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Agroclimatic procedures related to crop production in the North Central Region of the U.S.A.

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The University of Nebraska - Lincoln, 1988

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AGROCLIMATIC PROCEDURES RELATED TO CROP PRODUCTION IN THE NORTH CENTRAL REGION OF THE U. S. A.

by

Lorenzo Armando Aceves-Navarro

A DISSERTATION

Presented to the Faculty of

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In Partial Fulfillment of Requirements

For the Degree of Doctor in Philosophy

Major: Horticulture and Forestry

Under the Supervision of Professor R. E. Neild

Lincoln, Nebraska

November, 1987

TITLE

Agroclimatic Procedures Related to Crop Production in the North Central Region of the U.S.A.

BY

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AGROCLIMATIC PROCEDURES RELATED TO CROP PRODUCTION IN THE NORTH CENTRAL REGION OF THE U. S. A.

Lorenzo A. Aceves-Navarro, Ph.D.
University of Nebraska, 1987

Adviser: Ralph E. Neild

Though commonly available for many locations, summaries of weather normals on fixed time periods of one month are too long and out of phase with critical operations and stage of crops development such that their use in agriculture is limited. Discussed here is a procedure whereby these monthly data are used to derive daily normals that are more closely oriented to agricultural applications.

Agroclimatic parameters were developed for use in conjunction with these derived daily normals to determine and evaluate the growing seasons for a series of different crops. Normals from 132 stations were used to map determinations of the growing seasons for wheat, a cool season crop, and corn, a warm season crop in the North Central Region. Also presented are maps showing the potential for a second "double crop" after wheat and agroclimatic zones for corn. Applications of daily normals and agroclimatic parameters to other crops and agricultural situations at specific locations in the North Central Region are also discussed.

This dissertation is dedicated to my family, my wife, Alejandrina, my son, Christian, and my daughter, Lorena, for their support and comprehension.

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I. INTRODUCTION

A. General description of the North Central Region

The North Central Region (NCR) of the United States consists of the states of Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin. The region is located between 36° and 49° north latitude and between 80° and 104° west longitude. The NCR includes the Corn Belt and the northern half of the Wheat Belt (Havighurst, (41)). Although the NCR represents only 21% of the total area of the continental United States, it is the most important grain-producing region in the U.S.A. (White et al.,(126)). It produces 85% of the corn, 80% of the oats, 71% of the soybeans, 71% of the rye, 49% of the wheat, and 46% of the grain sorghum in the U.S.A. It is also an important livestock region, with 79% of the hogs, 45% of the dairy cows, and 40% of the beef cattle in the U.S.A. It is also the largest grain-producing region in the world (USDA, (118)).

The topography and soils are relatively uniform throughout the NCR. However, a perpendicular pattern of isotherms and isohyets, with temperature decreasing from south to north and precipitation decreasing from east to west, creates a complex interaction affecting the time and duration of the growing season and the moisture available for crops.

In temperate regions, the growing season is largely determined by temperature. However, only a few of the many climatological definitions of the growing season are crop-oriented. Realistically, the growing season begins when the temperature becomes warm enough to initiate seed germination or break dormancy of overwintering crops such as winter wheat or alfalfa. The season ends when temperature becomes too high or too low for crop growth or crop quality.

The growing season should be warm and moist enough to meet the thermal and moisture requirements for different crop species. Reported in the literature are temperature thresholds for determining the beginning and ending of the growing season. The thermal requirements of certain crop species and strains are also reported. Temperature thresholds and temperature requirements for other crop species and strains can be determined from analyses of climatological and phenological data. Monthly temperature and precipitation normals are available for climatic stations throughout the NCR. Statistical techniques are also available for developing necessary daily temperature and precipitation values from these monthly climatic normals.

1. Objectives

The objectives of this study are to: 1) describe the use of monthly climatic summaries to develop agriculturally

oriented normals; 2) map agroclimatic normals for important cool and warm season crops in the NCR; and 3) present examples of the use of agroclimatic normals in different agricultural situations at selected specific locations in the NCR.

II. AGROCLIMATIC NORMALS

Monthly normals of temperature and precipitation (1951 to 1980) are available for many locations in the NCR states (NOAA, (86)). These data allow comparison of seasonal climatic patterns between locations and are useful for planning certain activities. However, monthly climatic normals are often too long and out of phase with critical stages of crop development so that their use in agriculture is limited (Neild et al., (77)).

Life on earth evolved in a changing environment. Daily and seasonal changes in light, temperature and moisture are related to the earth's 24-hour rotation about its axis and its 365-day revolution around the sun. In temperate regions, plant growth and development are closely related to the occurrence of critical values in the rise or fall of seasonal temperature. They are also related to accumulations of temperature and precipitation between developmental stages. For example, winter wheat usually breaks dormancy when normal daily temperature first rises above 37° F. Corn

is usually first planted when normal temperature first rises above 55° F (Kincer, (57)). Studies with alfalfa in Minnesota show that about 1035° growing degree days above 36° F (GDD-36) are needed to reach first cutting (Sharrat, (108)). Studies in the U.S.A. (Michigan and Nebraska), Canada, England and U.S.S.R. show that the optimum time for planting winter wheat is also temperature related. This optimum period usually first occurs in September or October, when the temperature decreases to about 60° F and when there are only about 450°-550° F (GDD-40°) remaining for the seedling to develop three leaves (Bootsma and Suzuki (10), Wiese et al. (127), Croxall and Smith (25), Fernsted and Dreier (31), and Fedoseev (30)). Such daily temperature averages and accumulations may be used as agroclimatic parameters. They are not time-restrictive, but permit critical stages of plant development and associated agricultural operations for a particular location to be oriented to climatic patterns on a phenological or bioclimatic time scale. Thus, in temperate regions, daily average temperature can be used to determine the usual time when seasonal temperatures are warm or cool enough to initiate or limit plant growth. Daily temperature accumulations enable estimations of the expected times of occurrence of different stages of crop development and the moisture available for growth. Daily climatic normals are needed before parameters such as these can be used (Neild et al., (79)).