Genetic and Physiological Studies of Zinnia elegans, Z. angustifolia, and Their Interspecific Hybrids

Zinnia is a relatively small genus of the tribe Heliantheae (Asteraceae) comprising 17 species endemic to North and South America (19). Two cultivated species, Z. elegans Jacq. (2n = 24 or 48) and Z. angustifolia HBK (2n = 22), are classified within the subgenus Zinnia, a taxon of annual and perennial herbs with base chromosome numbers of n = 11 and n = 12. The subgenus Zinnia is subdivided further into sections, with Z. elegans in the section Zinnia and Z. angustifolia in the section Mendezia.

The majority of zinnia cultivars are derived from Z. elegans. This species is erect, from 10 to more than 100 cm in height, with brightly colored and variously shaped ray florets in single or multiple whorls, and ovate leaves (19). Cultivars of Z. elegans are prized as annual garden ornamentals due to a great diversity of flower colors, an abundance of flowers, and a variety of plant forms. The popularity of Z. elegans is evidenced by worldwide cultivation and a high ranking in total unit sales of seed packets sold by U.S. seed companies. Twenty-seven All-America Selections have been awarded to zinnia cultivars, a number unsurpassed by any other garden annual, either flower or vegetable.

In contrast, Z. angustifolia (formerly Z. linearis Benth.) (19), is less extensively cultivated and is morphologically distinct from Z. elegans. It is characterized by a short and compact stature (up to 40 cm), profuse branching, linear leaves, and masses of small flowers 2 to 4 cm in diameter, with orange or white ray florets in a single whorl (19). This species exhibits limited morphological variation compared to Z. elegans.

Despite the popularity of Z. elegans as an ornamental species, disease problems have long been recognized. Three pathogens in particular are known to incite moderate to severe epiphytotics on this species: Erysiphe cichoracearum DC. ex Merat (powdery mildew), Alternaria zinniae Pape (alternaria blight), and Xanthomonas campesstris pv. zinniae Hopkins & Dowson (bacterial leaf and flower spot) (1, 10–12, 15, 19). Powdery mildew is the most serious disease in the United States, and appears to be the major contributing factor to declining sales of zinnia seed in recent years.

Genetic resistance offers a reliable alternative to chemical control of crop diseases and eliminates the hazards of adding potential pollutants to the environment. Zinnia angustifolia is highly resistant to all three diseases (1, H, 12, 19) and therefore represents a valuable gene pool for genetic manipulations.

Research on genetics of Z. angustifolia, Z. elegans, and their interspecific hybrids

Studies were initiated at the Univ. of Maryland in 1979 to determine if interspecific hybrids between Z. angustifolia and Z. elegans could be obtained, with the primary goal of developing disease-resistant hybrids with novel plant forms and flower colors.

Interspecific hybridization between Z. elegans and Z. angustifolia was successful and resulted in seed-propagated hybrids when Z. angustifolia was the female parent, but not when Z. elegans was the female parent (2). Hybrids were obtained from the latter crosses when immature embryos were excised and cultured in vitro. The percentage of pollinated florets with embryos from Z. angustifolia X Z. elegans matings was comparable to intraspecific matings among Z. angustifolia (7). Although the rate of pollen tube growth was slower in interspecific compared to intraspecific matings, prezygotic barriers to hybridization were otherwise not apparent. In reciprocal (Z. elegans X Z. angustifolia) matings, barriers acted between pollen tube penetration of the stigma and syngamy to greatly inhibit fertilization (4, 6).

Embryo abortion, poor seedling emergence, and abnormal development of some hybrids acted as postzygotic barriers to interspecific hybridization. Abnormal hybrids were characterized by small deformed leaves, absence of (or deformed) flowers, and slow growth as compared to normal hybrids (2). Variation in the percentage of emerged Z. angustifolia X Z. elegans interspecific hybrid seedlings and morphologically normal hybrids was attributed largely to Z. angustifolia clonal genotypes used as maternal parents, with minor or no effects by Z. elegans lines used as paternal parents (7). Variation in the percentage of emerged seedlings was due to differences among clones in amount of hybrid embryo breakdown and ungerminable seed. Cytological observations of morphologically normal and abnormal interspecific hybrids revealed identical chromosome numbers (2n = 23), although the mitotic index of the latter was lower. Genetic analysis of percentage of emerged seedlings and percentage of normal hybrids of emerged seedlings suggested control by multiple genes inherited from the Z. angustifolia genome. In addition, nuclear genes of the Z. angustifolia genome significantly affected plant height, fresh weight, number of nodes, and days to flowering of normal hybrids. Results have shown that adequate sampling of the Z. angustifolia gene pool enhances exploitation of genetic variability present within the species and allows improvement in the number and vigor of interspecific hybrids obtained.

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due mainly to cultivar differences. Days to flowering was more a function of mean daily temperature than photosynthetic photon flux (PPF) for spring, summer, and fall crops, whereas late flowering of the winter crop was due to lower mean daily temperature and PPF. Results of this 2-year study demonstrate that Z. elegans can be scheduled accurately as a greenhouse cut flower crop on a year-round basis.

Clearly, the results from our research on Zinnia have contributed significant new genetic information on factors controlling hybridization, inheritance of disease resistance, and ray petal pigmentation of Z. elegans, Z. angustifolia, and their interspecific hybrids. Furthermore, the physiological information regarding control of vegetative and reproductive development should expand the usefulness of Zinnia elegans. The Z. angustifolia × Z. elegans interspecific hybrids will probably have greatest utility as bedding plants. In contrast, Z. elegans can be produced year-round in the greenhouse as a novelty cut flower in addition to its use as a bedding plant.

The variation in presently cultivated minor floricultural crops, such as zinnias, has remained largely unexamined. Systematic evaluation of minor crops, including genetic manipulations and physiological research, would be of immense value to the floriculture industry, in which changes in consumer preferences and marketing channels are commonplace. Much work remains to be done to assess fully this potential.

Literature Cited