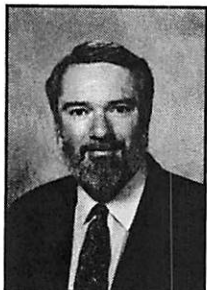


GREENHOUSE PRODUCTION OF MARIGOLDS

by J Raymond Kessler, Jr., Auburn University



Marigolds have long been popular with American gardeners as one of the premiere summer annuals. They perform well in dry, hot, sunny locations producing dark-green, fine textured foliage and bright-colored flowers throughout the summer and into the fall. There may be more sizes, flower types, and growth habits of marigolds than any other bedding plant. Marigolds range in size from six inches tall to over three feet. Therefore,

dwarf cultivars are appropriate in containers or as bedding plants edging flower borders while taller cultivars can be used as bed fillers, in the rear of the border, or as cut flowers. In the past, marigolds had a strong fragrance that some people found objectionable. Newer cultivars are somewhat less pungent, but still have the characteristic marigold smell.

CULTIVARS

Two different species of marigold are commonly grown, African marigold (*Tagetes erecta*) and French marigolds (*Tagetes patula*). Neither African nor French marigolds come from Africa or France, respectively, both species are native from New Mexico and Arizona southward to Argentina. Marigold flowers are available in single, semi-double, or double petal arrangements with white, yellow to orange, gold, or red flower colors. Red and crimson flower colors are found in the triploid and French types, but not the African type. Flower sizes range from 1-inch in the French type to five inches in the African type. Breeders have worked extensively to create cultivars in a wide range of colors, plant sizes, and flower forms. Crosses between African and French marigolds have resulted in triploid cultivars. The following are the major horticultural types:

African type

Cultivars of *Tagetes erecta*, sometimes referred to as American marigolds, are larger plants than the French type, often with few, larger double flowers. In the double flowered cultivars, there are crested doubles where the flowers appear mounded and full, and anemone doubles where the flowers appear flat and wide with the center recessed.

French type

Cultivars of *Tagetes patula* are usually smaller plants than the African type, usually 6- to 8- inches with some cultivars reaching 12- inches in height. Though double flower petal arrangements are available, single and semi-double are more common. The single flowering cultivars stand-up to rain and humidity better in the South than double flowered cultivars.

Triploid type

These cultivars are breeding crosses between *Tagetes erecta* and *Tagetes patula*. One advantage of these cultivars is that they provide the longest overall display of color in the landscape, often lasting through the hot summer weather into August and September. However, seed germination during production may be considerably slower than for the African and French types. These plants are sterile so they will not produce viable seed.

The Alabama Agricultural Experiment Station has established a trial garden at the E.V. Smith Research Center near Shorter, AL to evaluate annual garden plants. Fourteen African cultivars and 25 French cultivars were visually rated bi-monthly on a scale of 0 (dead) to 5 (superior plants in flower) for garden performance during the summer of 1997. The 10 best performing African and French cultivars are listed in Table 1 and 2. Average seasonal performance rating for the 10 best African and French cultivars ranged for 2.9 to 2.3 and 3.2 to 2.6, respectively. Cultivars in the 'Antigua' and 'Inca' series were highly rated among the African type and those in the 'Bonanza', 'Bounty', and 'Hero' series were highly rated among the French type.

PLUG PRODUCTION

Growers pay a premium price for high quality marigold seeds. Therefore, care and planning are necessary to ensure the maximum number of transplantable seedlings will be produced from an ounce of seed. For the best results in starting marigold seed, purchase F₁ hybrid seeds fresh each season from a reputable supplier. In planning the number of seed to order for production, consider that there are 9000 to 13,000 seeds per ounce depending on species and cultivar.

If seed must be kept from one season to the next, store them in a dark, cool, dry environment protected from insects and rodents. As a general rule, store seeds under conditions where the sum of the Fahrenheit temperature and percent relative humidity does not exceed 100. For example, where seeds are stored at 45°F, the humidity should not exceed 55 percent. Refrigerators, dedicated to seed storage, are often used with the seeds sealed in containers containing a desiccant material.

The 406 or 512 plug flats are small enough for economic production while providing enough room for growth until transplanting. However, larger plug sizes may be used to meet special production goals. The most effective way to sow marigold seed is with an automatic seeder. Marigold seed can present problems when using an automatic seeder because the seeds are long and thin and because the "fuzzy tail" (bristle-like projections at the basal end of the seed) interferes with the mechanical seed-sowing process. Some brands of seeders come with special attachments for handling marigold seed. Seed suppliers have also developed "de-tailed" seed, where they remove the tail. Marigold seed may also be purchased

that are coated with a water-soluble, inert material to facilitate sowing.

Sow seeds in plug flats containing a moist, well-drained, sterile medium such as one of the many peat-lite mixes available commercially for plug culture. Germinating media pH should be in a range of 5.8 to 6.5 with an electrical conductivity level of less than 0.75 mmhos/cm based on the 2:1 extraction method. Thoroughly moisten the medium with room temperature water before sowing seeds. Light is not required for marigold seed germination. Therefore, sow seeds directly on the medium surface and cover the seeds with a thin layer of #2 coarse grade vermiculite. Vermiculite helps maintain adequate moisture around the seed.

Seed of the African and French types germinate in three to five days at 75° to 80°F medium temperature. Seed of the triploid type may require several days longer. Bottom heat greatly enhances seed germination and early growth, especially on crops early in the spring season. Keep the germinating medium moist, but not saturated. Reduce the moisture level and reduce the night temperature to 68° to 70°F once the radicle (root) emerges. Begin fertilizing seedlings once or twice per week at 50 to 75 ppm nitrogen using a 15-0-15 fertilizer or calcium nitrate and potassium nitrate when cotyledons (seed leaves) unfold. Increase this rate to 100 to 150 ppm nitrogen when true leaves develop.

GROWING ON

If marigold plugs are purchased from a propagator, unpack and examine the seedlings carefully. The plants should be an appro-

priate size for transplanting. Over-grown seedlings are difficult to grow into a high quality plant, while seedlings that are too small will be difficult to transplant and slow to establish. Remove several seedlings from sample flats and examine the root system. Marigold roots should be large, white and fuzzy covering about two-thirds of the outer surface of the medium. Look for signs of over-watering and root diseases indicated by brown or black discoloration. Examine the foliage for diseases, insects, or nutrient problems.

Be prepared to transplant plugs immediately. Generally, marigold seedlings are ready to transplant from plugs when three to four mature leaves are present. It is important to transplant when seedlings just begin to crowd. Marigold plugs are usually shipped at a size that is ready to transplant. Holding plugs in the greenhouse longer than the optimum transplant size results in stunting and premature flowering. Plant seedlings at about the same level they are growing in the plug trays, but no deeper. Dibble the transplant medium to the depth of the root ball and firm-in the seedling gently. Water newly planted seedlings thoroughly, immediately after transplanting.

Growing medium

For growing on, a light, well-drained, peat-lite medium with a 5.8 to 6.5 pH and an electrical conductivity less than 1.0 mmhos/cm based on the 2:1 extraction method is recommended. A media pH lower than 5.8 should be avoided to prevent iron and manganese toxicity. Symptoms of toxicity appear as speckling, necrotic mar-

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gins, necrotic spots on the older leaves, and, in extreme cases, death of the growing tip. Toxicity symptoms may also appear with over-application of micronutrients. This may occur when the grower uses a water-soluble fertilizer containing micronutrients after adding a commercial micronutrient fertilizer during the mixing of the medium. Some marigold cultivars are more sensitive to this problem than others.

Temperature

Grow marigolds at 60° to 65°F night temperatures and 65° to 72°F day temperatures for high quality plants. Use 65°F night temperatures for a week to 10 days after transplanting to establish the root system, then drop to 60°F if desired.

Fertilization

Do not fertilize marigolds for 7 to 10 days after transplanting or until the roots reach the sides of and bottom of the container. Thereafter, fertilize on a constant liquid fertilization basis at 100 to 150 ppm nitrogen using a fertilizer about equal in nitrogen and potassium content. Many growers alternate between 20-10-20 and 15-0-15 or calcium nitrate and potassium nitrate applied once or twice per week. Avoid fertilizers with nitrogen high in ammonium form (greater than 40%), such as some 20-20-20 formulations, if the media temperature is below 65°F. Growers should test medium pH and soluble salts in-house on a weekly basis and send samples for laboratory testing every two weeks. Recommended foliar analysis ranges for marigolds are given in Table 3. Fertilizer rate can be reduced by one-half in the last week or two to harden off plants before shipping to the retail market.

Photoperiod

Many marigold cultivars are facultative short-day plants meaning that plants flower more quickly under short day-lengths, but will eventually flower regardless of photoperiod. African cultivars display more of a photoperiodic response than French or triploid types. The critical photoperiod for *Tagetes erecta* is between 12.5 and 13 hours meaning that plants flower more quickly at day lengths shorter than this. Cultivars of the African type can be provided artificial short days using black cloth from 5:00 PM to 8:00 AM to achieve faster flowering. Start applying black cloth in the first 2-3 weeks after seed germination beginning in late February. Black cloth application will reduce the time to flower by up to 2 weeks and produce more compact plants. However, not all cultivars require black cloth. Recent breeding work has focused on developing African cultivars that are day-length neutral, thus black cloth is not beneficial. Photoperiod control is rarely needed or practiced for the French and triploid marigolds during normal spring production.

Light

Marigolds require as much light as possible, especially with early spring crops. When arranging bedding plants in the production area, place marigold crops in the brightest areas possible, preferably areas with glass or clear plastic glazing. Be sure the greenhouse glazing is clean and free of shading compound.

Growth Retardant

Generally, control seedling growth and prevent stretching by managing the environment, nutrition and watering first, then if needed, apply chemical growth retardants. Height control is usually not

needed on the French and triploid types. Height control is usually not needed on the French and triploid types. Marigolds respond to two applications of B-Nine at 2500 ppm (B-Nine), one week apart or one application of Cycocel (750 - 1500 ppm), Bonzi (4 - 10 ppm), or A-Rest (50 - 100ppm).

Scheduling

Crop production times differ not only for the three horticultural types of marigolds but also among cultivars within each type. Production time will generally decrease as light intensity and temperature increases during the spring production season. Production time for African marigold cultivars can also be modified by natural photoperiod. Therefore, growers should keep detailed records of crop performance and timing to improve future scheduling efforts.

African types

Generally, the African cultivars require up to two weeks longer to flower than the French and triploid types. In the Southeast, seedlings in 406 plug flats generally require five weeks from sowing to be ready to transplant and five weeks in jumbo market packs for a total production time of 10 to 11 weeks. The total production time for a single plug-grown seedling in 4-inch pots is 11 to 12 weeks.

French types

In the Southeast, seedlings in 406 plug flats generally require four to five weeks from sowing to being ready to transplant and three to four weeks in 48 - to 32 - cell market packs for a total production time of seven to nine weeks. The total production time for a single plug-grown seedling in 4-inch pots is 10 to 11 weeks. Ten-inch hanging baskets with four or five seedlings per container require 10 to 13 weeks total production time.

Triploid types

In the southeast, seedlings in 406 plug flats generally require five weeks from sowing to being ready to transplant and two to three weeks in 48 - to 32 - celled market packs for a total production time of seven to eight weeks. The total production time for a single plug-grown seedling in 4 - inch pots is 10 to 11 weeks.

COMMON PROBLEMS

Insects and related pests

Spider mites, aphids, thrips, and leaf miners can be problems on marigolds. Slugs and snails can be a problem under damp conditions.

Diseases

A protective application of a fungicide for *Alternaria* leaf spot is recommended, especially on the African type. Damping-off (*Pythium* and *Rhizactonia*) in seedlings and grey mold (*Botrytis*) on flowers can be problems. Tomato spotted wilt virus (TSWV) can be a major problem and is carried by thrips. Southern bacterial wilt causes stunting, wilting, and death, while bacterial leaf spot causes small black spots that turn necrotic. There are no known controls so infected plants should be destroyed.

Table 1. Best performing African marigold cultivars in the 1997 trial.¹

Cultivar	Flower Color	Rating ²
Antigua Primrose	Yellow	2.9
Antigua Goldsmith	Gold	2.8
Discovery Yellow	Yellow	2.8
Inca Yellow	Yellow	2.7
Inca Orange	Orange	2.6
Antigua Yellow	Yellow	2.6
Marvel Yellow	Yellow	2.6
Inca Mix	Mix	2.5
Marvel Deep Orange	Orange	2.4
Antigua Mixture	Mix	2.3

¹Trials held by Auburn University and Alabama Agricultural Experiment Station at the E.V. Smith Research Center.

²Marigold cultivars were rated on a scale of 0 (dead) to 5 (superior plant in flower) for garden performance.

Table 2. Best performing French marigold cultivars in the 1997 trial.¹

Cultivar	Flower Color	Rating ²
Bonanza Harmony	Red	3.2
Bonanza Flame	Red	3.0
Hero Orange	Orange	2.9
Bounty Yellow	Yellow	2.8
Hero Bee	Red, yellow	2.8
Bonanza Bee	Red, yellow	2.8
Hero Flame	Red	2.8
Bounty Goldsmith	Yellow	2.8
Bounty Spry	Yellow, Red	2.8
Little Hero Flame	Red	2.6

¹Trials held by Auburn University and Alabama Agricultural Experiment Station at the E.V. Smith Research Center.

²Marigold cultivars were rated on a scale of 0 (dead) to 5 (superior plant in flower) for garden performance.

Table 3. Marigold normal foliar analysis ranges

Element	Percent	Element	ppm
N	3.32-3.62	Fe	92 - 115
P	0.49-0.54	Mn	275-558
K	2.79-2.88	Zn	76-97
Ca	2.36-2.72	Cu	19-25
Mg	1.33-1.44	B	34-40
S	1.34-1.44	Mo	0.22-0.62

Source: Plant Analysis Handbook II, MicroMacro Publishing, 1996.