficult to cultivate but much less frequently seen in cultivation than *N. pseudonarcissus*. At present not listed in The Plant Finder (Philip and Lord, 1998), although perhaps spasmodically obtainable from specialist nurseries.

Comments: This is a very attractive variation on the *N. pseudonarcissus* theme, and certainly different enough in appearance to be worthy of cultivation as a separate entity.

4. *NARCISSUS ALPESTRIS* Pugsley

Description: Similar in general details to *N. pseudonarcissus* (see above) but flowers wholly white and pendent, with the perianth segments (corolla) also drooping and lying alongside the trumpet.

Flowering period: March-April (to May in the wild)

Distribution: Pyrenees.

Conservation Status: A rather localised plant and as such perhaps rather vulnerable to change of land use: 'Limited number of habitats but large populations not currently threatened' (Salmon, unpublished data, 1996).

Cultivation: Not difficult to cultivate in a cool position with humus-rich soil, but very slow to increase into clumps, hence it is always rare in horticulture. It is reported that 'seedlings take a long time to reach flowering size' (Blanchard, 1990).

Comments: This is a very attractive small trumpet daffodil with white flowers of very unusual form, but it is very rare in cultivation; currently The Plant Finder lists it as being available from only one specialist nursery.

5. *NARCISSUS ASTURIENSIS* (Jordan) Pugsley

Description: Bulb 1-1.5 cm diameter. Leaves grey-green, 5-15 cm long, 2-6 mm wide. Flower stem 7-10 cm tall, one-flowered. Flower uniform yellow, horizontal or slightly pendent; trumpet (corona) 8-16 mm long, flared outwards at the mouth and crenate; perianth segments (corolla) held out almost at right angles to the trumpet, 7-14 mm long.

Flowering period: February-March (sometimes January in gardens)

Distribution: Northern Portugal, northern and north-central Spain.

Conservation Status: Although apparently fairly widespread and common in places, in some areas its numbers have been reduced: 'Endangered in Portugal' (Eckersley *et al.*, 1992). 'Still common and widespread in Spain' (Salmon, unpublished data, 1996).

Cultivation: *N. asturiensis* is a very hardy, easily cultivated species, flowering very early in the year. It is a native of mountain meadows and appears to do best in acid soils.

Comments: This is the tiniest of the small trumpet daffodil species. Its diminutive charm and very early-flowering habit are the main attractions and it is one of the most popular and well-known of the wild narcissus species. However, in spite of this, it is currently not very readily obtainable (based on catalogue search).

6. *NARCISSUS TRIANDRUS* Linnaeus

Description: Bulb 1-1.5 cm diameter. Leaves dark green, 15-30 cm long, 1.5-3 mm wide. Flower stem 15-20 cm tall, with 1-3 (rarely to 6) flowers. Flower white or creamy-yellow, pendent; cup (corona) 5-15 mm long; petals reflexed, 1-2.5 cm long.

Flowering period: February-March (to May in the wild)

Distribution: Northern Portugal, northern Spain.

Conservation Status: Although the typical form (subspecies *triandrus*) appears to be in no danger, some of its variants could become threatened by changing land use - agriculture, building etc. For example, subsp. *concolor* - 'Vulnerable, always scarce and habitat change will soon put into Endangered [category]' (Salmon, unpublished data, 1996); 'scattered and not plentiful' (Norman, unpublished data, 1996).

Cultivation: *N. triandrus* is not difficult to cultivate if given the right conditions, namely an acid sandy soil in a position where it does not become too hot in its summer dormant period. It is suitable for positions in dappled shade, for example among shrubs.

Comments: This is a very beautiful, dainty species having pendent, bell-like flowers with reflexed petals. The appropriate common name is "Angel's tears daffodil". The form usually seen in gardens is the white *N. triandrus* 'Albus' but it varies considerably in the wild from white through creamy yellow to a deeper yellow (subsp. *concolor*). From the commercial point of view it would be worth offering at least the white 'Albus' and a good yellow form. The current Plant Finder shows that few nurseries list *N. triandrus* (4 outlets) or subsp. *concolor* (three outlets). The great attractiveness of *N. triandrus* suggests that it would be a very suitable subject for offering pot-grown whilst in flower.

7. *NARCISSUS ASSOANUS* Léon-Dufour

Description: Bulb 1-1.5 cm diameter. Leaves green, 10-20 cm long, 1-2 mm wide, rather rush-like. Flower stem 7-20 cm tall, with 1-2 (rarely to 3) flowers. Flowers very fragrant, deep yellow, horizontal or slightly pendent; cup (corona) about 5 mm deep and 10-15 mm across with a crenate mouth; perianth segments (corolla) standing out at right angles to the cup, about 0.7-1 cm long; tube long and slender, 1.2-2 cm long.

Flowering period: March-April (to July in the wild)

Distribution: South-western France, southern and eastern Spain.

Conservation Status: Not threatened in the wild.

Cultivation: *N. assoanus* is a native of limestone rock formations, growing in rocky places and alpine meadows. In cultivation it is 'easily grown on dryish alkaline soils as well as being a good plant in a pan, and readily sets seeds' (Blanchard, 1990).

Comments: An attractive small Jonquil Narcissus, better known in the past as *N. juncifolius* and *N. requienii*. With its dwarf habit and intense fragrance it has value for the unheated glasshouse or conservatory but also appeals to alpine/rock garden enthusiasts. Would probably attract attention if offered in flower, or in a pre-pack with colour photograph.

8. *NARCISSUS RUPICOLA* Dufour

Description: Bulb 1-1.5 cm diameter. Leaves grey-green, 10-15 cm long, 1.5-3 mm wide. Flower stem 8-12 cm tall, one-flowered. Flowers fragrant, uniform yellow, held horizontally or facing slightly upwards, with a slender tube 1.5-2.5 cm long; cup (corona) shallow, 3-5 mm deep and 7-10 mm across, lobed or crenate at the margin; petals held out flat, 7-15 mm long, usually broad and overlapping.

Flowering period: April (March-June in the wild)

Distribution: Northern Portugal, central Spain.

Conservation Status: Not in any immediate danger, although the situation probably needs to be monitored:
'Rare, widespread but in small colonies, some recently lost to over-planting with pines' (Salmon, unpublished data, 1996).
'Widespread and in good populations in Central Spain' (Norman, unpublished data, 1996).

Cultivation: *N. rupicola* needs a well-drained acid soil since it inhabits rocky places on acid formations in the wild. It is suitable for sunny positions on a rock garden, and grows well in pots in a cold glasshouse.

Comments: One of the most attractive of the dwarf Jonquil-type of narcissus; perhaps mainly for the specialist bulb or rock garden enthusiast, although it would be irresistible to any keen gardener if offered for sale in flower!

9. *NARCISSUS WILLKOMMII* (Sampaio) A. Fernandes

Description: Bulb 1-1.5 cm diameter. Leaves deep green, 20-35 cm long, 2-3 mm wide. Flower stem 15-25 cm tall, with 2-3 flowers. Flowers very fragrant, uniform deep yellow, held horizontally, with a slender tube 10-15 mm long; cup (corona) 4-6 mm deep and 8-11 mm across, 6-lobed at the margin; petals slightly reflexed, 8-13 mm long.

Flowering period: April

Distribution: Southern Portugal, south-western Spain.

Conservation Status: This appears to be under some threat in the wild:
'Vulnerable in Portugal' (Eckersley, 1992)
'Endangered in Portugal. Habitat lost to cultivation' (Salmon, unpublished data, 1996)

Cultivation: *N. willkommii* is not well-known in cultivation; it occurs in marshy ground in the wild and cultivation in the open ground should be relatively simple.

Comments: Like other members of the Jonquil group, this is an attractive species with fragrant flowers and certainly worthy of cultivation. It is, however, not well-known and is clearly a plant under some degree of threat in its wild state. It is included here because of this, as an example of how this project might play a part in the conservation of some of the rarer species.

10. *NARCISSUS BULBOCODIUM* Linnaeus

Description: Bulb 1-1.5 cm diameter. Leaves deep green, 10-15 cm long, 1-2 mm wide. Flower stem 5-15 cm tall, one-flowered. Flower uniform pale to deep yellow, held horizontally; trumpet (corona) conical-shaped and flared outwards, up to 2.5 cm long with a crenate mouth; perianth segments (corolla) very narrow, much smaller than the trumpet, held out away from the trumpet, about 5-15 mm long and only 2-5 mm wide.

Flowering period: January-March

Distribution: South-western France, Spain, Portugal, Morocco.

Conservation Status: There is a great problem in making statements about the conservation status of *N. bulbocodium* since, taken as a whole and including all its variations, it is very widespread and common. However, certain local variants, which may be of great interest horticulturally, are in some cases under threat because of their restricted distribution. For example, subsp. *nivalis* is thought to be 'Vulnerable through use of marginal land for livestock' (Salmon, unpublished data, 1996) and subsp. *conspicuous* is 'Rare through limited distribution, although not Threatened' (Salmon, unpublished data, 1996).

Cultivation: Variants of *N. bulbocodium* are frequently cultivated by bulb enthusiasts and rock garden/alpine gardeners in the unheated glasshouse (alpine house) or cold frame. Under these conditions it flowers very early in the year and its flowers can be appreciated at close quarters. However, it can be grown very successfully outdoors, as the 'alpine meadows' at Savill Gardens and Wisley demonstrate, where this species is growing in thousands and seeding freely. It appears that acid sandy conditions are much preferred, with a plentiful supply of moisture during the spring growing period.

Comments: This is a very distinctive species, the 'trumpet' quite different in shape from most other daffodils, although there are several related species with similar flower form. The flared, conical trumpet has resulted in the common name of 'hoop petticoat daffodil' for this whole group of species.

Within the group there are many variations, from white (*N. cantabricus*) to pale lemon-yellow (*N. romieuxii*) and deeper yellow (*N. bulbocodium* forms); paler forms of *N. bulbocodium* are often referred to as *N. bulbocodium* var. *citrinus*.

N. obesus, or *N. bulbocodium* var. *obesus*, has generally larger, deep yellow flowers and prostrate leaves; this may be of interest in that it grows wild on neutral or alkaline soils in the wild, thus in gardens it does not require such acid conditions as *N. bulbocodium* in which to thrive.

The white *N. cantabricus* is extremely attractive but is less easy to cultivate in the open ground, largely because of its very early-flowering habit, sometimes as early as November. For this reason it and the pale yellow *N. romieuxii*, which also flowers early, are normally grown under cold glasshouse conditions.

The more robust forms of *N. bulbocodium*, intended for planting in the open garden, should be very 'saleable' if offered pot grown in flower.

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Gordon Hanks
2 December 1998