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CAN SEASONAL RAINFALL FORECASTS BE USED TO GUIDE DRYLAND COTTON MANAGEMENT?

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Abstract

Weather researchers are becoming increasingly successful at making long-range forecasts of precipitation. In this study, we attempt to determine if farmers in the Texas High Plains could use this information to help determine what plant populations they should use in their dryland cotton fields. Results of this study suggest that, if reasonably accurate long-range forecasts of rainfall are not available for the critical period when cotton plants are setting and filling bolls, then dryland cotton farmers should not deviate from current practices involving the use of relatively low plant populations.

Introduction

In the semi-arid Texas High Plains, rainfall during the growing season is the primary factor affecting dryland cotton yields. Potential evapotranspiration (PET) during the growing season characteristically exceeds rainfall, and farmers in this region have accommodated this deficiency by planting their dryland cotton fields to relatively low plant populations (typically around 4 plants m^{-2}). If more water were available while the cotton plants were setting and filling bolls (as in the case of irrigated fields), the use of higher plant populations could result in increased yields. But the relatively low plant populations currently used in dryland cotton fields reflects the uncertainty regarding the amount and timing of rainfall during the growing season in this region.

If farmers knew in advance that the growing season would be wetter than normal, could they use this knowledge to justify planting higher plant populations in anticipation of increased yields? In recent years, meteorologists and climatologists have made significant progress in improving the accuracy of long-range weather forecasts, through increased understanding of hemispheric weather phenomena such as El Niño. If forecasters could predict with reasonable accuracy whether the coming growing season in the Texas High Plains would be wetter than normal, could farmers use this information to increase dryland cotton yields by planting higher plant populations? The objective of this study is to investigate this possibility.

Materials and Methods

The effect of growing season rainfall on yield was investigated using the cotton growth model Cotton2K [1]. This model is capable of simulating the growth and yield of the cotton crop based on daily observations of temperature, solar radiation, and precipitation. The model was run using 30 years of synthetic weather data generated for the Lubbock area using the WGEN program [2]. WGEN can produce an unlimited number of years of daily weather data that statistically resemble actual weather data for a region. For each year of synthetic weather data, Cotton2K was run for six plant populations: 10, 000, 20,000, 30,000, 40,000, 50,000, and 60,000 plants per acre. Results of these simulations were analyzed to determine the relationship between yield, plant population, and growing season rainfall.

Results and Discussion

Average growing season (May through October) rainfall for the 30 years of synthetic weather data (14.8 in) was close to the average actual growing season rainfall (14.3 in) for this region. Of the 30 synthetic years of weather data, 15 had above-average rainfall. Simulations made assuming full irrigation of the cotton crop (no water stress) resulted in an average lint yield of around

2000 lb ac^{-1}, which is close to values observed in well-watered experiments in this region. For the irrigated simulations, there was no consistent relationship between yield and seasonal rainfall.

For the dryland cotton simulations, yield was positively correlated with seasonal rainfall for all six plant populations. This supports the common observation that dryland cotton yield in the Texas High Plains is dependent upon growing season rainfall.

Results of the dryland simulations are summarized in Table 1. For the entire 30 years, highest average yields occur for the lower plant populations (10,000 to 20,000 plants ac^{-1}). This is consistent with current dryland farming practices that involve plant populations of around 4 plants m^{-2} (16,000 plants ac^{-1}). Even with these relatively low plant populations, one can expect crop failures in around 6-8 out of 30 years. Here, crop failure is somewhat arbitrarily defined as lint yields below 75 pounds ac^{-1}, based on conversations with farmers in this region. Average yields decrease and number of years with crop failures markedly increase with plant populations above 20,000 plants ac^{-1}.

If we restrict the analysis to the set of 15 years with above-average rainfall, we see that the average yield for these 15 years is greater than the average yield for the entire 30-year set. This would be expected, since yields at a given plant population were positively correlated with growing season rainfall. However, average yields for the years with above-average rainfall were not a function of plant population. Similarly, the greatest yield for any one year did not appear to be a consistent function of plant population. Thus, while farmers should expect to achieve higher yields in wetter than average years, there appears to be no consistent advantage to using plant populations greater than what they normally use.

This is explained by the results shown in the fifth and sixth columns in the table. For the entire 30-year set, the number of crop failures for plant populations above 20,000 plants ac^{-1} is around twice the number for plant populations of 20,000 plants ac^{-1} or less. However, for the years with above average rainfall, the number of crop failures for plant populations above 20,000 plants ac^{-1} is around 3-4 times the number for plant populations of 20,000 plants ac^{-1} or less. The higher percentage of crop failures with higher plant populations reduces the corresponding average yields for the set of years with above average rainfall. For the higher plant populations, why should there be a higher proportion of years with crop failures for years with above average rainfall? This results from the fact that while there may be an above average amount of rainfall during the growing season, the rain might not fall during the critical period when cotton plants are setting and filling bolls (late July and August). In the Texas High Plains, warm-season rain comes in isolated thunderstorms. Increased number or strength of thunderstorms may result in above average rainfall, but if these rains occur early or late in the growing season, they may contribute little to increasing yields.

Thus, if a farmer plants higher plant populations (above 20,000 plants ac^{-1}) in anticipation of a rainier growing season, and if the increased rains don't occur during the critical period when cotton plants are setting and filling bolls, then the farmer is more likely to experience a crop failure than if he/she had used lower plant populations. To be effective, long-range forecasts of increased rainfall would have to be available for the relatively brief critical period when the yield of the crop is largely being determined.

Conclusions

If reasonably accurate long-range forecasts of rainfall are not available for the critical period when cotton plants are setting and filling bolls, then dryland cotton farmers should not deviate from the current practice of using plant populations in the range of 10,000 to 20,000 plants ac^{-1}. Such a practice will minimize the number of crop failures and, on average, will produce yields during years with above average rainfall that are comparable to those achievable with higher plant populations.

References

1. http://departments.agri.huji.ac.il/fieldcrops/cotton/Cotton2KModelDoc.htm

2. Richardson, C.W., and D.A. Wright. 1984. WGEN: a model for generating daily weather variables. U.S. Department of Agriculture, Agricultural Research Service, Washington, D.C., ARS-8, 88p.

Table 1. Results of Cotton2K dryland cotton yield simulations.

plant population (plants/ac)	average lint yield, all 30 years (pounds/ac)	average lint yield, above-average rainfall years (pounds/ac)	greatest lint yield (pounds/ac)	number of years with crop failure in all 30 years	number of years with crop failure, above average rainfall years
10,000	234	340	579	6	1
20,000	208	280	536	8	2
30,000	135	290	505	16	6
40,000	154	349	721	15	6
50,000	114	313	420	19	7
60,000	115	306	692	19	8