Coping with Climate Change in Vegetable Production Systems

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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

https://en.wikipedia.org/wiki/Ancestral_Puebloans
Cooperative Extension Service
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

https://en.wikipedia.org/wiki/Agriculture_in_the_prehistoric_Southwest
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
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IRRIGATION
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

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/cool 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

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!

http://justsopress.typepad.com/garden_klog/images/2008/05/08/080502_008.jpg
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
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

http://www.igcusa.com/Hobby/bc/BC-capecod-large.jpg
Hot Weather Protection

• Shading using structures or companion plants
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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
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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)

[Image of Tepary Beans](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

[Image of cowpeas]  

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 \textit{(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°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’

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 argyroserperma*

- *C. argyroserperma*: Includes ‘Cushaw’, many of the best tasting pumpkins and squash
  - Requires a long, warm growing season
  - Many are grown for their edible seeds

- *C. argyroserperma* 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’ \((C. \text{moschata})\)

- 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

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
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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!