Influence of Irrigation Water Quality and Quantity on Peanut Production in the Texas High Plains

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ABSTRACT

The Southern High Plains of Texas experienced a significant influx of peanut acreage over the past three years. Much of the new acreage and increased interest in peanut production is associated with cross-county transfer and cropping flexibility provisions of the 1996 Farm Bill. In 1998, more than 190,000 acres of peanut were planted in the area, which comprises about 14 counties. Because of the dependence on irrigation in this semi-arid region, water quantity and quality are constant concerns. Texas experienced a severe drought in 1998, during which many producers encountered moderate to severe problems with well capacities and water quality. This study was implemented to assess the influence of water quantity and quality on peanut yield and grade. Soil and water samples were obtained from 36 fields in Dawson and Terry counties at the beginning and end of the growing season, and subjected to detailed salinity analyses.

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NC-7 (virginia market type) was the variety at all locations. Yield and grade data were obtained from each site. Regression analyses indicated boron in irrigation water and the soil sodium adsorption ratio (SAR) were negatively correlated with yield. Boron levels greater than 0.75 ppm and soil SAR values greater than 5 caused appreciable yield reduction. Peanut quality also was assessed and chloride and water salinity both correlated with reduced grades. Chloride levels in irrigation water above 450 ppm significantly reduced grades as did salinity values exceeding 2,100 umhos/cm. Well capacity also was categorized and results indicate that for optimum peanut yield (yield goal of 5,000 lbs./acre), wells must have a minimum capacity of approximately 4.5 to 5.0 gallons/minute/acre.

INTRODUCTION

The Southern High Plains of Texas has experienced a significant influx of peanut acreage over the past four years. Much of this increased acreage and interest in peanut production has been associated with the cross-county transfer and cropping flexibility provisions of the 1996 Farm Bill. From 1995 to 1998, peanut acreage in the region increased from 44,000 to more than 190,000 acres were reported in an 18 county area (Texas Agricultural Statistics, 1995 and 1998). Peanut production from the region represents approximately 57% of total statewide production. The west Texas region is characterized as a semi-arid environment with average annual rainfall of 18 to 22 inches. Extreme summer temperatures coupled with high winds contribute to excessive evapotranspiration rates.

Because of the dependence on irrigation in the region, water quantity and quality are a constant concern. Marginal quality irrigation water is becoming a problem throughout many areas of Texas, but especially the High Plains region. Three primary factors affect water quality: total soluble salts (salinity), sodium hazard (SAR), and toxic ions (chloride, sulfate, sodium and boron). The susceptibility of crops to marginal quality water varies, with cotton exhibiting significantly more tolerance to salinity and toxic ions than either corn or grain sorghum (USDA, Handbook 60). Literature regarding water quality effects on peanut is extremely limited. Greenhouse experiments conducted in Israel indicated that yield of peanut grown in artificially salinized plots was reduced to 50% at EC of 4.7 mmhos/cm, and 20% at EC of 3.8 mmhos/cm. (Shalhevet et al., 1969). Boron fertility studies conducted by McGill and Bergeaux (1966), and Morrill et al. (1977) indicated sensitivity of peanut to excess soil boron, with a range of 0.6 to 1.5 kg B/ha resulting in reduced yields and potential toxicity.

Due to the rapid increase in peanut acreage in west Texas, and the need to maintain proper crop rotation, many producers are utilizing moderately productive farmland. Field observations during the 1997 season showed peanut to be extremely sensitive to marginal quality irrigation water (Lemon, 1997). This study was initiated to assess the influence of water quantity and quality on peanut yield and grade in the Texas High Plains.

MATERIALS AND METHODS

A study of 36 field sites was conducted in 1998 in Dawson and Terry County, Texas to initiate an assessment of the influence of irrigation water quality and quantity on yield and grade of peanut. Soil and water samples were obtained from each location at the beginning and end of the season. Initial samples were collected in June and final samples were collected in October or November, depending on harvest date.

Water samples represented water entering the pivot. It is common to have one to four wells comprising a system, thus samples were collected at the pivot point after the system had been flushed for one hour. Water samples were collected in sterile plastic bottles. Samples were analyzed within two days of collection at the Texas Agricultural Extension Service Soil, Water and Forage Testing Laboratory in College Station, TX. The irrigation water analysis included soluble cations (Ca, Mg, Na, K), soluble anions (B, Cl, SO_4, NO_3), pH, and electrical conductivity (EC).

Soils represented the Amarillo series, and consisted of Amarillo fine sandy loam (fine-loamy, mixed, thermic Aridic Palenstalfs), and Amarillo loamy fine sand (fine-loamy, mixed, thermic Aridic Palenstalfs) intergrades. These soils have less than 0.5% organic matter and a pH of 7.5 to 7.9. This series possesses a significant clay accumulation at 14 to 16 inches deep. Soil samples were collected from the surface 6 inches according to Texas Agricultural Extension Service guidelines and analyzed for nutrient status (N, P, K, Ca, Mg, Na, Zn, Mn, Fe, Cu, S, B). In addition, samples were subjected to a detailed salinity analysis utilizing the saturated paste extract to determine soluble cations (Ca, Mg, Na, K) and anions (Cl, SO_4) and electrical conductivity.

All locations were planted between the last week of April and the first week of May with virginia market-type NC-7. Virginia production in Texas is primarily contract-additionals and shellers specify NC-7 as the variety. Fertility, herbicide and fungicide programs were different across locations, but followed general Texas Agricultural Extension Service guidelines for west Texas. Fields were dug and combined by the producer or custom harvesting operators. Across locations, days from planting to digging ranged from 140 to 160 days. Fields experiencing severe water quality related problems were dug early (140 days) to prevent additional pod loss.

Regression analyses were used to determine relationships between various soil and water parameters, and peanut yield and grade. Multiple regression analyses were performed, but were deemed inappropriate due to excessive multicolinearity. Only significant regressions are presented.

RESULTS AND DISCUSSION

Soil and water samples were obtained at the beginning and end of the season to assess changes over time. Although some soil and water parameters changed over the season, the initial samples (obtained in June) exhibited more significant correlations with yield and grade. Consequently, only the June sampling was utilized for analysis.

Peanut Yield

Regression analyses indicated significant yield correlations associated with boron in irrigation water, soil SAR and well capacity. Peanut yield response to boron in irrigation water is presented in Figure 1. Yields were negatively correlated with increasing boron concentrations ($P<0.001$). Boron concentrations ranged from 0.1 to 1.2 mg/l across locations. The regression equation [yield = 5042 - (2179*boron)] indicated that for each 0.1 mg/l increase in boron concentration, yield was reduced by approximately 218 lbs./acre. A clustering of data points at 0.75 mg/l boron suggested a possible critical threshold level. Critical boron levels in irrigation water for cotton and grain sorghum are 3 mg/l, and 2 mg/l for corn (McFarland et al. 1998).

Similar to boron, peanut yield was significantly reduced with increasing soil SAR (Fig. 2, $P<0.001$). Sodium adsorption ratios in soil ranged from 0 to 7.5 across the 36 locations. The critical soil

SAR value for cotton, grain sorghum and corn is 10 (McFarland et al. 1998). Based on regression analysis, for each one unit increase in SAR, peanut yield was reduced by approximately 374 lbs/acre. The sodium adsorption ratio is a calculated value used to express the relative proportion of sodium compared to calcium and magnesium. The distribution of data points was clustered between SAR values of 2.5 to 5.0. Although limited data points exist beyond the range, the regression suggests that the critical SAR for peanut may be less than that for cotton, grain sorghum and corn.

Peanut producers in the Southern High Plains traditionally set their yield goals in excess of 5,000 lbs/acre. Well capacity is critical in meeting this goal since peanut is a fully irrigated crop in west Texas. Yield was positively correlated with increasing well capacity (Fig. 3, $P<0.006$). Within the study, well capacities ranged from 2.5 gallons/minute/acre to 7.5 gallons/minute/acre. Regression analysis indicated that wells must have a minimum capacity of 4.5 to 5.0 gallons/minute/acre to attain 5,000 lbs/acre yield goals. This is especially critical for growing seasons with low rainfall, and/or years with limited antecedent soil moisture. Texas was in drought conditions during the spring and summer months of 1998, and most irrigation systems could not meet the water demands of the developing peanut crop.

Peanut Grade

Peanut kernel quality was significantly correlated only with irrigation water chloride and total soluble salt concentrations. Total sound mature kernels (TSMK) were reduced with increasing chloride in irrigation water (Fig. 4, $P<0.001$). Chloride levels ranged from 100 to 750 mg/l across locations, and peanut grades ranged from 64 to 76 TSMK. The EC of the irrigation water which ranged from 600 to 3,000 umhos/cm across locations also correlated with reduced grades (Fig. 5, $P<0.001$). Distribution of the data points indicated a critical threshold for EC of approximately 2,100 umhos/cm, and 400 mg/l for chloride. Grade reductions associated with increasing salinity and chloride may be related to reduced Ca uptake by the kernels. Increased levels of Na, Cl, Mg and K associated with saline water may have an antagonistic interaction with soil solution Ca. Several studies have reported the detrimental effects of high concentrations of K and Mg on peanut kernel quality (Bolhuis and Stubbs, 1955; Hallock and Allison, 1980; Lynd and Ansman, 1989).

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Figure 1. Peanut Yield as Influenced by Boron in Irrigation Water.

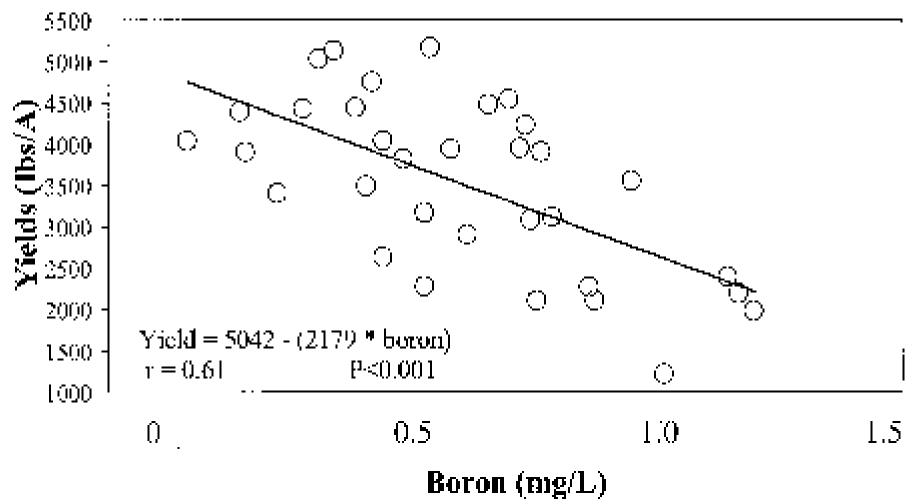

Figure 2. Peanut Yield as Influenced by Soil SAR.

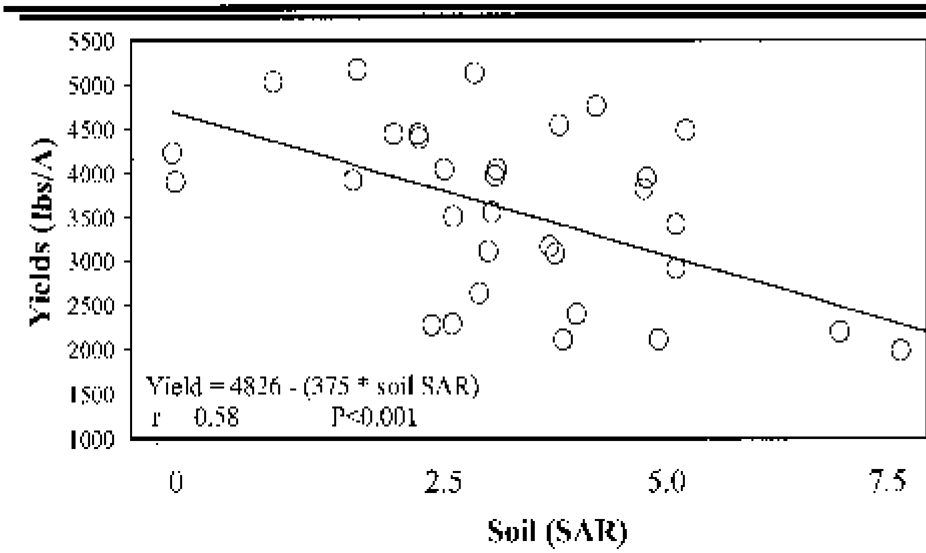

Figure 3. Peanut Yield as Influenced by Irrigation Well Capacity.

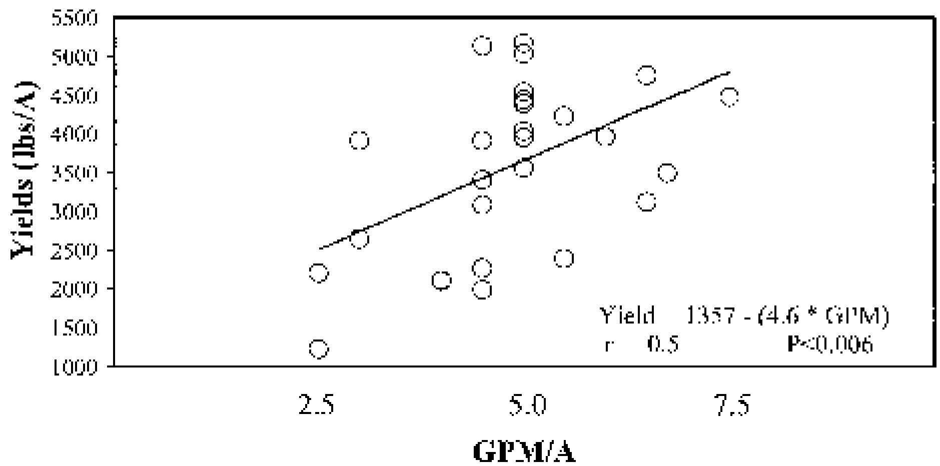

Figure 4. Peanut Grade as Influenced by Chlorides in Irrigation Water.

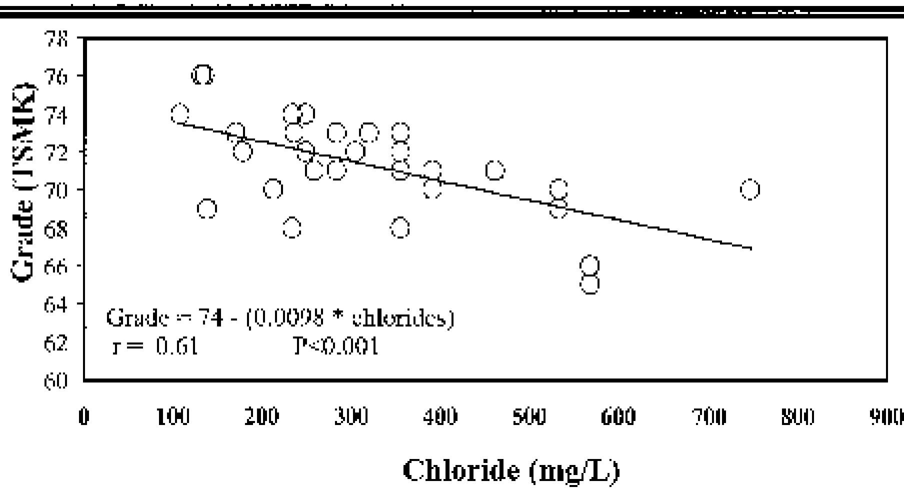

Figure 5. Peanut Grade as Influenced by Irrigation Water Salinity.