What Weather Cards were we Dealt in 2003 - Heat and Moisture - and Fall Soil Moisture

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Introduction

The 2003 growing season experienced extraordinary weather, which resulted in significant production limitations in many areas while other areas received record yields. Most noteworthy were the moisture restrictions where, depending on the timing and severity had varying degrees of effects on final yield. A review of the 2003 growing season weather provides some insight into what occurred above and below the soil surface and what the effect was on crop production.

Crop Water Use

Growing season precipitation will rarely be adequate to supply crop water requirements through the growing season. Therefore spring soil moisture is an important source of additional crop water; in particular rainfall occurring prior to fall freeze up and post spring thaw. Snowmelt is another source of spring soil moisture but to a limited extent due to its low water content and the high proportion of blow-off and runoff. Determining the spring soil moisture reserve is vital for developing optimum management strategies in areas where moisture shortage is a production limitation. While initial spring soil moisture and growing season precipitation are the two sources of crop water, it is important to not consider moisture status as a function of available water alone. Depending on the crop type, the phenological stage, and the atmospheric forces that drive evapotranspiration, crop water demand will vary, putting more or less pressure on the available water supply. In addition, not all water entering the system is equally accessible. Intense rainfall events or rain falling onto a wet soil surface will most often result in runoff, providing no benefits or even worse, can cause extended saturation of the soil. Excess soil moisture that is not taken up by the roots can be lost as result of deep drainage. As the soil within the root zone dries, more effort is required by the plant roots to extract water from the soil. This interaction between supply and demand will ultimately determine the success of a crop.

To provide an overall indication of the regional soil moisture situation in the province, Manitoba Agriculture, Food and Rural Initiatives employs a first generation agrometeorological model (Raddatz, et al. 1996) to simulate the various soil, plant, and atmospheric interactions within crops. These models estimate potential evapotranspiration (Etp) with an empirical regression equation (Baier and Robertson 1965; Baier 1971). Then based on the crop type and stage of development, the derived ratio of actual evapotranspiration (ETa) to ETp is used to estimate crop water use based on changing crop coefficients (Hobbs and Krogman 1968; Sammis et al, 1985). In the event that precipitation does not meet crop demand and soil moisture within the root zone is inadequate, roots cannot extract the necessary moisture required for transpiration and crop moisture stress results.

The main advantage to using a computer model to estimate regional soil moisture is that it is very difficult to mobilize the resources to undertake a province-wide soil moisture survey on a regular basis. Furthermore, policy and resource deployment decisions must be based on timely information, and dealing with such a dynamic variable as soil moisture, sudden changes in conditions can have significant impacts on crop outlooks. One of the limitations to using soil moisture models is that all models are simplifications of reality; therefore it is impossible to recreate each and every variable and interaction that takes place. Also, a regional model must ignore many local factors such as local soil variations, topographical effects, pest pressure, fertility, and others. It is therefore not intended nor recommended that regional models be used at a field level.

When dealing with soil moisture and moisture stress, it is imperative that crop type be considered. This will have effect on the amount of moisture required, the quantity that is accessible, the length of time that it is required, and the yield response. Perennial crops are the first crops to start using moisture in the spring. A full ground cover and high leaf area ensures early crop water demand at rates at or near ETp. Crop water demand remains relatively high as long as temperatures permit (Figure 1). Annual crops will begin using water much later as they must first become established. Therefore the seasonal moisture requirements will be much lower through the early part of the season until the crop reaches the vegetative growth stage at which point water demand is highest. Depending on whether the crop ripens early, such as wheat, or carries on through the latter part of the growing season, such as corn, moisture demand will differ significantly.

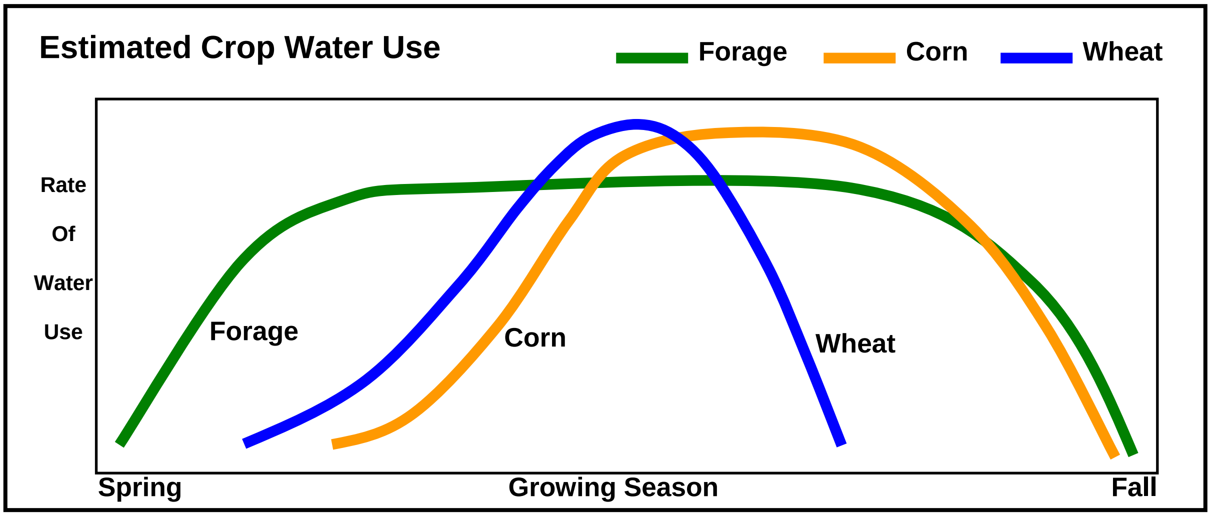

Figure 1: Estimated crop water use patterns for various crops

2003 Regional Perspective

The east and central parts of southern Manitoba experienced normal to near normal precipitation amounts during the growing season (Figure 2). This resulted in ideal moisture conditions in most areas providing above average yields and very little moisture stress in the east and average yields in the central region with some lower soil moisture contents associated with forages late in the season. Southwest Manitoba began the season with adequate soil moisture reserves in most areas, however due to precipitation well below normal and temperatures above normal, available soil moisture was depleted rapidly. This ended up being detrimental to forage and crop production as crop water demand exceeded supply early in the season. Most of the northwest region experienced near normal precipitation amounts however low spring soil moisture combined with high heat resulted in poor hay and pasture production. Much of the Interlake experienced conditions similar to the northwest, including warmer temperatures and rainfall slightly below normal with exception of some areas that received well below normal precipitation.

Despite some very hot and dry conditions, many annual crops yielded surprisingly well. Part of this success can be attributed to a warm and relatively dry spring in most parts of the province. This allowed planting to take place early and crops to become established, and in some cases ripe, prior to the onset of extreme moisture stress. Combined with annual crop water use trends in Figure 1, crop success can be attributed primarily to fortunate timing.

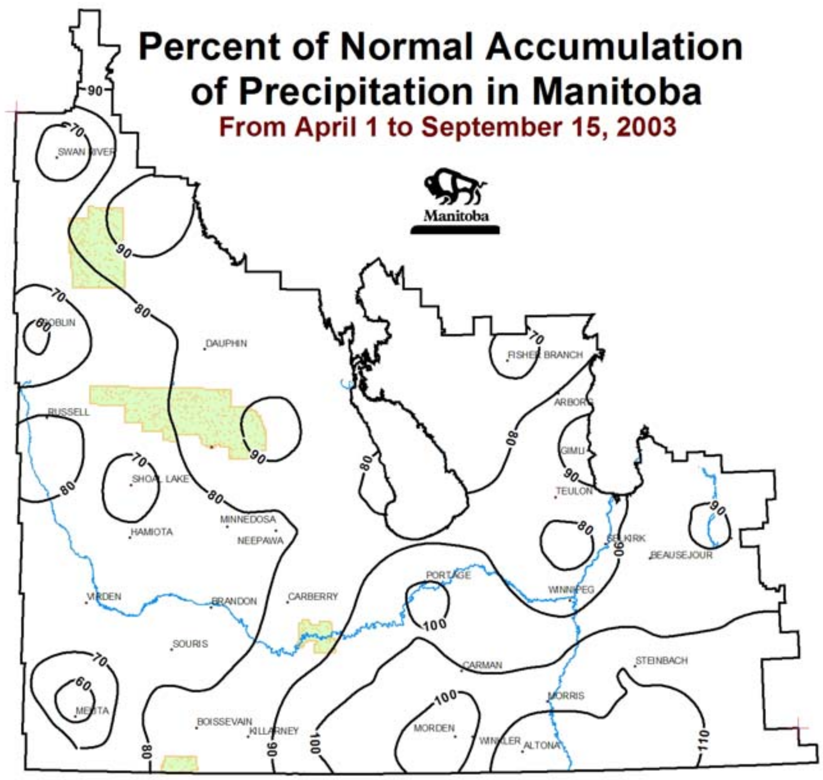

Figure 2: Percent of normal rainfall from April 1 to September 1, 2003

Fall Soil Moisture and Spring Forecasts

Most recent estimates of fall soil moisture shows western Manitoba remaining at less than 50% of soil water holding capacity within the root zone, with the lowest values tending to occur west of Virden (Figure 3). Winter snowfall will provide some additional moisture however spring rainfall will be the most important factor to ensure adequate initial soil moisture for satisfactory crop production.

Current Environment Canada seasonal forecasts for precipitation anomalies (available online: http://weatheroffice.ec.gc.ca/saisons/index_e.htm issued December 1, 2003) predict above average precipitation for both the 0-3 month (December 2003, January, and February 2004) and the 3-6 month (March, April, and May 2004) periods. It should be noted however that long-term forecasts have a historical percent correct of less than 50%. A somewhat more effective method of predicting spring soil moisture is to compile it based on the actual fall soil moisture estimates. Assuming close to average conditions over the winter, additional moisture from snowmelt-water infiltration is added to the current estimate, providing an indication of total available soil moisture for early spring. Assuming conditions are not too different from normal, this method may provide a reasonable estimate. One of the limitations to making any sort of predictions of crop production so far in advance is that one or two well-timed rainfall events of sufficient magnitude can significantly alter the production outlook.

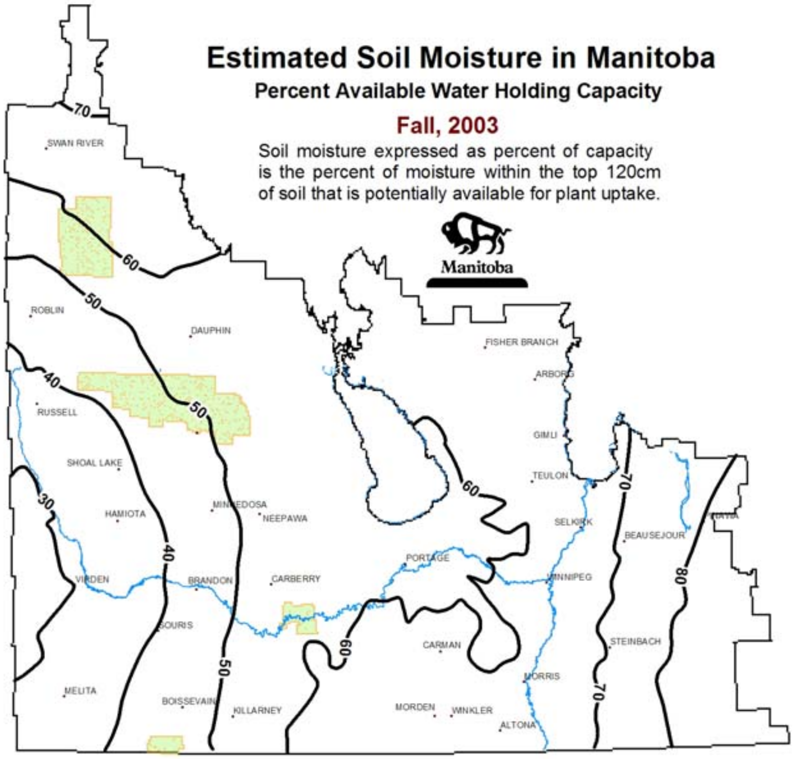

Figure 3: Estimated soil moisture. Fall 2003.

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