

Analysis on Responses of Drought Stress on Soil Moisture and Maize Yield Structure

Ji Xiaona, Chen Yunxi, Yu Huayou
Inner Mongolia Ningcheng bureau of meteorology, China, Chifeng
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Abstract. Taking the drought stress and normal irrigation fields where plant the same varieties of corn, an experiment by drilling soil was conducted to study the effects of drought stress on characteristics of the soil gravimetric moisture content, water storage and water consumption. The result showed that the effect of drought stress enhanced significantly after the tasseling stage, the soil moisture was markedly lower than that in the normal irrigation field. During the reproductive period, the soil water storage of drought stress area was lower than the normal irrigation field, and the variation of the soil water storage in shallow layer was bigger and smaller in the deep layer. Moreover, the drought stress influenced on the maize yield seriously, and the indexes of maize yield under the drought stress were significantly lower than the normal water treatment, the hundred grain weight decreased by 23.3%, and the grain yield fell by 35.6%.

Keywords: Drought stress; soil gravimetric moisture content; Water storage; Water consumption

1. Introduction

Ningcheng county is a semi-arid monsoon climate zone located in the south of Chifeng city. Its topography is high in west and low in east, and solar-thermal resources is abundant, but lack of natural precipitation, and uneven distribution of time and space. Under the comprehensive influence of climate, hydrology, geology, soil and topography factors, floods occur occasionally. There are two rivers that across the county from southwest to northeast and form the backbone of irrigation and drainage, and its irrigation condition is better. The county is divided into four seasons obviously: Spring warm up quickly, wind is far larger and more, rainfall is less, climate is dry, and spring drought is frequent. In summer, the condition of high temperature, concentrated rainfall, simultaneous rain and heat is favorable for the growth of crops, but sometimes heavy rain causes flooding, and summer drought is frequent in recent years. Autumn is short and fast, temperature drops quickly, enough sunlight is beneficial to mature and harvest of crops, but the change probability of rain is large in autumn, sometimes the continuous wet weather occurs. The cold and dry winter has less rainfall, and a cold wave invades regularly. In conclusion, the weather of county is complex and changeable, disasters is various, frequent and large-scale, these seriously restrict the economic development, and drought is one of the most serious meteorological disaster.

Ningcheng county dominated by agriculture is an important commodity grain base in Inner Mongolia. In 2015, the crop planting area of county is 1.59 million unit area which covers corn of 975000 unit area that accounts for about 60% of the cultivated area. Drought reduces the maize yield by 25% ~ 30%, even lead to rejection in parts of the regions, is the first limiting factor which influence corn growth and yield in arid and semiarid regions[1-2]. Rahmat (2007) indicated that the yield components and grain yield were significantly affected by water supply. Sen (1952) recorded highest yields from irrigation and recommended irrigation at the tasseling and flowering stages. For insufficient water in Ningcheng, the research on influence on the soil moisture change and corn yield under the drought stress is helpful to find a more reasonable irrigation mode to enhance production on the basis of reducing appropriately irrigation water, which improves fully the efficiency of using water and provides scientifically decision-making serve for field management.

2. Materials and Methods

2.1 Materials

The experimental data is from the observation data in the whole growth period of corn in 2015, the corn planting area is located in a village of Ningcheng where annual average temperature is 7.3°C, annual rainfall is 444.5mm or so, April-September rainfall is 404.1mm. The soil texture is silt, pH value is 8.58 and a weak alkaline, underground water level is about 8m, the volume weight of soil between 10cm and 50cm is 1.37 ~

1.48 g/cm³, field moisture capacity is 21.1%~28.5%, wilting moisture is 2.6%~5.7%. In 2015, the average temperature is 8.2°C higher than the calendar year 0.9°C, the annual precipitation is 365.2mm fewer than the calendar year 17.8%.

In 2015, maize variety is 'Jade 4' which was sowed on April 20 and mature on September 22, the growth period is 155d. The experimental field was divided into normal irrigation(NI) and drought stress(DS) field, whose acreage was 0.11hm² and 0.1hm² respectively. The two fields adopted the horse-drawn plough, seeding rate was 60kg/hm², sowing depth about 0.06m, spacing 0.5m, planting distance 0.37m, and fertilized diammonium phosphate 375 kg/hm² before sowing. NI irrigation mode: the first irrigation was completed on June 25 with 1046.2m³, the second on August 4 with 900.0m³, and the last on August 21 with 200.0m³. DS irrigation mode is without irrigation in the whole growth period. There are 55 rainfall in the whole growth period with 263.5mm.

2.2 Methods

During the period of getting the experimental data, we drilled the soil of two fields to get the weight of soil moisture content of the sample on the eighth day every ten-day, double repeated experiment from 10cm to 50cm for a layer of per 10cm were conducted in each section, each experiment repeated 50cm. Soil gravimetric moisture content was measured by drying and weighing the soil sample, and calculated the total soil moisture storage(S) and water consumption(CW) [5] further.

$$S = 10 \times \sum_i \rho_i \times w_i \times h_i$$

Among them, ρ_i 、 w_i 、 h_i is the volume weight of soil、the soil gravimetric moisture content and the soil thickness in the i -th layer respectively, $i = 1, 2, \dots, 5$ is the soil layer.

$$CW = R + I + \Delta S$$

And R is the precipitation, I is the irrigation amount, and ΔS is the change of the soil water storage. For the drought stress area, $I = 0$. Moreover, due to the groundwater level is more than 8m, supplemental groundwater is neglected.

3. Results and Analysis

As shown in fig. 1a), the soil moisture between 10cm and 20cm change relatively severe under drought stress, the soil gravimetric moisture content is lower than that under normal irrigation 16.9% in the whole growth period. Due to abundant rain, the change trend of soil moisture content of two fields is close from sowing to seeding stage. In late June, crop enter the jointing stage, and have a gradual increase in demand for water, the weight of soil moisture content curve has a downward trend. Especially in July, the weight of soil moisture content decline obviously under drought stress at the beginning of drought, and begin to be lower than the normal water supply field. After supplying water on July 20, the soil moisture content of two fields appear a significant difference.

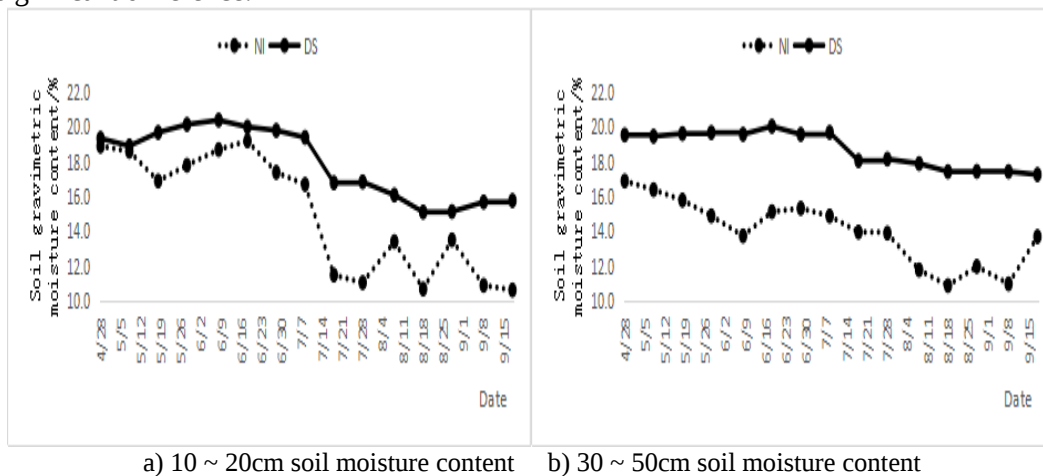


Fig.1. Soil gravimetric moisture content under drought stress

As you can see from fig. 1 b), the soil moisture content of 30~50cm change relatively flat than 10~20cm under drought stress. With the growth of crops and duration of drought stress, the shallow soil is not enough to supply moisture that crop require for normal growth and development, and root increase gradually the use