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Determine yield response factor of forage corn in water stress conditions, nitroxin and nitrogen different levels (case study: Markazi Province, Iran)

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Abstract

Markazi Province is located in central of Iran between 49° and 48' eastern longitude and 34° and 3' northern latitude. One of the strategy crops in Arak is forage corn. In order to determine the yield response factor (K_y) of forage corn, hybrid (*Maxima*) at different growth stages under water stress, Nitroxin and nitrogen application levels experiment was conducted in 2012 in Arak, under field conditions. This research was examined split-split plot in a randomized complete block design with four replications. Irrigation treatments consisted of two levels (I_0) and deficit irrigation (I_1) as the main factor, Nitroxin in three levels: zero, 0.5 and 1 milliliter per 25 kg of seed and nitrogen levels containing zero, 125 and 250 kg per hectare, which was considered as a minor factor. In order to acquire the actual evapotranspiration (ET_a) of net requirement irrigation was measured in the field and to calculate potential evapotranspiration (ET_O) using FAO Penman mantis. To determine the yield response factor (K_y) Stewart's formula was used. Coefficients were calculated for the four growth stages of plant growth, vegetative stage, stem elongation, flowering and ripening product, respectively: 0.24, 1.6, 0.54, 0.28 and 1.6 were obtained for the entire period. The results shown a satisfactory correction between k_y calculated in this research and other studies.

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Introduction

Corn is one of the most important crops in the Markazi province. Know crop yield is a function of the amount of water available to plant roots, and it is useful for farm management. On the other side water is the main factor limiting yield production in arid and semi-arid regions. Water stress has an important effect on water consumption and maize yield. The yield response to water deficit of different crops is of major importance in production planning. Several studies have been done in the world on a variety of parameters that affect the yield response factor. The relationships between crop water use (ET) and yield have been a major focus of agricultural research in arid and semi-arid regions (Oktem *et al.,* 2003). The other experiment in semi-arid climate conditions in Tadla (Morocco) The yield response factor (K_y) for the silage maize for both growth seasons was 1.12. Under the Tadla semi-arid climate, it is proposed that silage maize should be irrigated as a priority before other crops with a K_y lower than 1.12. It is also recommended that, under limited water supplies, irrigation be applied during the linear phase of growth of this crop (Bouazzama *et al.,* 2012). A positive linear relationship between grain yield and water use has been recognized by several authors (Gencoglan *et al.,* 1999; Istanbulluoglu *et al.,* 2002; Fatih *Et al.,* 2008). Where all of these are optimal throughout the growing season, yield reaches the maximum value as does evapotranspiration (ET_m) water storage (SWS) has an impact on water availability (WA) for a crop and, subsequently, on actual yield and actual evapotranspiration (ET_a) (English, 1990). Using K_y for planning, design and operation of irrigation projects allows quantification of water supply and water use in terms of crop, yield and total productions for a project area (English, 1990). When irrigation water is limited, but distributed equally over the total growing season, the crops with the higher K_y values will suffer a greater yield loss than the crops with a lower K_y values. Both the likely losses in yield and the adjustments required in water supply to minimize such losses can be quantified (English, 1990). Similarly, such quantification is possible when the likely yield losses arise from differences in the K_y of individual growth periods (English, 1990). Using different maize hybrids, the K_y values of 1.00 for the hybrid Kn606 and 1.50 for the hybrid H708 were derived in Portugal (Popova *et al.,* 2006). The main goal of this research was to determine K_y for maize under deficit irrigation in northwest Iran.

Materials and methods

The experiment was conducted at the experimental farm at a distance of 5 km from the Arak city, Iran in 2011. The longitude and latitude of this region has 49° and 48' eastern and 34° and 3' northern respectively. The height of this region is 1635 meter above sea level. Area has a cold climate and steppe. The average rainfall is 250 mm per year. The maximum temperature in summer reaches 40°c and in winter arrives to 30°c. In this study, we used the hybrid corn Maxima (*Zea mays cv Maxima*).This hybrid is type of dent corn and medium maturity duration. Full maturity period of 120 days to 95 days for seed and forage production respectively. Irrigation treatments consisted of two irrigation levels (I_0) and deficit irrigation (I_1) as the main factor, Nitroxin in three levels, zero, 0.5 and 1 liter per 25 kg of seed and nitrogen of levels 0, 125 and 250 kg per hectare, which was considered as a minor factor. Irrigation was carried out to permanent sprinkler irrigation system. The experiment was conducted the split-split plot in a randomized complete block design. The number of rows in each plot determined 4 rows and length of each row 6 meter and spacing of seed on row was 19 cm. The seeds were mixed with Nitroxin before planting in the shade.

Method applied deficit irrigation and the formula used

Since the establishment of full- the activation time of 4 hours for optimum irrigation sprinklers, it was necessary to develop deep roots in the area (Based on irrigated farm's design) it's time declined to consult the experts Irrigation 2.5 hours. Volume of irrigation water used on the farm at any stage of conventional irrigation and drought stress was calculated for each section. To ensure the least amount of moisture by the roots at low water wt% moisture measurement method in accordance with Equation (1) was used after carrying out the necessary calculations were compared in table 1.

$$\text{Formula 1: Weight percent moisture} = \frac{W_2 - W_1}{W_2} \times 100 \quad (1)$$

Table (2) shows the farm irrigation scheduling. One of the main goals of this experiment was to determine the sensitivity factor to water (K_y) forage maize under deficit irrigation regimes, respectively. The meteorological data for 20 years (1992-2011) was used area. To determine the potential evapotranspiration (ET_o) and FAO Penman mantis to determine actual evapotranspiration (ET_a) The farm was used to measure pure water. Finally, to determine the sensitivity coefficient to water (K_y) Stewart's formula has been used in formula (2). This is a standard formulation, relates these four parameters (Y_a, Y_m, ET_a, ET_m) to a fifth: K_y, which links relative yield decrease to relative evapotranspiration deficit. Where Y_a and ET_a correspond to the actual yield and ET, respectively, and Y_m and ET_m are the maximum yield and ET attainable for the crop grown under optimum agronomic conditions, respectively.

$$1 - \frac{Y_a}{Y_m} = K_y \left(1 - \frac{ET_a}{ET_m}\right) \quad (2)$$

Furthermore, the K_y for total growing period is calculated using Equation 3, according to Jensen (1968):

$$\frac{Y_a}{Y_m} = \prod_{i=1}^{N} \left[1 - K_{y,i}\left(1 - \frac{ET_{a,i}}{ET_{m,i}}\right)\right]$$

Where: $K_{y,i}$ = Yield response factors for different growth stages $ET_{a,i}$ = The actual evapotranspirations in various growth stages, and $ET_{m,i}$= Maximum evapotranspiration in vegetative period, flowering, grain filling, and ripening period calculated using CROPWAT PC software (FAO, 1992). Therefore crop coefficient values were calculated for the four developmental stages of maize include: vegetative stage, stem elongation, flowering and ripening of crop growth period.

Results

The results showed that there is little difference between k_y calculated in this study with those reported by FAO (Table 3). The calculated values of K_y reported by FAO (1979) has adapted well. The results of this study Indicated good agreement with the K_y values reported by some researchers in the Qazvin plain, Iran (Njarchi *et al.,* 2011). Also, this value was higher than the ones determined by some researchers in Turkey, which ranged from 0.99 to 1.04 (Mengu and Ozgurel, 2008, Dagdelen *et al.,* 2006). However, the obtained value in the present study was close to that observed by a team of researchers in Tanzania the reported value of 1.9 (Igbadan *et al.,* 2006), and some researchers in Nebraska, USA (from 1.54 to 1.74) (Payero *et al.,* 2008). The results of this research do compare well with K_y computed by two of the researchers in Brazil and some results in Australia (Andrioli and Sentelhas, 2009). The average yield response factor (K_y) for corn crop was determined 0.99 in Mazandaran Province (Akbari Nodehi *et al.,* 2011).

Table 1. Comparison between soil moisture weight percent in conventional irrigation and stress field in different depths.

Soil depth (cm)	Weight percent moisture (irrigated fragments)	Weight percent moisture (drought fragments)
10	0.25	0.19
20	0.33	0.26
30	0.24	0.21

Table 2. Irrigation Schedule.

Crop	Planting date	First irrigation	Irrigation interval (day)	Total irrigation times	Harvesting time
Maize	28 Jun	29 Jun	7	12	29 Sep

Discussions

According to the method applied in the irrigation field was calculated k_y. The results obtained showed the highest growth rate among all phases of plant sensitivity to low irrigation flowering period while the stages of the investigation showed the lowest ky, respectively. So, with a good management can be tolerated in the field of irrigation water to the plant at different stages of development, product and ultimately achieve the possible development of in the course of the dehydration plant sensitivity coefficient is less than 1. So that these conditions can have an optimum yields the best performance with minimal damage to the product.

Table 3. yield response factor of corn (K_y) with the values reported by the FAO (1979) states.

Crop	Vegetative		Flowering		Grain filling		Ripening		Total growing period	
Maize	Arak	FAO	Arak	FAO	Arak	FAO	Arak	FAO	Arak	FAO
	0.24	0.4	1.6	1.5	0.54	0.5	0.28	0.2	1.15	1.25

Conclusion

K_y value's is calculated based on the study compared to the amount reported by the FAO (1979) is higher than other stages in the vegetative stage. Therefore concluded that the restrictions on irrigation, the yield loss is greater than the value reported by the FAO. It is recommended K_y values calculated at various stages in the research and development of forage maize vary also be studied in different soil and climatic conditions.

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