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The potential of South African indigenous plants for the international cut flower trade

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Abstract

A broad review is presented of recent developments in the commercialization of southern Africa indigenous flora for the cut flower trade, including potted flowers and foliages ("greens"). The botany, horticultural traits and potential for commercialization of several indigenous plants have been reported in several publications. The contribution of species indigenous and/or endemic to southern Africa in the development of cut flower crop plants is widely acknowledged. These include what is known in the trade as gladiolus, freesia, gerbera, ornithogalum, clivia, agapanthus, strelitzia, plumbago and protea. Despite the wealth of South African flower bulb species, relatively few have become commercially important in the international bulb industry. Trade figures on the international markets also reflect the importance of a few species of southern African origin. The development of new research tools are contributing to the commercialization of South African plants, although propagation, cultivation and post-harvest handling need to be improved. A list of commercially relevant southern African cut flowers (including those used for fresh flowers, dried flowers, foliage and potted flowers) is presented, together with a subjective evaluation of several genera and species with perceived potential for the development of new crops for the florist trade. It is concluded that research should be focused on potential markets rather than on preconceived product concepts. A special national effort is required to maximize the opportunities presented by the rich diversity of the flora and to develop an internationally competitive cut flower industry.

Keywords: Commercialization; Crop development; Cut flowers; Foliages; Potted flowers; South African flora

1. Introduction

International interest in South African indigenous floriculture increased since the middle of the eighteenth century, when Linnaeus started naming and describing the rich abundance of new floral plant examples, albeit in dried form, received initially from the Western Cape. Since then, numerous botanical travelers and explorers, including Thunberg, Drège, Burchell, Masson and more recently Hutchinson (1946, see also Beukes, 1996), described in detail the novelty of the southern African flora. The uniqueness of the flora has been the focus of international interest, especially in the Cape Floral Kingdom, which is the smallest and most diverse of the six Plant Kingdoms of the world, all contained in one country. This region, well known as the Fynbos Biome, contains nearly 9000 species, of which more than 60% are endemic (Goldblatt and Manning, 2000). The rest of southern Africa is equally rich in botanical diversity, with 21 817 species and, if subspecies, varieties and forms are included, a total of 24 035 taxa (Germishuizen and Meyer, 2003). The popularity of the South African flora is also reflected in the fact that Kirstenbosch Botanical Garden is one of the main tourist attractions in Cape Town (www.info.gov.za/aboutsa/tourism) and that South Africa has a proud record of regularly winning gold medals at the Chelsea Flower Show in the United Kingdom (www.sanbi.org/index).

2. The commercial importance of South African cut flowers

Several South African plant species are well known internationally as the source of genetic material for cut flowers that

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have been hybridized, registered with plant breeder's rights and distributed world-wide. These include species of *Clivia*, *Freesia*, *Gerbera*, *Gladiolus*, and *Protea*. Species and hybrids of several other genera are currently the subject of international interest among breeders, including *Agapanthus*, *Arctotis*, *Crocosmia*, *Disa*, *Eucomis*, *Erica*, *Haemanthus*, *Ixia*, *Lachenalia*, *Leucadendron*, *Leucospermum*, *Lobelia*, *Mimetes*, *Nerine*, *Nymphaea*, *Ornithogalum*, *Osteospermum*, *Pelargonium*, *Rhodohypoxis*, *Serruria*, *Sparaxis*, *Strelitzia*, *Streptocarpus*, *Tulbaghia*, *Venidium*, *Watsonia* and *Zantedeschia*. In Table 1, a list is given of all or most of the genera and species of historic or current commercial interest. The annual Hortifair (www.hortifair.nl/) in The Netherlands and other Flora Expo's in Europe and Asia are proof of the demand for South African ornamentals. For example, in the first 11 weeks of 2011, no less than 86 929 090 stems of "gerbera mini" were sold on the Dutch Flower Auction (FloraHolland clock sales), as well as 35 749 803 single-flowered freesias (April 2011/www.Floracultureinternational.com). *Gerbera*×*hybrida* appears to be the top commercial cut flower of South African origin; it is now the fifth most popular cut flower in the world (after roses, carnations, chrysanthemums and tulips). The history of commercial gerberas goes back to the Cambridge Botanical Garden in 1886, when a cross was made between *Gerbera jamesonii* and *G. viridiflora* (Johnson, 2010). The modern cultivars, classified in two categories (standard and mini) are probably partly derived from other species as well. Regularly updated EU surveys (www.cbi.eu/marketinfo/) provide production and consumption figures, as well as market values. In 2009, it was indicated that the economic crises have put pressure on the market for cut flowers. However, FloraHolland reported that for 2010 their turnover was more than € 4 billion, 7% higher than the previous year, which is promising for the cut flower trade (Kras, 2010). In comparison, Multiflora Johannesburg (the largest flower market in Africa) reported an annual turnover of € 18 million (Kras, 2011).

Although the first chincherinchees (*Ornithogalum* species) from the Cape were exported by ship in the 1890s, large-scale cut flower exports from South Africa started in the 1980s as a non-traditional high value commodity (Malter and Reijtenbagh, 1996). Off-season supply of cut flowers to Europe with low air freight rates and northbound freight capacity was positive, and floriculture in South Africa had very little government involvement causing the private sector to organize itself. Export trade figures released by the Perishable Products Export Control Board (PPECB) in the export directories of 2008 and 2010 (available at www.PPECB.com) indicate a downward trend since 2002/2003 for all flora exported, which includes cut flowers, ferns, orchids, reeds and grasses, as well as proteas and Cape fynbos. It appears that increased transport costs and perceptions about the high carbon footprint of imported goods are partly responsible for this trend. For the past five seasons, Central Europe was still the main destination, although the United Kingdom imports are rapidly increasing, mostly due to an increased demand for bouquets. The Eucarpia-section on ornamentals (www.eucarpia.org/) and IPA (www.ipa-protea.org/) conferences and proceedings provide further proof of interest in the South African flora. Coetzee et al. (2002), at a regional meeting of the Food and Agricultural Organisation of the World (FAO), reported that about 70% of flowers exported from South Africa are from the fynbos, and in the 2008/2009 season this increased to 84% (PPECB export Directory 2010, available at www.PPECB.com).

The globalization of ornamental plants and use of genetic material by the industrialized countries ("floral colonization") has received little attention, yet 83% of commercial flora in the USA had a foreign origin, with 453 species from South Africa. This is not seen as exploitation but as an enhancement for horticulture (Taylor, 2010). Roh and Lawson (1996) provided an extensive perspective on a selection of South African bulbous plants tested in cooperation with the United States Department of Agriculture (USDA). Modern-day interest lies in the biodiversity and in the breeding with new market trends and adaptations to local growing conditions. South Africa is regarded as a "hotspot" of diversity and an important source of the potential cut flower cultivars, as seen in the large number of species listed in Table 1. The National Environmental Management: Biodiversity Act of 2004 (NEMBA) that came into effect on the 1st of April 2008 specifically excludes ornamental plants from its provisions and regulations. In the bulbous ornamental plant industry, *Gladiolus* and *Freesia*, which originate from South Africa, are important fresh cut flowers in world markets (Coetzee et al., 1998), but in essence are "lost" to South Africa in terms of economic benefits (Coetzee, 2002). According to Kamenetsky and Miller (2010), the seven genera dominating the trade in ornamental geophytes or flower bulbs are *Tulipa*, *Lilium*, *Narcissus*, *Gladiolus*, *Hyacinthus*, *Crocus* and *Iris*, but *Freesia*, *Ornithogalum*, *Hippeastrum*, *Allium* and *Muscari* are also prominent. Internationally, interest is increasing in the wide range of ornamental plant diversity available in South Africa. Review articles on breeding results for new improved cultivars from indigenous plants explore the potential of new markets and increased trade (Wessels et al., 1998). During the late 1990s, the Agricultural Research Institute (ARC) and the Southern African Center for Cooperation in Agricultural and Natural Resources Research and Training (SACCAR) conducted studies (Wessels et al., 1997) to analyze the socio-economic impact of the "Proteaceae Development and Transfer Program", which started in 1974 and eventually ended in 2005. The financial analyses indicated a rate of return between 7 and 12%, showing that the Proteaceae research program was a profitable investment to society (Wessels et al., 1998). A study by Marasas et al. (1998) on *Lachenalia* research (since 1965) indicated negative results in financial and economic terms but the project was considered invaluable in terms of human capital development and the knowledge that was gained (Niederwieser et al., 1998). However, the industry experienced a downward trend and expectations based on future projections did not materialize. A survey in 2004 (Matthee et al., 2005) showed that the South African flower export industry is not operating to its full potential and that it lacks competitiveness in several aspects. New socio-economic studies to assess the current situation are recommended.

Baudoin et al. (2007) highlighted the fact that the FAO is committed to improve food security for reducing malnutrition

Table 1
List of indigenous southern African plant species of commercial interest in the florist trade (information mainly from Brown and Duncan (2006) and Maree and Van Wyk (2010). Uses are indicated as F = fresh flowers; D = dried flowers; Fol = foliage (mostly leaves, but also stems, fruits or small flowers); Pot = potted flowers (excluding foliage plants).

Species and family	Common and/or commercial name(s)	Use and/or potential use: + = low or none, ++ average, +++ = high
Adromischus species; Crassulaceae	Calico hearts	Pot+++
Agapanthus africanus (L.) Hoffmanns. (=*A. umbellatus* L'Hér.); Agapanthaceae	African lily, blue lily, blue african lily, lily of the Nile	F+++, Pot++
Agapanthus praecox Willd. (=*A. orientalis* (F.M.Leight.) F.M.Leight.); Agapanthaceae	African lily	F+++, Pot+
Agathosma species; Rutaceae	Buchu, anise buchu	Fol+++, Pot++, D++
Albuca species; Hyacinthaceae	Albuca, slime lily	Pot+++
Amaryllis belladonna L.; Amaryllidaceae	Belladonna lily, miniature amaryllis, cape belladonna, jersey lily	F+++, Pot+++
Androcymbium species; Colchicaceae	Cup-and-saucer, men-in-a-boat	Pot++
Anthospermum aethiopicum L.; Rubiaceae	Anthospermum, new look	Fol++
Arctotis x*hybrida*; Asteraceae	African daisy	Pot+++
Arctotis venusta Norl. (=*A. stoechadifolia* P.L.Bergius); Asteraceae	Blue-eyed african daisy	Pot++
Argyroderma species; Aizoaceae	Baby bottoms	Pot+
Aristea species; Iridaceae	Aristea	Pot+++
Aspalathus species; Fabaeae	Cape pea-flowers	Fol+
Asparagus species; Asparagaceae	Asparagus fern	Fol+++
Aulax umbellata (Thunb.) R.Br.; Proteaceae	Featherbush	Fol++
Babiana species; Iridaceae	Babiana	Pot+++
Begonia sutherlandii Hook.f.; Begoniaceae	Begonia	Pot++
Berzelia abrotanoides (L.) Brongn.; Bruniaceae	Abrotan	Fol++, D++
Berzelia galpinii Pillans; Bruniaceae	Baubles, galpinii	F++, Fol++, D++
Berzelia lanuginosa (L.) Brongn.; Bruniaceae	Berzelia, lanuginosa, Cape greens, kol-kol	Fol++, D++
Berzelia squarrosa (Thunb.) Sond.; Bruniaceae	Squarrosa	Fol+, D+
Brunia albiflora E.Phillips; Bruniaceae	Albiflora, white brunia	F+++, Fol+++, D+++
Brunia alopecuroides Thunb.; Bruniaceae	Alopecuroides	Fol+++, D+++
Brunia laevis Thunb.; Bruniaceae	Silver brunia	Fol++, D++
Brunia nodiflora L.; Bruniaceae	Spray brunia, stompie	Fol+++, D+++
Brunia stokoei E.Phillips; Bruniaceae	Rooistompie	Fol+, D+
Brunia alopecuroides Thunb.; Bruniaceae	Strawberry berzelia, white berzelia, red berries	Fol+, D+
Bulbinella latifolia (L.f.) Schult. and Schult.f.; Asphodelaceae	Cat's tail	F++
Bulbinella nutans (Jacq.) Spreng.; Asphodelaceae	Cat's tail	F++
Chaenostoma subspicatum Benth. *(=Sutera subspicatum)*; Scrophulariaceae	Sutera	Pot++
Chlorophytum comosum (Thunb.) Jacq.; Anthericaceae (Asparagaceae)	Spider plant, hen-and-chickens	Pot+++
Clivia miniata (Lindl.) Regel; Amaryllidaceae	Clivia, orange lily, bush lily, fire lily, flame lily	Pot+++
Conophytum species; Aizoaceae	Buttons	Pot++
Crassula species; Crassulaceae	Stonecrops	Pot+++
×*Crinodonna* cultivars (*Amaryllis belladonna* L.×*Crinum*); Amaryllidaceae	Crinodonna	F+++
Crocosmia aurea (Pappe ex Hook.) Planch.; Iridaceae	Crocosmia	F+++, D++
Crocosmia×*crocosmiiflora*; Iridaceae	Montbretia	F+++, D++
Cyanella species; Tecophilaeaceae	Lady's-hand	Pot++
Cyperus papyrus L.; Cyperaceae	Papyrus, Egyptian paper plant	Fol+++
Cyperus textilis Thunb.; Cyperaceae	Mat sedge	Fol++
Cyrtanthus species; Amaryllidaceae	Fire lily	F+++, Pot+++
Daubenya aurea Lindl.; Hyacinthaceae	Pincushion lily	Pot++
Diosma subulata J.C.Wendl.; Rutaceae	Florist buchu	Fol+++
Disa species and cultivars	Disa	F++, Pot++
Eleusine coracana Gaertn.; Poaceae (Gramineae)	Finger millet	D++
Empodium species; Hypoxidaceae	Autumn star	Pot++
Erica species; Ericaceae	Heather	F++, Pot++, D+
Eriocephalus racemosus L.; Asteraceae	White cotton	Fol
Eucomis autumnalis (Mill.) Chitt.; Hyacinthaceae	Pineapple lily	F+++, Pot+++
Eucomis bicolor Baker; Hyacinthaceae	Pineapple lily	F+++, Pot+++
Eucomis comosa (Houtt.) Wehrh.; Hyacinthaceae	Pineapple lily	F+++, Pot+++
Euryops pectinatus Cass.; Asteraceae	Bush daisy	Pot++
Ferraria species; Iridaceae	Spider iris	Pot++

Table 1 (*continued*)

Species and family	Common and/or commercial name(s)	Use and/or potential use: + = low or none, ++ average, +++ = high
Freesia×*hybrida* (and other species); Iridaceae	Freesia	F+++, Pot+++
Gazania krebsiana Less.; Asteraceae	Gazania	Pot+++
Geissorhiza species; Iridaceae	Satinflower, wine cup	Pot++
Gerbera×*hybrida*; Asteraceae	Gerbera	F+++, Pot+++
Gerbera jamesonii Bolus ex Adlam; Asteraceae	Gerbera, barberton daisy, transvaal daisy	F++, Pot++
Gethyllis species; Amaryllidaceae	Kukumakranka	Pot++
Gibbaeum species; Aizoaceae	Ostrich toes	Pot++
Gladiolus carneus D.Delaroche; Iridaceae	Painted lady	F++, Pot++
Gladiolus cultivars; Iridaceae	Gladiolus, glad, sword lily	F+++, Pot++
Gladiolus tristis L.; Iridaceae	Ever-flowering gladiolus, marsh afrikaner	F++, Pot++
Gloriosa superba L. (=*G. rothschildiana* O'Brien); Colchicaeae	Flame lily, glory lily	F+++, Pot+++
Gomphocarpus physocarpus E.Mey. (=*Asclepias physocarpa* Schltr.); Apocynaceae	Milkweed, swan plant	Fol++
Haemanthus albiflos Jacq.; Amaryllidaceae	Paintbrush	Pot++
Haemanthus coccineus L.; Amaryllidaceae	Blood flower, April fool	Pot++
Haemanthus humilis Jacq.; Amaryllidaceae	Paintbrush	Pot++
Haworthia species; Xanthorrhoeaceae	Haworthia	Pot+++
Helichrysum eximium Less. (=*Helipterum eximium* DC.); Asteraceae	Strawberry everlasting	F++, D++ (Red data species; cultivated material only)
Hesperantha species; Iridaceae	Hesperantha	Pot+++
Hessea species; Amaryllidaceae	Umbrella lily	Pot++
Hypoxis species; Hypoxidaceae	Star grass	Pot++
Ischyrolepis subverticillata Steud.; Restionaceae	Restios, besemriet	Fol++
Ixia cultivars; Iridaceae	African corn lily, wand flower	F+++, Pot+++
Kalanchoe species; Crassulaceae	Flaming katy	Pot+++
Kniphofia tysonii Baker; Asphodelaceae	Red hot poker, torch lily	F++
Kniphofia uvaria (L.) Oken; Asphodelaceae	Red hot poker, torch lily	F++
Lachenalia aloides (L.f.) Engl.; Hyacinthaceae	Cape cowslip, lachenalia	Pot+++
Lanaria lanata (L.) T.Durand & Schinz; Lanariaceae	Lambtails	Fol+
Lapeirousia species; Iridaceae	Cabong, lapeirousia, painted petals	Pot++
Ledebouria species; Hyacinthaceae	African squill	Pot++
Leonotis leonurus (L.) R.Br.; Lamiaceae	Lion's ear	F+++, D++, Fol++
Leonotis nepetifolia Schimp. ex Benth.; Lamiaceae	Wild dagga, lion's tail	Fol++
Leucadendron adscendens R.Br.; Proteaceae	Cone bush	Fol+++, D++
Leucadendron argenteum (L.) R.Br.; Proteaceae	Silver tree	Fol++, D++
Leucadendron conicum (Lam.) I.Williams; Proteaceae	Cone bush	Fol+++, D++
Leucadendron coniferum (L.) Meisn.; (=*L.sabulosum* T.M.Salter); Proteaceae	Cone bush	Fol+++, D++
Leucadendron comosum (Thunb.)R.Br.; Proteaceae	Cone bush	Fol+++, D++
Leucadendron daphnoides (Thunb.) Meisn.; Proteaceae	Cone bush	Fol+++, D++
Leucadendron decorum R.Br.; Proteaceae	Cone bush	Fol+++, D++
Leucadendron discolor E.Phillips and Hutch.; Proteaceae	Cone bush	Fol+++, D++
Leucadendron floridum R.Br.; Proteaceae	Cone bush	Fol+++, D++
Leucadendron galpinii E.Phillips and Hutch.; Proteaceae	Cone bush	Fol+++, D++
Leucadendron laureolum (Lam.) Fourc.; Proteaceae	Cone bush	Fol+++, D++
Leucadendron laxum I.Williams; Proteaceae	Cone bush, smart rose	Fol+++, D++
Leucadendron linifolium (Jacq.) R.Br.; Proteaceae	Cone bush	Fol+++, D++
Leucadendron macowanii E.Phillips; Proteaceae	Acacia-leaf cone bush	Fol+++, D++
Leucadendron muirii E.Phillips; Proteaceae	Cone bush	Fol+++, D++
Leucadendron nervosum E.Phillips and Hutch.; Proteaceae	Cone bush	Fol+++, D++
Leucadendron orientale I.Williams; Proteaceae	Cone bush	Fol+++, D++
Leucadendron platyspermum R.Br.; Proteaceae	Cone bush	Fol+++, D++
Leucadendron rubrum Burm.f. (=*L. plumosum* R.Br.); Proteaceae	Cone bush	Fol+++, D++
Leucadendron salicifolium (Salisb.) I. Williams; Proteaceae	Cone bush	Fol+++, D++
Leucadendron salignum P.J.Bergius; Proteaceae	Conebush	Fol+++, D++
Leucadendron stelligerum I. Williams; Proteaceae	Cone bush	Fol+++, D++
Leucadendron tinctum I. Williams; Proteaceae	Cone bush	Fol+++, D++
Leucadendron xanthoconus (Kuntze) K.Schum; Proteaceae	Cone bush	Fol+++, D++
Leucospermum species (selected); Proteaceae	Pincushions	F+++, Pot++
Leucospermum catherinae Compton; Proteaceae	Pincushion	F+++, D++
Leucospermum conocarpodendron H.Buek; Proteaceae	Pincushion	F++, D++

(continued on next page)

Table 1 (*continued*)

Species and family	Common and/or commercial name(s)	Use and/or potential use: + = low or none, ++ average, +++ = high
Leucospermum cordifolium (Knight) Fourc.; Proteaceae	Pincushion	F+++, D++, Pot++
Leucospermum cuneiforme (Burm.f.) Rourke; Proteaceae	Pincushion	F++, D++
Leucospermum erubescens Rourke; Proteaceae	Pincushion	F+++, D++
Leucospermum glabrum R.Br.; Proteaceae	Pincushion	F++, D++
Leucospermum lineare R.Br.; Proteaceae	Pincushion	F++, D++
Leucospermum patersonii E.Phillips; Proteaceae	Pincushion	F++, D++
Leucospermum reflexum H.Buek ex Meisn.; Proteaceae	Pincushion	F+++, D++
Leucospermum rodolentum (Salisb. ex Knight) Rourke; Proteaceae	Pincushion	F++, D++
Leucospermum saxosum S.Moore; Proteaceae	Pincushion	F++, D++
Leucospermum tottum R.Br.; Proteaceae	Pincushion	F++, D++
Leucospermum truncatulum (Salisb. ex Knight) Rourke; Proteaceae	Pincushion	Fol+++, D++
Leucospermum vestitum (Lam.) Rourke; Proteaceae	Pincushion	F++, D++
Limonium peregrinum (P.J.Bergius) R.A.Dyer; (=*L. roseum* Kuntze); Plumbaginaceae	Statice	F+++, D+++
Lithops species; Aizoaceae	Flowering stones	Pot++
Lobelia erinus L.; Campanulaceae	Edging lobelia, trailing lobelia	Pot+++
Massonia species; Hyacinthaceae	Hedgehog lily	Pot+
Metalasia muricata R.Br.; Asteraceae	Blombos	F+++
Mimetes cucullatus (L.) R.Br.; Proteaceae	Common pagoda, *rooi stompie*	Fol++, D++
Mimetes hirtus (L.) Salisb. Ex Knight; Proteaceae	Marsh pagoda, hairy mimetes	Fol++, D++
Moraea species; Iridaceae	Moraea, peacock iris	Pot++
Nebelia paleacea Sweet; Bruniaceae	Nebelia, *bergstompie*	Fol++
Nerine bowdenii W.Watson; Amaryllidaceae	Guernsey lily, spider lily, nerine	F+++
Nerine sarniensis Herb.; Amaryllidaceae	Guernsey lily, spider lily	F+++
Nymphaea nouchali Burm.f.; Nymphaeaceae	Water lily	F+
Ornithogalum dubium Houtt.; Hyacinthaceae	Orange star flower	F++, Pot++
Ornithogalum saundersiae Baker; Hyacinthaceae	Chincherinchee, star-of-Bethlehem	F++, D++
Ornithogalum thyrsoides Jacq.; Hyacinthaceae	Chincherinchee, star-of-Bethlehem	F+++, D++
Ornithoglossum species; Colchicaceae	Snake lily	Pot+
Paranomus species; Proteaceae	Scepter	F++
Pelargonium cordatum L'Hér.; Geraniaceae	Geranium, pelargonium, storksbill	Pot++
Pelargonium×*domesticum* Geraniaceae	Regal pelargonium, regals	Pot+++
Pelargonium graveolens L'Hér.; Geraniaceae	Geranium, pelargonium, storksbill	Pot++
Pelargonium peltatum (L.) L'Hér.; Geraniaceae	Ivy geranium, ivy-leaved geranium, hanging geranium	Pot+++
Pelargonium zonale (L.) L'Hér.; Geraniaceae	Geranium, zonal pelargonium, storksbill	Pot+++
Phaenocoma prolifera D.Don; Asteraceae	Everlasting	F++, D+++
Phylica ericoides L.; Rhamnaceae	Cape myrtle, white phylica	F++, D+++,
Phylica lasiocarpa Sond.; Rhamnaceae	Snowtops	Fol++, D++
Phylica plumosa L. (=*P. pubescens* Aiton); Rhamnaceae	Green phylica	F+++, D+++, Pot++
Polyxena species; Hyacinthaceae	Cape hyacinth	Pot+
Protea aristata E.Phillips; Proteaceae	Ladismith protea	F+(unpleasant odor)
Protea compacta R.Br.; Proteaceae	Bot river protea	F+++
Protea cynaroides (L.) L.; Proteaceae	King protea, giant protea	F+++, D++, Pot++
Protea effusa E.Mey. ex Meins.; Proteaceae		F++, D++
Protea eximia (Salisb. Ex Knight) Fourc.; Proteaceae		F+++, D++, Pot++
Protea grandiceps Tratt.; Proteaceae		F++, D++
Protea laurifolia Thunb.; Proteaceae		F+++, D+++
Protea lacticolor Salisb.; Proteaceae		F++, D++
Protea longifolia Andrews; Proteaceae		F++, D++
Protea lorifolia (Salisb. Ex Knight) Fourc.; Proteaceae		F++, D++
Protea magnifica Link; Proteaceae	Queen protea	F+++, D++
Protea mundii Klotzsch; Proteaceae		F++, D++
Protea nana (P.J.Bergius) Thunb.; Proteaceae		Fol++, D++
Protea neriifolia R.Br.; Proteaceae	Bearded protea, oleander leaf protea	F+++, D++
Protea obtusifolia H.Buek ex Meins.; Proteaceae		F+++, D++
Protea pityphylla E.Phillips; Proteaceae		F++, D++
Protea repens (L.) L.; Proteaceae	Sugarbush, sugar protea	F+++, D++
Protea scolymocephala (L.) Reichard; Proteaceae		F++, D++
Protea speciosa (L.) L.; Proteaceae		F++, D++
Protea susannae E.Phillips; Proteaceae		F+, D++ (leaves with unpleasant odor)

Table 1 (*continued*)

Species and family	Common and/or commercial name(s)	Use and/or potential use: + = low or none, ++ average, +++ = high
Pteronia paniculata Thunb.; Asteraceae	Gum bush, *gombossie*	Fol+
Retzia capensis Thunb.; Stilbaceae	Honeyflower, *heuningblom*	Fol+(Red data species; cultivated material only)
Rhodocoma species; Restionaceae	Restios	Fol++
Rhodohypoxis baurii (Baker) Nel; Hypoxidaceae	Red star, rosy posy, spring starflower	Pot+++
Romulea species; Iridaceae	Romulea	Pot+++
Rumohra adiantiformis (G.Forst.) Ching; Dryopteridaceae	Leather fern, leatherleaf fern, baker fern, iron fern, seven week fern	Fol+++
Sandersonia aurantiaca Hook.; Colchicaceae	Christmas bells, chinese lantern lily	F+++, Pot+++
Sansevieria trifasciata Hort. ex Prain; Dracaenaceae or Asparagaceae	Mother-in-law's tongue, bowstring hemp	Fol+++, Pot+++
Serruria florida (Thunb.) Salisb. Ex Knight; Proteaceae	Blushing bride, spiderheads	F+++, D+++, Pot++
Serruria rosea E.Phillips; Proteaceae	Spiderheads	F+++, D+++, Pot++
Sorghum bicolor (L.) Moench; Poaceae	Sorghum, great millet, broomcorn	Fol+
Sorghum nigrum Roem. and Schult.; Poaceae	Black millet, black sorghum, black witches' broom	Fol++
Sparaxis tricolor (Schneev.) Ker Gawl; Iridaceae	Sparaxis, harlequin flower	F+++, Pot++
Spiloxene species; Hypoxidaceae	Cape star	Pot+++
Staavia radiata Dahl; Bruniaceae	Glass eyes	Fol+++
Stoebe plumosa Thunb.; Asteraceae	Stoebe	Fol++, D++
Stoebe vulgaris Levyns; Asteraceae	Bankrupt bush	Fol++, D++
Strelitzia reginae Banks; Strelitziaceae	Bird-of-paradise, crane flower	F+++, Fol+++
Streptocarpus × hybridus; Gesneriaceae	Cape primrose, florist streptocarpus	Pot+++
Strumaria species; Amaryllidaceae	Cape snowflake	Pot++
Syncarpha vestita (L.) B.Nord.	White everlasting	F+++, D+++
Syringodea species; Iridaceae	Cape crocus	Pot+
Thamnochortus insignis Mast.; Restionaceae	Shell reed	Fol++, D++
Thunbergia alata Sims; Acanthaceae	Black-eyed Susan vine	Pot++
Trichocephalus stipularis (L.) Brongn. (=*Phylica stipularis* L.); Rhamnaceae	Hairy heads	Fol++, D++
Tritonia crocata Ker Gawl.; Iridaceae	Tritonia, flame freesia, garden montbretia	F++, Pot++
Tritonia cultivars; Iridaceae	Blazing star, garden montbretia	F+++, Pot+++
Tulbaghia simmleri Beauverd; Alliaceae	Broad-leaved wild garlic	F+++, Pot+++
Tulbaghia violacea Harv.; Alliaceae	Wild garlic	F++, Pot++
Tylecodon species; Crassulaceae	Miniature baobab	Pot++
Veltheimia species; Hyacinthaceae	Sand lily	Pot+++
Venidium fastuosum Stapf; Asteraceae	Cape daisy, monarch-of-the-veld	F++
Wachendorfia species; Haemodoraceae	Butterfly lily	F++
Walleria species; Tecophilaeaceae	Potato lily	Pot+
Watsonia cultivars; Iridaceae	Watsonia, bugle lily	F+++
Wurmbea species; Colchichaceae	Spider lily	Pot++
Zantedeschia aethiopica (L.) Spreng.; Araceae	Calla lily, arum lily	F+++, Pot++
Zantedeschia albomaculata (Hook.) Baill; (=*Z. melanoleuca* (Hook.f.) Engl.); Araceae	Calla lily, arum lily	F++, Pot++
Zantedeschia elliotiana (W.Watson) Engl.; Araceae	Calla lily, arum lily	F++, Pot++
Zantedeschia jucunda Letty; Araceae	Calla lily, arum lily	F++, Pot++
Zantedeschia pentlandii (R.Whyte ex W.Watson) Wittm.; Araceae	Calla lily, arum lily	F+++, Pot+++
Zantedeschia rehmannii Engl.; Araceae	Calla lily, arum lily	F+++, Pot+++

in under-developed countries. It is seen as a priority that the South African development of *Lachenalia, Ornithogalum, Eucomis* as well as Proteaceae for the key export market (60%) should be diversified to other markets. Promoting the development of the floriculture sector in developing countries not only assist in biodiversity conservation, but also lead to improved levels of employment and income (Baudoin et al., 2007). The monetary value of sales based on flowers of southern African origin however, does not currently provide a large enough source of income to justify major new research projects in South Africa. Furthermore, the South African indigenous flower trade is not yet fully regulated as an industry enterprise and is historically focused on the local market. International trends in increased transport cost, concern about carbon footprints, higher labor costs in South Africa compared to other large-scale producing countries and the economic crises since 2009 impacted negatively on the South African flower trade.

Successful commercialization of South African plants does not rely only on their unique esthetic features and attractiveness (Fig. 1; the main selection criteria for the choice of several species listed in Table 1), but in order to compete on international flower markets, they need to be true to type, available in large quantities for a relatively long marketing period, and have an acceptable vase life. This requires sustainable propagation and

cultivation practices with effective plant protection measures to control pests and diseases.

3. Research and development

Research on indigenous cut flowers and related products has been ongoing for many years, both by formal research institutions, as well as by private interests. The ARC's Vegetable and Ornamental Plant Research Institute at Roodeplaat, and previously the Department of Agriculture, has the national mandate to investigate cultivation and breeding aspects of indigenous plants (NIGS publication list 1934–1986, compiled by A. Nortjé, internal document, unpublished; ARC-Roodeplaat Research Report 1949–1999, ARC, Pretoria, unpublished). Hence numerous cultivars of *Lachenalia, Ornithogalum* have been released, supported by scientific publications, leaflets and presentations. When selected plants are released as selections or cultivars, their cultivation methods are supplied to potential growers. Research on fynbos and especially Proteaceae was based at the ARC research unit at Elsenburg near Stellenbosch, where new selections and cultivars have been developed. The program was initiated in 1974 by the Department of Agriculture after the first pioneering research by Dr Marie Vogts at Oudebosch near Betty's Bay, from 1960 to 1974. The fynbos research project expanded to

Fig. 1. Examples of South African contributions to the international cut flower industry. 1A, *Protea cynaroides* white cultivar; 1B, *Protea cynaroides* 'Madiba'; 1C, *Protea* 'Sylvia'; 1D, *Leucospermum* 'Rigoletto'; 2A, *Leucadendron* 'Buyani'; 2B, *Leucadendron* 'Falaza' (pot plant type); 2C, *Orothamnus zeyheri*; 2D, *Mimetes hirtus*; 3A, *Nerine* cultivars; 3B, *Clivia miniata*; 3C, *Agapanthus praecox*; 3D, *Crocosmia* × *crocosmiiflora*; 4A, *Disa uniflora*; 4B, *Eucomis autumnalis*; 4C, *Gloriosa superba*; 4D, *Rhodohypoxis baurii*. Photographs: 1A-D, 2A-C and 3A by E. Reinten; all others by B-E. van Wyk.

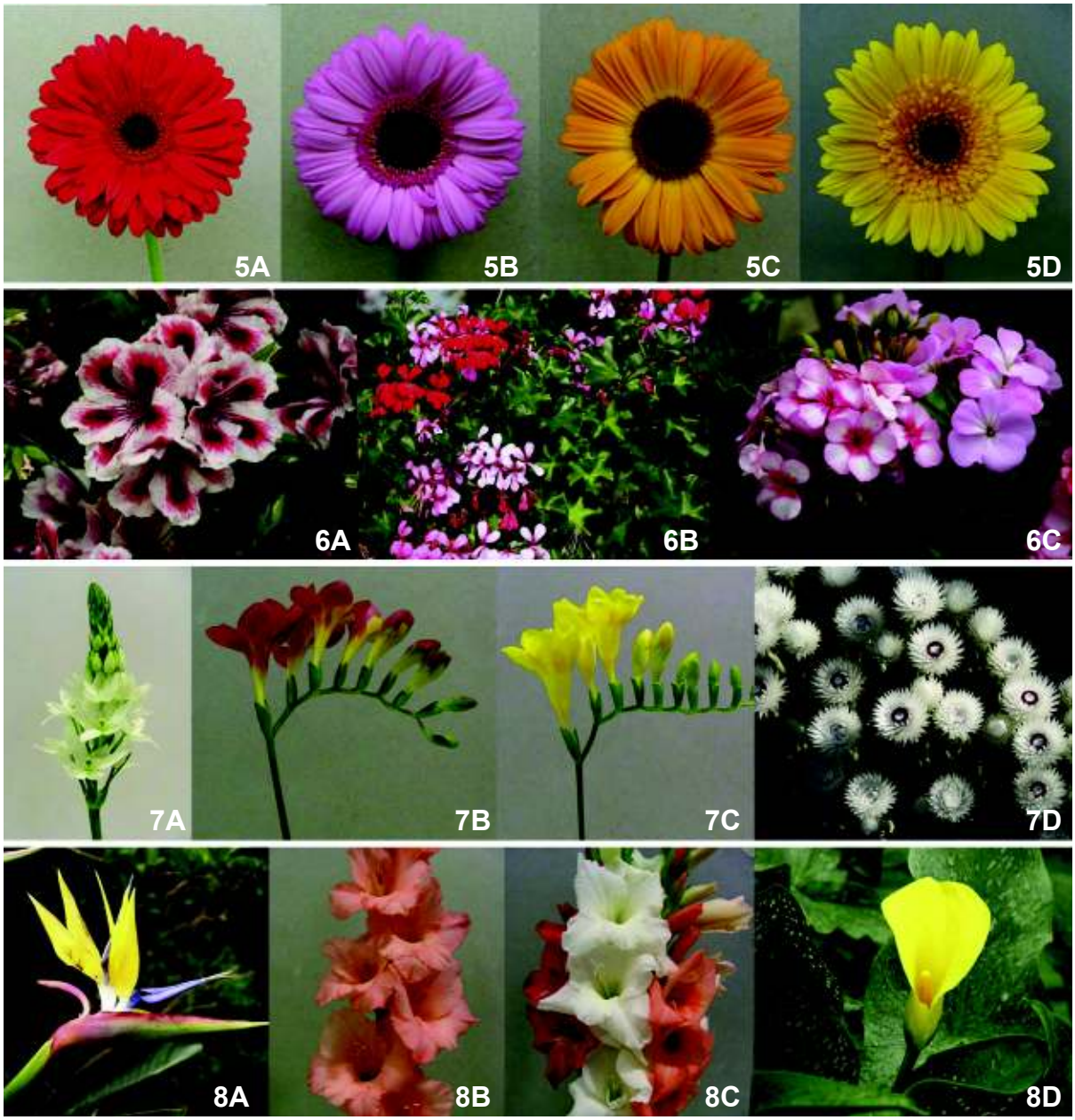

Fig 1 (*continued*). 5A-D, Modern *Gerbera* cultivars; 6A, *Pelargonium* × *domesticum*; 6B, *Pelargonium peltatum*; 6C, *Pelargonium zonale*; 7A, *Ornithogalum* cultivar; 7B,C, *Freesia* cultivars (red and yellow); 7D, *Syncarpha vestita*; 8A, *Strelitzia reginae* (yellow cultivar); 8B,C, *Gladiolus* cultivars; 8D, *Zantedeschia* cultivar. Photographs: 6A-C, 7D and 8A by B-E. van Wyk, all others by J Maree.

Tygerhoek Experimental Farm at Riviersonderend and since 1988 to the Elsenburg Experimental Farm. The first cultivar released by Dr Gert Brits was *Protea repens* 'Guerna'. Breeding continued and concentrated on interspecific hybrids with objectives to release "product lines" for longer flowering times, adaptability to cultivation and horticultural systems. Genetic resource conservation of economic important fynbos plant material is housed in a living and potted genebank (ARC-Roodeplaat Research Report 1949–1999, Pretoria, unpublished).

Research on indigenous plants has also been conducted at Universities to understand the potential of indigenous flora. Aspects being investigated include propagation by conventional means such as cuttings or seeds (Brits, 1987; Malan, 1992; Van Staden and Brown, 1977) or tissue culture (Jacobs et al., 1992; Liu et al., 2006; Rugge, 1995; Wu and Du Toit, 2010), cultivation methods (Schmeisser et al., 2010; Theron and Jacobs, 1992) and post-harvest physiology (Hannweg, 2004; Ferreira, 2005; Stephens et al., 2005). Valuable information on combating pests and diseases has also emanated from these research efforts (Bezuidenhout et al., 2010; Lubbe et al., 2004, 2006a,b; Marincowitz et al., 2008; Swart et al., 1998). A study by Crous and Groenewald (2011) found a wide range of microfungi in senescent *Phaenocoma prolifera* flowers and suggested that these may contribute to a loss of flower quality in both wild-harvested and cultivated flowers from the Cape Floral Region, especially when the products have to be transported over long distances.

Controlling the fungi may help to improve post-harvest quality. In addition, individual farmers and flower companies (www.futurefynbos.com/) are involved in research and development of indigenous flora for the cut flower market, especially to gain niche markets. The number of cut flower species being exported from various parts of the world has increased dramatically in recent years, apparently to satisfy a growing need for exciting novelty products (Maree and Van Wyk, 2010), but the trade figures include traditional flowers such as roses, carnations and chrysanthemums, so that the contribution of indigenous species are difficult to estimate. The cultivation and commercialization of indigenous plants for use as cut flowers or potted ornamentals have also been investigated by the South African Biodiversity Institute at Kirstenbosch (Brown and Duncan, 2006). There are notable success stories, such as the release of *Strelitzia reginae* 'Mandela's Gold', but there are still numerous indigenous genera and species that are in need of research and development (Table 1).

Breeders of bulbous plants have mostly relied on the selection of attractive mutants in the field or mutations induced by irradiation and other methods to broaden the range of forms and colors available (Krens and Van Tuyl, 2011). New market entries are constantly needed to satisfy the demand for novelty. Kleynhans (2011) compared successes from conventional breeding with the use of mutation technology. Hyacinthaceae members such as *Lachenalia, Ornithogalum, Eucomis* and *Veltheimia* are especially suitable for mutation breeding because new plantlets can be generated from single cells in leaf tissue using a combination of modern tissue culture techniques (Kleynhans, 2011). Several researchers have used indigenous floral crop plants for studies on micro-propagation with interesting contributions to science (Hannweg et al., 1996; Mycock et al., 1997; Niederwieser and Kleynhans, 1992). Niederwieser et al. (2002a) provided results of extensive studies on the potential of commercialization of certain Amaryllidaceae. Their results indicated difficulties with cultivation, flower initiation and vase life, as well as a lack of uniformity of bulb size and limited color diversity. These are important obstacles in the development of new flower crops suitable for large-scale commercialization. A detailed practical study conducted by Thompson et al. (2011) on *Watsonia*, normally used as a border plant in gardens, revealed that flowering success was not related to corm mass, but rather to the environment under which the corm was stored, or the conditions under which the plant was grown. The value of this type of study is that the relationship between climate and flowering is better understood.

The advancement of biotechnology techniques, which started out as tissue culture methods for large scale plant multiplication, has developed to a point where in vitro breeding techniques are now applied to generate novel genetic combinations (Morgan et al., 2009). Ruffoni et al. (2011) used a combined protocol of in vitro propagation and in vivo corm enlargement for new *Gladiolus* hybrids. Molecular techniques are used to develop transgenic plants (De Villiers et al., 2000) but a detailed review is not attempted here. Flow cytometry is currently used for ploidy analysis in plant breeding, not only to determine ploidy levels and genome sizes but also to evaluate the hybrid origin of seedlings (Leus et al., 2009). The application of biotechnology in South African bulbous plants was reviewed by Fennel and Van Staden (2004) and Niederwieser (2004). According to Moyo et al. (2011), South Africa has an opportunity to develop efficient and competitive plant biotechnology sectors. The process of plant barcoding, using certain DNA regions to identify plant material, could in future assist in cultivar development.

Requirements for the successful research and development of under-utilized floriculture crops were outlined by Niederwieser et al. (2002b). The process depends on sustainable funding over a long period and a multi-disciplinary team of breeders, horticulturists, plant pathologists and post-harvest experts working in close collaboration with commercial growers and marketing agents. Training and technology transfer are also important considerations for the long term development of the South African economy, so that public funding seems to be an important priority. The conservation of biodiversity by maintaining gene banks is an important responsibility of society (Littlejohn and De Kock, 1997; Niederwieser et al., 1998) and goes hand in hand with the need for logistic and financial support at a national level to develop a well-organized and more market-driven floriculture industry in South Africa.

3.1. Cut flowers

Most aspects of research on indigenous flower production have been reported extensively at national and international conferences. *Gerbera*, *Freesia* and *Gladiolus* have been especially important contributions to the horticultural world (Lewis et al., 1972; Wilfret, 1980), with hybrid flower sales currently or historically in the top 10 of total cut flowers sold annually on international markets. *Gerbera aurantiaca*, the rare and endangered Hilton Daisy (Johnson, 2010) and the vulnerable *Gladiolus scabridus* (Campbell and Bower, 2003), are just two examples of species with considerable commercial potential in cut flower breeding.

Research on fynbos, and especially the commercialization of *Protea*, *Leucadendron*, *Leucospermum*, *Serruria*, *Mimetes* and other Proteaceae for the cut flower market, has been well described (Littlejohn, 2000; Mortimer et al., 2002; Reinten and Coetzee, 2002). The International Society for Horticultural Science (ISHS) reprinted the reviews (in Horticultural Reviews, by editor Jules Janick) on the most important commercial Proteaceous ornamentals. These are for *Leucadendron* by Ben-Jaacov and Silber in 2006, *Leucospermum* by Criley in 1998 and *Protea* by Coetzee and Littlejohn in 2001 (ISHS, 2007). To date, 90 Proteaceae cultivars and selections have been released by the ARC (personal communication, L. Blomerus). Diseases associated with indigenous cut flowers, an important phytosanitary constraint to exports, have also been under investigation (Bezuidenhout et al., 2010; Lubbe et al., 2006a,b; Venecourt et al., 2003). According to Littlejohn (2000), the genetic resources of the southern African Proteaceae are major contributors to the commercial Proteaceae products traded in the international floriculture market, but a concern is the lack of consistent long term funding. The *Protea* industry in South Africa is changing rapidly as a result of improved

transport methods and new innovative export systems (Kras, 2010). Registration of new cultivars of proteaceous ornamentals by the International Protea register is web-based: www.nda.agric.za/docs/GenPub/IPR2010.pdf. Fynbos products, and especially Proteas, have for many years been a known export product from mostly the Western Cape. This existing export has more potential, and will increasingly find its own place in a wide array of floricultural products (Kras, 2010). As a result, the South African Proteaceae have become the subject of international research interests. Venecourt and Allemand (2003) described similarities and differences in cultivating pincushions and proteas in France and South Africa. Micropropagation by French researchers (Thillerot et al., 2006), and Australian researchers (Croxford et al., 2006) on South African fynbos is ongoing. At the University of La Laguna in Spain, Rodríguez-Pérez et al. (2009) continue with extensive basic research on Proteaceae, with investigations focused on cultivation methods. Internationally, there is an increase in the breeding of Proteaceae (Passarinho et al., 2008; Leonhardt et al., 2008).

It seems likely that more and more South African flowers will find their way to international cut flower markets. There is considerable research interest in selecting new species and breeding new cultivars of *Agapanthus*, *Bulbinella*, *Crocosmia*, *Disa*, *Eucomis*, *Erica*, *Ixia*, *Mimetes*, *Nerine*, *Ornithogalum*, *Serruria*, *Sparaxis*, *Strelitzia*, *Tulbaghia*, *Watsonia* and *Zantedeschia* for the cut flower industry. The orchid genus *Disa*, comprising of more than 130 species, is increasingly sought after as a cut flower and potted plant, so that research on its cultivation (Crous and Duncan, 2006; Pienaar and Combrink, 2007) has become an important priority. Research on the propagation, cultivation and post-harvest handling of indigenous plants is on the increase as the commercialization process continues.

3.2. Potted flowers

South African plants grown as potted flowers are sold in nurseries and florist shops worldwide. Among the most popular and conspicuous in Europe are cultivars of *Pelargonium zonale* and *P. peltatum*, the basis of an industry worth many millions of euros per annum. Potted flowers have become an important part of the florist trade (Maree and Van Wyk, 2010) and interesting new cultivars are being developed for this expanding market.

In South Africa, flowering potted plants of distinctive varieties of indigenous *Plectranthus* (Lamiaceae) have been developed by breeding and horticultural adaptations, mostly for the international market (Brits et al., 2001), resulting in compact, floriferous plants with large flowers and beautiful foliage. The genus *Ornithogalum* has also been the subject of local breeding efforts at ARC-Roodeplaat (Littlejohn, 2006), with a total of eight cultivars released up to date (Personal communication, R. Kleynhans). To overcome problems with *Ornithogalum* mosaic virus, an attempt was made to develop resistant transgenic plants (De Villiers et al., 2000).

Lachenalia research at ARC-Roodeplaat, and other institutions, has resulted in the release of 29 cultivars (personal communication, R. Kleynhans). Cultivation and handling methods to improve bulb storage, bulb preparation, and growing regimes have been extensively investigated (Claassens, 1990; Coertze et al., 2001; Du Toit et al., 2001, 2002; Engelbrecht et al., 2008, 2010; Kleynhans and Spies, 1999; Kleynhans et al., 2002, 2009; Kleynhans, 2006; Niederwieser, 2000; Roodbol and Niederwieser, 2002; Roodbol et al., 2002; Spies et al., 2008). The aim was to improve the crop and to overcome the problems posed by switching from southern to northern hemisphere climatic regimes. Kleynhans (2009) discussed in depth the need for utilizing basic research and the principles of genetics in the breeding of *Lachenalia* but also highlighted the importance of practical aspects such as the collection of germplasm, the physical and genetic characterizations and evaluation of germplasm (for creating variation) and the establishment of selection criteria. The knowledge and experience of both breeders and market evaluators are essential in new crop development. Although Kleynhans (2009) used *Lachenalia* as a case study, her observations are valid for all new floricultural crops. Most South African crops have not yet been researched in all basic aspects, thus there are many remaining questions relating to the breeding, propagation, cultivation and post-harvest treatment of indigenous plants.

The use and cultivation of indigenous bulbs, including large-scale production for exports, were boosted in South Africa by Hadeco (Barnhoorn, 1995). South Africa is exceptionally rich in geophytes (Manning et al., 2002), so that many more bulbous plants are likely to become commercially available as potted flowers. The most likely candidates (some based on appearance only) are listed in Table 1. These include species of *Albuca, Androcymbium, Aristea, Babiana, Bulbinella, Cyanella, Cyrtanthus, Daubenya, Empodium, Eucomis, Ferraria, Freesia, Geissorhiza, Gethyllis, Gladiolus, Haemanthus, Hesperantha, Hessea, Hypoxis, Ixia, Lachenalia, Lapeirousia, Ledebouria, Massonia, Moraea, Nerine, Ornithogalum, Ornithoglossum, Polyxena, Rhodohypoxis, Romulea, Sparaxis, Spiloxene, Strumaria, Syringodea, Tritonia, Tulbaghia, Veltheimia, Wachendorfia, Walleria, Watsonia* and *Wurmbea*. From this long list is evident that there is an almost limitless potential for developing new horticultural crops for the trade in potted flowers. Some attractive species are presently considered to be unsuitable because of practical difficulties relating to propagation, cultivation, irregular flowering, short flowering periods and other seemingly insurmountable obstacles. However, it is likely that the premium on novelty will increase in the future and that modern biotechnology will be used to overcome inherent flaws in order to create viable new crops.

Daly and Henry (2009) reported that potted geophytes as winter-blooming house plants are in demand for the USA market and gave results of an evaluation of *Gladiolus, Freesia, Ornithogalum, Babiana, Ixia, Ledebouria, Oxalis, Sparaxis, Tritonia, Aristea, Drimiopsis, Veltheimia, Watsonia* and *Lachenalia,* either as species or cultivars. Temperature-controlled greenhouse studies (Ehlers et al., 1998) were used to manipulate flowering and indicated variations between clones. Ehrich et al. (2007) reported on forcing South African Iridaceae as potted plants in Berlin, Germany, by manipulating the temperature regime and by transporting the bulbs between hemispheres to save energy and reduce production time. The unique *Sandersonia aurantiaca*, popularly known as Christmas bells or Chinese lantern

lily, has been extensively researched in New Zealand (Morgan et al., 2002), including aspects of cultivation, tuber storage and post-harvest treatment. Morgan et al. (2009) reported that *Sandersonia* seedlings show very little phenetic variation and that attempts are made to increase variation through hybridization with the related genera *Littonia* and *Gloriosa*. Some cultivars of *Aloe* are suitable for containers, such as the best-selling *Aloe* 'Hedgehog' that was released in 2006 (De Wet and Bean, 2011). After many years of local breeding efforts, more than 30 named *Aloe* cultivars have recently become available in South Africa. Success can be ascribed to a careful consideration of market demand in the selection criteria (in this case the requirements of landscape architects). Also of interest is the rich diversity of miniature succulents, which are ideally suited for container cultivation, including the genera *Argyroderma, Conophytum, Gibbaeum* and *Lithops* (Aizoaceae), *Adromischus*, *Crassula*, *Kalanchoe* and *Tylecodon* (Crassulaceae) and *Haworthia* (Xanthorrhoeaceae).

3.3. Foliages ("greens")

Products marketed as foliage or florist "greens" include bamboos, sedges, reeds, ferns and grasses. Fynbos "greens" and similar products from Australia (leafy stems with or without small flowers) are sometimes included in this category (Maree and Van Wyk, 2010). In the period 2002/3 to 2008/9, South African export figures for proteas and Cape fynbos dropped from 4 400 000 to 3 400 000 kg exported, while all flora exports (this includes cut flowers, ferns, orchids, reeds and grasses, as well as proteas and Cape fynbos, that amounted to 6 800 000 kg exported in 2002/3 and 7 200 000 kg in 2004/5, declined to ca. 5 000 000 kg in recent years (PPECB export directories for 2008 and 2010, available from www.PPECB.com). This is mostly attributed to air freight costs that have become prohibitive due to the long distances involved and the relatively low value of these products. Species of the Cape Restionaceae, although sometimes not considered to fit strictly into the category of "greens", are selected for ornamental pot and patio plants (May et al., 2007) and are in demand in the United Kingdom.

4. Conclusions

South African plants have made a substantial contribution to the world trade in ornamental plants and cut flowers, and are continuing to do so. A rich genetic resource is available for further development and hybridization. The local turnover in floriculture is unfortunately insufficient to allow for large and ambitious new breeding programs and research initiatives, so that public funding is required to stimulate growth in this potentially important industry. Success is likely to come from a more market-driven approach as opposed to the product-driven strategies of the past. There is also an urgent need for planning and coordination at national level to maximize the opportunities presented by the exceptionally rich floral wealth of South Africa and to ensure that local people benefit from this potentially valuable resource.

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