



Annuals and Perennials



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ACLP Annuals and Perennials Workshops 2023

Presenters: Dr. Ursula Schuch, Jon Berg and Shannon Scott

Learning Objectives & Agenda

Learning Objectives

1. Understand what type of plants annuals and perennials are, know flowering seasons, and know how to identify the top 20 plants and when they flower.
2. Be able to prepare a bed for annuals or herbaceous perennials including site and soil preparation.
3. Know how to measure and calculate the size of a planting bed and determine how many plants or flats of plants are needed for transplanting.
4. Know how to pick a quality plant at the nursery and how to transplant and take care of plants immediately following transplanting.
5. Understand how to maintain a flower bed including irrigation, fertilization, pruning/deadheading, insect and disease control, weed control, and mulching.
6. Understand how to prepare and manage wildflower beds, direct seeding of flowers, and container gardens.
7. Learn how to trouble shoot, identify, and manage the most common diseases, insects, and abiotic problems in flower beds.



AGENDA

Introduction to Annual and Perennial Plants

Types of plants used in color beds or containers: annuals, perennials, roses
Seasonal color: winter, spring, and summer

Top 20 plants for color beds

Installing Annual and Perennial Beds

Calculating number of plants/flats needed
Pre-planting site assessment and preparation, pre-irrigation
Bed preparation, soil preparation, soil attributes
Soil amendments
Pre-planting plant preparation, selecting for plant quality, plant transport
Planting: how and why, spacing, depth
Practical transplanting techniques, removing plants from container
Mulching and watering for establishment

Flower Bed Maintenance

Irrigation, fertilization, mulching, deadheading
Frost preparation (irrigation, frost cloth)
Managing weeds, insects, diseases, and preventative cultural practices

Seeding Flowers

Establishing and maintaining wildflower beds
Inter-seeding transplants

Container Gardens

Planting and maintenance of pots

Problem Solving

Identifying and correcting common problems
Diseases
Insects
Rodents
Abiotic problems



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Annuals and Perennials

- * *Herbaceous annuals*
summer and winter
- * *Herbaceous perennials*
bulbs, grasses, flowering
herbaceous plants
- * *Wildflowers*
- * *Roses*



Annuals



- *Complete life cycle in one growing season*
- *Spring and fall annuals, AZ different than other climates*
- *Provide instant color, long season of bloom*
- *Labor intensive bed preparation*
- *Some have high maintenance requirements*



Annuals

- *Cool-weather plants (winter annuals)*
 - Planted Sept. – Nov. at low elevations
 - Planted in spring at higher elevations
 - Bloom fall through spring
- *Heat-tolerant plants (summer annuals)*
 - Planted after last spring frost
 - Bloom through summer and fall



Important winter annuals

- petunia
- pansy
- snapdragon
- alyssum
- geranium
- lobelia



Important summer annuals

- vinca
- pentas
- angelonia
- ipomoea
- celosia
- portulaca
- lantana, a perennial, is used as annual



Transition plants

Sometimes planted before or after summer annuals, don't last an entire season

| | |
|---------------|--------------|
| poppy | anemones |
| ranunculus | canna |
| chrysanthemum | heliotrope |
| marigold | coleus |
| kale | calla lilies |
| gerbera | |



Perennials



- *Last several years depending on species*
- *Provide seasonal color*
- *May die back during their off season (winter or summer)*
- *Require maintenance*
- *Many perennials are used as annuals*



Perennials

When planting perennials consider:

- Light requirement
- Good soil drainage
- Time of bloom
- Plant height
- Flower color
- Foliage color and persistence



Ornamental grasses

- *Year-round interest*
- *Low maintenance*
- *Low water need*



Soil preparation for annuals

- Select good location
 - desired light levels
 - free of debris, weeds
 - loose, fertile, well-drained soil

Work soil only if not too wet or too dry.



Soil preparation for annuals

- **Irrigate** a day before preparing bed if soil is dry
- **Organic amendments**
 - Add 3-4 inches on top of soil to improve water-holding capacity, drainage, aeration
 - Compost, peat moss
- **Incorporate** into the top 8-12" of soil



Soil preparation for annuals

- Soil test to determine if fertilizer is needed
- Fertilizers
 - Add N and S shortly before planting
 - 1-2 lb of ammonium phosphate (16-20-0)
 - 3 lb of sulfur per 100 square feet
 - Incorporate 6-8 inches deep



Selecting a good quality bedding plant

Good quality bedding plant:

Important to ensure successful transplanting, establishment, and good performance. Plants that are too small or overgrown establish very slowly or not at all.



Selecting a good quality bedding plant

- Good quality plants:
 - Large enough top for the size container they grow in
 - Healthy green or appropriate color foliage
 - Regular size leaves, and no damaged leaves, stems, or flowers
 - Good number of flower buds and a few open flowers
 - Roots visible throughout root ball with healthy white root tips
 - No mat of circling roots at the base or sides of the root ball



Planting

- Use a trowel to dig a planting hole about the size of the root ball
- Gently loosen root ball if necessary and set in planting hole
- Plant at crown level, not too high and not too deep, barely cover top of container media with soil
- Pinch off any damaged plant parts, spent flowers or yellow leaves
- Gently fill and tamp soil around plant, do not pack soil hard around the plant



Planting

- Water by hand every half hour or every section
- Do not leave tags from nursery container in the planted bed
- Mulch to a depth of 1" to 2" as appropriate for plant species
- When finished planting, water again
- Water every other day until plants can go on a regular schedule depending on weather



Follow-up care

- Set irrigation to a schedule based on the local soil conditions and weather
- Fertilize every 3-6 weeks with a balanced fertilizer to stimulate growth and flowering
- Deadhead spent flowers down to a lower branch or leaf base
- Inspect plants for insects and disease, remove dying plants, and treat as appropriate
- Inspect bed for weeds and if present remove
- Inspect if mulch needs replacement



Maintenance of perennials

- Cutting back
- Staking
- Deadheading
- Mulching
- Fertilizing
- Dividing after several years



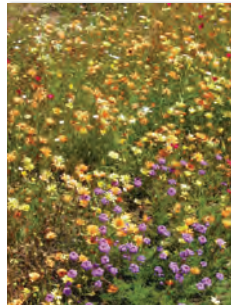
Wildflowers

- Plant in full sun
- Plant in well drained soil
- Rake seed bed before seeding about 1 inch deep and remove weeds
- Follow directions on wildflower seed label for amount of seed to use (e.g. 0.5 lbs/1000 sq. ft.)
- Sow seed, rake in lightly and press into soil until barely covered



Wildflowers

- Water frequently until seedlings are well established, then reduce irrigation
- Control weeds and thin thick patches of seedlings
- Fertilizer is not necessary unless the area is depleted of nutrients, if needed, use low N product at very low rate
- Irrigation during bloom can extend flowering
- Once flowers dry up allow to set seeds, mow to 4-6 inches to disperse seeds



Roses

Rose grades of bare root plants:

- No. 1 – three or more canes pencil thick
- No. 1-1/2 – two canes pencil thick

Roses can be purchased:

- Bare root
- Packaged
- Containerized



Planting roses

- Select healthy plants, immerse roots in water for a few hours before planting
- Plant bare root roses in mid-December through January in Southern and Western Arizona, in March and April in Northern Arizona. Container plants can be planted during the growing season.
- Plant in fertile, well-drained soil
- Space hybrid teas 3' to 5' apart, others to accommodate final plant size



Maintaining roses

- Irrigate deeply.
- Fertilize every 4 weeks from February until October, except in summer.
- Prune out dead and diseased wood, weak and crossing canes. Major pruning in late winter, minor pruning as necessary.
- Moderate pruning involves leaving 5-12 canes about 18-24 inches tall.
- Dead head flowers down to the next leaf with 5 leaflets.
- Learn about how to prune individual types of roses.



Flower bed design examples



Height

Mass display



Design examples continued



Layered

Themed



Design continued



Perennial beds

Annual beds



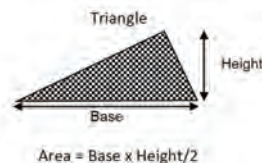
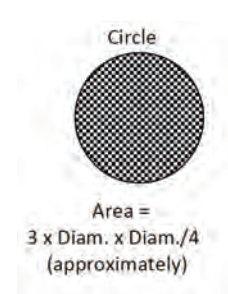
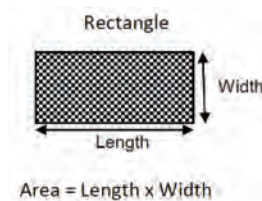
Resources

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- Irish, M. 2006. Perennials for the Southwest. Timber Press
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- Johnson, E.A. and S. Millard. 1993. How to Grow the Wildflowers. Ironwood Press.
- Johnson, E.A. 1997. Pruning, Planting and Care. Ironwood Press
- University of Arizona Cooperative Extension Publications:
- Flower Planting Guide for the Low Desert (2001)
<https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1100a.pdf>
- Rose Selection and Planting in the Low Desert (2002)
<https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1304.pdf>
 - Growing and Caring for Roses <https://cals.arizona.edu/extension/ornamentalhort/landscapemgmt/acfp/rosecare.pdf>
 - Trouble Shooting Problems of Bedding Plants in the Southwest
https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1723-2017_0.pdf
 - Diagnosing Problems of Roses in the Landscape (2010)
<https://cals.arizona.edu/extension/ornamentalhort/plantprotect/diagnoroseproblems.pdf>
 - Damping – Off (2011) <https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1029.pdf>
 - Diseases of Urban Plants in Arizona (1999)
https://cals.arizona.edu/extension/ornamentalhort/plantprotect/pldiseases_urban.pdf
 - Annual Flowers for Northern Arizona above 6,000 foot elevations (2013)
<https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1255.pdf>
 - Perennials for Northern Arizona above 6,000 feet (2002)
<https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1256.pdf>
 - Javelina Resistant Plants (2017) <https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1238-2017.pdf>
 - Recognizing and Treating Iron Deficiency in the Home Yard (2013)
<https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1415.pdf>

How to determine plants needed for flower beds:

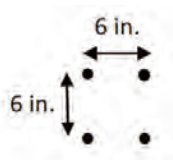
1. Calculate area to be planted for each species
2. Find out the species or cultivars to be used and their recommended spacing
3. Find out how many plants are in one flat (or what size container)
4. Calculate number of flats needed from table

1) Calculate area to be planted for each species



2) Find out the species or cultivars to be used & recommended spacing

- Planting on Center (OC)
 - Refers to the distance between plants
 - For example: 6 inches OC



3) Find out how many plants are in one flat (or what size container)



3) Calculate number of flats needed from table

Table to determine the area one flat of plants covers at different plant spacings.

| Distance between plants (inches) | Plants per square foot | Plants per flat | | | | | | | | | | | | | |
|----------------------------------|------------------------|----------------------------|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--|
| | | 4 | 9 | 16 | 25 | 36 | 42 | 48 | 49 | 60 | 64 | 72 | 81 | 90 | |
| | | Area covered (square feet) | | | | | | | | | | | | | |
| 4 | 9.00 | 0 | 1 | 2 | 3 | 4 | 5 | 5 | 5 | 7 | 7 | 8 | 9 | 10 | |
| 6 | 4.00 | 1 | 2 | 4 | 6 | 9 | 11 | 12 | 12 | 15 | 16 | 18 | 20 | 23 | |
| 8 | 2.25 | 2 | 4 | 7 | 11 | 16 | 19 | 21 | 22 | 27 | 28 | 32 | 36 | 40 | |
| 10 | 1.44 | 3 | 6 | 11 | 17 | 25 | 29 | 33 | 34 | 42 | 44 | 50 | 56 | 63 | |
| 12 | 1.00 | 4 | 9 | 16 | 25 | 36 | 42 | 48 | 49 | 60 | 64 | 72 | 81 | 90 | |
| 15 | 0.64 | 6 | 14 | 25 | 39 | 56 | 66 | 75 | 77 | 94 | 100 | 113 | 127 | 141 | |
| 18 | 0.44 | 9 | 20 | 36 | 56 | 81 | 95 | 108 | 110 | 135 | 144 | 162 | 182 | 203 | |
| 24 | 0.25 | 16 | 36 | 64 | 100 | 144 | 168 | 192 | 196 | 240 | 256 | 288 | 324 | 360 | |

Example:

The bed to be planted is 10 feet wide and 21.5 feet long which makes an area of 215 square feet.

The plants will be spaced 6" on center. They are available at the nursery with 36 plants per flat.

Using the table above, we know that plants planted 6 inches on center will require 4 plants per square foot.

Since you know that your plants are available in 36 plants per flat you also know that at this spacing one flat of plants will cover 9 square feet.

Therefore, calculate $215 \text{ (area to be covered)} / 9 \text{ (area covered by one flat)} = 23.88$ flats required, round up to 24 flats.

Or....use an app or online calculator

1) Enter bed measurements

2) Enter plant spacing

3) Decide on rectangular or triangular pattern

4) Divide by number of plants in each flat

$860 \div 36 = 23.88$

(round up to 24 flats)

Depending on the shape of the bed, you may need to do further calculations.

<https://www.inchcalculator.com/lawn-landscaping-calculators/>

Mulch vs. Organic Amendments

• Mulch

- Material added on top of the soil and remains there to conserve soil moisture, moderate soil temperature, and prevent weed establishment.
- Mulch can be organic such as compost or pine bark or inorganic such as gravel.



• Organic amendments

- Refer to material that is evenly spread over the top of the soil such as compost
- Amendments are incorporated to a depth of 8-12 inches before planting annuals or herbaceous perennials.



Calculating Mulch & Amendments

| How many cubic feet or cubic yards are needed? (1 cubic yard = 27 cubic feet) | | | | | | |
|---|---|----|----|--|-----|------|
| Area Square feet | Cubic feet needed to cover area to a depth of: | | | Cubic yards needed to cover area to a depth of: | | |
| | 1" | 2" | 3" | 2" | 3" | 4" |
| 25 | 2 | 4 | 6 | | | |
| 50 | 4 | 8 | 13 | | | |
| 75 | 6 | 13 | 19 | | | 0.9 |
| 100 | 8 | 17 | 25 | 0.6 | 0.9 | 1.2 |
| 200 | 17 | 33 | 50 | 1.2 | 1.9 | 2.5 |
| 300 | | | | 1.9 | 2.8 | 3.7 |
| 400 | | | | 2.5 | 3.7 | 4.9 |
| 500 | | | | 3.1 | 4.6 | 6.2 |
| 600 | | | | 3.7 | 5.6 | 7.4 |
| 700 | | | | 4.3 | 6.5 | 8.7 |
| 800 | | | | 4.9 | 7.4 | 9.9 |
| 900 | | | | 5.6 | 8.3 | 11.2 |
| 1000 | | | | 6.2 | 9.3 | 12.4 |

Annuals and Perennials

Annuals and herbaceous perennials are popular because they have flowers and foliage that is valued for their ornamental value.

Annuals

- Annuals complete their life cycle in one growing season
- Annuals in Arizona are categorized by the time they flower. In the low and intermediate elevation desert in Arizona we distinguish summer and winter annuals. Summer annuals are planted after the last frost and will bloom throughout the summer, while winter annuals are planted in fall and will bloom into early spring. Winter annuals cannot tolerate the high temperatures in summer, while summer annuals cannot tolerate the low temperatures in winter.
- Annuals planted at higher elevations (4,000 feet and above) are generally all planted after the last frost and do not survive in winter.
- Annuals provide instant color and have a long season of bloom
- Bed preparation for annuals, similar to vegetable beds, is labor intensive.
- Some annuals have high maintenance requirements beyond the regular fertilizing and irrigation (e.g. dead heading)
- Important winter annuals:
 - petunia, pansy, snapdragon, alyssum, geranium, lobelia
- Important summer annuals:
 - vinca, pentas, angelonia, ipomoea, celosia, portulaca, and lantana, a perennial used as annual.

Perennials

- Last several years depending on species
- Provide seasonal color
- May die back during their off season (winter or summer)
- Require maintenance (deadheading, cutting back, fertilizing, mulching, dividing)
- Many perennials are used as annuals
- Grasses are low maintenance, low water use perennials that provide year-round interest.
- When planting perennials consider:
 - light requirement, good soil drainage, time of bloom, plant height, flower color, foliage color and persistence

Selecting a good quality bedding plant

Selecting a good quality bedding plant is important to ensure successful transplanting, establishment, and good performance. Plants that are at the right stage for transplanting will be ready to grow vigorously in their new environment in the landscape. Those that are too small or overgrown will either establish very slowly or not at all.

Good quality plants should have:

- Large enough top for the size container they grow in
- Healthy green or appropriate color foliage
- Regular size leaves, and no damaged leaves, stems, or flowers
- Good number of flower buds and a few open flowers
- Roots visible throughout root ball with healthy white root tips
- No mat of circling roots at the base or sides of the root ball

If the top is too small, plants may be too young and not ready for transplanting. Sometimes those plants have not enough roots to hold the root ball together when it is taken out of the container. Often they also lack flower buds.

Overgrown plants that stayed too long in the container have a top that is too large for the size container it is growing in. Their foliage is often light green or yellow, they have few flowers, and few or no flower buds. Roots often form a thick mat at the bottom and outside the root ball.



The plants in the six-cell pack on the left are good quality with healthy foliage, flowers, and flower buds. They have an appropriate size for the size container they grow in. The root balls show healthy roots and are just starting to circle at the bottom (middle picture). Loosening the root with allow them to grow into the surrounding potting soil after planting (right picture).

Successful preparation, planting, and after-care of annual and perennial beds

Planting bed preparation

- Remove debris and weeds from the area to be planted
- If possible irrigate a day or two before starting bed preparation
- Evenly spread a layer 3-4 inches thick of organic material such as well cured compost on top of planting bed
- Evenly sprinkle a moderate amount of sulfur and fertilizer (see bag instructions) over the planting area
- Incorporate compost and fertilizer with a shovel or rototiller to a depth of 8-12 inches, rake planting bed to level and smooth surface

Planting

- Start planting in a corner with half the distance of on center distance from the edge
- Measure with a trowel in all directions how far you need to move
- Each planting hole should be about the size of the root ball
- Gently loosen root ball if necessary and set in planting hole
- Plant at crown level, not too high and not too deep, barely cover top of container media with soil
- Pinch off any damaged plant parts, spent flowers or yellow leaves
- Gently fill and tamp soil around plant, do not pack soil hard around the plant
- Water by hand every half hour or every section
- Do not leave tags from nursery container in the planted bed
- Mulch to a depth of 1" to 2" as appropriate for plant species
- When finished planting, water again
- Water every other day until plants can go on a regular schedule depending on weather

Follow-up care

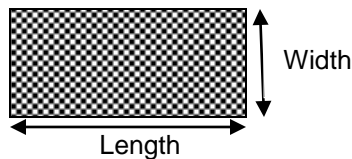
- Set irrigation to a schedule based on the local soil conditions and weather
- Fertilize every 3-6 weeks with a balanced fertilizer to stimulate growth and flowering
- Deadhead spent flowers down to a lower branch or leaf base
- Inspect plants for insects and disease, remove dying plants, and treat as appropriate
- Inspect bed for weeds and if present remove
- Inspect if mulch needs replacement

How to determine materials needed to install flower beds

1. Calculate area to be planted for each species.
2. Find out the species or cultivars to be used and their spacing.
3. Find out how many plants are in one flat (or what size container).
4. Calculate number of flats needed from table.

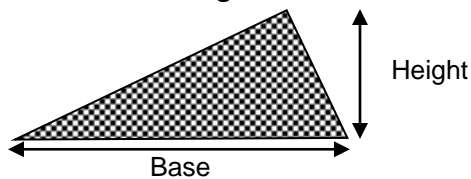
Calculating area

Rectangle



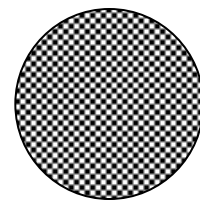
$$\text{Area} = \text{Length} \times \text{Width}$$

Triangle



$$\text{Area} = \text{Base} \times \text{Height} / 2$$

Circle



$$\text{Area} = 3 \times \text{Diam.} \times \text{Diam.} / 4$$

(approximately)

Planting on center (OC)

Refers to the distance between plants: 6 inches OC

Each plant occupies 36 square inches

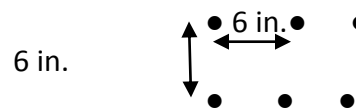


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| | | 4 | 9 | 16 | 25 | 36 | 42 | 48 | 49 | 60 | 64 | 72 | 81 | 90 |
| | | | | | | | | | | | | | | |
| | | Area covered (square feet) | | | | | | | | | | | | |
| 4 | 9.00 | 0 | 1 | 2 | 3 | 4 | 5 | 5 | 5 | 7 | 7 | 8 | 9 | 10 |
| 6 | 4.00 | 1 | 2 | 4 | 6 | 9 | 11 | 12 | 12 | 15 | 16 | 18 | 20 | 23 |
| 8 | 2.25 | 2 | 4 | 7 | 11 | 16 | 19 | 21 | 22 | 27 | 28 | 32 | 36 | 40 |
| 10 | 1.44 | 3 | 6 | 11 | 17 | 25 | 29 | 33 | 34 | 42 | 44 | 50 | 56 | 63 |
| 12 | 1.00 | 4 | 9 | 16 | 25 | 36 | 42 | 48 | 49 | 60 | 64 | 72 | 81 | 90 |
| 15 | 0.64 | 6 | 14 | 25 | 39 | 56 | 66 | 75 | 77 | 94 | 100 | 113 | 127 | 141 |
| 18 | 0.44 | 9 | 20 | 36 | 56 | 81 | 95 | 108 | 110 | 135 | 144 | 162 | 182 | 203 |
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Example 1.

The bed to be planted is 10 feet wide and 21.5 feet long which makes an area of 215 square feet.

The plants will be spaced 6" on center. They are available at the nursery with 36 plants per flat.

Using the table above, we know that plants planted 6 inches on center will require 4 plants per square foot. Since you know that your plants are available in 36 plants per flat you also know that at this spacing one flat of plants will cover 9 square feet. Therefore, calculate 215 (area to be covered) / 9 (area covered by one flat) = 23.88 flats required, round up to 24 flats.

Number of plants required per 100 square feet at various plant spacing

(OC = on center and refers to the distance from one plant to the next).

| Spacing (inches OC) | Plants per 100 sq ft | Spacing (inches OC) | Plants per 100 sq ft |
|------------------------|-------------------------|------------------------|-------------------------|
| 4 | 900 | 18 | 44 |
| 6 | 400 | 24 | 25 |
| 8 | 225 | 30 | 16 |
| 9 | 178 | 36 | 11 |
| 10 | 144 | 48 | 6 |
| 12 | 100 | 72 | 3 |
| 16 | 56 | | |

Example 1.

The bed to be planted is 10 feet wide and 21.5 feet long which makes an area of 215 square feet.

The plants will be spaced 6" on center, They are available at the nursery with 36 plants per flat.

At 6" OC 100 sq ft requires 400 plants (see chart above)

400 plants/100 sq ft x 215 sq ft = 860 plants needed

860 plants needed / 36 plants per flat = 23.88 flats = 24 flats needed

Mulch or amendment requirements

How many cubic feet or cubic yards are needed? (1 cubic yard = 27 cubic feet)

| Area Square feet | Cubic feet needed to cover area to a depth of: | | | Cubic yards needed to cover area to a depth of: | | |
|---------------------|---|----|----|--|-----|------|
| | 1" | 2" | 3" | 2" | 3" | 4" |
| 25 | 2 | 4 | 6 | | | |
| 50 | 4 | 8 | 13 | | | |
| 75 | 6 | 13 | 19 | | | 0.9 |
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Mulch refers to material that is added on top of the soil and remains there to conserve soil moisture, moderate soil temperature, and prevent weed establishment. Mulch can be organic such as compost or pine bark or inorganic such as gravel.

Organic amendments such as compost refer to material that is evenly spread over the top of the soil and then incorporated to a depth of 8-12 inches before planting annuals or herbaceous perennials.



Trouble Shooting Problems of Bedding Plants in the Southwest

Ursula Schuch



Fig. 1. Vinca showing symptoms of dying plants right next to healthy plants (top), severe chlorosis (lower left), and wilting (lower right). Close up inspection of shoots and roots and possibly laboratory analysis are necessary to identify the cause and implement control treatments.

Annual bedding plants create instant impact with long blooming flowers or colorful foliage. In the desert Southwest, bedding plants are installed twice each year: cool season bedding plants are planted at the beginning of fall and warm season plants at the beginning of spring. Installing new plants twice a year is a considerable investment of time and money. To protect this investment, regular inspections and care are necessary to maintain healthy plants. Regular maintenance tasks include removing weeds and debris, irrigation and fertilization, pruning shoots, and removing spent flowers. Inspection or maintenance frequency can vary from a few days



Fig. 2. Zinnia with symptoms of insect infestation and disease.

during initial establishment, especially during the hot time of year, to every other week once plants are well established.

When a plant is not thriving, the leaves, shoots, flowers, and soil should be examined closely to look for symptoms and determine the cause. Poor color foliage, leaves shriveling or falling off, or evidence of insects or disease on the plant indicate a health problem (Fig. 1 and 2). Small, stunted plants, lack or damage to flowers or flower buds, and plants falling over require close inspection to determine the cause. Soil that is too dry or too wet can be a problem and pulling out the roots of damaged plants can help to diagnose potential root

issues. Following are ten of the most common bedding plant problems encountered in the arid climate of the Southwestern United States. The first five are abiotic problems caused by factors such as drought, wind, freezing or overwatering; the next five are biotic problems, caused by different organisms. When trouble shooting, symptoms such as wilting foliage, yellowing leaves, and stunted growth are non-specific and may result from different causes. Some insects damaging plants may hide in flower buds or on the underside of leaves. Knowing the cultural practices and the history of a site, such as an irrigation system breakdown, flooding, or cold temperatures, can assist in trouble shooting. The origin of a problem should be positively identified before implementing control treatments. This may require laboratory analysis of a fungus or identification of an insect. Early detection may allow for control of an insect or disease problem with a simple spot treatment or by removal of damaged leaves or plants before a large area becomes affected. In all cases, selection of appropriate species for the season and the site, while implementing appropriate maintenance practices will prevent many problems in bedding plants.

1. Root balls of plants in nursery pots or transplants in the soil dry out

The growing medium used in small nursery containers dries fast, especially in a semi-arid environment when temperatures are high and relative humidity is low. Irrigating plants before and right after planting can prevent this. Once dry, root balls are often difficult to rewet. Several irrigation cycles may be necessary to rewet dry root balls of plants in containers. If the drought lasts too long, foliage wilts and eventually dies.

2. Overwatering

Bedding plants growing in excessively wet soil appear wilted even when the soil is wet. Foliage color can fade to light green and yellow and the leaves may drop (Fig. 3). Excessively wet soil not only lacks oxygen in the root zone, but also impedes uptake of nutrients and water by the roots, and can leach nutrients below the root zone. Roots in these conditions become prone to infection by fungal diseases. Appropriate soil drainage and allowing the soil to dry between irrigations will prevent this problem. Irrigation frequency and length of application should match the soil type, plant material, and weather conditions.

3. Physical damage from frost, wind, and excess heat

Foliage can be damaged and turn brown from both freezing and excessive heat. Strong winds can shred or dry out foliage, and blow off or damage flowers. Selecting the correct plants for the season and the microclimate can help avoid these problems. If frost is forecasted, tender plants in pots can be moved under



Fig. 3. Overwatering and poor drainage caused the decline of globe amaranth. Symptoms can also be caused by root diseases.

trees, a covered patio or can be covered temporarily. Flower beds in the open can be covered with frost cloth until the danger of freezing temperatures has passed. Proper watering will minimize damage to plants due to wind and heat by supplying moisture to continue transpiration and photosynthesis when demand for water is high.

4. Low light

Many bedding plants are labeled as full sun plants, indicating they require at least six hours of direct sun exposure daily. Low light conditions prevent full sun plants from carrying out photosynthesis at rates necessary to produce enough energy for healthy growth. Plants in low light conditions will appear long and spindly due to stretched internodes, canopies will appear thin due to fewer leaves, and leaves are larger and thinner than comparable leaves of plants receiving sufficient light. Leaf color can appear light green. Moving plants to a location with sufficient sunlight or replacing them with shade tolerant plants corrects this situation.



Fig. 4. Young leaves with iron deficiency show symptoms of interveinal chlorosis. Photo credit: Paul Bachi, University of Kentucky Research and Education Center, Bugwood.org

5. Plant nutrition

Nutrient deficiencies in bedding plants are often caused by high pH, low nitrogen, and low levels of micronutrients. High pH between 7.0 and 8.0 or greater is common in desert soils and irrigation water. Optimum conditions for most bedding plants growing in the landscape range from pH 5.5 to 6.5. Higher pH can limit uptake of micronutrients such as iron, manganese, zinc, and copper. Micronutrient deficiencies first appear on younger leaves and symptoms often include interveinal chlorosis where the veins of the leaves have a darker color and the area in between are light green or yellow (Fig. 4). Adding sulfur to the soil before planting will temporarily decrease the pH and can prevent this problem.

If annuals stop blooming or decrease significantly in growth after the first set of flowers has bloomed, lack of several nutrients can be the problem. Adding a complete fertilizer which contains nitrogen, phosphorous and potassium at regular intervals will stimulate more flowers and vegetative growth. Light green foliage starting with older leaves suggests lack of nitrogen and in severe cases the foliage can turn yellow. Regular application of fertilizer will prevent this and foliage should turn green within a couple of days. Other symptoms of nutrient deficiency or excess include smaller, distorted leaves, fewer leaves, weak stems, and discoloration of leaves.

6. Fungal diseases on roots

Several soil fungi attack especially the lower stems, the crown and roots of bedding plants. Fungi survive for many years in the soil or they can be present in the root ball of transplants. *Phytophthora*, *Pythium*, and *Rhizoctonia* fungi can infect a wide range of bedding



Fig. 5. *Rhizoctonia* (top) and *Pythium* (bottom) fungi caused root and stem rot. Photo credit top: R.K. Jones, North Carolina State University, Bugwood.org. Photo credit bottom: Chazz Hesselein, Alabama Cooperative Extension System, Bugwood.org

plants such as petunia, vinca, verbena, snapdragon, stock and others. Symptoms include rotting tissue at or below the soil line followed by wilting and plant death (Fig. 5). Healthy roots are light brown and root tips are white while infected roots turn brown or black with the outer layer easily pulled off. Very young plants are susceptible to damping off; that is seedlings fall over because the fungus damaged the stem tissue at soil level or the roots. Above ground parts are wilted with yellow leaves and stunted growth. Fungal root diseases are favored by overwatering, high temperatures, and soils with high clay content and poor drainage. Soil preparation before planting can improve drainage and prevent severe fungal root problems. Fungicides can be used once the disease causing organisms are identified. Diseased plants should be removed as soon as possible to prevent further spread. Bedding plants benefit when the top layer of the soil is replaced every couple of years to prevent a buildup of disease organisms.



Fig. 6. Symptoms of powdery mildew (top) and rust (bottom). Photo credit top: Mary Ann Hansen, Virginia Polytechnic Institute and State University, Bugwood.org. Photo credit bottom: Penn State Dept. Plant Pathology & Environmental Microbiology Archives, Penn State University, Bugwood.org

7. Fungal diseases on leaves and shoots

Powdery mildew and rust are fungal diseases found on the leaves, stems, flowers, and fruit of bedding plants (Fig. 6). Powdery mildew appears as white or gray powdery spots on the upper leaf surface and other above ground parts of the plant. Conditions favoring the disease are warm day temperatures and cool nights, moderate to high humidity, low light intensity, and poor air flow. Zinnias are very susceptible to powdery mildew. The best approach for prevention is to use resistant plant species or cultivars, thin dense growth to increase air flow, and plant only in appropriate light conditions. Fungicides and other compounds can prevent or control powdery mildew.

Rust is a fungal disease that can be diagnosed through the spores that appear on the lower leaf surface. Color of the spores varies from yellow and orange to brown. Snapdragon, sunflower, geranium and other plants



Fig. 7. Aphids (top) and adult whiteflies (bottom) feed on leaves and stems. Credit for both photos: Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org

are susceptible to rust. Rust infects plants under moist conditions. Keeping plant foliage dry and promoting good air circulation can reduce infection. Fungicides and neem oil can be used to control rust. It is best to plant resistant species or cultivars whenever possible.

8. Aphids and whiteflies

These insects are a problem when populations build up and damage plants by sucking sap from foliage and stems. Aphids prefer soft shoot tips and whiteflies are found on the underside of leaves (Fig. 7).

Aphids and whiteflies excrete sticky honeydew which stays on the leaves and is often colonized by sooty mold. This black-colored fungus feeds off the honeydew and is unsightly, but does not damage the plant tissue. Damage from aphids and whiteflies feeding on plants varies depending on the number of insects, but leaves may turn yellow and can die and shoot growth may be stunted. Besides the primary damage from feeding, these insects also transmit disease causing organisms such as viruses when feeding first on infected plants and then on healthy plants.

Aphids and whiteflies are best controlled when present in small numbers and regularly hosed off with a strong stream of water. Reduce the application of nitrogen fertilizer which stimulates growth of tender shoot tips that are attractive to aphids. Natural enemies can manage whiteflies and aphids but usually are not sufficient to permanently reduce large populations. Insecticidal soaps, horticultural oil, and insecticides are available to manage aphids and whiteflies.

9. Slugs and snails

Moist conditions and dense vegetation favor slugs and snails. Holes in foliage and flowers and shiny, slimy trails indicate the presence of these mollusks. Certain bedding plants such as geraniums, lantana, and some plants with stiff leaves and fragrant foliage are often not attacked by slugs and snails. Slugs and snails can be controlled with bait. Removing daytime hiding spots makes the area less inviting.

10. Vertebrate Pests

Rabbits can be desirable wildlife, but they can also cause damage feeding on plants and chewing through exposed irrigation lines. Rabbits are most active in the evening and early morning hours. Protecting flower beds with chicken wire or similar material will guard against rabbits. Burying the bottom 6 inches or more of a 4 foot tall fence into the ground will prevent rabbits from digging underneath. There are some chemical repellents that can be sprayed on plants, but they are usually effective for only a short period of time, they may require repeat applications, and animals may continue to feed if alternative foods are not available. Ground squirrels are active during daylight hours and are often found in gardens or landscapes that border the desert. They are excellent climbers and are not deterred by fencing unless

it covers an entire area. Control methods are difficult and include trapping and baiting. Woodrats or packrats are nocturnal and are also excellent climbers. Barriers and trapping are effective for managing woodrats. Gophers are burrowing rodents that can disturb and consume plants. Trapping and baiting are the most effective management strategies. See your local Cooperative Extension Office for additional information.

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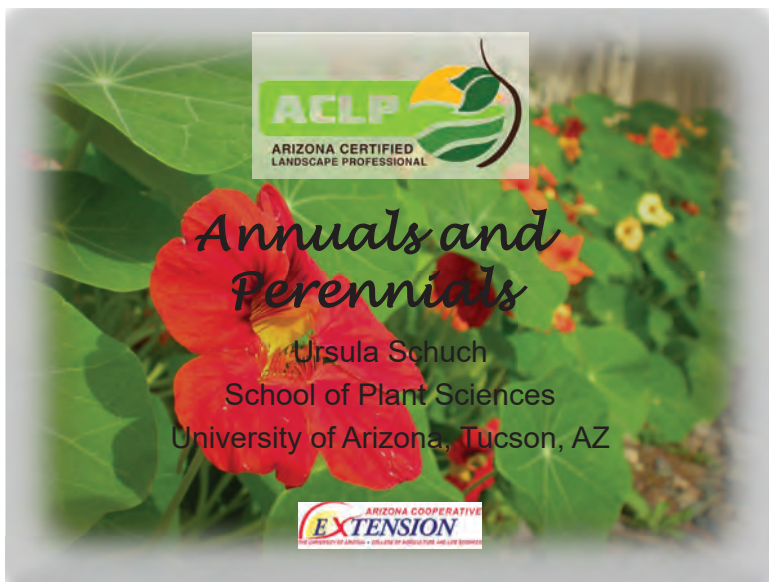
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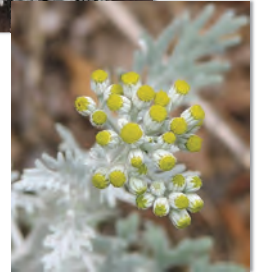
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Centaurea gymnocarpa
 dusty miller
 winter annual, full sun to partial shade



1



Lobelia erinus
 blue lobelia
 Winter, full sun annual



2

Viola x wittrockiana
 pansy
 Full sun to partial shade, winter annual, many varieties available



3

4

Dianthus spp.
 dianthus or Sweet William
 Full sun winter annual



Salvia coccinea
 tropical sage
 Full sun to partial shade transitional annual, may survive winter and summer depending on exposure



5

Angelonia angustifolia
summer snapdragon
summer annual, full sun but
best with filtered shade



6



Ipomoea batatas
sweet potato vine
Summer annual, full sun to full shade,
may last through winter if no frost



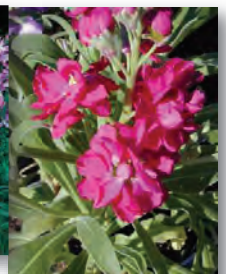
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Antirrhinum majus
snapdragon
Winter full sun annual



8

Matthiola incana
stock
Fragrant winter
annual



9



Catharanthus roseus
vinca
Summer annual, full sun,
botanical name important so as
not to confuse with *Vinca major*
the shade ground cover



10



Coleus spp.
coleus
For shade, transitional
season, summer and
winter, depending on
exposure

11



Lantana montevidensis
purple trailing lantana
Full sun, summer
flowering perennial

12



Lantana camara
bush lantana
Full sun, summer
flowering perennial

13



Lantana hybrid
Lantana
ground cover, full sun,
summer flowering
perennial

14



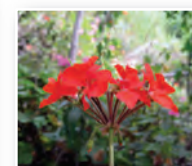
Petunia hybrida
petunia
Full sun, winter annual, may
last into early summer

15



Lobularia maritima
sweet alyssum
Winter annual, available
in shades of blue to
white, full sun to partial
shade

16



Pelargonium spp.
geranium
Winter annual, full sun, available
in many cultivars and colors

17





Pentas lanceolata
star flower/pentas
Full sun, summer
annual

18



Portulaca spp.
moss rose or purslane
Full sun to partial shade,
summer annual

19



20



Celosia spp.
cockscomb
Full sun, summer annual,
manageable variety is called
'New Look'



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