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Research Article

Study on the Productivity of Irrigation Water at Maize (Zea Mays)

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Abstract

The aim of this study is to investigate the irrigation effect and irrigation performance of grain maize grown under natural moisture and optimum irrigation on the basis of a long series of data obtained under field conditions. To investigate the nature of the dependence between grain maize productivity and irrigation rate, irrigation water productivity and extra yield over years of rainfall provision. The study covers a range of data for the period 1972 to 2013, characterized by uneven distribution of precipitation during the growing season, in the conditions of an optimal irrigation regime and natural water supply. The data is a result of field conditions in the area of Stara Zagora, Bulgaria.

As a result of this study, grain maize production capacities have been established for optimal irrigation and natural water supply. Calculate the irrigation water productivity, which ranges from6,72 to 48,72kg.ha-1.mm, over the years with different rainfall provision. There is a strong positive linkage between the extra yield and the productivity of the irrigation rate. The correlation coefficient was determined (r = 0,88). The rate of rainwater productivity development is dynamic but with smaller deviations from the rate of extra yield.

Keywords: Corn; Irrigation; Productivity; ANOVA

Introduction

The impact of climate change can be predicted after the study of their impact on the development and productivity of agricultural crops. Bulgaria falls into the most vulnerable zone of the countries most affected by climate change. The analysis of climate change in the country shows that during the summer months there was a decrease in soil moisture as a result of a rise in temperature and less rainfall during the period.

Grain maize is an important food, feed and technical culture. It is mainly grown for grain, which has a high nutritional value. Biological plasticity, short growing season, and high productivity are prerequisites for maize to occupy one of the first distribution sites. Against the backdrop of global water scarcity worldwide, the concern for balance in the water sector is coming to the fore.

Demand for water-saving technologies in plant-growing and refinement of the effectiveness of irrigated water is a matter that has been studied by a number of researchers.

The scientific developments on the complex influence of agrotechnical factors and the variable weather conditions on crop productivity are still insufficient, which requires that research in this area be continued. The climate in Bulgaria is characterized by unsustainable humidification. Research suggests that under the influence of climate change, water supplies will decrease as a result of more rapid evaporation of water from irrigated areas and water bodies [3,11].

Productivity and efficiency of resource use in maize (Zea mays) are key issues for agriculture. The uneven humidification and the increase of the air temperatures highlight the question of the nature of the relationship between the productivity of maize and the elements of the climate [8,17].

A number of studies in the world and in our country have demonstrated the impact of water deficiency on the productivity of maize [2,9]. Growth and development of culture are conditioned by abiotic factors, and productive options are directly related to nutrients, precursor, sowing density, and so on. There is a lot of factual material about the influence of the different technological elements on the productivity of culture [1,4,7,15,16].

The aim of this study is to investigate the irrigation effect and irrigation performance of grain maize grown under natural water supply and optimum irrigation on the basis of a long series of data obtained under field conditions. To investigate the nature of the dependence between grain maize productivity and irrigation rate, irrigation water productivity and extra yield over years of rainfall provision.

Material and Methods

For the purpose of the study, data on grain maize yields were analyzed. The study covers a range of data for the period from 1972 to 2013, characterized by uneven distribution of precipitation during the growing season. The study determined the productivity of the crop under the conditions of an optimal irrigation regime and natural water supply. Data is a result of polls conducted under field conditions. The experience base is located in the region of Stara Zagora, Bulgaria. Climatically, the experimental field is related to the European continental climate area, which includes the region of Eastern Central Bulgaria, covering the Thracian valley.

The extra yield obtained as a result of the irrigation rate has been calculated. The effect of irrigation water has been determined by years. Irrigation of corn is carried out gravitationally, by furrows. To determine the nature of the dependencies, irrigation data for grain maize is used with optimum moisture content and without irrigation. The irrigation time is determined by soil samples. Moisture dynamics of the soil layer is determined by weight method over 7-10 days. The huts were carried out as necessary to maintain 80% of the FC for the 0-100 cm layer. Depending on the distribution and the amount of precipitation, irrigation norms of different sizes were implemented.

A statistical analysis was performed with ANOVA. Dependencies are determined by regression dependencies and coefficients of regression are derived

Results and Discussion

The natural moisture yields range from 1000 kg.ha^{-1} to 8590 kg.ha^{-1} for the 1972-2013 period. The variation is mainly due to the quantity and distribution of rainfall during the growing season. For the conditions of Bulgaria, the average annual precipitation for a period of 88 years is 556,5 mm, for the growing season 298,7 mm, for the July-August period it is 92,4 mm. The sum total for the representative period of the current climate (1961-1990) is 568,0 mm, 304,6 mm and 98,6 mm respectively. The sum of the average daily air temperature over the period above 10°C is 3 900-4100°C. During the study period, the daily average temperatures did not differ significantly from those for a multi-year period.

Grain maize is a culture that is responsive to irrigation. Perennial studies of irrigation scheduling of corn showed that water deficit in the soil builds up at the end of the vegetation and its size is directly dependent on the amount and distribution of rainfall and the size of the irrigation rate [17].

The yields obtained from optimum irrigation range from 4570 kg.ha^{-1} to 16,840 kg.ha^{-1}. The productivity of grain corn is largely dependent on the water supply content [12]. Variation in yields is influenced by the magnitude of the irrigation rate, but there are deviations that lead to the conclusion that yields depend not only on irrigation but also on many other factors entering the complex from agro-technical measures [6,10].

In the present study was made an analysis as to how effectively the water resource was used to increase yields for grain maize. The irrigation water productivity varies widely from 6,72 to 48,72 kg.ha^{-1}.mm. From the attached table, it can be seen that at the same irrigation rate (M = 210 mm) the irrigation water ranges from 21,33 kg.ha^{-1}.mm to 32,29 kg.ha-1.mm. At a rate of 262 mm, an extra yield of 4714 kg.ha^{-1} in 2011 and 7430 kg.ha^{-1} in 2013 is achieved. This increase in crop productivity increases the efficient use of imported irrigation water and water to obtain 17,99 kg.ha^{-1} of one cubic meter of water and in the first year and of 28,36 kg.ha^{-1}.mm.

Extra growth is incredibly dynamic in years. In 1990, under the influence of irrigation (M = 300 mm), 11,110 $kg.ha^{-1}$ of additional production was generated, which formed 37.03 $kg.ha^{-1}.mm$ of irrigation water. The amount of extra yield obtained during the 1978 survey was only 4150 $kg.ha^{-1}$. The magnitude of the irrigation rate of maize is 314 mm. This year, as a result of a given cubic irrigation water, the yield of corn for grain was increased by only 13,22 $kg.ha^{-1}$.

Figure 1 shows the dynamics of the additional yield in years. The analysis shows how, in the case of different irrigation norms, additional extraction is obtained within wide limits. Years of study are characterized by different amounts of precipitation.

Figure 1: Additional yield in corn grain, in the period 1972-2013.

Statistical analysis of the data establishes the nature of the dependencies between the individual factors studied, additional yield and productivity of the irrigation norm.

The analysis of the data shows that there is a strong positive linear relationship between the additional yield and productivity of the irrigation norm. The correlation coefficient was determined, r = 0.88. The correlation analysis of the data shows that between the additional yield and productivity of the irrigation rate there is a strong positive linear relationship or dependency is linear (Figure 2).

Figure 2: Relationship between the additional yield and productivity of irrigation water in corn grain, in the period 1972-2013.

As a result of the applied dispersion analysis, the coefficient of determination was established. In the present study, it has a value (R2 = 0,77), indicating that approximately 77% of the variation of the dependent sign (irrigation productivity) is explained by regression.

Study of the linear relationship between the amount of irrigation and the additional yield is established correlation coefficient (r = 0,36). Linear regression represented in figure 3 shows the low degree of correlation between the independent variable of irrigation and the dependent variable additional yield.

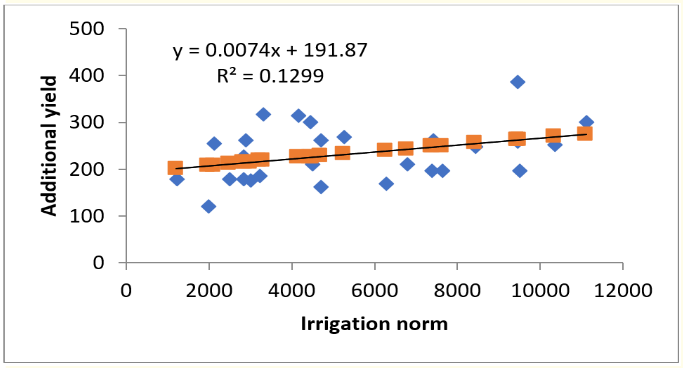

Figure 3: Relation between the irrigation norm and the additional yield of maize for grain, in the period 1972-2013.

Knowing the nature of dependencies is a prerequisite for the efficient use of water resources. Dwindling water resources worldwide is a prerequisite for precision irrigation technologies, to develop a strategy to reduce water consumption not effective.

Therefore, a thorough study of the relationship between the factors determining the productivity of irrigation water is necessary.

In this connection is presented the rate of development of the additional yield (Figure 4). For the 27-year study period, it showed very different and dynamic values. The highest was the rate in 1981 with 2,34 kg.ha^{-1}and the least developed in 2004, when it was -0,63 kg.ha^{-1}, averaging from -0,35 to 0,64 kg.ha^{-1}. These results can be explained by the different values of the irrigation rate during the years surveyed.

Figure 4: Dynamics of additional yield for the period 1972-2013.

Important is the rate of irrigation water productivity (Figure 5). Its values are also dynamic as with additional yield, but with smaller amplitudes. In 2005 and 2013 the two highest scores were recorded – 1,49 and 1.58 kg.ha^{-1}.mm, and in 2000 the lowest -0,61 kg.ha^{-1}.mm. Its varying values are due to the difference in irrigation rate, rainfall provision during the survey period. The positive relationship between the irrigation water productivity and the extra yield is also confirmed.

Figure 5: Dynamics of irrigation water productivity for the period 1972-2013.

Conclusions

As a result of this study established the productive capacity of maize grain at optimal irrigation and natural waterproofing.

It is calculated productivity of irrigation water from 6,72 kg.ha^{-1}.mm to 48,72 kg.ha^{-1}1.mm, over the years with varying security of rainfall.

It is the existence of a strong positive linear correlation between the extra yield and productivity of irrigation. The correlation coefficient was determined (r = 0,88).

The rate of development of the productivity of the irrigation water is dynamic, but a smaller amplitude as the rate of additional yield.

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