Modeling 100 Years of Water-use of a No-Till Double Crop Forage Production System

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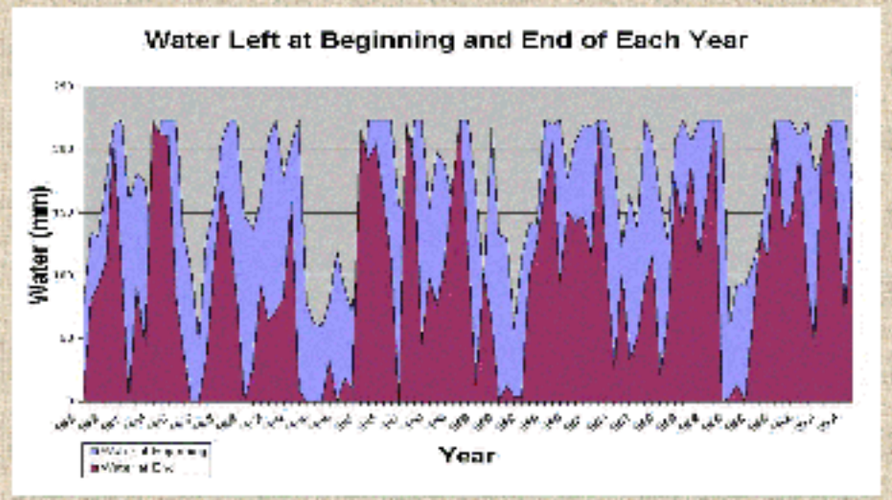
ABSTRACT

Forage production in past years has been limited to one crop per year by producers. Due to limited water resources in the area, maximum economic yields, agricultural producers need to utilize no-till practices. It may be possible with improved no-till equipment and crop management to harvest more forage per growing season. The objective of this project was to look at 100 years of historical weather and determine the theoretical potential to grow two forage crops per year. To complete this objective, daily reference evapotranspiration (ETo) and ET budgets for peanut and sunflower forage crops were calculated using the Penman equation for a period of 100 years. The Penman equation requires daily maximum and minimum temperatures, precipitation, average wind speed, solar radiation, dew point, and relative humidity. All of this data was available from 1906-2005. For 1905-1990 only daily maximum and minimum temperatures and precipitation were recorded. Estimates for these years were calculated using average values from 1991-2005. From 1905-1990, a peanut crop was estimated to harvest 85% of the years with adequate soil water equivalent to 11.5 cm in twenty only of the years and was permanent wilt point 8% of the years with adequate soil water equivalent to 11.5 cm in twenty only of the years and was permanent wilt point 8% of the time. Sorghum was stressed 20% of the time and at a permanent wilt point 20% of the time. From 1991-2005 was more stressed 20% of the time and at a permanent wilt point 0% of the time. The sunflower was stressed 45% of the time and at a permanent wilt point 5% of the time. From 1905-2005 peanut was stressed 11% of the time and was permanent wilt point 8% of the time. Sorghum was stressed 6% of the time and at a permanent wilt point 3% of the time. The results show that with proper management, advanced equipment, and available soil water, it may be possible to harvest two successful forage crops in a year for most years.



METHODS & PROCEDURES

100 years of historical weather data along with the Penman equation were used to complete this model. The weather data was put into Microsoft Excel and analyzed. The weather records used were provided by the Dickinson Research Extension Center and the North Dakota Agricultural Weather Network. The Penman equation is used to determine reference ET. In order to complete the Penman equation, daily maximum and minimum temperature, precipitation, average wind speed, solar radiation, dew point, and relative humidity were used. All of this data was available from 1991-2005. For 1905-1990 only daily maximum and minimum temperatures and precipitation were recorded. Assumptions for these years were developed using averages from 1991-2005.

Penman Equation

$$ETo = c[W(R_n) + (1-W)f(u)(e_a - e_d)]$$

- ETo = reference crop evapotranspiration (mm/day)
- W = temperature related weighting factor
- R_n = net radiation in equivalent evaporation (mm/day)
- f(u) = a wind-related function
- $(e_a - e_d)$ = difference between the saturation vapour pressure and the actual vapour pressure, both in mbar
- c = an adjustment factor to compensate for the effect of day and night weather conditions

INTRODUCTION

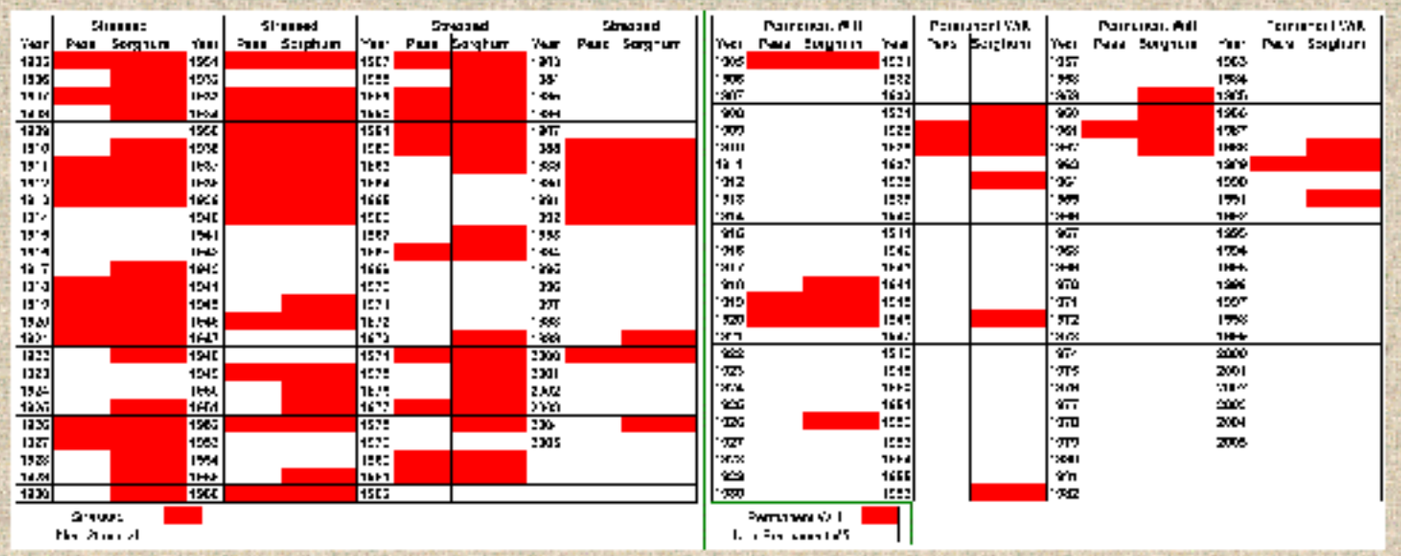
Traditionally agricultural producers in southwest North Dakota grow one forage crop per year. However, with advanced equipment and proper management, it may be possible for producers to raise two forage crops per year. By examining and modeling 100 years of historical weather, the most optimum available environment to cultivate or actively growing crops in a given year can be studied in order to maximize yields.

OBJECTIVE

The objective of this project was to look at 100 years of historical weather data and use a water balance model to estimate crop yields. The model depicts estimated water use and soil water balance during a 100 year period at the beginning and end of the year. It also provides information on a yearly basis of irrigation and precipitation at the point. The Penman equation was used to determine reference ET.

ASSUMPTIONS

- No tillage system.
- No plant disease or insects present.
- No insect or weed problems present.
- Planting in each forage crop in southwest North Dakota.
- Plant available water-holding capacity of 22.5 cm.
- Water available from August 27 – April 15 is stored in the soil.
- If plant available water reaches 11.25 cm, yield will be 100% of the potential.
- If plant available water reaches 11.25 cm, yield will be 50% of the potential.
- Peanuts are planted on April 15 and harvested on June 10.
- Sorghum is planted on July 8 and harvested on August 30.
- Adapted crop varieties were used.



RESULTS

From 1905-1990, a peanut crop was estimated to harvest 85% of the years with adequate soil water equivalent to 11.5 cm in twenty only of the years and was permanent wilt point 8% of the years. Sorghum was stressed 20% of the time and at a permanent wilt point 20% of the time. From 1991-2005 was more stressed 20% of the time and at a permanent wilt point 0% of the time. The sunflower was stressed 45% of the time and at a permanent wilt point 5%. From 1905-2005 peanut was stressed 11% of the time and was permanent wilt point 8% of the time. Sorghum was stressed 6% of the time and at a permanent wilt point 3% of the time. The results show that with proper management, advanced equipment, and available soil water, it may be possible to harvest two successful forage crops in a year for most years.

CONCLUSION

With proper management, advanced no-till equipment, and adequate amounts of moisture, it may be possible to grow two crops in one year for most years. This project was mainly feasible by reviewing 100 years of historical weather and developing a yearly model. The model ensures an available soil water under an adequate crop.

LITERATURE CITED

- "Handbook of Agriculture"
- "Modeling Plant and Soil Systems"
- "Crop Water Requirements FAO 24"
- "World Resources Water FAO 17"