



Opportunities for Drought Mitigation in Texas Agriculture



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Introduction

Drought in Texas is common, and agriculture is first to feel its effects. Farmers, ranchers, the agricultural industry and the research and extension community which support agriculture all put great amounts of energy and resources into mitigating drought, and although much progress has been made, drought lives and continues to do monumental damage to the agricultural community. While many may perceive this as an agricultural problem, the dire situation now experienced by agriculture is indeed an issue that should be of concern to the entire nation. The droughts of 1996 and 1998 caused more than \$4 billion in direct losses to agricultural producers, and at least \$11 billion was lost when damages to associated industries are included. The reason that agriculture is first to bear the brunt of drought is that in dryland agriculture, forage and crops have only the reserves of water stored in the soil to rely upon until the next rain. Good agricultural soils may hold 5- to 10 inches or perhaps a bit more of plant available water in the effective rooting zone of crops. Some crops utilize one half inch or more water per day during periods of high temperatures and windy conditions. If the soil profile is not recharged before planting season or rainfall does not come before the crop uses the reserves of water stored in the soil, drought damage begins to take its toll.

If we take a simplistic look at potential ways to mitigate the impact of drought, they would include various technologies to:

- ✓ More effectively utilize available precipitation
 - increase storage of water in the soil profile during precipitation events by reducing runoff
 - more efficiently utilize stored soil moisture
- ✓ Reduce production input costs in dry years, yet capture opportunities during favorable weather
- ✓ More accurately predict needs for crop inputs under hot, dry conditions
- ✓ Reduce evaporation and transpiration losses of water in cropping systems
- ✓ Increase heat and drought stress tolerance of crops and forages
- ✓ Increase irrigation water use efficiency
- ✓ Enhance precipitation

While the above concepts are relatively simple, implementation of known technologies is in many cases tricky in today's depressed agricultural economy. This paper takes a closer look at many of the potential technologies to mitigate the impact of drought in agriculture. It is not through the adoption of one or several of these technologies that Texas agriculture will become less vulnerable to drought, but through a conscientious and reasoned integration of applicable practices which mitigate drought and reduce risk of production into a viable crop production system.

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Technologies to reduce the impact of drought on agriculture

✓ **More effectively utilize available precipitation**

Much of Texas rainfall comes in high intensity events associated with thunderstorms and tropical weather systems. In soils with relatively low infiltration rates, these storms result in a large amount of runoff, and due to the short duration of the rainfall, may do little to fill water storage capacity deep in the soil profile. Any effective way to increase the recharge in the high-intensity, short duration rainfall events must include a means to slow the rate of water runoff, thereby increasing the length of exposure to the soil surface, giving more time for infiltration. This can be accomplished by several methods. No-till, or high residue farming offers a relatively low cost method for accomplishing this by covering the surface of the land with plant residue, which slows the impact of rain drops on the soil surface, and gives more resistance to water, tending to diffuse runoff and to reduce the tendency for channelized flow. This accomplishes the goal of increasing the amount of infiltration by increasing exposure time of water to the soil surface.

Management practices which reduce surface soil compaction can have a profound influence on infiltration rates is the condition of the soil surface. A hard, compacted surface tends to shed water and reduce infiltration. One of the primary causes of surface compaction is the force of raindrops. Heavy surface residue and narrow row spacings on crops to cause a rapid canopy cover are helpful in reducing surface compaction. Other methods to increase infiltration include land shaping such as terracing, bench terracing and land leveling.

Several technologies exist to enhance the relative yield of precipitation events. These include devices the use of any of the various designs of furrow dikers and land pitters, which shape many uniformly spaced reservoirs to catch precipitation near the site on which it falls. These devices create mini- reservoirs safely that hold water until it infiltrates into the soil, reducing runoff and resulting in nearly even distribution of stored water in a field. This practice not only increases stored soil moisture, but also significantly reduces the potential for erosion. Most of these systems do not work well in a no-till or minimum tillage production system. Another water harvesting technique used in vegetable production is the use of

plastic mulches, which catch rainwater and deliver it to furrows established before the mulch was applied. These mulches can save many acre-inches of irrigation water traditionally used to wet bed to establish the crop. Leaving crop residues in the field during the winter is a common technique in the plains to capture and hold snow. Plowed fields retain little snowfall due to high winds, which often accompany snowfall, but stubble catches and holds snow even in high winds.

Most of the Texas wheat crop is grazed for some portion of the growing season, and as much as 2 million acres may be grazed out, leaving little residue and a hard, compacted surface due to hoof action of the livestock. In this situation, where little crop residue remains and the surface is hard, sweep tillage may significantly increase infiltration and water storage.

Soil water holding capacity varies with texture. Sands hold very little crop available water, usually around 1.0- to 1.2 inches per foot of soil, while soil with a clay loam texture may hold 1.5- to 2.0 inches of plant available water per foot. Plant available water for the crop is a function of water holding capacity of the soil and the effective rooting depth. It is the reservoir of water stored in the soil profile that allows Texas farmers to regularly make crops despite the unpredictable and erratic rainfall we receive. While coarse textured (sandy) soils have less water holding capacity per foot of soil, the effective rooting zone may be deeper than in heavier soils because larger pore space in coarse textured soils carries more oxygen to favor deeper rooting. In heavy soils subjected to prolonged wet periods, crops form shallow root systems and are unable to effectively utilize deep stored moisture. To utilize the water stored deep in the subsoil, farmers must take care to prevent the development of or detect and eliminate compacted "plowpans" which limit deep rooting and favorable gaseous exchange in the soil. Probes and penetrometers are convenient tools to detect plowpans. For example is a probe can be easily pushed 2.5 feet in a clay loam soil before it is stopped by dryer, harder soil, a farmer could estimate that 4- to 5 inches of plant available water might be available, using this information to better plan cropping choices.

Research has also indicated that nutrition of the crop, and in particular phosphorus (P), and nitrogen (N) fertility status are important for developing deep

root systems capable of efficiently extracting water from the lower soil profile. In soils prone to drought, check soils for P stratification. If P is short below the top 2- to 3 inches of the surface soil, deep, banded P will improve water use efficiency in many crops.

✓ **Reduce production costs in dry years, yet capture opportunities during favorable weather**

Much of the financial loss in crop production associated with drought occurs because farmers must spend a large portion of production expenses of a crop prior to the hot, dry weather that induces drought stress. These costs include land preparation, fertilizer, seed, herbicides, fungicides and insecticides. These are all necessary and required costs to maximize financial returns under favorable weather conditions, but might be foregone or delayed if drought conditions were certain. If farmers had a better predictive capability with respect to drought, many of these costs could be delayed or avoided. A better knowledge of the amount of stored soil moisture in the various farm fields would also be key to arriving at a more informed decision on the probability of getting a return on various investments in crop production.

✓ **More accurately predict needs for crop and range management inputs under hot, dry conditions**

Models being developed by the Texas Agricultural Experiment Station are addressing the problem of assessing risk of production inputs when facing dry weather. The *Yield Estimator* model will give farmers realistic estimates of crop yield based upon soil series, available moisture, predicted precipitation and crop inputs. Other technologies under development include a system to plot NEXRAD imagery of precipitation patterns on a high-resolution grid to get better estimates of accumulated and total precipitation. Another system would gather an advanced, very high-resolution image from NOAA satellites depicting vegetative conditions across the state and plot images on the same mapping scale as the NEXRAD images. These maps would give the observer a good handle on where drought or near drought conditions exist in the state and allow the crop model to better predict justifiable inputs. Adapting these models to on farm use will require some large scale testing, ground truthing and educational efforts.

In addition to the crop management and weather models, range scientists are using the TxLEWS model to assist ranchers in adjusting stocking rates. One of the major causes of loss in drought is a precipitous decline in cattle prices associated with massive destocking of ranges under drought conditions. These models use weather data and vegetation indices to better predict the need to remove cattle or other stock in an orderly fashion from rangeland to protect forage species and protect prices from the sudden drop which frequently occurs in response to large numbers of livestock suddenly hitting the market.

✓ **Reduce water loss in range and cropping systems through evapotranspiration**

There are many methods used to reduce water losses in crops. These include:

- 1) Plant early maturing varieties or hybrids. Earlier maturity will result in fewer days of evapotranspiration than crops with later maturities.
- 2) Plant early. The greater portion of the crop life cycle completed during the cooler weather during the spring, the less water required. In warm season crops such as cotton or peanut, early planting can be harmful, as seedling disease can damage root systems and reduce water capture. Early planting of cool season annuals can have quite the opposite effect, if the planting date falls in the hot weather of late summer or early fall.
- 3) Plant cool season annuals. Cool season annuals have a lower evaporative demand on a daily basis during the growing season, but a longer growing season may offset gains. Scientists in south Texas are introducing medics, a cool season forage crop with high forage quality and great drought tolerance.
- 4) Plant narrow rows. Early canopy closure by the crop will reduce temperatures in canopy, reduce evaporative losses, and increase water use efficiency. Scientists have recently developed production systems in corn and cotton that improve water use efficiency by up to 30 percent using narrow rows and high plant populations.
- 5) Use no-till or high residue farming systems. Crop residues reflect light and heat, thereby reducing evaporative losses.

- 6) Use plastic or other mulches. These mulches reduce evaporative losses.
- 7) Carefully manage weed control. Weeds are prolific water users. Carefully use herbicides or other means of control to prevent this loss of water in croplands, range and pastures. Transgenic crops offer great new opportunities for weed control.
- 8) Brush control has the potential to increase yield of range grasses as well as significantly enhancing the recharge of ground water and/or stream flow in many affected areas.

✓ **Increase heat and drought stress tolerance of crops and forages**

Traditional plant breeding, biotechnology, and the use of previously unavailable genes due to the combined efforts of breeders and genetic engineers offer great potential for production of crops with great resistance to heat and drought. This potential for biotechnology in this arena is great and is at a very early stage of development. Conventional crop breeding has accomplished much in this area. Scientists tested corn hybrids at Lubbock in the drought of 1998 that yielded 30 bushels per acre more than conventional hybrids under extreme heat and drought.

There is also a great potential to evaluate and adapt new crops that either tolerate or have mechanisms which escape drought. Examples would include medics, amaranth, cowpeas, chickpeas, niger, pigeonpea, lablab, lupines, safflower, sunflowers, mustard and other *Brassica* species, castor and others.

✓ **Increase irrigation water use efficiency**

Approximately 60 percent of Texas water resources are currently used for agricultural irrigation. While this fraction is expected to decline with increasing urban competition for water resources, irrigated agriculture is a backbone in keeping a dependable supply of high quality food and fiber available to today's consumers. There are many irrigation systems available. Of primary importance to the farmer are cost, water use efficiency and fuel efficiency. To have a high water use efficiency, a system must deliver water uniformly across the field and have minimal losses into the environment, either through evaporation, deep percolation or runoff.

Modern LEPA (low energy, precision application) and drip irrigation systems, can exceed 95 percent efficiency in water deliver, whereas some of the old flood irrigation systems with earthen ditches may deliver far less than 50% efficiency. In order to have a high crop water use efficiency, farmers must use a highly efficient irrigation system, coupled with agronomic practices which result efficient crop production. Without the use of highly productive agricultural practices, water use per unit of production increases and efficiency declines. The widespread adoption of highly efficient irrigation practices has the potential to dramatically improve water use efficiency in much of irrigated agriculture in Texas.

✓ **Enhance Precipitation**

Several projects are ongoing in Texas to use aerial cloud seeding to enhance indigenous precipitation. These efforts have the potential to make more water available for agricultural uses.

Summary

Texans are at a crossroads with respect to managing our water supply and demand, and agricultural usage and water management on agricultural lands is an important part of the equation on how we as a state deal with drought. Technologies available that can greatly improve water yield from watersheds, which increase water use efficiency and reduce the vulnerability of agriculture to drought. As the demand for our water resources increase from both urban and agricultural sector and the water supply becomes more scarce and precious, the contribution of agriculture in the efficient use of water will become more significant.

For additional information see our website at:
<http://taexsoilcrop.tamu.edu>