age, such as hot plates, or hot air blasts.

Despatching operations that need to keep plants tightly held together with a protective skin to reduce in-transit drying out could utilise the speed and handling advantages of shrink wrap. Two operations in our own nursery are presently being investigated in this regard. Firstly the export of small rooted cuttings or liners sent by air, which are presently packed in plastic insulated rolls, may be better prepared and presented using shrink wrap film. Secondly, plants that are held in cold store during transporation or storage, and are therefore likely to dehydrate, could also benefit from a protective shrunk wrap coating.

Whatever shrink wrap plastic's potential is in nursery production, it is an extremely fascinating and interesting product and one option that nurserymen may look to in the future, to improve the handling, despatching, and presentation of plants.

PROPAGATION OF AMARYLLIDS: A BRIEF REVIEW

C.B. CHRISTIE

Department of Horticulture and Plant Health
Massey University
Palmerston North

INTRODUCTION

The amaryllids comprise a family of interesting monocotyledonous plants that have long been prized for their very attractive inflorescences. A small number of the genera have become economically significant as cut flowers and potted flowering plants, e.g. *Narcissus, Nerine,* and *Hippeastrum.*

The propagation of the Amaryllidaceae may be achieved by use of the following four methods: seed, separation, bulb cutting, and tissue culture. The techniques employed in each of these methods will be briefly reviewed.

PROPAGATION BY SEED

Most species will produce seedlings that are reasonably true to type; however the natural heterozygosity and capacity for interspecific and intergeneric hybridisation has been exploited in the production of hybrid nerines (20) and plants such as × *Amarine* (*Amaryllis belladonna* × *Nerine*) and × *Brunsdonna* (*Brunsvigia* × *Amarylyis belladonna*).

Plants are easily propagated from seed if it is set. Seed of amaryllids is of two distinct types:

(a) fleshy berry(ies) clustered in an umbel borne on top of the old peduncle. e.g. *Amaryllis*, *Clivia*, *Hymenocallis* and *Nerine*. The fleshy endosperm of these seeds contains sufficient moisture to permit germination of seed on top of the ground without additional moisture. However, when this is allowed to happen seedlings often fail to penetrate the ground and obtain sufficient anchorage for rapid, continuous development. Sowing seed in a free draining medium, e.g. 60/40 pumice/peat at 20°-25°C. (as soon as the seed matures) usually results in prompt germination within about four weeks. *Scadoxus* and *Haemanthus* may show a type of epicotyl dormancy with the germination process taking about six months to complete (4).

(b) Dry membranous seeds borne in loculicidal dehiscing capsule (s), also on top of the old peduncle, e.g. *Habranthus*, *Hippeastrum*, *Narcissus* and *Zephyranthes*. This type of seed will usually germinate readily if sown under warm conditions as above, but some species may benefit from moist stratification, e.g. *Narcissus* as they have a low temperature requirement for germination. Therefore, sow in autumn outdoors and expect seedlings to appear in the spring (17).

Seed germination is basically hypogeal in form with seedlings producing only a limited number of leaves that may persist for more than one growing season. During this time a small bulb will be enlarging at the base of the leaves. Seedlings of many species will flower in two or three years from seed but some, e.g. Crinum and *Narcissus* may take four or five years to mature.

SEPARATION (OR DIVISION)

Offsets or daughter bulbs are produced in two ways, either the replacement system seen in *Narcissus* where the primary growing point divides slowly producing double-nosed bulbs before separating into independent plants. This results in a slow rate of increase of about 1.6 bulbs per year. Some daughter bulbs may also be produced by the following system.

Or in the case of *Chlidanthus*, *Hippeastrum* and *Sternbergia*, bulbs are initiated in the bases of senescing bulb scales on the perimeter of the bulb. The death of the outer scales allows these daughter bulbs to continue development, only being weakly attached to the mother bulb. Bulbs are best left undisturbed until a separate root system has developed, then during the bulb's dormant period large offsets may be detached from the mother bulb (17). The number of daughter bulbs produced in some genera, e.g. *Eucharis* is proportional to the size of the mother bulb (3).

The scale or leaf bases are the primary regions of meriste-

matic activity; rapid multiplication occurs where more than one new bulb is initiated in each of these regions. The small amaryllids e.g. *Sprekelia*, may often increase fairly rapidly by this method; however the large bulbed amaryllids e.g. *Brunsvigia* and *Crinum* are very slow to increase in this manner.

BULB CUTTING

Efforts to stimulate bulb propagation by controlled mutilation (22) produce better results than leaf cuttings as for many Liliaceae. Cross cutting and scooping of bulb bases (as for *Hyacinthus*) produced up to 10-15 new daughter bulbs for every parent bulb sacrificed this way (12). Investigation reveals that each bulb base contains many preformed bulb meristems and in addition, further meristematic loci may arise adventitiously (7). Further increases in bulb multiplication rates are possible by slicing a bulb into a number of sectors each composed of scale pieces and a section of basal plate. This practice was originally called fractional scale-stem cuttage (22), but has more recently become known as bulb-chipping' (5). If the subdivision of bulb sectors is continued the multiplication rate continues to rise for a while. The limit of subdivision for most amaryllids is reached when two scales remain connected together by a small amount of basal plate; this is twin-scaling (1,2,10,11). The procedures employed in twin-scaling and chipping are discussed in the following literature (6,9,12,21) and pertinent points are highlighted below.

Select healthy bulbs of a good size for the genera undergoing propagation, e.g. (*Narcissus* 10cm, *Nerine* 14-16cm); very large bulbs of some genera, e.g. *Brunsvigia* and *Crinum* have proved less useful than smaller bulbs. The optimum time for propagation is usually shortly after the bulb enters its normal resting phase. Bulbs should be dug up at this time and cleaned by removing any persisting foliage, the dry outer scales, the roots and the dead outer exterior of the basal plate with a sharp knife. Protective gloves should be worn for the remainder of the dissection process as the sap of amaryllids contain a number of alkaloids that may irritate the skin. Knives used for the preparative work should be cleaned and possibly sterilised in alcohol before being used for further work. Bulbs may also be disinfected at this stage by swabbing with alcohol or dipping in a 0.5% a.i. formalin solution for 1-2 minutes (avoid inhalation of the fumes).

With a clean knife cut off the neck of the bulb and discard; now proceed to cut the bulb into a number of sectors with their common center passing through the central axis of the bulb; this should ensure that each of the "chips" prepared at this stage contain both leaf bases and basal plate. The

number of "chips" prepared from each bulb depends on the bulb size or circumference; unlimited subdivision may not be restricted by meristematic sites but most probably by limitations in growth regulator and carbohydrate supply in both small chips and twin-scales. (Very small scales produce bulbils that are slow to commence normal vegetative growth).

Small bulbs, e.g. 10-12cm may be cut into 8-16 chips; if this material is going to be cut into twin-scales then 8-10 *sections would be made. The number of scales within each* bulb depends both on the genera and bulb size. *Eucharis*, *Haemanthus* and *Narcissus* contain relatively few scales compared with *Amaryllis*, *Brunsvigia* and *Crinum*. The large number of scales and the presence of many fibres interconnecting scales in these bulbs makes them prime subjects for chipping and not scaling.

If bulbs are going to be scaled then each of the chips must be carefully cut into twin-scales. Separate the scales into pairs and then proceed to cut through the basal plate to detach each pair of scales, working from the exterior to the interior of the bulb. Store cut scales in a plastic bag to minimise desiccation. When a batch of scales has been cut they should be soaked in a fungicide to inhibit growth of *Penicillium* and other fungi that attack the scales during incubation. A 20-30 min. soak in 0.2% benomyl has been used with limited success and would be better replaced by or used in combination with 0.4% captafol or 0.4% clorthalonil.

Excess moisture must be removed prior to incubation, but as this can be quite difficult when dealing with large batches of scales, encouraging results have been attained when the fungicide was added to the incubation medium. Best results are obtained when scales are incubated in thin plastic bags containing a slightly moistened (0.25-10%) material such as vermiculite, perlite, or peat/perlite (10/90) which have all proved satisfactory when sufficient material is used to separate each piece of bulb tissue. Bags are sealed and stored in the dark at 20°C. for 12-20 weeks. The plant material should be checked regularly to remove senescing scales.

Bulbils arise most frequently at the base of the innermost scale on the abaxial side (24) and first become visible between scales after 4-6 weeks incubation. As bulbils develop, the parent scales lose weight and begin to shrivel as reserves are transferred to the new bulbils. When this process is complete the bulbils will have attained their maximum size and will be ready for transfer to a potting medium and growth in an unheated greenhouse.

Most genera will flower in 2-4 years from scaling. Follow-

ing propagation by scaling some rejuvenation has been noticed with very rapid development of daughter bulbs occurring at the base of the new bulb in some *Nerine* and *Hippeastrum* cultivars (9,22).

The following amaryllid genera have been propagated successfully by twin-scaling in New Zealand and overseas: *Amaryllis, Brunsvigia, Childanthus, Clivia, Crinum, Eucharis, Galanthus, Habranthus, Haemanthus, Hippeastrum, Hymenocallis, Leucojum, Lycoris, Narcissus, Nerine, Pancratium, Sprekelia, Sternbergia* and *Vallota* (1,9,2,23).

TISSUE CULTURE

Sterile culture techniques have been developed for the propagation of many important amaryllids, e.g. *Eucharis, Hippeastrum, Narcissus* and *Nerine.* However the techniques have been relatively slow to be exploited by commercial laboratories because of large differences in the response of individual cultivars, reduced growth after several subcultures, and lack of growth after transfer to *in vivo* conditions (13,14,16,18,19). The early work concentrated on the use of shoot apices and excised twin-scales as explants (8,15), but this has been extended to include meristematic tissue located on individual leaf bases, scapes, peduncles, and ovary tissue.

Explants are sterilised in alcohol rinses and by soaking in a hypochlorite solution, followed by sterile water rinses and aseptic transfer to a suitable culture medium based on a standard Murashige and Skoog medium. Cultures are most often incubated at 15-25° C. with an extended (16-24 hr.) photoperiod.

The optimal explant response to plant growth regulators was cultivar-dependent but some growth will occur on a range of media. Growth of callus through a more organised state of shoots and bulbs occurs in 2-12 months. Continuous adventitious shoot formation has been difficult to sustain; further multiplication has been possible with regular splitting of shoots and bulbs as an *in vitro* "chipping" technique.

Transfer of dormant *Narcissus* bulbils to *in vivo* conditions requires a period of chilling *(in vitro)* before normal growth will resume. Substantial losses will occur with some genera if initially transferred to a non-sterile *in vivo* growing medium.

Literature shows that the following amaryllid genera have been multiplied by tissue culture laboratories in New Zealand and overseas: *Amaryllis, Anoiganthus, Clivia, Eucharis, Galanthus, Haemanthus, Hippeastrum, Ipheion, Leucojum, Narcissus, Nerine, Scadoxus, Vallota* and *Worsleya* (13,15,16,23).

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OUR WAY WITH FOG PROPAGATION OF TISSUE-CULTURED PLANTS

PETER W. SPEAR

Pe Ge Pe Enterprises,
51 Amberly Avenue, Auckland, 8.

For many years I have advocated the propagation and growing on of plants using fog as opposed to mist. The advantages I saw as an engineer and operator of a tissue culture lab were many. Although the initial cost of the first unit is a little high, subsequent units are comparatively cheap.

Our experience in the lab and with growing on plants out of flask was such that they required a high humidity but no great water application.

What was it we required?:

i) Control of transpiration and evaporation during propagation, and initial planting out of tissue-cultured plants.
ii) Application of chemicals to plants after establishment — foliar feeds, fungicides, insecticides, or any other crop enhancing water soluble chemicals.
iii) No over-wetting of growing media.
iv) Frost protection during winter.

Considerations:

Safety — we were conscious of the need to have no extreme high pressure lines for water. Many systems in use here and overseas use up to 500 psi water pressure and correspondingly piping and installation can be expensive when lasting qualities are considered, e.g. stainless steel or copper lines. Filtration of water in high pressure units is expensive and involves considerable maintenance.

The system involves the use of a small air compressor and receiver delivering up to 6 cfm. This will allow up to 6 units to be run off the compressor. Each nozzle is controlled by an indicating Martonair 25/5 solenoid valve for air and water so that there is no dripping or air escape when not in use. Water is controlled by a Martonair flow control, and air with a Norgren regulator and gauge.

How does the system fit into the plant propagation scene?