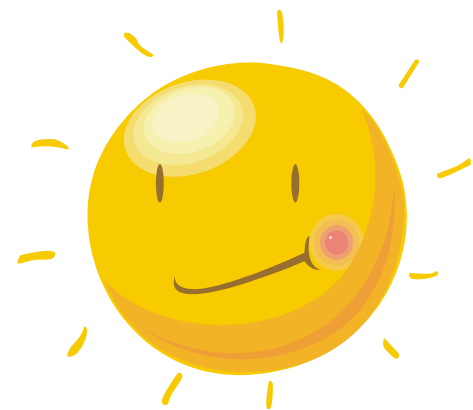


Coping with Climate Change in Vegetable Production Systems

Dr. Stephanie Walker
Extension Vegetable
Specialist



Vegetable Production in NM

- Challenges in the Southwest US include:
- Areas at higher elevations have a shorter growing season
- Areas at lower elevations have limited and unpredictable rain events – supplemental irrigation usually needed

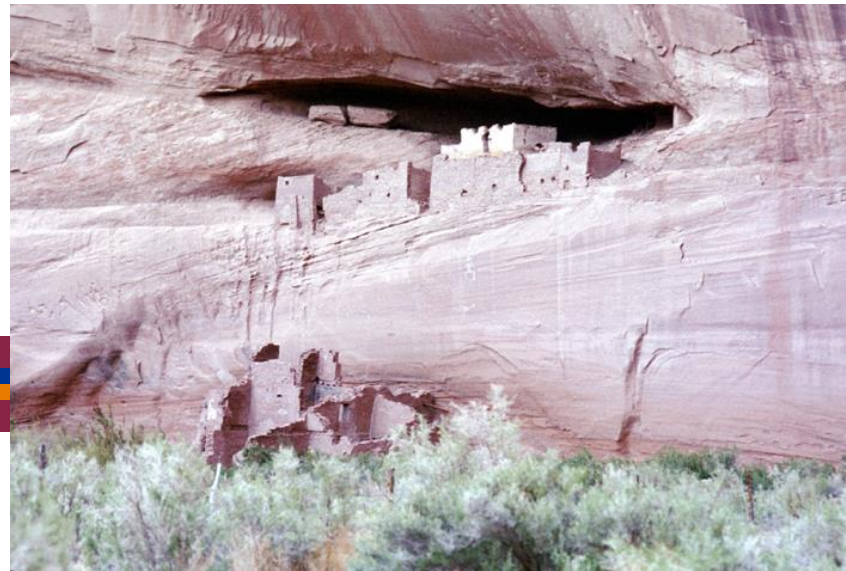
The Ancient Ones: Anasazi

- Vegetable production has a long history in the Southwest
- Ancient Native Americans developed many strategies to cope with challenging conditions



Early Southwest Agriculture

- Irrigation canals, dams, diversions constructed by northern NM Pueblos
- Trincheras (trenches) built to collect water, reduce erosion, prevent frost damage
- Floodplain planting



Early Southwest Agriculture

- At Chaco Canyon, rainwater runoff was collected from mesas where it was channeled to fields to produce crops
- Crop selection – seed was saved from plants that survived and matured under the challenging conditions



Key Concepts

- Global warming is on-going
- Impact on Southwest US based on historic trends = warmer & drier



Impacts to Vegetable Production (+)

- Milder winters with longer frost-free seasons
- Longer growing season
- Higher carbon dioxide (CO₂) levels benefit growth of some plants
- Crop specific benefits (ex. Higher quality red chile; prolonged harvests of melons, tomatoes)

Impacts to Vegetable Production (-)

- Increased periods of severe heat
- Increased disease and pest pressure
- Increasing periods of drought along with scarcity of irrigation water
- Increased rate of soil and water salinization
- Increased extreme weather events (hail, torrential rainfall)

How Can We Cope?

- Know our specific challenges
- Develop strategies to address our situations
 - Implement best production practices
 - Irrigation and infrastructure planning
 - Variety selection and crop diversity

Coping with Climate Change

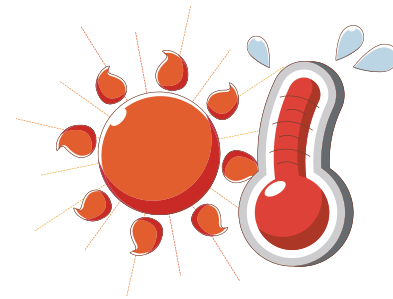
BEST PRODUCTION PRACTICES

Know Your Vegetable Plants

- Many vegetables expire at cold temps; some suffer at high temps



- Plant vegetables for growth during their preferred temperature



- Warm Season vs. Cool Season Vegetables

Warm vs. Cool Season Crops

- **Warm season crops:**
 - Injured or killed by frost
 - May stop setting fruit at high temperatures (>95°F)
 - Squash, melons, tomatoes, eggplant, okra, cucumber, beans, chile, bell peppers

Warm vs. Cool Season Crops

- **Cool season crops:**
 - Tolerate (or are improved) by frost
 - Growth slows at very low temperatures
- Broccoli, carrots, spinach, lettuce, Swiss chard, kale, onions, beets, radishes

Prepare Soil to Maintain Moisture

- Best soil is deep, well drained & contains plenty of organic matter
- Organic matter holds soil moisture
Example: Sponge vs. Gravel



Know your soil

- Soil type affects frequency and duration of watering
- Most soil in NM is very low in organic matter
- Increasing organic matter greatly increases moisture holding capacity of soil
- To increase:
 - Add compost and manure
 - Use organic mulch

Compost

- Benefits of compost
 - Organic matter
 - Aeration
 - Soil moisture
- Make your own compost
- Compost must reach 130°F for approx. 7 days



http://www.aggregatepros.com/images/Compost_Heap_lg.jpg

Compost

- Ingredients
 - Leaves, manure, yard clippings, food scraps
- Turn often
- Keep moist, not wet
- Don't add
 - Meat, dairy, slow decomposing items



Compost

- When to add
 - Pre planting
 - Post planting
- How to add
 - Till in
 - Mulch



http://www2.grist.org/images/advice/how/2008/08/19/shovel-o-compost_h528.jpg

Coping with Climate Change

IRRIGATION

Water

- The vast majority of vegetable crops grown in New Mexico will require some supplemental irrigation
- Controlled application can aid in vegetable management for drought tolerance



Water Harvesting

- Gray Water: Example: Place bucket in shower to catch water while it's heating
- Rainwater Harvesting: Depending on size of collection area, even small rain events can provide helpful quantities of irrigation water

Water

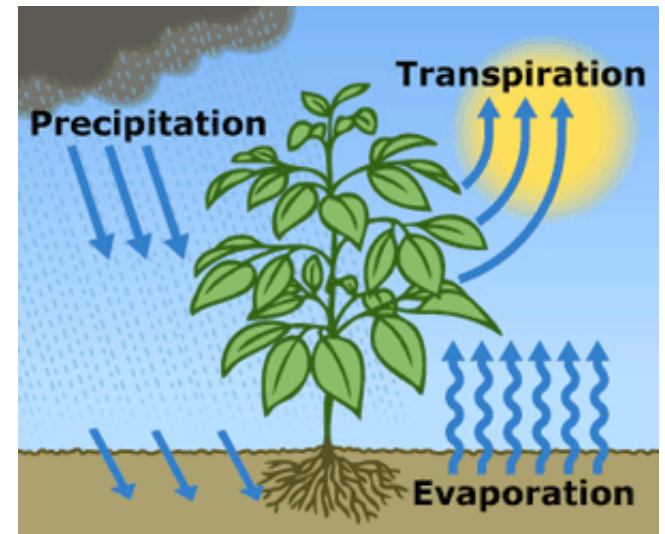
- Too much water can also stress or kill plants
 - Water-saturated soil can ‘smother’ roots
 - Many soil borne diseases thrive in overly wet soil
- Dig down to roots to check moisture

Water Requirements Through the Season

- Know your plants, including critical windows for optimal watering
- Germination and transplant establishment periods are always critical
- Critical water stage for most vegetables is while consumable part is growing
- 'Fruiting' vegetables (tomato, chile peppers, melons) is at flowering and fruit set

Disorders: Blossom End Rot

- Caused by Calcium (Ca) deficiency at growing point in fruit
- Drought stress during fruit set prevents transportation of Calcium



Encourage Deep Root Growth

- The deeper the roots, the better a plant can hold up to drought stress
- Less frequent, deep watering encourages
- Water slowly to let moisture percolate
- Some vegetables naturally have shallow roots so wouldn't benefit: Onions, Lettuce
- Deep rooted vegetables include: Asparagus, Squash, Tomatoes

Deliver Water Directly to the Roots

- Sprinklers and flood irrigation are *less* efficient
- Drip irrigation and soaker hoses are *more* efficient
- Water in early morning or evening to minimize evaporation



Olla Irrigation

- Use of unglazed, terra cotta pots filled with water and buried next to growing plants
- Ollas are fitted with caps to reduce evaporation
- Ollas are refilled when needed & maintained at least 50% full



<http://permaculturenews.org/2010/09/16/ollas-unglazed-clay-pots-for-garden-irrigation/>

Coping with Climate Change

MODIFY THE GROWING ENVIRONMENT

Basic Tools for Cold Weather Protection

- Microenvironments
- Mulch
- Cloches
- Row Covers

More Advanced

- Cold frames
- Hoop houses
- Greenhouses



Microenvironments

- Spaces in your yard or garden that are protected from cold winds and weather
- Sheltered spots that create a buffer in temperature
 - Against a house
 - Between two buildings
 - Beside a wall
 - Between taller, larger plants



Mulch

- Material placed on soil surface around vegetable plants
- Organic mulch helps increase soil organic matter
- Be careful to not introduce weed seed



Mulch

- Types
 - Straw, leaves, wood chips, newspaper, plastic, pecan shells, compost
- How to apply
 - Once plants are established, cover ground 2 – 4 inches
 - Water to help settle
 - Don't cover vegetable plants



Mulching

- Pros
 - Keeps weeds at bay
 - Conserves soil moisture
 - Warms/cools soil temp
- Cons
 - Could harbor pests
 - Labor and cost investment
 - Warms/cools soil temp



http://thailand.ipminfo.org/images/components/Organic_farm_egg_plant_mulching_3.JPG

Lithic Mulch

- Use of pebbles, or other stone-type materials
- Used in Galisteo Basin of NM by early Native American farmers
- Useful in dry, desert environments
- Reduces water evaporation,
- Reduces soil erosion
- Increases water infiltration
- Increases soil temperature



Cloches



Burpee.com



<http://www.naturemoms.com/blog/wp-content/uploads/2008/02/milk-jug-cloche.jpg>

Cloches (rhymes with slosh)

- Provide protection to small, tender plants from frost, wind, and rain
- Wall-of-water, soda bottles, milk jugs, and food containers
- Remove or open when temperature rises
- While getting a head start on your garden you are saving these items from the landfill!



Row Covers

- Provides some protection against freezing temperatures (about 4-6° F boost)
- Hoop supported vs. floating
- Perforated polyethylene vs. spun bonded polyester or polypropylene
- Water permeable
- Air permeable
- Remove or open when temperature rises





http://tinyfarmblog.com/wp-content/uploads/2008/06/spr08_row_cover_everywhere.jpg



<http://www.gallupgrowers.com/blog/wp-content/dsc00334.jpg>

Cold Frames

- Protects from early frosts
- Good place to start germination of hardy seeds
- Cool season vegetables will thrive within, even with freezing temperatures outside
- Safe place to start transplants being hardened off
- Easy to construct



Hoop Houses

- Meets the needs of small farmers and gardeners
- Relatively inexpensive to construct
- Must be opened and closed to maintain optimum temperatures for plants growing inside



Cold & Hot Weather Protection - Greenhouses

- Protected space for year round vegetable production
- Sturdy and permanent against wind, snow, and rain
- High cost and labor investment
- High maintenance



Hot Weather Protection

- Shading using structures or companion plants



Coping with Climate Change

COMPANION PLANTING

Companion Planting Concepts...

- Plants have predictable strengths and weaknesses when grown in set environments
 - Physical structure
 - Root growth
 - Phytochemical production
 - Susceptibility or resistance to diseases
 - Relative attraction to pests
- ***Certain plants can benefit - or harm - others when placed in close proximity in the garden***

1) Trap Cropping

- A companion plant is used to attract pests away from the main plant
- Examples: Collards more attractive to diamond back moth; used to protect cabbage
Hubbard squash most attractive for squash bugs
- Be careful to not attract *more* pests to your garden

2) Symbiotic Nitrogen Fixation

- Nitrogen fixing crops are used to boost available N to a main crop
- Example: Use of legumes as companion crop
- Keep in mind-- most of the N fixed by the legume will be used by the legume; limited amounts will be available to the main crop

3) Biochemical Pest Suppression

- Some plants exude phytochemicals that suppress or repel pests or diseases; neighboring plants may also benefit
- Example:
 - Rye residue suppresses germination of weeds; transplanted tomatoes, broccoli do fine

4) Physical Spatial Interactions

- Pair tall, sun-loving plants with low growing shade to best optimize space
- Corn plants are believed to disorient adult squash vine borers; prickly squash vines may discourage vertebrate pests from dining on the corn
- Example: 'The Three Sisters'

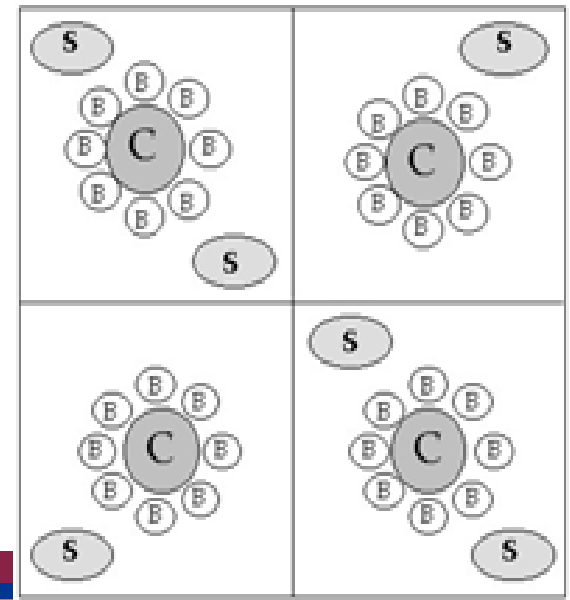
The Three Sisters

- Corn, Beans, and Squash benefit each other when planted closely together
- Corn provides support for beans
- Beans (legume) provide nitrogen to soil
- Squash leaves keep weeds suppressed



Zuni Waffle Garden

- Waffles are approx. 12' x 12'
- Each individual square is indented and surrounded by a high rim
- Sunflowers are often planted along the edges
- Allows maximum water efficiency in arid, southwest climate



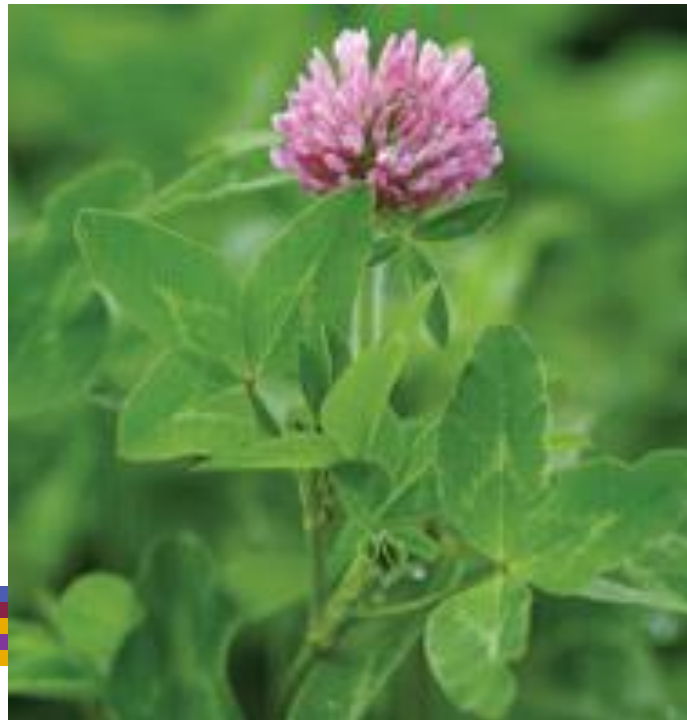
5) Nurse Cropping

- Tall or dense-canopied plants may provide protection to delicate companion plants
- Oats have long been used to prevent weed growth and allow for establishment of alfalfa or other forage crops



6) Beneficial Habitats

- A companion plant provides a desirable habitat for beneficial insects and other arthropods



7) Security Through Diversity

- ‘Not putting all your eggs in one basket’
- Univ. of Cal. research demonstrated that mixing of broccoli cultivars can reduce aphid pressure
- *Excellent insurance against total crop failure during challenging climatic conditions!*

Intercropping

- Plant two or more crops in the same space
- Avoid wasting 'unused' space
- Take advantage of difference in growth rate; harvest quick maturing crop while slower maturing crop is still growing to full size
 - Carrots and radishes
 - Cabbage and lettuce



Crop Diversity

- Monoculture versus polyculture
- Monoculture is especially risky in times of uncertain growing conditions
- Diversity minimizes losses during adverse conditions

Coping with Climate Change

WATER-WISE VEGETABLES

Consumptive Use of Water

- Irrigation requirements impacted by:
 - Type of vegetable
 - Growth stage of plant
 - Time to harvest
 - Environmental conditions

Reduce Time to Harvest

- Look for quick maturing vegetable varieties, including determinate, bush type vegetables
- Start with transplants



Transplants – Potential Benefits

- Can be used to obtain earlier maturity
- Reduce the time plants are exposed to adverse field conditions
- Reduce overall water use
- Helps stand establishment (older seedlings better able to withstand many early season diseases and pests)

Transplants

- Start 4 - 8 weeks before planting outside
- Plant seed in clean potting soil and planting containers
- Provide ample light and warmth for best results
- Harden off seedling before planting outside
- Some vegetable crops are not suited for transplanting

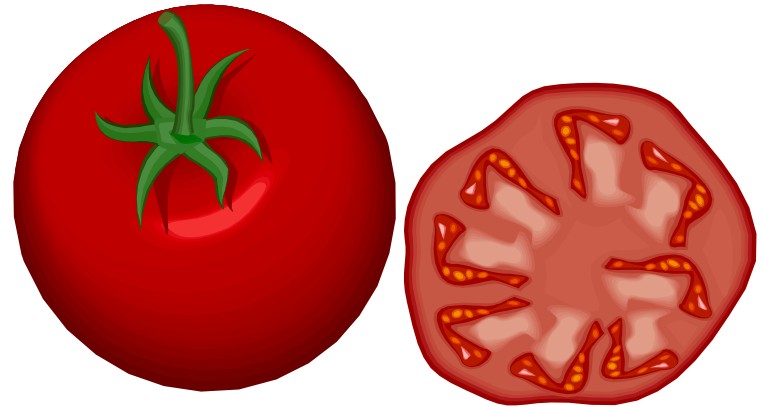


Selecting the Vegetable and Cultivar

- Know your vegetables
- Determinate vs. indeterminate
- Days to maturity

Tomato Cultivars

- Drought-tolerant varieties:
 - Pineapple
 - Yellow Pear
- Look for early maturing varieties
- Tomatoes
 - ‘Early Girl’ 52 days
 - ‘Better Boy’ 75 days
 - ‘Zapotec’ 80 days



Additional Thoughts on Cultivar Selection...

- Different cultivars of the same type of vegetable exhibit different tolerance to hot and cold temperatures
- Look for guidance in seed catalogs, from fellow gardeners, as well as your own experience

Low Water-Use Vegetable Crops

- Tepary Beans
- Black-eyed Peas (Cowpeas)
- Okra
- Asparagus
- Squash (some varieties)

Tepary Beans (*Phaseolus acutifolius*)

- From the Papago Indian phrase “t’pawi”, meaning “it’s a bean”
- Small beans in a wide variety of colors (black, white, brown, mottled)



http://commons.wikimedia.org/wiki/Category:Phaseolus_acutifolius

Tepary Beans

- Native to the American Southwest where they've been a staple crop for thousands of years
- Tepary beans were planted in flooded arroyo; with no additional irrigation, harvest was ready in about two months

Cowpeas (*Vigna unguiculata*)

- Originated in Africa
- Need little water to grow; grow poorly if watered too much
- Thrive in high heat



<http://www.rareseeds.com/store/vegetables/cowpeas/>



Baker Creek Heirloom Seeds

Cowpeas

- Black-eyed peas, as well as many other types
- Immature beans can be eaten like green snap beans
- Most produce long vines; allow 3-5' between rows



http://en.wikipedia.org/wiki/Black-eyed_pea

Okra (*Abelmoschus esculentus*)

- Member of the mallow family (Malvaceae), closely related to hibiscus and cotton
- Origins in northern Africa
- Grown for their immature pods
- Known for glutinous consistency (gumbo)

<http://www.graphicpenguin.com>



Okra Planting

- Okra plants prefer humidity and heat
- Well-drained, fertile soil is optimum
- Intolerant of prolonged wet soil
 - Plant in areas with good drainage
- Plant when soil is warm ($> 60^{\circ}\text{F}$)



Okra Harvest

- Harvest pods when less than 4" (2-3" optimum); larger pods are tough & bitter
- Harvest every other day (4-6 days after flowering)
- Wear gloves & long sleeves when harvesting
- 'Clemson Spineless': 56 days to harvest



Asparagus (*Asparagus officinalis*)

- Tolerant of heat, drought and salinity
- Perennial; productive for many years
- Dioecious
 - male and female plants
- Modern varieties all male for higher yield



<http://en.wikipedia.org/wiki/Asparagus>

Asparagus

- Wild asparagus near the Rio Grande



Asparagus Culture

- Start from crowns
- Don't harvest 1st year
- Stop harvesting
 - spears are less than diameter of a pencil
- Allow ferns to develop to feed the plants



Asparagus Varieties

- Open-pollinated varieties:
‘Mary Washington’
‘Martha Washington’
- Hybrid, all-male varieties:
‘Jersey Giant’
‘Jersey Knight’
‘Purple Passion’



<http://garden.lovetoknow.com/wiki/images/Garden/3/31/Asparagus.JPG>



www.parkseed.com

Squash (*Cucurbita* species)

- Four species: *C. pepo*, *C. maxima*, *C. moschata*, *C. argyrosperma*
- One of the staple crops of Native American in the Southwest
- Some varieties are particularly drought tolerant



Squash: *Cucurbita argyrosperma*

- *C. argyrosperma*: Includes 'Cushaw', many of the best tasting pumpkins and squash
 - Requires a long, warm growing season
 - Many are grown for their edible seeds
- *C. argyrosperma* varieties:
 - 'Tennessee Sweet Potato',
 - 'Hopi Cushaw'



Squash: *Cucurbita moschata*

- *C. moschata*: Includes the butternut and “cheese pumpkins”
- *C. moschata* varieties: ‘Waltham Butternut’, ‘Long Island Cheese’

'Seminole Pumpkin' (*C. moschata*)

- Cultivated by the Seminole Indians in Florida
- Large, spreading vines
- Fruit with long shelf-life



<http://www.southernexposure.com>

Squash: *Cucurbita maxima*

- *C. maxima*: Includes many of the winter squash
- *C. maxima* varieties: Kabocha, Buttercup, Hubbard

Red Kuri Squash (*C. maxima*)

- Also called 'Baby Red Hubbard'
- Thick-skinned, orange colored, winter squash
- Delicate, chestnut-like flavor
- Drought tolerant

http://en.wikipedia.org/wiki/Red_kuri_squash



Squash: *Cucurbita pepo*

- *C. pepo*: Includes most of the summer squash, and small to medium-sized ornamental pumpkins
- *C. pepo* varieties: Zucchini, Spaghetti, Acorn, Delicata

Summer Squash

- Zucchini (*C. pepo*) cultivar 'Dark Star'
-bred for deep, penetrating roots for
drought tolerance



<http://www.seedsofchange.com>

Coping with Climate Change

PROTECT BIODIVERSITY

Seed Saving

- Ancient art practiced by humans since the dawn of agriculture
- Prior to WWII, gardeners had to save seed
- With rise of commercial seed industry, the art of seed saving declined
- Increasing interest in heirlooms, seed libraries and locally adapted varieties creating resurgence

Reasons to Save Seeds

- Reproduce cultivars that do well in your area
- Ensure long-term survival of excellent cultivars



In Summary, Coping With Climate Change in Vegetable Production:

- Improve soil health
- Use water resources efficiently
- Modify the growing environment through season extension techniques & shading
- Practice correct seed saving techniques

In Summary, Coping With Climate Change in Vegetable Production:

- Diversify your crop mix
- Experiment & keep records
- Know the unique conditions of your farm or garden and plan for flexibility

Thank You!

