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Title: Irrigation Management and Drought Stress Resistance

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Problem and Need: Increases in peanut acreage in the Texas Southern High Plains (TSHP) have led to an increased demand for research-based information, demonstration of applicability in the field, and delivery of usable information to peanut producers and the peanut industry. Several geological, geographical, and climatic features make the TSHP different from most U.S. peanut producing areas; these include low annual precipitation and low humidity. Evaporative demand greatly exceeds precipitation, and irrigation capacity generally is insufficient to meet crop water demand, hence varying degrees of deficit irrigation are common. Optimum irrigation management is essential to produce acceptable yields of high quality peanuts, to balance the cost of irrigation with its benefits, to produce a good fit of peanut production within the overall farm enterprise, and to conserve limited water resources.

Irrigation Strategies: Irrigation studies conducted at Agricultural Complex for Advanced Research and Extension Systems (Ag-CARES, Lamesa, Dawson County, Texas) and other locations have demonstrated that low energy precision application (LEPA) and low elevation spray application (LESA) can be used effectively for irrigation of peanuts. Work conducted at the Western Peanut Growers Research Farm (WPGRF, Gaines County, Texas) has investigated potential difference in effectiveness between types of LESA application nozzles and how to optimize management of LESA and LEPA technologies under given field conditions.

Research conducted during the 1995 to 1999 crop years at Ag-CARES by Schubert and others increased our knowledge of water management for peanut in the TSHP. We learned that under these soil and water conditions, alternate-furrow LEPA at 75% evapotranspiration (ET) replacement throughout the fruiting period (extending almost to harvest) produced high yields of good quality peanuts with acceptable irrigation efficiency. Our understanding of some of these relationships is still general, and a greater understanding of mechanisms is needed. We are developing information as to whether Ag-CARES results are applicable to other peanut soils with water-holding capacities, effective rooting depths, characteristic vertical/horizontal water movement, etc. that are different from those at Ag-CARES. The research team involved in this work in recent years have expanded observations onto new soil types, adding technical and measurement capacities not available for the Ag-CARES research in the past, and adding producer field surveys and demonstrations to our research and education efforts in water management for the peanut crop in the TSHP. Information gained will have applicability in other peanut growing regions.

Conservation of the groundwater resource and management of input costs must be balanced with supplying adequate moisture for acceptable peanut yield and quality. LEPA irrigation, in which water is supplied directly into alternate furrows from a center pivot with circular row orientation is highly efficient in supplying water to the root systems of plants. Successful peanut production requires that the pod development zone also be kept at some adequate moisture status. In the absence of adequate moisture in the top few inches of soil, peanut plants that have adequate deep moisture develop normal top growth, numerous flowers and pegs, but few pods. Intuitively, one may not expect LEPA to keep the pod development zone moist enough for good peanut production. Observations under different planting patterns (at Ag-CARES) strongly suggest that alternate furrow LEPA provides adequate moisture for conventional single-row planting patterns, but may not provide adequate moisture in the pod development zones of double-row and ultra narrow row patterns on the dry-furrow side of the beds. Further, while there seems to be sufficient lateral movement (for single row planted peanuts) of soil moisture in the Amarillo series soil at Ag-CARES, there is indication (from this research) that this may not always be the case in coarser soils, such as the Brownfield series soil at the Western Peanut Growers Research Farm (WPGRF).

<u>Drought Stress Reaction of Peanut Lines</u>: During the period of 1984 through 1992, more than 250 germplasm lines, plant introductions, and cultivars from many sources were studied under rain-fed and/or line source gradient irrigation conditions in South Texas and West Africa, in association with the Peanut Collaborative Research Support Program. Relative performance under varying degrees of stress conditions was used along with other experimental data relating to disease reaction, agronomic traits, etc. in the Texas A&M-based project "Disease-Resistant Peanut Varieties for Semi-Arid Environments". The entries studied exhibited a wide range in productivity and magnitude of values for experimental parameters measured over the years. The potential value of data generated in breeding and selection programs for improved water-use efficiency are yet to be fully investigated. Although some of the germplasm is probably not adapted to the intensive peanut production of West Texas and other U.S. growing regions, there remains the possibility that some of the germplasm may be a source of improved production efficiency under irrigated conditions. As the new TSHP-based peanut breeding program of Dr. Mark Burow continues, improved efficiency of irrigation water use and drought-stress performance of peanut lines will be investigated more fully.

Plan of action: Research has continued at Western Peanut Growers Research Farm (WPGRF) (Gaines County, Brownfield fine sand [thin surface] with some Springer and Brownfield soils [moderately deep]), and at Ag-CARES (Dawson County, Amarillo fine sandy loam). Experimental treatments include applicator type, irrigation scheduling (timing and quantity of water applied), site-specific soil water holding capacity, and relationship of soil moisture and disease development. This research is supported by various sources, including the High Plains Precision Agriculture Initiative, Texas Peanut Producers Board, The Peanut Foundation, National Peanut Board and Texas A&M University System Agriculture Program (Texas Agricultural Experiment Station and Texas Cooperative Extension). Peanut yield, grade, pod and kernel size distributions, maturity, and crop value are measured. Peanut flavor attributes and fatty acid profiles are determined for selected samples. In some fields and field areas yields are mapped with a Global Positioning Satellite (GPS) referenced peanut yield mapping system (PYMS).

Research Results: Field research was conducted during the 2001 through 2003 crop seasons at WPGRF and Ag-CARES. At WPGRF, we have applied the same base irrigation level (75% ET) by low pressure LEPA (drag hose), LESA and MESA (low drift spray and wobbler) applicators, as well as multiple irrigation rates applied by the LEPA method only, and a "managed LEPA" strategy (described below). Treatments at Ag-CARES included only the 75% ET level of the LEPA application and "managed LEPA" approaches. The LEPA method applies water only to the soil surface of alternate furrows, whereas LESA and MESA methods apply water uniformly to soil and plant surfaces. In 2002 an additional method of prescribed in-season "LEPA-LESA-LEPA" or "managed LEPA" strategy was included at both research sites. This treatment indicated very promising results in 2002, so it was repeated in the 2003 season. In 2001, LESA irrigation out-yielded LEPA at both WPGRF and Ag-CARES. Comparison of LEPA and LESA results in 1998 and 2001 at Ag-CARES has led us to suspect that there may be a variety-by-irrigation method interaction under the hot, dry conditions in both years, because LEPA excelled with Tamrun 88 in 1998 while substitution of some LEPA applications with LESA significantly increased FlavorRunner 458 yields in 2001.

In 2002, we dropped the 125 % ET water level at WPGRF, adding a "managed LEPA" treatment in which LEPA is used in the early vegetative stages, LESA during fruit development, and LEPA in late season. In the 2002 and 2003 seasons, we used Florunner, Tamrun 96, and FlavorRunner 458 in all irrigation treatments at WPGRF and Ag-CARES to investigate potential variety-by-irrigation method interactions. Through plant mapping and other observations, we followed plant development at both sites and continued to monitor temperature and relative humidity in the canopy of each application method. We also added in-field recording rain gauges and soil moisture sensors for more intense data collection. We determined yield, grade, and other quality factors for peanuts produced under the various irrigation regimes. Yield was determined through plot sampling (4 rows by 20 ft.) and by the Peanut Yield Mapping System (PYMS) equipped combine.

<u>Results from Irrigation Application Rate Study:</u> Irrigation application rates targeting 50%, 75%, and 100% evapotranspiration replacement were applied through LEPA irrigation during the 2003 cropping season. Standard LEPA practice included application by drag hoses in alternate furrows, circular planting pattern to match traffic of the center pivot irrigation system, and furrow dikes (to the extent practical) to improve in-furrow water application uniformity. Furrow dikes are extremely difficult to maintain in the sandy soils at WPGRF. Yield was determined through small plot sampling (4 rows by 20 ft. for each treatment and replication block) and with the PYMS-equipped peanut combine. Samples were graded in the laboratory to determine whether different irrigation treatments effected differences in product quality. Table 1 summarizes the yield responses of each variety to irrigation application rates using the PYMS data, as well as the grades obtained from the small plot samples at WPGRF. When 120 randomly selected observation points (for each treatment -by- variety combination) from the PYMS were compared, yields for all cultivars were lowest under the 50% ET treatment and highest for 100%ET (full irrigation) treatment. Peanut grades from the 75% ET and 100% ET treatments were not significantly different; lower grades resulted from the 50% ET treatments.

Table 1. Mean harvested yield and grade by irrigation treatment, WPGRF 2003.

Irrigation Treatment	LESA (75%ET)	MESA / wobbler (75%ET)	LEPA-LESA-LEPA (75%ET)	LEPA 75%ET	LEPA 100% ET	LEPA 50% ET
PYMS Yield (lb/ac)						
Florunner	3,360 c*	3,915 a	3,911 a	3,587 b	3,905 a	2,743 d
Tamrun 96	3,407 b	3,898 a	3,550 b	2,972 c	3,776 a	2,617 d
FlavorRunner 458	3,453 b	3,769 a	3,407 b	3,391 b,c	3,640 a	3,226 c
Plot Yield (lb/ac)						
Florunner	4,188	4,728	3,881	4,308	4,535	3,441
Tamrun 96	3,868	4,495	4,028	4,148	4,348	3,174
FlavorRunner 458	4,201	4,722	3,201	3,828	3,835	2,914
Grade						
Florunner	74.7 a,b	77.2 a	70.7 c	72.0 b,c	74.3 a,b	68.9 c
Tamrun 96	73.8 a	74.8 a	68.9 b,c	69.5 b	70.8 b	66.6 c
FlavorRunner 458	76.6 a	76.3 a	71.4 b	73.1 b	72.8 b	67.8 c

* *Note: values in each row followed by the same letter are not significantly different at 0.05 probability.*

Results from Irrigation Application Method Study: Throughout the 2000 and 2001 cropping seasons two LEPA methods (drag hoses and bubbler-mode nozzles) and two spray methods (low drift spray and wobbler-type nozzles) were used at WPGRF to apply water at a base target irrigation rate of 75% crop evapotranspiration replacement. Because results from drag hoses and bubbler LEPA applicators were similar, the bubbler applicator was discontinued and only drag hoses were used for LEPA applications in 2002 and 2003. This allowed space for inclusion of an additional application strategy (LEPA-LESA-LEPA) at the site during 2002 and 2003. At Ag-CARES, LEPA drag hoses and LESA low drift spray nozzles were used to apply water at a base target irrigation rate of 75% crop evapotranspiration replacement. Yields at both locations were determined by small plot sampling (4 rows by 20 ft. for each treatment and replication block) and with the PYMS-equipped peanut combine. Samples were graded in the laboratory to evaluate product quality.

Effects of irrigation method treatments are summarized in Table 1 (WPGRF) and Table 2 (Ag-CARES). At WPGRF, all the peanuts responded well to the full irrigation (100%ET) LEPA and to the 75% ET MESA-wobbler treatments. The managed LEPA (LEPA-LESA-LEPA) strategy also netted favorable results. The strictly spray treatments (LESA and MESA) indicated higher grades. This apparently results from higher maturity, facilitated by the more consistent wetting pattern in the pegging zone. Of all the varieties, it appears that Florunner may have responded most favorably to LEPA, while Tamrun 96 responded more favorably to the spray treatments (MESA-wobbler, LESA, and LEPA-LESA-LEPA).

In previous years' work at WPGRF, there have been mixed results from the comparison of spray irrigation methods (LESA and MESA) with the LEPA applications. At Ag-CARES in Dawson County - especially under deficit irrigation conditions - LEPA has tended to outperform spray irrigation. The soil at WPGRF is coarser, and the topography is steeper than at the Ag-CARES facility. Each location is representative of many fields in commercial peanut production. At the time of this writing, collaborators are continuing to analyze the research data, and we have recently developed some information tools that will help in analysis of conditions at both sites (and others) to further clarify limits (soil conditions, irrigation water capacities that affect the relative advantages of the irrigation methods and strategies available.

Table 2. Peanut Yields (lb/ac) from Peanut Yield Mapping System (PYMS) at Ag-CARES 2003.

Variety	**All Irrigation Methods**	**LEPA**	**LESA**
Florunner	3,491 a*	3,643 a	3,339 a
FlavorRunner 458	3,397 a	3,572 a	3,221 a
Tamrun96	3,345 a	3,544 a	3,146 a

Irrigation Method	**All Varieties**	**FlavorRunner 458**	**Tamrun96**	**Florunner**
LEPA	3,586 a*	3,572 a	3,544 a	3,643 a
LESA	3,235 b	3,221 b	3,146 b	3,339 b

** Note: values in each row followed by the same letter are not significantly different at 0.05 probability.*

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