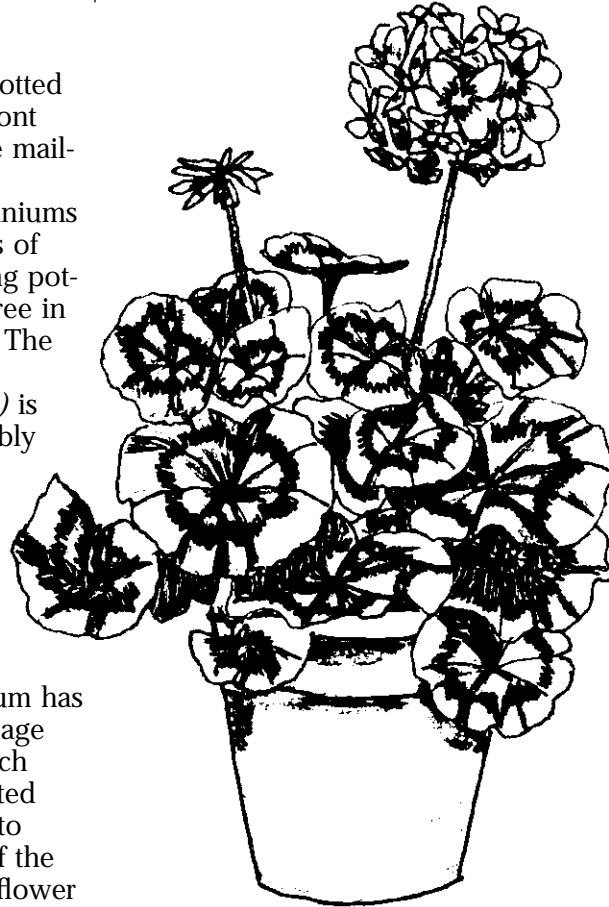


Greenhouse Production of Zonal Geranium

In spring and summer, potted red geraniums on the front steps or plants around the mailbox are a common sight throughout America. Geraniums rank number one in terms of units sold among flowering potted plants and number three in terms of wholesale value. The exact origin of geraniums (*Pelargonium x hortorum*) is unknown, but they probably resulted from intercrossing between several species native to South Africa, including *P. zonale*, *P. inquinans*, *P. scandens*, and *P. frutescens*.

The traditional geranium has red flowers and green foliage and is grown in 4- or 6-inch pots. These plants, marketed mostly from early April into June, make up the bulk of the potted-plant market. The flower color mix traditionally preferred by customers is 45 percent red, 30 percent salmon, 15 percent pink, and 10 percent white. However, customers often want different container sizes, different flower and foliage colors, and cultivars that perform in either sun or partial shade. They also want cultivars suited to large open gardens, planter boxes, window sills, or hanging baskets. The most popular container sizes are 3-inch pots, 4- to 4½-inch pots, and 6- to 6½-inch pots. A few zonal geranium cultivars that have recently become available perform well in hanging baskets.



In addition to choosing which flower colors and container sizes to market, growers have a number of other procedures to follow and considerations to keep in mind, including the following:

- Keeping the greenhouse sanitized to avoid disease
- Selecting cultivars
- Making propagation choices
- Managing stock plants
- Using the “fast-cropping” method

Greenhouse Sanitation

Years ago, growers retained plants selected from the seasonal crops to use as stock plants for the next season. Cuttings were taken in winter, rooted, and maintained under minimum conditions until early spring for forcing. Several events caused a drastic change in this procedure. For one thing, the economics of greenhouse space utilization combined with the development of the “fast-cropping” method made the old procedures impractical. Major crop losses from serious systemic diseases such as bacterial blight (*Xanthomonas peraragonii*) and *Verticillium* wilt have also changed cultural practices. Because there are no chemical protectants or cures for these diseases, the crop must be destroyed once infected.

Today, vegetative material comes almost exclusively from specialized propagators who use culture-indexing and other laboratory procedures to eliminate systemic organisms such as vascular wilt, bacteria, viruses, and fungi. Purchasing culture-indexed, clean materials is essential for successful zonal geranium production. However, because the culture-indexing process does not alter resistance or susceptibility to pathogens, plants can still become infected if exposed to diseases during production. The success or failure of a production program for geraniums therefore depends on employees' strict adherence to

and awareness of sanitation! Use the following rules to keep your greenhouse sanitized:

- Steam or chemically treat all pots, flats, media, etc. that may come in contact with plants.
- Ensure that growing medium is pathogen free. Store media in disinfected containers or bins.
- Be sure the greenhouse is clean and free of weeds, pests, and plant debris before planting.
- Use raised benches with surfaces that are easy to sanitize.
- Disinfect benches, walkways, sidewalls, etc. between crops.
- Disinfect irrigation systems, such as drip emitters and water breakers, between crops.
- Isolate geranium production steps from other crops.
- Do not put anything that falls on the floor back on the bench.
- Hang hose ends and water breakers—do not let them touch the floor.
- Enter the stock plant area only with clean clothes and hands.
- Wear disposable gloves when handling stock plants or cuttings.
- Never dip cuttings in solutions or powders.
- Avoid moving or touching media or pots unnecessarily.
- Avoid practices that might splash or move media from the floor to the bench tops or pots.
- Do not put your feet on the bench!
- Limit and supervise casual visitors.
- Train employees to recognize and properly dispose of suspect plants.
- Remove all weeds within the greenhouse and within 30 feet outside the greenhouse.

To sanitize equipment, soak it in a 10 percent hospital disinfectant solution for 60 minutes or a 10 percent household bleach solution for 30 minutes.

Effective sanitation for geraniums requires that management commit to establishing a certain state of mind or awareness among employees. This involves instructing everyone to treat areas in which geraniums are handled as “clean areas.” Train employees from the first day to recognize plant problems, where these problems originate, how they spread, and what employee behaviors are appropriate within clean areas to prevent problems from spreading. Monitor these areas closely to determine the effectiveness of training.

Cultivar Selection

Cultivar selection for zonal geraniums is often very market driven. However, for greenhouse production, consider flower earliness, flower and plant uniformity within a cultivar or series, reasonable bench spacing for the market circumstances, minimal growth retardant use, and a broad range of flower colors. A list of zonal geranium cultivars suitable for greenhouse production in the Southeast is included at the end of this publication.

Crop-Starting Options

Two propagation options are widely used by geranium growers. The first option is to purchase “clean” cuttings of named cultivars for growing stock plants from which cuttings are taken for production. The second option is to purchase rooted cuttings of named cultivars from specialized propagators. The decision to grow stock plants and carry out propagation in-house versus ordering rooted cuttings is largely an economic one and depends on the size of the operation, the space and facilities available, and the skill of the growing team. Some suppliers have recently provided a third option. Growers who have the facilities and want to root cut-

tings in-house can order unrooted cuttings for less than what rooted cuttings cost.

Stock Plant Production

Geranium stock plants are generally a long-term crop, so care should be taken in media selection and cultural practice. Rooted cuttings for stock plants are generally potted into containers from 6-inch pots to bushel-basket sizes containing a well-drained, well-aerated, peat-lite medium that does not compact and that decomposes slowly. Growers may choose to purchase a commercially prepared medium or mix their own. For a mix-your-own, pulverized dolomitic limestone (to a pH of 5.8 to 6.5), superphosphate, and micronutrients in the fritted form are added at the time of mixing.

Watering is usually done using an automatic system, often microtube watering. Stock plants are typically given full sun, except during the summer to reduce heat in the greenhouse. Stock plants are frequently fertilized using a fertilizer tank mix rather than commercial fertilizer so that nutrient levels can be adjusted based on monthly soil tests. Start fertilizing at constant liquid feed of 250 parts per million (ppm) nitrogen and potassium.

Media testing and tissue analysis are important components in maintaining adequate fertility for geranium stock plants. Test every 2 to 4 weeks during production. Send samples from each planting to the Soil Testing Laboratory, Auburn University, Alabama, or to a commercial laboratory. Table 1 lists specific recommendations for tissue analysis nutrient levels. If one or more nutrients fall out-

Table 1. Zonal Geranium Foliar Analysis Nutrient Level Ranges

Nutrient	Percentage	Nutrient	ppm
Nitrogen	3.3 to 4.8	Boron	30 to 100
Phosphorus	0.4 to 0.7	Copper	7 to 16
Potassium	2.5 to 4.5	Iron	100 to 300
Calcium	1.0 to 2.0	Manganese	40 to 150
Magnesium	0.2 to 0.7	Zinc	10 to 50

side of these ranges, take corrective steps promptly so that the plant growth rate is not adversely affected.

The objective of a geranium stock plant program is to generate all the cuttings possible at a time when they are needed for finished production. The two methods of stock plant management that are commonly employed are conventional stock production and multiplication stock production.

Conventional Stock Production

Using this method, you can pot cuttings into large or small containers from May to August, depending on the number of cuttings you want to obtain over the life of the stock plant. Four weeks after potting or when the cuttings are 6 inches tall, give the cuttings a soft pinch. This will cause the cutting to develop three to five lateral shoots. Take cuttings every 2 weeks thereafter, leaving three to four nodes on the lateral shoots for additional shoots. These early cuttings are often discarded. Remove all flower buds and large leaves when you remove cuttings. Completely defoliate all stock plants in November or December to allow light into the plants and to reduce potential disease problems. Harvest cuttings for the finished crops from January through March.

Multiplication Stock Production

This method requires smaller containers, usually 6-inch pots, and a shorter production time. Pot rooted cuttings in November or December, and remove, root, and pot cuttings as they become available. Continue to take cuttings from all plants, and use early cuttings as additional stock plants. By early spring, you can obtain a 1 to 40 (original cuttings to final cuttings) increase in plants with this method. This may be the most efficient use of greenhouse space for small- to medium-sized growers and requires no special skills in developing stock plants.

Spraying ethephon (Florel) on stock plants increases the cutting number by 20 to 30 percent and retards growth, reducing internode length and leaf size as well as delaying flower development. Apply it at a rate of 350 to 500 ppm after pinching or after removing cuttings. Applying ethephon just before removing cuttings may increase rooting.

The environmental and nutritional condition of the stock plants can have a big impact on the rooting of cuttings. Oversucculent cuttings do not root well. Therefore, provide moderate moisture and temperature with high light for optimum cutting results. You will obtain the highest rooting percentage from stock plants that receive a medium level of nitrogen and higher levels of phosphorus and potassium.

Propagation

Cuttings

Harvest cuttings early in the morning, preferably by snapping them off manually. It is important to break the cuttings evenly, with no jagged edges. If you use a knife, make sure it is sharp, and sterilize it with disinfectant after cutting each stock plant. Make terminal cuttings about 2 to 3 inches long (larger is not better) with two maturing leaves. Remove any basal leaves and petioles that may end up below the soil line. In cases where cutting material may be limited, single-eye cuttings can be used. A stem may be divided into several single-eye cuttings composed of an internode and node with attached leaf and dormant lateral bud. Single-eye cuttings require 2 to 3 weeks longer to reach a flowering stage.

Rooting Medium

Geraniums can be rooted in a variety of media including conventional peat-lite medium, strips containing peat, specialized cubes, trays, rock wool, or other synthetics. These may include cell-packs, Jiffy strips, Oasis blocks, or Jiffy pellets. Regardless, make sure the rooting medium is exceptionally well-aerated, well-drained, and sterile, with a pH of 5.8 to 6.2. Some sources recommend using a rooting hormone; others do not. It appears that rooting hormone can benefit slow-rooting cultivars and cuttings from poorly managed stock plants. If you choose to use a hormone, 500 ppm Indolebutyric acid (IBA) works well. Do not dip cuttings into hormone solution or powder. Use a puff-duster to apply powders to the cutting bases, or use a mister to apply liquids. You can also dip cuttings in 2,500 to 5,000 ppm B-Nine the day before sticking to help speed rooting.

Spacing

Stick the cuttings into the rooting medium $\frac{1}{4}$ to $\frac{1}{2}$ inch deep, but no deeper. Space geranium cuttings so the leaves of adjacent cuttings do not overlap. Use about 2 inches between cuttings, or 22 to 36 cuttings per square foot. Because *Botrytis* can be a serious problem in propagation, adequate spacing and excellent ventilation are essential.

Temperature

The most rapid rooting occurs with a 60° to 62°F night temperature in combination with 68° to 72°F bottom or medium heat. Try to keep day temperature in the 75° to 80°F range.

Light

Geranium cuttings need high light during propagation but can benefit from some shade late in the spring to control temperature. In propagation, be sure light levels are 1,800 to 2,800 footcandles until roots form (12 to 18 days), then 2,800 to 3,600 footcandles until transplant.

Scheduling

Under ideal conditions and depending on the cultivar, calluses should form on the basal end of the cuttings in about 5 days. Roots should appear at the base of the cuttings about 12 to 18 days after sticking. Cuttings are usually ready to transplant in 3 to 4 weeks.

Mist

Mist intervals vary with the condition of the cuttings, time of year, environmental conditions, and performance of the misting equipment. The goal, however, is to maintain foliage turgidity with a minimum amount of foliage wetting. There should be little or no runoff into the propagation medium. As a beginning

point, start with 5 seconds on every 5 minutes on the first day. Watch the foliage, and adjust the rate as needed. Decrease the mist interval until misting ends by day 18. Mist at night for the first 6 days at 5 seconds on every hour.

Fertilization

Do not fertilize the cuttings until roots are present. However, as soon as roots appear, begin fertilizing with 250 to 300 ppm of nitrogen and potassium.

“Fast-Cropping” Geraniums

Profitable geranium production depends on finishing as many crops as possible in a given greenhouse area in the shortest time possible. This cultural procedure is used to produce a 4- to 4½-inch-pot geranium from a rooted cutting with one flower open in about 6 weeks. Procedures are exacting and require exceptional attention to detail.

Potting

Pot rooted cuttings 6 weeks before sale in a peat-lite medium with at least 80 percent total porosity. You can use a commercially available mix or prepare one yourself. Medium components may include sphagnum peat moss, vermiculite, perlite, aged pine bark, or calcined clay. In a mix-your-own medium, add dolomitic limestone to a pH of 5.8 to 6.2, superphosphate at 4½ pounds per cubic yard, and a commercial micronutrient formulation according to the manufacturer's recommendation. Unrooted cuttings can be direct-stuck in pots and rooted under mist to finish in 10 weeks. Maintain the plants pot-to-pot for 3 to 4 weeks, and then space them at four plants per square foot.

Watering

Water newly potted cuttings two or three times the first day to ensure complete saturation of the medium. Apply enough water so that 10 to 15 percent of the total volume drips from the bottom of the container.

Afterward, water whenever the medium surface lightens in color and the pots feel light in weight. The best time to water is in the morning when the temperature is increasing so that foliage dries as quickly as possible. Many growers use an automated watering system, such as microtube irrigation or ebb-and-flow, when plants are placed at final spacing.

Temperature

Optimal day temperatures depend on light intensity. On bright days, begin ventilation at 75° to 80°F with a night temperature of 65°F. On cloudy, overcast days, begin ventilation at 72°F. Bottom heat to a 70° to 72°F medium temperature promotes rapid root growth, especially just after potting. Night temperature should be 65° F with a 70° to 72°F media temperature.

Light

Provide full sun as long as temperatures can be maintained at less than 85°F. Too much light and high temperatures can cause foliage to wilt in early afternoon, even if the medium is moist, and can cause reddening of the petioles and stems. You may need to shade the greenhouse glazing during late spring and summer. Light intensity that is too low causes stems to stretch, light-colored soft growth, and delayed flowering.

Fertilizer

Use a constant liquid feed of 15-15-15 or 15-0-15 at 250 ppm nitrogen with one clear watering per week to prevent soluble salts buildup. Avoid soluble fertilizers with more than 40 percent of the total nitrogen in the ammonium and urea forms, such as some 20-20-20 fertilizers. A monthly drench application of Epsom salts (magnesium sulfate) at 16 ounces per gallon may be needed to prevent magnesium deficiency.

Growth Retardant

Cycocel (chlormequat) is the growth retardant commonly used on geraniums to reduce final height. Rates vary from 750 to 1,500 ppm, depending on the application method, cultivar vigor, and environmental conditions. A 1,500 ppm spray is applied 14 days after planting, with a second application 14 days later only if needed on vigorous cultivars. Some growers prefer to use 750 ppm beginning 14 days after planting and additionally 3 to 4 times at weekly intervals as needed. Apply only to well-watered, unstressed plants early in the morning or on cloudy days. Spray a light mist or until the leaves glisten, never to runoff. This can be accomplished by applying 1/2 gallon of solution per 100 square feet of bench area. Even under the best conditions, Cycocel may cause some foliar yellowing on younger leaves, particularly at higher rates. Plants should recover in a few weeks.

Pests

Whiteflies, aphids, spider mites, fungus gnats, and caterpillars can all be problems on geraniums. In recent years, whiteflies have been a persistent and difficult problem to control.

Zonal Geraniums for Greenhouse Production in the Southeast*

Cultivar	Color	Source
American Red	Red/scarlet	Ball Seed Co.
American Rose Splash	Red/scarlet	Ball Seed Co.
Designer Red	Red/scarlet	Ball Seed Co.
Designer Bright Red	Red/scarlet	Ball Seed Co.
Satisfaction Red	Red/scarlet	Ball Seed Co.
Satisfaction Bright Red	Red/scarlet	Ball Seed Co.
Showcase Scarlet	Red/scarlet	Ball Seed Co.
Atlants 96	Red/scarlet	Fischer USA, Inc.
Diabolo	Red/scarlet	Fischer USA, Inc.
Grand Prix	Red/scarlet	Fischer USA, Inc.
Rumba	Red/scarlet	Fischer USA, Inc.
Samba	Red/scarlet	Fischer USA, Inc.
Tango	Red/scarlet	Fischer USA, Inc.
Tango Dark Red	Red/scarlet	Fischer USA, Inc.
Medallion Dark Red	Red/scarlet	Oglevee, Ltd.
Sassy Dark Red	Red/scarlet	Oglevee, Ltd.
Kim	Red/scarlet	Oglevee, Ltd.
Ritz	Red/scarlet	Oglevee, Ltd.
Sincerely Yours	Red/scarlet	Oglevee, Ltd.
Melody Red	Red/scarlet	Oglevee, Ltd.
Designer Bright Lilac	Lavender/magenta/purple	Ball Seed Co.
Designer Lilac Chaffon	Lavender/magenta/purple	Ball Seed Co.
Designer Purple Rose	Lavender/magenta/purple	Ball Seed Co.
Satisfaction Bright Lilac	Lavender/magenta/purple	Ball Seed Co.
Calypso	Lavender/magenta/purple	Fischer USA, Inc.
Disco	Lavender/magenta/purple	Fischer USA, Inc.
Kardino	Lavender/magenta/purple	Fischer USA, Inc.
Tango Violet	Lavender/magenta/purple	Fischer USA, Inc.
Tiffany	Lavender/magenta/purple	Fischer USA, Inc.
Aurora	Lavender/magenta/purple	Oglevee, Ltd.
Fox	Lavender/magenta/purple	Oglevee, Ltd.
Laura	Lavender/magenta/purple	Oglevee, Ltd.
Veronica	Lavender/magenta/purple	Oglevee, Ltd.
Designer Hot Coral	Pink/salmon	Ball Seed Co.
Designer Salmon Rose	Pink/salmon	Ball Seed Co.
Satisfaction Pink	Pink/salmon	Ball Seed Co.
Satisfaction Hot Pink	Pink/salmon	Ball Seed Co.
Satisfaction Salmon	Pink/salmon	Ball Seed Co.
Showcase Salmon	Pink/salmon	Ball Seed Co.
Bravo	Pink/salmon	Fischer USA, Inc.
Bravo Light Pink	Pink/salmon	Fischer USA, Inc.
Charmant	Pink/salmon	Fischer USA, Inc.
Dolce Vita	Pink/salmon	Fischer USA, Inc.
Gloria	Pink/salmon	Fischer USA, Inc.
Helena	Pink/salmon	Fischer USA, Inc.
Montevilleo	Pink/salmon	Fischer USA, Inc.
Rokoko	Pink/salmon	Fischer USA, Inc.
Schoene Helena	Pink/salmon	Fischer USA, Inc.
Tango Light Salmon	Pink/salmon	Fischer USA, Inc.
Evening Glow	Pink/salmon	Oglevee, Ltd.
Peaches	Pink/salmon	Oglevee, Ltd.
Patriot Salmon Blush	Pink/salmon	Oglevee, Ltd.
Patriot Bright Pink	Pink/salmon	Oglevee, Ltd.
Patriot Light Pink	Pink/salmon	Oglevee, Ltd.
Sarah	Pink/salmon	Oglevee, Ltd.
Melody	Pink/salmon	Oglevee, Ltd.
Lollipop	Pink/salmon	Oglevee, Ltd.
Lotus	White	Fischer USA, Inc.
White Truffle	White	Oglevee, Ltd.
North Star	White	Oglevee, Ltd.
Raspberry Ice	White	Oglevee, Ltd.

* Cultivar information provided by Ball Seed Co., West Chicago, IL; Fischer USA, Inc., Boulder, CO; Oglevee, Ltd., Connellsville, PA.

Diseases

The list of diseases that can be a problem on geraniums is extensive and includes bacterial blight, blackleg, *Alternaria* leaf spot, bacterial fasciation, cutting rots, cottony stem rot, black root rot, rusts, bacterial leaf blight, *Verticillium* wilt, Southern blight, and numerous viral diseases.

Specific control measures for insect and disease problems can be found in Extension Circulars ANR-500A and ANR-500B, *Alabama Pest Management Handbook, Volumes 1 and 2*, or contact your county Extension agent.

Additional Reading

Ball, V., ed. 1998. *Pelargonium x hortorum* (Zonal Geraniums). Ball Redbook, 16th ed. 657-675. Ball Publishing, Batavia, Illinois.

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White, J.W. 1993. *Geraniums IV*. 4th ed. Ball Publishing, Batavia, Illinois.



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For more information, call your county Extension office. Look in your telephone directory under your county's name to find the number.

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