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Full Length Research Paper

Cultivars, conduction, photoperiodic and quality chrysanthemum in Brazil

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Chrysanthemum is classified as one of cut flowers with great variety of colors and inflorescences. This review aims at presenting the cultivars, as well as detailing the conduction, photoperiod and quality of chrysanthemum in Brazil. It concludes that the reaction time required for the induction of flowering until the early opening of the flowers varies among cultivars. The method of conduction varies according to the consumer market. The quality parameters established in the flowers are fundamental to the selection criteria.

Key words: Flowers, quality, production, *dendranthema morifolium* (Ramat.).

INTRODUCTION

The production and marketing of flowers and ornamental plants in Brazil acquired a commercial scale from the 50s through the Portuguese immigrants (Rodrigues, 2005). In the 60s, the activity increased with the Japanese and Dutch immigrants mainly in the state of São Paulo. In 1989, the emergence of Velling Holambra (auction system in marketing, deployed in Holambra Agricultural Cooperative Ltd. - Holambra, SP - State) influenced the evolution of the internal market, which led to 20% increased production per annum (Barbosa, 2003).

Chrysanthemum is one of the most important ornamental crops worldwide and is produced both as cut flower and as pot plant. Year-round production can be

achieved in greenhouses by controlling climate conditions. In the winter months, especially in more northern latitudes, this means that high energy inputs are required because the greenhouses must be heated in order to maintain good plant quality and production levels (Van Der Ploeg and Heuvelink, 2006). The consumption of chrysanthemum in Brazil is due to its wide variety of colors, shapes, size and durability of its flowers, but also in virtue of the possibility of production throughout the year (Ball and Higgins, 1997). This review aims presenting the cultivars, as well as detailing the conduction, photoperiod and quality of chrysanthemum in Brazil.

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CHRYSANTHEMUM

The florists chrysanthemum *dendranthema* x or *grandiflorum* (Ramat.) Kitam. (syn. *D. grandiflora* Tzvelev., *D. morifolium* Ramat., and *Chrysanthemum morifolium* Ramat.), family Asteraceae, is a complex hybrid produced by seeds and segregates in different ways. Most of the species that make up the lines of current cultivars is original from Asia, particularly China (Kofranek, 1992). The word "Chrysanthemum" means golden flower, coming from the Greek "chrysos" gold and "antheon" flower. There are reports of its cultivation for over 2,000 years as a garden plant in Asia and it is considered the national flower of Japan (Gruszynski, 2001). France stood out in the past by creating new cultivars. Currently, the United States is more developed in the studies to obtain new cultivars (Petry, 2000).

Chrysanthemums are perennials, branched stems and pubescent, rarely more than 1 m in height. Its leaves are oval, irregularly cut and flowers gathered in chapters apical or axillary, with discs and central yellow ligules (petals) of multiple colors, depending on the variety. In general the hybrid forms have bent sections, the long ligules and often intriguingly curved. The colors, though based in white, yellow, purple and red tones, can be presented in myriad shades. Thousands of hybrids of chrysanthemum are classified into three major groups for convenience of horticulturists: chrysanthemums tubular, with ligules shaped thin tubes; globular chrysanthemums with curved ligules back, which gives the inflorescence the form of a sphere, though not always perfect and, Japanese chrysanthemums, with ligules long spirally arranged slightly. All night flowers during the months of long and short days have negative photoperiod (Borges, 1995).

Chrysanthemum is actually a composite inflorescence, with flowers born in a receptacle or chapter (Borges, 1995). The most common forms of inflorescences include: a) single or daisy-like, consisting of one or more rows of pistillate external (petals) and inner flowers in a central flat disk; b) Anemone or sunflower, similar to the simple but central disk flowers are tubular and elongated; c) pompons, globular inflorescences, formed by small petals, the flowers of the inner disk are not apparent; d) Similar to decorative pompons, composed primarily of female flowers, but the outer petals are longer than the inner one, giving a flattened appearance; e) spider, and spaghetti fuji, inflorescences similar to decorative but more flattened and the outer petals quite long and tubular, and in some cases, alternating longer and shorter; f) ball or standard is a decorative type, with curved petals giving a globular (Gruszynski, 2001).

Cultivar classification

Cultivars with flowers of simple type groups belong to

Reagan, Rex and Repin, the decorative type, groups Tinsel and Polaris, the tubular 'Super White', 'Super Yellow' and 'Recital'; ball type, 'Snowdon' and pom-pom type, 'Funshine', 'Yoko Ono', 'Statesman' and 'Faroe' (Gruszynski, 2001).

As for the number of flowers per stem, chrysanthemums are cultivated in two basic ways, according to the market demand and variety: a) "disbuds" or the withdrawal of secondary flowers on each stem is left only to the terminal flower, removing the lateral buds; b) "spray": is made only from the central flower removal, which usually would open before the other, thereby allowing the other to develop more evenly. As for the number of stems per changes are: a) single rod, only one rod per seedling planted; b) multiple stems, several rods, usually 3 to 5 per seedling planted main stem, which is obtained by sprouting stimulated by the lateral removal of the apical meristem (Motos and Oliveira, 1999; Gruszynski, 2001).

Growth phase and conditions

Chrysanthemum is classified as a short-day plant that is naturally induced to flowering periods of days less than 14:30 h light, they vary according to the variety and temperature Tolloti (2001). To keep plants' vegetative growth, allowing them to achieve the desired stem height, they are lit at night. Note that one should never leave a period longer than four hours without lighting (Gruszynski, 2001). Long days should be continued until the plant reaches the desired height, depending on the market.

After the vegetative growth phase, begins the induction phase to flowering. At this stage, the short days may be obtained either naturally (in the winter months in higher latitudes from 25 to 40° South - March-September) as artificially generally through the use of curtains polyethylene (plastic) or black cloth. Plants should be in the dark for at least 12 h. Another important definition is the reaction time, which is the period measured in weeks, required between the start of induction of flowering until early opening flowers (Gruszynski, 2001). Reaction cultivars group of 6 weeks take six weeks from the start of short days until flowering, varieties have from 6 to 15 weeks of reaction time, commercially lie between 7¹/₂ and 11 weeks for cutting (Bellé, 2000; Gruszynski, 2001). Plants with slow reaction time too slow to be produced and its cultivation is generally not economically feasible (Gruszynski, 2001). Already on Holambra-SP/State producing region, cultivars of pot-chrysanthemum are classified differently: early cultivars are those with blooming in a period 7 to 8 weeks, medium, flowering between 8 to 9 weeks and, the late cultivars are those with blooming above 9 weeks of short day length (Royal Van Zanten, 2004). Karlsson et al. (1989), studying the effects of radiation and temperature on the chrysanthemum

cycle, found that the time needed to flowering in short days decreased with increasing radiation, and for a constant temperature of 20°C, the time necessary for the bud apical bloom decreased 29 days with increasing radiation. Arbos (1992) observed that the minimum temperature of 11°C or less, depending on the cultivar in the production of chrysanthemums, can bloom during the day since temperature is equal to or higher than 16°C which occurs in response to temperature conditions; Cathey (1954), cited by Larson (1997) and Tombolato (2004), classifies the cultivars of chrysanthemums into three groups: thermopositive - cultivars that require nighttime minimum temperatures of 16°C to flourish; thermonegative - includes cultivars that bloom with night temperatures not exceeding 16°C and thermozero, cultivars that normally bloom in night temperatures between 10 and 27°C. During production, high temperatures in the range of 27 to 32°C may influence the growth of some cultivars, causing delay of induction, floral abnormalities and uneven flowering. The severity of damage still depends on the exposure time and the tolerance of cultivars to these temperature conditions (Whealy et al., 1987).

Growing of bottled chrysanthemum should be performed in sunny locations because the inflorescences are small and very thin branches when with over-shadowing, reducing the pots quality (Arbos, 1992; Gruszynski, 2001; Rodrigues, 2005). The need for greenhouse to chrysanthemum production is not only due to allow for the control and uniformity of flowering, but also by the weather conditions, such as protection against torrential rain, hail, strong winds, besides more effective pest control in protected environments, which the culture is extremely sensitive (Miranda et al., 1994). The balance between the parameters, height, leaf area, size of flowers and size of stems leads to a relationship between plant, flower and pot in the formation of aesthetics that is assessed by what is called quality (Tolotti, 2001).

The quality of a product is defined as a set of attributes that make this product into salable. The acceptability of these products by consumers is evaluated based on visual characteristics such as size, shape, and condition (health, turgor and maturity) (Magalhães et al., 2005). Effects of temperature on number of leaves: Leaf unfolding rate shows an optimum response (optimum around 25°C) to 24 h average temperatures between 12 to 28°C (Larsen and Hiden, 1995; Carvalho et al., 2002), but this optimum response was shown to be stronger when considering day temperature alone (Carvalho et al., 2002). Another report, using 17 cultivars, suggests a linear rise with increasing day temperature and night temperature (De Jong and Smeets, 1982). However, the temperature range in that experiment was smaller (10 to 17°C) and well below the optimum temperature reported. In stem elongation, total stem-length is determined both by the number of internodes (that is, number of leaves)

and by internodes length (Pearson et al., 1995). During the light/dark (LD) period, stem longation is reduced at lower average temperatures, due to a decreased number of internodes and decreased internodes length (De Jong and Smeets, 1982). It is unclear whether this response is the same for all cultivars. De Jong (1982) concluded, for 25 cultivars grown at 14 and 20°C average temperatures, that stem-length was influenced by the interaction between average temperatures and cultivar. Internode length is dependent on the difference between day temperature and night temperature (that is, DIF). Plants grown under a negative DIF have shorter internodes compared to plants grown under a positive DIF, at the same average temperatures (Karlsson et al., 1989c; Bertram, 1992; Carvalho et al., 2002). However, Langton and Cockshull (1997) concluded that internode length of Bright Golden Anne' could not be explained by DIF, but their experiment lasted only 10 days, so that the internodes had not yet fully elongated. This can explain why their findings conflict with the majority of other authors, as shown by Carvalho et al. (2002).

Temperature has a significant influence on this trait, especially in winter conditions when light levels are low. In general, time to flowering shows an optimum response to temperature usually between 17 and 22°C, depending on the cultivar (Hiden and Larsen, 1994; Adams et al., 1998; Persson and Larsen, 1998). Some researchers have investigated the effect of temperature applied at different phases of the cultivation period. Temperature during the LD period has no influence on time to flowering (De Jong and Smeets, 1982; Wilkins et al., 1990). The SD period can be divided into a period of flower initiation and a period of flower development (Karlsson et al., 1989a), and both are sensitive to temperature. There is also an interaction between light and temperature. In spring, a higher number of lateral shoots was found with increasing temperature, while in winter no effect of temperature was found on lateral shoot number (Schoellhorn et al., 1996).

Over a large range of cultivars and temperatures (14 to 26°C), the diameter of individual flowers on plants that grew at lower temperatures was higher (Bonaminio and Larson, 1980; Tsujita et al., 1981; Willits and Bailey, 2000; Nothnagl et al., 2004; Carvalho et al., 2005). However, there were differences between cultivars in the extent of this response. The effect of sub-optimal temperatures on individual flower size is mainly a result of the extended growth period of the flower, as the growth rate is only marginally affected (Nothnagl et al., 2004). It is therefore likely that, under higher light conditions when the cultivation period is not so extended by temperature, flower size is also less affected by temperature. In fact, Carvalho et al. (2005) found an increased flower size at 17°C compared to 21°C in a winter greenhouse experiment, where the growth period was extended by 7 days, while in a climate room experiment with higher light conditions, no effect of temperature on flower size was

found between 15 and 24°C. In the latter experiment, the cultivation period was extended by only 2 to 3 days.

Records on the effects of temperature on total biomass at flowering are contradictory. Total plant mass was found to decrease (Karlsson and Heins, 1992), remain constant (Tsujita et al., 1981; Carvalho et al., 2005) or to increase (Tsujita et al., 1981; Lepage et al., 1984) with decreasing temperatures. Because temperature influences plant development, it also influences partitioning of assimilates to different plant organs. This should be reflected in the effect that temperature has on the mass of individual plant organs. In Dutch greenhouses, decreasing the temperature set point from 20 to 18°C reduces energy consumption by 20% on an annual basis (Korner, 2003). One obvious character to look for when breeding a more energy efficient chrysanthemum cultivar is no delay, or is reduced delay, in flowering at sub-optimal temperature under low light conditions. There is a large variation between chrysanthemum accessions for this trait, which makes it possible to select cultivars in which the cultivation period at sub-optimal temperatures is less delayed. In the 1980s, when oil prices were high, research focused on reducing fuel use by reducing (night) temperatures in the greenhouse (Van Der Ploeg and Heuvelink, 2006).

Factors that influence cultivar quality

Environmental factors, plant population and the genetic characteristics of each cultivar are determinants of the final product quality. This capacity, in turn, can be evaluated by the inflorescence size, length and rigidity of the stem, opening degree and general health. The creation of different standards or quality classes are extremely important for product recovery, but the Brazilian Association of Technical Standards (ABNT) has no official standards for classification and it has always generated difficulties of understanding among producers, intermediaries and consumers, given the range of qualitative criteria to judge the product because each producer follows his own criterion of classification (Silveira, 1997).

Motos and Oliveira (1999) report that the products currently marketed by Veiling-Holambra, which is one of the major trading centers of the flowers Brazil, are subjected to a system of classification and standardization of products recognized throughout the country. The system is based on the classification of products from established parameters among groups of producers, based on market needs. The classification is made on the properties during harvest and at the time of marketing, it is reviewed by the staff of Veiling - Holambra. The products are separated into four groups (A1, A2, B and C).

Quality A1: Lots consisting of plants of excellent quality.

The plants must be presented free of pests, diseases, with stems and firm, with good support, well formed, with uniform flowering, all with the same degree of ripeness and coloring. The leaves may have slight chemical residues. The rods must not "suckers" side. Plant size should range from 23 to 35 centimeters, thus keeping proportion with the size of pots;

Quality A2: Lots formed by plants of good quality. The products may have light infestations of pests and diseases, they cannot be compromising the look and durability of plants, leaves may have a few chemical residues, lots may present slightly non-uniform and out of sizes required for classification A1, with plants but it is also present in proportion to the pots;

Quality B: Regular quality products do not fit the standards required for classifications A1 and A2; and

Quality C: Products of poor quality showing off all the required standards for ratings above and cannot be marketed.

CONCLUSION

The Brazilian Institute of Floriculture (Ibraflor, 2000), based on the Veiling standards, officially reared its own standard rating system for 21 products, including the chrysanthemum. The stems height increased to four categories: 60, 70, 80 and 90 cm in packs of 12 rods. Regarding the other parameters for qualification, classes A1, A2 and A3 have subjective aspects involving phytosanitary, quality of foliage, flowers opening point, product presentation, linear aspect of the stems and water quality post-harvest. Standards such as stem diameter and fresh weight, characteristics that confer rigidity to the stem and add quality to the final product are not mentioned. The flower diameter is a determinant of quality, especially in this cultivar, due to its visual appearance; also it has no class standards (Ibraflor, 2002).

Conflict of Interests

The authors have not declared any conflict of interests.

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