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IRRIGATION CAPACITY IMPACT ON LIMITED IRRIGATION MANAGEMENT AND CROPPING SYSTEMS

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INTRODUCTION

Irrigation capacity is an important issue for irrigation management. Having enough capacity to supplement precipitation and stored soil moisture to meet crop water needs during the growing season to maximize grain yield is important. However, declines in the Ogallala Aquifer have resulted in decreases in well outputs to the point where systems on the fringe of the aquifer can no longer meet crop water needs during average growing seasons and especially during drought years. Changing cropping practices can impact the irrigation management by irrigating crops that have different water timing needs so that fewer acres are irrigated at any one point during the growing season and concentrating the irrigation capacity on fewer acres while still irrigating the majority or all acres during the year.

Many producers have not changed cropping practices with marginal capacity systems due to management increases and the potential for an above-average year. However, the risk of producing lower yields increases. Crop insurance has been used to offset those lower yields. However, the frequency of insurance claims has increased to the point where practices need to be changed on these systems.

Literature Review

System capacities are a function of soil type, crop water use and precipitation. The soil type acts as a bank where moisture reserves can be utilized during times when the irrigation system is not watering between cycles and during time periods when the system capacity is inadequate to meet crop water needs. Soils such as silt loams have a greater water holding capacity compared to sands

Lower capacity systems generally are inadequate for meeting crop water needs during the peak water use growth stages. This also coincides with the reproductive growth stages and less average annual precipitation during that time period of a summer crop. Water stress during that time period has more impact upon yield than during the vegetative and late grain-fill growth stages (Sudar et al, 1981; Shaw, 1976). Having water stress earlier or later is more desirable than during the reproductive growth stages of tassel, silking and pollination.

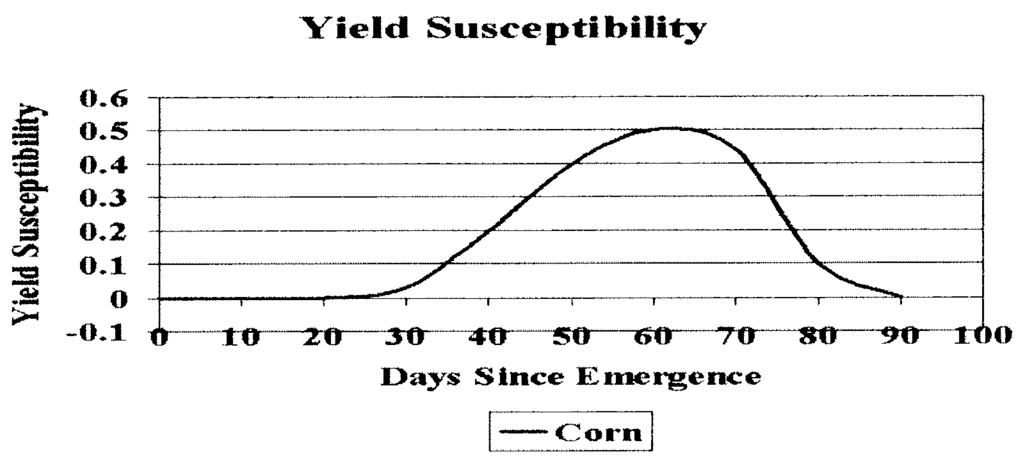

Figure 2. Yield susceptibility to water stress for corn (Sudar et al., 1981).

The Crop Water Stress Index (CWSI; Idso et al., 1981; Garner et al., 1992) normalizes the canopy-air temperature differential for the drying capacity of the air. It is calculated from measurements of infrared canopy or leaf temperatures, air temperature, and vapor pressure deficit and varies between 0 (no water stress) and 1 (full water stress, no transpirational cooling of the leaf). CWSI has been shown to be highly correlated with other measurements of water stress (Nielsen, 1989; Li et al., 2010) such as leaf and canopy CO_2 exchange rate, leaf and canopy transpiration, leaf water potential, stomatal conductance, and plant available water in the soil profile.

Methods

The system capacity research was conducted at the Central Great Plains Research Station near Akron, CO. Three irrigation capacity strategies and timings were used to determine the response of corn to early season and late season water stress. The experimental field was divided into three sections and irrigated with a solid set irrigation system with an application rate of 0.42 inches per hour. The three capacities and timings were: 5 gallons per minute per acre (gpm/a) with season long irrigation (Full), 2.5 gpm/a with season long irrigation (Inadequate) and 6.7 gpm/a with irrigation delayed until 2 weeks prior to tassel

Stomatal conductance measurements show the speed at which water vapor transpires from the leaf tissue to the atmosphere. Water stress results in lower conductance as compared to non-stressed vegetation. Stomatal conductance measurements were taken with a Decagon Leaf Porometer model SC-1. Three measurements were taken per plot on the most fully developed leaf in the upper canopy fully exposed to the sun. Measurements were taken between 1300 and 1600 MDT when water stress impacts on transpiration should be the greatest. Atmospheric conditions such as temperature and humidity have a significant impact on stomatal conductance so comparisons within a day are relevant as compared to day to day comparisons within a water treatment.

Results

The different irrigation treatments resulted in differential water stress development (Table 1). Water stress was generally less in 2009 compared with 2010 due to increased rainfall in 2009 (seasonal CWSI for the full irrigation treatment was 0.12 in 2009 and 0.24 in 2010). In both years CWSI values were highest during the vegetative growth stages under the GSL treatment when irrigation was withheld during the vegetative period (CWSI = 0.59 in 2009 and 0.47 in 2010, averaged over hybrids). The water stress was relieved after tasseling for the GSL treatment when irrigation was applied on the same schedule as applied for the full treatment (CWSI = 0.11 in 2009 and 0.24 in 2010,

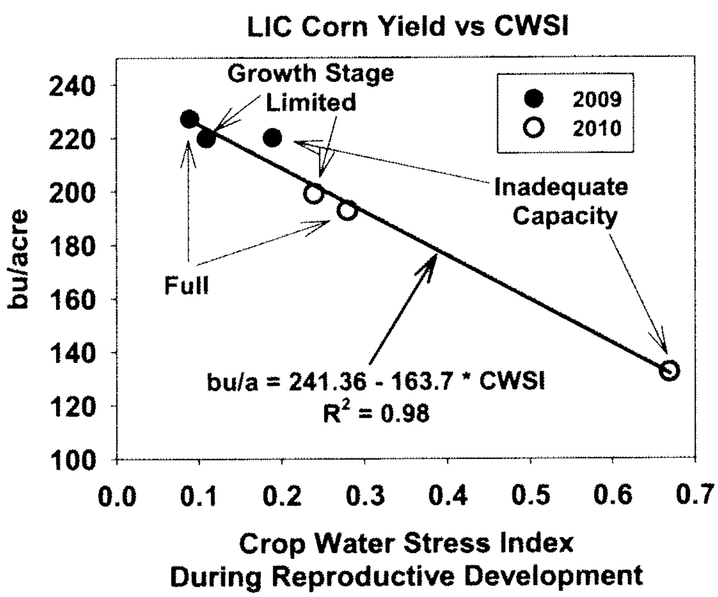

Figure 3. Corn yield vs crop water stress index.

averaged over hybrids during the reproductive stages). Because of the greater rain in 2009 the inadequate capacity treatment did not develop the high levels of water stress seen in 2010 (CWSI = 0.09 during vegetative stages and 0.19

The ET values generally followed the same pattern as CWSI, with greater water use corresponding to lower CWSI. There were no differences in ET due to hybrid. Water use was about three inches less in 2010 than in 2009 for the full irrigation treatment, resulting in about 34 bu/a lower yield in 2010 compared with 2009 for the full irrigation treatment. Under the more favorable growing conditions of 2009, ND4903 produced higher yield than the other two hybrids under full irrigation (252 vs. 214 bu/a) and under the growth stage limited irrigation . But all three hybrids produced the same yield under the inadequate capacity irrigation treatment (220 bu/a). In 2010 NE5321 had much lower yield (164 bu/a) than the other two hybrids (207 bu/a) under full irrigation; ND4903 had lower yield (188 bu/a) than the other two hybrids (204 bu/a) with the growth stage limited treatment. Yields were lowest in 2010 with the inadequate capacity treatment, with ND4903 yielding highest (140 bu/a) and NE5321 yielding lowest (122 bu/a).

Irrigation capacities had a significant impact on stomatal conductance during the growing season in 2010 (Table 2). System capacities less than adequate had lower stomatal conductance as compared to adequate capacities. Early in the growing season, stomatal conductance for inadequate, growth stage and full irrigation were similar on June 29. Since irrigation was not initiated until just prior to tasseling on the growth stage treatment, lower stomatal conductance rates were observed in early July as compared to full irrigation while the inadequate capacity was similar to full. Lack of precipitation during late June and July resulted in reduced stomatal conductance on July 26 for both inadequate and growth stage management as compared to full irrigation. This water stress for inadequate and growth stage treatments was during tassel emergence. Irrigation was initiated on the growth stage treatment at this time with application amounts that would be similar to maximum transpiration rates. Stomatal conductance rates for the growth stage treatment on August 13 were similar to full irrigation while the conductances under the inadequate capacity treatment were less than under both growth stage and full irrigation. The difference in stomatal conductance between full irrigation and inadequate capacity increased later in the growing season (August 20) indicating that water stress levels were increasing in the inadequate capacity management.

Conclusions

Timing and capacity had an impact on grain yield when precipitation was below average. Grain yields with an inadequate capacity resulted in a 32% reduction in grain yields as compared to full irrigation capacities. Timing irrigation towards reproductive growth with a higher capacity resulted in similar grain yields. Reducing irrigation during the vegetative growth stage resulted in higher crop water stress indexes. However, an irrigation capacity which can meet crop water needs reduced the crop water stress index to values similar to full irrigation capacities and resulted in little or no yield loss.

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